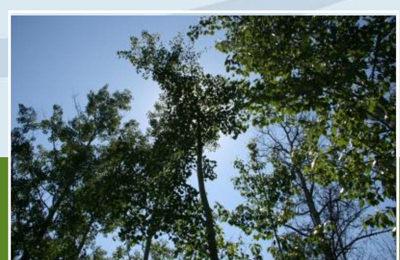
Ecosystem-based Adaptation (EbA): The role of EbA to address climate change in Southern Alberta

March 2014

Prepared by Tracy Lee and Ken Sanderson

MIISTAKIS INSTITUTE



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Ecosystem-based Adaptation (EbA):

The Role of EbA in Addressing Climate Change in Southern Alberta

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Executive Summary

The climate is warming, resulting in global scale change to our natural environment and impacting our economic and social systems. To address these changes national and regional governments are developing climate change adaptation strategies and plans (UNFCCC). Adaptation is characterized as coping with or exploiting changes, through action of some sort.

There are different ways to approach adaptation; but one approach that is recently garnering attention is *ecosystem-based approaches to adaptation* (EbA). EbA is characterized by a focus on adaptation as a function of resilience. Hence, a key premise of EbA is to protect the ecosystem that provides life supporting systems (ecosystem services) humans need to survive. EbA is built on the notion that a healthy functioning ecosystem is more resilient (greater flexibility) and therefore better able to adapt to ecosystem stress, such as climate change. Restoring or maintaining ecosystem resilience therefore reduced the vulnerability of communities to climate change. Ecosystems provide services that play a role in adaptation to climate change, for example, risk reduction of natural disasters (floods, drought); food security, sustainable water management and livelihood diversification.

A review of EbA strategies highlight there are examples from around the globe where EbA has been an effective approach for addressing the risks associated with climate change. The greatest potential benefit of EbA is the ability to achieve multiple policy objectives, such as addressing adaptation and mitigation simultaneously, potential to benefit soci-economic development, and ensuring environmental protection and conservation of biodiversity. EbA tends to result in the development of no-regret strategies, because of the multiple other benefits achieved from implementation.

Although EbAs are gaining in popularity they are considered under-utilized as an approach for climate change adaption when compared to more traditional actions such as infrastructure development.

This report presents the results of a broad review of climate change adaptation (CCA) action plans, peer-reviewed literature, relevant case studies, and adaptation theory, undertaken to begin a preliminary framing and collection of CCA strategies for the grassland natural region in southern, Alberta. In this report the authors make the case for the Ecosystem-based Adaptation (EbA) approach to play a strong role in the development of strategies to reduce the implications of climate change on environment, social and economic systems in southern Alberta.

Biodiversity Management and Climate Change Adaptation Project Background

The Biodiversity and Climate Change Adaptation Project was conceived by the Alberta Biodiversity Monitoring Institute (ABMI) in response to the need to define the scope of change required to effectively manage biodiversity under a changing climatic regime, and to support Alberta's biodiversity management system with essential knowledge and tools for successful adaptation to a changing future climate.

The rationale for this initiative rests on the importance of biodiversity to Albertans, and the complex relationship between climate and biodiversity. Biodiversity, which includes species and their ecosystems, supports the delivery of numerous ecosystem services. These include provisioning services (e.g., food, fibre, fuel, water), regulating services (e.g. water and air filtration, flood regulation), cultural services (e.g., nature recreation, wildlife viewing) and supporting services such as soil formation and wildlife habitat. Because these biodiversity related services are impacted by a changing climate, and because the relationship between climate and biodiversity is uncertain, knowledge gaps constrain effective adaptation. Proactive investments in the knowledge and tools for effective biodiversity management under a changing climate regime will deliver significant benefits to people and avoid crisis-driven interventions that are by their nature reactive, costly and often ineffective.

The goal of the *Biodiversity Management and Climate Change Adaptation* project is to develop essential knowledge and tools to support the management of Alberta's biodiversity and promote successful adaptation to a changing climate. The project is comprised of four objectives:

1. Predicting the impacts of climate change on Alberta's native species and ecosystems

2. Predicting invasive species responses to climate change

3. Assessing strategies to support climate sensitive species-at-risk

4. Developing and evaluating adaptation policy and tools to manage biodiversity in a changing climate

The *Local adaptations for biodiversity-related ecosystem services* sub-project (concisely, the *Local Adaptations* sub-project) lead by the Miistakis Institute directly supports objective 4.

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INTRODUCTION

> *Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased* (IPCC 2013).

The climate is warming, resulting in global scale change to our natural environment and impacting our economic and social systems. To address these changes national and regional governments are developing climate change adaptation strategies and plans (UNFCCC). Adaptation is characterized as coping with or exploiting changes, through action of some sort. Lim et al (2004) describe adaptation as "a process by which strategies to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed, and implemented." The need for assisting communities to adapt to climate change is urgently needed (Munang et al. 2013). The Insurance Bureau of Canada, reported the province of Alberta has experienced an increase in natural disasters, hail storm, wind storm and flooding, costing over 730 million dollars in damages between 2009-2012. Don Forgenson of IBC says "Adaptation is realistic, pragmatic, global and forward thinking."

There are different ways to approach adaptation; but one approach that is recently garnering attention is *ecosystem-based approaches to adaptation* (EbA). EbA is characterised by a focus on adaptation as a function of resilience. Hence, a key premise of EbA is to protect the ecosystem that provides life supporting systems (ecosystem services) humans need to survive. The Convention on Biological Diversity (CBD) defines EbA as, "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change." Recently, the CBD (2010) evolved the definition to "sustainable management, conservation and restoration of ecosystems, as part of an overall adaptation strategy that takes into account the multiple social, economic and cultural co-benefits for local communities."

EbA is built on the notion that a healthy functioning ecosystem is more resilient (greater flexibility) and therefore better able to adapt to ecosystem stress, such as climate change (Munang et al. 2011). Restoring or maintaining ecosystem resilience therefore reduced the vulnerability of communities to climate change (Sudmeier-Rieuz et al. 2006). Ecosystems provide services that play a role in adaptation to climate change, for example, risk reduction of natural disasters (floods, drought); food security, sustainable water management and livelihood diversification (Munang et al. 2013). One of the main benefits of EbA is its potential to achieve multiple benefits. For example of an EbA strategy to sustainably manage wetlands and floodplains has multiple benefits, such as the maintenance of water flow and water quality, flood control, and water storage all of which contribute to the reduced risks of drought. However, besides reducing vulnerability to natural disaster, other benefits include improved recreational opportunities (fishing), regulation of water, and enhanced carbon storage. Given the multiple benefits of EbAs, they are often termed *no regret strategies*. That is, given the un-certainty around the frequency and extent of environmental impacts expected from climate change, EbA actions will still provide benefit to communities even if climate change impacts are less severe than predicted.

Although EbAs are gaining in popularity they are considered under-utilized as an approach for climate change adaption when compared to more traditional actions such as infrastructure development (UNEP 2014). A more typical response to flood control is to take an engineering-intensive approach and invest in hard or grey infrastructure to prevent further flooding. Although in many cases hard infrastructure maybe an appropriate response, EbA can complement those more traditional approaches to adaptation, and have the benefit of working with nature instead of against it (which is often the case in more traditional approaches to adaptation).

ROLE OF THIS REPORT

A part of the *Biodiversity Management and Climate Change Adaptation* project, the Miistakis Institute is developing a climate change adaptation decision-support tool for southern Alberta rural municipalities. The tool will assist municipal staff, council and their communities in understanding the changes and effects climate change is predicted to have in their area, the implications of those effects for local life, and the strategies the municipality can undertake to become more resilient in the face of a changing climate regime.

This report presents the results of a broad review of climate change adaptation (CCA) action plans, peer-reviewed literature, relevant case studies, and adaptation theory, undertaken to begin a preliminary framing and collection of CCA strategies for use within the decision-support tool. In this report the authors make the case for the Ecosystem-based Adaptation (EbA) approach to play a strong role in the development of strategies to reduce the implications of climate change on environment, social and economic systems in southern Alberta.

HARD AND SOFT APPROACHES TO CLIMATE CHANGE ADAPTATION

Coined originally as hard and soft paths to energy production by Lovins, these terms are now being applied to climate change adaptation (Sovacool 2001). A hard path to climate change adaptation is characterized by human-built infrastructure, large scale disturbances to local communities and ecosystems, capital intensiveness, and low flexibility and adaptability. A soft path to climate change adaption, such as EbA, is characterized by natural infrastructure, empowerment of local communities, non-capital or human resource intensiveness, and an ability to respond to alterations in climate change projections (Sovacool 2001).

Hard paths are more widely applied and tend to be the way policy makers and planners think about adaptation. For example, in 2013, the City of Calgary experienced a large scale flood, which damaged thousands of homes and businesses, due to an extreme rain event. The flood mitigation plans to reduce the future risk of flooding include $830 million of added infrastructure, including berms, dams and a diversion tunnel. The discussion around adaptation has tended to focus on large-scale human infrastructure projects as mitigation to future flood events. This hard approach is the predominant response to natural disasters. A concern with this approach is the ability of governments to respond with large scale infrastructure projects if the frequency and scale of natural disasters increases as predicted with climate change.

Some of the critiques of the more traditional approaches to adaptation, sector based, or hard approaches include high costs, resource needs, and possibility of maladaptation (obstruction of natural processes) (IPCC 2012). In addition, hard paths usually work against nature and do not promote the protection of biodiversity and ecological systems, potentially having negative effects on the systems on which humans depend (Jones et al. 2012).Ultimately, as Ostrom (2010) points out, adaptation efforts might be most effective where soft and hard paths are considered together and integrated. To better understand the opportunity of an EbA to climate change adaptation in the Alberta context, the authors review literature on EbA programs to determine success. In addition, case studies are explored and examples where EbA has been used effectively in combination with hard approach are highlighted.

Making the case for EbA

To understand the full potential of EbA, Munroe et al. (2011) undertook a global review of how EbA has been used to address climate change impacts and the effectiveness of this approach. The authors found 132 relevant studies, and reviewed 81 in detail. Their conclusions draw out some important considerations; most significantly that the majority of papers reviewed identified EbA as an effective approach. This review provides documentation that EbA is being used all over the globe, with the highest percentage of examples from Asia (23%) and Europe (44%). In addition, EbA projects cover a broad range of climate hazards, but the majority address implications from changes in precipitation levels, such as flooding and drought. This review highlights extensive and successful use of EbA type projects across the globe.

'No Regrets' Strategies

The greatest potential benefit of EbA is the ability to achieve multiple policy objectives, such as addressing adaptation and mitigation simultaneously, potential to benefit soci-economic development, and ensuring environmental protection and conservation of biodiversity (Munang et al. 2013). For example, implementing a program to support farmers restoring wetlands improves the system's resilience to drought and flooding, predicted impacts of climate change. However, it also increases carbon storage (climate change mitigation), supports biodiversity, and increases water supply and quality (increasing agricultural yield). In the UK, the Parrett Catchment Project developed an EbA to aid in water regulation. By working with farmers on soil and nutrient management practices aimed at retaining soil moisture, the region maintained healthier soils and helped reduce water run-off, important components of building a resilient ecosystem that can respond to climate change impacts (Doswald and Osti 2011). The strength of EbA is that maintenance of ecosystem services, such as protecting water supply, often requires the same best management practices or policies as adapting to climate change. In other words, EbA often results in *no regret actions*, where strategies would yield benefits even in the absence of climate change.

No regrets strategies are an important consideration for decision makers, because climate change represents a high level of uncertainty (Hallegatte 2009). Although it is well known the climate is changing and many locations are already experiencing impacts from climate change the level of emissions humans continue to release into the atmosphere will dictate future impacts. How humans respond to emission reduction targets coupled with uncertainty in climate modeling create complexities in predicting climate change risks accurately. Therefore, no regret strategies have the distinct advantage of providing a tangible benefit to decision makers and society while reducing the risk of uncertain climate change impacts.

Cost Effectiveness

One of the other stated benefits of an EbA approach is that they tend to be more cost effective than ‘hard’ approaches. One of the most well-published examples is from the Maldives, where coral reefs offer protection from tropical storms. Climate change is predicted to increase the frequency and severity of those storms. An EbA to prevent the degradation of the reefs by establishing a protected marine park would cost $34 million (USD) start-up and $47 million annually, and result in other benefits such as tourism and sustainable fishing, estimated to generate $10 million annually. If the reefs continues to be degraded from over fishing and mining activity, and needs to be replaced with a seawall or other forms of protection to reduce the risks of storms, the cost is estimated at $1.6 to $2.7 billion (Munand et al. 2013).

One area where cost benefit has been explored in more detail is comparisons between *grey* and *natural* or *green* infrastructure. Grey infrastructure includes hard approaches to climate change adaptation such as dams and berms; natural infrastructure refers to the "interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife" (EPA 2014). A summary of the benefits of investing in natural infrastructure developed by World Resources Institute (2013) determined the cost savings of a green infrastructure approach can be high. For example, numerous case studies have shown that high source water quality (achieved through strategies also applicable to an EbA) reduced costs associated with treatment of drinking water (Ernst 2004, LAWPC 2012, EPA 2010). One example is a source drinking water cost-benefit analysis from the Crooked Creek Watershed in Portland, Oregon. This study calculated the potential cost savings of investing in natural infrastructure projects over grey infrastructure as $12-110 million over a 20 year period. A simple binary comparison between installing a new water filtration system and investing in natural infrastructure (such as increasing riparian buffers, protecting source water habitat through conservation easements, reforestation and culvert replacement) indicated a conservative $12 million savings over a 20 year period. However, once extra benefits such as carbon sequestration (climate change mitigation) and habitat gain for fisheries are factored in, another $72-125 million in economic benefit can be added (Talberth et al. 2013).

Another well-known example of the cost effectiveness of a natural versus grey infrastructure approaches occurs along the Tualctin River in Oregon where a clean-water service is used to reduce thermal load. The grey infrastructure approach of two mechanical chillers was compared with maintaining a forested riparian area along the river where large trees would shade the water. The cost savings of the natural infrastructure approach of establishing riparian areas was between $50-145 million, and – as is typical with EbA approaches – provided numerous other benefits, such as enhanced fish habitat and recreational opportunities, reduced carbon emissions, and increased carbon sequestration (Niemi et al. 2006). The City of Melborn, Oregon also took this approach to cooling water after a cost-benefit analysis showed a saving of up to three times the value of a grey infrastructure approach (OACWA 2012).

EbA Use Limited

Despite the immense benefits highlighted from taking an EbA approach to climate change adaptation and it's potential to contribute to mitigation, the use of EbA is still considered limited (Munang et al. 2013). One of the key challenges to implementing EbA approaches is mainstreaming the concept into the decision making process. A review of EbA has shown use by decision makers is limited. Munroe et al (2011) highlight some other challenges to implementing EbA programs, such as:

- Technical challenges, such as design and implementation knowledge;
- Limited public awareness about EbA and the multiple benefits associated with an ecosystem approach;
- Organizational challenges arising from the diversity and number of partners that need to be engaged in these projects;
- Overall capacity limitations (institutional, financial and technical) mean many agencies lack the technical knowledge to champion EbA; and
- Political need for policy integration.

These challenges highlight the need for a stronger integration of environmental considerations into other sectors. In addition, lack of technical knowledge appears to be a significant issue, potentially limiting opportunities for EbA development and implementation even where there is desire. This highlights the importance of sharing case studies where an EbA has been implemented, as well as the documentation on the issue of concern, partners involved, multiple benefits and costs associated with the program.

EbA Case studies

A review of cases studies helps illustrate how EbA approaches have been used effectively and creatively. Three case studies are highlighted where EbA has been implemented as a climate change adaptation strategy, two of which integrate more traditional approaches with EbA. As well, the cases highlight the partners involved, multiple benefits achieved and cost benefit assessment of the projects. The three examples were chosen to highlight climate hazards predicted to occur in southern Alberta, namely increased frequency and severity of drought and flooding, and increased water scarcity.

Flint River Basin – Adapting to Drought

The Flint River Basin in Georgia is an agricultural landscape of 250,000 acres, supporting over $2 billion in farm-based revenue annually. The area is subjected to frequent droughts and, coupled with intense water use by agriculture, has resulted in low water levels in the Flint River. There is concern that climate change will exacerbate water scarcity issues, impacting agricultural production and threatening the ecological health and biodiversity associated with the river system (Watson and Scarborough XXXX).

To address this challenge, a collaboration of farmers, USDA's Natural Resources Conservation Service, and The Nature Conservancy (TNC) developed a multi-pronged approach to conserving water. The farmers (over 1000) employed an EbA approach by changing management practices around crop rotation and soil health to help with water retention. In addition, a researcher developed a variable rate irrigation system, which enabled farmers to turn off water for a pivot irrigation system and skip watering in areas where water was not needed. This low tech system combined with EbA management practices resulted in a 30% reduction in water use, representing annual conservation of over 15 million gallons of water within the Flint River system (Watson and Scarborough XXXX).

This example highlights the use of different adaptation approaches (EbA and technological innovation), and the diversity of partners involved. It also provides evidence of the need for locally-developed solutions to climate change.

Living River Initiative – Preparing for floods

The Napa River Basin in California provides an example where both built infrastructure and EbA strategies were employed to reduce damage from flood events. The basin supports over 70,000 people, and has been subjected to frequent flood events, with a major event in 1986 leading to the evacuation of 5000 people and $100 million (USD) in property damage. The initial suggestion for preventing further flooding was to have the U.S. Army Corps of Engineers deepen the river channel, but local citizens were against the idea as it would have impacts on water quality and wildlife habitat. A coalition formed with representation from 25 agencies and organizations and the Living River Initiative was formed with a goal of "increasing the river's capacity to handle flood waters while restoring natural shape and alignment." The strategies involved restoring 900 acres of land to marshes, wetlands and riparian habitat. The project included the purchase of private land, including residences, commercial structures, warehouses and a trailer park (Almack 2010). The total cost of the project is estimated at $400 million, and will be shared between rate payers, federal and state government.

The community identified multiple benefits from this approach besides reduced risk of damage from future flood events, including increased recreational opportunities, increased development in near-by properties due to decreased risk of flooding, increase in water quality and restored wildlife habitat (Almack 2010). This example integrates flood protection and watershed management to address risks associated with climate change, decreasing the impact of flood events by building resilience into the system. The EbA-type strategies – restoring wetlands, marshes and riparian areas – also have climate change mitigation potential by increasing carbon sequestration opportunities. In addition, this example successfully uses integration of hard and soft approaches to climate change adaptation, as berms were removed in some areas and built in others, based on land use planning which integrated adaption approaches.

Keystone Engineers – Cost effective strategy for adapting to climate change

In the Escalante River Basin of Utah, beaver reintroduction and habitat restoration have been identified as a cost effective strategy to help build ecosystem resilience and as an adaptation strategy to climate change. The basin is 360,000 acres, and includes 3 national forests and 200,000 acres of farm land, predominately livestock with some crops. Historically beavers were prominent in the region, but now are considered rare.

The National Forest Service, Utah Fish and Wildlife and Grand Canyon Trust are supporting initiatives to re-introduce beavers to the landscape. Beavers play a critical role in ecosystem structure and function and promote dynamic and resilient systems that will be better able to withstand the impacts from climate change. Westbrook et al. (2010) noted that when beavers are removed from a landscape there is a substantial loss of ecosystem services. Beavers are recognized as a cost effective approach over alternative approaches to improving the health/resilience of wetland and riparian systems (Muller-Schwarze and Sun 2003). A study by Buckley (2011) noted that re-introducing beaver back into the Escalante River Basin would add $138-414 million (USD) in ecosystem service values, such as water storage, filtration, aquifer recharge and increased habitat.

Based on premise that beavers are integral to maintaining ecosystem services and building a resilient system, the State of Utah developed a beaver management plan. This plan classified beavers as protected wildlife, and focused on maintaining beavers on the landscape. In addition, the Grand Canyon Trust developed a beaver restoration program, which inventoried national forests within the watershed to identify sites where beavers could be re-introduced successfully. Beavers will be re-located from irrigation canals and other places where they are in conflict with humans to sites within the national forest. The Trust is also working with landowners to promote the conservation of beavers on private lands.

THE ROLE OF EBA STRATEGIES IN CCA ACTION PLANS

Climate Change Adaptation (CCA) Action Plans enable a community to better understand the risks and opportunities associated with climate change and to develop appropriate response strategies. The development of strategies and associated actions, takes place in the planning step of climate change adaptation processes, whereby strategies are developed to address the expected climate change impacts. This information becomes the foundation for creating short and long term action plans to move the community toward climate resiliency. Ecosystem-based Adaptation (EbA) strategies

Catalogue of strategies relevant to Southern Alberta

To assist in our on-going development of a municipally-focused decision-support tool for climate change adaptation, the authors developed a preliminary catalogue of EbA strategies usable by southern Alberta municipalities.

Based on a review of climate change action plans, the authors highlight examples of EbA-type strategies that are relevant to the implications predicted to occur in southern Alberta, in particular impacts to a grassland and agricultural landscape. The review does not consider hard approach strategies, but it is recognised these types of strategies may play an important role in southern Alberta (e.g., installing larger-diameter culverts to handle storm events of increasing severity.

The focus of the review was on strategies that address many of the identified implications predicted to occur due to climate change, but not yet on actions associated with a strategy. For example, an EbA strategy to protect wetland and riparian areas, may include numerous actions such as purchase of important wetland parcels by municipality, education of landowners on wetland legislation, development of incentive programs for landowners to protect riparian areas, or promotion of best management practices for cattle and wetland or riparian areas (e.g., off-site watering). Proposed actions are highly dependent on the local context where decision makers can take into consideration actions already being undertaken and type of actions that are needed, such as education, incentive programs, policy development, and/or regulation change.

It is also important to note that many EbA strategies used to build a climate resilient community are not solely in the hands of the municipal government, though they may play a critical role. Our review is therefore not limited to strategies specific to a municipal government. This highlights the need for numerous and varied partners to build a climate resilient community.

The catalogue includes a listing of the EbA Strategy, the Implications to which it relates, and the reference Source. See *Appendix A: Preliminary EbA Strategy Catalogue*.

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Appendix A: Preliminary EbA Strategy Catalogue

EbA Strategy	Implications	Reference
Restore and create floodplains, wetlands and riparian areas	water scarcity, water quality, extreme weather events, biodiversity	Missoula CCA Action Plan[i], GOA Agriculture[ii]
Protect existing floodplains, wetlands and riparian areas	water scarcity, water quality, extreme weather events, biodiversity	Missoula CCA Action Plan, GOA Agriculture
Maintain beavers on the landscape	water scarcity, water quality, extreme weather events, biodiversity	Missoula CCA Action Plan
Restore beaver on landscape	water scarcity, water quality, extreme weather events, biodiversity	Missoula CCA Action Plan
Maintain pollinator habitat	agricultural production, biodiversity	Nexus[iii], CBT[iv] (toolkit)
Maintain biodiversity on the landscape	spread of invasive species, biodiversity	Nexus
Reduce water consumption and demand	water scarcity, water quality, extreme weather events	CBT, Headwater Economics
Adopt soil management practices that conserve soil moisture	water scarcity, agricultural production, extreme weather events, increase risk of grass fire	GoA Agriculture
Diversify crops	Agricultural production, extreme weather events	GoA Agriculture, CBT
Adjust crop rotation better suited to the climate	Agricultural production, extreme weather events, water scarcity, water quality	GoA Agriculture
Implement energy efficient audit on farm	reduce emissions	GoA Agriculture
Reduce methane emissions through manure treatment	water quality, reduce emissions	GoA Agriculture
Increase efficiency of irrigation system	water scarcity, water quality, agricultural yield	GoA Agriculture, CBT
Follow and track research on production efficiencies, new management strategies, livestock systems.	water scarcity, water quality	GoA Agriculture

Update municipal documents to incorporate expected changes due to climate change, ie. Sustainability plans, municipal development plans….	water scarcity, water quality, extreme weather events, biodiversity	Headwaters Economics[v]
Promote increase food production, food preservation and seasonal eating	agricultural production	CBT
Maximize access to agricultural land for local growers	agricultural production	CBT
Protect agricultural land	agricultural production	CBT
Review and change ownership of water rights to protect values and livelihoods	water scarcity, water quality, extreme weather events, biodiversity	Missoula CCA
Implement measures to reduce wildfire severity	extreme weather events	Missoula CCA
Maintain and enhance natural systems and ecosystem services	Biodiversity, water scarcity, water quality, extreme weather events	Missoula CCA
Manage landscape to maintain and enhance connectivity	biodiversity	Missoula CCA
Encourage regional, provincial and federal agencies to assist municipalities in becoming climate resilient		CBT
Prepare hazard management plans (flooding and drought)	extreme weather events	CBT
support watershed management plans with focus on building resilience	water scarcity, water quality, extreme weather events, biodiversity	CBT
Implement water quality monitoring		CBT
Promote and protect large landscapes for biodiversity resilience and connectivity of green space	biodiversity	Headwaters Economics

[i] Koopman, M.E., Alban, J., Randall, B., Haggerty, M. and R. Rasker. 2011. Missoula County Climate Action: Creating a Resilient and Sustainable Community. Climate

[ii] Alberta Agriculture and Food. 2007. A Changing Climate for Agriculture, How can we Prepare. On-line access **Feb 2014** from: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl9706/$FILE/cchcwpmarch2007.pdf

[iii] ICLEI -Local Governments for Sustainability (Management) Inc. 2012. Finding the Nexus: Exploring Climate Change Adaptation and Biodiversity. ICLEI Canada. Toronto, Ontario. On-line access **Feb 2014** from: http://www.icleicanada.org/images/icleicanada/pdfs/Nexus_Series_Adaptation_Biodiversity_Final_sm.pdf

[iv] Columbian Basin Trust. 2012. Climate Change, Impacts and Adaptation in the Canadian Columbian Basin, From Dialogue to Action. 54 pp. On-line access **Feb 2014** from: http://www.cbt.org/uploads/pdf/DialoguetoAction_Final_lo-res.pdf

[v] Headwaters Economics. 2012. Implementing Climate Change Adaptation. Lessons Learned from Ten Examples. Headwaters Economics. Bozeman, Montana.