Report to the Governor's Task Force on Climate Change

STRATEGIES TO IMPROVE WISCONSIN'S CLIMATE RESILIENCE AND READINESS

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Wisconsin Initiative on Climate Change Impacts (WICCI):

A partnership of the University of Wisconsin-Madison Nelson Institute for Environmental Studies and the Wisconsin Department of Natural Resources

40 Science Hall
550 North Park Street
Madison, Wisconsin 53706
www.wicci.wisc.edu

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Introduction: Improving Wisconsin's Climate Resilience and Readiness

Through Executive Order 52, Governor Tony Evers directed the Department of Natural Resources to make its scientific data available to the Task Force by working with the Wisconsin Initiative on Climate Change Impacts (WICCI) and University of Wisconsin-Madison Nelson Institute for Environmental Studies to collect updated, impartial scientific data on the rate of climate change in Wisconsin and its impact on Wisconsin's natural environment. The WICCI is a statewide collaboration of scientists and stakeholders formed in 2007 as a partnership to evaluate climate change impacts on Wisconsin. Our working groups are made up of scientists, experts, and practitioners. With this report, we present information on impacts from climate change specific to Wisconsin and science-based solutions and strategies to address these impacts. While we provide some policy ideas to consider, our primary aim is to help inform policy priorities by providing expert analysis on key issues for consideration by the Governor's Task Force on Climate Change. For a video overview of climate impacts in Wisconsin, please visit the WICCI website.

Environmental/Social Justice

Throughout this report, we highlight issues of environmental justice where climate impacts put Black communities, Tribal Nations, other communities of color, and low-income communities disproportionately at risk. Justice requires the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income.

Climate Science Update

Our climate is changing in many ways. From record melting of Arctic sea ice to more extreme storms, massive wildfires, and prolonged drought, communities around the world are already experiencing the impacts. The science linking these climatic changes to human-caused increases in greenhouse gasses – especially carbon dioxide – is clear. Indeed, since the middle of the 19th century, scientists have known that:

> *"An atmosphere of [carbon dioxide] would give to our earth a high temperature; and if as some suppose, at one period of its history the air had mixed with it a larger proportion [of carbon dioxide] than at present, an increased temperature … must necessarily have resulted." (Eunice Foote, 1856)*

Over the last 165 years Eunice Foote's scientific hypothesis about our planet's past has been borne out in a lived experiment that we carry into our future. And, as carbon dioxide continues to accumulate in our atmosphere, we will continue to experience its effects in our changing climate.

In Wisconsin, our climate is changing along with the rest of the world. And, like elsewhere, Wisconsin citizens and businesses are already feeling the impacts. In the decade since WICCI released its 2011 Assessment Report[1], the WICCI Climate Working Group has continued to advance our understanding of climate change in Wisconsin. Three main findings have emerged:

- New analyses of historical climatic changes over the last ten years – especially seasonal warming, precipitation changes, and increases in extreme climatic events – are consistent with findings and projections from WICCI's 2011 Assessment Report
- Additional information from new climate model simulations and analyses continue to support the findings and projections from WICCI's 2011 Assessment Report
- New scientific findings and analyses add additional confidence to findings from WICCI's 2011 Assessment Report, and provide new insight on specific climatic impacts that are relevant for Wisconsin

This section provides a brief update to the climate science presented in the WICCI 2011 Assessment Report.

Historical Temperature and Precipitation Changes

One of the clearest signs of climate change is the increase in temperature that our planet is experiencing. Since 1880, average global temperatures have increased by about 1.8°F. According to National Oceanic and Atmospheric Administration (NOAA), average annual global temperatures have increased steadily since the 1960's. ***Figure 1*** shows deviations from the average global temperature (depicted as the horizontal line at 0.00 degrees C. Every blue bar is a year that was colder than average temperature of the 20th century; red bars are years that were warmer than the 20th century average. Nineteen of our planet's twenty warmest years have occurred since 2001 with 1998 (the warmest

[1] Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.

year in the 20th century) being the twentieth. In fact, it is likely that the *coldest* year we will experience in the next century will still be *warmer* than 1998. Global temperature is projected to continue to warm by an additional 2.7°F by 2050 and 3.6-7.2°F by 2100[2].

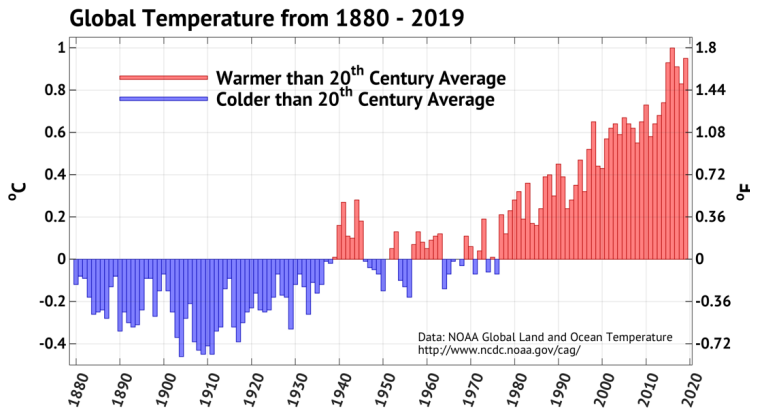

Figure 1. Global temperature anomalies from 1880-2019. National Oceanic and Atmospheric Administration (NOAA). Plot produced by the Wisconsin Initiative on Climate Change Impacts.

Wisconsin is warming. To determine changes in Wisconsin's climate, the WICCI Climate Working Group analyzed regional data from a global network of observations compiled by the National Climatic Data Center[3]. This dataset shows that Wisconsin has become 2.1°F warmer since the 1950s, with winters warming more rapidly than summer (***Figure 2***). Further, the updated trends confirm that nighttime low temperatures are warming faster than daytime high temperatures[4]. *These seasonal and daily temperature changes are consistent with global climate model predictions reported in the WICCI 2011 Assessment Report.*

Wisconsin is becoming wetter. In fact, since the 2011 WICCI Assessment report was released, all nine of Wisconsin's climate divisions have reported their wettest decade in recorded history. Since 1950, Wisconsin's annual precipitation has increased by about 4.5 inches, or about 15% (***Figure 3***). Winter precipitation has increased by over 20% since 1950, which is consistent with statistically significant increases in snowfall over the state since 1950[5]. Most of Wisconsin's precipitation occurs during the warm season, but over much of the state annual increases are dominated by increases during spring and fall. It is worth noting that the drastic increase in annual precipitation is larger than expected from climate change alone: the recent increases in precipitation are likely due to some combination of climate change and (random) natural variations. *The robust precipitation increases during winter and spring are consistent with projections made in the 2011 WICCI Assessment Report.*

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[2] Chapter 12 of the IPCC Fifth Assessment Report: Collins, M., R. Knutti, J. Arblaster, J.L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner, 2013: Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/report/ar5/syr/

[3] See https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ncdc:C00005; Vose, R. S., and Coauthors, 2014: Improved Historical Temperature and Precipitation Time Series for U.S. Climate Divisions. *J. Appl. Meteor. Climatol.*, **53**, 1232–1251, https://doi.org/10.1175/JAMC-D-13-0248.1

[4] Additional graphics are available from the WICCI website at http://www.wicci.wisc.edu

[5] From Wisconsin State Climatology Office: http://www.aos.wisc.edu/%7Esco/seasons/graphics/WI-00-snow-djf.gif

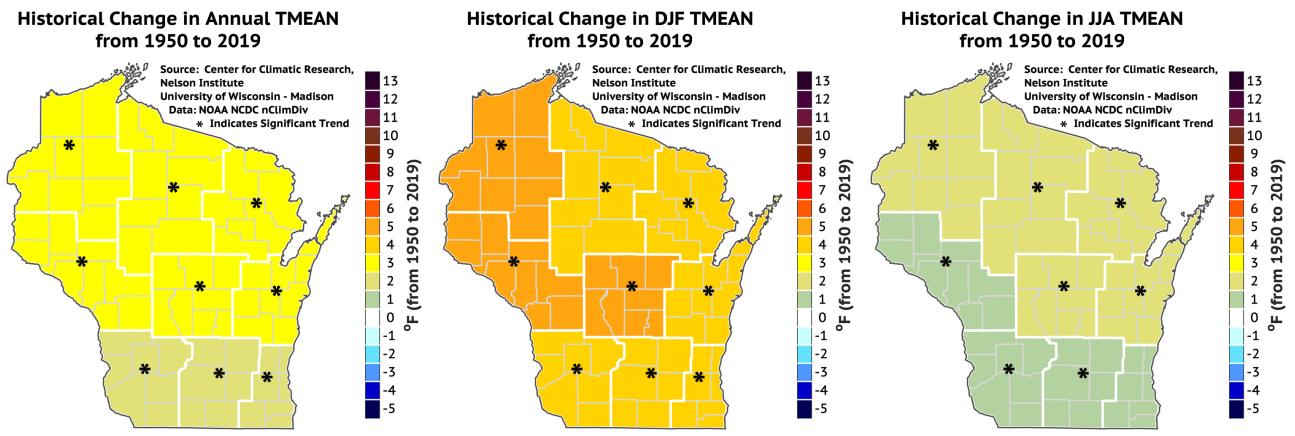

Figure 2. Changes in (left) annual, (middle) winter, and (right) summer mean temperature from 1950-2019. Changes are calculated as trends over the time period 1950-2019 (°F per year) times the number of years (70yr). Asterisks indicate that the trend is statistically significant. Data source: NOAA NCDC nClimDiv.

Extreme precipitation events are becoming more common in Wisconsin. Increases in extreme precipitation since the 2011 report have taken a significant toll on Wisconsin communities, inflicting tens to hundreds of millions of dollars of damage over the last decade. ***Figure 4*** shows that numerous communities have experienced 100 year or greater rainfall events over the last decade and that the 2010s was Wisconsin's wettest decade in recorded history. Flooding related to these events has led to significant damage to business and residential infrastructure, agricultural communities, and human health and well-being. While increases in extreme precipitation were predicted in the 2011 WICCI Assessment report, new research since 2011 has led to significant improvements in our understanding of how climate change is likely to affect these events. Most notably, research shows that VERY extreme events – 100 year,

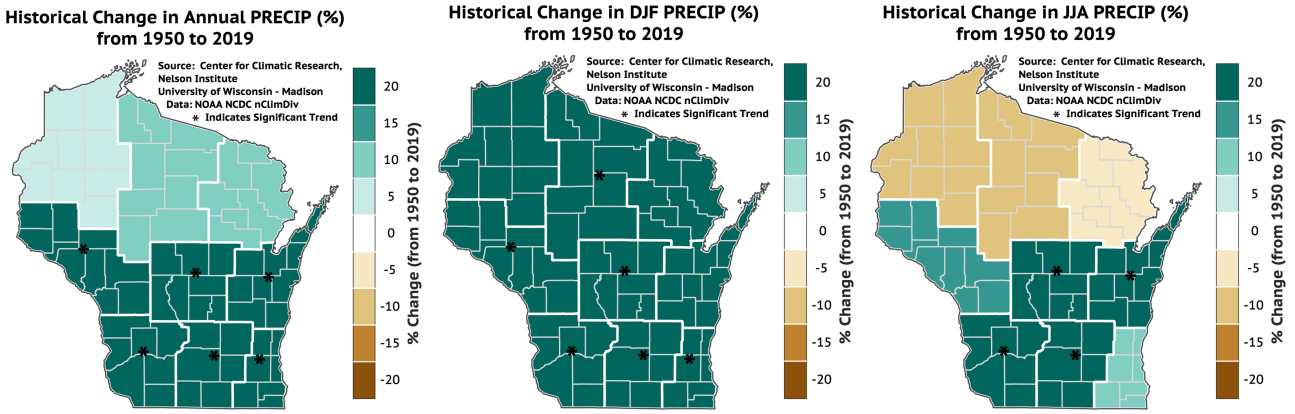

Figure 3. Changes in (left) annual, (middle) winter, and (right) summer precipitation from 1950-2019. Changes are calculated as trends over the time period 1950-2019 (°F per year) times the number of years (70yr). Asterisks indicate that the trend is statistically significant. Data source: NOAA NCDC nClimDiv.

500 year, or 1000 year events like those experienced in Northern Wisconsin during 2012, 2016, and 2018; or in August 2018 in South Central Wisconsin – are most strongly affected by a warming climate. While these events are rare, they are also exceedingly damaging and are becoming disproportionately more common globally as our climate warms.

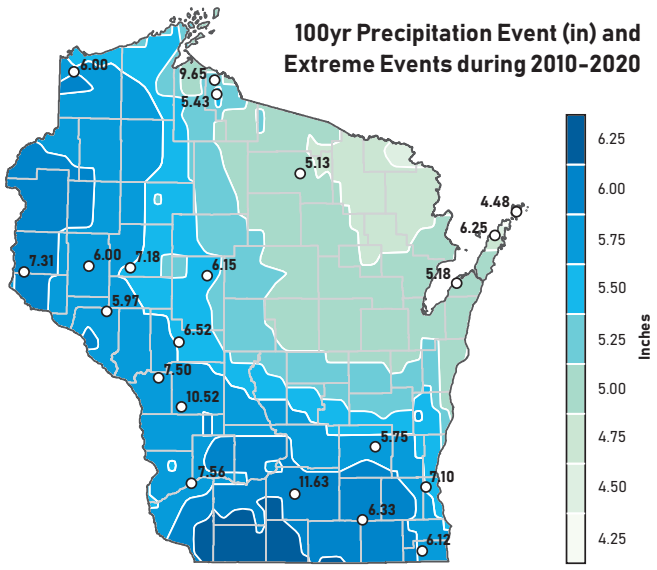

Figure 4. Climatological 100yr rainfall event magnitude (shading) together with historical extreme rainfall events over the time period 2010-2020 (dots with numbering). Each event is the largest daily rainfall recorded at a given location over the time period 2010-2020. For multi-day events, only the day with the largest rainfall is recorded. *Data from WICCI and E. Hopkins, State Climatology Office.*

Future Projections

To produce projections of temperature and precipitation into the 21st century, the 2011 WICCI Assessment Report used the University of Wisconsin Probabilistic Downscaling Data Version 1. This data uses a "statistical downscaling" technique in which global scale climate model projections are combined with local observations to produce estimates of climate variations and change over a more localized scale. This update uses the University of Wisconsin Probabilistic Downscaling Data Version 3 (WICCI Data), which is based on updated global models and an improved methodology. The WICCI Data includes nearly twice as many global models and, like the 2011 Assessment Report, results are presented either as an average over all models (maps), or as a range (10th-90th percentile) of possible changes that account for simulated natural variability as well as differences in physical processes across global model simulations (e.g. annual warming of 2.5°-7.5°F). The WICCI Climate Working Group has also produced "dynamically downscaled" projections in which the global models are used to force high-resolution regional climate models. These simulations provide additional information about potential climatic changes in Wisconsin, and results are reported from the dynamically downscaled projections where relevant.

In addition to a change in data source, the methodology for calculating future projections has changed since the 2011 WICCI Assessment Report. One major change is that future projections are now calculated relative to a baseline climatology of 1981-2010 rather than 1960-1999, in order to be consistent with new standards for defining a "climate normal."[6] Two different emissions scenarios are included where relevant: the RCP4.5 scenario is a "low-end" global emissions scenario over the next century and the RCP8.5 scenario is a "high-end" or "business as usual" scenario.

[6] https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals

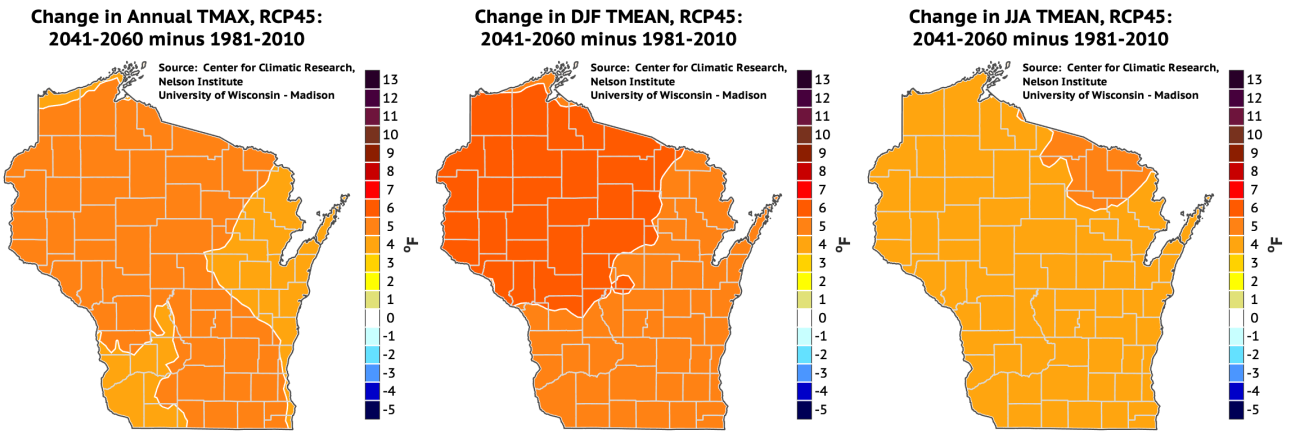

Figure 5. Projected changes in mid-21st-century (2041-2060) (left) annual, (middle) winter, and (right) summer average temperature for RCP4.5 "low-end" emissions scenario. *WICCI Data.*

The WICCI projections show very similar climatic changes to those in the 2011 WICCI Assessment Report. In particular, the WICCI projections show that under the low-end emissions scenario ***Wisconsin is expected to warm by 2.5°-7.5°F by mid-century***, with maximum warming during winter (3°-8°F) and minimum warming during summer (1.5°-7.5°) (***Figure 5***). Dynamically downscaled results are similar but have larger warming rates for summer due to increased dry soil conditions. For mid-century, projections for the high-end emissions scenario are very similar to the low-end scenario, with annual mean warming of about 3°F-9°F by mid-century. By late century (2081-2100) projections of annual mean temperature for the low-end and high-end emissions scenarios differ substantially with the low-end emissions scenario projecting annual mean changes of 3°-10°F, and the high-end emissions scenario projecting change of 7°-16°F (***Figure 6***). These drastic warming rates for the high-end emissions scenario indicate the importance of mitigation for reducing impacts of climate change.

Changes in mean temperature are also manifest on a daily basis by changes in the characteristics of extreme heat events. ***By mid-century, the number of extremely hot days in Wisconsin is likely to triple*** (defined as the number of days where temperature exceeds 90°F; ***Figure 7***), and ***the number of extremely hot nights is likely to quadruple*** (defined as the number of nights when daily temperature does *not* drop below 70°F). It is

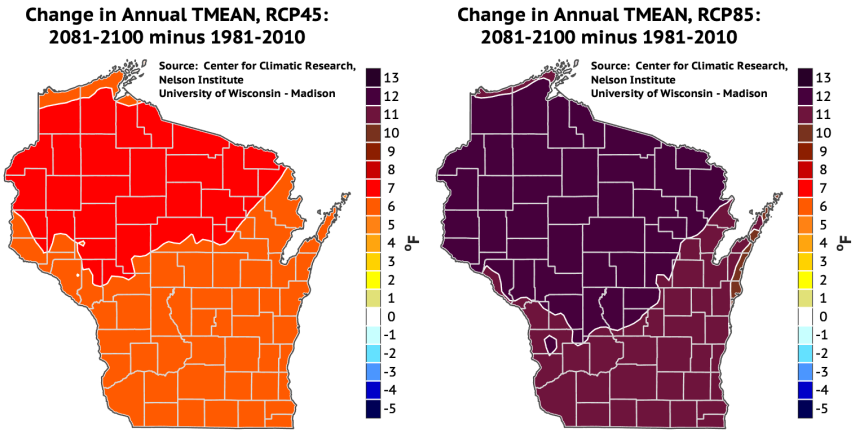

Figure 6. Projected changes in late-21st-century (2081-2100) annual average temperature for the (left) RCP4.5 "low-end" and (right) RCP8.5 "high-end" emissions scenario. *WICCI Data.*

noteworthy that by the late century under the high-emissions scenario, southern Wisconsin may experience 80 to 90 days per year – nearly an entire summer – with high temperatures exceeding 90°F. These extreme changes have disproportionate impacts on communities of color, elderly, individuals with existing health conditions, and economically disadvantaged communities who lack cooling capabilities.

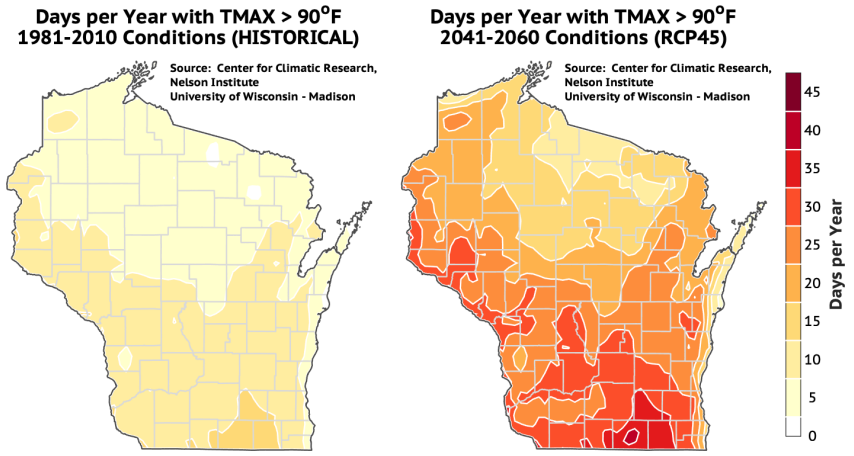

Figure 7. Annual extreme heat frequency (left) historical and (right) projected mid-21st-century (2041-2060) for the RCP4.5 low-end emissions scenario. Depicted are the number of days per year when the temperature exceeds 90°F. *WICCI Data.*

Precipitation is more variable than temperature, and as a result, future projections (***Figure 8***) have a larger range of possible changes than temperature. ***Annual mean rainfall in Wisconsin is expected to increase by mid-century***, but the change varies among models from a 5% decrease to a 15% increase. During winter, spring, and fall, precipitation is likely to increase, whereas summer precipitation has equal chances of increasing or decreasing. ***It is likely that extreme precipitation will increase in Wisconsin, with the very extreme values seeing the largest change***. For example, a daily 4" precipitation event typically occurs 6-10 times per 100 year (once every 10-15 year) in Southern Wisconsin. These events are likely to increase in frequency to 10-15 events per 100 year (once every 6-10 years; ***Figure 9***). These changes are even more pronounced for the late-century, high-emissions scenario, which projects 18-22 daily 4"

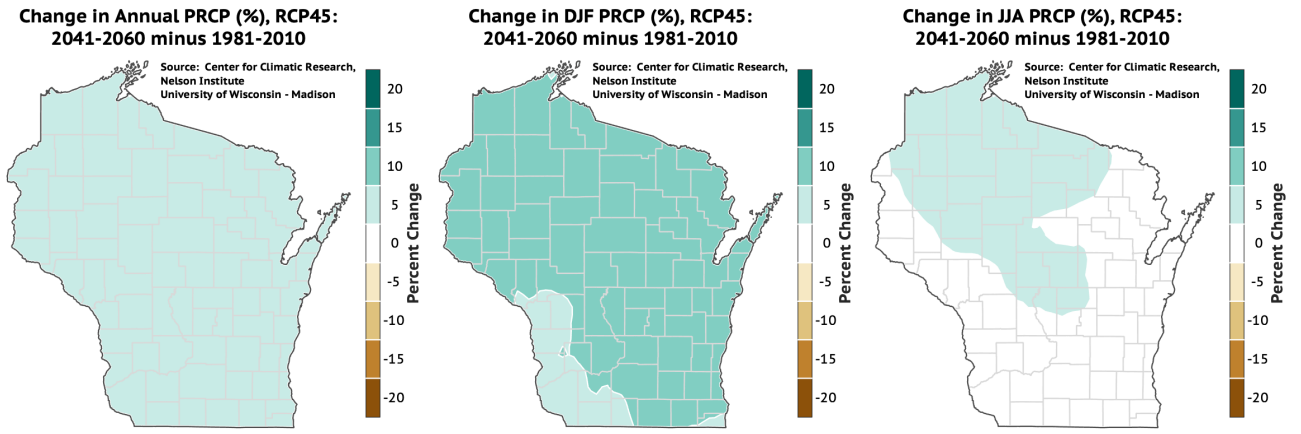

Figure 8. Projected changes in mid-21st-century (2041-2060) (left) annual, (middle) winter, and (right) summer average precipitation (percent) for RCP4.5 "low-end" emissions scenario. *WICCI Data.*

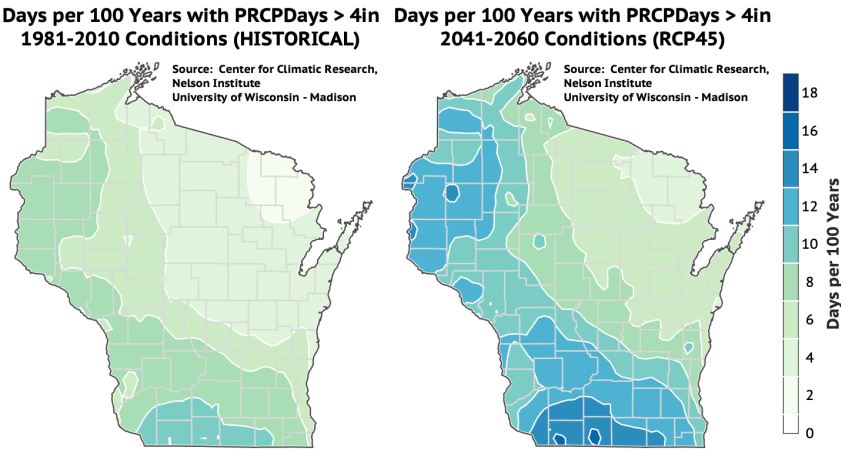

Figure 9. Projected changes in mid-21st-century (2041-2060) (left) annual, (middle) winter, and (right) summer average precipitation (percent) for RCP4.5 "low-end" emissions scenario. *WICCI Data.*

precipitation events every 100 years (approximately once every 5 years). These extreme precipitation events have immense impacts across the state, especially to agricultural communities.

Concluding statement

New analyses of observed historical climate trends, as well as new climate projections for Wisconsin provide additional confidence in expected climate change over the coming century. Observed historical trends show consistency with greenhouse-gas forced model simulations into the 21st century, especially with respect to observed seasonal changes. Future projections under a low-end emissions scenario suggest Wisconsin will continue to warm into the middle of the 21st century, including a tripling in frequency of extreme heat days. Wisconsin is also likely to become wetter in the coming century, with robust increases in winter, spring, and fall. Extreme precipitation events are likely to increase in frequency and magnitude. These changes are much larger under a high-end emissions scenario, pointing to the importance of reducing greenhouse gas emissions in order to limit climate change impacts to Wisconsin.

Subcommittee on Energy, Housing & Infrastructure

Investments in infrastructure are long term. Our rural roads, highways, airports, ports, dams, stormwater and wastewater systems – everything that supports our lives and livelihoods – have been and are currently being designed under climate conditions different than they will encounter during most of their service life. In rebuilding, and in designing new infrastructure, updated climate projections need to drive decisions of how and where to rebuild. Currently, these infrastructure investment decisions often do not take into account expected future changes in extreme weather including precipitation and temperature. This is because specific data on current and future climate variables are not available or are difficult to access. Although several large infrastructure projects in Wisconsin have considered future climate conditions, most have not, because this is something that is often beyond the limited resources of infrastructure managers or other decision makers in small communities. Further, many codes and standards require the usage of climate data that are out of date, and they do not require consideration of anticipated future climate conditions in facility planning. We suggest the following investments and actions to help all communities in Wisconsin to have the resources to proactively and efficiently evaluate alternatives and plan repairs and new facilities to consider future climate conditions.

Subcommittee on Energy, Housing & Infrastructure Strategies and Solutions Table	
Issue	**Strategies and Solutions**
Climate Data	***Create a State Climate Office and fund staff*** *to more efficiently collect state-wide climate data publish quantitative data on key climate variables for current and projected future conditions and provide guidance on ways to promote resiliency to climate change impacts in our communities.*
Infrastructure	***Encourage (and require where appropriate) that all new infrastructure planning and design projects specifically consider vulnerability and risk associated with future climate conditions.*** ***Provide new state funding for infrastructure replacement or repair*** *projects to proactively make infrastructure more resilient to future changes.* ***Provide a standardized method to evaluate and report embodied carbon emissions*** *from the most commonly used construction materials in Wisconsin and create Environmental Product Declarations for project development, bid evaluation, etc.* ***Long-term Goals (4-10 years): Pursue climate bonds*** *to accelerate green actions*
Mississippi River	***Develop a two-dimensional hydraulic model*** *that will aid in flood forecasting, management, response, and policy on a watershed basis. Use this model to evaluate current and future conditions for a variety of scenarios to define transportation, ecological, and planning impacts.*

Subcommittee on Energy, Housing & Infrastructure Strategies and Solutions Table *(Continued)*	
Issue	**Strategies and Solutions**
Coastal Resilience	***Conduct vulnerability assessments*** *in coastal communities to identify buildings and critical infrastructure such as ports, harbors, and marinas that are highly vulnerable.* ***Promote relocation, elevation, or acquisition/demolition of infrastructure and homes*** *to remove them from hazard areas. Examples: increasing working dock heights, converting marinas to floating dockage, and relocating water intakes to deeper water.* ***Promote the beneficial use of material dredged from Great Lakes harbors*** *by increasing funding that supports harbor dredging that sustainably uses the dredged material or creating new funding.* ***Long-term (4-10 years) priorities*** *Promote improved* ***coastal-specific stormwater and groundwater management practices near coastal bluff areas*** *through stormwater management plans and ordinances. Coastal-specific stormwater management plans could fund or incentivize practices like directing storm water and septic discharge away from the bluff, maintaining deep rooted native vegetation, and improving groundwater drainage to increase the stability of bluffs.*

Making climate information available and usable for Wisconsin Communities

Recent extreme weather events throughout Wisconsin have shown the shortcomings of existing infrastructure and disaster relief systems. They have also highlighted the need for providing communities with the best available weather and climate information. Nearly all states support state climate offices, which provide accurate and complete climatologic and weather data to everyone — local governments, residents, businesses, and agencies. Typically, state climate offices also provide the public with cost-effective services like hourly and daily data (including temperature, wind speed, dew point, barometric pressure, frost, and snowfall), climate monitoring, applied climate research, and long-range forecasts and interpretations of data, including "value-added" products tailored for users and impact applications.

Environmental/Social Justice

Providing the climate data proposed will relieve the burden of data assembly that is disproportionately heavy for small, rural, or disadvantaged communities. Climate data can also help us identify, engage, and address risks in disadvantaged communities.

Although the University of Wisconsin-Madison has a Wisconsin State Climatology Office, the office is the *only one in the country to operate as a purely volunteer effort*. The office receives no operational funding from any source and is led by two emeritus faculty/staff members. The lack of ongoing support hinders Wisconsin's ability to use relevant scientific information and promote resiliency to climate change impacts in our communities.

The Wisconsin State Climatology Office should also develop, maintain, and communicate a comprehensive database describing present and future climate conditions for use by Wisconsin infrastructure planners, engineers, and policymakers. This work will include the creation of climate data sets for present and future conditions of critical climate variables such as rainfall, temperature, humidity, wind, snow, freeze/thaw and other variables. The data will be presented in a consistent and easily accessible format. Critically, this effort will also identify state and municipal codes and standards that should reference this newly developed data, and communicate the use and value of the data by pilot infrastructure vulnerability and adaptive design demonstration projects for potable water, wastewater, public health, transportation, and water resources projects. Similar examples of the use of future climate data in public health and environmental assessments should be developed.

To provide appropriate staffing and reliable climate information to the state, we suggest recognizing the State Climatologist's role in statute and funding a state climate office.

For more background on this topic, please visit the Climate Working Group on the WICCI webpage.

Wisconsin's infrastructure is a source of greenhouse gases and vulnerable to climate impacts

Climate impacts to Wisconsin's infrastructure include more frequent and intense precipitation, higher annual precipitation amounts, earlier thawing in the spring and more freeze/thaw cycles combined with a greater number of rainy days, higher water table elevations, the potential for higher lake levels, and more intense heat waves. The impact of these changes will increase vulnerabilities of our roads and rail systems in Wisconsin, create public and environmental safety risks due to flooding, cause a higher likelihood of bridge and dam failure, and result in damage to and inaccessibility of commercial ports and other coastal facilities. More roadway damage may lead to a reduction in commerce as communities face the possibilities of more weight limit restrictions on non-arterial roadways for a greater fraction of the year, difficulty completing construction projects, and impacts to the traveling public and emergency vehicles. Guidance on the methodology of infrastructure risk assessment needs to be developed and publicized to reduce inefficient or inaccurate planning and expenditure due to uncertainty in climate change projections compounded with uncertainty in vulnerability of specific infrastructure.

Environmental/Social Justice

Communities with lower tax bases often do not have additional funds to repair or replace infrastructure with an eye toward climate resiliency. In addition, infrastructure failures can remove the only transportation route for emergency services, significantly impacting public health and safety during extreme storm events.

Mitigating climate change impacts will require major changes to our energy and transportation infrastructure to reduce greenhouse gas emissions. In addition to the design challenges, funding mechanisms will need to be adjusted. For example, our transportation system is based on fossil fuels taxation, which is unsustainable in the long term and makes it difficult to accelerate activities that support carbon-free energy sources. We suggest that revenue sources and financial planning be considered very early in the process of infrastructure greenhouse gas reduction efforts.

Many construction materials and construction processes have high-embedded carbon content, resulting in greenhouse gas emissions. Using lower carbon content materials, particularly in large projects, therefore represents an opportunity for meaningful climate change mitigation. We suggest that Wisconsin join the national trend towards infrastructure sustainability programs that encourage the use of sustainable materials, recycling, better planning, and more efficient construction practices that incorporate reductions in carbon emissions from construction materials. These programs can also benefit the regional economy by encouraging locally sourced materials and spur technical and business innovations. For such a program to be effective, however, it needs to establish unambiguous and technically sound guidelines, while providing simplicity and minimal burden for businesses to participate. Therefore, a study is necessary to: (1) Review existing infrastructure sustainability programs adopted elsewhere in the U.S.; (2) Evaluate current levels of embodied carbon emissions in construction materials and processes in Wisconsin in order to identify existing or potential mitigation strategies; (3) Develop practical and fair methods for evaluating and reporting embodied carbon emissions, considering the data available to state agencies and businesses; and (4) Investigate and suggest options to consider embodied carbon emissions in infrastructure project development and material procurement.

We suggest that Wisconsin establish funds to assess climate risk vulnerabilities of infrastructure systems, and funding to support upgraded infrastructure to make them more resilient to larger storm events and prolonged heat waves. State funding could supplement federal assistance to upgrade structures when they are repaired or replaced. Additionally, this climate risk vulnerability and project funding should specify that a full range of "green infrastructure" alternatives to conventional engineered systems be considered in infrastructure facility planning, such as native plantings and other features that can create additional water quality benefits and habitat for native fish and wildlife species, thus providing additional protection to those species from climate change impacts.

Many of the suggested strategies require collaboration, partnership, experimentation, and the communication of successful practices. More importantly common metrics are needed to adequately measure the impact of adaptation and mitigation measures across all municipalities in Wisconsin. To provide a statewide picture, the Infrastructure Working Group also suggests that an Office of Resilient Infrastructure be staffed and funded to accelerate the adoption of resilience prac**ti**ces in the state. This Office will coordinate collabora**ti**on and partnerships among public and private infrastructure agencies and universi**ti**es, seek supplemental funding from private equity and founda**ti**ons, and design and support climate change capacity building. This Office will also work with private sector partners and the UW system to spur novel technology adop**ti**on in the infrastructure resilience space.

We also suggest Wisconsin support transit and alternative commuting options that can help reduce strains on existing infrastructure, while reducing greenhouse gas emissions, and the need for future expansions. Currently many employers provide employee parking, which incentivizes a "car culture" and driving to work. We suggest employers in businesses, government agencies, and organizations could promote public transit and active transportation (such as biking) to their employees as a means of reducing greenhouse gas emissions and promoting public health.

For more background on these issues, please visit the Infrastructure Working Group on the WICCI webpage.

Infrastructure Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. *Encourage (and require where appropriate) that infrastructure planning and design projects specifically consider vulnerability and risk associated with future climate conditions.* 2. ***Provide new state funding for infrastructure replacement or repair*** *projects to proactively make infrastructure more resilient to future changes.* 3. ***Provide a standardized method to evaluate and report embodied carbon emissions*** *from the most commonly used construction materials in Wisconsin and create Environmental Product Declarations for project development, bid evaluation, etc.*

Infrastructure Strategies and Solutions Table (*Continued*)	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Other Priorities*** **Create a WI Green Compact** for municipalities to accelerate adaptation and climate mitigation, ensure alignment with state, regional and national goals and provide a way to measure our collective impact. **Support public private partnerships and incentives for innovative solutions** like electric-only bids for freight movement, electric vehicle purchases, and charging infrastructure, and the testing of emerging technologies (for example use of publicly owned right-of-way for solar generation). **Upgrade water infrastructure facilities** to reduce energy use and make operational changes to improve plant efficiency. **Create a redundant transportation system** for industries by building rail connections. **Promote walking, biking, and transit** as a way to reduce emissions of greenhouse gases. ***Long-term (4-10 years) Priorities*** **Pursue climate bonds** to accelerate green actions
Building Capacity – better understanding, tools, & innovations for infrastructure management.	**Conduct a statewide risk assessment** of bridges and stream crossings and fund upgrades and replacements to accommodate higher flows and revise standards for new construction. **Provide updated rainfall statistics** for Wisconsin to use in defining climate and watershed land-use conditions floodplain definitions and drainage master plans. **Design curriculum** that addresses climate data planning and usage and provide options for credentials. **Provide training** for county, municipal, and tribal agencies to identify local priorities and solutions through the UW-Extension's Climate Change Leadership Team.

Infrastructure Strategies and Solutions Table (*Continued*)	
Strategies	**Solutions**
Communicating – identifying & communicating risks, public outreach	**Develop and promote a flood risk-based approach** for urban drainage bridges and reservoirs, along with the use of adaptive design approaches that allow for future modifications. **Provide guidance to communities for using green infrastructure** and natural systems, particularly wetlands, in alternative analysis for infrastructure. **Design curriculum** that addresses climate data planning and usage and provide options for credentials. **Provide training** for county, municipal, and tribal agencies to identify local priorities and solutions through the UW-Extension's Climate Change Leadership Team. Partner with Wisconsin Department of Workforce Development and the Wisconsin Technical College System to ensure that training is credentialed.
Filling gaps – basic climate research, data gathering, benchmarking with other states	**Build capacity for climate financing solutions** in the transportation infrastructure sector. **Promote public-private partnerships** to incentivize cleaner transportation and the use of reduced carbon content materials.

Mississippi River commodity transportation, tourism, and ecology are seeing large scale losses due to climate impacts

The Mississippi River provides Wisconsin with a diverse array of services and natural capital. But the Mississippi River and communities in Wisconsin are at risk due to the increasing variability in river flows caused by changes in precipitation, snow melt, storm intensity, and land-use. The amount of water that flowed in the Mississippi River in 2019 was about double the historical average. Extended high water and fall flooding have occurred in seven of the last 10 years. Due in large part to flooding, growth in tourism along the Great River Road was down by 77% in 2019. In high-water years the excessive volume of water causes damage to infrastructure and thus significantly reduces the reliability of river transportation, resulting in delays in deliveries of agricultural chemicals and shipments of commodities. This is particularly impactful to the agricultural sector, which represents a $25 billion annual economic return to the Upper Mississippi River states, including Wisconsin. Natural resources like aquatic plant populations, a critical food source for hundreds of thousands of migrating waterfowl, and floodplain forests have suffered. Delivery of sediment and nutrients increases the prevalence of harmful algal blooms and contributes to the expansion of the Gulf hypoxic zone. A "Weather, Climate and Catastrophe Insight report" found that 2019 flooding in the Mississippi River Basin (including Wisconsin) accounted for approximately $10 billion in economic loss, ranked the third highest loss from natural disasters globally. The Mississippi is a very large river, managed to provide multiple services. Impacts to those services have been and will continue to be large, and any real solutions will necessarily be large in scale.

Environmental/Social Justice

Flooding can have a major impact to communities along the river, especially smaller communities. More effective modeling will increase the abilities of those communities to plan and prepare for storm events so they can minimize damage to homes and businesses.

We suggest Wisconsin focus its efforts on flood hazard mitigation approaches, land management policies that help slow sediment and water movement within tributary watersheds, and transportation investments that help offset future reliability concerns with navigation on the Mississippi River. Further, we suggest the development of a two-dimensional hydraulic model that can delineate the new active floodplain and describe water and sediment dynamics. This model will aid in resiliency design of habitat projects on the Mississippi River, flood forecasting, and management responses for flooding and drought.

Mississippi River Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priority*** ***Develop a two-dimensional hydraulic model*** *that will aid in flood forecasting, management, response, and policy on a watershed basis. Use this model to evaluate current and future conditions for a variety of scenarios to define transportation, ecological and planning impacts.* ***Other priorities*** **Redefine the active floodplain** thorough planning, land buybacks and moving infrastructure to higher ground. **Invest in agricultural management** approaches that restore and maintain soil health. **Optimize beneficial uses of dredged sediment** to help reduce or stabilize costs of increased dredging that will be required for navigation and ecological functions. **Protect remaining floodplain forests** by repair and reinforcement of eroding island borders and constructing new forested islands. **Increase buffer strips around rivers** and restore degraded buffer areas for nutrient capture and slowing sediments and water movement. **Prohibit new agricultural tiling** and remove sensitive areas from production to slow the movement of water over the landscape.
Building Capacity – better understanding, tools & innovations for resource management	**Evaluate transportation investments** that help offset future reliability concerns with navigation on the Mississippi River.

Great Lakes coastal industry and community stability are at risk from climate change

Both high and low water level extremes are anticipated under a changing climate along the Great Lakes coastline. This would include potentially higher highs, lower lows, and more rapid fluctuations than seen in the historical record. Increased waves and storm surge and decreased stability of coastal bluffs are also anticipated. These climate changes will impact coastal-dependent industries and millions of people who live in the coastal area. Also, as water temperatures increase, coastal beaches and drinking water intakes are more likely to be impacted by potentially toxic blue-green algal blooms. Finally, dredging to maintain critical channel depths may increase under a changing climate, as longer and more frequent periods of low Great Lakes water levels may be expected due to increased periods of drought and/or increased evaporation from warmer temperatures and reduced ice cover.

Environmental/Social Justice

Underrepresented populations in coastal communities are often the most vulnerable to coastal hazards such as flooding and beach closures due to contamination. Milwaukee's South Shore beach, for example, is the worst beach in the Great Lakes in terms of water quality and is used primarily by under-represented communities.

We suggest a proactive approach to increase coastal resilience that includes conducting vulnerability assessments to identify critical infrastructure to protect homes, ports, harbors, and marinas. To conduct the vulnerability assessments, we suggest the framework developed during an assessment in 13 communities in southeastern Wisconsin as part of the Southeastern Wisconsin Coastal Resilience project. The assessments made communities more aware of their vulnerabilities and sparked specific projects to strengthen their resilience to coastal hazards during both low- and high-water periods.

We further suggest relocating homes and protecting critical port facilities to remove them from hazard areas. Relocation of homes and communities in response to erosion and flooding is becoming increasingly common in coastal areas around the United States. A few decades ago, Bad River Nation properties at risk in northern Wisconsin, while not directly on the coastline, were relocated in an effort to remove homes from the Bad River floodplain in Odana, Wisconsin. Relocation of buildings away from high-risk coastal areas is often considered as part of a larger planning strategy referred to as a "managed retreat," where a community focuses on purchasing, relocating or demolishing homes that are in imminent danger from coastal erosion processes rather than constructing control structures. Outreach and education are often needed to help make the case for managed retreat programs. Because the cost of relocation can be a significant portion of the value of some homes and/or exceed the financial means of some coastal residents, a need-based funding mechanism could be developed to support relocation of homes from hazard areas. The voluntary acquisition and conversion to open space of at-risk coastal property may also improve public access to Wisconsin's Great Lakes coasts for residents without the financial means to own coastal property.

Finally, we suggest promoting the beneficial reuse of material dredged from Great Lakes harbors. Sediment is routinely dredged from Wisconsin's Great Lakes harbors to maintain critical channel depths for both commercial and recreational boat passage. Much of the material is considered uncontaminated and does not need to be placed into rapidly filling and costly confined disposal facilities for contaminated sediments. Alternative uses for the clean

dredged material could provide significant cost savings as well as **sustainable** environmental benefits, including beach nourishment, habitat creation or restoration, land creation and construction fill, landfill caps and covers, and topsoil creation and enhancement. In the long term, to address the destabilizing effects on Wisconsin's Great Lakes coastal bluffs from stormwater and groundwater, we suggest improved coastal-specific stormwater and groundwater management practices near coastal bluff areas through updated stormwater management plans and ordinances.

For more background on these issues, please visit the Coastal Resilience Working Group and Great Lakes Working Group on the WICCI webpage.

Coastal Resilience Strategies and Solutions Table

Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Conduct vulnerability assessments*** *in coastal communities to identify buildings and critical infrastructure such as ports, harbors, and marinas that are highly vulnerable.* 2. ***Promote relocation, elevation, or acquisition/demolition of infrastructure and homes*** *to remove them from hazard areas. Examples: increasing working dock heights, converting marinas to floating dockage, and relocating water intakes to deeper water.* 3. ***Promote the beneficial use of material dredged from Great Lakes harbors*** *by increasing funding that supports harbor dredging that sustainably uses the dredged material or creating new funding.* ***Other priorities*** **Perform frequent routine infrastructure inspections**. **Resupply sand beaches** after large storm events. **Construct or enhance port and facility protection** structures to slow erosion and damage (may lead to increased erosion at neighboring properties). ***Long-term (4-10 years) priorities*** Promote improved **coastal-specific stormwater and groundwater management practices near coastal bluff areas** through stormwater management plans and ordinances. Coastal-specific stormwater management plans could fund or incentivize practices like directing storm water and septic discharge away from the bluff, maintaining deep rooted native vegetation, and improving groundwater drainage to increase the stability of bluffs.

Coastal Resilience Strategies and Solutions Table (*Continued*)	
Strategies	**Solutions**
Building Capacity – better understanding, tools & innovations for resource management	**Document facility impacts at high water levels** to help communicate expected impacts of high water conditions that may be forgotten during low water periods.
Filling gaps – basic research, data gathering, and benchmarking.	**Explore slope stability techniques** to improve bluff stability.

Subcommittee on Healthy Communities & Strong Economy

Climate impacts pose regional and local health risks in Wisconsin and will severely impact at-risk populations by causing death from illness, extreme heat, floods, the spread of disease, or increased exposure to pollution. We need access to accurate climate data to inform local approaches to sustainability, to reduce the risks to our communities, and maintain our tourism base. We also need strategies to communicate climate impact risk to the public and empower them to assess community risks, develop effective risk mitigation plans, and implement policies and plans that reduce these risks.

Healthy Communities & Strong Economy Strategies and Solutions Table	
Issue	**Strategies and Solutions**
Human Health	***Fully embrace clean energy, walkable communities, public transportation, and green building design.*** ***Set up systems to monitor, prevent, prepare, and provide timely public communication on health issues****.* ***Support comprehensive planning*** *that addresses relationships with authorities and customers, emergency response, and resource needs.*
Tourism	***Assist local communities with sustainable design*** *of tourism and outdoor recreation assets.* ***Enhance state tourism and outdoor recreation industries' ability to diversify their event offerings****.* ***Support comprehensive contingency planning*** *that addresses relationships with authorities and customers, emergency response planning, and resource needs.*

Healthy Communities & Strong Economy Strategies and Solutions Table (*Continued*)	
Issue	**Strategies and Solutions**
Community Sustainability	***Deliver research-based climate change adaptation education*** *statewide for local governments and Tribal Nations through UW-Madison Division of Extension's Climate Change Leadership Team.* ***Assemble an Adaptation Task Force to develop guidelines for comprehensive planning grant****s to help communities assess climate risks and prepare climate adaptation policies and practices.* ***Fund comprehensive planning grants*** *to help local governments and Tribal Nations assess their climate risks and develop place-based strategies to reduce their vulnerabilities while promoting cost savings, improved health, and self-sufficiency through local clean energy generation and storage.* ***Fund community climate preparedness grants*** *to help local governments and Tribal Nations implement climate adaptation plans and policies to increase their resiliency.* ***Fund research*** *to assess costs and benefits of climate adaptation policies and practices implemented in Wisconsin and evaluate their ability to reduce community climate risks while advancing other community goals.*

Protecting human health by accelerating Wisconsin's transition to clean, renewable energy

In communities across the Midwest, climate change is harming our health now. These harms include heat-related illness, worsening chronic illnesses, injuries and deaths from dangerous weather events, infectious diseases spread by mosquitoes and ticks, illnesses from contaminated food and water, and mental health problems. As flooding is becoming more common in our state, our communities are at risk from contaminated drinking water that can trigger outbreaks of water-borne illnesses. When houses flood, there are also serious concerns of respiratory health risks, including asthma, which can be irritated by mold growth. Wisconsinites who rely on well water are some of the most likely to be harmed by water contamination due to flooding. Unless we take concerted action, these harms to our health are going to get much worse**. The most important action we can take to protect our health is to reduce heat-trapping pollution by reducing energy waste and accelerating the transition to clean renewable energy in our Wisconsin communities.**

Environmental/Social Justice

The health impacts of climate change are not felt equally by all. Groups more vulnerable include communities of color, children and pregnant women, the elderly, immigrant groups, Tribal Nations, certain occupational groups, lower income households, and persons living with disabilities or chronic diseases. **When considering climate policy to protect the health of Wisconsin communities, it is imperative that policies address historical injustices and not exacerbate already existing health equity issues**.

In addition to limiting climate change, accelerating a transition to clean energy has the added benefit of cleaning up our air and our water so that we can all *immediately* enjoy better health. Exposure to air pollution is associated with an increased risk of severe outcomes with respiratory disease. In the current COVID-19 pandemic, researchers are finding that counties in the US with increased exposure to air pollution have higher death rates from COVID-19. A recent report prepared by David Abel and Katya Spear of the Center on Wisconsin Strategy (COWS) looked at an energy scenario of 100% in-state electric power, mostly from renewables. Wisconsin health benefits from improved air quality include an annually avoided 1,910 premature deaths, 650 respiratory emergency room visits, 1,580 cases of acute bronchitis, 49,400 respiratory symptom cases, 873,000 minor restricted activity days, 148,000 work loss days, 34,400 cases of asthma exacerbation, 670 hospital admissions, and 650 heart attacks. Switching to 100% clean energy in Wisconsin alone translates into an economic value of 18.2 billion dollars annually.

The health of anyone can be harmed by climate change, but some of us face greater risk than others. Children, student athletes, pregnant women, the elderly, people with chronic illnesses and allergies, and the poor are more likely to be harmed. Low-income families are especially vulnerable. They spend more of their income on transportation, have more exposure to vehicle pollution, and are at higher risk of injury and death due to collisions. Low-income families are also the most vulnerable to heat related illness worsened by urban heat island effects and may not have access to cool places or air conditioning. The term urban heat island refers to the increased temperatures around cities because asphalt and concrete surfaces absorb the sun's energy instead of reflecting it. A move to clean energy, walkable communities, public transportation, and green building design would enhance social justice in the state.

Finally, Wisconsin needs to set up systems to monitor, prevent, prepare, and provide timely public communication on health issues. Examples include: early warning systems for health and extreme weather events, advising hospitals and health systems on preparedness, enhancing surveillance and community resilience in the face of climate-related disasters, fostering public discussions on climate-related issues and effective collaborations among professionals in local and state government in the areas of transportation, agriculture, natural resources, zoning, etc.

For more background on these issues, please visit the Human Health Working Group on the WICCI webpage.

Human Health Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. *Fully embrace clean energy, walkable communities, public transportation, and green building design.* 2. ***Set up systems to monitor, prevent, prepare, and provide timely public communication on health issues****.* 3. ***Support comprehensive planning*** *that addresses relationships with authorities and customers, emergency response, and resource needs.*
Communicating – identifying & communicating risks, public outreach, training	**Build community emergency preparedness** and readiness for extreme circumstances, and how to make decisions to rebuild or retreat.

Tourism and outdoor recreation face declining seasonal recreation opportunities

Tourism is one of the largest economic drivers in Wisconsin. Outdoor recreation across all four seasons contribute to our sense of place and are the basis for many tourist activities in Wisconsin. Winter activities like snowmobiling, cross-country and downhill skiing, sledding, winter fat tire biking, ice-skating, and ice fishing draw tourists and support local economies across the state. These activities are being impacted by warmer winters due to temperature and precipitation fluctuations that affect the snowfall, snowpack, and ice conditions that Wisconsin's winter recreation is built upon. Warm weather activities in Wisconsin are too vast to list but include swimming, birding, hiking, and biking. Severe storms and rainfall, changing lake levels, and more extreme heat are impacting these events. With 15,000 inland lakes, two Great Lakes, and over 56,000 miles of rivers, there is a high demand for beaches and water-based activities in Wisconsin. We are seeing more frequent and severe harmful algal blooms in our lakes and an uptick in pests and infectious diseases. The increased frequency of and severity of storms will impact coastal shorelines, beaches, marinas, and other infrastructure and could reduce access for recreational opportunities. Additionally, Wisconsin's fall color season cannot be discounted. This short, but fast-growing, tourism season has been affected by extreme heat events and unpredictable precipitation levels that impact both the length and intensity of the state's fall color touring opportunities and activities.

Environmental/Social Justice

Contingency planning is needed to protect at-risk groups in the case of an emergency. At-risk groups include the elderly, people with disabilities, or people for whom English is not their first language.

Low-income communities need financial resources to prepare for, escape from, and recover from natural disasters.

Smaller communities and businesses need help to reduce the long-term costs of maintenance for assets like beaches and trails.

Communities will require help to plan for changes in outdoor recreational opportunities across all four seasons. Assisting communities with sustainable design ideas for their tourism and outdoor recreation assets will help ensure continued access to the outdoors, both for local residents and visitors.

We suggest that Wisconsin assist local communities with sustainable design of tourism and outdoor recreation assets. This includes providing additional funding for trail maintenance, training for resilient management plans, and resources that help local decision makers incorporate data and climate change projections into project development. We further suggest the state enhance state tourism and outdoor recreation industries' ability to diversify. Part of this strategy includes building on the Wisconsin Department of Tourism's current "Tourism Assessment Program." This program provides an asset inventory tool to identify diversification opportunities within the community. Although it is not yet part of the program, opportunity exists for visioning exercises to consider alternatives and back up plans for cancelled events and brainstorming solutions for bringing visitors back if they have a negative experience. Finally, we suggest that Wisconsin build capacity around comprehensive planning that addresses relationships with authorities

and customers, emergency response planning, and resource needs. Topic areas that should be covered include extreme storm events, heat safety, beach safety, and best practices in the field of outdoor recreation.

For more background on these issues, please visit the Tourism and Outdoor Recreation Working Group on the WICCI webpage.

Tourism Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Assist local communities with sustainable design*** *of tourism and outdoor recreation assets.* 2. ***Enhance state tourism and outdoor recreation industries' ability to diversify****.* 3. ***Support comprehensive planning*** *that addresses relationships with authorities and customers, emergency response, and resource needs.* ***Other priorities*** **Support habitat and urban forest management** plans, projects, and programs for vulnerable species. **Adjust stream management** to changing climate patterns. **Support trail maintenance** with funding or partnerships to support more frequent maintenance and re-scoping locations of trails and access points. **Support sustainable trail, beach, and related infrastructure design**, construction, and maintenance to increase resilience to extreme events.
Building Capacity – better understanding, tools & innovations for resource management	**Enhance and increase statewide partnerships** to help mitigate costs or event cancellations. **Support a study** of challenges and opportunities for outdoor events that can be used as "best practices" for events across all four seasons. Consider how damage to infrastructure and access points might affect availability of resources for **underserved and at-risk populations.**

Tourism Strategies and Solutions Table (*Continued*)	
Strategies	**Solutions**
Communicating – identifying & communicating risks, public outreach, training	**Provide information for communities to use in their event plans** to address climate impacts by adjusting timing and marketing, diversifying offerings, and/or having back up plans for event locations and timing. **Build community emergency preparedness** and readiness for extreme circumstances, and how to make decisions to rebuild or retreat. **Increase outreach and education on beach safety** information.
Filling gaps – basic climate research, data gathering, benchmarking with other states	**Work with stakeholder groups** to consider alternatives/backups for cancelled events, how to get out event information, and ways to prevent permanent losses of tourists due to bad experiences. **Monitor technological advances** in the field of outdoor recreation. Examples include algal removal at beaches. **Work with tribal historic preservation officers** to develop solutions to protect and preserve cultural resources, including wild rice.

Building climate-resilient communities to improve human health and safety

Wisconsin's climate is changing. Climate challenges include more hot and muggy weather, more intense and frequent heavy rainfalls, freezing winter rain instead of snow, followed by deep winter freezes (polar vortex). These changes affect the stability of Wisconsin's economic sectors as well as human health and safety in rural, Tribal Nation, suburban, and urban communities. These impacts extend to environmental resources and activities that are important to Tribal Nations, such as wild rice and trout fishing. Adapting to climate change means reducing risks and a long perspective that considers potential impacts on current and future generations. The capacity to adapt to evolving climate challenges varies across the state. To enhance community resilience to climate extremes, local governments and Tribal Nations need accurate information on at-risk populations, properties, and infrastructure and place-based responses that limit negative climate impacts and promote resilience to evolving climate conditions. Tribal Nations have already begun planning for climate change and are sharing their work on the Northeast Indigenous Climate Resilience Network webpage.

Environmental/Social Justice

Low-income communities, Tribal Nations, Black communities, and other communities of color are often the first and most heavily impacted by climate change.

State and local government policies shape the built environment and impact the natural environment in profound ways. Policies can be catalysts for community sustainability, prosperity, and enhanced quality of life. Or policies can increase community vulnerability and exacerbate potential climate risks. Moreover, local government planning capacity varies widely across urban, suburban, and rural communities. We suggest that state and regional institutions work closely with local governments and Tribal Nations to enhance their capacity to assess community risks, develop effective risk mitigation plans, and implement policies and plans that reduce these risks in ways that also create social, economic, and environmental co-benefits. UW-Madison Division of Extension, specifically its Climate Change Leadership Team, could lead in delivering statewide climate adaptation education and outreach to local governments and Tribal Nations. An Adaptation Task Force (the Climate Change Leadership Team and experts from planning, engineering, design and other disciplines) could be created to provide technical guidance for adaptation planning and implementation initiatives. In addition, state-funded adaptation grants could help local governments and Tribal Nations take action to update comprehensive plans, revise codes and land use policies, and develop plans to implement resilient infrastructure.

For more background on these issues, please visit the Community Sustainability Working Group on the WICCI webpage.

Community Sustainability Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Deliver research-based climate change adaptation education statewide*** *for local governments and Tribal Nations through the UW-Madison Division of Extension's Climate Change Leadership Team.* 2. ***Assemble an Adaptation Task Force*** *to develop guidelines for comprehensive planning grants to help communities assess climate risks and prepare climate adaptation policies and practices.* 3. ***Fund comprehensive planning grants*** *to help local governments and Tribal Nations assess their climate risks and develop place-based strategies to reduce their vulnerabilities while promoting cost savings, improved health, and self-sufficiency through local clean energy generation and storage.* 4. ***Fund community climate preparedness grants*** *to help local governments and Tribal Nations implement climate adaptation plans and policies to increase their resiliency.* 5. ***Fund research*** *to assess costs and benefits of climate adaptation policies and practices implemented in Wisconsin and evaluate their ability to reduce community climate risks while advancing other community goals.* ***Other priorities*** Fund UW-Madison Division of Extension to facilitate collaborative resilience planning across the state.

Subcommittee on Land Use & Conservation

Natural habitats and the plants and animals that inhabit them have always evolved, but their evolution cannot keep pace with the rapid rate of change in current climate conditions, thus strategies are needed to protect them. With higher temperatures, the range of plant and animal species currently inhabiting Wisconsin will shift northward and species from south of the border will expand into southern Wisconsin. These movements will impact biodiversity in the state as species that are unable to adapt either move or die out. The agricultural sector faces challenges like wetter conditions that promote soil loss, reduce nutrients available for crops, and cause surface water degradation. We suggest the following solutions to address these climate impacts.

Land Use & Conservation Strategies and Solutions Table	
Issue	**Strategies and Solutions**
Agriculture	***Increase the amount of perennial grasses and cover crops****/continuous living cover on agricultural land.* ***Include more rotational grazing*** *as part of livestock and cropping systems management so less grain, which needs large amounts of nitrogen fertilizer, is required for animal feed.* ***Improve nutrient and manure management practices*** *to reduce liquid manure storage and better align nutrient application rates with plant nutrient need.*
Water Resources	***Establish a long-term monitoring sites network*** *of stream, inland lakes, wetlands, and nearshore sites on the Great Lakes to track how surface waters are responding to climate change.* ***Establish the Wisconsin Surface Water Applied Research Program*** *to incentivize and enable the state's research community to solve surface water challenges.* ***Protect and restore lake and river shoreland areas*** *to make them more resilient to changing water levels and minimize property damage.*
Great Lakes	***Identify, purchase, and protect coastal*** *wetlands and ridge and swale dune systems that are resilient to Great Lakes water level fluctuations****.*** ***Implement practices on the landscape to increase storage capacity of Great Lakes watersheds,*** *stabilize streambanks and reduce streambank erosion, preserve and protect wetlands, install green infrastructure, and incentivize conservation farming practices.*

Land Use & Conservation Strategies and Solutions Table (*Continued*)	
Issue	**Strategies and Solutions**
Native Plants, Natural Communities and Wildlife	***Provide tax incentives to property owners*** *who place their land into conservation easements and agree to restore the land to promote native plants and natural communities.* ***Work with the Wisconsin Prescribed Fire Council*** *to develop prescribed burning legislation that demonstrates statewide support for the safe implementation of this critical tool.* ***Support a holistic deer management plan that incorporates the impacts to tree regeneration and plant communities in the process of establishing deer population goals****.* ***Adjust and reassess wildlife regulations*** *for climate-sensitive species by evaluating hunting regulations and protection status.* ***Implement wildlife habitat management changes*** *to provide food and cover that align with expected future conditions.*
Forestry	***Update forest plans for state, county, Tribal Nation, and Managed Forest Land*** *to explicitly consider climate change risks along with site-level factors, as well as identify appropriate adaptation and mitigation actions.* ***Establish, promote, and incentivize best management practices*** *for climate adaptation and mitigation in the forestry sector.* ***Maintain and expand forest cover and urban tree canopy*** *through tax, grant, and land conservation initiatives, targeting lands that offer the greatest potential for continued carbon storage and sequestration (U.S. Forest Service Legacy Program, Knowles-Nelson Stewardship Program), and tax incentives and outreach to private landowners).*

Land Use & Conservation Strategies and Solutions Table (*Continued*)	
Issue	**Strategies and Solutions**
Fisheries	***Identify and preserve stronghold populations of brook trout*** *by increasing protections of critical streams and watersheds for this native fish and developing habitat (making stream channels narrow and deep, reducing streambank erosion, reconnecting streams to floodplains and wetlands, providing strategic shading).* ***Manage fisheries to prevent overharvest and protect productive populations*** *by identifying and protecting sentinel lakes with resilient cool and coldwater fish, riparian buffers, and land management to reduce runoff.* ***Prevent expansion of native warmwater and invasive species*** *via outreach and education, best management practices, and expanded invasive species monitoring.* ***Protect commercially and recreationally important Great Lakes fisheries****, such as yellow perch and whitefish, through harvest control rules and protection of spawning and nursery habitats.*

Keeping agricultural fields green year-round to benefit Wisconsin agriculture and environmental health

Warmer winters and wetter springs, along with increased extreme rainfall events, have created economic and management hardships for Wisconsin farmers in recent years. Waterlogged soils have delayed planting in the spring and harvesting in the fall. Extreme heat has decreased milk production and increased water usage. These wet conditions have also harmed water quality due to more nutrient runoff and soil erosion from cropped fields. Other WICCI working groups mention these water quality problems and include the need to address agricultural runoff in their priorities.

Environmental/Social Justice

Healthy soils benefit communities and producers by helping to slow runoff, regulate greenhouse gases, infiltrate water, and retain nutrients. Promoting perennial vegetation will also help mitigate flooding and prevent water pollution that can be particularly difficult for low-income communities to

Today there is a move in agriculture toward keeping fields green year round. The change in land-use over the last 200 years across a large portion of Wisconsin from tallgrass prairie and oak savanna/grassland to row crop agriculture has led to higher yields but also increased greenhouse gas emissions, decreased soil health, and increased agrochemicals in our surface and drinking water. The trend toward larger animal confinement operations has amplified this reliance on feeding grain to livestock and a loss of pasture grazing. Tillage practices needed for row-crop farms have reduced soil health and the ability of agricultural soils to store carbon. This decline in soil health has led to higher rates of inorganic nutrient fertilizer and liquid manure applications to sustain production levels, one of the most pressing concerns for agriculture in Wisconsin today.

To make Wisconsin's agricultural system more resilient to climate change, we need continuous living cover systems that allow farmers to decrease greenhouse gas emissions and increase the ability of soils to store carbon. The easiest solutions are to increase perennials (alfalfa hay, grass, and pastures) and cover crops (annual crops planted when fields are fallow) on agricultural land, include more rotational grazing as part of livestock operations so less grain is needed for animal feed, improve nutrient and manure management practices to reduce liquid manure and better align nutrient applications with plant nutritional needs, and avoid grassland or natural vegetation conversion to row crop production or urban development.

We suggest Wisconsin promote practices to keep agricultural fields green all year with perennial vegetation and cover crops as a way to store more carbon in the soil, reduce soil erosion and nutrient runoff, and increase biodiversity. Marginal agricultural lands that are taken out of production could provide potential sites for installing solar infrastructure. These actions will increase resiliency to extreme weather events while improving environmental conditions, human health, and agriculture's overall resiliency to a changing climate. They will also support a move towards more sustainable energy production.

For more background these issues, please visit the Agriculture Working Group on the WICCI webpage.

Agriculture Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Increase the amount of perennial grasses and cover crops****/continuous living cover on agricultural land.* 2. ***Include more rotational grazing*** *as part of livestock and cropping systems management so less grain, which needs large amounts of nitrogen fertilizer, is required for animal feed.* 3. ***Improve nutrient and manure management practices*** *to reduce liquid manure storage and better align nutrient application rates with plant nutrient need.* ***Other priorities*** **Avoid grassland or natural vegetation conversion** to row-crop production or development, as well as avoid conversion of productive agricultural land to development. **Use incentives to minimize water use and encourage water infiltration** in agricultural and urban development practices **Accelerate implementation of total maximum daily load** programs. **Incentivize companies and farmers to reduce nutrient runoff in the watershed**
Building Capacity – better understanding, tools & innovations for resource management	**Incentivize farmer-led watershed initiatives** to improve water infiltration and reduce nitrogen application, erosion, and sedimentation through practices such as non-invasive cover crops, buffers around riparian and lakeshores, planting perennial crops/forage, no-till planting and other strategies.

Big shifts are needed to protect Wisconsin's rivers, lakes, and wetlands from climate impacts

Wisconsin industry, communities, plants, wildlife, and fisheries depend on the quality of our 84,000 miles of streams, 15,000 lakes, 5.3 million acres of wetlands, and groundwater resources. Climate change threatens water quality, public health, fisheries, and wildlife. Further, changing precipitation patterns have led to more extreme high and low water levels. Our expectations and regulations for managing the areas around our lakes, rivers, and wetlands need to shift if we are to maintain the quality of our water resources in this rapidly changing climate. Flooding along lake shorelines and rivers reveals the need to update zoning regulations that protect the near-shore environment from development, protect and restore wetlands, enhance water storage and infiltration in upper watersheds, and manage lake levels in a way that anticipates future highs and lows. We also need to address nutrient runoff and promote water conservation and water infiltration practices in agricultural and urban areas to minimize water use and increase climate resiliency.

Environmental/Social Justice

In many regions of the state, access to lakes is limited to those who can afford lakefront property. To increase climate resilience and equitable access to recreational opportunities, state or local governments could buy shorelands prone to flooding to prevent property damage and improve public access to lake shorelines.

Wisconsin has an incredible network of university, federal, state, and local researchers who, with funding, could tackle environmental, social, and economic questions related to surface water quality and quantity and who could develop a robust long-term monitoring program to track how surface waters respond to climate change. While agencies have targeted research in specific areas, the state has no centralized way to identify and share research priorities, solicit ideas from the state's research community, and advance the work most likely to benefit the state in understanding and managing surface waters.

We suggest Wisconsin dedicate funding to establish an applied Wisconsin Surface Water Research Program. This program could administer an annual research competition to incentivize and enable the state's research community to solve surface water challenges, similar to Wisconsin's Groundwater Research and Monitoring Program.

In addition, we recommend establishing a network of stream, inland lake, shoreland, Great Lake, and wetland monitoring sites to track surface water response to climate change. The network should include sensors that monitor temperature and water levels, ice on and off dates, water chemistry, harmful algal blooms, and other biological metrics of surface water condition. This information can then be used to better manage surface waters under shifting baselines.

For more background on these issues, please visit the Water Resources Working Group on the WICCI webpage.

Water Resources Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, enhanced water quality and quantity policies, management practices, land conservation, and green infrastructure	***Top priorities*** 1. *Establish a **long-term monitoring network** of streams, inland lakes, wetlands, and nearshore sites on the Great Lakes to track how surface waters are responding to climate change.* 2. ***Establish the Wisconsin Surface Water Applied Research Program** to incentivize and enable the state's research community to solve surface water challenges.* 3. ***Protect and restore lake and river shoreland areas** to make them more resilient to changing water levels and minimize property damage.*

Water Resources Strategies and Solutions Table (*Continued*)	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, enhanced water quality and quantity policies, management practices, land conservation, and green infrastructure	***Other priorities*** **Identify opportunities to reconnect rivers with their floodplains** where possible and use grade control and other low-impact practices to reverse bed and bank erosion and re-establish floodplain connection and functions. **Incentivize increased wetland protection and restoration**, particularly in headwater and floodplain wetlands, in order to reduce flooding and reduce infrastructure damage. **Expand funding for wetland flood storage demonstration projects** to help counties test and evaluate various practices that reduce flood risks and damages. **Restore habitat** for declining and culturally important wetland/aquatic species like wild rice. **Improve urban stormwater management** practices to reduce flooding by incentivizing green infrastructure such as bioswales, rain gardens, natural fences, and rain barrels, along with pervious pavers in paved roads and parking lots. **Prevent the spread of invasive species** by all methods, including promoting physical barriers to prevent aquatic invasive species passage like fish passage barriers (dams), electric, acoustic and carbon dioxide deterrents, and chlorinated locks. **Manage lakes that already have dams** to anticipate extreme events and consider flood risks on lakes maintained artificially high for summer recreation. **Maintain minimum lake levels during drought** by limiting groundwater extraction and directing agricultural drain water into wetlands and other infiltration areas to facilitate groundwater recharge. **Separate stormwater and sanitary sewers in urban areas** **Design and build adaptable/temporary structures**, such as rolling or floating piers, to accommodate extreme events. **NOTE: strategies to protect coldwater fisheries are addressed in the fisheries section.**

Water Resources Strategies and Solutions Table (Continued)	
Strategies	**Solutions**
Building Capacity – better understanding, tools & innovations for resource management	**Prevent transportation of aquatic invasive species by developing water quality regulations** and local-scale prediction and prevention strategies. Regulations should close existing and potential future transport vectors for aquatic invasive species, including design standards for boat manufacturers to prevent transport. **Adjust Great Lakes ballast water regulations** to decrease risk of invasion by aquatic invasive species. Reevaluate water quality standards and permitting standards to reduce phosphorus, chloride, and fecal contaminants.
Communicating – identifying & communicating risks, public outreach, training	**Continue outreach efforts to maintain 100% compliance with aquatic invasive species** prevention efforts. **Draw input from lake associations and other local organizations** to drive large preventative measures at the local level. **Expand youth education** and community-based social marketing to achieve higher compliance rates. **Provide education and outreach aimed at shifting cultural norms** regarding idyllic lake shorelines to include natural vegetation and minimize human structures. **Include state support for the Wisconsin Water-Science Policy fellowship** **Set expectations for fluctuating rather than static lake levels**
Filling gaps – basic climate research, data gathering, benchmarking	**Identify seepage lakes in the state with large lake level fluctuations** **Monitor and define the range of lake levels expected**

Coastal natural resources vital to Great Lakes communities and Tribal Nations are at risk from climate change

Environmental/Social Justice

Fisheries, other native wildlife, and wild rice have tribal value culturally, provide food, and can economically support Great Lakes communities.

Climate impacts to Great Lakes natural areas include warmer weather, less extreme cold, wetter overall climate, and extreme precipitation events. These climate impacts are increasing the likelihood of introduction and impact from invasive species, changing species distribution and composition in high value areas such as coastal wetlands and forests, degrading coldwater fisheries in Great Lakes tributaries, increasing inputs of nutrients and sediment, and increasing harmful algal blooms, especially in Green Bay and the south shore of Lake Superior. Intense storm events are leading to losses in dune and swale systems that are unique to Great Lakes shorelines. Great Lake nearshore and coastal beaches that provide access to the public for recreation are being closed due to human health concerns from algal blooms and high *E. coli* levels. Coastal wetlands are high-priority areas that provide habitat for fish, wildlife, and wild rice that support Great Lakes communities and Tribal Nations economically. They also improve water quality and provide protection from storms and floods. More extreme high and low water levels on the Great Lakes are leading to coastal wetland and beach loss. Protecting these important habitats will have ecosystem-wide impacts across the Great Lakes.

We suggest that state funding be provided to identify, purchase, and protect coastal wetlands and ridge and swale dune systems. These state funds could be used as a match for federal funding opportunities like the Great Lakes Restoration Initiative, allowing more area to be set aside for protection and restoration activities. We also suggest that Wisconsin promote practices to increase storage capacity of Great Lakes watersheds and stabilize streambanks to make them more resilient to storms and decrease runoff during storm events. Finally, we suggest that Wisconsin incentivize conservation farming practices to reduce nutrient and sediment runoff and improve water quality.

For more background on these issues, please visit the Great Lakes Working Group on the WICCI webpage.

Great Lakes Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Identify, purchase, and protect coastal*** *wetlands and ridge and swale dune systems that are resilient to Great Lakes water level fluctuations.* 2. ***Implement practices on the landscape to increase storage capacity of Great Lakes watersheds,*** *stabilize streambanks and reduce streambank erosion, preserve and protect wetlands, install green infrastructure, and incentivize conservation farming practices.* ***Other priorities*** **Increase modeling to identify risks of invasive species in the Great Lakes** basin; pre-emptively move high-risk species to the Chapter NR40, Invasive Species Identification, Classification and Control Rule; and increase invasive species control, both terrestrial and aquatic. **Restore coastal wetlands** to make them resilient to changes in water levels through varying topography and planting resilient species in habitat restoration projects. **Identify and protect resilient natural areas and coastal wetlands**. **Develop monitoring and rehabilitation plans for at-risk species**. **Create and enhance coldwater refuges** to maintain appropriate habitat. **Support development and implementation of watershed restoration plans**. **Increase storage capacity in especially high-nutrient runoff areas** such as the Fox-Wolf Watershed. **Reconnect tributaries to their floodplains and restore wetlands** within watersheds.
Building Capacity – better understanding, tools & innovations for resource management	**Incentivize farmer-led watershed initiatives** to improve water infiltration and reduce nitrogen application, erosion, and sedimentation through practices such as non-invasive cover crops, buffers around riparian and lakeshores, planting perennial crops/forage, no-till planting and other strategies.

Plants and natural community threats and extinction rates are accelerating due to climate change

Non-climate stressors that compromise Wisconsin's native habitats are increasing across the state, and their impacts are exacerbated by a rapidly changing climate. Climate change amplifies these non-climate stressors to the point where once-diverse habitats are simplified, associated wildlife species diminish or disappear, and important ecosystem services are lessened (such as fewer wetlands to absorb floodwaters). Species extinction rates are accelerating and more species may be added to Wisconsin's list of threatened and endangered species, potentially increasing regulatory burdens. Certain iconic and biologically important tree species such as oak and pine will continue to suffer, impacting both the large number of wildlife species that use them and the timber industry. Sustainable harvests of culturally important species, such as wild rice, ginseng, and blueberries, will become limited. Pollinators will diminish, which can have untold impacts on our native habitats, agricultural production, forestry, and food systems. Finally, hunting, fishing, hiking, bird watching, and other outdoor recreational opportunities will diminish as habitats degrade. There is, therefore, an urgent need to increase "boots on the ground" to restore and protect vulnerable native habitats.

Environmental/Social Justice

Black communities, First Nations, other communities of color, and low-income communities are disproportionally affected by flooding and air pollution, which can be partially mitigated through habitat restoration. These communities may also lack access to public lands.

Because healthy and diverse habitats can better absorb the stresses of a rapidly changing climate, we suggest managing the most problematic non-climate stressors affecting our native habitats, including habitat loss and fragmentation, invasive species, lack of prescribed fire, excessive deer browse, and nutrient runoff. Strategies include tax incentives for property owners that place their land into conservation easements, supporting prescribed burning as a tool for land managers, and holistic deer management planning. For more background on this topic, please visit our Plants and Natural Communities Working Group on the WICCI webpage.

While the above climate change impacts and strategies apply partially to Wisconsin's wildlife species, they also face some unique impacts that merit unique or complementary approaches, including adjusting wildlife regulations for climate sensitive species, and implementing habitat management changes to enhance food and cover for wildlife.

For more background on wildlife and climate change, please visit our Wildlife Working Group on the WICCI webpage.

Plants, Natural, and Wildlife Communities Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Provide tax incentives to property owners*** *who place their land into conservation easements and agree to restore the land to promote native plants and natural communities.* 2. ***Work with the Wisconsin Prescribed Fire Council*** *to develop* ***prescribed burning legislation*** *that demonstrates statewide support for the safe implementation of this critical tool.* 3. ***Support a holistic deer management plan that incorporates the impacts to tree regeneration and plant communities in the process of establishing deer population goals.*** 4. ***Adjust and reassess wildlife regulations*** *for climate-sensitive species by evaluating hunting regulations and protection status.* 5. ***Implement habitat management changes*** *to provide food and cover that align with expected future conditions.*

Plants, Natural, and Wildlife Communities Strategies and Solutions Table *(Continued)*	
Strategies	***Solutions***
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Other Priorities*** **Provide consistent funding for early detection and control of prohibited invasive species** under Chapter NR40, Invasive Species Identification, Classification and Control Rule. **Support grant program funding** for the Wisconsin Department of Natural Resources Hunter Recruitment, Retention, and Reactivation program. **Increase funding for the restoration and monitoring of native habitats by supporting existing conservation programs** like the Wisconsin Conservation Corps, Wisconsin Department of Natural Resources Landowner Incentive Program, and the Knowles-Nelson Stewardship Fund. **Support restoration and management** by promoting a statewide network of local cooperative partnerships (Blue Mounds Area Project, Southwest Wisconsin Grasslands Network, Pheasants Forever Farm Bill biologists, Wisconsin Cooperative Invasive Species Management Areas, Wisconsin Land and Water Association). **Promote wildlife habitat conservation** on private lands outside of protected areas, including restoring degraded landscapes with high-potential habitat quality, reducing barriers to wildlife movement across private land, adding buffer zones, enhancing green infrastructure and promoting sustainable urban landscapes, managing public or private agricultural land to provide compatible wildlife use, and managing forest structure to provide compatible wildlife use.
Building Capacity – better understanding, tools & innovations for resource management	**Bridge the gap between land managers and climate scientists** through partnerships, workshops, and grant programs. **Endorse *Recovering America's Wildlife Act* and the *Botanical Sciences and Native Plant Materials Research, Restoration, and Promotion Act***

Plants, Natural, and Wildlife Communities Strategies and Solutions Table *(Continued)*	
Strategies	***Solutions***
Communicating – identifying & communicating risks, public outreach, training	**Engage communities in wildlife conservation** through outreach and technical assistance programs for the public, access for wildlife recreation, increased local community involvement in wildlife management, promotion of community-managed conservation lands, and respect for the values of indigenous communities in management decisions.
Filling gaps – basic climate research, data gathering, benchmarking with other states	**Employ existing decision-support tools** like The Nature Conservancy's Conserving Nature's Stage to identify climate-change-informed priorities for protection and management.

Deer browsing and milder winters are threatening Wisconsin's forests and forest industry

Wisconsin's 17 million acres of forests provide numerous benefits including clean water, wildlife habitat, recreational opportunities, and diverse raw materials for the forest products industry. Forests are also a valuable tool to mitigate climate change as they sequester carbon in active growth and store carbon in forest soils and living and dead wood. Trees in urban areas enhance community well-being and help address urban heat island effects. Yet, as Wisconsin's winters have become milder and shorter over the past several decades, we have seen impacts, such as a decline in snowfall and a corresponding increase in winter rain, a shorter duration of frozen ground, and a longer frost-free growing season. These impacts can help tip the competitive balance in forests from species like native boreal trees towards non-native southern species that are better able to take advantage of the longer growing season. Warmer winters also mean less lethal conditions for pests and diseases. In addition, climate change is expected to favor white-tailed deer, thus increasing deer-browsing pressure that may limit the ability of forests to regenerate a desirable mix of species. Finally, frozen ground is necessary to conduct forest management in much of northern Wisconsin to protect sensitive soils, cross wet areas, and haul logs on unpaved roads. As winter temperatures have increased, the reliable operating window for forest management has compressed.

Environmental/Social Justice

Healthy and resilient public lands provide important benefits that are accessible to all Wisconsin citizens, regardless of economic status or demographics and contribute to aggressive climate mitigation efforts in other sectors.

Urban forests and county parks can contribute to environmental justice by ensuring that all residents have access to the human health and psychological benefits that forested areas provide.

Helping forests adapt to climate change can help ensure that treaty rights are maintained for Wisconsin's tribal communities.

These wintertime climate trends have significant impacts on forest ecosystems, as well as on forest management operations and the entire wood-products supply chain. We suggest the Department of Natural Resources require that forest management plans address both adaptation strategies and the need to store carbon dioxide for state-owned land and private landowners who participate in tax incentive programs, such as Managed Forest Law. Counties and municipalities should consider climate change in managing their forests. We further suggest that a diverse team of experts from different organizations be convened to develop best management practices to address the health and quality of forests for habitat, timber, water resources, restoration, recreation, timber sale implementation, hauling, and other forest management aspects. Similar efforts are needed for urban areas. These best practices should be promoted through sustained outreach and training with forestry professionals, in cost-share and grant opportunities, and through forest certification requirements. Finally, we suggest that urban tree canopies and existing forest land be maintained through tax, grant, and land conservation initiatives. Specifically, we suggest support for the U.S. Forest Service Forest Legacy Program and the Knowles-Nelson Stewardship Program, with an emphasis on reaching private landowners, who own more than half of Wisconsin's forest land.

For more background these issues, please visit the Forestry Working Group on the WICCI webpage.

Forestry Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Update forest plans for state, county, Tribal Nation, and Managed Forest Law ownership*** *to explicitly consider climate change risks along with site-level factors, as well as identify appropriate adaptation and mitigation actions.* 2. ***Establish, promote, and incentivize best management practices*** *for climate adaptation and mitigation in the forestry sector.* 3. ***Maintain and expand forest cover and urban tree canopy*** *through tax, grant, and land conservation initiatives, targeting lands that offer the greatest potential for continued carbon storage and sequestration (U.S. Forest Service Legacy Program, Knowles-Nelson Stewardship Program, and tax incentives and outreach to private landowners).* **Other priorities** **Support a holistic deer management** plan that incorporates the impacts to tree regeneration and plant communities in the process of establishing deer population goals. **Develop a reliable "frozen ground" status system** to alert loggers, truckers, and forest managers about potential sensitive conditions. **Promote innovative logging equipment and practices**, such as equipment with very low ground pressure or harvest systems. **Provide training** for loggers, foresters, and timber sale administrators. **Increase flexibility for timber sale contracts** and administration without compromising accountability.

Forestry Strategies and Solutions Table *(Continued)*	
Strategies	**Solutions**
Building Capacity – better understanding, tools & innovations for resource management	**Prepare tree nurseries to facilitate assisted migration** with sufficient quantities of in-demand species and tracking where seeds are being collected in order to document success. **Conduct an economic analysis of deer impacts** to better understand the widespread effects of deer on forest regeneration.
Communicating – identifying & communicating risks, public outreach, training	**Enhance input from forestry and agricultural stakeholders**, such as the WI Forestry Council, in establishing deer population quotas. **Provide training on climate change risks**, adaptation, and mitigation for professional foresters and landowners.
Filling gaps – basic climate research, data gathering, benchmarking with other states	**Expand monitoring of forest regeneration**, both in natural and planted stands, to assess deer damage as well as climate impacts.

Iconic coldwater fisheries are at risk from climate change

Fishing is an important part of our culture and is an important part of our economy in Wisconsin. Coldwater streams, including 10,000 miles of trout streams, represent an economically important recreational fishery for the state. Wisconsin's cool and coldwater fish assemblage includes some of the most popular and sought-after fish in the state, including lake whitefish, lake trout, cisco, walleye, muskellunge, and yellow perch. Walleye and muskellunge also support culturally important Ojibwe fisheries across the Ceded Territory of Wisconsin, approximately the northern third of the state. Climate impacts, including extreme heat events, may lead to rapid warming that exceed tolerable ranges of temperature for Wisconsin fish species, leading to die-offs that are at a minimum unsightly and which may have negative population-level effects if really extreme. Warming of water temperatures in coldwater streams becomes limiting for trout species, which may lead to the loss of economically and culturally important recreational fisheries. There are no warmwater or coolwater fishes that can replace coldwater fishes, such as trout in streams, in terms of providing recreational fishing opportunities and a source of sustenance. This makes it especially important for Wisconsin to protect or rehabilitate coldwater stream habitat and fish populations, including native brook trout. Great Lakes fisheries, such as lake whitefish and yellow perch, are also important both commercially and recreationally for local communities and an important source of sustenance for Tribal Nation fishers.

Environmental/Social Justice

Cold water fisheries, including cisco, walleye, and brook trout, comprise some of the most iconic fish species in the state. They have spiritual, cultural, and nutritional importance to First Nations, help feed low-income communities, and economically support rural communities.

Without action, habitat loss combined with fishing and expansion of invasive species and warmwater competitors may result in the loss of many of these populations. Near-term fisheries management to prevent overharvest and protect productive populations can promote resilience to other stressors, like increasing temperatures. In the long-term, identifying lakes with resilient cool and coldwater fish assemblages for priority protection, enhancing fish habitat, and land use management to reduce runoff of sediments and pollutants will increase the resilience of fish populations to the effects of climate change. This will ensure a healthy food source for all of Wisconsin's residents. We suggest that Wisconsin set appropriate, scientifically based harvest control rules and protect spawning and nursery habitats to enhance natural reproduction and recruitment for cool and coldwater fisheries.

For more background on these issues, please visit the Fisheries Working Group on the WICCI webpage.

Fisheries Strategies and Solutions Table	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Top priorities*** 1. ***Identify and preserve stronghold populations of brook trout*** *by increasing protections of critical streams and watersheds for this native fish and developing habitat (making stream channels narrow and deep, reducing streambank erosion, reconnecting streams to floodplains and wetlands, providing strategic shading).* 2. ***Manage fisheries to prevent overharvest and protect productive populations*** *with strategies including identifying and protecting sentinel lakes with resilient cool and coldwater fish, riparian buffers, and land management to reduce runoff.* 3. ***Prevent expansion of native warmwater and invasive species*** *via outreach and education, best management practices, and expanded invasive species monitoring.* 4. ***Protect commercially and recreationally important Great Lakes fisheries****, such as yellow perch and whitefish, through harvest-control rules and protection of spawning and nursery habitats.*

Fisheries Strategies and Solutions Table (*Continued*)	
Strategies	**Solutions**
Taking action – managing risk in the face of uncertainty, including upgrades to infrastructure, better management, land set asides, green infrastructure	***Other priorities*** **Develop shovel-ready habitat enhancement plans** ("fish sticks"/tree drops and gravel/cobble additions) to maintain important spawning and refuge habitat for fishes when lake water levels drop. **Manage land use to reduce runoff** and implement agricultural, urban, and riparian best management practices that are best suited to withstand intense precipitation and flooding. **Reduce nutrient loading** to deeper lakes that mix from top to bottom twice a year to help ensure that habitat remains accessible to sensitive species during times of high heat. **Adjust stocking and management** of the fishery to favor species that are best suited for current conditions and prevent spread or increase of warmwater species in undesirable locations. **Adjust fishing seasons** to reflect timing changes in spawning, set appropriate harvest control rules, and reduce fish mortality. **Improve effectiveness of invasive species control measures.**
Building Capacity – better understanding, tools & innovations for resource management	**Identify waterbodies and fisheries that are most at risk** and implement habitat protection and enhancement programs prior to extreme events to mitigate impacts from extreme weather events.
Communicating – identifying & communicating risks, public outreach, training	**Set stakeholder expectations** for future fisheries and promote best management practices.

Wisconsin Initiative on Climate Change Impacts Working Groups

The mission of the Wisconsin Initiative on Climate Change Impacts (WICCI) is to generate and share information that can foster solutions to climate change in Wisconsin. Representatives from WICCI's 13 working groups contributed the content for this report.

Working Group Issue Area	Members
Agriculture	Chris Kucharik, University of Wisconsin-Madison Sara Walling, Department of Agriculture Trade and Consumer Protection
Climate	David Lorenz, University of Wisconsin-Madison Michael Notaro, University of Wisconsin-Madison Steve Vavrus, University of Wisconsin-Madison Dan Vimont, University of Wisconsin-Madison
Coastal Resilience	Adam Bechle, Wisconsin Sea Grant Natalie Chin, Wisconsin Sea Grant David Hart, Wisconsin Sea Grant Julia Noordyk, Wisconsin Sea Grant
Community Climate Adaptation	Asligul Gocmen, University of Wisconsin-Madison Sherrie Gruder, University of Wisconsin-Madison Anna Haines, University of Wisconsin-Madison Shiba Kar, University of Wisconsin-Madison Jim LaGro, University of Wisconsin-Madison Lisa MacKinnon, Dane County Jonathan Meiman, Wisconsin Department of Health Services Colleen Moran, Wisconsin Department of Health Services Brian Ohm, University of Wisconsin-Madison Jenny Peek, Wisconsin Public Radio Catherine Techtmann, University of Wisconsin-Extension William Walker, Wisconsin Department of Natural Resources
Fisheries	Zach Feiner, Wisconsin Department of Natural Resources Alex Latzka, Wisconsin Department of Natural Resources Matthew Mitro, Wisconsin Department of Natural Resources Greg Sass, Wisconsin Department of Natural Resources Stephanie Shaw, Wisconsin Department of Natural Resources Syob Tseheye, Wisconsin Department of Natural Resources

Working Group Issue Area	Members
Forestry	Fred Clark, Wisconsin's Green Fire Matt Dallman, The Nature Conservancy Lauren Dupey, UW-Madison Division of Extension Stephen Handler, U.S. Forest Service and NIACS Jason Holmes, Bayfield County Brad Hutnik, Wisconsin Department of Natural Resources Tony Johnson, UW-Madison Division of Extension Linda Parker, U.S. Forest Service Kris Tiles, University of Wisconsin-Madison Alex Wrobel, Great Lakes Indian Fish & Wildlife Commission
Great Lakes	Madeline Magee, Wisconsin Department of Natural Resources
Human Health	Megan Christenson, Wisconsin Department of Health Services Jon Meiman, Wisconsin Department of Health Services Colleen Moran, Wisconsin Department of Health Services Jonathan Patz, University of Wisconsin-Madison
Infrastructure	Camilla Correll, Emmons & Olivier Resources Maria Hart, Nomad Planners David Liebl, University of Wisconsin-Madison Rob Montgomery, Emmons & Olivier Resources Ken Potter, University of Wisconsin-Madison Michael Schwar, Stony Point Hydrology Nadia Vogt, Milwaukee Metropolitan Sewerage District Daniel Wright, University of Wisconsin-Madison

Working Group Issue Area	Members
Plants and Natural Communities	Owen Boyle, Wisconsin Department of Natural Resources Peggy Burkman, National Park Service Ellen Damschen, UW-Madison Jason Fleener, Wisconsin Department of Natural Resources Jason Granberg, Wisconsin Department of Natural Resources Sarah Johnson, Northland College Kelly Kearns, Wisconsin Department of Natural Resources Carly Lapin, Wisconsin Department of Natural Resources Ryan O'Connor, Wisconsin Department of Natural Resources Hannah Panci, Great Lakes Indian Fish & Wildlife Service Shea Schachameyer, Wetlands Specialist, Bad River Band of Lake Superior Chippewa Danielle Shannon, Northern Institute of Applied Climate Science Quita Sheehan, Vilas County Amy Staffen, Wisconsin Department of Natural Resources Matt Zine, Wisconsin Department of Natural Resources
Tourism and Outdoor Recreation	Michele Allness, Wisconsin Department of Natural Resources Linda Cadotte, City of Superior Natalie Chin, Wisconsin Sea Grant Todd Breiby, Wisconsin Coastal Management Program David Eades, Bayfield Chamber and Visitors Bureau and Wisconsin Harbor Towns Association Mike Friis, Wisconsin Coastal Management Program Robert Holsman, Wisconsin Department of Natural Resources David Marcouiller, University of Wisconsin-Madison Phil Rynish, Wisconsin Department of Natural Resources Meghan Salmon-Tumas, Northland College Anne Sayers, Wisconsin Department of Tourism David Spiegelberg, Wisconsin Department of Tourism Gabrielle VanBergen, Red Cliff Band of Lake Superior Chippewa Dreux Watermolen, Wisconsin Department of Natural Resources
Water Resources	Tim Asplund, Wisconsin Department of Natural Resources Jen Hauxwell, Wisconsin Sea Grant Steve Elmore, Wisconsin Department of Natural Resources Katie Hein, Wisconsin Department of Natural Resources Madeline Magee, Wisconsin Department of Natural Resources
Wildlife	Benjamin Zuckerberg, University of Wisconsin-Madison