Assessment of Climate Change Impacts on Local Economies

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Abstract

The Intermountain West is in the bull's eye of climate change impacts in the United States. Climate change impacts will range from increased risk of droughts, floods and wildfires, landscape level vegetation change, exacerbation of the heat island effect and ozone non-attainment, to changes in river flows and reservoir storage. These impacts will compel households, businesses, farmers, land managers, and local governments to adapt. The key question is whether adaptation will be ad hoc or guided. There are cost-efficient reasons to incorporate climate change impact planning into all local government decision-making from building codes to transportation planning. Many adaptation measures, such as energy efficiency, switching to diffuse renewable energy, smart urbanization, and water conservation, will not only allow households, businesses, and governments to save money, but also will produce co-benefits such as increased comfort, economic development, and greater resilience to climate variability and other natural hazards. Local governments can incentivize end users to invest in adaptation through regulation, partnerships with utilities, rebates, grants and bonding, leading-by-example, and education.

About the Author

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What is adaptation?

"Adaptation involves adjustments in natural or human systems in response to actual or expected climate change impacts to reduce harm or exploit beneficial opportunities. Adaptation action is taken by individuals, households, communities, businesses, and governments…Adaptation reduces vulnerability and increases resilience" (ADB 2009).

Why climate change adaption at the local government level?

"Many ... (climate change) impacts – changing temperature and weather patterns, drought, flooding, and sea level rise – will be felt most directly at the local level, which is also where we have the best ability to prepare for these changes. For that reason, many local governments are now embracing climate change adaption as a sister strategy to their climate mitigation efforts" (ICLEI 2009a).

What types of climate change adaptations?

It is imperative "to develop practical strategies for reducing the overall vulnerability of economic and ecological systems to weather and climate variations. Some of these are 'no-regrets' strategies that will provide benefits regardless of whether a significant climate change ultimately occurs in a region. No-regrets measures could include improving climate forecasting based on decision-maker needs; slowing biodiversity loss; improving water, land, and air quality; and making our health care enterprise, financial markets, and energy and transportation systems more resilient to major disruptions" (NA 2008).

I. Introduction

Adaptation to climate change impacts is inevitable because of the now unavoidable impacts already locked in by cumulative, historic greenhouse gas (GHG) emissions. However, the pace and cost-effectiveness of adaptation activities will be determined in part by the role of governments. Although individuals and businesses will have incentives to respond to climate change impacts without policy intervention, for example to save money on cooling and heating expenses by insulating, or buying an energy efficient air conditioner or home, so called "autonomous adaptation", the pace and integration of adaptation could be accelerated and enhanced with "planned" or "policy-driven" adaptation (ADB 2009). Governments can facilitate adaptation measures "through policies, investments in infrastructure and technologies, and (through information provision or incentives designed to hasten) behavioural change" (OECD 2008). "Adaptation can operate at two broad levels: building national and local adaptive capacity, and delivering specific adaptation actions" (ADB 2009).

A "number of typologies have been developed to classify adaptation activities. For example, adaptation measures have been classified according to: timing (anticipatory *vs.* reactive); scope (local *vs.* regional, short-term *vs.* long-term); purposefulness (autonomous *vs.* planned); and adapting agent (natural systems *vs.* humans, individuals *vs.* collective, private *vs.* public)" (OECD 2008). In this report we focus on anticipatory, local, planned, longer-term, collective, public, and public-incentivized private adaptation of principally human systems.

Given that climate change adaptation is inevitable, it will be most cost-effective if those adaptations with the highest net-benefits are implemented first. The net-benefit approach is not only relevant for each individual adaptation activity but also in a more regional, national and "global context where trade-offs might need to be considered between the costs of climate polices and the residual damages resulting from climate change" (OECD 2008). Some climate change adaptations will require large upfront costs, e.g. constructing or extending light rail systems, or will involve some inconvenience, e.g. insulating old buildings and retrofitting toilets. A comprehensive climate change adaptation plan is key to overcoming such funding and nuisance barriers by both traditional means of public provision and regulation and also by designing effective market-based incentives. There is also a need for climate scientists and governments to inform the public about the need for, and cost-effectiveness of, climate proofing urban, rural, and amenity communities.

II. Background

The Intermountain West (IMW) states (see Figure 1) offer superior recreation opportunities and climate, which in part explains some of their attractiveness and staggering growth rates (Carruthers and Vias 2005). They also happen to be in the eye of the climate change impact storm in the United States. The challenge for IMW local governments is how best to manage climate change adaptation. The choices are: to react to impacts, for example larger floods; plan for impacts by sector, i.e. water, transportation; or comprehensively plan for climate change impacts across all sectors of the local economy. There are likely efficiencies that can be realized with comprehensive planning.

Figure 1: Intermountain West

"The threat of global climate change is one of the most significant scientific and *political* challenges of our time" (Betsill and Bulkeley 2006, emphasis added). Initial climate change policy efforts focused on international negotiation over the division of responsibility for past emissions and for future emissions reductions. Mitigation, not adaptation, was central in these negotiations. "More recently the debate on climate change has shifted and mitigation approaches have been complemented by a new paradigm, i.e. that of *adaptation* to the risks induced by climate change" (Alber and

Kern 2008). This paradigm shift has in turn shifted the focus from national governments to local government. In some cases actions will be taken at the local level, funded locally, or by federal grants, and in other cases regional action will be required, such as in long-term joint land-use/transportation/open space planning. Local government is an appropriate level of government for climate change adaptation because local governments in the US have broad jurisdiction over key areas of local economies that determine the carbon-intensity of development and the climate proofing of the community. Namely, local governments have authority over land-use planning, transportation planning and provision, waste management, building codes, and water and energy utilities (Betsill and Bulkeley 2006). Because local governments are responsible for so many human systems that will be impacted by climate change, it is not surprising that many city and local governments in the US, without any mandate from federal government to mitigate or adapt to climate change, have taken the initiative (Betsill and Bulkeley 2006). Another key reason for sub national activity in climate change mitigation and adaptation in the United States was the policy vacuum at the federal government level under the Bush Administration[1] (Betsill and Bulkeley 2006; Resnick 2006; Schreurs 2008).

Adding weight to the argument that the local level is the appropriate level of government for many adaptation measures, the Obama Administration's early policy decisions have directed funding and authority to local governments. The American Recovery and Reinvestment Act of 2009[2] appropriated $3.2 billion for the Energy Efficiency and Conservation Block Grant Program that provides federal grants to states, local governments, and tribes to conserve energy, improve energy efficiency, and invest in renewables. The states of Arizona, Idaho, Nevada, and Utah received a combined $140.5 million.[3] Although, the federal government is likely to play a significant role in the shaping of, as well as the funding of, climate change mitigation, most likely through a GHG cap-and-trade program, it is likely that much of the adaptation policy action will still be taken at the local and state government level. A number of cap-and-trade programs currently being debated in Congress would channel a proportion of the funds from the sale of GHG emission permits to fund renewable energy development. A large proportion of such funding will likely be channeled through local governments.

[1] In 1998 under the Clinton Administration the US signed the 1997 Kyoto Protocol to the United Nation's Framework Convention on Climate Change. However, in 2001 the Bush Administration withdrew its support for the protocol. Australia is another example of a nation where inaction at the federal level may have spurred climate change protection activities at the state and city levels (Betsill and Bulkeley 2006).

[2] Also called the Stimulus Plan of 2009.

[3] Arizona received $63,817,400, of which The City or Tucson's grant was $5,155,300 and the City of Phoenix's $15,223,500. Idaho received a total $16,956,700 in grant money, of which $2,039,200 is directed to the City of Boise. Nevada received $31,983,500, of which $5,449,200 is dedicated to the City of Las Vegas, and Utah received $27,777,600 in federal grants, of which $2,116,500 is for SLC (US DOE 2009).

II.I. Local Solutions and Transnational Networks

The focus on local government as the solution is not new it was a central theme of the 1992 United Nations Conference on Environment and Development and Agenda 21.[4] Many Agenda 21 sustainability initiatives overlap with GHG mitigation and adaptation.

> "Local authorities construct, operate and maintain economic, social and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, and assist in implementing national and sub national environmental policies. As the level of governance closest to the people, they play a vital role in educating, mobilizing and responding to the public to promote sustainable development" (United Nations 1993).

What are the opportunities for climate change adaptation at the local level? There are several areas of the economy over which local governments have authority including the sustainability of their own enterprises. In the language of social scientists the modes of governance local governments can deploy are categorized into four main forms:

1. "Self-governing" e.g. buying renewable power[5], retrofitting local government buildings;
2. "Governing by provision" e.g. providing bus services, composting, and incentives;
3. "Governing by authority" e.g. enforcing congestion charges, requiring energy efficient buildings; and
4. "Governing through enabling" e.g. facilitating partnerships with energy service companies, public information campaigns (Bulkeley and Kern 2006; Alber and Kern 2008).[6]

Bulkeley and Kern 2006 note that currently "the majority of measures undertaken in relation to climate protection are concentrated in the self-governing mode and in the energy sector, in particular in the energy management of municipal properties." More energy-efficient local government buildings are the low-hanging fruit. It is unclear whether such demonstration projects will spur the wider uptake of renewable energy and

[4] Agenda 21 is a United Nations Environment Program that describes objectives, actions, and the means of implementation at the international, national, and local levels to achieve more environmentally-sustainable development.

[5] Such green energy purchases can go further than just warming and cooling local government buildings sustainably. The purchases themselves may help create a market for solar power. In fact one aspect of the CCI's climate change program is the idea of combining the buying power of cities to bring down the costs of energy efficient products. The organization has negotiated discounts with manufacturers: participant companies gain by expanding their market and participant cities save money on energy efficiency retrofits and the purchase of fuel efficient vehicle fleets and energy efficient street lighting (CCI 2009b). In addition local governments may extend their role through the licensing green contractors to reduce barriers to the public's acceptance of new technology.

[6] An alternative characterization of local governments is "as (i) estate managers, i.e. as employers and major consumers of energy and other resources and as managers of transport and buildings; (ii) service providers, which includes the responsibility of emergency planning and social care; and (iii) community leaders, covering community strategies and partnerships" (Alber and Kern 2008 adapted from UKCIP and the Nottingham Declaration)

insulation products elsewhere in their communities without the push of tighter building codes, or the pull of rebates and grants.

As in the United States, one of the most intransigent climate change problems in Europe is reducing vehicle miles travelled. It is not that local governments have no levers to pull but rather that political opposition by citizens and businesses dissuades them from action. Possible demand management measures available to local governments are "reducing the available road space for private vehicles, improving infrastructure provisions for alternative transport and, perhaps most importantly, through the use of workplace charging levies and road user charging" (Bulkeley and Kern 2006). The focus of many transportation plans is on the most politically acceptable option, the provision of alternatives, for instance light rail and bicycle lanes. Land-use planning, specifically of transit-centered communities, is another politically acceptable option. This focus on the:

> "self-governing and enabling modes of governing for climate protection therefore creates particular capacity challenges for local government: to create financial incentives for action; to persuade others of the need for action; and to co-ordinate action across different arenas and sectors in order to generate new governing capacities" (Bulkeley and Kern 2006).

Academic research has more recently focused on climate change activities at the local level both because it is "where implementation of national climate change policies and programs must occur...(and because) Such research is also critical for improving our understanding of the obstacles preventing yet greater activity and effectiveness in local and state climate programs and measures" (Schreurs 2008). One key to diffusing climate change awareness and mitigation and adaption efforts is the role of "agenda setters" (Schreurs 2008). Agenda setters provide concrete national examples of best practices in accelerating the uptake of energy efficiency, renewable energy, smart growth and transit-centered development that can be emulated by other local, city, and state governments. Beacons for more sustainable cities in the IMW are Albuquerque, New Mexico; Denver, Colorado; and Salt Lake City, Utah. These IMW pioneer cities provide more relevant peer-to-peer learning (ICLEI 2009b; Schreurs 2008; Kern and Bulkeley 2009; Jänicke and Jacob 2004), benchmarking, and encouragement (Jänicke and Jacob 2004; Kern and Bulkeley 2009) for other IMW communities, than east coast or west-coast pioneers. This is because they currently function in more broadly similar environments (e.g. vast open space, large tracts of federal land, semi-arid, sprawling cities, same water rights allocation mechanism (prior appropriation), etc.) and will be subject to similar climate change impacts (e.g. more and longer droughts, heat waves, devastating forest fires, etc.).

In addition to pioneers there are global networks of cities that are fostering climate change adaptation and mitigation activities at the city and local government levels. Leading transnational groups operating in the United States are International Council for Local Environmental Initiatives- Cities for Climate Protection™ (ICLEI-CCP™), C40 Cities (C40), and the Clinton Climate Initiative (CCI).[7] The phenomenon of the international network of cities promoting climate change solutions is best understood within the framework that urban areas are major GHG emitters, accounting for 80 percent of the world's GHG emissions (C40 Cities 2009a). Therefore city level solutions have the potential to greatly reduce overall emissions through the diffusion of best practices and the implementation of climate change adaptation policies and activities. Transnational networks provide a new form of "global environmental governance" that not only influence national policy, but have also "initiated policies and programs for managing GHG emissions (and adaptation) independent of their national governments", and in the case of the ICLEI "serves as the voice of local authorities in international climate change negotiations" (Betsill and Bulkeley 2006). However, recent research suggests that ICLEI-CCP™ and other such transnational municipal networks are, in practice, "networks of pioneers for pioneers" (Kern and Bulkeley 2009). The passivity of many members can in part be explained by the fact that many smaller cities may not have the human capital to participate more fully, and that climate change protection is currently a voluntary activity.

The C40 suggest that cities plan on implementing the following:

- "Creating building codes and standards that include practical, affordable changes that make buildings cleaner and more energy efficient.
- Conducting energy audits and implementing retrofit programs to improve energy efficiency in municipal and private buildings.
- Installing more energy efficient traffic and street lighting.
- Implementing localized, cleaner electricity generation systems.
- Developing bus rapid transit and non-motorized transport systems.
- Using clean fuels and hybrid technologies for city buses, rubbish trucks, and other vehicles.
- Implementing schemes to reduce traffic, such as congestion charges.
- Creating waste-to-energy systems at landfills.
- Improving water distribution systems and leak management" (C40 Cities 2009b).

Meanwhile, ICLEI's stated goal is to work with local governments to "develop local capacity to identify and to reduce the vulnerabilities associated with climate change" (ICLEI 2009d). The U.S. program, the Climate Resilient Communities™ Program,[8]

[7] As of March 31, 2009 there were: 1,126 cities in 33 countries in the ICLEI-CCP, of which 569 are in the US and 46 are in the Intermountain West; 40 cities are part of the C40 Climate Leadership Group, but there are no cities from the Intermountain West; and the same 40 cities are Partner Cities in the CCI which also includes 14 Affiliate Cities, one of which is in the Intermountain West, Salt Lake City, UT.

[8] The ICLEI Climate Resilient Communities™ Program aims to assist local governments in both assessing their vulnerabilities to climate change impacts and prioritizing actions to reduce these vulnerabilities in three key "community systems: the built, natural and social environments which collectively provide the key services or activities within a community or region". The goals of the program are to: "Increase the ability of local governments

"builds on the Five Milestone Methodology that ICLEI established for climate change mitigation. Participating communities will assess vulnerabilities, establish targets and goals, and plan and take action to enhance their resiliency to a changing climate"[9] (ICLEI 2009e). ICLEI USA has a 22 member Advisory Group that has been tasked with "brainstorming the types of tools and guidance that will be useful to local governments as they work through the process of climate change adaptation, identifying regional variations in adaptation issues and strategies, and serving as a pilot group for new adaptation tools and guidance that ICLEI creates" (ICLEI 2009f). Note that because these networks lack:

> "the usual forms of authority afforded to governmental actors in hierarchical relations of power – i.e. regulation, sanction and force – networks rely on other forms of authority and persuasion…there are three core strategies deployed for internal governing: (1) information and communication; (2) project funding and co-operation; and (3) recognition, benchmarking and certification." But such "*laissez-faire* approaches, based on soft governing tools, reinforce differing patterns of network participation between leaders and laggards...it is easy to distinguish between a hard core of pioneers and a periphery consisting of relatively passive cities which have scarcely changed their behavior since joining the network" (Kern and Bulkeley 2009).

On a very practical level, transnational networks could be instrumental in climate change policy. CCI partnering with Microsoft, ICLEI-Local Governments for Sustainability, The Center for Neighborhood Technology, and Ascentium is developing "Project 2°" a website that includes an Emissions Tracker GHG measurement tool. It will enable cities to calculate their carbon footprint and evaluate the effectiveness of emissions reduction programs (CCI 2009a). This initiative will create a standardized tool that meets IPCC standards. Project 2° exemplifies the type of activity that would be financially and technically challenging for a local community to design but that has to be part of any future national or global climate mitigation program: the accurate measurement of GHG emissions.

Another influential organization is the U.S. Conference of Mayors. Their Climate Protection Agreement encourages participating cities to meet or exceed the Kyoto Protocol targets for emission reduction, specifically to reduce emissions by 7 percent from 1990 levels by 2012. Note that the setting of targets is typically a national

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to assess their vulnerability to future changes in the climate by linking them directly to the most current climate science on future regional impacts. Facilitate informed decision making based on climate science. Develop tools to assist communities to prioritize and implement adaptation actions. Increase the integration of climate change mitigation and adaptation planning. Train local government staff and leaders on effective planning implementation of adaptation strategies. Enable peer-to-peer learning among a national network of communities. Foster citizen support for and engagement in advancing their community's resiliency" (ICLEI 2009b).

[9] Beyond just providing goals ICLEI has developed the "Five Milestones for Climate Adaptation" methodology. The five steps are to: 1. "Conduct a Climate Resiliency Study 2. Prioritize Areas for Action and Set Goals 3. Develop a Climate Resilient Action Plan 4. Implement the Plan 5. Monitor and Reevaluate" (ICLEI 2009c).

government prerogative yet both the USCM and ICLEI-CCP incorporate emission reduction targets and monitoring and reporting requirements (Betsill and Bulkeley 2006). The organization promotes the diffusion of best practices through guides that highlight actual examples of best practice in six categories: fuels, vehicles and transit; housing; municipal buildings, facilities & operations; air quality; climate change; and energy sources (USCM 2007a, 2007b). These guides also describe the obstacles to implementing climate programs and what the city did to overcome them. The Mayors' Climate Protection Awards are awarded to those cities, large and small, that are implementing the most effective programs. For example, in 2008 the first place winners were Seattle, Washington, and Carmel, California in the large and small city category, respectively. Only one IMW mayor received a prize, Colorado Springs, Colorado won in the Honorable Mention category (USCM 2008). A key policy issue is how best to incentivize households and businesses to participate and invest in climate change mitigation and adaptation.

III. Adaptation: Policy, Economics, and Opportunities

The IPCC Third Assessment Report classified adaptation options available to governments. These range from do nothing, sharing the losses through government insurance and relief programs, to more active adaptation. Active adaptation either reduces the exposure to risk, or enhances the resiliency of the economic agent to the risk (OECD 2008). Local governments then need the will, the authority, the capacity, and the funding to act. This will be easier if combined with increased public outreach and engagement both about the need for, and benefits of, GHG emission reduction and climate change adaptation.

III.i. Policy

III.i.a. Free-riding

A problem in climate change mitigation politics (and other public goods or activities that effect the commons) is free-riding (Lundqvist and von Borgstede 2008). This is because a locality's contribution to global cumulative GHG emissions, or to GHG emission reductions, is infinitesimal. Additionally, the Kyoto Protocol targets are a national (not a sub-national) responsibility and therefore local governments are mostly limited to measures of persuasion and direct provision to reduce GHG emissions (Sugiyama and Takeuchi 2008). But, in many countries first movers,[10] sometimes working with regional organizations (e.g. the Western Climate Initiative[11], WCI 2009), have overcome jurisdictional and other barriers, and developed mitigation and adaptation policies, that

[10] In Japan the first mover cities are Tokyo and Nagoya.

[11] The WCI includes Arizona, British Columbia, California, Manitoba, Montana, New Mexico, Ontario, Oregon, Quebec, Utah and Washington. WCI Observers are: Alaska, Colorado, Idaho, Kansas, Nevada and Wyoming in the US, Saskatchewan in Canada and Baja California, Chihuahua, Coahuila, Nuevo Leon, Sonora, and Tamaulipas in Mexico.

could be models for national policy (Sygiyama and Takeuchi 2008; Lundqvist and von Borgstede 2008). Climate change adaptation is often viewed as a means to secure "sustained economic and social development" (Lundqvist and von Borgstede 2008), to manage future risks, and to enhance a community's resiliency not only to climate change impacts, but other types of hazards and uncertainty (Alber and Kern 2006).

Many climate change adaptations "will have a public good character and as such may be provided by the state (local authorities or national governments). In making these adaptation decisions the authorities will apply traditional decision support tools, such as cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis" (OECD 2008). Local governments also have a role to play in incentivizing private individuals and firms to invest in adaptation, and in modifying behaviors through education, research, and public policy.

III.i.b. Uncertainty and Planning

A central complexity with climate change impacts is that the impacts are not known with certainty and the past may not be a good guide for future planning (Milly et al. 2008; Bates et al. 2008; Brekke et al. 2009). Downscaled climate change model outputs used directly, or as inputs to other decision tools, can provide information on climate risks to communities. Building planning capacity at the local government level that can integrate downscaled climate change impacts into every aspect of local governance and planning is a critical need. Federal or state governments, and universities might best provide downscaled climate projections. It may also be necessary to provide training to local governments and utilities on how best to incorporate projections into various decision support tools and models (ICLEI 2009d) and to educate local government planners to "accept that 'very likely' is a high enough probability to plan on implementing at least some policies" (Carter 2008). Risk is a function of exposure to a hazard (e.g. more heat waves, less snowpack reducing water supplies) and the resiliency of the community (e.g. cooling centers, conjunctive water management and treated water reuse). GHG mitigation can over time reduce the exposure to climate change induced hazards but it is adaptation that can reduce a community's current vulnerability to increased risk.

The uncertainty inherent in planning for climate change impacts extends to the utility and cost-effectiveness of associated adaptation policies. Uncertainties may be particularly high in natural systems (e.g. aquatic and terrestrial habitats) that are not only impacted by changing climate but also by other human stressors. Understanding the complexity of coupled human and natural systems requires interdisciplinary, integrated research (Liu et al. 2007). Furthermore, policymakers need to formulate policies, for example, to preserve biodiversity that take into account inherent uncertainties. "All-weather" policies that give emphasis to the precautionary approach, or attempt to minimize regret to future generations, no matter whether "climate change costs are catastrophically large or less than expected," may be preferable (Clarke 2008). Policies that have spillover benefits are also favored in this framework. For example, "policies for helping biodiversity adapt to climate change include building wildlife corridors to link up different reserve areas and facilitate natural species migrations (and) increasing the size of existing public reserve areas to increase environmental resilience" (Clarke 2008) which may have associated recreation, heat island mitigation, and aesthetic benefits. The author also notes "an interesting feature of 'all-weather' policies in a broader dynamic context with dynamic learning about costs and benefits, is that such policies reduce 'sunk cost' motivations for delaying policy actions." In other words, policies that are effective and cost-effective even if climate change impacts are zero should be implemented now. Once the focus shifts to action the issue becomes which adaptations to implement or foster first and how to pay for them.

Uncertainty is not a reason for inaction but rather a call for capacity enhancement and the implementation of "win-win" adaptations that make economic sense even if climate change impacts are zero. Adaptations that enhance the flexibility and resiliency of households, businesses, cities, and regions to a wider range of climate conditions and provide other co-benefits are particularly attractive in this framework (ICLEI 2009a; OECD 2008; ADB 2009).

III.ii. Economics

There are four elements to adaptation: the degree, and type of adaptation, the timing of the adaptation (OECD 2008) and the economic agent who does the adaptation.

III.ii.a. Net Benefits of Adaptation

Adaptation decisions will be taken under uncertainty. Where the "cost of inaction is substantial, adaptation decisions may be based on the precautionary principle"[12] and not on conventional benefit-cost analysis (OECD 2008). The economics of climate change adaptation compares the costs and benefits of action to the costs and benefits of inaction. The net benefits of adaptation are the avoided climate impacts, plus any co-benefits, minus the cost of the adaptation. The net benefits of no action are the costs of climate change impacts. Calculating the net benefits of either course – action or inaction – is complicated by the public good nature of the atmosphere, the difficulty in separating the climate component of adaptation costs and benefits, discounting, and the regional distribution of the costs and benefits.

A principle in benefit-cost analysis is the "with and without" principle. That is, what are the benefits and the costs with the program and what are the benefits and costs without the program. Adaptation ideally should reduce the costs associated with climate change impacts, for instance a heat warning system and cooling centers should reduce heat-related hospital visits. This calculation is not straightforward as without the program,

[12] In cases where irreversible harm may ensue without action this principle states that there is a moral and political responsibility to act.

the status quo in a world experiencing impacts from climate change, is not static, i.e. more people would have been at risk to higher temperatures. That is, there will be "residual damages" (OECD 2008). Additionally, most cost estimates are for 'hard' adaptation measures such as building a new reservoir, and "ignore potential 'soft' adaptation responses, such as land use planning and building codes…(and) promoting efficient water use through recycling…Such behavioral adaptations, in fact, might go a long way in lowering the overall cost of adaptation. They might also induce decisions and choices that internalize both current and anticipated climate risks" (OECD 2008). That is, if risk is priced correctly, households, businesses, and governments will have incentives to make cost-effective adaptation investments and behavioral change.

Other challenges are measuring the climate component of some adaptation activities that might be motivated by other policy goals (OECD 2008). For example, changes to farming practices, land use planning, and infrastructure design, might be motivated by dust control, historic preservation, and long-term cost savings, but they also make communities more resilient to climate change impacts. The scope of what costs to include in any analysis is also crucial: adaptation costs may increase several-fold if, in addition to measures that directly reduce climate damages, measures to improve baseline "adaptive capacity" are also included (OECD 2008). At the same time it is important not to double-count benefits or costs. The OCED report cautions that because of the uncertainty surrounding cost estimates, costs alone should not determine adaptation priorities.

III.ii.b. Co-benefits of Adaptation

Spillover benefits or costs are those side benefits or costs associated with an adaptation activity. The Intergovernmental Panel on Climate Change Fourth Assessment Report notes "adaptation measures are seldom undertaken in response to climate change alone" (Adger et al. 2007). The cost-effectiveness of adaptations is improved by the fact that most measures also reduce risks and costs associated with climate variability and hazards. For example, snowmaking is not only an adaptation to climate change but also to more general inter-annual variability in snowfall. Another example are the spillover benefits of transit-centered neighborhoods that reduce vehicle miles traveled[13], as well as congestion, and improve quality of life. Reduced vehicle emissions, in turn, can reduce summertime ozone levels resulting in fewer hospital visits for respiratory-related illness. In this example, the adaptation activity may also prevent the loss of federal highway funds. This is a disincentive for those cities that fail to implement plans to improve air quality after being designated a nonattainment area under the Environment Protection Agency's (EPA) National Ambient Air Quality Standards under the Clean Air Act.[14]

[13] VMT account for between 25% and 35% of all GHG emissions in the west. It is also a fast growing source of GHG emissions. Therefore "slowing the growth in ...VMT, is crucial to reducing ...(GHG) emissions – and more compact urban form is a major way to achieve this goal (Carter 2008).

[14] The EPA monitors eight-hour and one-hour ground-level ozone. Some counties in the IMW are already nonattainment areas; Phoenix and Mesa in Arizona, Las Vegas in Nevada, and Sierra, Nevada, Placer, and San Bernardino counties in California (EPA 2009a), and the Denver metro area in Colorado (EPA 2009b). The EPA

Because the EPA can tighten the standards every five years, and because warm weather worsens ground-level ozone, it is likely that some cities in the IMW that are already in non-attainment status will need to do more to reach, or maintain, attainment standards. Policies that reduce vehicle miles travelled, volatile organic compounds emissions,[15] or ameliorate the Urban Heat Island effect, will have the spillover benefit of reducing ground-level ozone. Another example is enhanced energy efficiency in new and old residential buildings that not only cuts energy use, saving homeowners and businesses money, but also improves comfort and could reduce heat stress-related health costs. Additionally, energy retrofits create green jobs, and demand management reduces the need to permit and construct new power stations. Because of associated spillover benefits many climate change adaptation measures are no-regret measures.

III.ii.c. Timing of Adaptation

Local governments have experience with medium-term planning horizons, for instance planning transportation, water, and wastewater infrastructure for projected growth. Planning for climate change also has a longer-term horizon. There are three factors that determine the efficient timing of climate change adaptation investments.

> "The first is the difference in adaptation costs over time. The effect of discounting would normally favor delay in adaptation measures, and so would the prospect of potentially cheaper and more effective adaption techniques that might be available in the future. However, there is also a class of adaptations where early action is cheaper. They include adjustments to long-term development plans and long-lived infrastructure investments…The second factor is the short-term benefits of adaptation…Early adaptation will be justified if it has immediate benefits, for example by mitigating the effects of climate variability…Also in this category fall adaptations that have strong ancillary, benefits…The third component has to do with the long-term effects of early adaptation. Early adaptation is justified if it can lock in lasting benefits, for example by preventing long-term damage to ecosystems" (OECD 2008).

Despite the difficulties in measuring net benefits and timing climate proofing investments, climate change adaptation will either occur in a piecemeal fashion, as economic agents respond to climate change impacts, or via a more holistic process directed by government policy. If local governments plan for climate change policy, tools will likely include provision and regulation as well as education and incentives because of the necessity to modify and/or accelerate behavioral change by households and businesses.

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reviews the standards every five years based on scientific information. In the most recent 2008 review the EPA tightened the 8-hour standard to 0.075 ppm from the 0.08 ppm 1997 standard (EPA 2009c).

[15] Albuquerque's "Air Aware-Gas Cap Exchange Project" replaced faulty vehicle gas caps reducing volatile organic compounds leakage, reducing ozone pollution and its associated health impacts, as well as reducing GHG emissions (USCM 2007a).

III.ii.d. Economic Incentives

There is a critical role for economic incentives as well as direct regulation and public financing of climate change adaptation. Because of the cost-effectiveness of many adaptations, in part due to co-benefits, a degree of autonomous adaptation is expected. However, policy instruments can incentivize greater participation in adaptation behavior and investments. Local governments might use markets, create markets, regulate, or engage the public (OECD 2008).

There are particular challenges in protecting the resiliency of natural systems from climate change impacts. Namely "property rights over natural resources are ill defined and their services are not valued properly in the market" (OECD 2008). Local governments may resolve to protect the natural environment and the ecosystem services provided by riparian habitats, desert systems, or alpine regions by creating or expanding reserves. For example, the Sonoran Desert Conservation Plan[16] in southern Arizona by protecting large areas of the Sonoran Desert may reduce the vulnerability of species to adapt to a changing climate and protect ecosystem services for local and regional populations.

III.iii. Opportunities and Barriers to Climate Change Adaptation at the Local Level

The motivation for local governments to engage in any adaptation activity is a function of political will, capacity, the cost-effectiveness of specific programs, and funding. The difficulty for local governments is that "municipalities are reluctant to apply an authoritative mode of governing through regulative measures and strategic planning for climate protection…a lack of willingness to act locally in the face of political, business and public opposition can be observed – even if the capacity to intervene exists" (Alber and Kern 2008). Nevertheless, it is easy to overstate the challenges. The bottom line is that designing lower-carbon communities, planning for hotter summers and more flooding, and thinning forests to reduce wildfire risk, is relatively straightforward. However, persuading the public that these investments should be made and funded will require creativity and commitment.

Many U.S. municipalities, and even small towns, probably have the "adaptive capacity…to improve resilience and manage adaptation" (Alber and Kern 2008). There may also be a competitive advantage to being a leader in sustainability. Companies decide to locate where their workers wish to live. A good example of a progressive city in the United States is Portland, Oregon. Portland attracted Intel, numerous other technology and brand companies, like Nike, in part because the city offers a high quality of life with livable, transit-centered neighborhoods. Many local governments understand the advantages of being a leader, not a laggard, in building sustainable, high quality-of-

[16] See Pima County website at, http://www.pima.gov/CMO/SDCP/

life cities.[17] In the IMW a number of cities and communities have voluntarily engaged in climate change policy. This is not to underestimate "that the process of translating a rhetorical commitment to climate protection into effective policies is far from straightforward" (Betsill and Bulkeley 2006).

Carter (2008) identifies six main obstacles to climate change action in the IMW; these can be grouped into two main categories, lack of political support, and lack of planning resources. There is a general lack of political support for climate change mitigation or adaption policies outside of the major urban areas and resort communities in the IMW. Public apathy is partly an outcome of "party affiliation and (the) lack of effective education…. (and) preferences for energy consumptive lifestyles" (Carter 2008). In addition "long-standing cultural beliefs about limiting the role of government and protecting private property and citizens' rights, (mean that) such areas may have a history of resisting zoning and other policies that would regulate land use patterns or growth issues" (Carter 2008). Nevertheless, high gas prices in 2007 and 2008, and the 2008 Presidential Election[18] changed the landscape of many IMW states perhaps making communities more receptive to adaptation, particularly if the public is educated about the IMW's vulnerability and the cost-effectiveness of many adaptation policies. A particularly effective approach may be to shift the debate from climate change to "energy independence (e.g. wind power generation) and…reviv(ing) rural economies" (Carter 2008). A focus on the spillover benefits of climate change adaptation programs might also overcome any concerns that citizens have about the "value of local action on climate change" (Carter 2008). A final barrier in this arena is perhaps the perceived lack of peer communities to learn from, however as Carter (2008) points out, eight of the 11 IMW states, have climate action plans, and when climate change adaptation is viewed through a broad lens, i.e. energy independence, there are many more communities to learn from.

A second set of obstacles identified by Carter (2008) coalesces around capacity. Climate change can seem overwhelming and many local governments cite the lack of resources, both human and capital, to invest in climate resiliency. However, many climate change mitigation and adaptation policies have a quick payback or can save local governments money. Given the vulnerability of the IMW and resistance to acting in the face of uncertainty, Carter (2008) suggests, "enacting effective mitigation policies that also have adaptation value ... (as) a key first step". This approach not only would improve current resiliency but also reduce the necessity for more expensive adaptation in the future. Another issue is that planners and other decision-makers need local-specific, downscaled

[17] Nevertheless, it is important that all cities make progress in climate change adaptation. To this end Alber and Kern (2008) suggest that transnational city groups "counterbalance the gap between pioneers and laggards by setting tiered standards which attract members with varying levels of performance and ambition."

[18] In the 2008 Presidential election WA, OR and CA (voted Democratic in 2004), were joined by NV, CO, and NM in voting for the Democratic Presidential candidate. The Senate and House races saw pick ups for the Democrats too. In the Senate the Democrats picked up Senators in CO, MN and OR, and in the House AZ, CO, ID, and NV all picked up one Democratic house member while NM picked up two. Democratic governors are also in a majority in the IMW with governships in CO, MT, NM, OR, WA, and WY.

climate change impact information. There are resources that local communities can tap into other than transnational networks. For example, the National Oceanic and Atmospheric Administration's Regional Integrated Sciences and Assessments (RISA) program that supports climate based stakeholder relevant research. Four of the eight programs are in the west, and all the IMW states, except Montana, are covered by one of these RISAs (Carter 2008). Another resource that local governments can draw on is the Agricultural Extension Service based at land grant universities. Some, such as the Arizona Cooperative Extension Service, support a dedicated Climate Science Extension Specialist.[19]

Political will and capacity are two significant obstacles, but probably the largest obstacle to climate change adaptation investments at the local government level is funding. Although some cities, such as Boulder, Colorado and London in the United Kingdom have raised new taxes to pay for climate change adaptation, this is the exception.[20] In contrast, Canadian municipalities can apply to the Green Municipal Fund for grants and low-interest loans for mitigation and adaptation activities. This fund is managed by the Federation of Canadian Municipalities and was endowed with C$550 million (~$494 million) by the Canadian government (FCM 2009). Meanwhile, although the Energy Independence and Security Act of 2007 authorizes up to $2 billion annually be made available to cities and towns in the form of energy efficiency and conservation block grants, the funds have to be appropriated by Congress each year (Alber and Kern 2008). Yet, a significant boost in funding for state and local government renewable energy and energy efficiency initiatives arrived with the American Recovery and Reinvestment Act of 2009. The "stimulus package" includes $3.2 billion in funding for energy efficiency and conservation block grants, $3.1 billion for State Energy Programs for renewable energy and energy efficiency technologies, $5 billion for the Weatherization Assistance Program, $300 million for the Clean Cities Program which provides assistance for cities to purchase higher fuel efficient vehicles, and $400 million in grants for transportation electrification. Many of these programs rely on state and local governments to apply for, and dispense, grant funding.

Other sources of funding for energy-related adaptation spending is the U.S. Federal Budget for Fiscal Year 2010 (OMB 2009). The budget, though not yet approved, proposes to reduce America's GHG emissions[21] through a GHG emissions cap-and-trade program. Emission permits would be auctioned with up to $150 billion from the auction

[19] Dr. Michael A. Crimmins. The University of Arizona. College of Agriculture and Life Sciences. Soil, Water and Environmental Science. http://ag.arizona.edu/swes/people/cv/crimmins.htm

[20] In 2006 Boulder, CO voters approved Initiative 202 that introduced the Climate Action Plan Tax. The tax is collected by the electric utility on electricity consumed. The tax is set to expire in 2012. It raises around $1 million per year that is channeled to energy efficiency programs. The average household pays $1.33 per month and the average business $3.80 per month (CiBCO 2006). Since 2003 The City of London in the UK has levied congestion charges. In 2009 vehicles pay £8 per day (~$13/day) to drive into Central London with some discounts and exemptions (TFL 2009). By law the revenue from the charge is invested back into London transport. The congestion charge has reduced the number of vehicles entering the congestion charging zone, increased ridership on buses, and increased bicycling.

[21] The proposal is to cut emissions by 14% from 2005 levels by 2020 and by ~83% from 2005 levels by 2050.

dedicated to renewable energy investments over a 10-year period starting in Fiscal Year 2012. Meanwhile, the reauthorization of the Transportation Act during 2009 (covering five years of program funding) offers an opportunity to increase funding for greener transportation. Success in cutting vehicle miles traveled has been elusive in Europe, Japan, and the United States, which has meant that the proportion of GHG emissions from this sector continues to rise, despite gains in average fuel efficiency. A comprehensive transportation plan integrated with climate change policy could tackle this issue.

IV. Climate Change Impacts and Actions in the Intermountain West

Climate change impacts in the IMW will not be exactly similar to those facing other communities in the United States. For example, in the IMW there is no coastline, the region is highly urban, it contains large tracts of federally managed and tribal lands, and there are large distances between major metropolitan centers, which makes solutions like high-speed rail less viable in some instances. Table 1 provides a summary of the main climate change impacts and potential adaptations. Following Table 1, case studies of climate change adaptations in urban, rural, and amenity IMW communities are presented.

Table 1: Intermountain West Climate Change Impacts and Possible Adaptations

Impact	Adaptation
Less snowpack at lower elevations, shorter ski seasons	Snowpack is a significant reservoir in the IMW. Adjusting to less overall snowpack and earlier snowmelt may require new infrastructure (dams), more conjunctive use, and conservation. Snowmaking is the worldwide adaptation technology but it also requires significant quantities of water and energy. Cities may contract with ski resorts to lease treated effluent for snowmaking. In some cases it may be possible to shift runs to higher elevation or to concentrate snowmaking on those runs that are more favorable because of aspect or elevation. Other adaptation strategies include more intensive use of resorts during a shorter ski season through marketing and pricing. Some resorts, particularly those at low latitudes, e.g. in New Mexico and Arizona, and those at low elevations may close. The snowmobiling and cross-country sectors may decline, as snowmaking is infeasible for these sports.
More flooding	Regulation of floodplain development based on new maps of at-risk areas. Local governments may have to increase property buy-outs. Climate proofing infrastructure. New or enhanced flood control infrastructure may be needed and concurrent efforts to reduce urban runoff may be cost-effective, such as rainwater harvesting, storm runoff capture and recharge, and permeable pavement, etc.
Droughts – more extensive and longer in duration	Increased pressure on water resources for humans and ecosystems. Many surface waters in the IMW are over-allocated and dedicated allocations to environmental flows are often absent. Competition between users is likely to increase and without explicit environmental flows aquatic and riparian ecosystems will likely degrade. In some states legislation will be needed to permit environmental flows. To reduce water supply reliability risks some communities may build reservoirs or increase conjunctive use. Groundwater management in many aquifers should be enhanced. Increased treated effluent use for environmental flows, landscaping, power plant cooling, and recharge. New infrastructure and management guidelines are being developed in some watersheds, e.g. the Colorado River, to reduce shortage risk. Regional water authorities with a more diverse portfolio of water supplies and funding sources may provide a better model for sustainable water supplies than multiple small water utilities. Demand-side management through block rate pricing, water-efficiency rebates, and education campaigns. The Southern Nevada Water Authority's successful campaign to reduce water consumption could be a model. On the regulatory side,

	assured water supply rules for urban and rural dwellers and habitat conservation efforts. In farming: better climate information, research and development on heat-resistant varieties, new tillage regimes, efficient irrigation systems, dry-year option contracts with cities/environmental groups.
Heat stress and the Urban Heat Island effect	The 2003 European heat wave resulted in thousands of deaths, particularly in France, and of the elderly. Other impacts were forest fires, disruptions to rail travel, and avalanches triggered by glacier melt. All these impacts are possible in the IMW, particularly in those areas where people are unused to high temperatures. Programs to improve the energy efficiency of new buildings and retrofits of older buildings will not only reduce energy consumption and peak loads but also improve indoor comfort. Local governments will need to develop contingency plans for heat hazards. This could entail a heat alert system, the identification of vulnerable populations and the barriers to relief i.e. no air conditioning, no transportation to get to a cool place, the dissemination of public information, and the provision of transportation to cooling centers. Local governments could upgrade building and landscape codes and land use plans to minimize urban heat island buildup. Ozone pollution is exacerbated by heat. Local authorities could develop alert systems for high ozone levels to reduce related respiratory health impacts. In some cases local officials may need to implement plans to reduce driving on risk days, provide alternative transportation, or tax congestion.
Disease	The habitat of some disease vectors will expand with climate change. In some cases eradication programs may be developed, medics will require additional training to identify emerging diseases, and new efforts will be needed to educate the public about new risks and prevention behaviors.
Fragile ecosystems – tipping points and landscape level change, invasives and biodiversity	Conservation plans need to be integrated and comprehensive, yet responsive to changing conditions. Pest control, e.g. of bark beetle, through biological or other means. Promotion of coordinated actions on invasive eradication and control.
Wildfires	Restrictions on building in wildfire prone areas. Public education in the wildland-exurban interface on defensible space policies. Fuel reduction programs such as selective thinning. Public education about campfires, cigarette disposal, etc. During extreme fire danger periods closures of national, state, and local parks.

IV.i. Urban Community

The IMW is highly urbanized.[22] Given that cities are the number one source of GHG emissions and that much of the growth projected in the United States, and the IMW, will occur in urban areas, there is a very real opportunity for land use planners at the local government level to influence the design of cities at the macro and micro levels. Strategies could include transit-centered communities and energy efficient buildings powered by renewable energy. Comprehensive development plans that incorporate climate change mitigation and adaptation will not only ensure that the cities of tomorrow are more sustainable but also more livable. "Metro regions endowed with high innovative and creative capacities" (Alber and Kern 2008) are incentivized to meet climate change challenges. Such cities compete with other cities for sustainability kudos; however, many more urban centers are not endowed with such capacity, and for these communities the challenges of understanding possible climate change impacts on their communities, and responding to those challenges, are daunting. A first step is to understand that urban centers in the IMW are dynamic, and that this dynamism offers an entry point for local governments to foster climate change adaptation.

Of the top 10 states for projected residential growth in the period 2000-2030, eight are in the IMW: Nevada, Arizona, Utah, Idaho, Colorado, New Mexico, Oregon, and Washington. In Arizona, around 2.86 million units will need to be built in this period, meaning that by 2030, 54 percent of the total housing stock will have been built after 2000. For Utah, the figures are 0.92 million units, with 58 percent of the total residential building stock in 2030 being new build. Of the 10 fastest growing megapolitan areas, three are in the IMW, with Las Vegas in number one position, Phoenix at number three, and Salt Lake City at number eight (Nelson 2004).[23] The state trends for commercial and institutional buildings are somewhat different, but five of the top 10 growth states are in the IMW with the top three positions filled by Nevada, Arizona, and Utah.[24] Although the current economic slowdown has likely dampened growth from these projections, the take-home message is that because "half of what will be the built environment in 2030 doesn't even exist yet…the current generation (has) a vital opportunity to reshape future development…the challenge for leaders is to create the right market, land use, and other regulatory climates to accommodate new growth in more sustainable ways" (Nelson 2004).

Nelson (2004) notes that there are at least five reasons to believe that new development patterns will not necessarily parallel those from the 1990s, i.e. urban sprawl. First, many

[22] Data from the 2000 Census reports that urban population in the U.S. was 79% of the total. The following states in the IMW have higher rates of urbanization than the U.S. average: AZ (88.2%), CA (94.4%), CO (84.5%), and WA (82%) (USCB 2008). Rapid urbanization during the period 2000-2010 means that the 2010 Census will likely report higher urbanization rates in all IMW states with perhaps NM and OR surpassing the national average rate.

[23] Las Vegas is projected to need 0.81 million units which will mean by 2030 60% of the total housing stock will be new, the same numbers for Phoenix are 1.34 million units and 55% of total houses, and for SLC it is expected that 0.38 million units will be built and that by 2030 51% of the housing stock will have been built after 2000.

[24] By 2030 Nelson (2004) projects that 70% of all commercial and institutional units in NV will have been built after 2000, 69% in AZ, and 68% in UT.

growth cities in the IMW are hemmed in by federal or tribal land holdings, for example Phoenix, Arizona, and therefore will have to grow inward. Second, serving infrastructure to sprawling cities is expensive, which may incentivize local governments to encourage infill and urban renewal type developments. Third, gentrification can favor denser, more urban living (Carter 2008), and fourth, there is some evidence that preferences are shifting towards "new urbanism", i.e. more sustainable, lower-carbon neighborhoods (Carter 2008). Fifth, much of the growth will be for high-density, multi-family rental units. Because the next generation of residential, commercial, and institutional buildings is yet to be built, local governments in the IMW have a real opportunity through transportation planning, renewable energy ordinances, and building codes to promote transit-centered neighborhoods, comprising energy efficient, renewable-powered buildings. There is an opportunity now to literally design the urban communities of tomorrow.

There are examples of "new urbanism," or comprehensive planning, in the IMW. Albuquerque, New Mexico is one of the featured cities in the USCM's Best Practices Guide (USCM 2007b) for their ALBUQUERQUEGREEN program.[25] This comprehensive program has the potential to transform the Albuquerque of tomorrow. A key advantage of a comprehensive program is that "potential conflicts and trade-offs between climate change policy and other polices" are avoided (Alber and Kern 2008) and synergies and co-benefits can be more cost-effectively maximized. The program will make the city a test case for the implementation of climate change solutions. It will provide other similar IMW cities, like Tucson and Phoenix in Arizona and Las Vegas in Nevada, with a peer city upon which to model their own mitigation and adaptation activities.

IV.i.a. Urban Heat Island and Excessive Heat Events

The Urban Heat Island (UHI) "amplifies local temperatures and principally occurs when natural landscapes are converted to urban areas. Higher temperatures occur because dense concentrations of materials like asphalt and buildings absorb more heat during the day and release it more slowly at night than natural ground cover such as soil and vegetation."[26] See Figure 2. For example, in the period 1949-2005 researchers record that average annual minimum temperatures in Tucson, Arizona increased by 5.4˚F, of which 3.6˚F is attributable to the UHI (Comrie 2000). The UHI is of concern because

[25] "The plan…targets eight core areas: 1) Integrating the City's growth into a network of mixed use, compact, and transit oriented urban villages; 2)increasing transit use, walking, and cycling; 3) increasing energy efficiency of buildings and supplying them with renewable clean energy; 4) creating a network of connected green ways, parks, natural areas, and community gardens; 5) integrating decentralized, small scale, renewable resource-oriented infrastructure systems within existing large-scale systems; 6) integrating sustainability priorities into the City's culture; 7) ensuring that economic development includes a clear commitment to increased performance on sustainability objectives; and 8) ensuring that City management provides sustainability leadership by engaging City staff, key stakeholders, and the citizenry on sustainability initiatives and strategies" (USCM 2007b).

[26] Southwest Climate Change Network, at http://www.southwestclimatechange.org/impacts/people/urban-heat-island.

warmer minimum temperatures and higher average daily temperatures increase: the "misery hours" for residents; cooling energy use for businesses and residents; ozone levels and heat-related illness and death; crime; and plant and animal heat stress. "Secondary impacts of urban warming" might include social behavior impacts as children and adults spend more hours inside air-conditioned spaces rather than playing outside or walking in neighborhoods (Baker et al. 2002). The UHI is created by land use change/urbanization, however in combination with background climate change warming it will likely make many cities in the IMW much warmer over the next century.

Climate change models predict more, more extreme, and longer duration heat waves with many of the worst impacts in the IMW. Heat waves are a public policy concern because of increased morbidity and mortality during excessive heat events (EHEs) and because heat waves contribute to poor air quality and in some case to infrastructure damage. The UHI exacerbates EHEs because it contributes to "higher daytime maximum temperatures and less night time cooling…urban heat islands can increase health risks during EHEs by increasing the potential maximum temperature residents are exposed to and the length of time that they are exposed to elevated temperatures" (EPA 2006a). The EPA has guidelines for public officials and the public to prepare for and manage the effects of EHEs.

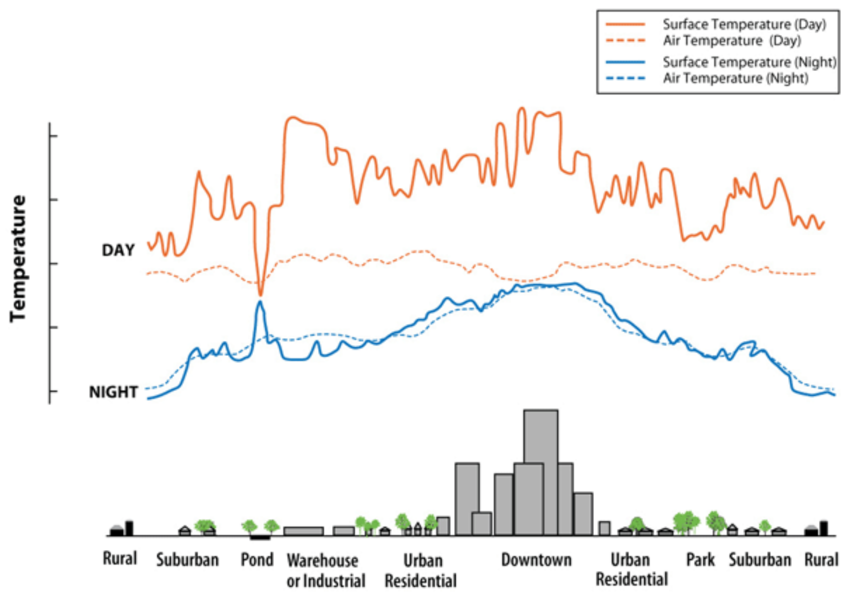

Figure 2: Heat island effect.
Source: EPA, http://www.epa.gov/heatislands/images/UHI_profile-rev-big.gif

The four main elements of the EHE program are: timely "prediction" of events; "risk assessment"; "notification and response"; and "mitigation" (EPA 2006a). EHEs must reflect local conditions since an event and its associated risks are a function of vulnerability and levels of adaptation. The EPA suggests a number of "community interventions" that public officials should plan for, including warning the public of imminent risks, providing information on what to do, and identifying at-risk populations (EPA 2006b). Other measures include the provision of transportation to public or private buildings designated as public cooling centers, extension of operating hours of public buildings used as cooling centers, suspension of utility cut-offs, and the rescheduling of large public outdoor events (EPA 2006a).

The EPA EHE report (EPA 2006a) reports on three EHE case studies in Philadelphia, Pennsylvania; Toronto, Canada; and Phoenix, Arizona. Phoenix is an interesting case study because although the city routinely experiences excessive heat, heat-related deaths are relatively low. Part of the explanation is that: relative humidity in the summer is low; access to air conditioning is widespread; local experience of heat and understanding of the hazard is high; and there is a general willingness to change behaviors in heat (EPA 2006a). Nevertheless, there is evidence that heat-related medical dispatches (morbidity) increase in Phoenix with the heat index[27] (Golden et al. 2008). Furthermore, the July 2005 EHE in Phoenix, provided evidence of what can happen with prolonged high temperatures, namely that "an exceptionally severe and long-lasting (two weeks) EHE can overwhelm even highly adapted populations" (EPA 2006a). Planning for an EHE of 30 days duration is different from planning for a seven-day EHE. Because it is unlikely that people will use cooling centers for extensive periods, if climate models predict increased duration of EHEs, there may be a need for more proactive adaptation and mitigation. For example, a preparedness plan might include retrofits of at-risk residences, e.g. for the poor, old, sick, mobility- and cognitively-impaired, the socially isolated, and those living on upper floors of buildings (EPA 2006a). Retrofits might include insulation, cool roofing, exhaust-fans and (efficient) air conditioners, as well as the provision of financial assistance for energy costs. These interventions will also constrain peak energy demands (OECD 2008).

Other adaptation measures will center on land use planning and design codes (Baker et al. 2002). The authors argue that mitigation is essential given that much of the projected population growth in the United States will be centered in metropolitan areas. UHI has already impacted some IMW metropolitan areas. Increased night time and average daily temperatures have increased the number of "misery hours" (Baker et al. 2002) in already hot, desert cities. For example, in the twentieth century urban temperatures in Phoenix increased by 4.2˚C compared to a 1.7˚C increase in more rural areas (Golden et al. 2008).[28] Higher temperatures are not uniform but spatially determined by type of development. For instance, urban core temperatures rose by 2.2˚C in the period 1990-2004, compared to 1˚C in infill areas, and by 0.5˚C for the desert fringe, all compared to an ex-urban reference temperature (Brazel 2007). New research has linked urban development and local temperatures in Phoenix: for every 1000 houses built in the period 1990 through 2004, mean minimum June temperatures within 1 km of a

[27] The Heat Index incorporates measures of both temperature and humidity in a "feels like" temperature.
[28] In the Baker et al. 2002 study they calculated that night-time temperatures rose 5˚C and average day-time temperatures by 3.1˚C, at the Sky Harbor Airport, from 1948 to 1995.

temperature station, rose by 1.4˚C. These "model coefficients provide planners and city officials with a tool to estimate the (localized) temperature effects of new home construction" that will "enable local planners to better understand the climatic effects of new home development in different zones of the city" (Brazel 2007). This information could also be used in designing heat emergency response plans and integrated mitigation measures. Programs could include increased tree and vegetative cover, green and cool roofs, and cool pavements. Many of these elements are incorporated in Phoenix's Downtown Phoenix Urban Form Project, the "connected oasis" (City of Phoenix, 2008). Many mitigation efforts have co-benefits, for example, the City of Phoenix suggests the connected oasis will create an identity and sense of place, advance economic development, and enhance tourism (City of Phoenix, 2008). Tourism dollars may provide an added incentive to act, because the UHI "compromise(s) the region's capacity to market itself as a year-round tourist destination" (Brazel et al. 2007).

The EPA has a guidebook on heat island mitigation and ICLEI has an Urban Heat Island Initiative program[29] that provides assistance to local governments. The program includes models for "developing a heat island resolution and a model policy framework" (EPA 2009d). Good practice examples are the City of Tucson, Arizona with its cool roof demonstration project. Tucson also requires that air-conditioned city facilities use cool roofing materials for new and replacement roofing. The city had to revise its "general bid criteria to ensure that materials used are equivalent to those on the ENERGY STAR Roofing Products list" (EPA 2009d). Other goals for demonstration projects are to help develop green jobs by creating demand, contractor certification, and training programs (EPA 2009d). Because neighborhood level heating varies substantially in large part as a response to neighborhood-level landscaping (Harlan et al. 2006), greenscaping is an important local-level mitigation strategy. Many cities in the IMW have tree-planting programs, for example Trees for Tucson and TreeUtah. These programs provide incentives for residential tree planting, advice on tree selection and strategic placement to provide shade and reduce energy consumption (EPA 2009d). More comprehensive planning efforts that incorporate heat island mitigation as a central goal can be found in Gilbert, Arizona, Highland, Utah (EPA 2009d), and Phoenix, Arizona (Baker et al. 2002).

IV.i.b. Urban Renewable Energy and Energy Efficiency

The DSIRE database is an incredible resource that documents by state all utility, local, and state financial incentives for renewable energies and energy efficiency, as well as all local and state rules, regulations, and policies that enable and incentivize the wider uptake of renewable energy and energy efficient appliances, fleets, and buildings (DSIRE 2009). The IMW states have suites of financial incentives and enabling rules and policies for renewable energies and energy efficiency. For example, in the financial incentives category there are state personal/corporate tax credits/deductions for renewables, green building incentives, property tax assessment reductions and exemptions, solar tax exemptions, and utility/state loan and rebate programs. Under the

[29] http://www.iclei.org/documents/Global/Progams/CCP/ICLEI_HotCities.pdf

rules, regulations and policies categories, IMW states have appliance/equipment efficiency standards, building energy codes, contractor licensing, energy standards for public buildings, equipment certification, green power purchasing, interconnection and net-metering policies, renewables portfolio standards, solar access law and solar and wind permitting standards, that all in some way facilitate, and/or accelerate, the diffusion of renewables and energy efficiency at the local level. Below we expand on some of the policy options undertaken by IMW cities.

A number of IMW cities are implementing incremental climate change-reduction and -proofing policies. The City of Tucson, Arizona[30] has developed a: Drought Preparedness and Response Plan (2003-2007), signed the Mayors' Climate Protection Agreement (2006), opened an Office of Conservation and Sustainable Development (2006), developed a Framework for Advancing Sustainability (2008), completed a Regional Greenhouse Gas Inventory (2008), passed a Rainwater Harvesting Ordinance (2008), set up a Climate Change Advisory Committee (2008-ongoing) and a Joint City-County Water Task Force (2008-ongoing), and supports Community Initiatives. City officials use ICLEI's guidebook for local, regional and state governments on preparing for climate change (ICLEI 2007).

The 2006 GHG inventory reported emissions of 7.32 million metric tons (MMT) CO_2e (up 34 percent from 1990 levels) of which just 2 percent were attributable to government activities.[31] This inventory exposes the reality of GHG abatement: individuals and businesses must shoulder the bulk of emission reductions, but there are things that local governments can do to incentivize and facilitate mitigation and adaptation. There may also be a role for the provision of public transportation options. David Schaller, Administrator, Office of Conservation and Sustainable Development, City of Tucson, summed it up, stating that the role of local government is to "keep options open" and that "inaction is not an option" and "good governance involves risk management and building up the community's resilience." He compared climate change preparedness to local emergency preparedness, but over a longer time horizon. City officials also recognize that early actions might avoid high economic and social costs of delayed adaptation, and that many adaptation measures deliver multiple community benefits. For example, rapid solar energy deployment creates local jobs, keeps money locally, and positions the city securely in regional and global economy.

Tucson has a number of initiatives to improve energy efficiency and promote renewable energy. Tucson's Solar Program has installed photovoltaic and solar thermal systems on city buildings and in doing so tackled some barriers to green energy. These barriers included changing the bid process so that officials could consider the life-cycle costs of

[30] Pers comm. David Schaller, Administrator, Office of Conservation and Sustainable Development, City of Tucson. May 13, 2009.
[31] The residential sector contributed 24% of the total, commercial 20%, industrial 19%, transportation 33%, and landfill gases 4%.

solar power, and not be forced to accept the lowest-cost bid. This program also required officials to overcome warranty and construction concerns, and to develop partnerships with utilities, and to apply for grants (USCM 2007b). In a creative partnership the city pays for energy audits for commercial clients, and Tucson Electric Power, the main electricity utility, pays for the energy efficiency upgrades identified. On the regulatory side, on June 17, 2008 the city passed an ordinance that all new single family and duplex residential properties must have solar stub-outs for photovoltaic and solar hot water systems effective March 1, 2009 to receive a building permit. State tax code was modified to provide a tax rebate for each stub-out. Tucson Electric Power has its own set of incentives. Residential and commercial customers can choose up-front incentives or performance-based incentives to help pay for solar water heating and solar photovoltaic electricity.[32] [33] These are in addition to state and federal tax credits that reduce the cost of the system to the customer. At the state level the Arizona Corporation Commission has renewable energy requirements for energy utilities out to the year 2025. The requirement for 2009 is 2 percent of retail kWh sold, rising to 5 percent in 2015, 10 percent in 2020, and 15 percent of all retail power sold from 2025.[34] These requirements accelerate the development of renewables in the state.

Also at the state level, there are a number of house bills in the 2009 session that if passed would incentivize climate change adaptation in Arizona. For example, HB2335 *Improvement districts – renewable energy* would create improvement districts in cities that could bond for energy efficiency and solar energy investments paid for by higher property taxes. The ALBUQUERQUEGREEN program also utilizes conservation bonds to fund energy efficiency and renewable energy (USCM 2007b). Bonds are a useful financial tool to overcome two significant barriers to the wider uptake of energy efficiency measures and renewable energy: high upfront costs and uncertainty about recouping the investment. Bonds spread the payment over a longer time horizon, and the investment is tied to the house, not to a particular homeowner. HB2336 would create County Renewable Energy Incentive Districts to do the same thing in unincorporated areas. Meanwhile, HB 2332 *Schools; energy contracts* would "allow(s) school districts to enter into energy performance and renewable energy power purchase contracts and utilize the savings realized from these contracts." Finally, HB2329 would cap permit fees for residential photovoltaic and solar water heating systems, while HB2337 would tighten energy standards for residential, commercial and state buildings.[35]

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[32] See Tucson Electric Power website at, http://www.tucsonelectric.com/Green/Home/Solar/spaceheating.asp and http://www.tucsonelectric.com/Green/Home/Solar/electric.asp

[33] See Tucson Electric Power website at, http://www.tucsonelectric.com/Green/Business/Commercial.asp

[34] 2007 Renewable Energy Standard and Tariff Rules. Appendix A, R14-2-1804. http://www.azcc.gov/divisions/utilities/electric/res.pdf

[35] The bill if passed would establish voluntary statewide goals for the construction of energy efficient residential and commercial buildings based on the 2006 International Energy Conservation Code (IECC) as published by the International Code Council: 15% of new buildings are on average more efficient than the 2006 IECC in 2012; 30% of new buildings are on average more efficient than the 2006 IECC in 2016; and 50% of new buildings are on average more efficient than the 2006 IECC in 2020.

The USCM Best Practices Guide describes programs that deserve merit. Salt Lake City's Environmentally and Economically Sustainable Business Program (e2 Program) focuses on providing information and research to small- and medium-sized industrial and non-industrial businesses to assist them in saving money through efficiency and sustainability activities. The program includes an "e2" brand (USCM 2007b). The Colorado Springs Utilities has a rebate program to reduce demand. Rebates are available for homeowners who purchase energy efficient household appliances, lighting and insulation. Commercial customers can also receive efficiency rebates for high-efficiency lighting and for reducing peak demands (USCM 2007a). The utility also offers rebates to install solar photovoltaic systems and has a net metering program so that participants receive credit for the solar power their systems generate (USCM 2007a). The rebate programs save energy and water, reduce summer peak demand, generate more clean energy and are "funded through avoided or deferred operational costs or rates" (USCM 2007a). These types of focused programs also contain lessons in overcoming barriers to implementing climate change protection policies that can be useful for other cities in the IMW.

IV.i.c. Urban Water Resources

Urban water supply reliability is a serious concern in many IMW states. Drought is a common occurrence in the semi-arid areas of the region. Climate change model projections of precipitation are less reliable than temperature projections, but the combination of higher temperatures and shifting precipitation patterns will likely result in more frequent and intense droughts, reductions in stream flows, and lower reservoir elevations. In turn this will impact water supply reliability, water quality, aquatic and riparian habitats, navigation, hydroelectric power generation, tourism and recreation. Improving long-term water supply reliability will take a combination of supply-side and demand-side measures (OECD 2008), for example, desalinating brackish water and water transfers and water efficiency rebates and increased reuse.

A prominent example, not in the IMW, but in California, links agricultural adaptation and urban water supply reliability via a market mechanism: a water transfer. Such market-based mechanisms may become more widespread as cities and irrigation districts[36] adapt to a more constrained water future. In 2002, the Imperial Irrigation District (IID) in southern California entered into a 75-year water conservation and transfer agreement with the San Diego County Water Authority (SDCWA). The SDCWA provided $130 million in up-front funding to IID to pay for on-farm and system-wide water efficiency investments (IID 2009). There also are funds to mitigate economic displacement from land fallowing. The initial phase of this program transfers water made available through land fallowing, but from year 19 of the agreement, conserved water will replace fallowed water. Up to 200,000 acre-feet of water a year will be transferred from IID to SDCWA. This landmark agreement demonstrates that water transfer contracts between irrigation districts and urban water providers are one mechanism to enhance water supply reliability for cities, while at the same time

[36] In the IMW irrigation districts often have large holdings of senior surface water rights.

providing funds for system, and on-farm water efficiency improvements, and cash payments for transferred water. It is likely that such transfers will become commonplace in the IMW.

An infrastructure-based project to enhance urban water supply reliability is the Drop 2 Storage Reservoir just north of the U.S.-Mexico border, made possible by joint funding from California, Arizona and Nevada. This reservoir will facilitate better management of Colorado River water deliveries to the downstream nation of Mexico that will reduce annual delivery overages that average 69,000 acre feet of water. This project is now possible under the new system management rules passed in 2007 (Reclamation, 2007; ROD 2007). The project is expected to conserve 600,000 acre-feet of water over the period 2011 through 2036, water that will be divided between the contributing states in proportion to their contribution to reservoir construction costs.[37] After 2036, the water conserved by Drop 2 will remain in Lake Mead, reducing the probability of future shortages in the basin. This project is one of several under new Colorado River system management rules that allow for more creative, flexible solutions to future water supply reliability concerns.

Arizona's Water Banking Authority (AWBA) is a state-based program for improving urban water supply reliability. The AWBA created in 1996 banks, or stores, Arizona's unused Colorado River allocation in order to secure future water supplies in the state. Banked water will be recovered as needed.[38] By the end of 2007, the AWBA had stored 3,013,614 acre-feet of water, of which, 527,447 acre-feet of water was stored for the neighboring state of Nevada. The remaining 2,486,167 acre-feet of water has been stored to secure water deliveries for small communities along the main stem of the Colorado River in Arizona, and urban, commercial and Native American water users in Maricopa, Pinal and Pima counties (AWBA 2008).

Another example of innovative thinking is the Southern Nevada Water Authority (SNWA). SNWA is a regional water authority providing water for the Las Vegas Valley, Nevada. In addition to Drop 2, SNWA is developing other Colorado River system projects, and has water banking programs in Nevada, with California, and a large (up to 1.25 million acre feet of water) program with Arizona.[39] SNWA has an impressive water conservation program, which has reduced "annual water consumption…by nearly

[37] Nevada's Southern Nevada Water Authority (SNWA) agreed to pay $115 million of the total $172 million construction cost in return for an additional 400,000 acre feet of water allocation which will be available for the period 2011 through 2036. Arizona's Central Arizona Water Conservation District (CAWCD) and California's Metropolitan Water District of Southern California (MWD) each agreed to contribute $27.8 million to the construction costs in return for an additional entitlement to 100,000 acre feet of water each over the period 2016-2036.

[38] See AWBA website at, http://www.azwaterbank.gov/awba/

[39] A brief description of these Colorado River conservation projects can be found at http://www.snwa.com/html/wr_colrvr.html

21 billion gallons[40] between 2002 and 2008 despite a population increase of 400,000…(The) conservation goal (is to reduce use to) 199 gallons per capita per day (GPCD) by 2035 (through conservation programs, incentives, and rebates). The community used 254 GPCD in 2008".[41] The focus of water conservation has been on outdoor water use.

The profile of water use by SNWA customers explains the focus of their conservation programs on outdoor water use. Of total water supplied in 2006, 44 was used by single-family residences, and 15 was used by multi-family residences. Within the residential sector, 70 percent of total demand was used outdoors, essentially a consumptive use.[42] SNWA provides a residential landscape rebate of $1.50 per square foot of grass removed, for the first 5,000 square feet, after which the payment reduces to $1 per square foot. This program saves on average 55 gallons of water per year per square foot of turf removed.[43] SNWA also offers rebates on rain sensors and sophisticated smart irrigation controllers that can save 500 gallons per household per rainy day. Other rebates tackle other outdoor water uses, such as pool cover rebates available for temporary and permanent mechanical covers that can save between 10,000 to 15,000 gallons of water each year. SWNA also partners with NV Energy to incentivize homeowners to upgrade their pool pumps and save up to $200 per year on energy costs.[44] SNWA also provides incentives and rebates for other water efficiency programs such as water efficient car washes, and for commercial and industrial users, golf courses, multi-family units, and hotels and resorts that can benefit from a linen exchange program.[45] All of these programs not only save water and energy for customers but also conserve southern Nevada's water resources for times of drought and future growth. These programs will continue to provide real examples of the costs and benefits of various incentives and rebate programs, in terms of reduced water/energy use, and also provide practical advice on overcoming barriers to uptake that could be lessons for other water and energy utilities in the IMW.

Another IMW urban water utility that has recently stepped up efforts to conserve water is Tucson Water, which is a department of the City of Tucson in Arizona. It serves approximately 775,000 people in a 350-square-mile service area. Tucson Water has an inclining block rate charge for residential water use.[46] The utility has a high efficiency toilet rebate also available for multi-family and commercial facilities. For commercial and multi-family properties the utility offers irrigation system upgrade rebates[47] and free

[40] Approximately 64,447 acre feet of water out of a total 500,000 acre feet per year water supply.
[41] See SNWA's website at, http://www.snwa.com/html/wr_conservation_achievements.html
[42] See SNWA's website at, http://www.snwa.com/html/wr_conservation_water_use.html
[43] See SNWA's website at, http://www.snwa.com/html/cons_wsl.html
[44] See SNWA's website at, http://www.snwa.com/html/cons_coupons_pool.html
[45] See SNWA's website at, http://www.snwa.com/html/cons_biz.html
[46] Single family, duplex and triplex use charges are $1.23 per 100 cubic feet (Ccf) for the first 15 Ccf used, $1.23 then for use 16-30 Ccf $4.52 per Ccf, for use 31-45 Ccf a higher charge of $6.41 per Ccf and for use over 45 Ccf the highest rate of $8.94 per Ccf. See TW's website at, http://www.ci.tucson.az.us/water/rates.htm
[47] See TW's website at, http://www.ci.tucson.az.us/water/rebate.htm

installation of pre-rinse nozzles for restaurants and commercial kitchens in a joint program with Southwest Gas. Other incentives include a new WaterSmart Business Program (since fall 2008) where businesses can win recognition at the copper, silver, gold and platinum levels depending on their level of water saving. The utility also has a strong, long-standing reclaimed water program that supplies 14 golf courses, 35 parks, 47 schools, and 700 single-family residences. In 2005, reclaimed water deliveries saved 15,038 acre feet of drinking water, enough to supply 39,000 families for a year.[48] The city also recharges treated wastewater at an artificial wetland.[49] The water is recovered and used during summer months and in the fall, for reseeding golf courses, when demand for reclaimed water is at its peak. The success of the reclaimed water program required enabling legislation, rules, regulations and design standards, at the city, county and state levels. The city has also been a leader in rainwater harvesting. The first commercial rainwater-harvesting ordinance in the United States was passed in 2008 in Tucson. [50] The ordinance requires a landscape water budget for all new commercial developments and that a minimum 50 percent of the budget is supplied by harvested rainwater. These programs are a model that could be adapted by other urban water utilities in the IMW.

IV.i.d. Flooding and floodplain development

The other main water-related threat is damage from flooding. Many climate change models predict larger and more frequent flooding. There is a role for local governments to play in flood proofing their communities through investments in mitigation and adaptation activities such as riparian habitat rehabilitation, concrete lining of river banks, the buy-out of homes in the floodplain, and information provision. The federal National Flood Insurance Program (NFIP) provides incentives or subsidies for communities to participate in the Community Rating System (CRS). Specifically, local government-funded flood mitigation activities "that exceed the NFIP's minimum floodplain management standards" are scored[51] and "communities that implement programs to improve their flood preparedness rating are rewarded with insurance premiums discounts"[52] (Zahran et al. 2009). The NFIP CRS program incentivizes local residents, who pay the reduced premiums, to persuade local governments to fund community-wide

[48] See TW's website at, http://www.ci.tucson.az.us/water/reclaimed.htm

[49] The Sweetwater Wetland facility recharges an average 6,500 af year.

[50] The city had to modify Tucson Code (Chapter 27, Water, Article 1, Section 27-15(A)) to include this provision. Ordinance No. 10597, October 14, 2008 http://www.ci.tucson.az.us/water/docs/rainwaterord.pdf

[51] "The CRS rewards 18 flood mitigation activities organized into four categories of flood management. Series 300, or public information activities, involve local government actions that inform local populations about flood hazards, insurance, and protection measures. Series 400 activities (maps and regulation) involve regulatory enactment and enforcement actions that exceed the NFIP minimum standards. Series 500 activities (damage reduction) involve damage reduction measures like acquiring, relocating, or retrofitting existing buildings and maintaining drainage and retention basins. Series 600 activities (flood preparedness) coordinate local managerial efforts to minimize the effects of a flood on people, property, and building contents. Up to 4500 points are awarded for flood mitigation activities, with points earned by a locality corresponding to financial benefits in the form of flood insurance premium discounts" (Zahran et al. 2009).

[52] For example, for a score between 500 and 999 a community would receive 5% discount on both Special flood hazard area (SFHA) premiums and non-SFHA premiums. For a score between 2000 and 2499 the discounts are 20% and 10% respectively, and the maximum score 4500+ the premium discounts are 45% and 10%, respectively (Zahran et al. 2009).

flood protection activities. Zahran et al. (2009) find that the NFIP CRS program encourages both local government flood mitigation activity and the purchase of more subsidized flood hazard insurance policies. However, the

> "CRS program actually rewards floodplain in-migration and development through lower insurance premiums. Such unintended consequences of policy create a situation of "moral hazard"…(whereby) economic agents in response to a policy or program… makes them less careful about their actions than true losses would dictate, effectively changing the likelihood of incurring those losses…In the present case, potential homeowners and/or businesses may be more willing to move into high-risk flood areas than is socially optimal, since the NFIP reduces the cost of associated floodplain insurance."

Given that climate change is projected to increase flood risk, it is paramount that the incentive structures in the CRS are modified, so that local government flood preparedness activities are still encouraged, but that homeowners/businesses are discouraged from moving into the current and projected floodplain.

Chivers and Flores (2002) contend that the NFIP could be made more efficient, principally by discouraging residential development in the floodplain if property owners had sufficient information concerning flood risk and the cost of flood insurance. One aspect of the information problem is that homeowners often do not understand probabilistic forecasts and underestimate flood risk. Therefore part of the solution may include local governments making more effort to educate their constituents about probabilistic flood hazards (Kousky and Kunreuther 2009). Using survey information in Boulder, Colorado, Chivers and Flores (2002) found that homebuyers were ill-informed about the flood risk and flood insurance premiums for their new homes prior to closing, at which time it is often too late to renegotiate the sales price. Consequently, the price of a residence in the floodplain is often not discounted to account for the risk of flood damages and high flood insurance premiums so that development in the floodplain is higher than would be expected. They conclude that the information asymmetry between the seller and buyer is a barrier to the efficient operation of the NFIP. They suggest that the program could be improved by requiring sellers to provide buyers with a flood elevation certificate and a NFIP flood insurance quote prior to closing. Communities that require such disclosures could receive CRS points. Meanwhile, some IMW communities are providing their constituents with such information. Pima County in Arizona, where Tucson is located, has developed an online search tool that allows anyone to view the floodplain status of any home in the county.[53] The county also has a flood insurance and CRS website with information on the NFIP and links to calculators to estimate flood insurance premiums.[54]

[53] Pima County Regional Flood Control District's Flood Hazard Parcel Search http://buzz.dot.pima.gov/rfcdapps/parcelsearch/Default.aspx
[54] http://rfcd.pima.gov/fpm/insurance.htm

Accurate and up-to-date floodplain maps also are essential information for flood damage mitigation (Kousky and Kunreuther 2009). The Federal Emergency Management Agency (FEMA) has a program to modernize and update flood maps for use in the NFIP. It is necessary to update the maps because "flood hazard conditions are dynamic." Environmental conditions can change and risk is a function of development in the floodplain. Furthermore, the NFIP maps should be updated as better data and improved techniques for identifying flood hazard become available.[55] By providing updated assessments of flood risk, the maps allow local governments to improve management of the floodplain. The program will also digitize maps making them more accessible to local communities. Communities in the IMW are responding to new information including redrawing floodway boundary lines, for example in Boise, Idaho.[56] Meanwhile, the Western Governors' Association (2006) would like western states to adapt to future flood risk. Ideally local governments in the IMW would develop flood plans that include risk assessments of flood hazard given projected development in a watershed and under various climate change scenarios (Kousky and Kunreuther 2009).

Local governments in the IMW are investing in mitigation and adaptation activities that reduce flood hazard for their communities. For instance, Arizona's Pima County is revising its Riparian Habitat Mitigation Guidelines to ensure that development does not diminish the benefits afforded by riparian vegetation in reducing flood and erosion damage.[57] Meanwhile, provision 16.48.020 of Pima County's Floodplain and Erosion Management Ordinance requires flood detention basins for all residential, commercial and industrial development to mitigate the increased risk of flooding associated with development. The Flood Control District of Maricopa County, Arizona, where Phoenix is located, embraces structural, soft-structural, and non-structural (such as their Floodprone Properties Acquisition program) flood hazard reduction policies. This integrated approach to flood hazard reduction enables the district to leverage flood control projects so that they can provide multiple benefits such as groundwater recharge, recreation, and riparian habitat preservation and rehabilitation.[58] Local governments may also be able to use enhanced climate forecasts to plan for flood events (Wernstedt and Hersh 2001). Shorter term weather information can also be helpful in a flood warning system, for example, the Flood Control District of Maricopa County operates a network of real-time rainfall and stream flow gages to assess real-time flood risk.

Researchers note that the traditional approach of local governments to flood risk reduction is investing in flood protection structures and updating building codes. These approaches are often insufficient because flood risk remains; such investments may encourage encroachment in the floodplain, and flood control infrastructure can damage

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[55] http://www.fema.gov/plan/prevent/fhm/mm_main.shtm

[56] The Floodway Boundary Line may be relocated due to refinements of the floodway calculations based upon new information concerning the existing conditions (The City of Boise, Idaho Boise Municipal Code, Chapter 11-12 Floodplain Ordinance. Section 11-12-06.04 Relocating the Floodway (Line) B).

[57] http://rfcd.pima.gov/wrd/riparian/stdsrevision.htm

[58] http://www.fcd.maricopa.gov/Projects/PPM/planning.aspx

the flood calming properties of the riverine system. Stevens et al (2008) argue that the most effective approach is for land-use planners to direct development away from flood-prone areas. Their research finds that the values and the role of land-use planners are critical in mitigating flood risk (Stevens et al. 2008). Land use planners that value flood hazard mitigation and are willing and able to work with both stakeholders and those providing technical information are also most effective working with developers to steer development away from the most hazardous sites. The authors suggest that local governments should empower land-use planners to work with developers to influence design and location of proposed development with regards to flood hazard mitigation rather than relying solely on regulations. Such an approach would create the flexibility that some research shows may help to reduce any conflict between climate change mitigation and flood hazard adaptation activities[59] (Hamin and Gurran 2009) at the local government level. Integrated climate change land-use planning could address actual and potential conflicts. Kousky and Kunreuther (2009) suggest that the NFIP could be adapted to reward communities that plan for future potential increases in flood risk resulting from development and climate change.

IV.ii. Amenity Community

The IMW boasts many scenic landscapes, including numerous national parks such as Grand Canyon, Yellowstone, Grand Teton, Arches, Canyonlands, Zion, Bryce Canyon, Capitol Reef, Mesa Verde, Glacier and Great Basin, and National Recreation Areas like at Lake Mead and Glen Canyon (Lake Powell). The states of Colorado and Utah are home to many of the world's best ski resorts and other recreation opportunities center around the region's rivers and forests. The region also contains other large federal land holdings managed by the Bureau of Land Management, and the U.S. Forest Service, as well as a large number of Native American reservations.

IV.ii.a. Ski Resorts[60]

The IMW boasts some of the world's best ski resorts. However, we do not focus on these resorts in this section. Because they are world-class, due in large in part to their superior location in terms of high elevation and plentiful natural snowfall, these communities have sufficient financial and managerial resources to adapt to climate change impacts, at least in the mid-term, through a combination of technological and managerial adaptations. The region also is home to numerous smaller, more marginal, ski resorts that are already economically vulnerable to climate variability impacts, and are at risk from longer-term climate change impacts. These same resorts are often mainstays of their local winter economies.

The ski industry has long been recognized as vulnerable to climate change impacts. Climate change models predict declining snowpack and shorter snow seasons,

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[59] For example climate change mitigation might include higher density housing while flood hazard adaptation policies might require the setting aside of large tracts of land in the floodplain or for stormwater detention basins.
[60] This section is abstracted from Bark and Colby (2009) with permission of the authors.

particularly at low elevation and low latitudes. The result is that, without adaptation strategies, ski resorts will have to make a profit during a shorter season, or marginal resorts will close. Actual vulnerability will vary by resort as a result of elevation, latitude, aspect, size, diversification of business, and other factors. Adaptation measures can be technological "landscaping and slope development; a move to higher altitudes and north facing slopes; glacier skiing; and artificial snow making" or behavioral such as business diversification (OECD 2008).

The current global adaptation strategy is snowmaking. Private resorts, local communities, and sometimes the federal government are involved in financing snowmaking adaptation. A key reason for public support is that ski resorts, often located in rural regions, are often a mainstay of the local winter economy and a key employer. For example, in Arizona there are four ski resorts that cater to mostly in state, and some out-of-state skiers. Two of the resorts are small and marginal because of their relatively low elevation. The two other resorts are higher elevation, larger, and cater to around 250,000 skiers per season. They also have the financial resources (private and federal funds) to invest in snowmaking. Sunrise Park Resort (Sunrise) is located on the White Mountain Apache Reservation and is the only tribally owned resort in the state. The Arizona Snowbowl (Snowbowl) is the highest elevation resort in the state, the most northern, and is conveniently located on the outskirts of Flagstaff with easy road access to the largest metropolitan area in the state, Phoenix.

Different land ownership and water rights influence the relative ability of the resorts to adapt. Snowbowl's plans for facility expansion had to pass an environmental impact assessment because of its location on U.S. Forest Service land, and only after successful litigation with local tribes and environmental groups, have been allowed to proceed.[61] Water rights are a major restraint on future development of skiing in Arizona and were the focus of this legal action. Snowbowl has no water rights, and therefore its snowmaking plan was dependent on approval of a proposed water lease with the City of Flagstaff for treated effluent to manufacture snow at the resort. New snowmaking infrastructure will cover 95 percent of the skiable terrain. This investment will put Snowbowl on par with climate change vulnerable low elevation, high latitude ski resorts in central Ontario, Canada that have snowmaking capabilities for 100 percent of skiable terrain (Scott McBoyle and Mills 2003). Sunrise also has a snowmaking plan that is part of its proposed tribal water rights settlement legislation. The settlement would require the federal government to plan, design, and construct snowmaking capacity and infrastructure for all three peaks at the ski resort (Senate Bill 3473, §8 (d)). To fund this snowmaking investment, the bill requests a $25 million appropriation (Senate Bill 3473, §16(e)).

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[61] A consortium of tribes and environmental groups opposed using reclaimed water on the sacred San Francisco Peaks. In 2007 they won their case in a Ninth Circuit Court of Appeals ruling (Navajo Nation v. NSFS, 2007). Snowbowl operators appealed this decision arguing that snowmaking was necessary to ensure the future of the resort and the economic benefits it brings to northern Arizona. In August 2008 the Ninth US Circuit Court of Appeals overturned the previous ruling.

The future of the ski industry in Arizona is clear: the two large resorts will invest in snowmaking adaptation for most of their skiable terrain, to enable them to open more consistently in the short-term, and to remain open later in the century. Meanwhile, a couple of consecutive poor seasons, combined with land ownership and water resource constraints, may usher more rapid restructuring at the smaller resorts, which in turn would have a more immediate impact on the surrounding local economies. Their location on U.S. Forest Service land might indicate that the resorts will return to forestry or mixed-use, non-snow-based recreation. Many researchers have predicted such a pattern of closures worldwide, with marginal low elevation, and low latitude resorts being forced to close as the snowline migrates to higher elevations and higher latitudes. The bottom-line is that "location can be crucial to success" (US National Assessment 2000; see also OECD, 2006). Nevertheless, by the end of the century it is likely that Sunrise and Snowbowl will again be somewhat marginal despite their snowmaking investments, because temperatures during the ski season will often be too high to manufacture snow (Scott McBoyle and Mills 2003; Bark Colby and Dominguez 2009).[62]

The fortunes of Arizona's ski industry matter because the surrounding communities are dependent on the revenues, and employment, generated by the resorts. The ski industry is a notable winter season local economic driver and employer in the rural White Mountains (Sunrise) and in Flagstaff (Snowbowl) (Gibson and Evans 2002; USDA 2005). Gibson and Evans (2002) estimate a recreation dependency ratio for the entire White Mountains region.[63] A recreation dependency ratio is the percentage of total income in the region generated by the recreation sector. The White Mountains area is not as 'developed' as Flagstaff, and thus Sunrise is proportionately more important than Snowbowl to the local community. The authors estimate that the recreation dependency ratio in the White Mountains is 44 percent. However, this overall statistic hides variation between communities: the town of Sunrise's dependency is 90 percent and nearby Greer's is 79 percent. They also calculate a specific winter dependency ratio. The data show that although winter recreation is important to some communities in the region, overall this season generates just 27 percent of annual sales compared to the summer season's 33 percent. But Sunrise is highly dependent on winter recreation, with a winter dependency ratio of 60 percent. The White Mountains' winter recreation dependency ratio is more than three times higher than that of Snowbowl (USDA 2005). These data show that although the ski industry in Arizona is small, it is economically important to the White Mountain Apaches, and also to the surrounding communities in the White Mountains. It is also important to the Flagstaff area where Snowbowl is located. Importantly, the ski resorts bring winter tourism revenues that balance out peak summertime visitation patterns.

[62] Newer snowmaking equipment can efficiently make 15 cm of snow base per day at -2ºC compared to older equipment that makes just 10 cm snow base per day and requires lower temperatures of at most -5ºC.
[63] This includes the off-reservation towns of Show Low, Pinetop-Lakeside, Greer, and Springerville-Eager and Sunrise and Whiteriver on the reservation.

If Sunrise and Snowbowl were to close, winter season employment in the White Mountains region and in Flagstaff would be expected to decline. Current investments in snowmaking are likely to delay the decline in winter-recreation based revenues over the short term, easing the structural adjustment. A comprehensive regional development plan for a warmer and drier future is needed. This might include investment in alternative sectors such as four-season recreation and retirement (Gibson 1997). Longer-term climate change may boost non-winter recreation and revenues (Scott 2003; US EPA 2003). Both ski resorts have strong non-winter recreation programs.

A change in climate could further shift recreation visitation to the summer months, as Phoenix and Tucson valley residents seek respite from even higher summer temperatures. Second houses bought by such "Alpine-birds" might counter declines in real estate values near ski resorts expected as snow conditions worsen later in the century (Bustic Hanak and Valletta 2008). The shoulder seasons, spring and fall, might also benefit. Currently they account for just 20 percent each of annual recreation revenue in the White Mountains region (Gibson and Evans 2002). However, a change in recreation seasonality could have other implications. For example current tourism infrastructure might be inadequate to meet higher demand, or additional visitation might increase environmental stress.

Ski resorts are a proverbial "canary in the coal mine" for climate change local economic impacts. Climate change models predict shorter snow seasons, which undermine the longer-term economics of resorts. However, snowmaking investments enable resorts to adapt at least in the medium-term. Snowmaking also allows resorts to even out the impact of more general climate variability (Adger et al. 2007). But by the end of the century, this adaptation may no longer be technically viable, forcing resorts to optimize opening times with peak holidays, and to redirect resources to spring, summer, and fall recreation. Climate change is likely to accelerate restructuring in the ski industry worldwide, favoring resorts at higher elevation and latitudes, and also more geographically diversified companies, and those able to implement and afford snowmaking investments. In the IMW, the winners are likely to be resorts in the higher latitudes such as those in Montana and Wyoming, and at higher elevations in Colorado and Utah, while the losers may be in New Mexico, Nevada, and Arizona (Morris and Walls 2009). Policymakers need to develop a comprehensive regional development plan, particularly for more rural, ski-resort dependent communities, to ease future structural adjustment resulting from a drier and warmer future climate.

IV.ii.b. Federal Land: National Forests and National Parks

Many climate change impacts on national forests will also be experienced in national parks in the IMW. Forested areas weakened by drought and higher temperatures are vulnerable to beetle infestations that have caused unprecedented landscape-level tree mortality across the Southwest and IMW (Breshears et al. 2005; Mueller et al. 2005;

Shaw, Stead and DeBlander 2005; Gitlin et al. 2006; Raffa et al. 2008; Adams et al. 2009). Key concerns associated with regional tree die-off are a "reduction in habitat for wildlife, enhanced opportunities for invasion by exotic species, formation of novel communities, alteration to the hydrologic cycle, and temporal disruptions in ecosystem goods and services…(and) regional carbon budgets" (Adams et al. 2009). Other research has shown that regional warming may also be responsible for tree mortality in old-growth forests across the western U.S. and lower recruitment of saplings (Van Mantgem et al. 2009). The large-scale forest die-offs may be an early indicator of climate change stress in the IMW, and given that national forests and national parks are not only iconic U.S. recreation and tourism resources, but are also important to the local economies of many rural communities, it is imperative to assess management responses that might reduce negative impacts.

Fettig et al. (2007) analyzed the effectiveness of vegetation management practices for mitigating the negative impacts of bark beetle infestations in forest ecosystems, and also identified knowledge gaps that need to be filled in order to make informed treatment decisions. It is also necessary to find funding for mitigation activities. "Standing and fallen trees … (provide) large fuel stocks for forest fires" setting the stage of massive wildfires (Morris and Walls 2009). The American Recovery and Reinvestment Act of 2009 authorized $15 million for "'Wildland Fire Management hazardous fuels reduction" through the Bureau of Land Management, and a further $500 million for "Wildland Fire Management" through the USFS, of which $250 million is for "hazardous fuels reduction, forest health protection, rehabilitation, and hazard mitigation activities on Federal lands" and $250 million will be channeled to "State and private forestry activities including hazardous fuels reduction, forest health, and ecosystem improvement activities on State and private lands."[64] These programs will not only reduce fuel loads, improve forest health, and reduce wildfire risks, but will also generate jobs, and spur development of local biomass energy industries.

Wildfire damage and large-scale tree die-offs not only provide fuel for future wildfires, but they also compromise visitor experience at national forests and parks. This is in part because "deceased trees…pose a serious threat to the safety of recreationists" (Morris and Walls 2009) and because such areas have compromised scenery and viewsheds (Loomis et al. 2001). Wildfires also reduce visitation, and associated visitor spending in the local economy, because of closures. In the summer of 2008 officials in Colorado and Wyoming closed 38 campgrounds because of safety concerns surrounding massive tree die-offs (Morris and Walls 2009). The 2002 wildfire season in Arizona is estimated to have reduced visits to Sunset Crater National Monument by 12,000 visitors, which in turn reduced local economic spending by around $225,000 (Ponnaluru 2005). Morehouse, Frisvold and Bark-Hodgins (2007) found that visits to the Bandelier National Monument in New Mexico fell by 7 percent during a year of extreme drought, and by 21 percent with the Cerro Grande fire in 2000. Starbuck, Berrens and McKee

[64] For example, Arizona has received $8 million through the programs.

(2006) estimated the negative impact on local economies of catastrophic fires in New Mexico. Their research found that destructive fires reduce forest visits in the subsequent year by 7 percent, reducing recreation-based local economic output by $81 million. Following the severe 1988 fires in Yellowstone National Park, visits dropped 15 percent in the subsequent year, but recovered to pre-fire numbers the second year after the fire (NPS 2009). These studies indicate that there are economic incentives to reduce fire risk.

Loomis Gonzalez-Caban and Englin (2001) investigated hiker and mountain biker recreation responses to forest fires in Colorado national forests using visitor surveys. Specifically, the authors model visitation behavior at various time-steps after a crown fire and non-crown (prescribed burn or ground) fire. They find that hikers hike less in areas that have experienced crown fires, and take more trips to areas that have not had non-crown fires. They also found, somewhat unexpectedly, that hikers return quickly to areas with recent crown fires because they "typically experience a profusion of wildflowers," whereas they take time to return to areas that have experienced a non-crown fire. "The opposite pattern is evident … for mountain bikers. They take significantly more trips over time in areas that have had no crown fires or have largely recovered from crown fires…in areas with non-crown or ground fires; however, biking trips barely change over time." This difference between the responses of the different recreationists is probably attributable to the large number of obstructions caused by crown fires that require cyclists to dismount, and carry their bikes over downed trees. The authors recommend that the U.S. Forest Service "publicize the locations and recreation trails affected by a crown or high-intensity wildfire … (so that) visitors (can use) this fire-related information…to better satisfy their recreation preferences," and the overall recreation experience supplied.

Climate change is also likely to impact wildlife in national forests and parks. Landscape level change in forest habitats, higher winter temperatures, and changes in parasite and disease populations, will alter conditions for wildlife. Big game animals can migrate, but are constrained by suitable habitats. Some species may adapt better than others. For instance white-tailed deer and elk populations may expand, while moose populations will likely decline (WMI 2008). In turn, these changes in species types and numbers will affect local communities that are dependent on big game hunting. These communities may have to adapt by reducing hunting permits of at-risk species, increasing permits for other species, and modifying wildlife management practices to cope with increased risk of drought.

In addition to the ski slopes, rivers, and mountains, national parks in the region attract around 35 million visitors annually who spend an estimated $1.3 billion in the region (Ponnaluru 2005). Two national parks in the IMW are at high risk of losing their "namesake resources": Glacier and Joshua Tree. There are forecasts that all glaciers in Glacier National Park will disappear by 2030 with consequent changes to stream flow, aquatic life, and related habitats. The park drew 2 million visitors in 2007 (Morris and Walls 2009) but it is unclear that it will have quite the same attraction when the glaciers have gone. Meanwhile, higher temperatures will likely kill Joshua trees in the "southern half of the tree's range which includes the national park" (Morris and Walls 2009). Again, without the unique tree the nature of park visitation will change. The park is also a popular spot for rock climbing, horseback riding, mountain biking, off-road vehicles, and nature viewing (Morris and Walls 2009). Park rangers will have to adapt their management for these new uses.

Many researchers predict that climate change will boost overall national park visitation in the IMW. Using a survey instrument, Richardson and Loomis (2004) estimated how changes in climate might affect visitation in Rocky Mountain National Park in Colorado. They conclude that climate change is likely to result in increases in visitors, in large part because visitors respond positively to warmer temperatures. They argue that the main draw, alpine scenery, will remain largely unchanged, but that the seasonality of visitation will change, and the park, and surrounding communities, will have to adapt. The authors suggest that similar visitation pattern shifts are also likely in other high-altitude alpine parks, specifically Glacier, Grand Teton and Yellowstone. Similar impacts are also likely in other non-federally managed alpine regions in the IMW. The results from this study support the results of an earlier national study that concluded that climate change would result in net benefits for recreation-dependent communities (Loomis and Crespi 1999). However, park and recreation managers need to plan for shifts in visitation patterns, and perhaps more overall visitors, to ensure that they do not strain often fragile natural resources. Adaptation might include compulsory visitor shuttles to "eliminate traffic and parking problems (and pollution), protect vegetation and restore tranquility" such as those introduced in Zion National Park in 1997.[65]

Ma (2009) examines 25 years of visitation data for 42 sites in the national park system and reiterates earlier findings that warmer temperatures increase park visitation overall - warmer July temperatures discourage visits, but warmer January temperatures increase visits, except in low desert parks. The research suggests that the regional distribution of recreation visits will change. Tourism in northern Arizona, northern New Mexico, and southern Utah is likely to expand, but will likely decline in the southern parts of Arizona, New Mexico, and California. Losing communities will have to diversify income sources, while gaining communities will have to manage tourism growth.

Climate change impacts will also be apparent in shifted peaks in stream flows, perhaps lower stream flow and warmer water temperatures, as well as lower elevations in some reservoirs and lakes in the IMW. These changes will likely negatively impact river- and stream-based recreation, such as white water rafting, in the region. Ponnaluru (2005) estimated that for each 1 percent drop in Lake Powell reservoir levels recreation visits decline 5 percent. Other research reports that in response to the 5.4 percent decline in

[65] See National Park Service's website at, http://www.nps.gov/zion/planyourvisit/zion-shuttle-system.htm

Lake Powell's elevation and 2.1 percent drop at Lake Mead in the extreme 1999 and 2003 drought, half a million fewer visits were recorded at the Glen Canyon National Recreation Area (GCNRA) in 2003 and 900,000 fewer at Lake Mead National Recreation Area (LMNRA). The authors estimate losses in visitor spending of $32.1 million and a consequent loss of 758 jobs at the GCNRA and losses of $28.1 million and 680 jobs at the LMNRA (Morehouse, Frisvold and Bark-Hodgins, 2007). The federal government may have to close some national parks, create new parks or alter the boundaries of existing parks, and change management in the face of climate change impacts.

IV.iii. Rural Community

Water supply reliability is a growing concern in many communities in the IMW. Rural communities that rely on private wells, or small water utilities, are especially vulnerable, because they do not have the resources to diversify water supply sources or manage large storage reservoirs or aquifers. In Arizona since 1980, development within groundwater Active Management Areas (AMAs), which encompass the urbanized areas of the state, can only occur if the developer can prove that there is a 100-year continuously physically and legally available "assured water supply" (AWS). These AWS rules ensure that development is linked to water supplies. However, outside of the AMAs, essentially the rural areas of the state, a developer need only prove "adequate water supply". This rule is essentially like the AWS rules, except that if the Arizona Department of Water Resources determines that water supplies are inadequate, the developer may still sell lots, under the requirement that they inform the first buyers of the inadequate water determination. There is no legal requirement for any subsequent purchasers of the home to be informed of inadequacy.

Concern about the "long-term water reliability for water users and the downstream consequences of inadequate ground water management" prompted the state legislature in 2007 to allow "counties and cities (by unanimous vote of their elected officials) to disallow new subdivisions in areas that do not have a 100-year (adequate) water supply" (Bark and Jacobs 2009). As of April 2009, 13 towns and cities outside of the AMAs have become "mandatory adequacy jurisdictions" (ADWR 2009).[66] This example shows how rural communities can, through legislative action combined with community support, enhance the sustainability of their communities. A more sustainable rural community is likely to be more attractive to newcomers and businesses.

For some rural (agricultural) communities, climate change adaptation may include leasing water to cities or to environmental groups. Rural agricultural communities in the IMW often have large volumes of senior water rights. In some instances, irrigation districts, or individual farmers, may find it beneficial to enter into a dry-year option contract with a city, to temporarily lease water during drought periods. The contract

[66] Benson, Bisbee, Douglas, Huachuca, Sierra Vista, Tombstone, and Wilcox in Cochise County, San Luis, Somerton, Welton, and Yuma in Yuma County, and the towns of Clarkdale and Patagonia.

might be triggered, by low reservoir elevations (such as in Aurora, Colorado see UACWD 2004) or some other drought indicator, such as minimum stream flow (such as in the Klamath Basin, Oregon see GAO 2005). Once exercised, the participating irrigator will fallow annual crops, leasing the conserved water to the city or to environmental groups. The irrigator benefits if the lease price exceeds the expected returns from farming with the leased water, and other costs associated with the transfer such as expenses to mitigate soil erosion, while the city benefits by securing a drought water supply. The alternatives are either the city imposes involuntary supply cuts on its residential and commercial customers[67] (such as during the 2002-2003 drought in Denver, Colorado) or purchases water rights, so-called "buy and dry." Buy and dry permanently removes irrigated agriculture from rural areas, reducing farm-related purchases and employment in the region. Dry-year options are one mechanism whereby rural communities can actively respond to climate change impacts.

IV.iii.a. Ranching and Farming

Warmer temperatures that result from climate change are expected to impact agriculture, human health, and energy and water demand. Some of the impacts on farming are known because warmer temperatures associated with the Urban Heat Island have already brought forward the sowing and harvesting dates of some major crops. For example cotton was sown 14 days earlier and harvested 22 earlier, on average, in the period 1997-2000, in the Phoenix valley than in a rural area directly west of the metropolitan area (Baker et al. 2002). Heat-related stress to cotton plants reduces the quality of the cotton crop and also reduces dairy production (Baker et al. 2002). There is other research that suggests drought, and reduced forage, may lead to delays in breeding, and reduced body weight of calves and cows (Eakin and Conley 2002). Ranchers and other farmers are continuously adapting to climate. Climate change will be yet another uncertainty that they must minimize through pasture rotation, water tanks, supplemental feed, and management decisions about the optimal time to stock and destock herds, and the participation in federal subsidy programs. However, there is some evidence that "farm level adjustments (planting different varieties or shifting the sowing and harvesting calendar), which are assumed to cost very little, can lead to significant benefits in terms of offsetting damages" (OECD 2008).

A similar pattern to regional losses and gains in tourism in the IMW is likely to be repeated in agriculture (Adams et al. 1998). Agriculture-dependent communities will need to respond to climate change induced shifts in agricultural revenues and employment. There is a role for local government intervention particularly in the development and interpretation of climate information (Adams et al. 1998; Eakin and Conley 2002). The aforementioned NOAA RISAs have a mission to reach out to stakeholders with relevant climate information. The need for such information will likely expand, and the RISAs must find ways to provide it.

[67] Landscapes and lawns browned and golf courses were closed during the drought to protect the fairways.

V. Conclusions

Downscaled general circulation models predict severe climate change in the IMW. Climate change impacts will include higher summer temperatures, more frequent and devastating wildfires, likely landscape level vegetation change, less snowpack, earlier snowpack melt, more frequent, intense, and longer duration droughts, and also flooding. These impacts will entail higher costs to local governments but will not necessarily lead to greater vulnerability. What makes the IMW less resilient to another set of stressors is combining climate change impacts with the region's rapid population growth and urbanization (Nelson 2004), sprawling infrastructure-intensive development (Carter 2008), already over-allocated surface water supplies and overdrawn aquifers, highly recreation-dependent local economies, existing problems with summer ground-level ozone pollution and excessive heat effects in some IMW metropolitan areas, and the large distances between metropolitan centers.[68] The need to adapt is pressing. But there are also opportunities in the IMW. First, there is no coast by definition. Second, the fast-growing urban populations provide some opportunities – such as building smart cities, increased human capacity for adaptation, and a growing source of treated municipal effluent for environmental flows, landscape irrigation, and snowmaking. Third, the vast landscapes and semi-arid climate in the southern half of the region are ideal for large- and small-scale solar energy development while other areas in the north are prime for wind generation. Strategic planning is the key to capitalizing on opportunities while making communities in the IMW more livable and sustainable.

The IMW could become a leader in climate change mitigation and adaptation. The center of the new green economy need not be on the east coast or in California: individual communities and states in the IMW, and perhaps the region as a whole, are in a position to lead. A prerequisite to achieve this goal is comprehensive climate change planning. The advantage of comprehensive climate planning over ad hoc mitigation and adaptation, is that synergies and co-benefits can be realized when lowest-cost, climate-proofing becomes integral to all levels of decision-making, from households and businesses to local government officials. An example of strategic planning is that Colorado aims to not only produce renewable solar and wind energy by building off its resource base, but also to lead in the design and manufacturing of solar cells and turbines, and in the downstream, renewable energy management, marketing, and financing industries.

Climate change adaptation will happen with or without comprehensive planning by local governments. This is because some climate change impacts are locked in (from historic and current GHG emissions) and will require a response from those impacted. At the local government level adaptation might include: increasing the diameter of storm sewers to manage larger floods; increasing water rates to pay for increased conjunctive management, new water supplies, and treatment for water reuse and impaired water

[68] The distance between Albuquerque and Denver is 440 miles, between Albuquerque and Phoenix 460 miles, between SLC and Phoenix 650 miles and between SLC and Las Vegas 420 miles.

quality; tree-thinning and ordinances on defensible space and fireproof building materials for the wildland-exurban interface (an alternative is to spend more on fire fighting); and introducing tighter building codes for municipal buildings to reduce energy costs and encourage diffuse renewable energy generation. Meanwhile, local government constituents will also autonomously adapt, for instance, to higher energy and water prices by purchasing higher efficiency appliances and machinery, and by retrofitting buildings, while golf and ski resorts may contract for municipal-treated wastewater for golf course irrigation and snowmaking.

Local governments are also being pushed by the 'guerrilla' action of their constituents. For example, homeowners and citizen groups are promoting rainwater harvesting, curb cutting to divert storm water to trees on the right-of-way, graywater landscape use,[69] and diffuse renewable electricity generation. Many local governments have responded to the actions and pressure of such groups by introducing rainwater and graywater ordinances, regulating 'green' contractors, and requiring utilities to provide net metering. Local governments also are responding to pull factors – for example, to increased federal funding of energy efficiency and renewables available in the Stimulus Package 2009 – by accelerating and expanding existing local programs. Local governments may also be forced to adapt to a lower carbon future by federal mandates, such as a federal GHG cap-and-trade program, that may require them to share the burden of reducing GHG emissions by designing and implementing mitigation programs. Beyond autonomous, ad hoc, opportunistic adaptation by local governments, homeowners, and businesses, what could local governments do to encourage more holistic climate change adaptation for their own activities and for their communities?

First, what is their motivation for doing more? A comprehensive approach to adaptation could maximize the benefits of action by prioritizing cost-effective adaptations first. Many of these actions will have significant co-benefits in terms of mitigating impending climate change and therefore the need for more drastic and expensive adaptation in the future. They also serve to increase the resiliency of a community to more general climate variability, and many of them also have coupled health cost reductions and quality of life benefits. Furthermore, there are competitive advantages to being a leader in the green economy and in fostering sustainable, more livable communities in terms of attracting economic growth. There are a number of IMW cities that are frontrunners in climate change policy (Carter 2008). Albuquerque New Mexico, has a comprehensive climate change program and Salt Lake City, Utah; Santa Fe, New Mexico; Denver, Colorado; and Phoenix and Tucson, Arizona are also vying for sustainability honors. Some amenity-based communities are also leaders in climate change adaptation; for instance, five of the top seven greenest ski resorts are located in the IMW.[70] But many more cities

[69] For example The Greywater Guerrillas, see http://www.greywaterguerrillas.com/greywater.html

[70] See http://www.treehugger.com/files/2009/02/the-top-7-greenest-ski-destinations.php. #1 The Aspen Skiing Company, Aspen, CO, #3 Park City Mountain Resort, Park City, UT, #4 Mt. Bachelor Ski Resort, Bend, OR, #5, Sundance Resort, Sundance, UT, #7 Alta Ski Area, Alta, UT. These resorts deploy a suite of green technologies such as wind and solar power, green buildings, energy audits to identify and deploy efficiency actions, purchasing energy

and towns in the IMW have not started to plan for climate change mitigation or adaptation. For these cities and communities there are scientific, political, financial, and human resource barriers to overcome, in order to design and implement climate change adaptation policy.

A foremost barrier to climate change adaptation is information on the array and timing of likely climate change impacts. Local governments and their constituents need to understand the vulnerabilities of their communities before adaptation policy is designed. An initial adaptation step is to access downscaled climate change impacts and vulnerability mapping. Technical and institutional capacity building will be required so that local government officials and policymakers can interpret this information, choose between appropriate, cost-effective policy responses, and convey policy decisions to their constituents (OECD 2008). Federal and state governments, regional climate networks, and universities could provide scientific information on downscaled impacts to local governments. Meanwhile, transnational networks of cities and local governments could provide useful, standardized methodology for GHG inventorying, boilerplate 'green' land-use planning and building codes, and informative peer-learning information. The latter could include the cost-effectiveness of various measures and how other local governments overcame political, funding, and human resource capacity constraints. Funding solutions might include partnerships with private industry and utilities, bonding districts, direct fees and taxes, and cost savings generated from the adaptation. Until the 2008 election, the IMW was Republican-leaning, which meant that the political will for action related to 'climate change' or 'green' measures was often lacking. Even today it is good local public policy to first educate constituents about the necessity for adaptation, the cost-effectiveness of adaptation, and perhaps even to repackage adaptation as more politically acceptable energy independence and economic development measures.

National and international networks have guidebooks specifically designed for local governments on steps to integrate climate change mitigation and adaptation planning into all levels of local government activity. A comprehensive plan would alter the trajectory of communities through the integration of macro-scale low-carbon compact urban planning (Nelson 2004; Alber and Kern 2008; Carter 2008; Ewing et al., 2007), and a suite of incentives targeted for individuals and businesses to mitigate and adapt to future climate. A comprehensive plan in the IMW would have additional features to deal with specific vulnerabilities such as securing reliable water supplies given projections for snowpack and stream flow. Future planning might incorporate: smart land-use planning including the creation and expansion of reserves; 'green' compact, transport centered urban cities; the provision of public transportation and designated bicycle lanes; the provision of cooling centers for extreme heat events; green building codes including mandates for renewable stub-outs and plumbing for graywater reuse;

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efficient snowmaking equipment, grooming and vehicle fleets, and education programs. The Aspen Skiing Company was the first of only two resorts in the US to earn a ISO certification as a green company.

new/tighter reliable water supply rules; wildfire protection measures; and rainwater harvesting codes for new residential, commercial and government buildings.

Designing future green development will require an overhaul of land-use, transportation planning, and building codes, while encouraging adaptation activity from current homeowners and businesses will require a different suite of policy tools. One example is building public acceptance and funding portfolios[71] for transportation alternatives to airports in suburban and ex-urban communities that were designed in an era of cheap gasoline (e.g. Denver's FastTracks, SLC's TRAX LRT, and Phoenix's METRO Light Rail). Incentives to accelerate the uptake of many lowest-cost adaptation measures need to overcome the upfront cost barrier and the hassle factor. For example, rebate and installation for retrofits of water-efficient and energy-efficient technologies will require partnerships with utilities and price signals to encourage conservation and the purchase of higher-efficiency appliances and insulation, etc. Local governments may also opt for direct policies designed to modify consumer behavior, for instance climate change fees[72] with revenues directed to mitigation and adaptation activities, legislation to create bonding districts for energy efficiency and renewable energy investment, demonstration projects, and information and education campaigns. The urgency of climate change adaptation in the IMW means in the language of political science that local governments will have shift to the "governing by authority" mode (Alber and Kern 2008) in order to realize cost-effective adaptation. Otherwise, they will spend a growing proportion of their budgets on crisis response.

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[71] For example, Denver's FastTracks system was built with sales tax bonds, pay as you go cash, federal funding, a local contribution, and public-private partnership funds. Phoenix' light rail system was approved by voters in 2000 and funded by a 0.4% sales tax. In 2004 voters approved Proposition 400 to extend the system west to Glendale and north to Scottsdale.

[72] Boulder CO's Climate Action Plan tax and London, England's congestion charge.

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