ACTION WITHOUT REGRETS IN A CLIMATE OF UNCERTAINTY: SMART INVESTMENTS WITH IMMEDIATE BENEFITS

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Politicians and scientists approach challenges from fundamentally different perspectives. At the core, scientists aim to remove context from their work. For politicians, context is crucial. Without context, policy-making – defining a course of action as a response to challenge – does not make much sense.[1]

This distinction helps in understanding why the debate over climate policy is so difficult. On the one hand, the findings of a review of the publications and citations of nearly 1,400 of the climate researchers most actively publishing in their field show that 97 percent agree on the tenets of human-induced climate change.[2]

From private sector groups to international organizations, warnings have emerged. A report prepared for the World Bank predicts that even if we somehow managed to stop increasing global carbon emissions immediately, we will still experience several centuries of additional warming.[3] PricewaterhouseCoopers concludes that pledges made as part of the 2009 Copenhagen climate change negotiations will be insufficient to meet the target of limiting global warming to a rise of 2°Celsius (3.6° Fahrenheit) or less.[4] Assuming existing policies and declared government intentions are implemented, an International Energy Agency report finds that a long-term increase of more than 6° Fahrenheit is probable.[5]

With such striking agreement among experts to inform policymakers, it would seem clear that immediate action would be supported by policymakers.

However, the American public expresses a less cohesive opinion. Anthony Leiserowitz, Director of the Project on Climate Change Communication at Yale University, suggests from recent survey research that there are "six Americas … six very different communities within the United States" when it comes to global warming. Based on survey research, Leiserowitz and his colleagues conclude that only about 39% of the public is "alarmed" (12%) or "concerned" (27%).[6] A Duke University survey reported in USA Today on February 15, 2013, finds about one out of six adults believe climate change is "not much" or "not at all" a serious threat.[7] Public opinion is an element of the context for public policy.

In sum, the gap between what policymakers are hearing from the scientists and what they are hearing from the public introduces uncertainty into the calculus that drives action. While there is a growing realization that some degree of climate change is inevitable, there is no consensus on precisely how fast change will occur and precisely how much change there will be. The demand for perfect information in an imperfect world has bred paralysis.

In this paper, we propose ideas for breaking the paralysis by looking at the issue as if we were making a business decision. Is there an economic threat? Is there a strategy we can deploy to counter the threat (or, seize any opportunities)? Are there actions we can take that minimize risk of the impact of negative events?

The Malcolm Baldrige Quality Award is the equivalent of the gold medal for U.S. organizations. "Measurement, analysis, and knowledge management" has been called the "brain center" of the Baldrige Performance Excellence Program. Recognizing that perfect information is not possible, however, the ability to intelligently manage risk is now recognized by Baldrige examiners as a crucial factor in assessing the sustainability of an organization.

In "Risk Management and Climate Change" – recently published in the journal *Nature Climate Change* – placing decisions in the context of risk management is suggested to be the most effect way of bridging the gap in thinking about decisions that need to be made to deal with climate. The authors argue that situations where there is uncertainty about the probabilities of a specific

[1] See Will J. Grant and Rob Lamberts, "Scientists and Politicians – the same but different?" The Conversation, November 18, 2011 at http://theconversation.edu.au.
[2] William R. L. Anderegg, James W. Prall, Jacob Harold, and Stephen H. Schneider, "Expert credibility in climate change," Proceedings of the National Academy of Sciences, June 21, 2010.
[3] See *Turn Down the Heat*, a report prepared for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics, November, 2012, Executive Summary, page 1. Also noted in Eric Klineberg, "Adaptation," *The New Yorker,* January 7, 2013.
[4], "Too Late for Two Degrees? Low Carbon Economy Index 2012," PricewaterhouseCoopers, November, 2012.
[5] See International Energy Agency, *World Energy Outlook*, 2011.
[6] Anthony Leiserowitz, Director of the Yale Project on Climate Change Communication, "Gauging Public Opinion on Climate Change Policy," Talk of the Nation, National Public Radio, May 4, 2012. The other four "communities" of the public are those still making up their mind (about 25%), disengaged (10%), doubtful (15%), or dismissive (10%).
[7] USA Today, "Your Say: More costly to address climate change or ignore it?", February 15, 2013, page 11A.

outcome and in which stakeholders differ in their degree of risk tolerance, a risk management approach allows policymakers a way of thinking about the appropriate actions to take.[8]

We argue that decision-makers must accept the fact that climate risks require human judgments today, despite the absence of all desired scientific data, and taking intelligent risks is necessary to sustain the economic engines of the state's economy and our way of life.

> *"We are well aware of the uncertainty that surrounds [climate change] scenarios and we know that different scholars and studies sometimes disagree on the degree of risk. But the fact that such scenarios cannot be discarded is sufficient to justify strengthening current climate change policies."*
> Dr. Jim Yong Kim President, World Bank Group[9]

To act in the face of uncertainty and skepticism, decision-makers can begin by identifying and acting on options that are worthwhile now – actions that would yield economic and environmental benefits that are immediate and exceed the costs of the action – and continue to be worthwhile irrespective of the nature of the climate in the future. These are called "no regret" options.[10]

Preparing for Change: Why Action is Necessary

In mathematical terms, "risk" is defined as the product of probability (likelihood) and impact.

Extensive weather observations recorded for Minnesota over decades have led scientists to conclude that the climate is changing and is likely to continue to change as the result of warming.[11] A Minnesota Environmental Congress (March, 2013) shared new information on the quickening pace of change. The impact will be felt in the economy and by people, particularly the elderly and economically disadvantaged. In short, Minnesota's economy and its people are at risk.

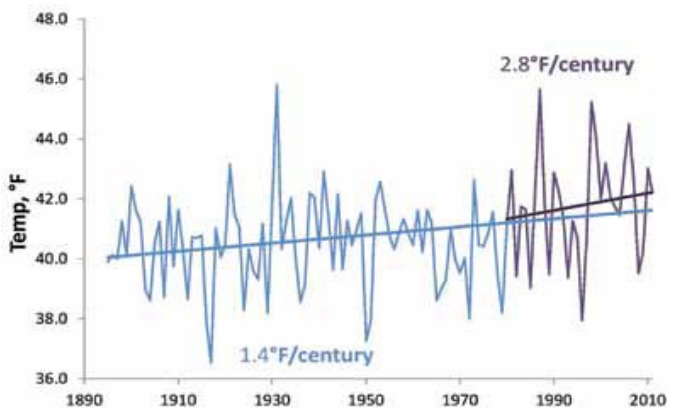
1. Minnesota's Climate is Changing

In *Minnesota Weather Almanac*, Dr. Mark Seeley concludes that four trends are statistically detectable during the last three decades at most of the state's climate stations:

> "… (1) warm winters, during which higher temperatures have been both persistent and substantial; (2) higher minimum temperatures; (3) increased episodes of high summer dew points; and (4) greater annual precipitation, most profoundly in seasonal snowfall and thunderstorm rainfall. …it appears these climate trends are not about to reverse themselves."[12]

The State Climatologist also concludes that Minnesota's climate has shown substantial changes that are consistent with increased warming. Over the period from the start of the National Weather Service records for Minnesota in 1891 to the early 1980s, Minnesota's average annual temperature essentially did not change. Since the early 1980s, the temperature has risen slightly over 1° Fahrenheit in the south to a little over 2° Fahrenheit in much of the north. Further, the trend has been upward, with much of the warming occurring in the last three decades.[13] In testimony before the Minnesota

Figure 1. Minnesota Average Annual Temperature



Source: Minnesota State Climatology Office. Reproduced from Minnesota Environment and Energy Scorecard (2013).

Senate Energy and Environment Committee, meteorologist Paul Douglas pointed out that seven of the 10 warmest years in Minnesota have occurred since

[8] See Kunreuther, Heal, Allen, Edenhoher, Field, and Yohe, "Risk Management and Climate Change," Working Paper #2012-16, Risk Management and Decision Processes Center, The Wharton School, University of Pennsylvania, October, 2012. Published in *Nature Climate Change,* Volume 3, pages 447-450, May, 2013,.

[9] *Turn Down the Heat*, page vi (Forward).

[10] "No regret" options are defined in Willows and Connell (eds.), *Climate Adaptation: Risk, Uncertainty, and Decision-Making*, United Kingdom Climate Impacts Programme (UKCIP) Technical Report, Oxford, England, 2003.. The report also considers "low regret" options, which are defined as options where the cost implications of the decision are very low while, bearing in mind the uncertainties of future climate change projections, the benefits under future climate change may be potentially large.

[11] See Minnesota Pollution Control Agency at www.pca.state.mn.us under Quick Links/Topics/Climate Change.

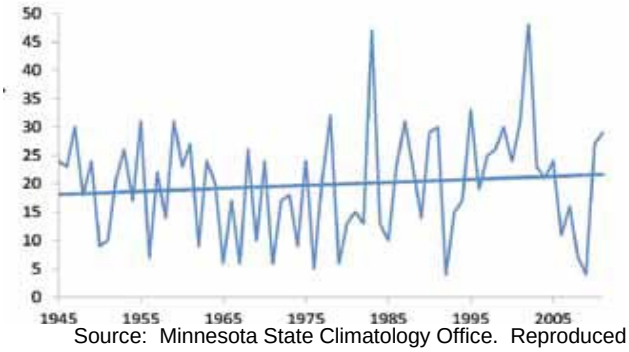
[12] Seeley, Mark W., *Minnesota Weather Almanac,* Minnesota Historical Society Press, 2006. Dr. Seeley is a professor in the College of Food, Agriculture and Natural Resource Sciences at the University of Minnesota.

[13] State Climatology Office, DNR Division of Ecological and Waters Resources at http://climate.umn.edu/climateChange/climateChangeObservedNu.htm.) During roughly the same period – from 1895 to the present – the average temperature in the United States has increased by about 1.5° Fahrenheit.; more than 80% of the increase as occurred since 1980. (See: Public comment draft of the National Climate Assessment, Section 2, Our Changing Climate, page 35.)

1998 and suggests that the first decade of the 21st Century may be the warmest in the last 1,000 years.[14]

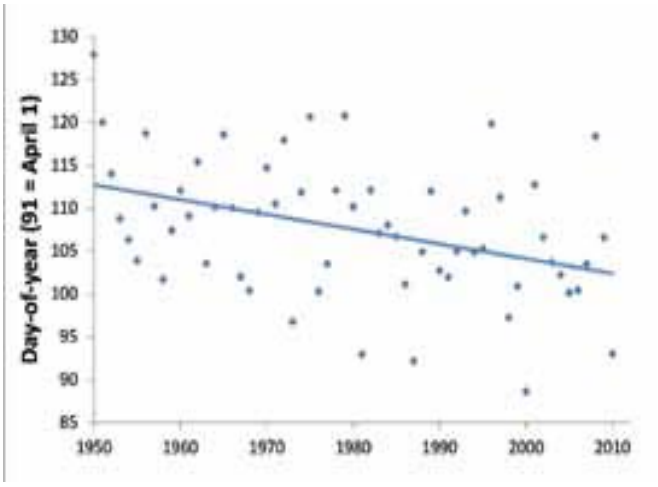
Increasing annual average temperatures tell only part of the climate change story. More frequent episodes of high dew points are occurring, resulting in more frequent high heat indexes. Increased water vapor in the atmosphere and higher temperatures produce more rainfall, with the incidence of thunderstorms increasing. In the Midwest, the yearly frequency of the largest storms – those with 3 inches of rainfall or more in a single day – has increased more than 70 percent over the last decade and more than doubled over the last 50 years.[15] New National Oceanic and Atmospheric Administration rainfall frequency data (NOAA Atlas 14) show that the amount of rainfall for given frequencies has risen substantially.

Figure 2. Annual Number of Days with Dewpoints Over 70° (Twin Cities)



Source: Minnesota State Climatology Office. Reproduced from Minnesota Environment and Energy Scorecard (2013).

A statistical trend line reveals that ice on Minnesota lakes is arriving later and leaving earlier. The trend in the average "ice-out date" for Minnesota lakes shows lakes are thawing sooner.[16] On Lake Superior, researchers at the Minnesota Sea Grant Program find that since 1980, surface water temperature of Lake Superior in summer has warmed twice as much as the air above it. Over the winter, the area of the lake covered by ice is decreasing by about 0.5% per year. Ice cover in Lake Superior has decreased from 23% to 12% over the last century.[17]



Source: Minnesota State Climatology Office. Reproduced from Minnesota Environment and Energy Scorecard (2013).

Regardless of efforts to reduce greenhouse gas emissions, some degree of climate change will occur and warming will continue.[18] Even with substantial emission reductions, the National Climate Assessment and Advisory Committee concludes that by the middle of the century, the average temperature of the Midwest Region – which includes Minnesota – will increase by approximately 3.8° Fahrenheit, relative to the average for 1979 to 2000. If the current high emissions trend scenario is followed, the increase will be approximately 4.9° Fahrenheit.[19]

Moreover, modeling efforts now suggest that it is likely that warming will occur even more rapidly than initial models predicted. *Turn Down the Heat*, a report prepared for the World Bank, points to the likelihood that global warming will be one and one-half times as great as the target of the Copenhagen climate negotiation pledges even if all pledges are fully implemented. There is a one-in-five chance that warming could be double the 3.6° Fahrenheit target of the Copenhagen pledges as early as the 2060s.[20] The report for the World Bank goes on to argue that such a warming level would not be the end point. A further warming to levels over 11° Fahrenheit would likely occur over the following centuries.[21]

Figure 3. Minnesota Average Ice-Out Date

[14] Testimony before the Minnesota Senate Energy and Environment Committee, January 22, 2013.
[15] *Minnesota Environment and Energy Report Card* (2012), page 21.
[16] *Minnesota Environment and Energy Report Card* (2012), page 21.
[17] Minnesota Sea Grant at www.seagrant.umn/edu/climate/superior.
[18] Minnesota Pollution Control Agency, Climate Change in Minnesota. See www.pca.state.mn.us at "Quick Links/Adapting to a Changing Climate.")
[19] National Climate Assessment and Advisory Committee, *National Climate Assessment: Draft for Public Comment*, January 11, 2013, page 618 (Midwest Region). The projections for the end of the century (2081-2100) are approximately 5.6°F for the low emission scenario, and 8.5°F for the high emission scenario.
[20] *Turn Down the Heat*, Executive Summary, page 1. A change of 2 degrees Celsius is equal to a change of 3.6 degrees Fahrenheit.
[21] *Turn Down the Heat*, page 1 (Executive Summary).

"*Climate change is the greatest economic challenge of the 21st Century."*
Christine Lagarde, Managing Director, International Monetary Fund (IMF).[22]

2. The State's Economy Will Be Affected by Climate Change

Impacts of climate change will be directly felt throughout Minnesota's $281.7 billion (in 2011 dollars) economy.[23] More extreme weather will impact agriculture and forestry. In turn, this will affect both durable and non-durable goods manufacturing. Hunting, fishing, and other major elements of the tourism industry will experience significant impacts as ecosystems are altered by a changing climate. Shipping on the Mississippi River will be affected by flooding from more extreme storm events and droughts. More intense storms will challenge the state's infrastructure.

Agriculture and the economic development of Minnesota are synonymous. In 2007, the market value of agricultural products sold was nearly $13.2 billion, with about 53% of the value related to crops ($7.0 billion) and about 47% to livestock and poultry ($6.1 billion).[24]

In the near-term, the Midwestern part of the country could see benefits from global warming. The Midwest growing season has lengthened by almost two weeks since 1950.[25] Although variations by crop are expected, longer growing seasons and rising carbon dioxide levels are projected to increase the yields of some crops. However, these benefits increasingly can be expected to be offset by extreme weather events, such as heat waves, droughts, and floods, which the National Climate Assessment and Advisory Committee believes are likely to influence future crop yields more than changes in average temperature or annual precipitation.[26] In the longer term, combined stresses associated with climate change are expected to decrease agricultural productivity, although significant advancements in genetic and agronomic technology could change this outlook.[27]

Relying on 15.4 million acres of commercial timberland in the state,[28] Minnesota's ***forest products manufacturing and related sectors*** is estimated to directly contribute $9.7 billion annually to the state's economy. Manufacturing using harvested products makes up the bulk of this sector of the economy and accounts for nearly $800 million in exports of manufactured wood products, pulp, paper, and paperboard. Changes in Minnesota's forests due to warming will have a direct impact on this industry.[29]

In testimony before the Senate Energy and Environment Committee in January, 2013, University of Minnesota professor Dr. Peter Reich told members that "climate change will affect ecosystem structure, function, and biodiversity" of Minnesota forests, as well as "forest dependent human communities and economies."[30] Dr. Reich predicts that northern pine, spruce, and aspen will do poorly with climate change. Central oak and maple can be expected to expand north, but natural migration is not expected to keep pace with climate change. There is a risk of decline in species in their current range from stress due to drought and invasions of insects.

Similarly, contributors to the current draft of a National Climate Assessment report conclude that rising temperatures will drive the habitats of many species of trees in the Midwest northward. This will not only impact the forestry industry in the region, but also will affect the region's role as a net absorber of carbon.[31]

Major parts of the economy of the State of Minnesota are built on the natural environment – ***hunting, fishing, and other major elements of the tourism industry***, for example. The United States Fish and Wildlife Service's National Survey of Fishing, Hunting and Wildlife-Associated Recreation finds that hunters, anglers, and wildlife watchers spent over $3.9 billion (2006) on their activities in Minnesota.[32] This part of the economy also is at risk to experience significant impacts as

[22] Comments reported from the World Economic Forum in Davos, Switzerland, February 6, 2013.
[23] United States Department of Commerce, Bureau of Economic Analysis, Regional Economic Accounts, estimates for 2011. Data is total nominal GDP, of which $254.3 million is attributed to private industries and $27.4 billion to government. Real GDP (inflation adjusted is estimated at $244.9 billion (chained 2005 dollars).
[24] United States Department of Agriculture, 2007 Census of Agriculture – State Data.
[25] National Climate Assessment and Advisory Committee, page 620 (Midwest Section). This change is due in large part to the earlier timing of the last spring freeze.
[26] National Climate Assessment and Advisory Committee, page 620 (Midwest Region).
[27] National Climate Assessment and Advisory Committee, page 617 (Midwest Region).
[28] Peter Reich, "Challenges facing Minnesota's forests in coming decades," presentation to Minnesota Senate Energy and Environment Committee on January 22, 2013.
[29] Deckard, Donald and Skurla, James, *Economic Contribution of Minnesota's Forest Products Industry – 2011 Edition*, April, 2011, pages 4 and 7-8.
[30] Peter Reich, "Challenges facing Minnesota's forests in coming decades."
[31] National Climate Assessment and Advisory Committee, page 617 (Midwest Region).
[32] U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. *2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Minnesota*, Issued March, 2008. See Highlights, page 4. Data includes participation and expenditures by both residents and non-residents. 2011 survey results are not yet available for all states.

ecosystems change in the coming decades as a result of a changing climate.

Heat, flooding, drought, late spring freezes, changes in pests and disease prevalence, and increased competition from non-native or opportunistic native species are among the stresses that individually and collectively are projected to alter habitat and ecosystems that support the hunting and fishing economy of Minnesota.

A January, 2013, report from the National Wildlife Federation concludes that Midwestern states will see changes in wildlife populations by midcentury, if current trends are not altered.[33] Diminished numbers of migratory waterfowl and pheasants; further declines in the moose population; and reductions in walleyes, northern pike, and brook trout are forecast. Episodes of large-scale fish kills likely will become more prevalent, and a warmer climate will provide an advantage for undesirable invasive species to prosper. Great Lakes research indicates higher temperatures, increases in precipitation, and lengthened growing seasons favor production of blue-green and toxic algae that can harm habitat, fish, water quality, and potentially heighten the impact of invasive species already present.[34]

The ***infrastructure*** that supports economic activity (roads, bridges, waterways, and the electrical grid, for example) and public health and welfare (water supply systems, for example) has been largely constructed based on the assumption of a static climate. This assumption is now in being challenged and has profound implications for the infrastructure that supports our economy.

- The infrastructure for ***navigation and flood control*** is susceptible to climate change and other forces because the designs are based upon historical patterns of precipitation, water levels, and stream flow that no longer hold.[35] The potential impact on the state's economy is substantial, as Mississippi River ports at Minneapolis and St. Paul handle over 4.1 million tons of commodities with a value in excess of $1.0 billion (2008)[36] and more than $1.7 billion in commodities are shipped from, received at, or transported between Minnesota ports on Lake Superior.[37]

  While less ice formation on the Mississippi River has the potential to increase seasonal windows for navigation, the National Climate Assessment and Advisory Committee concludes that as the result of changes in precipitation patterns, "inland waterways may well experience greater floods, with high flow velocities that are unsafe for navigation and shut channels down intermittently."[38] Studies indicate that the severity and frequency of flooding throughout the Mississippi River Basin is increasing. There have been two 300- to 500-year floods over the past 20 years in the Upper Mississippi/Missouri River Basin. On the other end of the spectrum, drought can lower vessel drafts on rivers and in lock pools.

  However, global warming may provide benefits for Great Lakes shipping. Reduced ice cover has the potential to lengthen the shipping season. The navigation season has increased by an average of 8 days since 1994, and the Welland Canal in the St. Lawrence River remained open nearly two weeks longer.[39] While changes in lake levels could affect the amount of cargo carried by ships traversing the Great Lakes, current estimates of lake level changes are uncertain, even for continued increases in global greenhouse gas emissions. Most model projections indicate only a slight decrease or even a small rise in levels.[40]
- Climate change will stress ***water supplies and supply systems***. An analysis performed for the Natural Resources Defense Council (NRDC) in 2010 concludes that climate change will greatly increase the risk that water supplies will not be able to keep up with the demand for withdrawals in many areas.[41] A front page article in the February 24, 2013, Minneapolis *StarTribune* cites issues specific to Minnesota and suggests climate change "could make matters worse."[42]

  Two of the principal reasons for the projected water constraints are shifts in precipitation and increased evapotranspiration. The combination of decreased precipitation in some regions and increased potential evapotranspiration in most regions indicates that

[33] National Wildlife Federation, *Wildlife in a Warming World*, January, 2013. Cited in the Minneapolis StarTribune editorial – "State species at risk as climate heats up" – on page A8 (Opinion section).
[34] National Climate Assessment and Advisory Committee, page 632 (Midwest Region).
[35] National Climate Assessment and Advisory Committee, page 629 (Midwest Region).
[36] United States Army Corps of Engineers at http://outreach.lrh.usace.army.mil/Basin/UMRiver/text/default.htm.
[37] United States Army Corps of Engineers at http://outreach.lrh.usace.army.mil/States/MN/MN_GL.htm. Total tonnage was 34.3 million tons, with over 30 million tons shipped out of the state (91% of which was iron ore).
[38] National Climate Assessment and Advisory Committee, page 202 (Transportation Section).
[39] National Climate Assessment and Advisory Committee, page 631 (Midwest Region), citing Millerd, 2011.
[40] National Climate Assessment and Advisory Committee, page 632 (Midwest Region), citing Angel and Kunkel, 2010. Earlier models projected much lower levels, because they overstressed water loss due to evapotranspiration from the land within the Great Lakes drainage basin.
[41] Natural Resources Defense Council, *Climate Change, Water, and Risk*, July 2010. The analysis was prepared for the NRDC by Tetra Tech.
[42] "MINNESOTA DRAINING ITS SUPPLIES OF WATER," Minneapolis StarTribune, February 24, 2013, page 1.

many areas will face decreases in overall available precipitation. The challenge will be exacerbated by projected increases in water withdrawals from ground water, lakes and rivers, and reservoirs. The analysis completed for the NRDC suggests slightly over one-half of Minnesota's counties will be at risk for water shortages, although most (39 counties) fall into the moderate risk category and only eight face high or extreme risk.[43]

Minnesota industry requires a sustainable water supply. For example, Minnesota has two major refineries and 21 ethanol plants (2011).[44] It is estimated that these facilities alone require over 280 billion gallons of water per year to operate at their full capacities.[45]

Other infrastructure also is at risk. Road culverts and storm sewers may be undersized (or, inappropriately sized) to handle increased run-off from more severe storms. The electrical grid serving the state, which currently has major upgrades under development, will need to be constructed to withstand stronger winds and other storm elements in the future.

Minnesota already suffers among the highest insured catastrophe losses in the United States and more severe weather events forecast as part climate change will have further impact. In 2008, ISO – a leading source of information about property/casualty insurance risk – reported Minnesota suffered nearly $1.6 billion in insurance losses from catastrophes. In 2007, Minnesota ranked second in these losses and third in 2008.[46] In 2011, data from NOAA shows 552 severe weather reports in Minnesota, with about 65 percent related to wind (330 reports) or tornadoes (30) and 35 percent related to hail (192 reports).[47]

3. Minnesotans Will Be Put At Risk

Climate change will pose risks for individual Minnesotans as well, particularly the elderly and economically disadvantaged.

Potential health risks of climate change cited by the Centers for Disease Control and Prevention (CDC) as the greatest potential risks to human health from a changing climate are heat-related morbidity and mortality; asthma, respiratory allergies, and airway diseases; and waterborne diseases.

Increased average temperatures and increasingly frequent and severe extreme heat events produce ***increased risks of heat-related illness and death***.[48] During heat waves, one study calculates that deaths increase by 4%, when compared with non-heat wave days. Individuals 65 years of age and older are more susceptible to heat effects than younger cohorts of the population and economically disadvantaged and socially isolated people face higher likelihood of death from heat than relatively better-off and connected segments of the population.

The latter outcome was illustrated by an extreme heat wave that swept Chicago in July, 1995. It killed 739 people. Eight of the 10 community areas with the highest death rates were virtually all African American and had pockets of concentrated poverty.[49] An unfortunate conclusion is that the expression of a changing climate in more severe heat and cold can be expected to fall disproportionately on lower income populations in the Midwest, making a response to climate change not only an economic imperative, but a response that is crucial to social justice.

While recognizing that further study to evaluate the fraction of respiratory disease risk that can be attributed to climate change and potentially mitigated or avoided is needed, the Centers for Disease Control and Prevention warns there is strong evidence of associations between a wide range of environmental variables impacted by climate and respiratory disease, such as ***asthma, respiratory allergies, and airway diseases***. More than 20 million people within the Midwest currently experience air quality that fails to meet national ambient air quality standards. This exposure to degraded air quality is projected to be amplified under higher

[43] See water supply sustainability by state accompanying *Climate Change, Water, and Risk* at http://www.nrdc.org/globalWarming/watersustainability/index.asp.

[44] Minnesota Department of Agriculture, 2011. The Department also is the source of the production estimate.

[45] A University of Minnesota study (2009) determined that it takes 19 gallons of water to grow and harvest corn and then process it into a gallon of ethanol. (Environmental Science and Technology, cited in University of Minnesota press release, "Midwestern ethanol plants use less water than western counterparts, U of M study shows," April 13, 2009.) Based on a production capacity in 2011 of 1.1 billion gallons of ethanol, the industry's demand for water in Minnesota exceeds 20 billion gallons, annually. The Flint Hills refinery in Rosemount has a processing capacity of about 320,000 barrels per day. (Koch Industries, Inc. fact sheet, last updated July, 2012.) Accepting that it takes about 1,850 gallons of water to refine a barrel of crude oil, the Flint Hills refinery is capable of using nearly 600 million gallons of water per day, or nearly 220 billion gallons per year. The St. Paul Park refinery, previously owned by Marathon Petroleum Company and sold to a private equity firm in 2010, has a capacity of 74,000 barrels per day (*Minneapolis StarTribune*, October 6, 2010, Business Section), which means it is capable of using nearly 137 million gallons of water per day, or almost 50 billion gallons per year.

[46] Information from the Insurance Information Institute presented to the Minnesota Senate Energy and Environment Committee on January 22, 2013. ISO is the Insurance Services Office, Inc.

[47] Information from the Insurance Information Institute presented to the Minnesota Senate Energy and Environment Committee on January 22, 2013. NOAA is the National Oceanic and Atmospheric Administration.

[48] National Climate Assessment and Advisory Committee, page 624 (Midwest Region).

[49] Klineberg, page 32.

temperatures, and thus increase the human health effects from heat waves.[50]

Climate directly impacts the incidence ***of waterborne disease*** through effects on water temperature and precipitation frequency and intensity. For example, droughts may cause problems with increased concentrations of effluent pathogens and overwhelm water treatment plants. Aging water treatment facilities are particularly at risk. Climate-induced changes in the frequency and intensity of extreme weather events could lead to damage or flooding of water and sewage treatment facilities, increasing the risk of waterborne diseases.

Taking Action: Embracing the Principles of Risk Management

If there is a chance of something going wrong from which loss, injury, or damage will occur, risk exists. As discussed in the preceding pages, climate change poses a risk to the economy, people, and the environment.

Risk management is a business practice that involves creating plans and taking actions to minimize or eliminate the impact of negative events. Two important "risk control tools" to apply to the risks posed by climate change are mitigation and adaptation.[51]

Mitigation is a strategy that implements tactics to permanently eliminate or reduce the long-term risk and hazards of climate change. Adaptation includes tactics designed to adjust to climate change by moderating potential damage, taking advantage of opportunities, or coping with the consequences of change. While mitigation tackles the causes of climate change, adaptation forestalls its effects.

Both mitigation and adaptation are necessary to minimize the damages from climate change and to adapt to the pace and ultimate magnitude of the changes that occur.[52] Compared to the many analyses of policies and practices to mitigate climate change by reducing emissions, the study and application of adaptation to climate change is just emerging.

In 2007, the Minnesota Legislature passed and the Governor signed into law the Next Generation Energy Act (Minnesota Statutes, Chapter 216H). The Act focused on mitigation of climate change by setting greenhouse gas (GHG) emission reduction goals -- 15%, 30%, and 80% for 2015, 2025, and 2050, respectively -- measured from a baseline of emissions in 2005. In 2008, the Legislature instructed the Minnesota Pollution Control Agency (MPCA) to track progress toward meeting these goals and report biennially to the Legislature.[53]

Burton and colleagues argue in a report prepared for the Pew Center on Global Climate Change that the next stage of climate efforts "must deal squarely with adaptation—coping with those impacts that cannot be avoided. This is both a matter of need, as climate change is now underway, and a matter of equity, as its impacts fall disproportionately on those least able to bear them. It also may be a condition for further progress on mitigation."[54]

> *"Adaptation planning should incorporate risk management methods and tools to help identify, assess, and prioritize options to reduce vulnerability to potential environmental, social, and economic implications of climate change."*
> Guiding principle for decision-makers, Interagency Climate Change Adaptation Task Force.[55]

Minnesota also has recognized the potential of focusing on adaptation, while continuing to pursue the mitigation goals of the Next Generation Energy Act. In July, 2009, an Interagency Climate Adaptation Team (ICAT) was formed to develop an adaptation plan for the state. A preliminary report – *Adapting to Climate Change in Minnesota* (August, 2010) – was developed as "a

[50] National Climate Assessment and Advisory Committee, page 625 (Midwest Region).

[51] "Risk control tools" include avoidance, loss control, separation, and risk transfer. Loss control is synonymous with the strategies of adaptation and mitigation, reducing risk by lowering the chance that a loss will occur or by reducing its severity if it does occur.

[52] National Climate Assessment and Advisory Committee, page 984 (Adaptation).

[53] See Minnesota Statutes, Section 216H.07, subdivision 3. In January, 2012, the Agency reported that, based on three years of data (2008 data), "Minnesota GHG emissions are declining, but at a weak rate that may leave the state short of its reduction goals under the *Next Generation Energy Act*." (See "Greenhouse Gas Emissions in Minnesota: 2007-2008, Second Biennial Progress Report – Technical Support Document," page 8. On January 24, 2013, the MPCA presented an update to the Senate Committee on Environment and Energy, using 2010 data. The update indicated a decrease in emissions of 3 percent from 2005 to 2010.

[54] Burton, Diringer, and Smith, "Adaptation to Climate Change: International Policy Options," Prepared for the Pew Center on Global Climate Change, November, 2006, page 1. The generic benefits of adaptation are identified by Burton and his colleagues in "Climate Adaptation: Risk, Uncertainty, and Decision-Making." These benefits include (1) Increasing the robustness of infrastructure designs and long-term investments, (2) increasing the flexibility of vulnerable managed systems (e.g., by making mid-term adjustments), (3) enhancing adaptability of vulnerable managed systems, (4) reversing trends that increase vulnerability to climate; and (5) improving awareness and preparedness. See UKCIP Technical Report, page 66

[55] The Interagency Climate Change Adaptation Task Force was initiated in 2009 and is co-chaired by the White House Council on Environmental Quality, the Office of Science and Technology Policy, and the National Oceanic and Atmospheric Administration.

framework for future planning, investigation and action."[56]

Minnesota state agencies are working within the framework of the ICAT to develop adaptation tactics addressing extreme heat, flooding, and wind damage, for example. Amendments to the State's building codes have been adopted to include minimum energy efficiency requirements intended to provide long-term GHG emission reductions. Further, Minnesota cities and counties are undertaking adaptation practices. In fact, the National Climate Assessment and Advisory Committee reports that most adaptation efforts to date have occurred at local and regional levels.[57]

1. Action Without Regrets

In light of increasing evidence that Minnesota's climate is changing and the implications of climate change for the state's economy, the logic of risk management prescribes that we should invest today to safeguard against future climate-related losses that could be much greater than the investments we could make to mitigate them. But, we are left with the question: Among the myriad choices we could make, which do we choose?

A useful approach offered from risk management theory is the selection of "no regret" -- or, at least, "low regret" -- options. In this theory, we feel "regret" if we discover that a decision made in the past produced less benefit than we expected, or when we have missed an opportunity as a result of a decision (for example, a decision to do nothing). A decision option that is assessed to be worthwhile now -- in that it would yield immediate economic benefit and environmental benefits which exceed its cost -- and continues to be worthwhile irrespective of the nature of future climate is an example of a "no regret" option. A "low regret option" exists where the cost implications of a decision are very low while the benefits under future climate change may potentially be large. However, the uncertainties are stronger and could lead to more "regret."[58]

Focusing on "no regret" options is a cautious decision strategy. But, it is a strategy that will encourage decision-makers to take action today because the investments they will make will provide positive returns regardless of the precise nature of climate change in the future. Further, it will allow decision-makers to agree on actions that produce "win-win" situations – options that reduce the impacts of climate change and have other environmental, social, or economic benefits. Such decisions do not need to be taken for reasons that are directly motivated by the need to adapt to climate change, but will have the benefit of simultaneously delivering some longer-term adaptation benefits.

Using a "low regrets" strategy allows decision-makers to select options with the lowest level of regret when compared to plausible future scenarios. It is a less cautious approach and recognizes that "no regret" options are not always available.[59]

Admittedly, implementing "no" or "low" regret options may go only part of the way to resolving challenges -- for example, while restoring wetlands might improve groundwater recharge, rapid climate change resulting in severe drought might still require building costly water supply reservoirs or pipeline connections (e.g., for rural water supply systems in southwestern Minnesota) in the future – but they will have allowed decision-makers to take important initial steps now.

2. Smart Investments: Actions We Won't Regret

What are some of the ideas for action that we won't regret? Consider the 10 ideas in Table 1 below. The ideas are linked to the challenges climate change introduces to our economy, the infrastructure that supports economic growth, and public health and welfare discussed above.

Many of the ideas are not new or original. Paul Moss, the coordinator of the Minnesota Interagency Climate Adaptation Team, points to several in a recent opinion piece in the *StarTribune*, for example.[60] Other experts have contributed their ideas, as well.[61] What they are is smart investments -- good ideas being adapted to meet multiple objectives.

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[56] Minnesota Pollution Control Agency, Adapting to Climate Change in Minnesota: Preliminary Report of the Interagency Climate Adaptation Team, August, 2010, page 1.

[57] National Climate Assessment and Advisory Committee, January 11, page 992 (Adaptation). Examples of local government action in Minnesota include:

- Throughout 2012, the City of Minneapolis involved experts and community representatives to develop a comprehensive set of emissions reduction strategies in three areas: buildings and energy, transportation and land use, and waste and recycling.
- Dakota County was the first county in the state to complete a greenhouse gas inventory and uses it as a baseline to guide efforts to improve energy efficiency in County buildings and fuel efficiency in County vehicles that reduce the costs of government.
- The Minnehaha Creek Watershed District's "Weather-Extreme Trends" (WET) initiative for stormwater management systems. The WET project aims to facilitate a stakeholder-driven adaptation planning process based on stakeholder ideas that will build the capacity of regional decision makers and prepare the watershed and communities for projected climate change.

[58] UKCIP Technical Report, page 66.

[59] For these options, a "minimax" regret calculation is employed. It seeks to define the lowest value of maximum regret. For information on "minimax" regret calculations, see Kunreauther et al. at page 7 and the UKCIP report at 62 to 65.

[60] Paul Moss, "Adaptation to climate isn't all or nothing," *Minneapolis StarTribune*, February 25, 2013, page A11.

[61] Kristin Raab and Linda Bruemmer of the Minnesota Department of Health and Dan Shaw and John Jaschke of the BWSR have been particularly helpful in sharing ideas included in Table 1.

Conclusion

"Even a correct decision is wrong when it is taken too late," former Chrysler CEO Lee Iacocca observed.

That the climate of Minnesota and the world is changing is clear. While it also is true that there is no consensus on precisely how fast change will occur and precisely how much change there will be, decision-makers must recognize that to be prudent risk managers they must take intelligent risks today.

Nearly 20 years ago, Ian Burton outlined described six reasons to adapt to climate change immediately. [62] His reasons then – anticipatory and precautionary adaptation is more effective and less costly than forced, last minute adaptation or retrofitting; climate change may be more rapid and more pronounced than current estimates suggest; and immediate benefits can be gained from better adaptation to climate variability and extreme events, for example – are equally appropriate and even more powerful today. Although he did not use the exact term, Burton was urging taking intelligent risks then that we have even greater reason to take now.

Taking intelligent risk – that is, seizing an opportunity where the potential gain outweighs the harm that could occur if the opportunity is not explored – is not a radical idea. Dr. Harry Hertz, the President of Baldrige Performance Excellence Program, uses an analogy to explain the idea of intelligent risk:

> If individuals avoid fire completely – that is, are being risk-averse – they will have a cold home, cold showers, and lots of cold food. If they use fire effectively – that is, take intelligent risk – it will make their lives better and more comfortable. If they use fire recklessly and in an uncontrolled fashion – taking an unintelligent risk, or being a daredevil – they will get burned and lose their assets.[63]

If decision-makers choose to avoid risk completely because we cannot define with precision how much and how fast change will occur or there is no complete public consensus, they risk significant impacts on core Minnesota industries; disruptions in transportation of goods and materials, as the Mississippi River faces both low flows from drought and unmanageable flows from floods; changes in ecosystems, including damage to the state's sport fishing and hunting industries; and threats to public health. If decision-makers respond effectively – that is, take intelligent risks – they will set the table for a stable economy and to protect public health.

Embracing the concepts of risk management provides a way of making the required decisions. Identifying smart investments in actions we won't regret is a wise choice for a sustainable future. This is not being a daredevil. It is being a wise steward of Minnesota's future.

> *"… climate change affects everything. The solutions don't lie only in climate finance or climate projects. The solutions lie in effective risk management and ensuring all our work, all our thinking, is designed with the threat of a 4°C world in mind."*
> Dr. Jim Yong Kim President, World Bank Group in the Forward to *Turn Down the Heat*

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[62] Ian Burton, "The growth of adaptation capacity: practice and policy" in *Adapting to climate change: an international perspective,* Springer-Verlag, New York, NY, 1996, pp. 55-67. Burton is Professor Emeritus at the University of Toronto.
[63] Harry Hertz, "Insights on the Road to Excellence," December, 2010 at nist.gov/baldrige/insights.

Challenge	Table 1. Smart Investments: Actions We Won't Regret
More frequent large storms/flooding	**Use of natural treatment practices for effective water management.** A variety of practices that increase soil organic matter and associated water holding capacity – such as perennial crops, conservation tillage, conservation drainage, cover crops, buffer strips, and infiltration basins -- help manage water resources. Incorporating these practices will aid in maintaining agricultural productivity, enhancing water storage on the landscape, and reducing runoff during strong storm events and flooding. In addition, they will improve the recharge of groundwater and water quality (challenges associated with climate change) and help maintain agricultural productivity (an economic threat of climate change).
	Restoring wetlands. Wetlands detain heavy rainfall and help reduce flooding. They also support the recharge of ground water and help improve water quality and provide habitat for wildlife, helping support the state's multi-billion outdoor recreation economy. (Constructing rain gardens as part of construction projects can produce similar benefits.)
High heat indexes	***Aiding the aged and disadvantaged.*** Heat stress is expected to increase as a result of increased summer temperatures and humidity as climate changes. For the United States, mortality increases 4% during heat waves compared with non-heat wave days. There is evidence that minority and lower-income communities suffer health risks associated with exposure to excessive heat and air pollution disproportionately.[64] A study conducted in the aftermath of a heat wave that hit Chicago in July, 1995 that killed 739 people (roughly six times the number of people who died in Superstorm Sandy) identifies the importance of organizing communities so that residents know which of their neighbors are vulnerable and how to assist them. Death from the heat wave was 11 times less likely in communities organized to know and help their neighbors than in otherwise similar neighborhoods in the city.[65] Development of programs based on what worked in Chicago and the implementation of heat warning systems where they do not exist will save lives, combat one of the outcomes of climate change, and enhance social justice. The National Climate Assessment and Advisory Committee flatly states: "Heat response plans and early warning systems save lives." [66]
	Planting urban trees. Trees help in cooling to lessen the effects of extreme heat. They also absorb air pollutants; break the force of precipitation from heavy storms, improving infiltration into the soil; and help reduce summer energy demand. Trees help increase home values and promote healthy behaviors, making it more comfortable to walk and bike on hot days.
Stress on infrastructure that supports the state's economy	***Incorporating climate change into local water plans.*** Historically, water management facilities and conservation practices have been built and regulated by policies based on the assumption of relatively stable climate conditions. Recent climate trends and projected impacts show that these historical assumptions will not be effective to manage the changing conditions of the future. While some local water management authorities have begun to incorporate climate change within their planning, a "no regrets" opportunity is to require climate change be addressed for "priority concerns" of local water management plans that are

[64] See studies cited in Sadd, Pastor, Morello-Frosch, Scoggins and Jesdale, **"**Playing It Safe: Assessing Cumulative Impact and Social Vulnerability through an Environmental Justice Screening Method in the South Coast Air Basin, California," International Journal of Environmental Research and Public Health, 2011, page 1442.

[65] Eric Klineberg, "Adaptation: How Can Cities Be "Climate-Proofed?" *The New Yorker,* January 7, 2013, page 32.

[66] *National Climate Assessment; Draft for Public Comment*, page 624 (Midwest Region).

Stress on infrastructure that supports the state's economy (continued)	provided for under the Metropolitan Surface Water Management and Comprehensive Local Water Management Acts.[67] This could be done either as a requirement of statute or by including such a requirement in Minnesota Rules or other plan guidance.[68] For example, local water management plans address priority water management concerns, such as: • Design and construction of culverts that pass water under local roads. A requirement to consider the implications of a changing climate is likely to affect the design and construction of culverts. Proper sizing can help detain runoff to reduce downstream flood risks, as well as protect road stability. • Conservation practices and associated drainage infrastructure that provide multiple benefits relating to water quality, agricultural sustainability, flood damage reduction, and improved wildlife habitat. Such a requirement could also help address other climate change concerns, such as healthy forests and minimizing impacts of climate change on wetlands.
	Adapting the building materials we use. Using light-colored roofing materials can help in saving energy – and, dollars – for home owners by avoiding the retention of heat that results from darker roofing.
Fishing, hunting, and wildlife-associated recreation	***Maintain plant diversity.*** Diversity increases resiliency by helping plant communities and agricultural systems that support wildlife to continue functioning as intact systems during climate variation. Decreasing fragmentation, creating corridors, and buffering existing natural areas provide genetic pathways for plants species and allow for migration by wildlife. Best use of prescribed burns, grazing, and natural flood regimes can help maintain plant diversity. Filling niches with native species also prevents the establishment of invasive species, which are likely to be a heightened effect of climate change.
	Establish resilient habitat. Minnesota's 16 million acres of forestland, 6 million acres of peatlands, and 235,000 acres of remaining native prairie provide critical habitat that supports a multi-billion dollar sector of Minnesota's economy. They also store vast amounts of carbon, and could store more if managed to do so. Permanent protection of grasslands via easements and acquisition of critical lands from willing sellers; restoration activities including buffer strips, native plant seeding, wetland restoration and water level management; and enhancement of prairies and grasslands through prescribed fire, conservation grazing and invasive species control will produce multiple benefits.[69] (This idea should be considered a low regret opportunity, as it imposes a significant opportunity cost, if implemented.)
Public health (also see "High heat indexes," above)	***Increasing active transportation*** (e.g., the use of bicycles) ***and promoting walkable communities***. Such initiatives reduce GHG emissions and pollution from vehicles, while promoting better health (reduced obesity, diabetes, and other chronic diseases) through physical activity.
	Promoting local food production, such as community gardens. Locally-sourced food decreases GHG emissions because food is transported fewer miles; increases access to fresh fruits and vegetables, part of a healthier diet; and increases physical activity for growers.

[67] See Minnesota Statutes, Sections 103B.301 to 103B.355.

[68] Minnesota Rules, Chapter 8410 spells out plan requirements for counties and watershed-based organizations

[69] Minnesota Prairie Conservation Plan has been proposed to shelter wildlife and support a strong recreational economy, while also slowing flooding, protecting the state's waters from non-point sources of pollution, and supporting the agricultural economy. The Minnesota Prairie Conservation Plan is partnership of conservation organizations, including the U.S. Fish and Wildlife Service, Department of Natural Resources, Board of Water and Soil Resources, Natural Resources Conservation Service, Nature Conservancy, Minnesota Prairie Chicken Society, Conservation Fund, Audubon Minnesota, Pheasants Forever, and Ducks Unlimited.