# Iowa Climate Change Adaptation & Resilience Report

2011

How should hazard mitigation and other community planning programs respond to climate change?

# Executive Summary

This report presents the findings of a pilot project initiated by the U.S. Environmental Protection Agency (EPA) to work with stakeholders and governments in Iowa to identify barriers to and incentives for considering regional effects of climate change in hazard mitigation planning and other community planning processes. Communities in Iowa engage in multiple planning activities, including hazard mitigation planning and comprehensive or community planning, that can help guide them as they try to become more resilient to the effects of climate change. Iowa communities have been experiencing floods that are growing more severe and frequent, and state and local planners are working to identify local planning approaches that improve resilience to future floods and help communities recover after disasters. The first stage of this pilot project explored if and how climate change information should be considered in risk assessments and the implications this information may have for community planning options. The second stage focused on identifying adaptation solutions with mutual benefits and synergies across different planning requirements and emphasized the need to work across agencies and levels of government to optimize results.

Nine findings resulted from a series of meetings and conversations between partners from local, state and federal government and academia. These findings can be used to inform future work on the topic of how to support communities that want to incorporate climate science into local planning efforts. The findings include:

1. Local governments are at the forefront of adapting to climate change.
2. Land use is a primary determinant of community and regional climate change adaptation capacity.
3. Climate change data must be formatted and distributed in a way that is accessible and usable by state and local planners.
4. Local and state planners need to increase skill sets to effectively use climate change data.
5. Federal and state programs should create incentives that will improve the use of climate change data, including in the production of hazard mitigation plans.
6. Communities need to integrate planning processes, specifically hazard mitigation and comprehensive land use planning.
7. Federal and state programs and policies should give communities incentives to integrate planning processes, specifically hazard mitigation and comprehensive land use planning, and to incorporate no-regrets adaptation measures to produce symbiotic outcomes.
8. Federal agencies should align and leverage funding and focus on pre-disaster planning for community resilience and sustainability.
9. Investment decisions should take a regional perspective and be integrated across infrastructure types and sectors to realize co-benefits.

Communities are working hard to plan for natural disasters in order to protect their citizens, their property, and the public and private investments that have been made over generations. Policy changes at all levels of government will be necessary to help communities use climate change science to develop better plans. In the long term, different levels of government and neighboring jurisdictions can link local adaptation efforts to form regional responses to climate change risks.

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# I. Introduction

The state of Iowa has experienced catastrophic flooding three times in the past 17 years: 1993, 2008, and 2010. While many thought that 1993 would be the flood of record for the state, the floods of 2008 proved otherwise, producing federal disaster designations in 85 of Iowa's 99 counties. These events have focused attention on Iowa's changing climate and the associated risk such changes pose to Iowa communities. Climate scientists, hydrologists and engineers, city and county planners, community leaders, and other stakeholders are working to make Iowa and its many communities more resilient in the face of continued change in weather patterns. This report presents the findings that came out of a series of meetings and ongoing workgroups among these stakeholders to evaluate how to introduce information about future climate change impacts into local land use and hazard planning.

Two primary tools were identified early on in this effort to help build local resilience to flooding—comprehensive planning and hazard mitigation planning. Right now in Iowa, these two methods for assessing risk and preparing for more resilient futures are typically disconnected.

This study first explores how climate science and scenario planning can inform hazard mitigation and community planning, as well as what challenges exist for incorporating climate science in hazard mitigation planning. Second, the study explores opportunities to encourage integrating hazard mitigation and local comprehensive planning processes to adapt communities' land use decisions to the effects of climate change. The recommendations are intended to inform the Interagency Climate Change Adaptation Task Force, co-chaired by the White House Council on Environmental Quality (CEQ), White House Office of Science Technology and Policy (OSTP), and the National Oceanic and Atmospheric Administration (NOAA), as well as other audiences with programs and policies that are mentioned here. These pilot findings highlight the role that federal and state programs play in local adaptation efforts. The CEQ Task Force outlined eight guiding principles for adaptation in its October 2010 progress report "that should be

**CEQ Adaptation Task Force**
**Guiding Principles for Adaptation**

**Adopt Integrated Approaches**: Adaptation should be incorporated into core policies, planning, practices, and programs whenever possible.

**Prioritize the Most Vulnerable**: Adaptation plans should prioritize helping people, places and infrastructure that are most vulnerable to climate impacts and be designed and implemented with meaningful involvement from all parts of society.

**Use Best-Available Science**: Adaptation should be grounded in the best-available scientific understanding of climate change risks, impacts, and vulnerabilities.

**Build Strong Partnerships**: Adaptation requires coordination across multiple sectors and scales and should build on the existing efforts and knowledge of a wide range of public and private stakeholders.

**Apply Risk-Management Methods and Tools**: 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.

**Apply Ecosystem-based Approaches**: Adaptation should, where relevant, take into account strategies to increase ecosystem resilience and protect critical ecosystem services on which humans depend to reduce vulnerability of human and natural systems to climate change.

**Maximize Mutual Benefits**: Adaptation should, where possible, use strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management, and reduce greenhouse gas emissions including the development of cost-effective technologies.

**Continuously Evaluate Performance**: Adaptation plans should include measureable goals and performance metrics to continuously assess whether adaptive actions are achieving desired outcomes.

considered by governments, communities, the private sector, and others in designing and implementing adaptation strategies."[1] These eight principles are in line with the recommendations coming out of this pilot work group and emphasize the importance of integrating local plans with hazard mitigation plans.

**The overarching recommendation of the group is for FEMA and other federal agencies, the state of Iowa, and the local jurisdictions to work together to develop programs and incentives that encourage incorporating climate projections into the hazard mitigation risk assessment process and consider ways to encourage innovative, integrated hazard mitigation and comprehensive planning.** Such change will better equip communities to protect their citizens, their property, and the public and private investments that have been made over generations. For these improvements to happen, federal, state, and local governments and other stakeholders will have to rethink some existing programs and policies, and this group has recommended both near- and long-term steps in this direction. Iowa has already moved forward in this area by adopting the Iowa Smart Planning Principles and local comprehensive planning guidance, which includes integration of hazard mitigation strategies. But further steps are necessary.

## Purpose of Report

EPA approached the Rebuild Iowa Office (RIO) in the spring of 2010 to partner on a pilot project aimed at incorporating climate change adaptation and resiliency concepts in hazard mitigation plans. The proposed project stemmed from the Interagency Climate Change Adaptation Task Force's activities, including consideration of how to incorporate climate change into the missions and policies of federal agencies. EPA's interest in conducting this pilot in Iowa also grew from a successful partnership between the state, EPA, and FEMA to provide smart growth technical assistance to communities hard hit by the floods of 2008. This partnership led to EPA and FEMA signing a Memorandum of Agreement (MOA) to continue working on ways to incorporate smart growth and sustainable communities approaches into hazard mitigation planning and long-term community recovery. The efforts put forward in this pilot project fit within the scope of the MOA, and the findings of this report will help to define future collaboration between FEMA and EPA.

This report is intended to identify challenges to and incentives for considering regional effects of climate change in hazard mitigation and other community planning processes, incorporating the following approaches:

- Use predictive models and future climate scenarios for risk assessment, risk management, and scenario planning.
- Develop smart planning solutions that reduce risks and enhance community resilience.[2]

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[1] *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy*, October 5, 2010: http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf

[2] The Rebuild Iowa Office defines smart planning as a process that produces resilient communities that in turn attract economic development; proactively markets a region to attract opportunities for citizens, businesses, and government; facilitates good fiscal management; reduces the impact of natural and

- Incorporate broad changes into the current planning framework through smart planning solutions that reduce risks and enhance community resilience.
- Integrate these smart planning solutions into existing planning frameworks.

The project incorporated separate stages:

**Stage 1**: Climate change science and risk assessments.
**Stage 2**: The role of hazard mitigation and other community planning programs in responding to climate change.
**Ongoing**: Evaluation of progress and building awareness and skills.

Stage 2 participants worked to understand what communities can do to adapt to the predicted effects of climate change in Iowa, which were outlined and explained by the Stage 1 team and the report that is included below. The group as a whole sought to identify the challenges to adaptation efforts, addressing the following questions:

- At the municipal, regional, state, and federal levels, how will missions and operations be impacted by the climate change scenarios?

- What are new opportunities and changing policy frameworks that communities can take advantage of?

- What tools and policies do communities have to adapt to the effects of climate change and become more resilient?

- How are these tools and policies implemented, and can they be implemented in a way that effects change?

***The scientific understanding of climate change is now sufficiently clear to begin taking steps to prepare for climate change and to slow it. Human actions over the next few decades will have a major influence on the magnitude and rate of future warming. Large, disruptive changes are much more likely if greenhouse gases are allowed to continue building up in the atmosphere at their present rate. However, reducing greenhouse gas emissions will require strong national and international commitments, technological innovation, and human willpower.***

From *Understanding and Responding to Climate Change - Highlights of National Academies Reports 2008 Edition*

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man-made hazards; promotes the protection and preservation of sensitive and working lands, property, and human life; identifies priority projects and attracts greater private and public investment; encourages civic involvement and ensures that community members have a voice in the future of their communities; encourages the maintenance of rural character and strong community identities; and identifies a community's priorities and strengths. http://www.rio.iowa.gov/smart_planning/assets/planning_brochure.pdf

- Does hazard mitigation planning take on a more detailed land use component, or does comprehensive planning incorporate hazard mitigation?

The following sections describe the two pilot stages, provide an overview of report findings, describe climate change science and risk assessments, and offer conclusions.

## II. Report Findings

The primary findings and lessons developed through this project are intended to provide information to federal and state agencies whose programs influence local land use and hazard mitigation planning, to scientists and researchers that work to develop climate change information and tools that might impact local decisions and investments, and to communities trying to become more sustainable and resilient by investing in solutions that meet multiple local goals. This pilot project hopes to build on past recommendations given new science that projects increased rainfall and flood risks beyond historic trends in Iowa. The pilot findings include:

1. **Local governments are at the forefront of adapting to climate change.**
   a. Local governments can adopt plans such as comprehensive plans, strategic plans, and hazard mitigation plans that take into account the effects of climate change. Acting based on incentives and disincentives from state and federal governments, as well as using local funding streams, communities regularly make decisions that will affect future land use, including built and natural infrastructure that can protect the community and enhance resilience to future disasters. Communities can adapt to become more resilient by implementing policies and plans that take into account the best available information about a wide range of future conditions including population increases, flood risks, transportation demand, and other related projects.

2. **Land use is a primary determinant of community and regional climate change adaptation capacity.**
   a. Local land use policy and the incentives and disincentives that influence how land use policy is adopted at the local level determine how communities adapt to the effects of climate change. Adapting to the effects of climate change can occur naturally within ongoing local planning processes, such as investments and decisions about where to move or place infrastructure such as water, sewer, transportation, and housing.

   b. Iowa's smart planning legislation and its component smart planning principles, adopted in 2010, can also help communities put plans in place that include adaptation strategies addressing climate change. Planning will play an important role in changing societal actions that allow for adaptation to climate change. Comprehensive plans address such basic issues as community design and development density, setting priorities for infrastructure and capital facilities investments, developing policies for land use in floodplains and other high risk areas, and protecting critical natural resources.

   c. Political leaders and citizens rely on plan recommendations when making decisions on investment, design, and development strategies that use resources efficiently and sustainably. Planning documents can integrate climate change adaptation with other planning goals by recommending land use patterns that can protect property from expected environmental changes resulting from climate change (such as sea level rise, storm surges, and floods) and promoting contingencies in case of loss of supply of critical natural resources (such as potable water). The planning process is an ideal vehicle for raising public awareness of the increasing risks associated with development and investment in hazard-prone areas.

3. **Climate change data must be formatted and distributed in a way that is accessible and usable by state and local planners.**
    a. Different users access climate information in different ways, depending on their need. Flood insurance programs must base premiums on current rather than future hazard risk. With this constraint, the use of climate projections may be best focused on outreach campaigns to encourage flood insurance program participation, which might require community-specific educational materials describing projected future floods. In contrast, hazard mitigation plans are required to estimate the likelihood that a hazard will occur in the future, which requires discussion with community and hazard mitigation planners about appropriate methods to assess potential future flood magnitude and damage.

    b. Translating and integrating climate scenarios into local hazard information is relatively new and requires a better understanding of how the information may be useful in community planning. There is a strong need for dialogue between planners and climate information producers to understand how planning approaches based upon risk estimates can be adapted to consider climate scenarios. Giving a planning context to climate information is complex because community and hazard mitigation plans are multi-faceted decision processes. A questionnaire (see Appendix G) in Stage 1 of this pilot resulted in a list of considerations planners make when preparing hazard mitigation plans:
        i. Planners must link climate data and hazard risk to inventories of built structures and natural/societal resources in order to estimate potential losses.
        ii. Climate change information, such as projected annual rainfall and temperature, must be used by planners in light of hazards, such as floods, and community responses, such as energy usage and citizen willingness to participate in conservation programs.
        iii. Planners rely upon well-developed best practices for hazard risk assessment in order to ensure the information they use is of the highest quality.
        iv. Planners consider the mitigation and planning activities for which they can get grant funding when they determine which natural hazard risks and mitigation tactics to address.
        v. Mitigation of hazards in one community may affect the hazard profile of another, and climate change may alter the hazard profile of different communities in different ways.
        vi. Climate change data can be used to inform different plans and local planning decisions, and the appropriate planning process may vary by community, depending on the willingness of the community to consider climate change projections, the climate literacy of community leaders, and the planning needs of the community (e.g., whether the community is currently updating its hazard mitigation plan). Climate change data may enter community planning through land use plans, zoning designations, municipal ordinances, incentives for development and conservation, hazard risk estimates, and outreach materials. The community's need determines the type of climate information it uses.

vii. Planners may have limited staffs, so historical climate data and climate change projections must be available and accessible with minimal cost and effort.

c. Translating climate projections into estimates of future flood hazard faces three primary knowledge barriers:
   i. Traditional measures of rainfall extremes relate to only about half of flood events. This means it is difficult to confidently infer from projected increases in heavy rainfall what the future risk of floods might be.
   ii. Standard methods to compute future inundation maps have not been developed, which hinders estimates of potential future damages and economic loss.
   iii. The intrinsic variability of rainfall itself may present a challenge in that uncertainty of this magnitude is not addressed by approaches to estimate current risk based upon historical reports.

d. Federal and state agencies should provide support for regional workshops to produce region-specific reports that describe how climate change data can inform community and hazard plans.

e. Research grant programs are needed to support the development and evaluation of tools for translating climate projections into hazard scenarios.

f. Research and development grant programs are needed to develop sustained dialogue between planners, government agencies, and climate information producers to understand how to interpret and use climate-change-based hazard scenarios in community planning.

g. Regional and local planners would find it useful if NOAA, EPA, FEMA, or other federal partners identified approaches for including future climate data and illustrated those approaches with examples to demonstrate potential benefits and provide templates to encourage adoption.

**4. Local and state planners need to increase skill sets to effectively use climate change data.**

a. The role of planners in helping communities adapt to climate change is only now starting to evolve. As climate change and adaptation are discussed, planning professionals must be adequately trained to effectively participate in the dialogue and decision-making process. The pilot participants recognize that some small communities have no planner on staff and may require training for other local staff that serve in the role of a traditional planner. The pilot participants identified the following skills planners need in order to include climate change considerations in planning:
   i. Basic understanding of ecosystem functions.
   ii. Basic understanding of land use planning and zoning, including hazard analysis.
   iii. Fuller understanding of and engagement with the emergency management field.
   iv. Strategic thinking skills.
   v. Public relations, marketing, and education skills.
   vi. Basic understanding of low impact development and green infrastructure.
   vii. Consensus building and collaboration for multi-objective planning.

viii. Knowledge of funding resources and how money is spent in the community.
ix. Political savvy.
x. Data analysis/integration skills.

Appendix C includes potential training resources for planners and others professionals.

5. **Federal and state programs should create incentives that will improve the use of climate change data, including in the production of hazard mitigation plans.**
   a. Many communities complete hazard mitigation plans as an important step towards receiving grants that fund long-term hazard mitigation measures after a major disaster declaration. However, there is little precedent or support for communities to include future data in flood risk assessments and/or to take additional steps in hazard mitigation plans to account for climate change risks. FEMA has the potential to support and provide incentives to communities that go beyond the basic requirements of mitigation planning to add elements to these plans that respond to future impacts and have more overt, direct benefits to the community now and in the future. Some existing programs, such as the enhanced state hazard mitigation plan or the Community Rating System for the National Flood Insurance Program, provide additional points based on practices that go beyond basic protections, which could be an incentive.

   b. There are many ways to approach the challenge of including climate change science in hazard mitigation planning, including statutory reform, revised regulations, and providing incentives for communities. An incentive program, additional guidance, the establishment of case studies or best practices, or even prioritized funding for innovative plans could help local and state mitigation planning staffs invest time or resources in adaptation planning. FEMA could create an incentive for using climate change data by increasing the federal contribution when hazard mitigation plans take climate change projections into account.

   c. Best practices and precedents for using climate change data in preparation of hazard mitigation plans have not been established. Accessing and effectively using climate change data will require additional hours and work time by local planners; engineering consulting firms must establish new procedures, resulting in additional charges; and planners will need to determine how to incorporate scenarios established with climate change projections into land use planning.

6. **Communities need to integrate planning processes, specifically hazard mitigation and comprehensive land use planning.**
   a. The linkage between hazard mitigation planning and comprehensive land use planning historically has been weak. While a stand-alone mitigation plan is better than no plan at all, there are good reasons why local hazard mitigation plans should be linked to other community planning activities, particularly land use planning. The most important reason is that, unlike

the comprehensive plan, the local hazard mitigation plan has no legal status for guiding local decision-making, capital expenditures, or land use.[3] Local zoning ordinances, subdivision regulations, and other implementation mechanisms codify comprehensive planning efforts. Comprehensive plans help determine the pattern of future growth and can thereby help communities become more resilient as they make new investments and land use decisions. Hazard mitigation plans alone may not have the same consistent and implementable impact as that of comprehensive plans. By linking the two, both have the potential to increase their impact.

b. Existing requirements for hazard mitigation plans, such as the five-year renewal period, do not align well with local planning processes and goals for infrastructure investments, capital improvement projects, and major land use decisions. There is great potential to support the goals of hazard mitigation planning in local comprehensive plans. This pilot workgroup did not develop a list of example communities, either in Iowa or elsewhere in the United States, that show how to effectively integrate hazard mitigation and comprehensive planning. A follow-up step to this pilot might be to develop a list of example cities or counties that have effectively integrated the two plans. A good start is an American Planning Association (APA) report developed with FEMA titled *Hazard Mitigation: Integrating Best Practices into Planning (*PAS 560), which includes best practices and technical guidance for communities to integrate hazard mitigation into existing local planning processes.[4]

7. **Federal and state programs and policies should give communities incentives to integrate planning processes, specifically hazard mitigation and comprehensive land use planning, and to incorporate no-regrets adaptation measures to produce multiple benefits.[5]**

   a. Local planners have difficulty fulfilling existing requirements for preparing and updating hazard mitigation plans, especially when paired with the typically separate requirements of local comprehensive land use planning. Consideration of climate change adaptation is currently viewed as a cumbersome and time-consuming addition to an already difficult set of planning requirements. There may be ways to align these planning needs to reduce the workload of local planners and redundancy of potentially overlapping planning needs.

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[3] Schwab, James C. *Hazard Mitigation: Integrating Best Practices into Planning.* American Planning Association. 2010. http://www.fema.gov/library/viewRecord.do?id=4267

[4] Ibid.

[5] No-regrets adaptation measures refer to proactive options that provide benefits with or without changing climate conditions. One example is green infrastructure approaches, such as trees or green roofs, that can help manage increases in storm frequency and events, as well as urban heat island impacts, but will help to manage existing stormwater runoff despite possible climate change impacts. (Willows, R.I. and R.K. Connell, eds. *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report. Oxford : UKCIP. 2003.)

b. State programs, policies, and funding streams could encourage, or at least allow, cities and counties to meet multiple local goals with mutually supportive plans or even one single plan that meets hazard mitigation planning requirements and local planning needs.
   i. A state-level example specific to Iowa is the set of recommended incentives that has been proposed in the state legislature for Iowa counties and cities to use Iowa Smart Planning Principles to support adaptation. See Appendix A for the full list of proposed incentives.

c. Federal and state governments should consider programs and policies that could provide incentives, including but not limited to:
   i. FEMA Hazard Mitigation Assistance grant programs could consider incentives to fund comprehensive plans that sufficiently address hazard mitigation, rather than funding only stand-alone hazard mitigation plans.
   ii. The FEMA Long-Term Community Recovery (LTCR) process should provide guidance on how to integrate hazards into existing local planning mechanisms and consider options for funding to assist with implementation.
   iii. The National Flood Insurance Program, specifically the Community Rating System, could provide incentives for adaptation measures based on future-conditions modeling and climate change data.
   iv. Federal or state agencies could develop model ordinances to provide sample language for local policies that meet both hazard mitigation and local planning requirements.
   v. Technical assistance from federal and state agencies could be used to establish case studies and clear precedents for how to better integrate hazard mitigation planning and comprehensive planning.
   vi. States could offer greater cost shares for hazard mitigation plan implementation in communities with enhanced plans that link to comprehensive plans and incorporate climate change adaptation measures.

d. Consider potential links with other federal agencies.
   i. United States Department of Agriculture (USDA) Federal Crop Insurance Program or temporary Conservation Reserve Program (CRP) easements could allow compensation of temporary inundation of farm land in watershed uplands.
   ii. The HUD Sustainable Communities Regional Planning Grant Program allows applicants to consider hazard elements in regional sustainable planning activities.[6]

**8. Align and leverage federal funding and focus on pre-disaster planning for community resilience and sustainability.**

a. Federal agencies should consider adjusting statutorily established funding priorities to better support improved and integrated pre-disaster planning that can mitigate disaster impacts and help with recovery. Iowa has experienced an

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[6] HUD's Sustainable Communities Regional Planning Grant Program Fiscal Year 2011 Notice of Funding Availability, page 9. http://portal.hud.gov/hudportal/documents/huddoc?id=2011gensec.pdf.

increased frequency of recent flood events, and the common experience at both the state and local level is that resources are greater and more readily available after a disaster occurs. Although the pilot workgroup recognizes the proportionate need to respond to disasters once they occur, as well as the fact that FEMA identifies cost saving on recovery through better planning, the system still emphasizes recovery after disasters much more than planning to prevent disasters occurring in the first place. Historically, there has not been a dedicated pre-disaster stream of federal assistance for recovery planning, whereas since the Disaster Mitigation Act of 2000, mitigation plans and pre-disaster mitigation funds are in place prior to disasters to prevent disasters. In 2009, FEMA, HUD, and other federal agencies collaborated to start addressing this gap through the National Disaster Recovery Framework, which includes pre-disaster recovery planning as a key element. The National Disaster Recovery Framework should further be supported and implemented with dedicated funding and federal technical assistance for pre-disaster recovery planning.

b. Communities recovering from flood disasters in Iowa have identified the potential for building greater resilience to future flood events during the long-term recovery process. While the current ESF-14 process does not explicitly link recovery to building resilience to future disasters, the process provides an opportunity to address future disaster resiliency by incorporating existing hazard mitigation plan information, identifying the need to develop a hazard mitigation plan, and/or identifying and developing projects and programs that incorporate mitigation principles. FEMA and EPA supported five projects after the 2008 Iowa floods that provide examples of the value of integrating sustainable communities strategies and future disaster mitigation into the recovery process.[7] Increased support for disaster planning applies not only to communities in the process of disaster recovery, but also to communities that are writing FEMA disaster mitigation plans for the first time and that may not have experienced a flood disaster yet.

**9. Investment decisions should take a regional perspective and be integrated across infrastructure types and sectors to realize co-benefits.**

a. As many Iowa communities have found, communities can get more out of their resources by collaborating on multijurisdictional hazard mitigation plans and using larger watershed planning and regional land use planning tools. Communities might be able to take advantage of the National Resources Conservation Service's (NRCS) Resource Conversation and Development (RC&D) or Councils of Governments (COGs) to work across jurisdictional boundaries when planning for land use and infrastructure investments.

b. Communities can realize greater benefits in the case of additional climate change impacts and flood events, such as the value of avoided flood impacts, through better coordination among up- and downstream communities.

[7] U.S. EPA Office of Sustainable Communities. Smart Growth Technical Assistance in Iowa, http://epa.gov/smartgrowth/iowa_techasst.htm.

c. Cities and counties can make single investments that produce multiple benefits and achieve local goals.

d. The comprehensive planning process can help communities identify and prioritize regional strategies.

# III. Climate Science and Local Planning

In response to recent and devastating floods in Iowa, the pilot participants identified two primary tools early on in this effort to help build local resilience to flooding—comprehensive planning and hazard mitigation planning. Right now in Iowa, these two methods for assessing risk and preparing for more resilient futures are typically disconnected. The first part of this section explores how climate science and scenario planning can inform hazard mitigation and community planning, and challenges to incorporating climate science in these planning efforts. The second part explores opportunities for communities to integrate hazard mitigation and local comprehensive planning processes so that their land use decisions adapt to the effects of climate change.

Iowa's changing climate means that communities can no longer rely on past weather patterns to predict future conditions. Land use decisions and efforts to protect against future hazards such as flooding will have to take changing climate conditions into account.

## Current and Future Climate Changes in Iowa

Comprehensive local climate projections do not currently exist for Iowa communities, but the future development to local projections will improve community planners' ability to determine the impacts of climate change on future hazards and plan appropriately for hazard mitigation. However, substantial information already exists on current and future climate changes in Iowa. Changes have already been observed in precipitation, stream and river flow, temperature, and wind patterns.

- **Precipitation in Iowa has increased since the 1940s:** Total annual precipitation has increased about 10 percent since the 1940s, with more rain falling during spring and early summer and more heavy downpours.[8]
- **Changes in precipitation are impacting stream and river flow:** Stream and river flow have increased about 20 to 50 percent since the 1940s.[9] There are more days with high stream flow in central Iowa, and spring soil moisture is close to saturation more frequently.[10]
- **Statewide winter temperatures have increased:** On average, there are about five more frost-free days than in 1950, and thaw-freeze cycles are more frequent.
- **Wind speeds have declined over the last 30 years,** potentially worsening air quality.

Further changes are projected to occur in Iowa's climate in the future. By 2065:

- **Springtime precipitation is expected to increase,** resulting in heavier downpours.[11]

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[8] "More heavy downpours" are defined as a greater number of days when rainfall exceeds 1.25 inches. See Iowa State University, Climate Science Program, http://climate.engineering.iastate.edu/Document/Olsen_Amend_Report.pdf.

[9] Ibid.

[10] Ibid.

[11] Ibid. See also Appendix F.

- **Stream and river flow may increase by 20 percent or more.**[12]
- **Annual temperatures are expected to increase by 2.5 to 7.2°F.** [13]

These climate changes will impact the types and severity of hazards in Iowa, including:

- **Flood hazards:** Changes in precipitation and stream flow have already and will continue to increase the risk of riverine flooding, flash flooding, and damage due to expansive soils, especially during spring and early summer.[14]
- **Heat waves:** Higher average temperatures will lead to more heat waves, resulting in more heat-related illnesses.
- **Severe weather events:** Neither historical data nor future climate projections provide information on changes in the intensity or frequency of severe weather events, such as tornadoes or windstorms.

Further discussion and resources on current and future climate changes in Iowa are provided in Appendices F and H.

## Challenges of Current Climate Science

Iowa faces the same challenges as many other states in incorporating climate change science into local planning efforts. Iowa is fortunate to have an active climate science community, which has already conducted substantial research on the current and future impacts of climate change on the state. However, much of the current climate science data has yet to be formatted and distributed in a way that is accessible to and usable by state and local planners.

Climate Projection Data

The first challenge is that global climate projection data need to be translated into regional and local projections of future climate impacts. Global climate models provide the basis for determining projections of climate change at the regional and local levels. These models project future climate changes at a relatively large scale, providing average changes across entire regions such as the Midwest.[15] These projections do not provide enough detail to identify what the impacts will be on individual states, counties, or communities.[16] Because future climate changes are based on the amount of greenhouse gases that will be emitted in the future, we do not yet know the magnitude or severity of climate change. Global climate models deal with this uncertainty by presenting climate change projections based on different scenarios of future greenhouse gas emissions.

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[12] Ibid.

[13] See Appendix F.

[14] See Appendix F.

[15] America's Climate Choices: Panel on Adapting to the Impacts of Climate Change. Adapting the Impacts of Climate Change, Chapter 2: Vulnerabilities and Impacts. The National Academies Press. 2010. http://americasclimatechoices.org/paneladaptation.shtml.

[16] Ibid.

To create climate change projections for Iowa and its communities, global climate model data needs to be translated to a finer spatial scale. This process is called “downscaling” and will provide the necessary level of detail to determine projected climate change at county and local levels. Iowa’s climate science community has already documented observed changes in Iowa’s climate and is working to downscale global climate models to project future climate impacts for Iowa and its communities based on these models. For more information on climate projection data, see Appendix F.

<u>Translating Climate Projections into Estimates of Future Hazards</u>

There are three challenges to translating climate projections into estimates of future hazards in Iowa. First, changes in rainfall do not directly correspond to changes in flooding. Traditional measures of rainfall extremes relate to only about half of future flood events. This means that it is difficult to determine future flood risks on the basis of projected increases in heavy rainfall. Second, rainfall projections vary greatly. In many cases, small changes in weather patterns could significantly alter the intensity and location of rainfall. Finally, methods for mapping future riverine flooding are not well established, making it difficult to estimate property damage and other economic losses.

Climate scientists should address these challenges and improve the information available to planners in two ways. First, climate scientists should compare local projections from multiple downscaling techniques to determine whether daily rainfall projections are can be accurately downscaled. Second, climate scientists should work with hydrologists to conduct improved hydrological modeling of the floodplain that uses different scenarios of future climate changes to provide a more accurate picture of future flooding.

## Opportunities for Incorporating Climate Science into Local Planning

Integrating consideration of climate impacts into hazard mitigation and community planning is a relatively new area with no established best practices. The process for considering the impacts of current and future climate changes on hazard mitigation and land planning efforts will vary by community. Options for using climate change information and related estimates of future hazards include:

- **Using information on current and future climate changes in developing risk assessments for hazard mitigation plans.** For example, the city of Ames supplemented its existing Flood Insurance Rate Maps (FIRMs), developed by FEMA, with locally available information to develop improved assessments of flood risk for its hazard mitigation plans. The city conducted an additional floodplain study to accurately determine the boundaries of its 100-year floodplain. Ames’ approach could be taken even further if climate scientists and hydrologists could develop methods for a floodplain study to determine a 100-year floodplain boundary under changed climate conditions.
- **Developing smart planning solutions that reduce risks and enhance community resilience based on an improved understanding of future hazards:** Such solutions might include the development of a greenway to provide flood protection and storage capacity, as well as recreational opportunities; the concentration and/or relocation of existing development out of harm’s way; the identification of safe places to build, which can also be infill areas ripe for reinvestment; and the use of green infrastructure to help manage heavier precipitation. For example, the city of Cedar Falls recently passed legislation that includes a new floodplain ordinance that expands zoning restrictions from the 100-year floodplain to the 500-year floodplain, since this expanded floodplain zone better reflects the flood risks experienced by the city during the 2008 floods. This will help

to lessen the damage brought on by future flooding in the community and also discourages further use of fill material in the floodplain, which forces water into areas outside the floodplain.

- **Integrating smart planning solutions into existing planning frameworks**: These solutions can be integrated into existing comprehensive and other land use plans, zoning and building codes and other municipal ordinances, flood maps, and incentives for development and conservation such as the purchase or transfer of development rights, conservation easements, and the establishment of community land trusts.

For case studies of Iowa communities, see Appendix H.

## IV. Conclusion

Incorporating climate change considerations into hazard mitigation and community planning is an iterative process. Communities are beginning this process by using available data to structure future land use plans and make better decisions about where to locate new growth. Next steps will require improving local climate change scenarios through properly downscaling national datasets. Another step in the process requires translating climate change data into a format that is readily usable by land use planners, emergency managers, and other local decision makers and staff.

States, tribes, and communities across the U.S. are beginning to incorporate climate change projections into land use decisions. Federal and state agencies can support and encourage climate change adaptation at the local level through a number of mechanisms, including:

- Funding and supporting pilot projects with communities at the forefront of integrating climate adaptation and land use planning.
- Compiling case studies and best practices for how to effectively and legally incorporate climate change projections into local plans and for how to link land use plans with hazard mitigation plans.
- Conducting research that follows up on this report to further identify opportunities and challenges for adapting to climate change through local plans and hazard mitigation plans.
- Offering incentives for communities that use climate change projections in local plans and hazard mitigation plans.
- Offering incentives for communities to integrate planning processes, specifically hazard mitigation and comprehensive land use planning, and to incorporate no-regrets adaptation measures to produce symbiotic outcomes.

Communities are working hard to plan for natural disasters in order to protect their citizens, their property, and the public and private investments that have been made over generations. Policy changes at all levels of government will be necessary to help communities use climate change science to develop better plans. In the long term, different levels of government and neighboring jurisdictions can link local adaptation efforts to form regional responses to climate change risks.

## Appendix A: Iowa Smart Planning and Adaptation Strategies

The Iowa Smart Planning Act was signed into law on April 26, 2010.[17] This bill has three components:

1. Articulates ten Iowa Smart Planning Principles for application in local comprehensive plan development and public investment decision-making,
2. Provides comprehensive planning guidance for cities and counties, and
3. Establishes the Iowa Smart Planning Task Force with various responsibilities.

The Iowa Smart Planning bill does not mandate how communities should grow, rather it requires that communities and state agencies consider Smart Planning Principles when planning for the future and provides guidance concerning important elements local plans should include.

The first major section of the Iowa Smart Planning bill outlines ten Iowa Smart Planning Principles. These principles must be considered and may be applied when local governments and state agencies deliberate all appropriate planning, zoning, development, and resource management decisions. Application of these principles is intended to produce greater economic opportunity, enhance environmental integrity, improve public health outcomes, and safeguard Iowa's quality of life. The principles also address the need for fair and equitable decision-making processes.

Iowa Smart Planning Principles:

1. Collaboration.
2. Efficiency, Transparency and Consistency.
3. Clean, Renewable and Efficient Energy.
4. Occupational Diversity.
5. Revitalization.
6. Housing Diversity.
7. Community Character.
8. Natural Resources and Agricultural Protection.
9. Sustainable Design.
10. Transportation diversity.

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[17] Iowa Legislature. Senate File 2389, Division VII. http://coolice.legis.state.ia.us/Cool-ICE/default.asp?Category=billinfo&Service=Billbook&menu=false&ga=83&hbill=SF2389.

The bill stipulates that local comprehensive plans developed using the guidelines listed above shall address prevention and mitigation of, response to, and recovery from catastrophic flooding. The bill also stipulates that cities and counties shall consider and may apply Smart Planning Principles when developing or amending other local and regional land development regulations and planning processes.

The Iowa Smart Planning Principles reflect planning best practices: actions that communities can take to use infrastructure more efficiently, provide citizens with a range of housing and transportation choices, support community economic development, and move toward a more sustainable future. The Iowa Smart Planning Principles can also serve as the “new policies” and “new approach to planning” in Iowa envisioned by the APA.

The following provides examples of how the Iowa Smart Planning Principles can direct communities to climate change adaptation strategies and activities. The examples are not comprehensive and are presented for illustrative purposes.

**SMART PLANNING PRINCIPLE 1: COLLABORATION**

*Governmental, community, and individual stakeholders, including those outside the jurisdiction of the entity, are encouraged to be involved and provide comment during the deliberation of planning, zoning, development, and resource management decisions and during implementation of such decisions. The state agency, local government, or other public entity is encouraged to develop and implement a strategy to facilitate such participation*.

***Adaptation Planning Strategies***

- Local governments’ responses to climate change need to be based on the best possible science. Because climate change is bringing about previously unrecorded conditions, projections based on new scientific modeling are the best way to anticipate and respond. Planners can develop the knowledge and skills to be able to communicate complex scientific information to citizens to help them understand climate change and its associated risks.
- Current science indicates that the specific impacts of climate change are highly regional and even local in nature. Therefore, climate change policies cannot be based on a one-size-fits-all approach. Planning can promote processes designed to involve citizens in the identification and prioritization of adaptation strategies appropriate for their communities.
- Plan implementation often falls short because of citizens’ resistance to politically controversial strategies. Despite the recognized validity of the science, it is the reality that climate change has become highly politicized. Communities stand a greater chance of implementing climate change adaptation strategies if the planning process is used to educate citizens on the validity of climate change science, and to build among the public a committed constituency for climate change adaptation.

**SMART PLANNING PRINCIPLE 2: EFFICIENCY, TRANSPARENCY, AND CONSISTENCY**

*Planning, zoning, development, and resource management should be undertaken to provide efficient, transparent, and consistent outcomes. Individuals, communities, regions, and governmental entities should share in the responsibility to promote the equitable distribution of development benefits and costs*.

***Adaptation Planning Strategies***

- The natural systems affected by climate change - such as watersheds and aquifers – do not correspond to political boundaries. Coordination and collaboration to address climate change and its implications at a regional level can be encouraged through multi-jurisdictional planning processes.
- The planning process can be used to provide opportunities for collaboration among design professionals (e.g., planners, architects, engineers), scientists, social scientists, economists and other key professions to develop and carry out plans that adapt to the consequences of climate change.
- Affected stakeholder groups can be engaged in initiatives to create and implement climate change plans to ensure that no group is isolated from the process.
  As the 2008 floods illustrated in Cedar Rapids, the populations often at highest risk from natural disasters are low- to moderate-income families in older housing located in higher risk areas. Plans can recommend land use patterns, standards and regulations that will reduce the impacts of climate change on those populations least able to respond.

**SMART PLANNING PRINCIPLE 3: CLEAN, RENEWABLE, AND EFFICIENT ENERGY**

*Planning, zoning, development, and resource management should be undertaken to promote clean and renewable energy use and increased energy efficiency.*

***Adaptation Planning Strategies***

- Planning for the planting of more trees in the community can help reduce the amount of energy needed to acclimatize homes and businesses. Trees are a natural and renewable resource that provide shade and wind barriers. As climate change induces changing temperature patterns, it is important to find renewable ways to acclimatize.

**SMART PLANNING PRINCIPLE 4: OCCUPATIONAL DIVERSITY**

*Planning, zoning, development, and resource management should promote increased diversity of employment and business opportunities, promote access to education and training, expand entrepreneurial opportunities, and promote the establishment of businesses in locations near existing housing, infrastructure, and transportation*.

***Adaptation Planning Strategies***

- The planning process can be used to develop strategies for diversifying local economies, to reduce risks that a weather-related disasters affecting one or a small number of employers will have a disproportionately negative impact on the local economy. Strong, diverse local economies are also more resilient, which means that communities are better able to recover quickly after natural disasters.
- Planning can be used to provide incentives for businesses to adapt to the changing climate, such as revolving loan funds for independently owned local businesses to make structural changes that enable them to be better prepared to withstand weather-related emergencies and other side effects of climate change.

**SMART PLANNING PRINCIPLE 5: REVITALIZATION**

*Planning, zoning, development, and resource management should facilitate the revitalization of established town centers and neighborhoods by promoting development that conserves land, protects historic resources, promotes pedestrian accessibility, and integrates different uses of property. Remediation and reuse of existing sites, structures, and infrastructure is preferred over new construction in undeveloped areas.*

***Adaptation Planning Strategies***

- Planning and design can identify geographic areas within currently-developed areas of communities and regions that are not located in hazard-prone areas for infill development, redevelopment of existing neighborhoods, preservation of historic structures and the adaptive reuse of buildings.
- Through the planning process communities can develop incentives and policies that promote infill development, redevelopment of existing neighborhoods, preservation of historic structures and the adaptive reuse of buildings. Tax credits and other incentives and assistance should target the reuse and rehab of vacant properties.
- State housing, transportation and infrastructure programs can place a priority on infill development.
- At the same time, local governments can create post-disaster redevelopment plans that discourage the reconstruction of buildings and infrastructure in hazard-prone areas following climate related disasters.

**SMART PLANNING PRINCIPLE 6: HOUSING DIVERSITY**

*Planning, zoning, development, and resource management should encourage diversity in the types of available housing, support the rehabilitation of existing housing, and promote the location of housing near public transportation and employment centers.*

***Adaptation Planning Strategies***

- Plans can call for development patterns that mix land uses so jobs, services, schools, shopping and other destinations are near residents' homes and neighborhoods, and less reliant on transportation networks that may be disrupted by weather-related disasters. Plans can encourage specific actions that remove barriers to mixed use project financing.
- Plans can encourage policies that incentivize mixed-income development near job centers, to reduce the likelihood that weather-related disasters will disproportionately disrupt the employment of specific income classes.

**SMART PLANNING PRINCIPLE 7: COMMUNITY CHARACTER**

*Planning, zoning, development, and resource management should promote activities and development that are consistent with the character and architectural style of the community and should respond to local values regarding the physical character of the community.*

- Natural features (rivers, bluffs, woodlands) are the defining feature with which many communities are identified. Designing the built environment to protect and preserve the salient characteristics of the natural environment often will result in the side benefit of resiliency to natural disasters. For example, some river communities, such as Davenport, Iowa have eschewed structural flood protections in favor of an urban form that accepts flooding. Parkland and other open spaces along the river have come to be highly-valued community assets.

**SMART PLANNING PRINCIPLE 8: NATURAL RESOURCES AND AGRICULTURAL PROTECTION**

*Planning, zoning, development, and resource management should emphasize protection, preservation, and restoration of natural resources, agricultural land, and cultural and historical landscapes, and should increase the availability of open spaces and recreational facilities.*

***Adaptation Planning Strategies***

- Plans can promote standards, regulations and incentives for water conservation, so that communities are better prepared to respond to lower water supplies. Water availability should be considered in development reviews, planning decisions, infrastructure investments, and development incentives.
- Use planning policies regarding infrastructure investments, extension of urban services and utilities and preservation of natural or agricultural areas to create compact regional development patterns that avoid hazard-prone areas.
- Identify and protect wetland areas that are critical to slow the release of water into streams during times of extreme rain events.
- Establish strategies to promote redevelopment and compact new development that will minimize the conversion of farmland and woodland for urban use, to reduce the amount of impervious surface coverage in watersheds.
- Develop state plans and programs to help farmers incorporate environmental protection practices, such as wetland protection, wetland restoration, buffer strips and natural ground cover (grasses) that have been shown to lessen the "flashiness" of stream flow. Promote federal, state and local funding for preservation of open space, farm and forest land.

**SMART PLANNING PRINCIPLE 9: SUSTAINABLE DESIGN**

*Planning, zoning, development, and resource management should promote developments, buildings, and infrastructure that utilize sustainable design and construction standards and conserve natural resources by reducing waste and pollution through efficient use of land, water, air, and materials.*

***Adaptation Planning Strategies***

- The time horizons of plans themselves need to be extended to account for potential long-term impacts of climate change. Planners can no longer assume a "static" set of assumptions about the natural environment. 50- to 100-year time frames are not unreasonable planning horizons when developing scenarios about the future of a community's built environment.
- Plans can set design standards that promote the resiliency of the built environment in the face climate change. One example is to design sidewalks to distribute stormwater to open space for recharge and to prevent flooding.
- Design communities, neighborhoods and individual development projects using techniques that reduce heat absorption throughout the community and region to lessen heat-island effects during periods of extreme high temperatures.

**SMART PLANNING PRINCIPLE 10: TRANSPORTATION DIVERSITY**

*Planning, zoning, development, and resource management should promote expanded transportation options for residents of the community. Consideration should be given to transportation options that maximize mobility, reduce congestion, conserve fuel, and improve air quality.*

***Adaptation Planning Strategies***

- Plan schools and public facilities to be accessible by multiple modes (walking, biking, driving or transit) to reduce automobile reliance during times of emergencies.
- Encourage development patterns generally that support community resiliency by providing for multiple transportation options to employment centers and retail centers.

## Appendix B: APA Climate Change Policy Findings

> ***Adaptation and mitigation are two sides of the same coin. We must address both activities which exacerbate climate change as well as make plans to the changes that are occurring and will continue into the future.***
> From *APA Policy Guide on Planning and Climate Change*

To establish a framework for communities dealing with climate change and its implications, the American Planning Association (APA) formulated policy statements and compiled the *APA Policy Guide on Planning and Climate Change.*[18] Below are some key findings from this policy guide, many of which overlap with the findings from the Iowa Adaptation and Resilience Pilot and also demonstrate the necessary role of planning in addressing climate change.

**Finding 1**: Land use patterns play a significant role in reducing Vehicle Miles Traveled (VMT) and thus in reducing energy consumption and its associated greenhouse gas emissions. VMT can be reduced by promoting strategies such as compact development in close proximity to existing development, high density land uses arranged to encourage pedestrians, bicycle use and transit use by promoting higher densities, transit oriented and development of mixed use and clustering of uses. When viewed in total, the evidence on land use and driving shows that compact development will reduce the need to drive between 20 and 40 percent, as compared with development on the outer suburban edge with isolated homes, workplaces, and other destinations. It is realistic to assume a 30 percent cut in VMT with compact development. Making reasonable assumptions about growth rates, the market share of compact development and the relationship between $CO_2$ reduction and VMT reduction, smart growth could, by itself, reduce total transportation related $CO_2$ emissions from current trends by 7 to 10 percent as of 2050. (Ewing et al., *Growing Cooler*)

**Finding 2:** Transportation and parking policies can be employed to discourage private auto use and therefore reduce VMT and its associated $CO_2$ emissions. Current policies encourage auto use, and particularly individual auto use, through indirect subsidies. The cost to drivers is virtually the same whether they occupy road space at peak traffic hours or at off hours. The road use fees charged to truckers are far below the actual cost of their wear and tear on the road system. Parking fees are paid, at least in part, by employers, merchants and public agencies. Congestion-based pricing for road use has been shown to reduce traffic and related $CO_2$ emissions. Eliminating free/subsidized parking has been shown to result in an increase in carpooling and use of public transportation. Eliminating minimum parking requirements reduces the incentive to drive, while concurrently reducing the amount of impervious surface necessary for auto storage. Demand responsive on-street parking pricing reduces search traffic, thereby reducing VMTs from vehicles used looking for a place to park.

**Finding 3:** Local programs that encourage the preservation of historic buildings and their adaptive reuse result in energy conservation. These buildings are typically closers to population centers and adaptive reuse generally involves lower impacts on

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[18] *Policy Guide on Planning and Climate Change.* American Planning Association. 2011. http://www.planning.org/policy/guides/pdf/climatechange.pdf. Section reprinted with permission of the American Planning Association.

natural resources (e.g., tree cutting for lumber), than new construction. In addition the maintenance, restoration and adaptive reuse of existing urban areas (including their buildings, infrastructure and other assets) also reduces energy use and VMT.

**Finding 4:** Use of "green" building standards such as the LEED Rating System and similar systems result in energy conservation compared to conventional codes. About 75 percent of the electricity used in the country goes toward heating, cooling, and lighting buildings. Because more than 70 percent of electrical energy is generated by conventional electrical power sources such as coal- and gas-fired generation plants, reducing the amount of power consumed by buildings is as important to addressing climate change as reduction of auto emissions. Research indicates that sufficient energy falls on the roof and south face of buildings to satisfy the power demands of those buildings. Communities need to revise their zoning codes, building ordinances and ordinances to achieve energy conservation standards. In designing these revisions, the planning community will have to take leadership.

**Finding 5:** Providing a range of housing opportunities within a community decreases commuting and its associated greenhouse gas emissions. It also reduces the need for private vehicle trips associated with job commutes.

**Finding 6:** Communities can encourage the production and use of energy generated from renewable resources by changing land use, building and site design standards.

**Finding 7:** Changing the source of fuel used for electrical power generation from fossil fuels to renewable energy will significantly reduce greenhouse gas emissions. While renewables must be pursued and made economically available, technologies to cleanse emissions from traditional sources should be expanded. Coal generation of electricity produces the bulk of greenhouse gases. Steps should be taken to reduce the generation of greenhouse gas emissions from coal fired power plants.

**Finding 8:** Communities can be made more resilient and defensible to the effects of climate change through land use policies that encourage development in areas away from hazards such as wildfires, land erosion, and floods. This is also true in areas that have an appropriate level and mix of resources to allow sustainable lifestyles.

**Finding 9:** Protecting and enhancing green spaces in and near communities provides opportunities to protect and enhance carbon sinks in soils, vegetation, and streambeds to mitigate a warming climate. Green space protection programs should not only be sensitive to natural ecological processes and habitat needs, but should also include a fair calculation of greenhouse gas mitigation. For example, native old-growth forests outperform landscaped lawns, farms and gardens.

**Finding 10:** Promoting water conservation, and the use of nearby water sources reduces the amount of energy necessary to transport it, and therefore lowers greenhouse gas emissions.

**Finding 11:** Land use and urban design that retain natural areas and assets and incorporate indigenous plants or others that are appropriate to the community's climate reduce energy and water consumption.

**Finding 12:** Growing food for local consumption lowers transportation costs thereby lowering the use of fossil-based fuels.

**Finding 13:** Centralized facilities equipped with communications technologies such as videoconferencing allow community residents and businesses to conduct business and share information in ways that minimize travel thereby reducing VMT.

**Finding 14:** Planning and development policies to address climate change may have a different focus in major metropolitan areas, micropolitan areas, and rural communities. Policies may also vary in response to the ecosystem in which a community is located (such as coastal areas, river floodplain, desert or hillside). While all of these places can play a role in addressing climate change, the specific role may vary.

**Finding 15:** Planning is a tool that can assist decision-makers including regional agencies and collaborations; individual local governments; school districts; colleges and universities; neighborhood or other small area organizations; individual property owners; and state and federal regulatory and funding agencies to make better decisions and positively impact climate change.

**Finding 16:** Nationally, the transportation sector is responsible for approximately one-third of $CO_2$ emissions, and if current trends continue, those emissions are projected to increase rapidly. The transportation sector's $CO_2$ emissions are a function of vehicle fuel efficiency, fuel carbon content, and vehicle miles traveled (VMT). Significantly reducing emissions in the future requires improvements in all three areas.

**Finding 17:** Federal and state laws and regulations addressing vehicle fuel efficiency and fuel carbon content are critically important in helping to meet national climate change goals in the transportation sector. However, these laws and regulations can only succeed if VMT is reduced significantly at the same time. Current policy proposals to improve vehicle fuel efficiency and reduce fuel carbon content in the transportation sector would leave passenger vehicle $CO_2$ emissions well above 1990 levels in 2030, significantly off-course for meeting 2050 targets. This is due, in large part, to the fact that VMT is projected to continue growing over time. Therefore, it is important to develop planning strategies to reduce travel demand, and shift travel demand to transportation modes that have the lowest carbon output.

**Findings 18:** Economic strategies that reduce GHG emissions such as a nationwide and economy-wide cap and trade system for carbon emissions are needed to promote reduction in greenhouse gas emissions in an amount necessary to slow climate change.

**Finding 19:** Currently there are few communities regulating development in a way that accounts for or reduces greenhouse gas emissions.

**Finding 20:** There is a need for new standards, regulations, and technologies that can help reduce GHG and prepare communities to adapt to the effects of climate change. Revision of many existing standards and regulations should be undertaken to reduce emissions and better prepare communities to adapt to climate change.

**Finding 21:** Clearer definitions of the concepts and issues of climate change are needed to facilitate more effective public discussions of climate change and establish a greater willingness among the public and elected officials to make changes needed to mitigate climate change and prepare communities for adaptation.

**Finding 22:** Sea level is rising and the long-term impact of this phenomenon requires a systemic change in thinking. Traditional strategies that have been used and worked in the past such as shore protection and hardening, levees, and sea gates will probably be inadequate. New options including natural retreat, shoreline nourishment and land elevation should be incorporated. The highest priority for new regulatory or technological initiatives should be placed on those areas in which the most immediate and substantial risk exists and in which the impacts can be significantly reduced or avoided.

**Finding 23:** Drought and wildfire areas are intensifying and threatening more populations. This is due to a combination of the growth of new development into wilderness areas and changing rainfall patterns initiated by climate change.

**Finding 24:** Climate change and its impact on arable land will reduce the amount of land available for agriculture production or future development of any kind.

**Finding 25:** Planning for climate change should include anticipating the new opportunities and problems that may arise from moving to renewable or sustainable energy sources and making other societal changes recommended to slow climate change.

**Finding 26:** Climate models are an important planning tool that can help communities anticipate and respond to changes. For example, models that predict changing paths for ocean currents will impact different areas in different ways. Planning based on these models can allow the appropriate response at the appropriate location.

## Appendix C: Resources to Expand Skills for Planning for Climate Change

The role of planners in the hazard mitigation planning process is only now starting to evolve, and as climate change and adaptation are considered in hazard mitigation and local land use planning, planning professionals will need to be adequately trained to develop and implement plans that effectively consider both natural hazards and climate change. The pilot participants identified the following resources that can help planners develop skill sets identified in the survey conducted as part of this pilot:

- Basic understanding of ecosystem functions
  - USDA Forest Service has a website on ecosystem services and functions: *www.fs.fed.us/ecosystemservices/*
  - Arbor Day Foundation also has resources: *www.arborday.org* then search for "ecosystem services"
  - NatureServe provides background information on ecosystem functions: *www.ebmtools.org/roadmap/coreelements/1*
  - EPA's Watershed Academy provides background information on ecosystem services: *www.epa.gov/owow/watershed/wacademy/acad2000/ecosyst.html*
  - Lincoln Institute of Land Policy's 2004 publication *Practical Ecology for Planners, Developers and Citizens* provides guidance for planners on how to achieve ecological conservation through planning and design: *www.lincolninst.edu/pubs/976_New-Publication---Practical-Ecology-for-Planners--Developers--and-Citizens*
- Basic understanding of land use planning and zoning, including hazard analysis
  - *The Purpose of the Comprehensive Land Use Plan* by Gary D. Taylor of Iowa State University explains the basic functions of local comprehensive plans: *www.extension.org/pages/The_Purpose_of_the_Comprehensive_Land_Use_Plan*
  - The American Planning Association's report *Hazard Mitigation: Integrating Best Practices into Planning* discusses steps for including hazard mitigation goals in local plans: *http://www.fema.gov/library/viewRecord.do?id=4267*
  - New Partners for Smart Growth sessions: *www.smartgrowth.org/about/principles/default.asp* (click on each principle for relevant case studies, PowerPoints, etc.)
- Basic understanding of low impact development and green infrastructure
  - EPA's Green Infrastructure website includes regional training opportunities and a Municipal Handbook: *www.epa.gov/greeninfrastructure/*
  - Low Impact Development Center training: *www.lowimpactdevelopment.org/training.htm*
- Basic understanding of climate change adaptation and links to local land use planning
  - The Center for Sustainable Development provides training through four online courses on community-based adaptation to climate change: *www.csd-i.org/adapting-overview/*
  - The U.S. Department of Transportation provides several resources on adaptation planning as it relates to transportation planning: *climate.dot.gov/impacts-adaptations/planning.html*
  - EPA's Climate Ready Estuaries and Climate Ready Water Utilities both provide resources that local planners can use to protect ecosystems and water infrastructure from impacts from climate change: *www.epa.gov/climatereadyestuaries/* , *water.epa.gov/infrastructure/watersecurity/climate/*
  - ICLEI- Local Governments for Sustainability has many free climate adaptation resources, including case studies, fact sheets, and guidebooks: www.icleiusa.org/programs/climate/Climate_Adaptation/free-climate-adaptation-resources

- The Center for Clean Air Policy provides several resources, including documents such as *The Value of Green Infrastructure for Urban Climate Adaptation* and *Lessons Learned on Local Climate Adaptation*: www.ccap.org/index.php?component=programs&id=6
- Climate Central provides climate information in plain, accessible language for a range of audiences: www.climatecentral.org/

## Appendix D: Adaptation at the Local Level

Dr. Kamyar Enshayan, a Cedar Falls, Iowa, city council member and director of the Center for Energy and Environmental Education at the University of Northern Iowa, asserts that whether adaptation is accomplished through hazard mitigation plans or other means, consideration of future changes in climate must become an operational part of local governments, not just a plan that is developed and is disassociated from all other local decisions. In the article below, Dr. Enshayan describes two potential futures for an Iowa community, one that could be realized through careful and considerate planning and one that keeps on the path of business as usual.

**One Town, Two Futures**
*In honor of the victims of the Iowa floods of 2008*

It is year 2018, and after several weeks of intense rainfall, the National Weather Service is forecasting another week of rain and super-storms, and possibly record flood levels. The following is a description of two futures for the community you live in. See which future you wish to create for your town.

**Future I.** Immediately following the 2008 flood, residents worked with elected officials to develop a comprehensive 10-year plan. The goals were obvious: Avoid and retreat from flood hazard areas; significantly and steadily reduce community's vulnerability to floods; offer incentives to relocate your town's residents out of harm's way; reduce flood damage to private and public infrastructure.

The plan included numerous strategies. Your town officials had lined up a set of attractive financial tools, using local, state and federal funds for the next 10 years to offer buyout options (offers so compelling few could refuse) beyond what FEMA traditionally offered. As a result nearly all flood prone areas were now open space.

The town had offered a variety of relocation incentives including free lots, interest-free and low interest loans; excellent unoccupied homes in need of repairs elsewhere in town were purchased and offered at reduced prices to those willing to move to already established neighborhoods.

Your town had begun to see the floodplain as a "critical hazard reduction infrastructure" (rather than idle land waiting to be developed), and implemented zoning ordinances to guard the integrity of your town's floodplains. Your officials had worked closely with the DNR and towns upstream to ensure the proper management of the entire watershed, which ultimately affected your town.

Now, with record floods in the forecast, emergency responders, fire chief and council members are prepared but relaxed, drinking coffee and exchanging stories about the headaches of 2008. Now, with hardly anyone in harm's way, no one to rescue, little or no damage to city's infrastructure, your town is benefiting from the last 10 years of investing and implementing its plan. People now are standing by the flooded river, reflecting on the flood of 2008, and could now see the incalculable benefits of their hard work of the last ten years.

Your town is now regarded as a model community and an inspiration to other cities and states.

**Future II.** Literally days after the record flood of 2008, an astonishing amnesia began to set in. What flood? “That was just a once in a life time deal. Go ahead and rebuild in the same places.” Your town’s officials had forgotten so quickly: disrupted lives, lost business, stress, emotional drain, washed out roads, damage to public infrastructure, rescue workers put in harm's way, long meetings, time and resources devoted to disaster relief, etc.

“Let’s wait and see what FEMA will do for us this time” was the guiding principle and was viewed as sufficient enough “planning.” A few homes were bought out over the last 10 years and most of those families moved out of town because they could not afford to live in town with the buy-out dollars. Any thought of doing anything else was dismissed by the town officials as “difficult decisions” which supposedly would be made at some later point that never came.

Now that another “once in a life time flood” had come again, it was 2008 all over again: damage, disaster, more soil erosion, more water pollution, more disrupted lives, another round of calls for “donate to flood relief,” come to this or that fund raiser, more town meetings, more headache, more lost business, and more motor oil, weed killers and “orphan LP tanks” sent to Americans downstream.

Which one of the two futures do you prefer? Both are equally possible. Which one is in the best interest of the people of your town and your children? In a democracy, nurtured by vigorous civic engagement, we can create the future we want.

## Appendix E: Climate Change Information and Hazards in Iowa

This appendix was developed by Dr. Christopher J. Anderson, using data and sources listed in Appendix F, and were used as the basis for the Climate Science and Local Planning section above.

Climate change means past weather conditions may no longer be predictive of future conditions, and it is necessary to reevaluate the use of climate information in community planning and hazard mitigation. The American Planning Association recognizes that events of record may be exceeded in the future due to climate change, urging, in its policy guide to planning and climate change, the use of climate scenarios in community planning.[19] Climate scenarios may be defined in a number of ways as discussed below; however, salient to this report is that approaches are lacking for translating climate scenarios into hazard information (for example, floods are not a direct output of climate simulations). This appendix provides a baseline for the climate change science in section III above. This appendix discusses relevant climate data that can be used in estimating future hazards in support of the following goal:

- Working in Iowa, identify barriers to and incentives for considering regional effects of climate change in hazard mitigation and other community planning processes.
- Use predictive models and future data for risk assessment, risk management, and scenario planning.
- Develop smart planning solutions that reduce risks and enhance community resilience.
- Integrate these smart planning solutions into existing planning frameworks.
- Consider broader changes to existing planning frameworks.

Climate information relevant to hazards is provided for the entire state as well as two communities, Story County and Coralville, both of which recently have completed hazard mitigation plans. This information, in turn, will inform an analysis of the comprehensive and mitigation plans regarding climate change adaptation. This section is not meant to be a comprehensive review of potential climate model datasets or climate impacts for the Midwest. Instead, it is meant to be a practical resource by providing information specific to the problems of hazard mitigation of these two communities. By reading this report, government officials in Iowa should have the information needed and expressed in non-technical terminology to address the questions of (1) how is the climate changing in Iowa, and (2) what do changes in climate mean to these two communities in Iowa.

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[19] American Planning Association. *American Planning Association Policy Guide on Planning and Climate Change.* 2008: http://www.planning.org/policy/guides/pdf/climatechange.pdf

A critical point underlying this report is an understanding that climate model projections are not suitable for use as climate forecasts. A forecast requires future knowledge of climate drivers, such as greenhouse gas emissions, solar variability, and volcanic eruptions. It is not possible to predict these drivers; that is, sources for climate predictability are themselves unpredictable. Even with this limitation, it is possible to examine the potential for emerging vulnerabilities as climate changes. An approach suitable for vulnerability analysis is to consider climate scenarios -- postulated sequences of future climate drivers – that predict climate conditions under a range of specified but possible changes in climate drivers.[20]

The use of scenarios requires thoughtful consideration of how to incorporate climate projections in hazard risk assessment. The use of potential future hazards in the context of flood insurance and hazard mitigation programs is innovative. For example, the use of future projections to support flood insurance programs is constrained by the principle that flood insurance programs base premiums on current rather than future risk.

The relative newness of translating and integrating climate scenarios into local hazard information means understanding how they may be useful in community planning is itself an innovative topic. Recent evaluation of the use of climate information in management decisions indicates that it is more likely to be useable when it is placed within the context of decision processes.[21] Together, these findings strongly indicate a need for dialogue between planners and climate information producers to understand how planning approaches based upon risk estimates may be adapted to consider climate scenarios.

Giving a planning context to climate information is complex because land use and hazard mitigation plans are multi-faceted decision processes. A questionnaire (see Appendix G) was designed to learn from participants of this project what climate data they used and how it was applied within planning decisions. From this questionnaire and informal discussions with participants, a preliminary list of some considerations planners make when crafting mitigation plans was developed, as mentioned above.

This section supports the goal statement of this pilot project by providing a baseline of climate change information relevant to hazards for Iowa, including examples of local climate projections, and discussing approaches for translating climate information into hazard information. This information feeds into a second stage in which planners and government officials discuss the opportunities for using these climate data in hazard mitigation in light of the considerations outlined above and others. The following first describes statewide information on temperature and precipitation change, and associated changes in natural hazards. This serves as a point of reference for discussion of climate projections. The remainder of the report is focused on hazards for Story County and Coralville and

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[20] Nakićenović, N., et. al., 2000: IPCC special report on emissions scenarios, Cambridge University Press, Cambridge, UK, p 599.
[21] Lemos M. C., and B. Morehouse, 2005: The co-production of science and policy in integrated climate assessments. *Global Environmental Change,*15:57-68.

is divided into sections that summarize relevant climate change information for floods and severe weather. Other natural hazards either are considered a low threat in the hazard mitigation plans of the pilot communities or have very little research completed in regards to their potential changes as inferred from climate model projections.

*Climate Projection Data: Global Climate Model Data*

Global climate models (GCMs), driven by scenarios of global greenhouse gas emissions, provide the dataset from which projections of future local climate conditions are derived. Because future emissions of greenhouse gases are unpredictable – it depends on human choices, for example – a suite of possible future greenhouse gas emissions has been established and reported in the Special Report on Emissions Scenarios.[22] The emissions rates are derived from a matrix of possible outcomes about how global regions interrelate, how new technologies diffuse, how regional economic activities evolve, how protection of local and regional environments is implemented, and how demographic structure changes. The outcomes are summarized in four scenario families (A2, A1, B1, B2). The assumptions of the scenario families are provided in the IPCC Special Report on Emission Scenarios Summary for Policymakers. These include:

The A1 storyline and scenario family describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into four groups that describe alternative directions of technological change in the energy system.1

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented, and per capita economic growth and technological change are more fragmented and slower than in other storylines.

The B1 storyline and scenario family describes a convergent world with the same low population growth as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with moderate population growth, intermediate levels of economic development, and less

[22] Nakićenović, N., et. al., 2000: IPCC special report on emissions scenarios, Cambridge University Press, Cambridge, UK, p 599.

rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

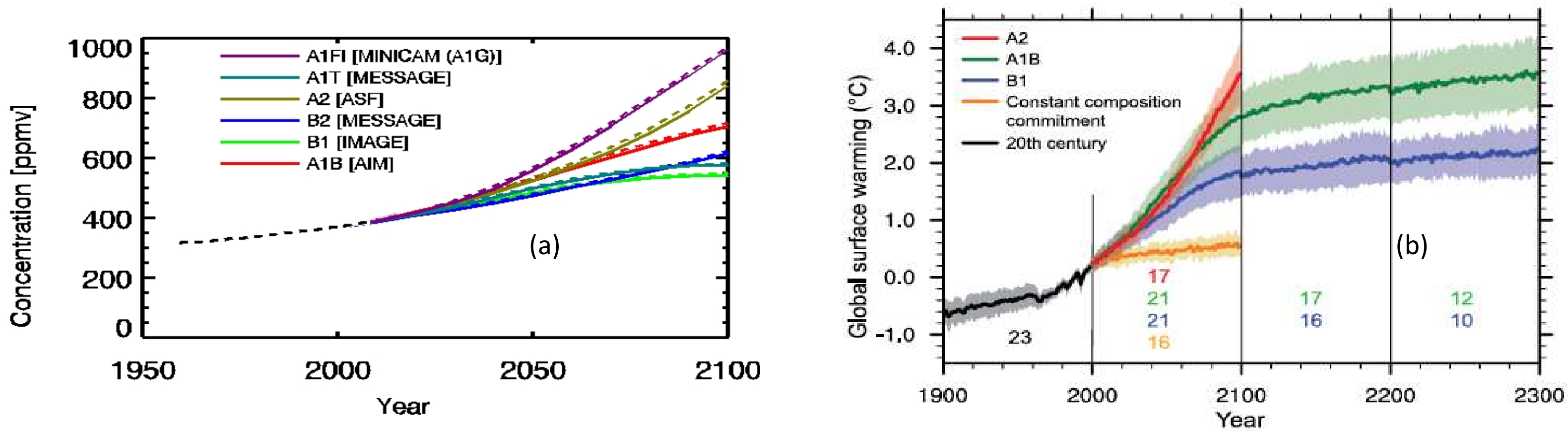


Figure 1. (a) Carbon dioxide concentration of global greenhouse gas emissions scenarios (http://www.ipcc-data.org/ddc_co2.html). (b) Average and range (shown by shading) of global temperature change simulated by GCMs given emissions scenarios for the 21st century.

The GCM data used in this report are the output from driving GCMs with three emissions scenarios A2, A1B, and B1 that were chosen to represent the range of possible scenarios from the four scenario families (Figure 1a). The A2 scenario produces an increase of greenhouse gas emissions at rates similar to today. By the end of 2100, the global average carbon dioxide concentration in the A2 scenario is roughly 2.5 times the 2000 level. The A1B scenario reduces the rate of greenhouse gas emissions by mid-century, and the $CO_2$ concentration by 2100 is just under twice the 2000 level. The B1 scenario supposes rapid changes in technology and global collaboration to reduce greenhouse gas emissions immediately. The carbon dioxide concentration level in the B1 scenario stabilizes just under 1.5 times the 2000 levels. Carbon dioxide concentrations for these three scenarios and the global surface temperature projection from GCMs resulting from A2, A1B1, and B1 are given in Figure 1.

The accuracy of GCM simulations is established by means of a 20th century scenario (20C) derived from observational estimates for solar variability, volcanic eruptions, and greenhouse gas emission inventories. Figure 2 shows the evolution of 20C global surface temperature from both GCM simulations and weather station measurements. The average global temperature of the GCM simulations (red line) replicates two warming periods in measurements (black line), one in the first 25 years and another in the final 25 years of the 20th century. This result illustrates the potential utility of GCMs for prediction of future conditions when given precise estimates of future drivers, but they should not be considered a measure of expected accuracy of GCM projections of future conditions since precise estimates of future drivers are not available. This cautionary note is underscored by results from an alternative 20th century scenario (20PI) in which greenhouse gas concentrations were held constant at pre-industrials levels. The average global surface temperature from GCM simulations (blue line) given 20PI diverges from measurements in the last quarter of the 20th century. This provides evidence of the influence greenhouse gas increases has had on global surface temperature, and it illustrates the potential error in prediction should climate predictions employ inaccurate estimates of future climate drivers. Experiments to assess accuracy of long-range climate predictions (from years to decades) have been initiated recently, and results should be reported over the next one to three years.

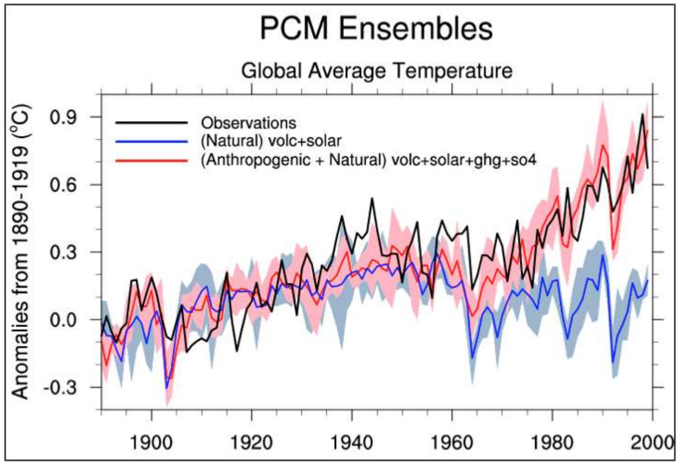


Figure 2. Global average temperature from measurements (black line); 20th century scenario with solar cycles, volcanic activity, and greenhouse gas increases (red line; pink shading represents the range of GCM results); and alternative 20th century scenario lacking greenhouse gas increases (blue line, shading represents range of GCM results).

*Regional and Local Climate Model Data*

Community planning considers the impact of hazards over areas much smaller than resolved in global climate model data, which typically has a horizontal grid with data points spaced 1-2$^{O}$ latitude apart. This disconnect in spatial detail means another layer of climate models must be used to translate global climate model data into local hazard data. The process of translating GCM data into local climate data is called downscaling, a name given because spatial detail is added by the technique (i.e. fine scale data is generated from coarse scale data). One consequence of downscaling is an increase in variability of projections within a region simply because variability of climate over short distances can be large. GCMs are incapable of simulating such details and, therefore, have fields with less variation. The approaches for downscaling are numerous, and the research community has not established a preferred generalized approach. The choice of which dataset is most appropriate is often based primarily upon the climate information needs of the data user, and the availability of the datasets that are often produced for the purposes of research studies rather than mass distribution. In this case, two datasets generated from downscaling methods that were designed to retain statistical consistency between GCM and historical data were chosen based upon two considerations: the ability to examine downscaled results from a large number of GCM projections and the ability to provide data at specific station locations, enabling direct comparison with historical station datasets that community planners have used.

A set of 112 climate projections was obtained from the Bias Corrected and Downscaled WCRP CMIP3 Climate Projections archive (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/dcpInterface.html). The data were generated from empirical relationships between local data and GCM data produced by simulations that were given emissions scenarios A2, A1B, and B1. The data are available on a 1/8$^{th}$-degree grid across the entire continental United States and are valid for the period 1950—2100. One disadvantage is the data set includes only monthly temperature and precipitation. The advantage of this data set is that it contains the largest number of projections available with resolution somewhat comparable to station measurements. This means the range of future values of monthly temperature and precipitation may be calculated and compared to station data, providing an indication of whether future conditions lie outside of the present range.

A second downscaled dataset was obtained to evaluate projections of daily precipitation to provide context for discussion of potential changes in floods. Similar to the dataset of monthly temperature and precipitation, the downscaling methodology establishes empirical relationships between measurements and GCM output.[23] The approach is applied to 10 GCM projections given the A2 scenario, and, therefore, represents a smaller range of potential future changes. Another key difference is the use of station measurements rather than 1/8$^{th}$ degree grid of interpolated measurements. This preserves a higher degree of spatial variability and permits comparisons at specific locations.

## Climate Change Information: Statewide

*Summary of Historical Statewide Climate Data*

- The current climate normal is much wetter with milder temperature than much of the 136-year record. The current statewide annual average temperature is 48.3$^{O}$F and annual precipitation is 34.0” (Figure 3). Most of the statewide precipitation increase has come in the first half of the year and increases are larger in eastern Iowa.
- The most prominent change in climate in recent years is an increase in frequency of very wet years (years with precipitation exceeding 40”). Very wet years have occurred 9 times since 1940 (the midpoint of the data record) after occurring only 2 times prior to 1940.
- Annual statewide temperature has decreased slightly since the 1930s, and the increase in very wet years is directly related to the reduction of very hot years (10 prior to 1940 and 5 since 1940). Statewide winter temperature has increased more than summer, and on average there are about 5 more frost-free days than in 1950.
- Statewide impacts on hazard risk associated with these changes include the following.

[23] Schoof, J. T., S. C. Pryor, and J. Surprenant, 2010: Development of daily precipitation projections for the United States based on probabilistic downscaling, J. Geophys. Res., 115, D13106, doi:10.1029/2009JD013030.

- Streamflow has increased 20-50% since 1940, and soils have been nearer saturation during spring more often in recent years compared to past years, increasing the risk of spring and summer river flood and expansive soils.
- Flash flood risk has increased.
- Thaw-freeze cycles are more frequent, raising risk to damage from expansive soil.
- Surface wind speeds (at the standard measurement height of 10 m) have been reported to be declining over the last 30 years. This may mean incidence of poor air quality has become more likely.

*Summary of Projected Statewide Climate Data*

- Climate conditions for 2010—2025 are expected to be similar to the statistics of the recent 10-20 years. The reason for this is that the effect of the current climate cycle is projected to be larger than of increases in greenhouse gases for the next 10-15 years.

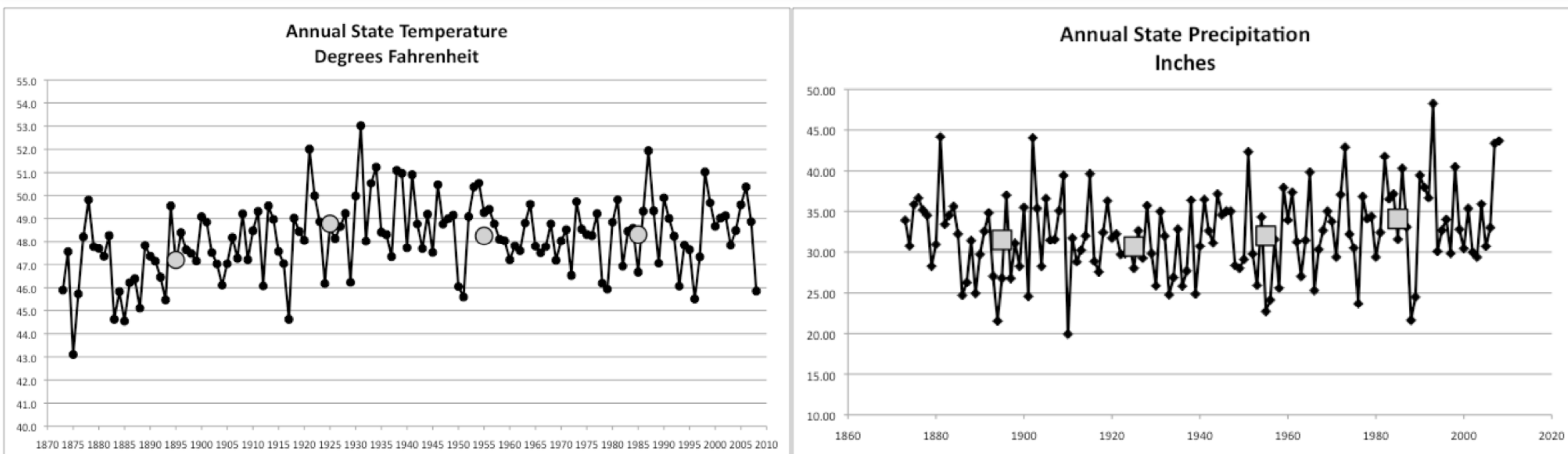


Figure 3. Statewide annual temperature and precipitation computed from State Climatologist 33-station data set. Grey-shaded boxes are 30-year average for 1881-1910, 1911-1940, 1941-1970, and 1971-2000.

- The projected climate norm for 2045—2065 has the following range of plausible conditions (Figure 4).
  - The projected range of increase in annual temperature range is 2.5—7.2$^{O}$F. The high end is associated with precipitation conditions slightly wetter than the 1930s. This suggests dry periods will be much, much warmer than the 1930s; while, wet periods will be slightly warmer than present. Thus, the risk of extreme heat is projected to increase.
  - The range of change of annual precipitation is -15% to +10%, with primarily an increase of precipitation in the spring and wider range of precipitation change in the summer. This means the projections likely indicate an increase of risk for river flood, flash flood, and expansive soils, especially during the spring and early summer.
  - The projection of drought risk is complicated in that risk for extreme heat is projected to increase, but the projected rainfall remains higher than historical drought periods.

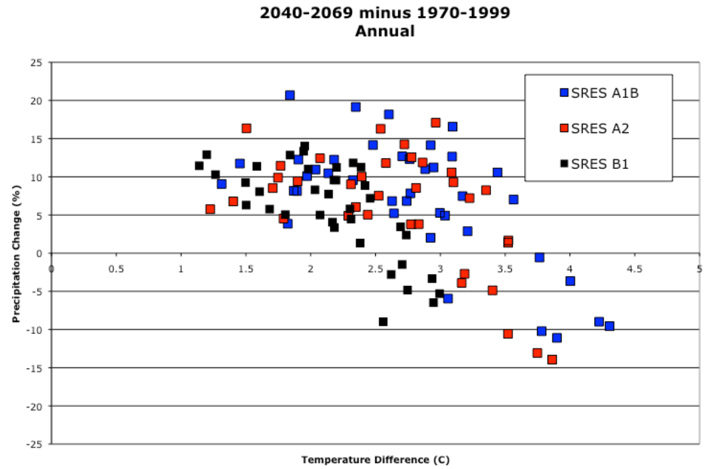


Figure 4. Difference of climate norms between the period 2040 to 2069 and the period 1979 to 1999 expressed as temperature difference ($^{O}$C) and precipitation percentage change for each of 121 climate projections.

*Discussion of Historical Statewide Climate Data*

The most reliable historical climate data are temperature and precipitation measurements made by cooperative observers for the National Weather Service (NWS COOP). The observers are trained by the NWS and follow standardized measurement procedures. The general public often hears reports of climate normal, and these reports are derived primarily from the NWS COOP data set, but it is infrequently reported that the standard for defining climate norms is dynamic, which is addressed below. State average precipitation and temperature are shown in Figure 3. While average measurements do not necessarily correspond directly with hazards, these data are standard summary climate measures and are presented here to provide context for comparison with climate projection data.

What is defined to be the climate norm is itself a dynamic standard. The World Meteorological Organization definition for computing the climate norm is to use measurements from the prior 30-year period ending at the most recent decade. The current 30-year averaging period is 1971—2000, and it will soon change to 1981—2010. Thirty-year averages are shown in Figure 3 for 1881—1910, 1911—1940, 1941—1970, and 1971—2000. Fluctuations of the 30-year average are evident with a range of 47.2 to 48.8$^{O}$F for temperature and 30.7 to 34.0” for precipitation. The most recent 30-year period is the wettest (34.0”) of the 4 periods, and its temperature (48.3$^{O}$F) is near the center of the range. This means Iowa's weather has been much wetter with milder temperatures than much of the past 136 years.

Changes of climate may be evident through either a gradual change of annual data occurring over many years (e.g., long-term trend toward wetter conditions) or changes in frequency of unusual events (e.g., increase frequency of heavy rainfall). In Iowa's temperature and precipitation record, year-to-year fluctuations are much larger than the long-term gradual change in annual data (Figure 3). This means long-term trend of annual data is essentially negligible, even if it is noticeable in annual temperature during 1873—1930.

A different story emerges when examining frequency of unusual years. A definition of very wet and dry years in Iowa is a year in which precipitation exceeds 40" or is less than 25", respectively. Since 1940 (the midpoint of the data series), very wet years have occurred 9 times and prior to 1940 they have occurred 2 times. In contrast, dry years have similar frequency before and after 1940 (7 versus 6). A hot year in the time series of Iowa's temperature is one in which annual temperature exceeds 50$^{O}$F, and a cold year as one in which annual temperature is less than 46$^{O}$F. The frequency of hot years is much less since 1940 (5 versus 10), and cold years have occurred with similar frequency before and after 1940 (7 versus 6).

The increase in frequency of heavy rainfall is a change noted across the entire United States. However, rainfall changes are largest across the northern United States, where it is widely regarded in the scientific community as one of the more remarkable changes in the United States Climate (CCSP 2008). What is unique about Iowa is the capacity of its soil to hold large amounts of water. As a result, years of unusual rainfall and temperature are related to one another. Hot years occur more frequently during extended periods of low rainfall (such as the 1930s), and this interplay between rainfall and temperature partly explains the recent absence of very hot years.

There are statewide changes in hazard risk associated with recent changes in temperature and precipitation and many of these are summarized in the document prepared for the Iowa Climate Change Advisory Council by Dr. Takle:

- Most of the statewide precipitation increase has come in the first half of the year and increases are larger in eastern Iowa. This means soils are nearer saturation during spring more often in recent years compared to past years, increasing the risk of river and flash flood and expansive soils, especially in the spring and early summer months.
- Surface wind speeds (at the standard measurement height of 10 m) have declined over the last 30 years. This may mean incidence of poor air quality has become more likely.
- Statewide winter temperatures have increased more than summer, and on average of there are about 5 more frost-free days than in 1950. This means thaw-freeze cycles are more frequent.

*Discussion of Statewide Climate Projection Data*

Climate projections provide plausible future conditions of temperature and precipitation, given a scenario of future greenhouse gas emissions. The impact of the current climate cycle on future conditions is expected to be more important than that of increases in greenhouse gases for the next 10-15 years. During this period, the climate norm is expected to be similar to the current climate norm.

The future period 2040—2069 should be much less impacted by the current climate cycle. Projected changes between the climate norms of 2040—2069 and 1970—1999 for statewide annual temperature and precipitation are shown in Figure 4. The range of warming by mid-century is 2.5—7.2$^{O}$F, which is greater than the 1.6$^{O}$F difference in norms during the 20$^{th}$ Century. The range of precipitation change is -10% to +15%. The top end of this range is comparable to the 10% increase of the climate norm during the 20$^{th}$ Century (30.7" to 34.0").

The relationship between higher temperature and drier conditions is evident in the climate projections. This implies that periods of dry conditions, similar to the 1930s, are likely to be much warmer than the 1930s; whereas, periods of wet conditions are expected to be only slightly warmer than present.

The change in seasonality of precipitation is projected to continue into the mid 21$^{st}$ Century. Rainfall increases are projected in the springtime, but in summertime, the range of projections includes both drier and wetter conditions. This means climate projections point to continued wet soils and increases in streamflow, particularly in spring and early summer. Since the percentage change of the projections is similar to the percentage increase of the 20$^{th}$ Century, it is reasonable to expect streamflow to increase at least 20%. This means the risks of river flood, flash flood, and expansive soils are likely to be higher.

The projection of a greater range of summer dry and wet conditions has implications for drought and heat waves. Summer dry conditions are projected to cause conditions warmer than the 1930s, implying a significantly higher risk for extreme heat. Drought is more complicated as a projection of 10% precipitation decrease still means precipitation exceeds that of the 1930s.

## Climate Change Information for Hazards: River Flood and Flash Flood

*Summary of Historical Data*

- The Ames hazard mitigation plan used FIRM and a city-approved flood plain study to identify the 100-yr floodplain (regulatory floodplain) from past discharge records. Recent damage estimates were tallied from NCDC storm damage reports and estimated losses were computed by incorporating floodplain maps into HAZUS-MH. Based on these data, the community determined the future probability of a flood event is similar to recent history such that one is likely to occur within the next 25 years.
- The Story County multi-jurisdiction hazard mitigation plan reviewed FIRMs, descriptions from residents and media reports, library historical data, past disaster declarations, and USGS maps. Historical frequency (based upon past 25 years) and future probability (likelihood of recurrence in one year, ten years, and 100 years) were similar in Cambridge (at least one chance in next

10 years), Maxwell (nearly 100% chance in next year), Nevada (nearly 100% chance in next year), Slater (nearly 100% chance in next year), Story City (nearly 100% chance in next year), Zearing (at least in one chance in next 10 years), Unincorporated (nearly 100% chance in next year).

- Rainfall measurements that correspond closely to flood incidence have not been widely established. The reason for this is that flood incidence depends on the travel time of water within the river network feeding into a community. This means rainfall from two days and 100's of miles away prior to a flood may be as important as rainfall the day of a flood within the community. The appropriate rainfall measurement is likely to be community dependent, though one study has identified for the Midwest a modest correlation between flood damage and frequency of two-day rainfall (Pielke and Downton 2000).
- Daily rainfall is the metric most readily available to planners participating in this pilot project. A relevant measure for planners is an engineering design criterion for water quality management of storm water for which storm infiltration amount of 1.25" is required. The frequency of days in which rainfall > 1.25" occurs has increased since 1940 in both Ames and Cedar Rapids, consistent with a statistically significant increasing trend of very high daily rainfall rates across the Midwest region (CCSP 2008). The number of such days had not exceeded 10 in any given year prior to the 1950s but has done so 5 times in Ames and 4 times in Cedar Rapids since the 1950s (Figure 5).

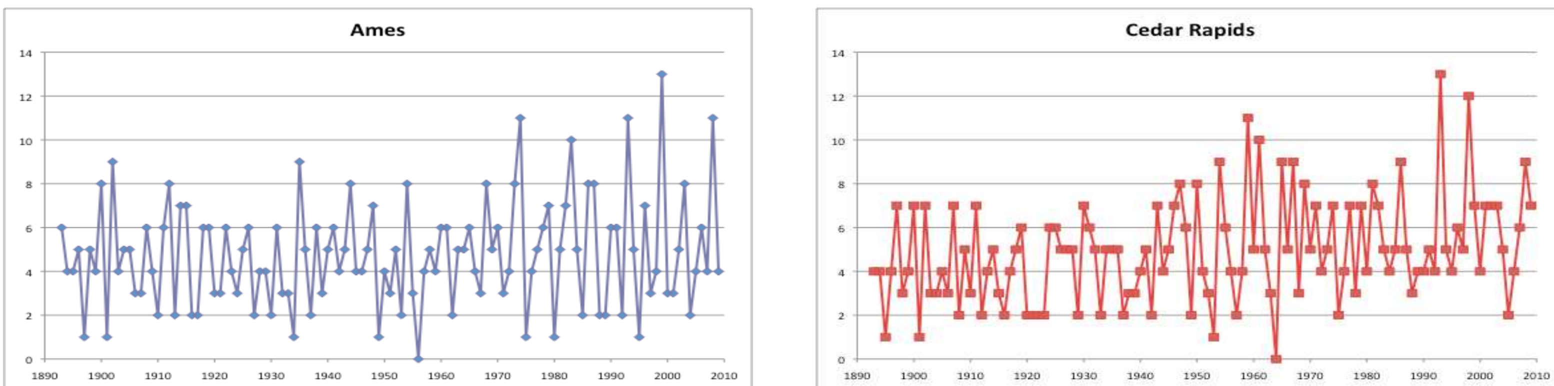


Figure 5. Number of days exceeding 1.25" precipitation at weather stations in Ames and Cedar Rapids. -

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- Recent rainfall measurements in the community and neighboring communities are likely the best guidance of expected rainfall statistics for the next 10-15 years.

- Climate projections of daily rainfall are highly experimental datasets. They generally contain greater spatial variability, i.e., larger range of values, than GCMs, due in part to local climate variability they include that is not resolved in GCMs as well as the variety of approaches that may be used to generate them. Projected changes by mid 21st Century from one downscaled data set (A2 Scenario only) of rainfall for Ames shows percentage change of annual precipitation from 1961-2000 norm that ranges 5 to 30% and change in number of days with precipitation > 1.25" that ranges 5 to 18 (Figure 6). At Iowa City, the ranges are -1 to -15% and -1 to -5 days, respectively.

*Discussion of Historical Data*

Rainfall is the climate measurement most closely related to flood incidence. However, research of 2008 Cedar Rapids flood by the Iowa Flood Center (IFC) has revealed that the most useful rainfall measure for a particular community is determined by the characteristics of the river system in which the community resides. This may explain why studies of various measures of rainfall have found that rainfall extremes in this region relate to about half of flood events and explain about half to two-thirds of annual variability in flood damage.[24] The IFC results indicate the best rainfall measurement needs to be accumulated over a characteristic area for a characteristic time period, both unique to each community. Thus, the most direct measure of flood risk available to planners at present is not rainfall but, instead, the historical record of flood elevation relative to existing structures as well as measurements from nearby stream gauges.

The hazard mitigation plans of Ames and Story County use a variety of historical data sources to estimate past flood occurrence and losses and to extrapolate future flood probability and losses. Information sources include FIRMs, floodplain maps generated by engineering consultants, media reports, descriptions from residents and emergency management professionals, disaster declarations, and USGS stream gauge data and maps. Both mitigation plans concluded that the likelihood of a flood in the future is similar to the recent past.

*Summary of Climate Projections*

Climate projections that provide daily rainfall data at historical measurement sites are generally experimental research datasets. Generally, GCM rainfall processes poorly replicate real-world processes in the Midwest, such as nocturnal rainfall maximum and

[24] Kunkel, Kenneth E., Stanley A. Changnon, Robin T. Shealy, 1993: Temporal and Spatial Characteristics of Heavy-Precipitation Events in the Midwest. Mon. Wea. Rev., 121, 858–866; Pielke, Roger A., Mary W. Downton, 2000: Precipitation and Damaging Floods: Trends in the United States, 1932–97. J. Climate, 13, 3625–3637.

dependence between rainfall and night-time wind fields.[25] Projections are provided, therefore, from the stochastic downscaling technique of Schoof et al.[26] that relates daily rainfall to broad scale weather conditions. These relationships are diagnosed from historical measurements and used to simulate rainfall frequency and amount given data from 10 GCMs that were driven by the A2 emissions scenario. While the results illustrate none of the variability due to consideration of emissions scenario, it more completely represents the spatial variability of rainfall in the Midwest.

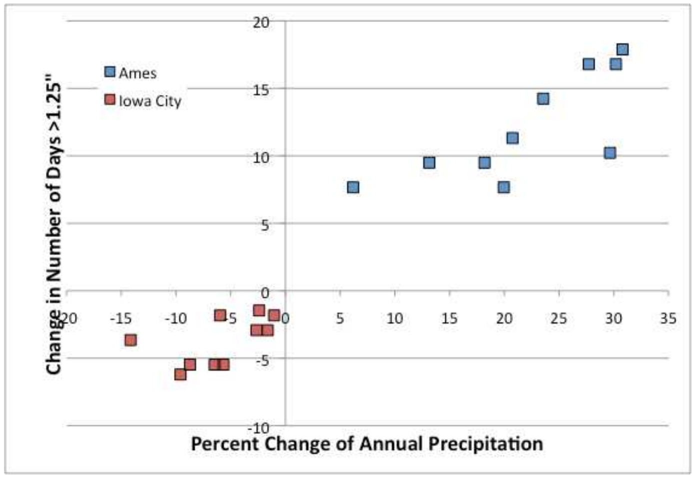


Figure 6. Projected change from 1961-2001 for 2046-2065 (A2 scenario only) of annual precipitation (percent change from present) and number of days with precipitation exceeding 1.25" for station locations in Ames and Iowa City.

It is widely reported that future climate conditions are expected to be supportive of increases in extremely high daily rainfall amounts. This is based upon an expectation of greater atmospheric moisture content, resulting from warmer ocean temperatures, particularly in the Gulf of Mexico and Caribbean Sea, and warmer atmospheric temperature.

Figure 6 shows projected changes for station locations in Ames and Iowa City. It shows the range of variability in rainfall statistics that is typical of climate projections that replicate the spatial variability of rainfall in the Midwest. Results for Ames and Iowa City have opposite signs with projections showing increases for Ames and decreases for Iowa City of annual precipitation and number of days with precipitation > 1.25". At the low end, the projected number of days with precipitation > 1.25" at Ames is a 50% increase above the maximum year in the historical record. In contrast, Iowa City shows a reduction to the frequency observed prior to the 1940s.

Statistics at both stations deviate from regional averages taken over more than 900 stations in the Midwest. Schoof et al. (2010) report that over this region, the rainfall amount of rainy days that occur with 5% frequency (about 18 per year) and 1% frequency (about 3-4 per year) both increase by 0.1" and 0.2", respectively. In the Ames projection, they increase by 0.3" and 0.5", and in the

[25] Ghan, Steven J., Xindi Bian, Lisa Corsetti, 1996: Simulation of the Great Plains Low-Level Jet and Associated Clouds by General Circulation Models. Mon. Wea. Rev., 124, 1388–1408.

[26] Schoof, J. T., S. C. Pryor, and J. Surprenant, 2010: Development of daily precipitation projections for the United States based on probabilistic downscaling, J. Geophys. Res., 115, D13106, doi:10.1029/2009JD013030.

Iowa City projection, they decrease by 0.1" and 0.3", respectively. Thus, the projection for high rainfall days in Ames is that their intensity will increase by about 10-20%; whereas, at Iowa City, their intensity is projected to decrease by 15-25%.

## Climate Change Information for Hazards: Severe Weather

*Summary of Historical Data*

- The Ames Hazard Mitigation Plan uses reports of tornado, wind, and hail archived by NOAA since 1950 to count historical frequency of severe weather events, determine annual occurrence rates and losses, and estimate future occurrence and losses. From these reports, the likelihood of a severe weather event in the next 25 years is rated as "high" with a "low" impact on people and the economy.
- Recent reports of severe weather are far more numerous than prior to the 1970s, particularly for weak tornadoes and windstorms. Severe weather awareness campaigns and increasing public interest in storm chasing and filming extreme weather events are suspected to be primary factors in this increase.  Thus, trends in severe weather reports due to changes in weather patterns are highly uncertain. Furthermore, the best estimates for severe weather frequency and intensity are from the past 20-25 years, when the public was more actively involved in reporting severe weather. Though, this record is too short at any one location to estimate the expected severe weather frequency, it is possible to aggregate reports over large regions to ascertain a regional risk for severe weather.

*Summary of Climate Projections*

- Climate models do not directly simulate severe weather events. It is not possible to directly compare climate model output to historical severe weather records or to evaluate future severe weather intensity or frequency.
- An alternative is to examine weather conditions favorable for severe weather occurrence in observations and climate model simulations. Projections from a single downscaled simulation of a single GCM given a single emissions scenario (A2) indicates changes in severe weather frequency are more likely in the summer months, when the number of days favorable for wind and hail may increase.

*Discussion of Historical Data*

Historical reports of severe weather (tornadoes, wind, and hail) are filled with reporting inconsistencies.[27] Chief among the factors is the increasing willingness of the general public to provide reports since the 1970s. The national number of tornado reports has more than doubled; hail and windstorm reports have increased even more. Although the NOAA archive of severe weather reports extends back to the 1950s, reporting inconsistencies essentially render useless all but the past 25 years of reports at any particular location.

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[27] Brooks, H. E., and C. A. Doswell III, 2001: Normalized damage from major tornadoes in the United States: 1890-1999. Wea. Forecasting, 16,168-176.

The short record combined with relative infrequence of severe weather means the time period of local datasets are too short to accurately estimate probability of severe weather. One approach to overcome short time periods is to aggregate reports over large areas. The National Severe Storms Laboratory (NSSL) has developed an averaging procedure that defines broad patterns of severe weather risk. Plots are available online at http://www.nssl.noaa.gov/hazard/totalthreat.html, and they show the historical frequency of potentially damaging tornadoes is 1 in 4 years.

A less precise approach is to build statistical relationships between weather variables and severe weather reports. This enables the development of a longer record of favorable conditions that should a thunderstorm form it would be likely to produce severe weather. The areas of relative risk for severe weather are consistent with the NSSL estimates of risk.

*Discussion of Climate Projection Data*

Climate models do not directly simulate severe weather events. Furthermore, GCMs may poorly replicate the conditions associated with severe weather. Instead, it is necessary to use downscaled data sets from using regional weather models that better represent weather spatial patterns of conditions related to thunderstorms and severe storms.

Detailed analysis for the late 21st Century of a single regional simulation indicates frequency of favorable severe weather conditions is most likely to be affected in summertime. Increases of atmospheric moisture and reductions in frequency of days with high wind speeds far above the surface could add 5-10 days on average for which conditions are favorable for hail and brief, but intense, windstorms.[28]

## Opportunities/Challenges to Incorporating Climate Projections

The lack of clear correspondence between traditional rainfall measurements and flood incidence produces a strong challenge to using historical and future rainfall information in mitigation planning. The reason is that it prevents the rainfall measurements do not predict inundation, and an inundation map is needed to estimate damages and economic loss.

A secondary challenge may be the intrinsic variability of rainfall itself. The ranges of downscaled results for Ames and Iowa City are very large, even before considering the differences between the two station locations. Part of the variability reflects the uncertainty inherent in relating rainfall to broad weather patterns. There are simply many situations in which subtle changes in broad weather patterns significantly alter the intensity and location of rainfall. This is why differences among the GCMs in weather characteristics such as low-level wind fields, atmospheric moisture, and position of storm tracks can produce large ranges in rainfall projections.

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[28] Trapp, R. J., N. S. Diffenbaugh, and A. Gluhovsky, 2009: Transient response of severe thunderstorm forcing to elevated greenhouse gas concentrations. Geophysical Research Letters, 36, L01703, doi:10.1029/2008GL036203.

However, future generations of GCMs are not expected to significantly reduce the range of results. Rather, the path forward should be more productive, particularly for identifying potential vulnerabilities, if the range is more completely filled in with a large number of local projections. This will better inform planners of extreme and moderate projections.

These challenges suggest two opportunities for researchers to improve the information available to planners. First, climate scientists should intercompare local projections from multiple downscaling techniques in order to be able to articulate whether daily rainfall projections are highly sensitive to the downscaling methodology. The optimal intercomparison would develop community-specific rainfall measures that accurately connect rainfall to the flood hazard associated with the community's river system.

A second opportunity for incorporating climate projection information into flood hazard mitigation lies in approaches for computing future flood probability. The city of Ames provides an example of how a path forward might be developed. It relied upon advanced hydrological modeling to better delineate a portion of its floodplain in the aftermath of the 1993 flood. Although the city's purpose was to better delineate floodplain boundaries, hydrological models may be used more broadly within land use and climate change scenarios. This is done to some extent already in the practice of design storms. Design storms are sometimes described as worst-case scenario rainfall events. The design storm rainfall is used to generate stream flow data that serve as input into flood inundation models to provide maps of areas inundated under the conditions of a worst-case scenario rainfall. This process should be adaptable so that it can incorporate rainfall data from climate projections and should produce what might be called future design storms. The approach can be generalized to incorporate not only alternative rainfall statistics but also alternative land use characteristics.

## Appendix F: List of Data and Information Sources

Dr. Eugene S. Takle (Director, ISU Climate Science Program) has written a statewide summary of recent climate changes and projections for the Iowa Climate Change Advisory Council: "Assessment of Potential Impacts of Climate Changes on Iowa Using Current Trends and Future Projections." It contains sections on precipitation, temperature, wind speed, solar radiation, cloud cover, stream flow, soil moisture, tile drainage, tropospheric ozone, carbon dioxide, soil carbon, and plant growth. It is available by request. Send email requests to gstakle@iastate.edu.

Dr. Sara C. Pryor (Indiana University) has edited a collection of papers on climate change in the Midwest in *Understanding Climate Change: Climate Variability, Predictability, and Change in the Midwestern United States.* It includes chapters on Midwestern summer cooling trends, increasing lengths of the frost-free season, stream flow in the Upper Mississippi basin, extreme rainfall, and severe weather.

Cornelia F. Mutel (Iowa University) has collected a variety of perspectives on the 2008 Cedar Rapids flood in *A Watershed Year: Anatomy of the Iowa Floods of 2008*. The book includes chapters on factors that contributed to the magnitude of the flood, discussion of flood forecasts, and description of the role of climate variability.

Joseph Barsugli, Christopher J. Anderson, Joel B. Smith, and Jason M. Vogel have co-authored an overview paper for non-technical audiences that contains descriptions of global climate models and methods for translating their results into regional and local climate information entitled "Options for Improving Climate Modeling to Assist Water Utility Planning for Climate Change." The report is available online at www.wucaonline.org/assets/pdf/actions_whitepaper_120909.pdf.

*Historical Climate Data*

Historical temperature and precipitation data were obtained from the State Climatologist Office and the Iowa State University Iowa Environmental Mesonet (IEM) archive. The state climatologist (*www.iowaagriculture.gov/climatology.asp*) has selected 33 weather stations in Iowa as a subset of all weather stations with data records exceeding 100 years with minimal evidence of impacts by changes in landscape and measurement technique. The period of record is 1873 to 2008. These stations are considered the highest quality climate data within the state and were used in this report to compute state average data.

The IEM maintains an archive of surface weather measurements from a collection of many measurement networks. Data used in this report come from the IEM Climodat tool (*http://mesonet.agron.iastate.edu/climodat/index.phtml*). It contains data from the National Weather Service Cooperative observer network that is the basis for the state climatologist's dataset. Individual stations, rather than state averages, are selected from the IEM data archive, all of which are included in the state average data obtained from the state climatologist.

FEMA Region VII maintains a list of data sources for hazards. A subset of this list containing resources directly relevant to the pilot communities is provided below. The full list is available by contacting FEMA Region VII: http://www.fema.gov/about/regions/regionvii/. Additional hazard information used by the communities in this pilot project includes storm damage estimates archived by the National Climatic Data Center, FEMA Flood Insurance Rate Maps, presidential disaster declarations, and stream gauge measurements available from the United States Geological Survey.

## Appendix G: Climate Change Information Questionnaire

**Questionnaire was provided to pilot project participants**

List Your Profession:
List the agency for which you work:

(1) Describe the ways in which climate data are used in your current professional activities?

(2) If you do not use climate data directly (such as temperature and precipitation), please describe any environmental data you use that is derived from climate data. This may include data sets such as flood plain maps and heat indices.

(3) From what sources (organizations, websites, other media) do you obtain climate data currently used in your professional activities?

(4) How useful are these data for your needs?

(5) Are they readily accessible and in a format optimal for your use?

(6) Please explain how these data could be improved?

(7) Please describe the information from Dr. Eugene Takle's review that is most relevant to your professional activities. The document title is: **Assessment of Potential Impacts of Climate Changes on Iowa Using Current Trends and Future Projections.**[29]

(8) Please describe whether the information is presented in a way that is understandable to you and appropriate for outreach activities.

(9) Please describe what information might be added to Dr. Takle's review that is relevant to your professional activities.

(10) What is the best method to provide information and updates to you about expected climate change and the implications for communities?

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[29] Takle, Dr. Eugene S. "Assessment of Potential Impacts of Climate Changes on Iowa Using Current Trends and Future Projections." Iowa Climate Change Advisory Council. December 2009. http://climate.engineering.iastate.edu/Document/Climate_Changes_for_Iowa_12.pdf

## Appendix H: Case Studies: Incorporation of Climate Change Adaptation in Hazard Mitigation and Community Plans

> ***Changes in climate due to global warming ultimately will be local in their effects. Changes can occur in the availability of arable land, length of the growing season, amounts of rainfall, temperature changes, levels of disruptive weather, and ecological balance, just to name a few. In addition to research about the implications of climate change for communities and urban areas in general, research is needed that will enable specific places to develop appropriate plans for action to mitigate and adapt to climate change.***
>
> *From the APA Policy Guide on Planning and Climate Change*

This appendix focuses on two Iowa jurisdictions with recently approved hazard mitigation plans, both of which experienced major flooding events in 1993 and 2008. These case studies review adopted planning initiatives and analyze the degree to which they are integrated and complementary efforts. In addition, this appendix discusses whether climate change and adaptation measures are incorporated and implemented into plans and outlines recommendations for respective jurisdictions.

The case studies include background information, including general community information and a brief overview of adopted comprehensive and mitigation planning efforts, the relationship between the Hazard Mitigation Plan and Comprehensive Plan, prioritized strategies and low-regret measures, and findings and recommendations.

While the Iowa Climate Change Adaptation and Resilience Pilot Project work primarily focused on natural hazards, both jurisdictions analyze natural and manmade hazards as defined by the state of Iowa's hazard mitigation plan and shown in the table on the following page. According to FEMA's requirements, local jurisdictions must address all these hazards as present in the community. Therefore, additional dialogue among policy makers at the local, state, and federal levels needs to address the impact of climate change on all hazards.

In hazard mitigation plans, there are four main categories of disasters: natural, human-caused accidental, human-caused purposeful, and other/combination hazards. Iowa's foundation for hazard mitigation is based on a hazard analysis and risk assessment that is comprehensive and multi-hazard, meaning that multiple hazards that can possibly occur anywhere in the state are considered and analyzed, and that the risk that each hazard poses is assessed in terms of a disaster or emergency situation that can be created from that hazard. Hazard analysis is a process for determining the emergency management needs of a jurisdiction when knowledge of the hazard is combined with the knowledge of the impact it would have on a particular community. The result is the measure of a jurisdiction's vulnerability and the probability of an incident occurring.

| STATE-IDENTIFIED HAZARD CATEGORIES | |
|---|---|
| **Category** | **Identified Hazard** |
| Natural | Thunderstorms/Lightning, Tornadoes, Windstorms, Hail, Severe Winter Storms, Extreme Heat, Expansive Soils, Earthquakes, Landslide, River Flood, Flash Flood, Drought |
| Human-Caused Accidental | Fixed Hazardous Materials Incident, Transportation Hazardous Materials Incident, Fixed Radiological Incident, Transportation Radiological Incident, Air Transportation Incident, Communications Failure, Energy Transportation Failure, Highway Transportation Incident, Pipeline Transportation Incident, Rail Transportation Incident, Water Transportation Incident, Dam Failure, Levee Failure |
| Human-Caused Purposeful | Attack, Public Disorder, Biological Terrorism, Chemical Terrorism, Radiological Terrorism, Conventional Terrorism, Cyber Terrorism |
| Other/Combination | Human Disease/Epidemic, Animal Disease/Epidemic, Structural Fire, Grass or Wildland Fire, Structural Failure |

## Case Study A: Coralville, Iowa

The city of Coralville is located in Johnson County in the east central part of Iowa, 75 miles west of the Mississippi River. The east corporate line of Coralville is the west corporate line of Iowa City. The close physical relationship between Coralville and Iowa City has been strengthened over the years by the presence of the University of Iowa. Founded in 1855, the university is the oldest and largest public educational institution in the state. Recent enrollment is approximately 29,000 students. The university and the University of Iowa hospitals and clinics provide employment for more than 24,000 people in the metropolitan area. As of the 2003 Special Census, Coralville's population reached 17,269; it is one of the fastest growing cities in Iowa.

*Comprehensive Planning*

The *Community Plan - Coralville Iowa*, originally adopted in 1992, is the city's comprehensive plan and contains the following elements: Community Profile, Housing, Economic Development, Public Works, Public Services, Land Use, Transportation, and Strategic Plan and Vision.

The future land use plan is the primary management tool presented in the *Community Plan* (and amendments). The plan and associated implementation strategies address items such as brownfield redevelopment, mixed-use development, multimodal transportation choices (including trails and transit), and conservation design developments.

Coralville has a strong stormwater management program and enforces a floodplain management ordinance (and the community is in the process of applying for CRS status). In addition, Coralville reviews an adopted Capital Improvements Plan during budget development. Following the 2008 flooding, Coralville undertook a planning process in cooperation with FEMA and the Rebuild Iowa Office (RIO) and developed the *Coralville Long Term Community Recovery Strategy.*

*Hazard Mitigation Planning*

The *Coralville Local Hazard Mitigation Plan* was approved in 2009, and plan authors indicate they reviewed the following documents: City of Coralville Zoning Ordinance, City of Coralville Subdivision Ordinance, Coralville Comprehensive Plan (Community Plan), and Coralville Long Term Community Recovery Strategy. The planning committee adopted the following goals:

- Goal 1: Protect existing properties within the city of Coralville.
- Goal 2: Protect the health and safety of the residents of Coralville.
- Goal 3: Improve the quality of life in Coralville.
- Goal 4: Ensure that public funds are used in the most efficient manner.

The *Coralville Local Hazard Mitigation Plan* contains a community profile that addresses the areas of climate, major rivers and streams, sub-watersheds, floodplain, elevations, land use, and bedrock faults. In the climate section, the plan states:

“Coralville's climate is similar to those of most cities in the upper Midwest. Due to its location in the central portion of North America, the climate is of continental character. Because Coralville is far from the moderating influence of a large body of water, a wide variation in both temperature and precipitation is experienced during the four district seasons. The distribution of precipitation throughout the year is well suited to agriculture, with the heaviest precipitation fall from April to September. Summer precipitation results primarily from thunderstorm activity, although longer, less intense rains are not uncommon in the area. Other forms of precipitation recorded in the area include: snow, hail, ice pellets, and sleet.”

In performing the risk assessments in the *Coralville Local Hazard Mitigation Plan,* planning committee members reviewed information from a variety of sources, including NOAA, the NTSB, Iowa DOT, and US Census, in addition to the plans and documents mentioned above. Within the specific hazard analyses, the plan references the review of historical data.

*Relationship between the Hazard Mitigation Plan and Comprehensive Land Use Plan*

Review of the aforementioned plans indicates that the hazard mitigation plan and the comprehensive plan for the city of Coralville are two entirely different documents. While the *Coralville Local Hazard Mitigation Plan* includes discussion regarding planning and zoning, building codes, capital improvements plan, and references to joint planning with Johnson County, the comprehensive plan is silent on the hazard mitigation planning process. However, this may be partly attributed to the fact that the most recent amendments to the *Community Plan* are dated 1995, prior to the DMA 2000 mitigation planning requirements and establishment of the most recent hazard mitigation plan.

The mitigation plan encourages references to mitigation goals and strategies to be incorporated into "Coralville's financial and physical planning documents" and recognizes a number of mitigation options already in place in the community, whether formally or informally. The plan states:

“Preservation of natural resources, property protection, infrastructure design, emergency response, building code enforcement and communications facilities are already high priorities and the documentation and discussion of these actions that took place during the planning process may lead to an increased level of coordination within area agencies.”

The hazard mitigation plan includes an action plan, which states:

> "Coralville has a number of preparedness plans and actions currently in place that would allow the city to prevent some hazards, lessen the impacts of others, and in general, allow the city to recover faster and in a more orderly manner in the event of a disaster:
>
> 6. Zoning and Land Use Planning - Coralville regulates development through zoning and land use planning to provide safer development patterns within the city limits. The city also engages in extraterritorial planning within two miles of its boundaries that ensures the city will continue to provide safe and regulated growth for its residents.
> 7. Building Codes - Coralville enforces building codes to ensure that new construction and significant remodeling projects are structurally sound to meet current fire codes."

*Prioritized Strategies –*
The *Coralville Local Hazard Mitigation Plan* prioritizes mitigation strategies using the STAPLEE action evaluation criteria, identifying both structural mitigation measures as well as other measures that could be classified as low-regret measures. Such measures are those actions that provide important benefits at relatively little additional cost or risk. They can use existing staff and/or technical resources, may simply require enactment of ordinances, or encourage educational programs and campaigns addressing behavioral changes, as well as other methods. The mitigation strategies that fall into this latter category include:

Building Codes
Community Outreach
E911 Capabilities and Cell Phone Triangulation
Emergency Operations Plans
Hazardous Materials Response
Multi-Jurisdictional Cooperation within Watershed
Smoke Detectors
Stormwater Management Ordinance and Amendments
Communication with Health Department
Dam Warning Signage
Early Warning Systems
Floodplain Management
Mass Casualty Preparation
Response Personnel
Standards-Compliant Radio Communication
Updated Floodplain Mapping

*Findings and Recommendations*
Climate change and how it relates to developing a more resilient community are not specifically addressed in either the hazard mitigation plan or the comprehensive plan (and associated elements) adopted by the city of Coralville. Primarily, the risk assessments are limited to past events and, as suggested in Stage 1 of the Iowa Climate Change Adaptation and Resilience project, opportunities to define future events should be incorporated to the greatest extent possible. To accomplish this goal, plan authors may need training on climate change information, or the city could include climate experts in the planning efforts.

That being said, Coralville has implemented many measures, including, but not limited to, recycling programs, multijurisdictional planning, conservation design, and stormwater management, that produce a more resilient community. A complete audit of comprehensive planning elements outlining compliance with the Iowa Smart Planning Principles and defining additional opportunities to link the hazard mitigation plan and the comprehensive plan would be a logical next step for Coralville to pursue, if it is not already under consideration.

Given the proximity to the Coralville Reservoir and the historical occurrences of flooding in Coralville, the community should establish future design storms and continue inundation mapping partnerships with the Iowa Flood Center to accompany the city's floodplain management program. Future design storms and mapping partnerships should also be incorporated into other community plans and decisions.

## Case Study B: Story County, Iowa

Story County is in central Iowa along Interstate 35 north of the Des Moines area. The county is also bisected east to west by U.S. Highway 30 (the historic Lincoln Highway). Story County consists of 16 townships, 15 incorporated cities, and four unincorporated towns. Iowa State University is located in Ames, the largest community in Story County. The population was estimated to be 87,214 according to the 2009 US Census. Each of the communities in Story County is responsible for land use planning and implementation strategies, and the unincorporated areas are governed by the Story County Board of Supervisors.

*Comprehensive Planning*

The Story County Board of Supervisors has adopted the County Development Plan (CDP)-Land Use Framework as a basis for managing growth and development in the unincorporated area of Story County. The CDP includes vision and goals, principles, guiding objectives, and implementation recommendations to be used as a framework to guide decisions about land use and related areas such as transportation and streets, economic development, public facilities, infrastructure, and other physical development items. The core premise embedded in the County Development Plan-Land Use Framework is to maintain and enhance the health, safety, and welfare of the county during times of change and to promote the ideals and values of county residents as changes occur.

The CDP is a land use plan and does not contain other elements normally addressed in a comprehensive plan. In 2011, the Story County Planning and Zoning Department staff will undertake a review of all plans and policies adopted by Story County to determine the degree to which Story County meets the Iowa Smart Planning Principles and to provide recommendations to develop a comprehensive plan for Story County. Story County does implement a unified subdivision and zoning ordinance, *Story County Land Development Regulations*, and these regulations contain provisions for conservation design, wind energy, solar energy, and other issues to encourage energy-efficient development. In addition, Story County participates in the NFIP and enforces a restrictive floodplain management ordinance and will be applying to be a CRS community in 2011. Story County does not have an adopted capital improvement plan; however, the Board of Supervisors annually approves the 5-Year Secondary Road Construction Program and map to prioritize road projects.

Story County continues to implement strategies to reduce the major sources of greenhouse gas emissions, improve water quality, provide economic development opportunities, and encourage sustainable practices by local governments and the general public.

Story County's green efforts began in 1997 and uses energy-efficiency practices, including geothermal closed-loop heating and cooling systems in the new construction of two buildings and replacement of chillers and cooling towers in the renovation of an existing building with geothermal technology. With such practices, Story County annually realizes energy savings of over 40 percent and reductions in GHG emissions of more than 4 million pounds.

The communities in Story County have regulatory tools and policies that guide their land use decision-making. The table on the following page lists these (excluding Ames).

| City | Regulatory Tools - Existing Policies and Regulations | | | | | |
|---|---|---|---|---|---|---|
| | *Building Code* | *Zoning Ordinance* | *Subdivision Regulations* | *Floodplain Management Ordinance* | *Comprehensive Plan* | *Capital Improvements Program* |
| Cambridge | YES | YES | YES | YES | YES | YES |
| Collins | YES | YES | YES | YES | NO | NO |
| Colo | YES | YES | YES | NA | NO | YES |
| Gilbert | YES | YES | YES | YES | YES | NO |
| Huxley | YES | YES | YES | YES | YES | YES |
| Kelley | YES | YES | YES | NA | YES | NO |
| Maxwell | NO | YES | YES | YES | YES | NO |
| McCallsburg | NO | YES | YES | IN PROCESS | YES | NO |
| Nevada | YES | YES | YES | YES | YES | YES |
| Roland | NO | YES | YES | YES | YES | NO |
| Sheldahl | NO | YES | YES | NA | NO | NO |
| Slater | YES | YES | YES | YES | YES | NO |
| Story City | YES | YES | YES | YES | YES | YES |
| Zearing | NA | YES | YES | YES | NA | NO |
| Story County (Unincorporated) | NO | YES | YES | YES | YES | NO |

*Hazard Mitigation Planning*

The Story County Multi-Jurisdictional Multi-Hazard Mitigation Plan was developed to:

- Comply with requirements of Iowa Administrative Code 605-7.2(4)(d)(1)(2) of Chapter 29C.
- Assess ongoing mitigation activities in Story County.
- Evaluate identified mitigation measures that should be undertaken.
- Outline a strategy to implement mitigation projects.

The plan updated hazard mitigation plans in 14 communities in Story County (Cambridge, Collins, Colo, Gilbert, Huxley, Kelley, Maxwell, McCallsburg, Nevada, Roland, Sheldahl, Slater, Story City, Zearing, and unincorporated areas of Story County), all of which were adopted by the respective city councils between 1999 and 2002. The city of Ames elected to update its local hazard mitigation plan individually and did not participate in the planning process. However, the plan recognizes the impacts of all hazards that might occur in Ames upon all the jurisdictions in the county.

The *Story County Multi-Jurisdictional Multi-Hazard Mitigation Plan* also recognizes areas of concern beyond the boundaries of the communities and Story County. Located north of Des Moines, population trends and the manner in which these expanding areas successfully address and mitigate hazards relate to the success of Story County's plan. The plan also recognizes the potential impacts of hazards at sites such as Camp Dodge in Johnston and the power station in Marshalltown, as well as agricultural activities and developments such as the wind farms to the north and east of Story County.

In order to properly develop mitigation strategies and projects, the planning team identified hazards that might affect the jurisdictions in Story County. The planning team initially reviewed and compiled hazard analyses for each community and the unincorporated areas. These hazards were identified through an extensive process using input from the local communities' planning committees, public input, research from past disaster declarations, review of current maps and performing geographic information system (GIS) analyses, and review of the 2003 *Story County Multi-Hazard Mitigation Plan*. In assessing risks, the following were reviewed:

- FIRM maps
- Identification of repetitive-losses properties
- Severe storm events (winter and summer)
- Library historical data
- Information from Story County Emergency Management Coordinator
- Media searches and websites
- Jurisdiction and agency experience
- Past disaster declarations
- USGS Maps
- Input from residents
- National Weather Service
- Story County MAPS (Mapping and Policy Support) Committee

Climate change is not addressed in the *Story County Multi-Jurisdictional Multi-Hazard Plan.* Risk assessments and hazard profiles were analyzed solely based upon historical occurrences, in addition to vulnerability and other criteria.

*Relationship between the Hazard Mitigation Plan and Comprehensive Land Use Plan*

Chapter Seven of the *Story County Multi-Jurisdictional Multi-Hazard Mitigation Plan* addresses the relationship between that planning effort and other comprehensive planning initiatives:

"As mitigation plans aim towards achieving a greater degree of sustainability for a jurisdiction, many of the strategies and research compiled in this planning process will be folded into other planning endeavors. Story County will be working with all communities in

Story County over the next few years in developing future land use plans for areas within two miles of the corporate boundaries. In addition, capital improvement plans for all participating jurisdictions and budgeting processes will account for the mitigation strategies selected by individual jurisdictions. By adopting the Story County Multi-Jurisdictional Multi-Hazard Mitigation Plan, the participating jurisdictions acknowledge that hazard mitigation must become an essential part of their activities regarding land use decision-making and ultimate enforcement of such regulations. For those jurisdictions wherein capital improvement plans do not exist, or in cases wherein adoption of a building code has been a proposed strategy, incorporation of such implementation measures will help towards achieving the goals and objectives of this plan."

In contrast, the *County Development Plan* does not address hazard mitigation but does outline strategies specifically designed to address flooding and lessen impacts on the environment.

*Prioritized Strategies*

The *Story County Multi-Jurisdictional Multi-Hazard Mitigation Plan* prioritizes mitigation strategies using the STAPLEE criteria, identifying structural mitigation measures as well as other measures that could be classified as low-regret measures. Such measures are those actions that provide important benefits at relatively little additional cost or risk. They can use existing staff and/or technical resources, may simply require enactment of ordinances, or educational programs and campaigns addressing behavioral changes, as well as other methods. The mitigation strategies that fall into this latter category include:

Adoption of building codes
Coordinate with local school district(s)
Damage assessment training
Establish alert systems for vulnerable populations
GIS mapping
Manufactured home development storm shelter ordinance
Phone tree
Snow removal ordinances and policies
Stormwater management plan
Underground installation of power lines ordinance
Watershed studies
Continued education for weather spotters
Adopt cost recovery ordinance
Promote Iowa One Call
Establish and adopt a quarantine and isolation ordinance
Initiate burn bans during dry and windy conditions
Connection of sump pumps ordinance
Create directory of resources
Enforce burning restrictions
Establish temporary shelters
List of individuals using oxygen and special health needs
Participate in CRS
Public awareness and education campaigns
Purchase flags for hydrants and identify hydrants prior to event
Tree trimming ordinance
Water rationing ordinance
Wellhead protection ordinance development
Shelter in place training
Promote use of bicycle trails
Develop neighborhood response teams
Observe Fire Prevention Week and conduct public education on safety
Public education on benefits of wearing motorcycle and bicycle helmets
Encourage realtors and local insurance agents to promote the use of weather radios.
Review possibility of using amateur radio systems as back-up communications systems.

*Findings and Recommendations*

Climate change and how it relates to developing a more resilient community are not specifically addressed in either the hazard mitigation plan or the comprehensive plan (and associated elements) adopted by Story County. Primarily, the risk assessments are limited to past events and, as suggested in Stage 1 of the Iowa Climate Change Adaptation and Resilience project, opportunities to define future events should be incorporated to the greatest extent possible. To accomplish this goal, plan authors might need training on climate change information, or the county could include climate experts in the planning efforts.

Story County will undertake a complete audit of comprehensive planning elements outlining compliance with the Iowa Smart Planning Principles and defining additional linkages between the hazard mitigation plan and comprehensive plan in early 2011. This process should establish a clear path to merge various planning initiatives into one comprehensive endeavor. One missing link, as identified in the FEMA review of the *Story County Multi-Jurisdictional Multi-Hazard Mitigation Plan,* is that the city of Ames and ISU are not included in the plan. The results of the audit should recommend strategies to meld all activities and jurisdictions into a comprehensive package.

Given the number of historical flooding events, Story County and its 15 communities and unincorporated areas should establish future design storms and review partnerships with the Iowa Flood Center regarding inundation mapping. Additionally, they should review opportunities to develop a comprehensive floodplain management program to be implemented consistently across the county and incorporate this program into other plans and decision-making processes of all communities.

## Appendix I: Pilot Participants

Christopher J. Anderson, PhD
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*Linn County*

Lori Morrissey
*Story County*

Brian Schoon
*INRCOG*

Gary Taylor
*Iowa State University*

Aaron Todd
*Rebuild Iowa Office*

EPA Headquarters and FEMA Headquarters and Regional staff served as technical advisors to the pilot workgroup.