Wisconsin Climate and Health Adaptation Plan

June 17, 2016

Wisconsin
Department of Health Services
Division of Public Health
Bureau of Environmental and Occupational Health

P-01447 (9/2016)

ACKNOWLEDGEMENTS

The Wisconsin Climate and Health Adaptation Plan was made possible through funding from cooperative agreement 5UE1/EH001043-02 from the Centers for Disease Control and Prevention (CDC) and the commitment of many individuals at the Wisconsin Department of Health Services (DHS), Bureau of Environmental and Occupational Health (BEOH), who contributed their valuable time and knowledge to its development.

Special thanks to the Wisconsin Climate and Health Program Staff:

Henry Anderson, MD, Principal Investigator

Colleen Moran, *MS, MPH*, Program Manager

Megan Christenson, *MS, MPH*, Epidemiologist

Mark Werner, PhD, Section Supervisor

Angelina Hanson, LTE

Jessica LeClair, *RN,* LTE

Margaret Thelen, LTE

For more information, please contact Colleen Moran, Climate and Health Program Manager, at Colleen.Moran@dhs.wisconsin.gov or at 608-266-6761, or visit our website at https://www.dhs.wisconsin.gov/climate/index.htm.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Wisconsin Department of Health Services (DHS) has created a Climate and Health Adaptation Plan to assist state and local agencies in adapting to a changing climate. This Wisconsin Climate and Health Adaptation Plan, created by the Wisconsin Building Resilience Against Climate Effects (BRACE) Program (also known as the Wisconsin Climate and Health Program), proposes strategies for adapting to the potential climate-related health impacts of a changing climate and weather patterns in Wisconsin. The plan outlines the role of partners in these strategies and includes a process for evaluating the strategies. The plan includes an inventory of current adaptation strategies that pertain to flood vulnerability, extreme heat, drought, winter weather, and vectorborne diseases. This inventory of adaptation strategies was created through a partner engagement process that involved in-person meetings of Wisconsin climate and health topic experts including: (1) BRACE, (2) Office of Preparedness and Emergency Health Care (OPEHC), (3) Wisconsin Environmental Public Health Tracking (WI-EPHT), (4) topic expert colleagues from the DHS, Bureau of Environmental and Occupational Health (BEOH), Health Hazard Evaluation (HHE) Section, and (5) Wisconsin Emergency Management (WEM).

The plan also describes a list of emerging topics that are a higher priority for Wisconsin to address. The emerging issues topic categories were selected based on input from the Wisconsin BRACE Science Advisory Group and from the use of a prioritization matrix. Three emerging issues emerged from this process: (1) flood vulnerability, (2) heat and respiratory health, and (3) emerging vectorborne diseases. Strategies for these emerging topics will consider target populations and relevant public health interventions.

DHS has partnered with local health departments to implement climate and health adaptation strategies through a pilot project mini-grant process that the BRACE program has implemented. As part of the process, grantees from 11 counties received training from the Wisconsin BRACE staff in the following topics: Wisconsin climate trends, community engagement models, adaptation planning, climate-related health impacts, vulnerability assessments, and strategic planning. Grantees worked with Wisconsin BRACE and local stakeholders to develop community engagement methods, adaptation strategies, and action steps to identify locally relevant climate adaptation strategies to be integrated into existing public health and emergency response planning mechanisms.

INTRODUCTION

For the past several years, DHS has been working on addressing the potential health impacts of a changing climate. This work, specifically the Wisconsin Climate and Health Adaptation Plan, has been supported by a Centers for Disease Control and Prevention (CDC) BRACE project grant that BEOH received in 2012 to study and prepare for anticipated climatic effects on the public's health. The overarching goal of this project is to enhance the statewide capacity of DHS to predict, assess, and effectively respond to extreme weather and climate events and potential health-related impacts. The Wisconsin Climate and Health Program seeks to expand partnerships, provide expertise, foster collaboration, and develop strategies to address health risk factors related to severe weather event indicators including: extreme heat, precipitation patterns, average temperature increases, drought, impacts on aquifers, surface water impacts and flooding, and winter weather events. Existing data, epidemiological studies, and climate models are being utilized to explore the ability to predict the future magnitude and public health burden for these risk factors, and to develop best practices to adapt and prepare for these events.

The goals of the Wisconsin Climate and Health Adaptation Plan are to inventory current climate and health adaptation strategies and to develop cross-sector partnerships to address the potential health impacts of a changing climate in Wisconsin. The plan will outline the role of partners in the plan's strategies and will include a process for evaluating the strategies. The timeframe for strategy completion will vary according to the activity; some will be short-term, others long-term. In addition to the inventory of current adaptation strategies, the plan will include a list of emerging topics that had not been prioritized in previous efforts by the Wisconsin Climate and Health Program. Strategies for these emerging topics will consider target populations and relevant public health interventions. The Wisconsin Climate and Health Adaptation Plan is a living document and will be updated to account for changes in partnerships and programs.

CHAPTER 1: CLIMATE

WISCONSIN'S CLIMATE

Wisconsin's climate is dynamic, and there is evidence of an increasingly wide range of extremes. Analysis of 60 years of climate and weather data by the Wisconsin Initiative on Climate Change Impacts (WICCI), a statewide collaboration of scientists and partners led by the University of Wisconsin-Madison (UW-Madison) Nelson Institute for Environmental Studies and the Wisconsin Department of Natural Resources (DNR), provides evidence that in general, Wisconsin has become warmer and wetter. As shown in Figure 1, the 2011 report by WICCI entitled "Wisconsin's Changing Climate: Impacts and Adaptation" indicates that Wisconsin has experienced an increase in annual average temperature of 1.5°F from 1950 to 2006.[1] The report also indicates that Wisconsin on the whole received a 10% increase in annual precipitation from 1950 to 2006.[1] The historical climate data in the WICCI report came from a network of 176 weather stations, which are part of the National Oceanic and Atmospheric Administration (NOAA) National Weather Service Cooperative Observer Program, for the period 1950 to 2006.

However, these changes are not homogeneous across Wisconsin. For example, average annual precipitation has been increasing in the southern and western regions but has been decreasing in the northern-most region (Figure 2). Both the quantity of precipitation and the frequency of precipitation events have been changing. According to the 2011 report from WICCI, heavy rainfall events have been increasing in both intensity and frequency in Wisconsin.

Figure 1. Change in annual average temperature (°F) from 1950 to 2006

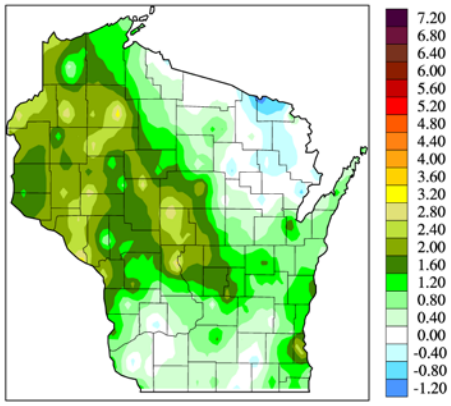
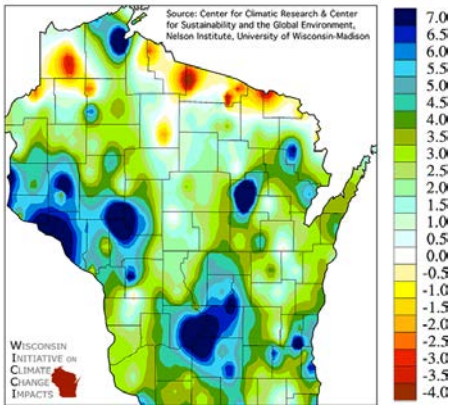


Figure 2. Change in annual average precipitation (inches) from 1950 to 2006

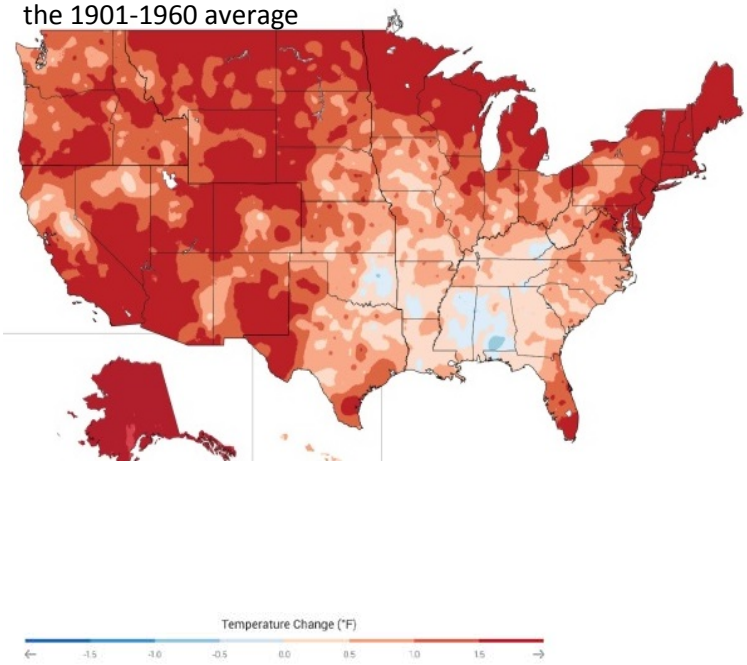


In addition to spatial variability of climate patterns across the state, there are also variations by season. Long-term weather trends indicate that Wisconsin is becoming warmer, and this trend is not occurring uniformly between seasons. While Wisconsin's annual average temperatures are increasing, most of this warming has occurred in winter and spring.[1] Historical trends of warming are anticipated to continue with the greatest warming occurring during winter months. If continued, such warming could lead to a decrease in snowfall with snow being replaced by ice, sleet, or rain during the winter.

NATIONAL AND GLOBAL CLIMATE

The trends of increasing temperatures and extreme rainfall events in Wisconsin are consistent with those seen at the national and global scales. The 2014 National Climate Assessment is a robust report developed by the U.S. Global Change Research Program that details climate trends in the United States (Figure 3).[2] The NCA report indicates that extreme weather events such as heat waves and heavy rainfalls have increased in recent decades.[2] These trends are anticipated to continue into the future.[A] According to the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA), 2015 was the warmest year on record for global average temperature in a dataset that dates back to 1880.[2] Furthermore, the previous record was set in 2014,[4] underscoring the warming of recent years.

Figure 3. Observed U.S. temperature change from 1991-2012, compared to the 1901-1960 average



[A] The 2013 Intergovernmental Panel on Climate Change report also confirms these trends, citing unprecedented warming of the global climate since the 1950s. (IPCC, Climate Change 2013: The Physical Science Basis, 2013)

CHAPTER 2: CLIMATE AND HEALTH IMPACTS IN WISCONSIN

As previously mentioned in *Chapter 1: Climate*, over the past 60 years Wisconsin has generally become warmer and wetter, especially during the winter months. A warmer and wetter Wisconsin will affect our health. To help better explain the human health impacts of these climate effects, the Wisconsin Climate and Health Program created a Climate and Health Profile Report (see Additional Resources A). This profile report was completed as part of Step 1 of the BRACE framework: Forecasting Climate Impacts and Assessing Vulnerabilities. This profile report uses evidence and research drawn from the Wisconsin Initiative on Climate Change Impacts (WICCI) and summarizes the human health impacts of concern in Wisconsin associated with a changing climate. Climate-sensitive human health impacts will most likely occur as a result of precipitation changes, heat extremes, drought, winter weather changes, disease vectors, and changes to surface water and groundwater and include the following:

- **Precipitation Changes:** A general increase in precipitation may occur across the state. Seasonal changes in precipitation may cause extended dry periods during the summer, but also flooding during heavy and intense rain periods.[1] Potential health impacts include risk of stress and mental health disorders,[3] flood-related food and waterborne illnesses,[4] injuries, and drowning.[5]

- **Surface Water:** Changes to precipitation volume, seasonality, and intensity may all lead to increased risk for flooding and flood-related health problems.[1] Flood events can produce increases in bacterial and viral infections and waterborne outbreaks among customers of municipal drinking water systems and recreational users of lakes and rivers.[6] Contamination of surface water with phosphorous and nitrogen may lead to blooms of toxin-producing blue-green algae that can pose a risk to residents, visitors, and their pets.[6]

- **Groundwater:** Extremely intense and frequent rainfall events may lead to excessively fast recharge of local groundwater levels, leading to "groundwater flooding." Conversely, water demands during extended dry periods may quickly draw down the local water table, leading to shallow wells going dry.[7] Drought conditions can potentially threaten and impact all water users. Residents utilizing groundwater for drinking water may notice water with different tastes or odors due to changes in water chemistry, and may be at risk for consuming heavy metals, organic matter, and other contaminants.[6,8]

- **Heat Extremes:** Average annual temperatures in Wisconsin could increase by 4-9°F by 2055.[1] Extreme heat is associated with increased loss of life.[8] Certain populations, especially the elderly and socially isolated individuals, are at increased risk of heat-related death.[9] Air quality degradation due to heat may lead to respiratory distress, and additional airborne pollen may lead to increased asthma exacerbations and other allergic episodes.[10,11]

- **Drought:** Drought conditions could lead to reduced drinking water quantities.[1] Drought conditions may lead to reduced drinking water availability, food insecurity, and respiratory distress from dust, pollen, and airborne particulates.[7]

- **Winter Weather Changes:** Winter storms producing heavy snowfall or ice can lead to more traffic accidents, deaths, and injuries due to poor travel conditions. Winter weather patterns in much of the state may shift to include more rain, sleet, or ice, which can damage power lines. The resulting power outages may place chronically ill patients on medical devices at greater risk.[1,6]

- **Disease Vectors:** Higher temperatures are associated with more cases of West Nile Virus, carried by mosquitoes, and Lyme disease, carried by deer ticks. Changing environmental conditions may also support new mosquito-borne diseases in Wisconsin, and a shift in the range of the lone star tick and new tick-borne diseases into Wisconsin.[12,13]

Previous Wisconsin climate and health work has focused on increasing knowledge, building capacity, and implementing public health strategies that address all of the climate impacts listed above. While many of these strategies will continue to be sustained through the Wisconsin Climate and Health Program, the scope of strategy focus will be limited to a few key impacts: (1) emerging vectorborne diseases, (2) heat and respiratory health, and (3) flood vulnerability.

CHAPTER 3: HEALTH EQUITY AND COMMUNITY ENGAGEMENT

HEALTH EQUITY

Not all individuals or communities are equally affected by extreme climate events. The most vulnerable sectors of the population, or populations of concern, can "include those with low income, some communities of color, immigrant groups (including those with limited English proficiency), Indigenous peoples, children and pregnant women, older adults, vulnerable occupational groups, persons with disabilities, and persons with preexisting or chronic medical conditions."[14]

Extreme weather events can increase the health risks of vulnerable populations. These populations generally have fewer resources to adapt to extreme weather events and may not have the agency to provide input into decision-making that affects their lives. As a result, climate impacts can exacerbate health and socioeconomic inequities in communities.[15] Health inequities arise from differences in living conditions and access to health resources and opportunities and are defined by the Centers for Disease Control and Prevention (CDC) as "preventable differences in health outcomes that are the result of the systemic and unjust distribution of social determinants or conditions that support health."[16] [B]

To strengthen climate resilience in public health strategic adaptation planning, it is critical that population characteristics be taken into account, as each may be indicative of the need for different strategies to accommodate different pre-existing vulnerabilities.[17] In fact, some adaptation strategies could inadvertently increase the environmental, economic, and health burdens on communities already bearing the burden of cumulative environmental exposures, social capital barriers, discrimination, poor health, and poverty.[18,19,20] Governmental agencies play a crucial role in addressing climate impacts and mitigating potential risks, and research has found that actions by local community stakeholders are also necessary.[21] Researchers have found that there is still a need for information that assesses the effectiveness of specific adaptations or strategies designed for vulnerable populations that may avoid or limit the projected public health impacts of extreme climate events.[22,23]

COMMUNITY ENGAGEMENT

The Wisconsin Climate and Health Program will expand upon the community engagement work it has done in the past. Previous community engagement activities by the Wisconsin Climate and Health Program included a number of community meetings with local public health agencies (LPHA). In these meetings, BRACE staff provided educational training on the historical and anticipated climate trends in Wisconsin and the ways in which public health could be impacted as a result of those anticipated changes (e.g., more intense and frequent storms). These meetings were designed to give LPHAs guidance on how to engage with community stakeholders, prioritize public health concerns, and develop strategies to address those concerns. In the next grant cycle the Wisconsin Climate and Health Program would like to expand its community engagement work significantly by working with, learning from, and engaging partner groups and organizations that represent impacted communities. This endeavor will

[B] The Intergovernmental Panel on Climate Change (IPCC) has defined vulnerability to climate impacts as "the degree to which geophysical, biological, and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change." (IPCC, Climate Change 2007: Synthesis Report, 2007)

bring a health equity lens to climate discussions to provide opportunities for stronger public health practice on climate issues. Building a collaborative structure for stakeholder participation and learning is a key principle in the BRACE framework.[24] For these reasons, the Wisconsin Climate and Health Program will form a Health Equity Advisory Team (HEAT), which will include organizations that represent Wisconsin's vulnerable populations and representatives from academia to provide expertise on implementing, monitoring, and evaluating BRACE strategies with a health equity lens. The formation of this team will help ensure that our implemented strategies will be community-driven and sustainable, will assist us to avoid unintended consequences, and will help avoid or reduce the burden of climate-related impacts on our most vulnerable populations.

CHAPTER 4: CLIMATE AND HEALTH ADAPTATION STRATEGIES – COMPLETE AND ONGOING

This chapter contains information on climate and health adaptation strategies that are currently being implemented in Wisconsin or have been completed recently with related available resources. The strategies in this chapter include those that the Wisconsin Climate and Health Program has completed as well as public health-climate strategies that partner organizations have been working on. These public health strategies were inventoried through a partner engagement process that involved in-person meetings of Wisconsin climate and health topic experts including: (1) BRACE, (2) OPEHC, (3) WI-EPHT, (4) topic expert colleagues from the DHS, BEOH, HHE, and (5) WEM. Strategies were inventoried and refined, and only those that fit the definition of adaptation ("any strategies that can reduce adverse health impacts or enhance resilience in response to observed or expected changes in climate and associated extremes")[25] were included.

FLOOD VULNERABILITY STRATEGIES*		
LEAD AGENCY	**STRATEGY**	**STATUS**
Building Resilience Against Climate Effects (BRACE)	Flood and Harmful Algal Blooms (HABs) toolkits	Complete and ongoing
	Fox River Valley flood mapping projects	Complete
	Integrated messaging with WEM (linking to tools/website).	Ongoing
	Waterborne disease data projections for Marshfield as related to precipitation change	In progress
Wisconsin Emergency Management (WEM)	Hazard mitigation plan and associated climate-specific strategies	Ongoing
Wisconsin Environmental Public Health Tracking (WI-EPHT)	Include historical and projected precipitation data in their publicly available EPHT tracking portal	In progress
	Public water data from DNR in portal including nitrates, arsenic, and other metals (both groundwater and surface water)	Complete and ongoing
National Weather Service (NWS) and United States Geological Society (USGS)	River gauge monitoring and alerts to general public	Ongoing
Health Hazard Evaluation Section (HHE)**	Beach monitoring	Ongoing
	Call-in numbers for HABs	Ongoing
	Online reporting for HAB-related illnesses	Ongoing
	Surveillance for *Legionella*	Ongoing

*Flood vulnerability strategies include those that relate to increased precipitation, surface water, and groundwater.

**These strategies are conducted by a Council of State and Territorial Epidemiologists (CSTE) Applied Epidemiology Fellow.

EXTREME HEAT STRATEGIES		
LEAD AGENCY	**STRATEGY**	**STATUS**
Building Resilience Against Climate Effects (BRACE)	Extreme heat toolkit	Complete and ongoing
	Heat Vulnerability Index maps and reports	Complete and ongoing
	Heat surveillance brief with EPHT	Complete
	Heat-related mortality projection for Wisconsin	Complete and ongoing
	Collaboration with Milwaukee Heat Task Force	Ongoing
Office of Preparedness and Emergency Health Care (OPEHC)	Work with LPHAs to modify current cooling facility reporting process using Partner Communications and Alerting (PCA) Portal.	Ongoing
	Partner messaging (long-term care, mental health/substance abuse providers)	Ongoing
	Work with WEM on integrated messaging	Ongoing
Wisconsin Emergency Management (WEM)	Public press releases	Ongoing
	Tracking cooling centers	Ongoing
Wisconsin Environmental Public Health Tracking (WI-EPHT)	Tracking indicators of heat stress emergency department (ED) visits, heat stress hospitalizations, heat-related mortality, heat vulnerability, and temperature	In progress

DROUGHT STRATEGIES		
LEAD AGENCY	**STRATEGY**	**STATUS**
Building Resilience Against Climate Effects (BRACE)	Drought toolkit	Complete and ongoing
Health Hazard Evaluation Section (HHE)*	Harmful Algal Bloom (HAB) surveillance	Ongoing
Wisconsin Emergency Management (WEM)	Coordination with federal, state, and local agencies to respond to drought situations	Ongoing
	Depending on severity, weekly drought reports are issued, and/or a state drought task force might be created.	Ongoing
Wisconsin Environmental Public Health Tracking (WI-EPHT)	Consider drought indicators for inclusion on the publicly available Tracking portal.	Ongoing

WINTER WEATHER STRATEGIES		
LEAD AGENCY	**STRATEGY**	**STATUS**
Building Resilience Against Climate Effects (BRACE)	Winter weather toolkit	Complete and ongoing
Office of Preparedness and Emergency Health Care (OPEHC)	Work with LPHAs to modify current warming center reporting process using PCA Portal	Ongoing
	Partner messaging (long-term care, mental health/substance abuse providers)	Ongoing
	Work with WEM on integrated messaging	Ongoing
Wisconsin Emergency Management (WEM)	Works in conjunction with the Department of Agriculture, Trade, and Consumer Protection (DATCP) to investigate consumer issues (e.g., price gouging)	Ongoing
	Track warming centers.	Ongoing
Wisconsin Environmental Public Health Tracking (WI-EPHT)	Cold-related mortality tracking	Ongoing
	Poison Center data on carbon monoxide calls, alert system, get internal alerts	Ongoing
	Collect ED visit and hospitalization data for carbon monoxide poisoning.	Ongoing
	Guidance for ice arenas for air quality testing for carbon monoxide and nitrogen oxides (NOx)	Ongoing

VECTORBORNE DISEASE STRATEGIES		
LEAD AGENCY	**STRATEGY**	**STATUS**
Building Resilience Against Climate Effects (BRACE)	Vectorborne disease toolkit	Complete and ongoing
	Active and passive tick surveillance	Ongoing
	Tick surveillance brief	In progress
Communicable Disease, DPH	Dead bird hotline for West Nile Virus surveillance	Ongoing

CHAPTER 5: CLIMATE AND HEALTH ADAPTATION STRATEGIES - EMERGING ISSUES

The emerging issues and associated adaptation strategies in this chapter include background information explaining why these issues were deemed "emerging," as well as a list of potential future collaborative partners. These potential future collaborative partners could take on a role ranging from advisory, to co-implementer, to lead agency, depending on the strategy. The decisions regarding partners and level of involvement with each strategy will be determined through the Wisconsin Climate and Health Program's Implementation and Monitoring Strategy (IMS). At that time, a monitoring and evaluation plan will be created to encompass the emerging issues strategies contained within this document (see BRACE 2016-2021 Conceptual Diagram in Appendix A.)

EMERGING ISSUES – SELECTION METHODOLOGY

This chapter describes the emerging issues the BRACE program wants to pursue in the future. These emerging issues are topic areas that rose to the surface after conducting a gap-analysis of climate and health work in Wisconsin. These emerging issues have been given priority status and are now a main focus of the Wisconsin Climate and Health Program. They were selected based on a variety of inputs: (1) conclusions on climate and health intervention strategies found by conducting literature reviews through the Midwest and Southeast BRACE Collaborative (a group of BRACE-funded states working together in the first grant cycle), (2) input from the Wisconsin BRACE Science Advisory Group, and (3) a matrix for analysis of possible strategies. This matrix was created and used (see Appendix B) to evaluate the various potential emerging issue topic areas and three topics emerged from this process: (1) flood vulnerability, (2) heat and respiratory health, and (3) emerging vectorborne diseases. The future strategies proposed for each of these topics were selected based on information obtained in Step 3 of the BRACE framework (Assessing Public Health Interventions), input from our Science Advisory Group, the use of a strategy matrix (see Appendix C), and the use of a Racial Equity and Social Justice Tool (see Appendix D).

The Wisconsin Climate and Health Program will focus on target populations that are most vulnerable to the health impacts of these emerging issues. The most vulnerable sectors of the population, or populations of concern, can "include those with low income, some communities of color, immigrant groups (including those with limited English proficiency), Indigenous peoples, children and pregnant women, older adults, vulnerable occupational groups, persons with disabilities, and persons with preexisting or chronic medical conditions."[25] During the first year of the next round of BRACE funding, specific target populations will be identified for each of the strategies listed under emerging issues.

EMERGING ISSUES – ADVISORY GROUP INPUT

These emerging issues will be the focus of the BRACE program in its next round of funding. Implementation, monitoring, and evaluation of the strategies listed here will be the Wisconsin Climate and Health Program's primary focus moving forward. Part of this new focus will include a stronger voice from the Wisconsin Climate and Health Program's two advisory groups: 1) the Wisconsin BRACE Science Advisory Group (SAG), and (2) the Wisconsin BRACE Health Equity Advisory Team (HEAT). The SAG has been a part of the Wisconsin Climate and Health Program since the program's inception; however, the

HEAT is a new advisory group that will be created and implemented in this next round of funding. These two advisory groups will provide topic expert and community-driven input into the Wisconsin Climate and Health Program's strategy selection, as well as its implementation, monitoring, and evaluation plans.

IMPLEMENTATION, MONITORING, AND EVALUATION PLANS

As mentioned previously, an Implementation and Monitoring Strategy (IMS) will be developed to encompass each strategy listed in this chapter. These implementation, monitoring, and evaluation plans of the IMS will be created with input from SAG and HEAT. Evaluation findings will be shared with the Wisconsin Climate and Health Program's partners and advisory groups and will be incorporated into revisions and updates of strategies.

FLOOD VULNERABILITY

FLOOD VULNERABILITY - BACKGROUND

Wisconsin contains 84,000 miles of rivers that flow through its 15,000 lakes and millions of acres of wetlands.[26] This landscape results in many low-lying areas with rivers and lakes experiencing annual flooding. An increase in the frequency and intensity of storms will increase the risk for flooding events in these areas of our state.

The public health impacts associated with flooding are well known and documented. They include physical injury and drowning, waterborne and foodborne illness, exposure to contaminated soil, respiratory illness, and mental health impacts (e.g., posttraumatic stress disorder). The severity of the flood, the geographic location, the built environment, and the socioeconomic vulnerability of the populations living in areas at risk of flooding are all factors that influence these health outcomes.

To address these public health concerns, the Wisconsin Climate and Health Program completed two projects that focused on flood vulnerability in Wisconsin's Upper Fox River Valley. This region is known for its flooding, has accessible data, and a sizeable at-risk population.

WHY IS THIS AN EMERGING ISSUE?

A gap analysis of BRACE projects related to increases in precipitation and flooding has demonstrated the need for additional planning for, preparing for, and responding to major flooding event.

POTENTIAL FUTURE PARTNERS

- Health Hazard Evaluation Section (HHE)
- Wisconsin Environmental Public Health Tracking (WI-EPHT)
- Urban and Regional Planning Commissions (RPCs)
- Metropolitan Planning Organizations (MPOs)
- Wisconsin Emergency Management (WEM)
- UW-Extension
- Local Public Health Agencies
- Health Care Systems and Clinicians
- Department of Natural Resources (DNR)
- University of Wisconsin (UW)
- Wisconsin Association for Floodplain, Stormwater, and Coastal Management (WAFSCM)
- City Planners
- Public Works
- Madison Community Foundation (MCF)
- Wisconsin Housing and Economic Development Authority (WHEDA)
- Tenant Resources Center

FLOOD VULNERABILITY STRATEGIES*		
LEAD AGENCY	**STRATEGY**	**FUTURE PARTNERS**
Building Resilience Against Climate Effects (BRACE)	Flood Vulnerability Index (FVI)	Health Hazard Evaluation Section (HHE)
	Develop flood vulnerability curriculum for planners.	UW-Madison Department of Urban and Regional Planning (URPL), Regional Planning Commissions (RPCs), Metropolitan Planning Organizations (MPOs)
	Develop surge capacity for environmental health staff for response to local extreme flooding events.	Health Hazard Evaluation Section (HHE) Department of Agriculture, Trade, and Consumer Protection (DATCP)
	Use FVI data to assist LPHAs in anticipating needs for free private well test kits.	Health Hazard Evaluation Section (HHE)
	Use FVI data to outreach to vulnerable populations (e.g., fact sheet on climate and wells).	Health Hazard Evaluation Section (HHE), health care systems and clinicians
	Evaluation of chemical and microbial contaminants in groundwater when detected (private well testing or municipal well monitoring)	Health Hazard Evaluation Section (HHE)
	Link to UW Stevens Point private well water viewer (sample of data from various sources)	Wisconsin Environmental Public Health Tracking (WI-EPHT)
	Built environment improvements (e.g., impervious surfaces; better stormwater management)	Department of Natural Resources (DNR), Univ. of Wisconsin, Wisconsin Association for Floodplain, Stormwater, and Coastal Management (WAFSCM), city planners; public works
	Education campaign/funding application for flooding remediation to landlords for moisture control	Madison Community Foundation (MCF), Wisconsin Housing and Economic Development and Authority (WHEDA), Tenant Resources Center

*Flood vulnerability strategies include those that relate to increased precipitation, surface water, and groundwater.

RESPIRATORY HEALTH AND HEAT

Respiratory health is affected by increases in temperature because heat can increase ground-level ozone concentrations. During an extreme heat event in which a rapid rise in temperature is recorded over a short period of time, ground-level ozone has been associated with increased daily mortality,[27] even at low concentrations.[28] During these events, the exposure to air pollution under extremely high temperatures is associated with exacerbations of respiratory diseases such as asthma and chronic obstructive pulmonary disease. Its impact can be assessed by the increase in the number of absences from work or school, emergency department visits, hospital admissions, and increased daily mortality.

Previous work funded through the cooperative agreement 5UE1/EH001043-02 from the Centers for Disease Control and Prevention (CDC) focused on extreme heat events and risk mapping. In 2014, the Wisconsin Heat Vulnerability Index report (Additional Resources D) was published with a series of maps that showed heat vulnerability across Wisconsin. These maps were created using a heat vulnerability index that accounted for population density, health factors, demographic and socioeconomic factors, and natural and built environment factors. A similar project for Milwaukee County was also published that year (Additional Resources E).

These two projects looked at the underlying factors that make an area more vulnerable to the health impacts associated with extreme heat events. In the next round of funding, the Wisconsin Climate and Health program plans on looking at how respiratory health is affected by long-term increases in temperature and increases in pollen counts, as described below.

RESPIRATORY HEALTH AND HEAT – POLLEN: BACKGROUND

Over the past 50 years, Wisconsin has generally become warmer and wetter, and factors relating to these trends have allowed for increases in the amount of pollen that is released by plants around the state. The increased length and severity of the pollen season is leading to potential health consequences for those already affected by allergies and asthma. The increasing amount of pollen has the potential to have a greater effect on children, who tend to be more vulnerable to ambient pollen.[29]

The life cycle of plants is strongly influenced by the environment, which controls the timing of growth and reproduction. Increased temperatures and ambient levels of carbon dioxide can directly influence pollination by determining the onset of flowering, number of pollen grains produced, and the amount of pollen released into the air.[30] Common ragweed (*Ambrosia artemisifolia*) is the most prominent seasonal allergen in the U.S.[31] Recent evidence demonstrates that the ragweed season has lengthened across areas of the Midwest by 21 days since 1995.[32] Other studies provide evidence that the allergenicity of pollen and the spread of non-native, potentially allergenic plant species are increasing.[33]

The health burden of pollen on impacted communities could be substantial. Over 35 million Americans suffer from pollen allergies,[34] and each year allergies cause 3.5 million lost workdays, 2 million lost school days, and more than $11.2 billion in treatment costs.[35] High ragweed pollen levels have been linked to increases in hospital visits.[36] Pollen exposure increases the risk by triggering life-threatening asthma attacks.[37] Half of all adults with asthma and at least two-thirds of children with asthma have allergies.[38] While most people with allergies can treat their symptoms to satisfaction with over-the-counter medications, about 20% of allergy sufferers see little to no improvement with medication alone because of the severity of their disease.[39]

WHY IS POLLEN AN EMERGING ISSUE?

Pollen monitoring can be difficult to normalize in part because there are very few American Academy of Allergy Asthma, and Immunology (AAAAI) certified counters across the state. Certified counters are specially trained and certified allied health workers who spend approximately two hours a day, three times a week counting pollen. The monitoring must be done under the direction of an allergist. There are three certified monitors in Wisconsin: Madison, La Crosse, and Waukesha all have certified counters. There are 13 monitors across the Midwest.

DHS, through the Environmental Public Health Tracking Program and the Asthma Program, track numerous asthma-related health indicators across the state, including:

- Annual number of asthma hospitalizations and emergency room (ER) visits by age, gender, race/ethnicity, and location
- Monthly average of hospitalizations and ER visits
- Monthly maximum daily number of hospitalizations and ER visits
- Monthly minimum daily number of hospitalizations and ER visits
- Daily number of hospitalizations and ER visits
- Annual unadjusted (crude) rate for asthma hospitalizations and ER visits, by age, gender, race/ethnicity, and location
- Annual age-specific rates of asthma hospitalizations and ER visits, by age, gender, race/ethnicity, and location
- Annual age-adjusted rate of asthma hospitalizations and ER visits, by age, gender, race/ethnicity, and location

However, pollen-specific counts for the entire state are not available. Wisconsin has a wide variety of ecosystems within the state, and pollen amounts could vary greatly across the state based on the plants present in the regions. A research study done in Australia looking to determine the differences in pollen concentrations across the country found that the variability of the pollen concentrations was significant, with different concentrations found in the same city.[40,41]

POTENTIAL FUTURE PARTNERS

- Wisconsin Asthma Program
- Wisconsin Environmental Public Health Tracking Program (EPHT)
- American Academy of Allergy Asthma, and Immunology (AAAAI)
- Urban and Regional Planners and Zoning Boards
- Public Schools
- Parks and Recreation
- Architects
- Wisconsin Housing and Economic Development Authority (WHEDA)
- Centers for Disease Control and Prevention (CDC)
- Housing and Urban Development (HUD)
- Health Care Systems and Clinicians

EXTREME HEAT STRATEGIES		
LEAD AGENCY	**STRATEGY**	**FUTURE PARTNERS**
Building Resilience Against Climate Effects (BRACE)	Built Environment Controls: Make urban environments resilient to mold, heat, flooding Reinvestment in low-income housing to withstand heat, flood, cold, etc. In-house common spaces for cooling shelters	Architects, Wisconsin Housing and Economic Development Authority (WHEDA), Centers for Disease Control and Prevention (CDC), Housing and Urban Development (HUD), Community Building Development Grant (CBDG)
	Work with utilities to ensure service during extreme heat events: Ensure that utility rates during heat waves do not spike, that there are emergency response plans(ERP) for power outages, and consider populations dependent on air conditioning and oxygen.	Wisconsin Emergency Management (WEM), Office of Preparedness and Emergency Health Care (OPEHC)
	Heat alerts: Messaging includes information on respiratory health data analysis to combine heat data with, ozone (respiratory health)	Wisconsin Emergency Management (WEM), Office of Preparedness and Emergency Health Care (OPEHC), Health care systems and clinicians
	Community Assessment for Public Health Emergency Response (CASPER) projects: (1) Milwaukee (2) rural area focused on heat and socioeconomic vulnerability Proactive CASPER	Office of Preparedness and Emergency Health Care (OPEHC), Centers for Disease Control and Prevention (CDC), Housing and Urban Development (HUD), Milwaukee Health Department, UW-Milwaukee Zilber School of Public Health
	Pollen outreach material	Physicians for Social Responsibility (PSR), Wisconsin Environmental Health Network WHEN), UW Department of Family Medicine (DFM), Health care systems and clinicians

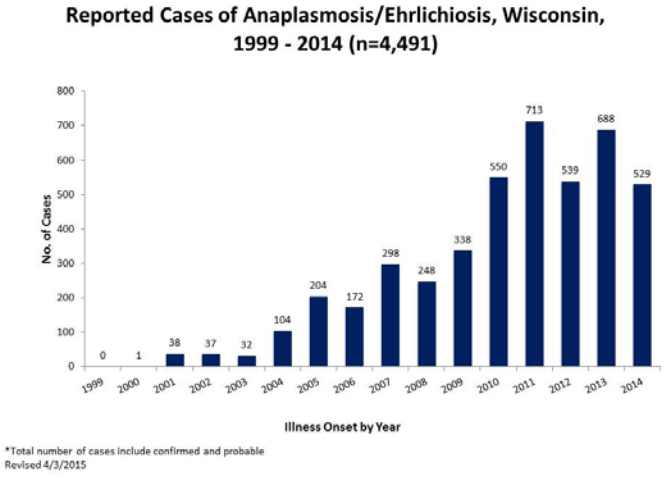
VECTORBORNE DISEASE

VECTORBORNE DISEASE - BACKGROUND

Wisconsin has experienced an increase in average annual precipitation, a longer growing season, and warmer annual average temperatures. Changes in temperature and precipitation are two environmental conditions that affect both the geographic distribution and lifecycle of mosquitoes and ticks, which are vectors (organisms, typically insects) that can transmit a disease. These environmental changes can make habitats more hospitable for the growth and survival of these vectors.

These changes in environmental conditions can adversely affect human health as exposure rates increase due to longer seasons of transmission. In Wisconsin, the vectorborne diseases typically encountered are transmitted by both mosquitoes and ticks. Ticks, specifically the blacklegged tick (commonly known as the deer tick), are the vectors for diseases such as Lyme disease, human anaplasmosis, ehrlichiosis, babesiosis, and Powassan virus.[42] Lyme disease is the most commonly reported tickborne disease in Wisconsin and was the state's fourth highest reported notifiable disease in 2015. Confirmed Lyme disease cases have increased in central and eastern Wisconsin in recent years, which may be due, in part, to warmer climate conditions.[44] Mosquitoes are vectors that can transmit an arbovirus (an arthropod-borne virus). The most commonly reported Arboviral infections in Wisconsin are West Nile virus (WNV), California encephalitis (CA), La Crosse encephalitis (LAC), and Jamestown Canyon (JC) (Arboviral Diseases).

In the last several years, a new non-native species of disease transmitting tick, the lone star tick, has been detected in Wisconsin. The nymph and adult stages of the lone star tick (*Amblyomma americanum)* have been found in the state.



Ehrlichiosis, a tick-borne disease, is becoming a growing concern in Wisconsin. Depending on the species of *Ehrlichia*, the tick vector transmitting the infection can be the *Ixodes scapularis* (blacklegged tick) or the *Amblyomma americanum* (lone star tick). The blacklegged ticks are now present in all of Wisconsin. The range of the lone star tick is expanding northward in the U.S. and emerging in certain areas of Wisconsin, possibly due in part to warmer winters.

Ehrlichiosis is an illness caused by several species of *Ehrlichia* (*E. chaffeensis, E. ewingii and Ehrlichia muris*-like). In Wisconsin, ehrlichiosis caused by *E. muris*-like is transmitted to humans through the bite of an infected blacklegged tick (*Ixodes scapularis*), the same tick that causes other tickborne diseases. Since 2008, there has been an increase in reported cases of ehrlichiosis in Wisconsin. A new *Ehrlichia* species (*Ehrlichia muris*-like, or EML) was discovered in Wisconsin and Minnesota in 2009. Illness usually occurs 5-14 days after exposure to an infected tick. Symptoms may include fever, chills, muscle pain, severe headache, and fatigue. Less common signs and symptoms may include

nausea, vomiting, diarrhea, joint pain, confusion, and rash. Severe symptoms may include respiratory and renal complications, particularly in elderly or immunocompromised individuals.[45]

WHY ARE VECTORS AN EMERGING ISSUE?

Vectorborne diseases have already been a focus area for the Wisconsin Climate and Health Program in the first round of funding (2012-2016). Addressing the gap in vectorborne disease baseline data was identified as a strategy that the BRACE program could implement; without this basic data it is difficult to fully understand the state of vectorborne disease in Wisconsin.

In order to address the issue of lack of baseline data about ticks, the BRACE Program has collaborated with the Eau Claire City-County Health Department and the UW-Madison Department of Entomology to conduct tick surveillance. These tick surveillance projects discovered that the tick infection rate for *Borrelia burgdorferi* (the pathogen that causes Lyme disease) in the Eau Claire area is approximately 40% and is ecosystem specific; this tick infectivity rate is high compared to the state average of 22%.[46] The surveillance also detected the lone star tick in Dane County. This is a concern because this type of tick can also carry *Ehrlichia chaffeensis,* which can cause ehrlichiosis in humans. The BRACE program has not yet addressed the baseline data gap for mosquito-borne disease.

These tick surveillance projects were a starting point for the Wisconsin Climate and Health Program's focus on vectorborne disease. Moving forward, the Wisconsin Climate and Health Program intends to continue to work collaboratively with various partners on vectorborne disease projects, with two goals in mind. First, it is imperative to continue to conduct surveillance to remain informed about what emerging vectors and their associated pathogens are present in Wisconsin. To this end, additional tick drags and environmental assessment are needed to determine the types of vectors, types of pathogens, and percentage of vectors carrying disease, and their ideal habitats. Second, moving forward, the Wisconsin Climate and Health Program intends to work more closely with health care providers and clinicians to ensure that there is efficient and full translation of surveillance into practice. Strategies will be created to ensure that both medical practitioners and patients in Wisconsin have the best available data on vectorborne disease in order to properly diagnose and treat these emerging diseases.

POTENTIAL FUTURE PARTNERS

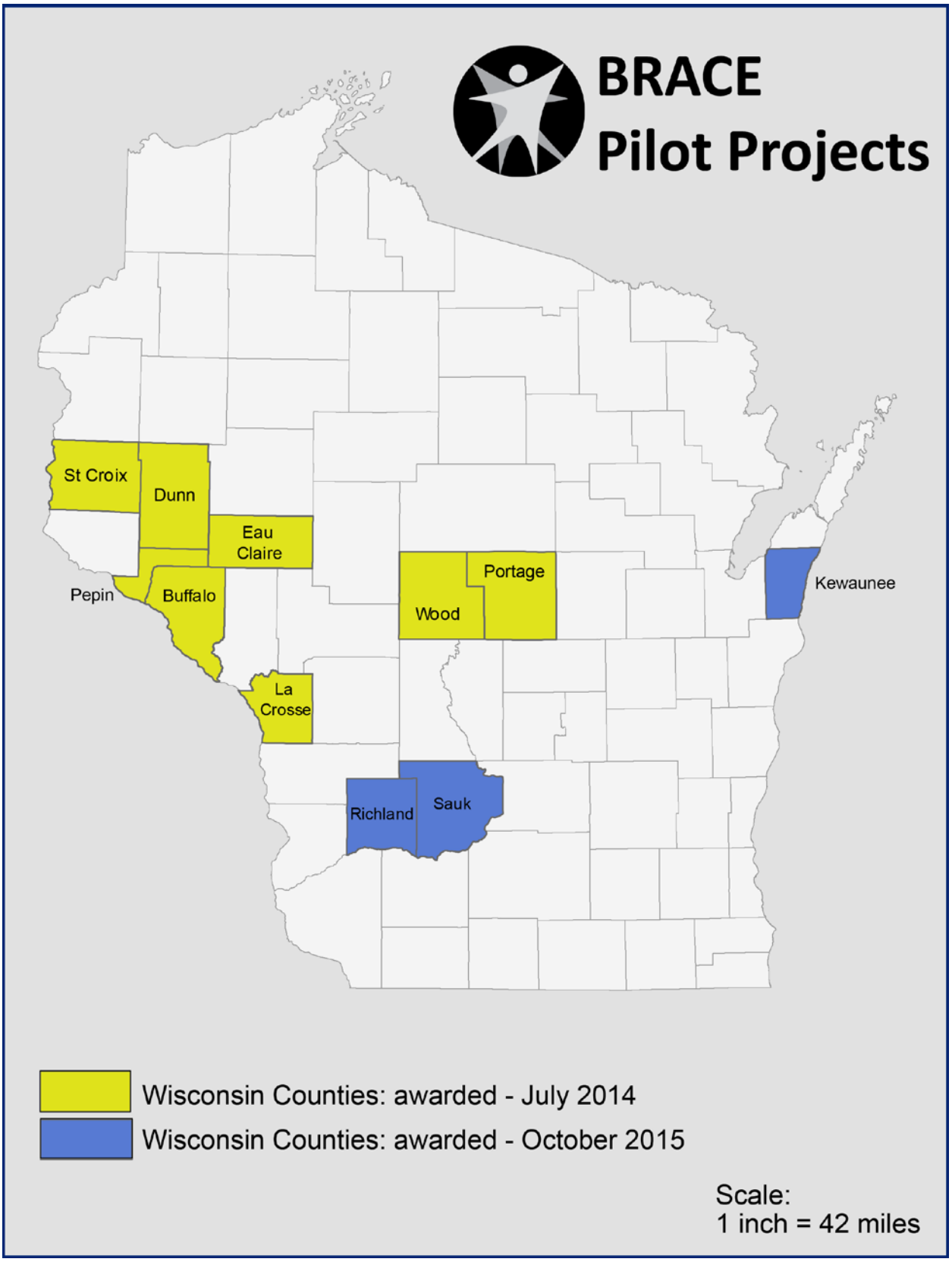
- Wisconsin Department of Health Services, Bureau of Communicable Diseases
- Wisconsin Department of Natural Resources
- UW-Madison
- County Health Departments
- Local Parks and Recreation
- Schools
- Planners and Zoning
- Health Care Systems and Clinicians

VECTORBORNE DISEASE STRATEGIES		
LEAD AGENCY	**STRATEGY**	**FUTURE PARTNERS**
Building Resilience Against Climate Effects (BRACE)	Targeted messaging, education to vulnerable populations Education about source reduction with an emphasis on high-risk times and locations	Department of Natural Resources (DNR), local public health agencies, UW-Madison, Department of Entomology, DPH Communicable Disease, Health care systems and clinicians
	Enhanced tick and mosquito surveillance	Local public health agencies, UW-Madison, Department of Entomology, DPH Communicable Disease
	Predicting high mosquito outbreaks (based on rainfall/temperature) and monitoring disease reports Targeted communication of this information to increase public awareness and encourage preventative measures	Local public health agencies, UW-Madison, Department of Entomology; DPH Communicable Disease, Health care systems and clinicians
	Sub-standard housing remediation Find funding sources to increase housing quality to reduce exposure to vectors	Madison Community Foundation (MCF),Landlord Association
	Lyme workgroup piloting data as possible WI EPHT indicator	Wisconsin Environmental Public Health Tracking (WI-EPHT)

CHAPTER 6: SUCCESS STORIES

As a home rule state, Wisconsin's state agencies offer deference to cities, municipalities, and counties in many aspects of governance. Consequently, the Wisconsin Climate and Health Program adopted as an organizing principle the importance of working with local communities to achieve its objectives. With funding from the CDC, the Wisconsin Climate and Health Program has been able to support capacity building at the county level through a series of pilot projects. Funds were made available through a competitive RFA process, where seven local public health agencies or county consortiums (involving 11 counties total) were awarded between $10,000 and $12,500 in grant funding to assess, prepare for, and respond to the public health impacts related to climate and extreme weather events. The first cohort of pilot projects were awarded in July 2014, and the second cohort were awarded in October 2015. Funding for these pilot projects extends through September 2016.

As part of the pilot project mini-grants, grantees received training from the Wisconsin BRACE staff in multiple areas including: climate trends and analysis, community engagement models, adaptation planning, environmental and health impacts; vulnerability assessments; and strategic planning. Grantees worked with BRACE and local stakeholders to develop and pilot community engagement methods, adaptation strategies, and action steps to identify locally relevant climate adaptation strategies to be integrated into existing public health and emergency response planning mechanisms. Based on the experiences of the mini-grant pilot projects as well as Wisconsin Climate and Health Program's experience facilitating these pilot projects, a Climate and Health Community Engagement Toolkit has been created to assist other local city, county, and tribal health departments in conducting their own climate and health community engagement exercises (see Additional Resources B).


BRACE
Pilot Projects
St Croix
Dunn
Eau
Claire
Pepin
Buffalo
La
Crosse
Wood
Portage
Kewaunee
Richland
Sauk
Wisconsin Counties: awarded - July 2014
Wisconsin Counties: awarded - October 2015
Scale:
1 inch = 42 miles

COHORT ONE PILOT PROJECT – SUCCESS STORIES

One way to illustrate the success of the Wisconsin Climate and Health Program is through these pilot projects. The following success stories summarize some of the main achievements in building capacity to prepare for and adapt to climate-related health concerns in La Crosse, St. Croix, Portage, and Wood Counties.

LA CROSSE COUNTY

The climate-related public health concerns prioritized by La Crosse County are health impacts caused by the increase in precipitation, extreme heat events, winter weather and extreme cold, and the overall mental health outcomes related to each of these climate effects. Through staff education and sustainability efforts, La Crosse County has integrated these public health concerns into the work of its Board of Health, County Board, and public health department. This initiative led to the formation of a workgroup that will identify and sustain program planning to reduce climate-related public health effects.

ST. CROIX COUNTY

Through the community engagement process, St. Croix County and key stakeholders prioritized three climate-related public health concerns: (1) mental health issues related to catastrophic climate events, (2) illness and mortality related to extreme heat events, and (3) winter weather impacts on injury, illness and mortality. Climate and health action steps developed by this community include increasing awareness of county mental health resources, providing training for health professionals on the prevention of and testing for vectorborne diseases, and handing out carbon monoxide detectors at the St. Croix County Fair. Information about additional projects and activities addressing these health concerns can be found in Additional Resources F.

PORTAGE AND WOOD COUNTIES

In Portage and Wood Counties, the local public health agencies and key stakeholders prioritized five climate-related public health concerns: water quality, food and water insecurity, mental health, resilient infrastructure, and vectorborne disease. Of the many strategies targeting these concerns, the group has considered improving surface water quality by implementing local ordinances that improve agricultural practices and disposal of animal waste, incorporating disaster behavioral health practices into existing emergency response plans, and working with urban planners to access potential infrastructural damage due to severe climate events. Information about additional projects and activities addressing these public health concerns can be found in Additional Resources F.

ADDITIONAL RESOURCES

A. Wisconsin Climate and Health Profile Report (accessible at this URL)

B. Wisconsin Climate and Health Community Engagement Toolkit (soon to be published, URL forthcoming)

C. Wisconsin Extreme Weather and Health Toolkits (accessible at this URL)

D. Wisconsin Heat Vulnerability Index report (accessible at this URL)

E. Milwaukee Heat Vulnerability Index report (accessible at this URL)

F. Success Stories – Cohort One Pilot Projects (soon to be published, URL forthcoming)

APPENDICES

A. BRACE 2016-2021 Conceptual Diagram

B. BRACE Emerging Issues Topic Matrix

C. BRACE Emerging Issues Strategy Matrix

D. Racial Equity and Social Justice Tool

E. List of Acronyms

References

1 Wisconsin Initiative on Climate Change Impacts (WICCI). Wisconsin's changing climate: impacts and adaptation. *Nelson Institute for Environmental Studies, University of Wisconsin and Wisconsin Department of Natural Resources*. 2011. Available at: http://www.wicci.wisc.edu/report/2011_WICCI-Report.pdf. Accessed October 30, 2013.

2 National Aeronautics and Space Administration NASA (NASA). NASA, NOAA analyses reveal record-shattering global warm temperatures in 2015. 2016. Available at: http://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-record-shattering-global-warm-temperatures-in-2015. Accessed January 27, 2016.

3 Portier CJ, Thigpen Tart K, Carter SR, et al. A human health perspective on climate change: a report outlining the research needs on the human health effects of climate change. *Environmental Health Perspectives and the National Institute of Environmental Health Sciences*. 2010. Available at: http://www.niehs.nih.gov/ health/assets/docs_a_e/climatereport2010.pdf. Accessed October 30, 2013.

4 Rose J, Epstein PR, Lipp EK, Sherman BH, Bernard SM, and JA Patz. Climate variability and change in the United States: potential impacts on water- and foodborne diseases caused by microbiologic agents. *Environmental Health Perspectives*. 2001; 109(Sup. 2): 211-220.

5 Greenough G, McGeehin M, Bernard SM, Trtanj J, Riad J, and Engleberg D. The potential impacts of climate variability and change on health impacts of extreme weather events in the United States. *Environ. Health Perspect.* 2001; 109:191-198.

6 Boxall ABA, Hardy A, Beulke S, et al. Impacts of climate change on indirect human exposure to pathogens and chemicals from agriculture. *Environmental Health Perspectives.* 2009; 117(4): 508-514.

7 Augustyn F, Chou B. Getting climate smart: a water preparedness guide for state action. 2012; American Rivers, Washington, DC and Natural Resources Defense Council, New York, NY. At www.nrdc.org. Accessed May, 2013.

8 Curriero FC, KS Heiner, Samet JM, Zeger SL, Strug L, and Patz JA. Temperature and mortality in 11 cities of the eastern United States. *American Journal of Epidemiology.* 2002; 155(1): 80-87.

9 Semenza JC, Rubin CH, Falter KH, et al. Heat-related deaths during the July 1995 heat wave in Chicago. *NEJM*. 1996; 335(2): 84-90.

10 Shea KM, Truckner RT, Weber RW, and Peden DB. Climate change and allergic disease. *J Allergy Clin Immunol*. 2008; 122 (3): 443-453.

11 Ziska L, Knowlton K, Rogers C, et al. Recent warming by latitude associated with increased length of ragweed pollen season in central North America. *PNAS.* 2011; 108(10): 4248-4251.

12 Chung WM, Buseman CM, Joyner SN, et al. The 2012 West Nile encephalitis epidemic in Dallas, Texas. *JAMA.* 2013; 310(3): 297-303.

13 WI DHS BCDER. Anaplasmosis and Ehrlichiosis Webpage. At http://www.dhs.wisconsin.gov/communicable/TickBorne/AandE/Index.htm. Accessed October, 2013.

14 USGCRP, 2016: *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment.* Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp.

15 Levy, Barry S. and Patz, Jonathan. Climate Change and Public Health. 2015. ISBN: 9780190202453.

16 CDC – Social Determinants of Health – Definitions. 2014. Available at: http://www.cdc.gov/socialdeterminants/definitions.html. Accessed 2/14/2016.

17 Patterson, Jacqui. NAACP. Equity in building resilience in adaptation planning. 2015.

18 Gould, S., and Rudolph, L. (2015). Challenges and Opportunities for Advancing Work on Climate Change and Public Health. *International journal of environmental research and public health*, *12*(12), 15649-15672.

19 Houghton, A., and English, P. (2014). An approach to developing local climate change environmental public health indicators, vulnerability assessments, and projections of future impacts. *Journal of environmental and public health*, *2014*.

20 Huang, C., Vaneckova, P., Wang, X., FitzGerald, G., Guo, Y., and Tong, S. (2011). Constraints and barriers to public health adaptation to climate change: a review of the literature. *American journal of preventive medicine*, *40*(2), 183-190.

21 Syal, S. S., Wilson, R. S., Mac Crawford, J., and Lutz, J. (2011). Climate change and human health—what influences the adoption of adaptation programming in the United States public health system? *Mitigation and Adaptation Strategies for Global Change*, *16*(8), 911-924.

22 Hosking, J., & Campbell-Lendrum, D. (2012). How well does climate change and human health research match the demands of policymakers? A scoping review. *Environmental health perspectives*, *120*(8), 1076.

23 Huang, C., Vaneckova, P., Wang, X., FitzGerald, G., Guo, Y., and Tong, S. (2011). Constraints and barriers to public health adaptation to climate change: a review of the literature. *American journal of preventive medicine*, *40*(2), 183-190.

24 Marinucci, G. D., Luber, G., Uejio, C. K., Saha, S., and Hess, J. J. (2014). Building resilience against climate effects—a novel framework to facilitate climate readiness in public health agencies. *International journal of environmental research and public health*, *11*(6), 6433-6458.

25 USGCRP, 2016: *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment.* Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann,

M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp.

26 Wisconsin Department of Natural Resources. Rivers and Streams. Available at http://dnr.wi.gov/topic/rivers/. Accessed April 11 2016.

27 Ren C, Williams GM, Morawska L, Mengersen K, and Tong S. Ozone modifies associations between temperature and cardiovascular mortality: analysis of the NMMAPS data. Occup Environ Med. 2008; 65(4):255-260.

28 Vedal S, Brauer M, White R, and Petkau J. Air pollution and daily mortality in a city with low levels of pollution. Environ Health Perspect. 2003; 111(1):45-52.

29 World Health Organization, Childhood Respiratory Diseases Linked to the Environment. Available at http://www.who.int/ceh/capacity/respiratory.pdf. Accessed May 6, 2016.

30 Galan, C., and Dominguez-Viches, E. Effect of climate change on plant distribution and phenology in the Iberian Peninsula. Alergol Immunol 2012; 9:101-103.

31 El-Qutob, D., Mencia, G., and Fernandez-Caldas, E. Recent advances in immunotherapy for allergic diseases. Recent Patents on Inflammation & Allergy Drug Discovery 2014; 8:24-35.

32 Ziska, L., K. Knowlton, and C. Rogers, National Allergy Bureau, Aerobiology Research Laboratories, Canada. 2014 update to data originally published in: Ziska, L., K. Knowlton, C. Rogers, D. Dalan, N. Tierney, M. Elder, W. Filley, J. Shropshire, L.B. Ford, C. Hedberg, P. Fleetwood, K.T. Hovanky, T. Kavanaugh, G. Fulford, R.F. Vrtis, J.A. Patz, J. Portnoy, F. Coates, L. Bielory, and D. Frenz. 2011. Recent warming by latitude associated with increased length of ragweed pollen season in central North America. P Natl. Acad. Sci.USA108:4248–4251.

33 Ziska, L.H., and Beggs, P.J. Anthropogenic climate change and allergen exposure: the role of plant biology. J Allergy Clin Immunol 2012; 129:27-32.

34 Nathan, R., Meltzer, E., Seiner, J., and Storms, W. Prevalence of allergic rhinitis in the United States. J Allergy Clin Immunol 1997; 99(6):S808–14.

36 Breton, M-C., Garneau, M., Fortier, I., Guay, F., and Louis, J. Relationship between climate, pollen concentrations of Ambrosia and medical consultations for allergic rhinitis in Montreal, 1994–2002. Sci Total Environ 2006; 370(1):39–50.

37 Huynh, B.T., Tual, S., Turbelin, C., Pelat, C., Cecchi, L., D'Amato, G., et al. Short-term effects of airborne pollens on asthma attacks as seen by general practitioners in the Greater Paris area, 2003–2007. Prim Care Respir J 2010; 19(3):254–9.

38 El-Qutob, D., Mencia, G., and Fernandez-Caldas, E. Recent advances in immunotherapy for allergic diseases. Recent Patents on Inflammation & Allergy Drug Discovery 2014; 8:24-35.

39 Calderón, M.A., Casale, T.B., Togias, A., Bousquet, J., Durham, and S., Demoly, P. Allergen-specific immunotherapy for respiratory allergies: From meta-analysis to registration and beyond. J Allergy Clin Immunol 2011; 127:30-8.

40 Beggs, P.J., Katelaris, C.H., Medek, D., et al. Differences in grass pollen allergen exposure across Australia. Australian and New Zealand Journal of Public Health. 2015; 39(1):51-55.

41 Katelaris CH, Burke TV, and Byth K. Spatial variability in the pollen count in Sydney, Australia: Can one sampling site accurately reflect the pollen count for a region? Ann Allergy Asthma Immunol. 2004; 93(2):131–6.

42 University of Wisconsin System. Preventing Tick Bites and Tick-borne Disease. Available at https://www.wisconsin.edu/ehs/osh/ticks/. Accessed April 11, 2016.

44 Rogers E., Christenson M., Sanderson S., Schumacher P., Jensen J., and Johnson D.J. Lyme disease trends in Wisconsin. Available at https://www.dhs.wisconsin.gov/publications/p01295.pdf. Accessed September 26, 2016.