Chapter 26. North America

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Executive Summary

The climate of North America has already been warming and changes in extremes and means are being observed. Some of these stresses are from changes in average conditions such as sea level rise, higher temperatures and earlier snowmelt. Other stresses are the result of changes in extreme events or disturbance. (e.g., wildfire and pests have disrupted many forests, ecosystems and human settlements across North America). Extreme climate events such as droughts and hurricanes have led to large economic losses. The region is very likely to face increasing warming and extreme high temperatures, higher sea levels, more intense precipitation and droughts, more intense storms, and reduced snowpack and higher sea levels. [26.1.1, 26.2.2, 26.4.1, 26.5]

Attribution of observed changes in North America to anthropogenic climate change has been established for some physical systems (e.g., snowpack), some ecosystems (e.g., forests dieback, vector diseases and pests distribution) and cases, but not in managed systems (e.g., agriculture). [26.2.2.1.1, 26.4.1, 26.6.1]

Ecosystems across North America are already being affected by climate change and are at high risk from further climate change. Biodiversity and ecosystem services are very likely to be reduced. [26.4]

For different reasons (e.g., lack of access particularly in Mexico, insufficient maintenance and ineffective management) the quality of *infrastructures* across North America increases vulnerability to climate change. [26.9]

Climate change is projected to pose major challenges to *water supplies*, flooding, and water quality, with water supplies of most concern in western and southern areas (already stressed) and flooding from poor drainage systems or from rivers of concern in most areas. Water quality threats are throughout the region. [26.3]

Human health risks include impacts from more extreme storm and heat events, air pollution, pollen, and infectious diseases. The effects can be modified by intervening factors including economic status, access to health care, and adaptations. Health impacts are likely to be greatest for economically disadvantaged both within and across countries in North America. [26.8]

North America is a major source of global food supplies. Increases in extreme events and exceeding thresholds can offset gains to North American agriculture productivity. Adaptation can ameliorate many, but not all, adverse impacts provided adequate institutional support. Small farmers in Mexico are among the most vulnerable groups to climate change. [26.6]

Interacting dynamic processes determine differences in *vulnerability* and *adaptive capacity*.

- *Rural communities* are relatively vulnerable because of high natural resource dependency, increased market specialization, high rural impoverishment (Mexico), and contraction of insurance and credit (Mexico). [26.7]
- *Urban centers'* capacities to respond relate not only to location, population demographics, social capital, wealth, values, behavior or political power, but also to built-environment features, levels of regional environmental degradation and the institutional settings regulating urban life. [26.10]

Most sectors of the North American economy have recent experience reacting and adapting to extreme weather, including hurricanes, flooding and intense rainfall, but lessons learned are often not well documented in the literature. [26.11]

Some economic sectors and settlements have begun adapting to climate. For example the *insurance* has changed practices in response to recent extreme events and in some northern areas, the design and construction of buildings has changed. [26.11.3]

A number of governments across North America have begun the process of addressing adaptation. This is particularly evident in municipalities. Some state and provincial governments have begun planning for adaptation.

The three national governments have also initiated adaptation activities, including providing technical support for adaptation. Many cities in the three countries have instituted at some adaptation planning (e.g., Boston, NY, Miami, San Francisco, Toronto, and Mexico City). These efforts are in a nascent stage and scholarship is starting to evaluate how effective they will be in reducing the impacts of climate change and in particular how effective they will be should climate change in line with relatively high projections of future greenhouse gas emissions. [26.10.4, Box 26-5]

Literature is emerging on such issues as the potential social effects of climate change including impacts on vulnerable populations and the potential for increased migration from Mexico to the north. [26.6.2, 26.10]

26.1. Introduction

North America ranges from the tropics to frozen tundra and contains a diversity of topography, ecosystems, economies and cultures. While across the continent, adaptive capacity is relatively high, there is diversity in levels of economic and human development, demographic dynamics and governance structures. The vulnerability of North American societies and ecosystems to climate change varies considerably depending on geography, scale, social or ecological systems, demographic sectors and institutional settings. This chapter attempts to account for some of this diversity by analyzing a number of economic sectors, regions, demographic groups and “natural systems” that will be affected by climate change in different ways. Impacts on the North American Arctic region are discussion in Chapter 28: Polar Regions.

Key Findings from the Fourth Assessment Report (AR4)

This section summarizes key findings on North America, as identified in chapters 13 and 14 of the Fourth IPCC assessment focused on Latin America/Mexico (Magrin et al., 2007) and Canada and the USA, respectively (Field et al., 2007). Over the past decades, economic damage (particularly to infrastructures in US and Canada) from severe weather, including hurricanes, other severe storms, floods, droughts, heat waves and wildfires has increased dramatically (high to very high confidence). Changes in precipitation, and increases in temperature and in the rate of SLR were also documented for Mexico.

Although Canada and the US have considerable adaptive capacity, their vulnerability depends on the effectiveness and timing of adaptation and the distribution of coping capacity, which vary spatially and among sectors (very high confidence). For Mexico the development of early warning systems and risk analysis in the areas of agriculture, human health, water resources, fisheries and coastal resources, has increased their capacity for planning and management (high confidence). In Canada and the US, traditions and institutions have encouraged a decentralized response framework where adaptation tends to be reactive, unevenly distributed, and focused on coping with rather than preventing problems. ‘Mainstreaming’ climate change issues into decision making was seen as a key prerequisite for sustainability.

Coastal communities and habitats in the three countries will be stressed by sea level rise, storm-surge flooding and other climate change impacts interacting with developmental and environmental stresses (e.g., salt intrusion, pollution population growth and the rising value of infrastructure in coastal areas) (very high confidence in chapter 14). Current adaptation is uneven and readiness for increased exposure is low.

For Mexico, land use changes have intensified the use of natural resources and exacerbated many of the processes of land degradation (high confidence). Significant species extinctions in many tropical areas of Mexico is projected (high confidence). Agricultural lands will be subjected to desertification and salinization processes in many areas (high confidence), and this will have important consequences for the well-being, particularly of rural populations. While increases in grain yields in U.S. and Canada were projected, the picture is mixed for wheat, maize), whose behavior is more erratic depending on the scenario imposed.

Millions in Mexico are projected to be at risk from the lack of adequate water supplies (medium confidence), while in the US and Canada rising temperatures will diminish snowpack and increase evaporation, affecting seasonal availability of water. This will imposed further constrains to over-allocated water resources, increasing competition among agricultural, municipal, industrial and ecological uses (very high confidence).

Changes in geographical distribution and transmission of diseases have been observed in Mexico and changes in the geographical distribution of dengue are also projected. Climate change impacts on infrastructure and human health and safety in urban centres of Canada and the US will be compounded by ageing infrastructure, maladapted urban form and building stock, urban heat islands, air pollution, population growth and an ageing population (very high confidence). Warming and climate extremes are likely to increase respiratory illness, including exposure to pollen and ozone. Climate change is likely to increase risk and geographic spread of vector-borne infectious diseases, including Lyme disease and West Nile virus.

Disturbances such as wildfire and insect outbreaks are increasing in Canada and the US and are likely to intensify in a warmer future with drier soils and longer growing seasons (very high confidence). Over the 21st century, pressure for species to shift north and to higher elevations will fundamentally rearrange North American ecosystems. Differential capacities for range shifts and constraints from development, habitat fragmentation, invasive species, and broken ecological connections will alter ecosystem structure, function and services.

Without increased investments in such countermeasures as early warning and surveillance systems, air conditioning, access to health care, hot temperatures and extreme weather in Canada and the US are likely to cause increased adverse health impacts from heat-related mortality, pollution, storm-related fatalities and injuries, and infectious diseases (very high confidence). Therefore chapter 13 suggested streamlining adaptation strategies with national / regional sustainable development plans.

26.2. Current and Future Trends

26.2.1. Demographic, Socioeconomics, and Institutional Trends

Canada, Mexico and USA differ in in three dimensions shaping vulnerability and adaptation: population dynamics, economic development, and institutional capacity. Notwithstanding the current economic crisis, Canada and United States have continued to enjoy generally higher levels of human and economic well-being than Mexico. While United States and Canada rank fourth and sixth on the 2011 Human Development Index, Mexico ranks fifty seventh. After registering rates of growth of about 2% yearly during 1987-2005, the per capita GDP (in 2005 dollars) of three countries decreased during 2008-2009 (particularly in Mexico). Yet, in 2011 the USA GDP per capita ($42,448 in 2005 dollars) was 1.2 times the Canadian one and 4 times the Mexican one, despite trade integration in the region.

The three countries have become more economically integrated following the 1994 North American Free Trade Agreement. For instance the US-Mexico border was before the 2007-2008 fall in trade, a region of dynamic growth in industry, employment and global trade of agricultural and manufactured goods (Robertson *et al.*, 2009). However, institutional asymmetry and fragmentation can be source both of opportunities (examples) and potential vulnerabilities in managing trans-border environmental resources and issues. (Wilder *et al.*, 2010);(1260 Scott, C.A. 2008)

Overall, population growth slowed in North America, although Mexico´s fertility rates were above replacement levels by 2010 (2.4 TFR). Population in North America is projected to keep growing over the next decades and reach 590 million in 2050 (1257 Anonymous). Also, 81% of the region’s population lives in urban areas in 2010. With small differences between countries, urban population could grow to 85% of the 2030 population, and Mexico is likely to experiment the largest increase (1262 United Nations Department of Economic and Social Affairs, Population Division 2010). Large population concentrations challenge capacity to cope with environmental impacts and to maintain functional urban infrastructure, such as water, electricity and transport networks(1213 Hallegatte, S. 2011). These challenges are severe in Mexico, where 14% of the urban population lives in slums, lacking basic infrastructure and services (1257 Anonymous).

A declining rural population currently faces lower income levels, reduced access to public services and labor markets that might enhance rural sensitivity to climate events. Rural population isolation could be aggravated high dispersion levels in areas of Canada and Mexico given. Rural poverty could be aggravated because agricultural changes, particularly in Mexico where 65% of the rural population is poor, agriculture production is seasonal, and most households lack insurance (1256 Scott, J. 2007)Increases in food prices, partially a result of climate events, contribute to poverty levels in urban and rural areas(1259 Anonymous);(Lobell *et al.*, 2011). Lower fertility rates and gains in life expectancy contribute to an aging population in North America. In 2010, 20% of the population was 60 years and older in Canada, 18% in USA, and 9% in Mexico; however ageing in Mexico is projected to progress rapidly, so that 27% of the 2050 population would be elderly(1262 United Nations Department of Economic and Social Affairs, Population Division 2010). Studies show that the elderly population is more vulnerable to extreme weather events, heat waves in particular, and risk increases for those living alone(1214 Martiello, M.A. 2010); Newsome 2011(Diffenbaugh and Scherer, 2011; White-Newsome *et al.*, 2011); (1144 Romero-Lankao, P. 2012). Expected increases of single-person households and female-headed households could also exacerbate population groups' vulnerability. Institutional capacity may be limited by challenges posed by population ageing and their stress on health and economic performance.

Education, another key determinant of adaptive capacity, is expected to expand to low-income households, minorities, and women; this could increase households' capacity to cope with environmental risks and could have a positive impact on economic growth (1261 Goujon, A. 2004). However, income disparities and poverty could hinder such improvements. Inequality in Mexico is larger, having a Gini index of 0.56, in contrast to 0.317 for Canada and 0.389 for USA(1264 OECD Volume 2010/2) . Limited economic growth expected in the short run for the region would not help to reduce the income gap across and within countries(1253 OECD 2010).

26.2.2. Physical Climate Trends

Summary of IPCC AR5 Assessment and CMIP5

Some processes important for climate change in North America are assessed in other Chapters of the AR5, including Chapter 2, Chapter 14 and Annex I of WGI, and Chapter 21 of WGII. Additional information is also available from the CMIP5 ensemble that is not included in Annex I of WGI.

Climate trends

Chapter 2 of WGI assesses observations of the climate system. It is noted that observations show increases in the occurrence of severe hot events over the U.S. over the late 20th century (922 Kunkel, K.E. 2008) WGI 2.7.1), a result in agreement with observed late-20th-century increases in extremely hot seasons over a region encompassing northern Mexico, the U.S. and parts of eastern Canada (Diffenbaugh and Scherer, 2011). These increases in hot extremes have been accompanied by observed decreases in frost days over much of North America (Alexander et al., 2006); (1149 Brown, P. J., R. S. Bradley, and F. T. Keimig 2010); WGI 2.7.1), decreases in cold spells over the U.S. (922 Kunkel, K.E. 2008) WGI 2.7.1), and increasing ratio of record high to low daily temperatures over the U.S. (Meehl, G. A., C. Tebaldi, G. Walton, D. Easterling, and L. McDaniel, 2009). However, mean cooling has occurred over central North America and the eastern USA (e.g., (Alexander et al., 2006); (922 Kunkel, K.E. 2008);; Peterson et al. 2008; WGI 2.7.1), associated primarily with changes in maximum temperatures (WGI 2.7.1). WGI notes that observations show increases in heavy precipitation over Mexico, the U.S. and Canada between the mid-20th century and the early 21st century(1151 Peterson, T.C. et al. 2009); (DeGaetano, 2009); WGI 2.7.2(Pryor, S. C., R. J. Barthelmie, D. T. Young, E. S. Takle, R. W. Arritt, D. Flory, W. J. Gutowski Jr., A. Nunes, and J. Roads, 2009)). Observational analyses of changes in drought are more difficult and equivocal over North America, with mixed sign of trend in dryness over Mexico, the U.S. and Canada (WGI 2.72 and Fig 2.42)(Dai, 2011). WGI notes evidence for earlier occurrence of peak flow in snow-dominated rivers globally ((1155 Rosenzweig, 2007); WGI 2.7.2). Observed snowpack and snow-dominated runoff have been extensively studied in the western U.S. and western Canada, with observations showing primarily negative trends in spring snowpack from 1960-2002 (with the most prominent exception being the central and southern Sierra Nevada) (Mote, 2006) and primarily earlier trends in the timing of peak runoff over the 1948-2000 period (Stewart *et al.*, 2006). WGI also assess observed changes in extreme storms in North America, noting that observational limitations prohibit conclusions about trends in severe thunderstorms (WGI 2.7.2) and tropical cyclones (WGI 2.7.3). The most robust trends in extratropical cyclones over North America are determined to be towards more frequent and intense storms over the northern Canadian Arctic and towards less frequent and weaker storms over the southeastern and southwestern coasts of Canada over the 1953-2002 period (WGI 2.7.4);(Wang, X. L. L., V. R. Swail, and F. W. Zwiers, 2006).

Climate change projections

Chapter 14 of WGI assesses processes important for regional climate change, with section 14.3.3 focused on North America. Many of the WGI conclusions are drawn from the WGI Annex I Atlas.

The CMIP5 ensemble projects robust seasonal warming over North America, with the greatest warming in winter over the high latitudes (WGI Annex I and Figure 26-1)(Diffenbaugh and Giorgi, in review). The CMIP3 ensemble suggests that the response of warm-season temperatures to elevated radiative forcing is far more robust than the response of cold-season temperatures, and that the response of low-latitude areas of North America is more robust than the response of high-latitude areas (Diffenbaugh and Scherer, 2011). In addition, the CMIP3 ensemble and an ensemble of high-resolution climate model simulations also suggest that the signal-to-noise ratio of 21st century warming is far greater over the western U.S., northern Mexico and the northeastern U.S. than over the central U.S. (Diffenbaugh, N.S, M. Ashfaq, and M. Scherer, 2011).

[INSERT FIGURE 26-1 HERE
Figure 26-1: Projected changes in the extremes of seasonal temperature, precipitation, snow accumulation and runoff. The panels show the percentage of years exceeding respective thresholds in the 2040-2069 period of the CMIP5 RCP8.5 realizations. The upper left panel shows the percentage of years in which the March accumulated snow amount falls below the 1976-2005 median value. The upper right panel shows the percentage of years in which the March-April-May (MAM) total surface runoff falls below the 1976-2005 minimum value. The lower left panel shows the percentage of years in which the June-July-August (JJA) surface air temperature falls above the 1976-2005 maximum value. The lower right panel shows the percentage of years in which the December-January-February (DJF) precipitation falls below the 1976-2005 minimum value. The top panels are from Diffenbaugh et al. (submitted to Nature Climate Change). The bottom panels are from Diffenbaugh and Giorgi (in review, Climatic Change Letters), with the field of view zoomed over the North American region.]

CMIP5-projects increases in seasonal precipitation over Canada and Alaska consistent with projections of poleward shift in the dominant cold-season stormtracks [add WGI section](Yin, 2005), extratropical cyclones (Trapp *et al.*, 2009) and areas of moisture convergence (WG1 14.3.3), as well as with projections of shift towards positive North Atlantic Oscillation (NAO) trends (Hori, M. E., D. Nohara, and H. L. Tanaka, 2007);(Karpechko, 2010); (Zhu, Y. L., and H. J. Wang, 2010); WGI 14.3.3). CMIP5- also projects decreases in seasonal precipitation over the southwestern U.S. associated with the poleward shift in the dominant stormtracks and the expansion of subtropical arid regions (Seager, R., and G. Vecchi, 2010); WGI 14.3.3). However, there are uncertainties in hydroclimatic change in western North America associated with the response of the tropical Pacific sea surface temperatures (SSTs) to elevated radiative forcing (Cayan, D. R., K. T. Redmond, and L. G. Riddle, 1999);(Findell, K. L., and T. L. Delworth, 2010);(Seager, R., and G. Vecchi, 2010); WGI 14.3.3).

Mexico and the western U.S. emerge as prominent aggregate climate change hotspots, particularly in the late 21st century period of RCP8.5, primarily as result of extreme seasonal heat, extreme seasonal dry conditions, and increases in interannual variability of seasonal precipitation (Diffenbaugh and Giorgi, in review). The CMIP5 models project substantial increases in the occurrence of extremely hot seasons in early, middle and late 21st century periods of RCP8.5, including greater than 80% of summers exceeding the late 20th century maximum during the 2070-2099 period (Diffenbaugh and Giorgi, in review). The CMIP5 ensemble also projects substantial decreases in surface snow amount over the U.S. and Canada, including greater than 80% (30%) of years with March snow amount below the late 20th century median (minimum) over much of the western U.S. and western Canada beginning the middle 21st century period of RCP8.5 (Diffenbaugh *et al.*, submitted). These decreases in spring snow amount are associated with substantial changes in the timing of total surface runoff, including greater than 30% of years above (below) the baseline winter (spring) runoff over the high elevation areas of the western U.S. and western Canada during the 2070-2099 period, greater than 50% of years below the summer maximum runoff over the high elevations of northwestern Canada, and greater than 30% of years above the baseline winter maximum runoff over most of central Canada during the 2070-2099 period (Diffenbaugh *et al.*, submitted) .

26.3. Water Resources and Management

26.3.1. Current Conditions

Chapter 3 of the WG2 report summarizes the observed impacts of climate change on the hydrology of North America including detection and attribution and also presents projections of the future. This chapter assesses impacts upon water conditions and uses for human society. Considering long-term average conditions and water demands, water conditions are already stressed (meaning that withdrawals or consumption are too large a fraction of renewable supplies) in parts of North America. Water withdrawals for most of the Continental USA west of the Mississippi River are already exceeding stressful levels especially in the southwest (Lane *et al.*, 1999). Essentially all of the Mexico north of and including Mexico City is highly water stressed with the Mexico City region itself very highly stressed (National Water Commission of Mexico, Statistics on Water in Mexico, 2010 Edition, June 2010. 2010). Depending upon the parameter monitored, 10 % to 30 % of the water quality monitoring sites in Mexico have polluted or heavily polluted water (National Water Commission of Mexico, Statistics on Water in Mexico, 2010 Edition, June 2010. 2010). In the USA, (1238 EPA, U.S. 2004) reported that about 44% of assessed stream miles, and 64% of assessed lake acres were not clean enough to support uses such as fishing and swimming.

26.3.1.1. Water Quality Impacts

Reduced flow conditions in rivers can result in a host of impacts on water quality due to temperature increases, increases in the concentrations of dissolved substances and changes in levels of dissolved oxygen ((1171 Daley, M.L. 2009)(Delpla *et al.*, 2009.),(Benotti *et al.*, 2010),(Novotny and Stefan, 2007)). Increased wildfires linked to a warming climate are expected to affect water quality downstream of forested headwater regions (Emelko *et al.*, 2011)). Simulation of lakes under higher air temperatures (Tahoe, Great Lakes, shallow polymictic lakes, Lake Onondaga) resulted in increased phytoplankton, and fish and cyanobacteria biomass, lengthened stratification periods leading to increased risks of significant hypolimnetic oxygen deficits in late summer triggering solubilization of accumulated phosphorous and heavy metals and accelerated reaction rates, and decreases in lake clarity due to less settling of fine sediments (Dupuis and Hann, 2009.), (Trumpickas *et al.*, 2009), (Sahoo *et al.*, 2010), (Taner *et al.*, 2011). Many found through simulation seasonal changes in nonpoint source loads due to climate change (Marshall and Randhir, 2008; Tu, 2009), but in some cases the total load staying the same (Praskievicz and Chang, 2011) in Oregon). (1176 Tu, J. 2009) (1178 Praskievicz, S. 2011),(Daley *et al.*, 2009), (Tong *et al.*, 2012), and (Wilson and Weng, 2011) all find that the joint impacts of climate change and development result in poorer water quality and, where investigated, climate change impacts are greater than land use changes.

Operators of drinking water treatment and distribution systems will be affected negatively by changes in physical-chemical-biological parameters and micropollutants (Delpla *et al.*, 2009), (Emelko *et al.*, 2011), (Trumpickas *et al.*, 2009).

Increased rainfall will result in more wet weather inflow to wastewater treatment plants. Plants will be more vulnerable to flooding due to increased river and coastal flooding and higher sea levels will lead to reduced hydraulic capacities. There will be reduced treatment efficiency due to increases in inflow and infiltration (New York City Department of Environmental Protection. 2008. *the NYCDEP Climate Change Program*, DEP with Contributions by Columbia University Center for Climate Systems Research and HydroQual Environmental Engineers and Scientists, P.C., New York, NY, Http://www.Nyc.gov/dep, 2008), (King County Department of Natural Resources and Parks, 2008. Vulnerability of Major Wastewater Facilities to Flooding from Sea-Level Rise.

Seattle, Washington: King County (WA) Department of Natural Resources and Parks, Wastewater Treatment Division, 13p, 2008), (Flood and Cahoon, 2011)). Higher sea levels will also threaten the sewage collection systems themselves(105 Rosenzweig, C. 2007), (King County Department of Natural Resources and Parks, 2008. Vulnerability of Major Wastewater Facilities to Flooding from Sea-Level Rise. Seattle, Washington: King County (WA) Department of Natural Resources and Parks, Wastewater Treatment Division, 13p, 2008).

26.3.1.2. Water Supply

In the arid and semi-arid areas of western USA and Canada and most of Mexico except the southern tropical area, water supplies most likely will be further stressed by climate change. Impacts in Mexico would include reduced water availability, increased water demand, salt water intrusion, and increased groundwater and surface water pollution (Leal *et al.*, 2008). This will most likely lead to overexploitation of groundwater even though the region already has many reservoirs(1193 Anonymous 2011). In the south central highland area of Mexico, dominated by metropolitan Mexico City and irrigation in the non-urban area, for scenarios A2 and A1B, it is projected that by mid-century there will be higher water stresses in all sectors due to decreased water availability, increased demand, and groundwater pollution (Leal *et al.*, 2008), (1193 Anonymous 2011),(1181 Mendoza, V.M. 1997). The Colorado River Basin portion in Colorado is not only facing decreased flows but crop irrigation requirements for pasture grass in the area, which are currently 80% of irrigated water use, are projected to increase by 20% in 2040 and by 31 % in 2070 (AECOM, 2010). In the Rio Grande basin in New Mexico under the most severe climate change scenario of three runoff is projected to be reduced by nearly 30% by 2080. In general, ecosystems and irrigation are the most stressed as water is transferred to urban and industrial users with greater economic productivity. Economic losses under the most severe climate scenario are at least $100 million per year in 2080. Water transfers will likely entail significant transaction costs associated with adjudication and potential litigation. In addition, transferring water reduces ecological, environmental, social, and cultural attributes (Hurd and Coonrod, 2012). In Canada, approximately two-thirds of irrigated land is found in southern Alberta . This region is projected to experience declines in mean annual streamflow, with summer declines being especially significant (Shepherd *et al.*, 2010.).

In other parts of the North American region, stresses due to climate change will most likely vary. Over the entire tropical southern region of Mexico, using the GFDLR-30, CCC and MTC models, no vulnerability of water reserves for these uses is projected for 2050(1181 Mendoza, V.M. 1997). By 2050, however, under greater precipitation projections the three GCMs show hydropower and water storage from 10 dams will likely become more vulnerable because the large amounts of excess water may cause floods that destroy the dams(1181 Mendoza, V.M. 1997). For Seattle, Everett, and Tacoma Washington, without adaptation to climate change, average seasonal drawdown of reservoir storage is projected to increase in all three systems throughout the 21st century. Reliability of all systems in the absence of demand increases, however, is robust through the 2020s and remains above 98% for Seattle, Everett and Tacoma in the 2040s and 2080s. With demand increases, reliability of the systems in their current configurations and with current operating policies progressively declines through the century(1108 Vano, J. 2010). Municipal utilities may face significant increases in water demand in what are now the spring and fall ‘shoulder months’ of demand

In the eastern USA, water supply systems will be impacted if streamflows and groundwater recharge lessen and snowpack storage is lost. In addition, systems will be further impacted by rising sea levels, increased storm intensities, salt water intrusion, increased low flows, land use and population changes and other non-climate related stresses (Obeysekera *et al.*, 2011), (Sun, G., McNulty, S. G., Moore Myers, J. A., & Cohen, E. C., 2008).

26.3.1.3. Flooding

Increased flooding will likely damage sectors ranging from agriculture and livestock in southern tropical Mexico(1194 Anonymous 2010; 1193 Anonymous 2011), urban infrastructure in areas such as Dayton OH)(Wu, 2010) and metro Boston (Kirshen *et al.*, 2006), and California water infrastructure, especially in the Bay-Delta region (1195 Anonymous 1995) . Without the development of additional flood management infrastructures, increased flooding due to climate change will be compounded, as it is now by, by urbanization (Hejazi and Markus, 2009), (Ntelekos *et al.*, 2010a) estimate that annual riverine flood losses in the USA could increase from approximately $2 billion now to $7 billion to $19 billion annually by 2100 under business as usual conditions of growth and floodplain management in the USA and climate change.

Drainage infrastructure designed using mid-20th century rainfall records will be subject to a future rainfall regime that is greater than current design standards (Mailhot and Duchesne, 2010), (Kirshen *et al.*, 2011).

26.3.1.4. Instream Uses

In the arid and semi-arid areas of Mexico, three GCMs models (GFDLR-30, CCCM and MTC) show hydropower will not be vulnerable to streamflow changes in 2050, due to water storage capacity inland. The desert areas show medium vulnerability for hydropower in 2050 because of low storage capacity (1181 Mendoza, V.M. 1997). By 2040 hydropower production in the US Pacific Northwest is projected to increase by approximately 5 % in winter and decrease by about 13% in summer, with annual reductions of about 2.5%. Larger decreases of 17.1% to 20.8% in summer hydropower production are projected for the 2080s(1125 Hamlet, A. 2010). Estimated impacts of climate change on the Peribonka River system in Quebec are that annual mean hydropower production would decrease by 1.8% for the period 2010-2039; in contrast, during the periods 2040-2069 and 2070-2099, there would be increases of 9.3% and 18.3%, respectively (Minville *et al.*, 2009). The extent to which benefits such as these can be realized will depend strongly on other demands for water that may exist. For instance, hydropower production is only one among many water management objectives in British Columbia; others include flood control, recreation, and ecological goods and services (Hamlet, 2011). Navigation in the Great Lakes basin would be negatively affected by reduced lake levels, due to restrictions on vessel drafts, reductions in the cargoes that can be carried. This would result in an increase in the number of trips needed to transport the same amount of cargo.

26.3.2. Energy-Water Nexus

The energy demands for water supply and wastewater treatment are (California, 2005), (U.S. DEPARTMENT OF ENERGY, ENERGY DEMANDS ON WATER RESOURCES, REPORT TO CONGRESS ON THE INTERDEPENDENCY OF ENERGY AND WATER, DECEMBER 2006, 2006), (Carlson and Walburger, 2007), (U.S. EPA. 2008. Ensuring a Sustainable Future: An Energy Management Guidebook for Water and Wastewater Utilities. 113pp. 2008), NYSERDA, 2008,GAO, 2011, McMahon and Price, 2011) are projected to increase under climate change ((National Association of Clean Water Agencies and National Association of Metropolitan Water Agencies, 2009: Confronting Climate Change: An Early Analysis of Water and Wastewater Adaptation Costs, Prepared by CH2M Hill, Inc. 103 Pp.), 2009)). Conversely, cooling of USA thermoelectric power plants accounts for approximately 50% of the nation's water withdrawals (Kenny *et al.*, 2009)). Some mitigation strategies for energy production such as carbon capture, nuclear power, and some biofuels will exacerbate stresses on water supplies and water quality (1223 Cooper, D.C. 2012), (1226 Delucchi, M.A. 2010), (Engelhaupt, 2007), (Powers *et al.*, 2011), (Stone *et al.*, 2010)). On the other hand, various carbon pricing policies may decrease thermoelectric power plant freshwater withdrawals and consumption in the continental USA compared to business as usual policies (Chandel *et al.*, 2010)).

26.3.3. Adaptation Strategies

Urban water adaptation options include improved drought management plans, reduced water consumption, system interconnections, improved water quality, improved coordination with other organizations in the water supply watersheds, holistic management of storm water, flood waters, water supply, and wastewater management, incorporating climate change impacts into municipal bond ratings, security through diversity of supplies including development of local resources, expansion of regional storage including aquifer storage, including projected future changes in climate into masterplans and source protection, land use management, and better alignment of revenues with fixed and variable costs (Lempert and Groves, 2010), (Smith, 2009), (105 Rosenzweig, C. 2007), , (Novotny and Brown, 2007), (Zoltay *et al.*, 2010), (Gleick, 2010), (Daigger, 2009), (de Loë, 2011), IMTA, 2010(IMTA, 2010, Efectos Del Cambio Climático En Los Recursos Hídricos De México, Volumen III. Atlas De Vulnerabilidad Hídrica En México Ante El Cambio Climático. Instituto Mexicano De Tecnología Del Agua, México. Available at Http://www.Atl.Org.mx/atlas-Vulnerabilidad-Hidrica-Cc/ , 2010),(1192 Leal Asencio, M.T. 2008). Based upon a survey of water managers in the mid-Atlantic USA, Dow et al (2007), however, found they are concerned about financial, regulatory, and management issues at least as much as water scarcity. (Flory and Panella, 1994) warn of the perils of demand hardening, where long-term water use conservation is so effective that extra water cannot be conserved during short-term droughts .

Irrigation can be adapted to reduced water availability by decreasing irrigation demands. A cooperative approach to accomplishing this during a drought took place in Alberta, Canada where water is apportioned under a "first-in-time, first-in-right" prior allocation system. In 2001, the parts of the Oldman River Basin faced a projected water supply of only 50% of the median annual flow. Rather than relying on the priority system to determine which users would receive water, a cooperative approach was brokered among license holders. As a result of this approach, considerable social and economic disruption was avoided. Importantly, farm production was not significantly reduced, largely because water use efficiency was increased. (1242 Anonymous 2008)recommends soil enhancement practices, greenhouses, efficient irrigation and a forestry focus on reforestation and conservation. Agriculture may also benefit from meteorological forecasting(1243 Anonymous 2008). Possible adaptations reported for some potential impacts due to biofuel production include improved farming practices and switching to less water consuming biofuel feedstocks (Engelhaupt, 2007), (Stone *et al.*, 2010).

One adaptation is to adjust water infrastructure over time as the climate changes. For example, the 540-foot high, 1300-foot long concrete Ross Dam in the state of Washington was built on a special foundation so it could be later raised in height. A distributed technology such as Low Impact Development storm management techniques can be added to a region as possible and necessary (Roseen *et al.*, 2011)

Some adaptations to the USA National Floodplain Insurance Program (NFIP) to lessen flood losses include: updating elevation and land use datasets every 10 years, improved hydrologic and hydraulic modeling, predicting extent of future floodplains as the climate changes and uncertainties decrease, eventually charging pre NFIP buildings full rates to decrease repetitive losses, and increasing enforcement of the NFIP. Others mentioned are European polices of "Making Room for Rivers", low-impact development, and removal of buildings in flood-prone areas (Ntelekos *et al.*, 2010b).

Adaptation policies for decreasing thermoelectric power cooling water use include replacement of once-through cooling systems with recirculating systems, less water intensive carbon capture and storage systems, dry and hybrid cooling systems, and increased use of saline and waste water with increased costs for the necessary water treatment (reference to be added).

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Box 26-1. The Columbia River Basin: Transboundary Challenges in a Changing Climate

The Columbia is the fourth largest river of North America, in terms of flow. Most of the annual precipitation in the Basin falls as snow in the winter and is released in the spring as snow melt. Under climate change April 1st snow-water equivalent (SWE) is projected to increase going to 2050 but, to decline in the post-2050 period. For all the locations there are projected increases in the winter (DJFM) runoff in all future decades, which will affect management tradeoffs based upon runoff timing(1244 Elsner, M., 2010);(1125 Hamlet, A. 2010);(1245 Mote, P.W., 2010).

Water management in the basin operates in a complex institutional setting, involving two sovereign nations (the 1964 Columbia River Treaty, hereafter referred to as "the Treaty"), indigenous peoples with defined treaty rights, and numerous federal, state, provincial and local government agencies(1247 Bates, B.C. 2008). The Treaty obligated Canada to construct water storage dams in the Columbia River Basin in British Columbia, and called for the ongoing, coordinated operation of storage and hydroelectric projects in British Columbia and the US Pacific Northwest for the purposes of flood control and power generation. The original Treaty did not recognize protecting or improving habitat conditions for salmon and other fish and wildlife in the Columbia, or any other environmental benefits, as an equal purpose for system operations.

At present, planning and analysis are being undertaken by both the US and Canadian sides to meet a 2014 decision point on future coordinated management of the basin. Potential management paradoxes exist in that changing system management to be more responsive to flexible power system needs may be opposite to fish sustainability goals. On the other hand, so-called ‘fish-first’ rules would reduce firm power reliability by 10% under the present climate and by 17% in years during the warm phase of the Pacific Decadal Oscillation (PDO)(1249 Payne, J.T. 2004).

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26.4. Ecosystems and Biodiversity

Climatic changes are expected to affect North American ecosystems in manifold and interacting ways. Because many elements of species physiology are sensitive to climate variables (e.g., (Root, 1988); (Adams *et al.*, 2009)), changes in temperature, precipitation amount and timing/form, carbon dioxide concentrations, sea-level rise, and fire patterns can have differential effects across species and ecological communities (Parmesan, 2006)). Recent research has documented gradual changes in phenology (Root *et al.*, 2005)) and distributions in North American ecosystems (e.g., (Kelly and Goulden, 2008)). For example, shifts in plant, mammal, bird, lizard, and insect species’ distributions in concert with 20th century temperature increases have been documented extensively in the western United States and eastern Mexico (Kelly and Goulden, 2008);(1229 Moritz, C. 2009); (Tingley *et al.*, 2009); (Parmesan, 2006);(Sinervo *et al.*, 2010). These gradual climate-induced shifts in species will probably interact with other environmental changes such as land-use change, hindering the ability of species to respond.

Different techniques have been used to assess the vulnerability of various North American ecosystems to changes in climate (e.g.,(Sala *et al.*, 2000);(Scholze *et al.*, 2006);(Loarie *et al.*, 2009). A risk analysis for ecosystems using coupled climate-vegetation models found >40% risk of substantial decreases in boreal forest ecosystems in Canada is estimated with >3 C global average warming (Scholze *et al.*, 2006)). The study assigned a high probability of increases in wildfires in the western U.S. (Scholze *et al.*, 2006). Due to topographic and projected climate differences, northwestern Mexico, central U.S., and central and northern Canada are estimated to experience some of the highest climate velocities – the rate at which climate isotherms move across the land per year (Loarie *et al.*, 2009). In particular for North American ecosystems, desert and xeric shrublands (0.71 km/yr), temperate grasslands (0.59 km/yr), and boreal forests (0.54 km/yr) are projected to experience the highest mean climate velocities between 2000 and 2100 (Loarie *et al.*, 2009).

In addition to gradual responses to climate variables, growing attention has been paid to the roles of extreme events and disturbance with a changing climate in North American ecosystems. Since the AR4, drought, wildfire, and insect infestation have emerged as major climate stressors to forests in the western United States and Canada (Westerling *et al.*, 2006); (838 Kurz, W.A. 2008);(Bentz *et al.*, 2010). Recent “climate change-type” droughts (Breshears, D. D., N.S. Cobb, P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer, 2005)) and projected increases in drought severity in southwestern United States and northwestern Mexico (Seager *et al.*, 2007) suggest that these ecosystems may be increasingly vulnerable to rapid changes such as vegetation mortality (Adams *et al.*, 2009); (Williams *et al.*, 2010); (Overpeck and Udall, 2010)) and an increase of biological agents such as beetles, borers, pathogenic fungi, budworms and other pests (Worral, J. J., L. Egeland, T. Eager, E.R. Mask, E.W. Johnson, P.A. Kemp, and W.D. Shepperd, 2008); (Breshears, D. D., N.S. Cobb, P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer, 2005);(Allen, C. D., A. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, P. Gonzales, T. Hogg, A. Rigling, and D.D. Breshears, 2010)).

Other extreme events such as floods and storm damage can also affect ecosystems in the eastern United States and Mexico (Chambers *et al.*, 2007). Nonetheless, North American forests were a net carbon sink between 1990-2007

(Pan *et al.*, 2011) but new measurements suggest a reduction in the global net primary production of 0.55 petagrams of carbon due a large-scale droughts in the past decade (2000 to 2009)(1210 Zhao,Maosheng 2010).

We discuss below observed and projected impacts due to droughts, infestations, and wildfires as salient emerging ecosystem stressors. The prominence of these stressors has emerged since the AR4, and thus we review them in greater depth.

26.4.1. Tree Mortality and Forests Infestations

Across large areas of western North America, tree mortality has already increased, likely in response to the impacts of climatic warming and drought (van Mantgem *et al.*, 2009)). Droughts of unusual severity, extent, and duration have affected large areas of southwestern North America, and resulted in regional-scale dieback of forests in the US (Breshears, D. D., N.S. Cobb, P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer, 2005)). An estimated 10.3-18% of forests/woodlands in this region have experienced high levels of mortality between 1984-2006 due to wildfire, drought stress, or beetle attack (Williams *et al.*, 2010)). Across the western US and Canada, trembling aspen (*Populus tremuloides)*, pinyon pine (*Pinus edulis)* and lodgepole pine *(Pinus contorta)* have experienced substantial die-off (Worral, J. J., L. Egeland, T. Eager, E.R. Mask, E.W. Johnson, P.A. Kemp, and W.D. Shepperd, 2008); (Anderegg *et al.*, 2012); (Raffa *et al.*, 2008)). Both the aspen and pinyon pine die-off have been related to extreme “climate change-type drought” events, in which severe drought is exacerbated by higher summertime temperatures (Breshears, D. D., N.S. Cobb, P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer, 2005); (Anderegg *et al.*, 2012). This indicates that even if drought intensity or severity does not increase, these systems will be vulnerable due to the temperature rise alone (Adams *et al.*, 2009). Widespread forest-mortality events triggered by extreme climate events can alter ecosystem structure, function, and severely impact biodiversity (Allen, C. D., A. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, P. Gonzales, T. Hogg, A. Rigling, and D.D. Breshears, 2010); (Phillips, O. L., L. Aragao, S.L. Lewis, J.B. Fisher, J. Lloyd, G. Lopez-Gonzalez, Y. Malhi, A. Monteagudo, J. Peacock, and C.A. Quesada, 2009)).

Increases in the average mortality rate of 4.7% yr –1 between 1963 and 2008 were reported for Canada's boreal forests, with higher increases in the mortality rate in western regions than in eastern regions (about 4.9 versus 1.9% yr –1 , respectively) (Peng *et al.*, 2011). Dieback of aspen was first observed in the early nineties (Hogg, E. H., J.P. Brandt, and B. Kochtubajda, 2002)). Aerial surveys and tree ring analysis suggest that the 2001–2003 droughts likely contributed to widespread mortality of aspen trees in western Saskatchewan and eastern Alberta (Williamson, T.B., S.J. Colombo, P.N. Duinker, P.A. Gray, R.J. Hennessey, D. Houle, M.H. Johnston, A.E. Ogden, and D.L. Spittlehouse, 2009);(Hogg, E. H. and P. Y. Bernier, 2005); (Hogg *et al.*, 2008);(Michaelian, M., E.H. Hogg, R.J. Hall, and E. Arsenault, 2010)).

Since tropical forests are often organized along environmental gradients of precipitation, frequent droughts may change forest structure and distribution at the regional scale. For example, this would favor greater prevalence of deciduous species in the forests of Mexico (Figure 26-2) (Trejo, I., E. Martínez-Meyer, E. Calixto-Pérez, S. Sánchez-Colón, R. Vázquez de La Torre and L. Villers-Ruiz, 2011);(Drake, B.G., L. Hughes, E.A. Johnson, B.A. Seibel, M.A. Cochrane, V.J. Fabry, D. Rasse, and L. Hannah, 2005)). The decline of oak forests in the state of Guanajuato Mexico was associated with occurrences of extreme temperatures and severe droughts, making the trees vulnerable to infestation susceptible fungal pathogens (Vázquez Silva, L., J.C. Tamarit Urias, J. Quintanar Olguín, and L. Varela Fregoso, 2004).

[INSERT FIGURE 26-2 HERE
Figure 26-2: Climate-induced species migration in Mexico. Source: Trejo et al., 2011.]

Drought and warmer temperatures have allowed budworm and other insects to become epidemic in regions in which they are usually endemic (Drake, B.G., L. Hughes, E.A. Johnson, B.A. Seibel, M.A. Cochrane, V.J. Fabry, D. Rasse, and L. Hannah, 2005)). There is little rigorous evidence that insect-attacked forests are more susceptible to fire. However, increased extent and frequency of insect epidemics like spruce budworm, jack pine budworm and forest tent caterpillar may hasten the conversion of ecosystems in changing climates (Drake, B.G., L. Hughes, E.A. Johnson, B.A. Seibel, M.A. Cochrane, V.J. Fabry, D. Rasse, and L. Hannah, 2005)).

Recent outbreaks of Mountain Pine Bark Beetles (MPBB) in the Western Rockies of the USA have devastated the lodgepole pine forests from Alaska down to Colorado (838 Kurz, W.A. 2008). In addition, outbreaks have emerged in the high elevation areas of the Rockies in the white bark pine systems and have resulted in massive die-offs of these highly vulnerable species. The climate controls on over-wintering populations of the mountain pine bark beetle have been overcome by recent warmer winters allowing a greater number of larvae to survive(855 Bentz, B.J. 2010) (see Box 26-2).

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Box 26-2. Mountain Pine Beetles

The influences of climate change on ecosystem disturbance, such as insect outbreaks have become increasingly salient and suggest that these disturbances could have a major influence on North American ecosystems and economy in a changing climate. Warm winters in Western Canada and U.S. have allowed the larvae of mountain pine beetle to overwinter, causing the "largest and most severe [outbreak] in history" from Alaska to Colorado (Bentz, 2008), with massive die-offs in some regions. An estimated 18,177 km2 of U.S. forests is affected (Williams *et al.*, 2010). British Columbia, Canada had the largest impact (Figure 26-3;(854 Brown, M. 2010), with mortality in over 7 million hectares (Aukema *et al.*, 2006)). The extent and severity of this outbreak is attributed to climate change (838 Kurz, W.A. 2008), and further expansion is projected into higher latitudes and elevations (Bentz *et al.*, 2010)). Such outbreaks can convert forests into carbon sources (Kurz *et al.*, 2008a; Kurz *et al.*, 2008b).

[INSERT FIGURE 26-3 HERE
Figure 26-3: Geographic extent of mountain pine beetle outbreak in North America. Source: Kurz et al., 2008.]

Predicted climate warming is expected to have profound effects on bark beetle population dynamics in the southwestern United States and Northern part of Mexico (478 Waring, K. M., D.M. Reboletti, L.A. Mork, Ch. Huang, R.W. Hofstetter, A.M. Garcia, P.Z. Fulé, and T.S. Davis 2009). Temperature-mediated effects may include increases in developmental rates, generations per year, and changes in habitat suitability. As a result, the impacts of *Dendroctonus frontalis* and *Dendroctonus mexicanus* on forest resources are likely subject to amplification (Waring, K. M., D.M. Reboletti, L.A. Mork, Ch. Huang, R.W. Hofstetter, A.M. Garcia, P.Z. Fulé, and T.S. Davis, 2009).

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26.4.2. Coastal Zones

The rate of sea level rise in North America has increased significantly during the 20th century. The increase in the absolute rate of sea level rise of 3 mm per year as observed in North Carolina is comparable with findings from other studies performed along the Atlantic coast (Leonard, L., J. Dorton, S. Culver, and R. Christian, 2009);(Kemp, A., B.P. Horton, S.J. Culver, D.R. Corbett, O. Van De Plassche, and R. Edwards, 2008)). Studies in Mexico show different values of sea level rise, depending on the site monitored: the highest value for the Gulf of Mexico has been observed in Cd. Madero, Tamaulipas (9.2mm per year), while that for the Pacific was observed in Guaymas, Sonora (4.2mm per year). Furthermore, the trend continues clearly to be that of an increasing rate of sea level rise (Zavala-Hidalgo, J., R. de Buen, R. Romero-Centeno, and F. Hernández, 2010), see section 26.10).

Highly productive estuaries, wetlands and mangroves occur across the East and West coasts of North America. The high diversity of flora and fauna that characterize these fragile ecosystems are vulnerable to extreme events such as the increase in hurricanes, marine temperature increases, and sea level rise. Sea level rise will result in the loss of coastal wetlands in many areas of North America due to erosion, flooding and saltwater intrusion. The combined forces of both sea level rise and other risks such as storm surge are of particular concern.

It is estimated that 1m rise in sea level by 2100 would, with no defensive measures taken, inundate approximately 9% of coastal areas along the Gulf and southern Atlantic coasts located at or below 6 m (Weiss and Overpeck J.T. and Strauss, B., 2011). Using a variety of national level data bases, (522 Weiss, J.L., J.T. Overpeck, and B. Strauss. 2011) estimate the areas more exposed to SLR are located in the south Atlantic and Gulf Coast states. Relatively the west coast is generally less exposed.

The U.S. coastal regions expected to be most vulnerable to sea level rise are concentrated along the Atlantic coast and the Gulf coast, including the coastlines of Florida, Louisiana, North Carolina, and Texas. Louisiana is projected to experience the greatest loss of wetlands due to rising sea level (Leonard, L., J. Dorton, S. Culver, and R. Christian, 2009), (Kemp, A., B.P. Horton, S.J. Culver, D.R. Corbett, O. Van De Plassche, and R. Edwards, 2008)). Rising sea levels are projected to change the flood level of mangroves and wetlands and to reduce the level of tolerance and recovery capacity of many plants. A loss of 20 to 94% is projected for these areas in the Gulf and Pacific coast of Mexico depending on dominant topography (Flores Verdugo, F.J., P. Moreno-Casasola, G. De La Lanza-Espino, and C. Agraz Hernández, 2010). Sea level rise has been suggested to cause beach erosion by reducing the distribution of plants in Galveston Island, Texas (Feagin, R.A., D.J. Sherman, and W.E. Grant, 2005).

Ecological effects of tropical storms and hurricanes indicate that storm timing, frequency, and intensity can alter coastal wetland hydrology, geomorphology, biotic structure, energetic, and nutrient cycling. The increase in the frequency of high intensity hurricanes will directly affect the mangroves over a period of at least25 years and completely change their structure and age (Kovacs, J. M., J. Malczewski, and F. Flores-Verdugo, 2004).

Elevated temperatures have been cited as the cause for the increase in bleaching events and direct effects of acidity and temperature severely threaten coral reefs and other marine ecosystems (Doney, S.C., V.J. Fabry, R.A. Feely, and J.A. Kleypas, 2009); (Hernández, L., H. Reyes-Bonilla, and E.F. Balart, 2010); (Mumby, P.J., I.A. Elliott, C.M. Eakin, W. Skirving, C.B. Paris, H.J. Edwards, S. Enríquez, R. Iglesias-Prieto, L.M. Cherubin, and J.R. Stevens, 2011)). Important coral reefs in terms of beauty and biological diversity, both in the Pacific, the Gulf of California, and the Atlantic Mesoamerica can be affected by sea warming. However, tropical corals are subject to many other stressors in the North Atlantic, including increased nutrient input from coastal development and the indirect effects of overfishing. The growing incidence of coral diseases, as well as disease prevalence and rate of spread on coral colonies, is attributed to increases in pathogen prevalence and virulence associated with global warming and low water quality (ICES (The International Council for the Exploration of the Sea), 2011)).

Bleaching will be exacerbated by the effects of degraded water-quality and increased severe weather events. In addition, the progressive onset of ocean acidification will cause reduction of coral growth and retardation of the growth of high magnesium calcite-secreting coralline algae. If CO_2 levels are allowed to reach 450 ppm (due to occur by 2030–2040 at the current rates), reefs are projected to be in rapid and terminal decline world-wide from multiple synergies arising from mass bleaching, ocean acidification, and other environmental impacts. Damage to shallow reef communities will likely become extensive with consequent reduction of biodiversity followed by Extinctions (Veron, J.E.N., O. Hoegh-Guldberg, T.M. Lenton, J.M. Lough, D.O. Obura, P. Pearce-Kelly, C.R.C. Sheppard, M. Spalding, M.G. Stafford-Smith, and A.D. Rogers, 2009)).

26.4.3. Adaptation and Mitigation Strategies

Both the relatively rapid rate of climate changes and the degraded and fragmented state of many forest ecosystems reduce the capacity of the species and ecosystems to adapt or to be resilient (Magrin, G., Gay, C. with Cruz Choque, D. Jiménez, J.C. Moreno, A.R. Nagy, G., Nobre, C. Villamizar, A., 2007), (Noss, 2001)). The capacity of forests to resist change depends on biodiversity at multiple scales. Increasing forest biodiversity in planted and semi-natural forests will have a positive effect on resilience and often on productivity (including carbon storage); >80% of the studies reviewed supported this concept(1212 Thompson, I.D. 2010).

Forest biodiversity is the key to reduce forest infestations and some Canadian adaptation options are to increase plant community composition and biological diversity(1230 Johnston, M., T. Williamson, A. Munson, A.Ogden, M. Moroni, R. Parsons, D. Price, and J. Stadt 2010). Efforts have been made in breeding programs for resistance to diseases and insect pests that have had significant local impacts; however, the successes are largely for a few of the main commercial programs which have had substantial resources and structures in place to deliver the gain (Yanchuk, A. and G. Allard, 2009).

Improving climate resilience and adaptation will require changes in the approach to protected area planning, establishment and management. Adaptation research suggests that improving climate resilience and adaptation in protected areas will be much more difficult and, in some cases, not sufficient if global temperature rise exceeds 2^{o}C above preindustrial levels. *(Mansourian and A. Belokurov and P.J. Stephenson, 2009).*

Forest tree species might need human help to cope with changes that exceed their natural capacity of adaptation. Human-assisted migration has been proposed as a potential management option to maintain optimal health and productivity of forests; in order to maximize adaptation to climate change (1211 Keel, B. G. 2007) (1237 Winder, R., Nelson E. A., and Beardmore, T. 2011).

Probably one of the more notable short-term changes in the policy arena is the discussion of GHG emissions reduction through CDM and REDD+ and management, conservation and restoration of forest carbon stocks. Mitigation through forestry, however, must also be cognizant of the manifold ways through which forests influence the climate both biogeochemically (e.g. carbon sequestration) and biophysically (e.g. albedo and roughness)(891 Anderson, R. G. 2011)

For the forest manager much of the challenge lies in adjusting management practices in favor of carbon accumulation, while at the same time maintaining biodiversity, recognizing the rights of indigenous people and contributing to local economic development(1231 FAO 2012)

26.5. Wildfires

26.5.1. Observed Trends

Wildfires have increased in the region recently. Since 2000, the annual acres burned in the U.S. have more than doubled, to 7.0 million (www.nifc.gov). The Western U.S. in particular has experienced a six-fold increase in forest area burned since 1986, and the average duration has increased from 7.5 to 37.1 days (Westerling *et al.*, 2006). 11 of the 20 largest fires on record in California occurred in the past decade (CDFFP, 2010). Historic patterns of fire occurrence in Western Canada have likewise increased significantly ((Williamson, T.B., S.J. Colombo, P.N. Duinker, P.A. Gray, R.J. Hennessey, D. Houle, M.H. Johnston, A.E. Ogden, and D.L. Spittlehouse, 2009)): while the average area burned between 1920 and 1979 was 1.5 million hectares, this figure has exceeded 5 million hectares several times since (Peter *et al.*, 2006)).The Northwestern US and southwestern Canada, previously largely free of fires, have experienced recent fire events (Westerling *et al.*, 2006); (Kitzberger *et al.*, 2007); (McKenzie *et al.*, 2004). In Mexico between 1999 and 2009 216 thousand hectares per year were lost in wildfires, but the worst year in the recent history was 2011, were 954 727 hectares were lost exceeding the area burned in 1998 (CONAFOR (National Forestry Comission), 2011))

Non-Climate-Related Contributing Factors

Drought conditions are strongly associated with wildfire occurrence, as they increase dead fine fuels, and thus promote the incidence of firebrands and spot fires (Keeley, J. E. and P. H. Zedler, 2009). During the 2002 drought in Alberta, the area burned was 5 times larger than average (Kulshreshtha, 2011). Historical fire records dating back 100 years indicate that large burned areas in mixed-conifer forests in Yellowstone National Park and drier central Idaho ponderosa pine forests coincide with drought intervals (Pierce, J. and G. Meyer, 2008). In southern California and Baja California Mexico, large conflagrations are usually associated with wind events that follow the long spring and summer droughts (Keeley, 2004); (Holden *et al.*, 2007). Phases (positive or negative) of ocean-atmosphere oscillations like the El Niño-Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO) and the Atlantic Multidecadal oscillation (AMO) contribute to drought conditions, sometimes for decades or more (Kitzberger *et al.*, 2007); (Collins *et al.*, 2006); (Heyerdahl, E. K., D. McKenzie, L. D. Daniels, A. E. Hessl, J. S. Littell, N. J. Mantua., 2008); (Brown *et al.*, 2008). In Mexico, ENSO events have led to uncontrolled wildfires and increases in area burned, mainly in the northwest and central-northern part of the country (Villers-Ruíz, L., y Hernández-Lozano, J., 2007)). . Southern and western Canada, Alaska and Mexico have all experienced a trend toward drier conditions since the 1950s (922 Kunkel, K.E. 2008). Increased drought conditions are projected for a large proportion of the Western interior, Florida, and Mexico by 2100.

Human behavior also contributes to wildfire activity. Increased human presence in fire-prone regions undoubtedly increases the probability of ignitions (Keeley, 2004); (CONAFOR (National Forestry Comission), 2011), and in Mexico in particular, the agricultural practice of burning stubble in the dry season near forests is a primary cause of ignition (CONAFOR (National Forestry Comission), 2011). Land management, such as grazing or fire suppression, also interacts strongly with wildfire probability. Land management changes in species composition and the concentration and arrangement of flammable fuels may alter the fire regime (Bond, W. J. and J. E. Keeley, 2005). Recent stand-replacing fires in ponderosa pine forests in US are attributed to changes in forest management, in combination with increasing temperatures and drought severity during the 20th century (Pierce, J. and G. Meyer, 2008). Fire suppression practices in fire-prone ecosystems can significantly enhance the risk of large fires. In mixed conifer forests, for example, which are associated with a natural cycle of small and non-crown fire regimes, fire suppression could increase the likelihood of massive crown-fires. Since the late 1800s, fire suppression, combined with ecological and climatic changes has greatly reduced fire frequency, amounting to a forest “fire deficit” in the western United States (1266 Marlon, J.R. 2012). While recent large fire events have begun to address the fire deficit, it is continuing to grow (1266 Marlon, J.R. 2012).

Since the late 1800s, combined effects of historical fires suppression, ecological, and climate changes caused a large decline in burning. Consequently, there is now a forest “fire deficit” in the western United States(1266 Marlon, J.R. 2012). While large fires in the late 20th and early 21st century have begun to address the fire deficit, it is continuing to grow (1266 Marlon, J.R. 2012).

26.5.2. Association with Climate Change

Future temperature and precipitation scenarios forecast not only increases in the frequency and intensity of drought conditions, thereby enhancing wildfire risk, but also longer and drier summers, drier winters, and warmer springs with earlier and more rapid snow melt in many parts of western North America, which are similarly linked to wildfire occurrence (Westerling *et al.*, 2006); (McKenzie *et al.*, 2004); (Flannigan *et al.*, 2005). The area burned in the North American boreal forest has been linked to the dynamics of large-scale climatic patterns (Macias Fauria, M. and E. A. Johnson, 2006; Macias Fauria, M. and E. A. Johnson, 2008), (Skinner, W.R., E. Shabbar, M.D. Flannigan, and K. Logan, 2006)). Climate effects on forests and wildfire risk are not uniform, however. Complex interactions among topography, altitude, forest composition, suppression history, forest health, and pest infestation all influence wildfire likelihood and severity (Romme *et al.*, 2006); (Schoennagel *et al.*, 2004); (Sherriff and Veblen, 2008).

26.5.2.1. Ecological Impacts

While fire plays a beneficial ecological role in many forest types, significant increases in their frequency and intensity, particularly in stands that have been subject to fire suppression, can alter the composition of those ecosystems. Increasing wildfire frequency can lead to changes in dominant vegetation types or changed community structure (Gedalof *et al.*, 2005). The introduction of fire into non-fire-prone forest types such as tropical forests can have a devastating impact on those ecosystems (CONANP and TNC, 2009)). Mediterranean-type vegetation has been identified as the system most vulnerable to wildfires (Fischlin, A., G.F. Midgley, J.T. Price, R. Leemans, B. Gopal, C. Turley, M.D.A. Rounsevell, O.P. Dube, J. Tarazona, A.A. Velichko, 2007).

26.5.2.2. Socioeconomic Impacts

While healthy forest ecosystems provide carbon sequestration that benefits climate change mitigation, forests affected by pests and fires do not, and wildfires themselves are a source of emissions. Furthermore, fires pose a direct threat to the property, health, and lives of people. Response expenditures increase accordingly: fire management costs for the 2003 Canadian fire season approached $1 billion (ibid.). In an analysis of fires in Montana from 1985-2007, Gude *et al*. (forthcoming) determined that a 1ºC increase in average Spring and Summer temperature is associated with a 305% increase in area burned and 107% increase in property protection costs.

Concurrently, population growth in the southwestern U.S., including housing development in the wildland-urban interface (WUI)—where structures intermingle with wildland vegetation (Gude *et al.*, 2008); (Hammer *et al.*, 2009); (Peter *et al.*, 2006);(Radeloff *et al.*, 2005); (Theobald and Romme, 2007)—has increased human exposure. Large financial losses have occurred despite record expenditures on fire suppression, a majority of which is directed at protecting property (USDA, 2006). Financial loss is not the only cost, the impacts to families and communities can be significant. The record-breaking 2004 fire season in Alaska directly threatened 20 communities (Trainor *et al.*, 2009). In Slave Lake, Alberta in 2011, a 4,700-hectare fire precipitated evacuation of the entire population of 6,700; one-third of the homes and businesses were destroyed, and $400 million of the total $700 million in losses were uninsured (CBC, 2011).

Wildfires pose direct health threats as well. To date, only a few dozen studies have been conducted on the health effects of wildfires, prescribed burns, and peat bog fires (Weinhold, 2011). According to the EM-DAT disaster database, over the last 30 years 155 people were killed in wildfires across North America: 103 in the United States, 50 in Mexico and 2 in Canada (CRED, 2012) Direct effects include injury and respiratory effects from smoke inhalation, with firefighters at increased risk (1267 Reisen, F. 2009; 1268 Reisen, F. 2011); (Naeher *et al.*, 2007). Adverse mental health outcomes are also a concern for fire victims (1269 Marshall, G. 2007); (Laugharne *et al.*, 2011)). At the population level, however, the indirect effects of wildfire become increasingly important, and a particular concern is the impact of wildfire smoke on respiratory diseases. Wildfire smoke contains high concentrations of particles and gases, including a number of products known to adversely affect human health (Naeher *et al.*, 2007);(Stefanidou *et al.*, 2008); (Wittig *et al.*, 2008)); (Delfino *et al.*, 2009); (Wegesser *et al.*, 2009). Epidemiological studies in N. America have consistently found associations between wildfire PM and respiratory distress, particularly among asthmatics and sufferers of chronic diseases such as COPD (Delfino *et al.*, 2009); (1270 Künzli, N. 2006) ; (Vora *et al.*, 2011); (Henderson *et al.*, 2011)). Cardiovascular outcomes associated with wildfire smoke have been less well defined, but a recent study of hospital admissions following a 2008 peat bog fire in North Carolina reported a significantly elevated risk of emergency department visits for cardiopulmonary symptoms and heart failure during the event (Rappold *et al.*, 2011)). Based on this evidence, it is possible to conclude with high confidence that, conditional on changing wildfire regimes under future climate, health impacts at the individual and population level of the sort observed historically would be expected to change accordingly.

26.5.3. Adaptation Strategies

Further research on the relationships between climate and wildfire and attention to the variable impacts of population growth, land-use planning, elevation, and forest structure is important to adaptation planning. Prescribed fire may be an important tool for managing fire risk in Canada and US (Hurteau and North, 2010);(1012 Hurteau, M.D. 2011); (Wiedinmyer and Hurteau, 2010). Managers in the U.S. have encouraged reduction of flammable vegetation around structures with some success (Stewart *et al.*, 2006). Physical aspects that influence likelihood of fire-related losses (housing density, type, building materials, etc.) can be altered in development planning (Cohen, 2000).

Such efforts, however, depend largely on the socio-economic capacity of communities at risk, the extent of resource dependence, community composition, and the risk perceptions, attitudes and beliefs of decision-makers, private property owners, and the public (Brenkert-Smith, 2010); (Collins and Bolin, 2009); (Martin *et al.*, 2009); (McFarlane, 2006); (Repetto, 2008); (Trainor *et al.*, 2009). Forest management also requires stakeholder involvement and investment. The provision of adequate information on smoke, managed fire/fire-use, pest management, and forest thinning is crucial, as is building trust between stakeholders and land managers (Chang *et al.*, 2009); (Dombeck *et al.*, 2004); (Flint *et al.*, 2008). Adaptation also requires institutional shifts in forest management from reliance on historical records toward incorporation of climate forecasting (Kolden and Brown, 2010); (McKenzie *et al.*, 2004); (Millar *et al.*, 2007).

26.6. Food Security

Climate change is projected to cause food price increases and declines in caloric availability globally (Nelson *et al.*, 2009). Diversion of production into biofuels can also affect supply and price (Searchinger *et al.*, 2008); (Liverman and Kapadia, 2010); (Valero-Gil and Valero, 2008). Canada and the U.S. are relatively food secure, although there are significant disparities. Households living in poverty and unengaged in food production are the most vulnerable. Mexico has high levels of food insecurity, where food constitutes a much higher proportion of household budget on average (Figure 26-4; (Juarez and Gonzalez, 2010). Indigenous peoples reliant on subsistence foods with high cultural relevance are also especially sensitive. Because North America is a major food exporter, shifts in productivity here have direct implications for global food security. The U.S. and Canada are the world's first and third largest exporters of wheat (*FAOstat exports: Countries by commodity, wheat* 2009), the second largest global human food crop. The U.S. also produces 41% and 38% of the global corn and soy crop, respectively (Schlenker and Roberts, 2009).

[INSERT FIGURE 26-4 HERE
Figure 26-4: Household Budget Share of Food Comparison. Compiled by Gerardo Otero, Simon Fraser University.]

26.6.1. Observed and Projected Impacts

Attempts to attribute observed changes in productivity to anthropogenic climate change remain inconclusive (Lobell *et al.*, 2011), Figure 26-5), but several studies highlight the climate sensitivity of productivity, attributing increases in yield in Canada and the U.S. since 1960 in part to warmer temperatures and high precipitation (Sakurai *et al.*, 2011); (Nadler and Bullock, 2011); (Pearson *et al.*, 2008). In contrast, observed impacts include a reduction in land area suitable for corn in Mexico (Rivas *et al.*, 2011); (Buechler, 2009). The impact of drought on agriculture is well-known. Drought-related losses borne by California's agriculture sector in 2008 alone reached $308 billion (CDFA 2009). Aridity also promotes soil salinity, currently costing Western U.S. agriculture $2.5 billion per year (Sabo et al 2010, cited in (MacDonald, 2010). Shifts in the timing of water availability also affect productivity. (Stewart *et al.*, 2005) attribute shifts earlier by 1-4 weeks in the timing of snowmelt stream flow from 1948-2002 across Western North America to temperature increase. Climate also affects product quality for several commodities, including coffee (Lin, 2007), wine grapes (Jones *et al.*, 2005); (Hayhoe *et al.*, 2004), wheat (Porter and Semenov, 2005), fruits and nuts (Lobell *et al.*, 2006); and cattle forage (Craine *et al.*, 2010).

[INSERT FIGURE 26-5 HERE
Figure 26-5: Nonlinear relation between temperature and yields. Source: Schlenker and Roberts, 2009.]

Many future projections of U.S. and Canadian agriculture anticipate productivity gains (Costello *et al.*, 2009); (Hatfield *et al.*, 2008); (Pearson *et al.*, 2008). Warming trends and a decrease in frost risk may enhance the yields of some crops in Western Canada (Wheaton *et al.*, 2010), and longer and warmer growing seasons allow for expansion of warm season crops or introduction of new crops (Nadler and Bullock, 2011).

Other recent studies express higher levels of caution and more attention to variability and extremes. Using historic data, (Schlenker and Roberts, 2009) determine that yield increases for corn and soy occur up to 29ºC and 30ºC; after which yields decline steeply, resulting in projected declines, without adaptation, of between 30-46% (B1) and 63-82% (A1F1) before 2100 (HAD3). Declining snow pack, new pests and diseases, hotter days during flowering, more intense precipitation, and lack of soil moisture are all noted threats to Canadian yields (Kulshreshtha, 2011). (1271 Jackson, L. 2009) warn of new agricultural pests and diseases in California. The Midwestern U.S. is also projected to face increased risk of invasive weeds and insects, and fruit and dairy productivity will likely decline with higher temperatures (Wolfe *et al.*, 2008). Rain-fed corn yields in Iowa are estimated to decline 23%–34% by 2055, on the basis of a downscaled scenario derived from 18 GCMs (Cai *et al.*, 2009)). (Chhetri *et al.*, 2010) forecast declines in corn productivity in southeastern U.S., even accounting for adaptation (RegCM2). (Monterroso Rivas *et al.*, 2011) anticipate a decrease in the spatial extent of land suitable for rain-fed corn production from 6.2% currently to between 3% (UKHadley B2) and 4.3% (ECHAM5/MPI A2) by 2050, and an increase in land classified as of limited suitability from 31.6 % currently to between 33.4% (ECHAM5/MPI A2) and 43.8% (GFDL-CM2.0 A2). The temperature-humidity index for livestock in Veracruz is expected to reach the dangerous zone by 2020, in both A2 and B2 scenarios and across three GCMs (Hernandez *et al.*, 2011).

While disagreement regarding the effects of increased CO_2 on productivity persists (e.g.,(835 Long, S.P. 2006), recent studies note that elevated CO_2 can result in reduced nitrogen and protein content in grains (Karl *et al.*, 2009), reduced forage quality, and declining efficacy of herbicides (United States Global Change Research Program (USGCRP), 2009).

Moisture deficits are likely to negate forecasted warming-induced increases in productivity (Pearson *et al.*, 2008); (867 Vano, J.A. 2010). Declines in water availability are projected for U.S. Western/Southwestern regions (United States Global Change Research Program (USGCRP), 2009). (Esqueda *et al.*, 2010)projects significant declines in water availability for Mexican agriculture, using A2 and B2 scenarios and three different GCMs.

Extreme events will affect agricultural yields and production costs (Chen and McCarl, 2009); (Kulshreshtha, 2011). According to the SREX, global increases in frequency and magnitude of warm daily temperature extremes and decreases in cold extremes are virtually certain in 21st Century. Increases in length, frequency and/or intensity of heat waves are very likely for most regions, and a 1-in-20 year hottest day is likely to become a 1-in-2 year event (A1b and A2 scenarios), or 1-in-5 (B1 scenario).

26.6.2. Vulnerability

1.9% of Americans and 2.8% of Canadians are employed in agriculture, compared to 25% of Mexicans(892 Saldaña-Zorrilla, S.O. 2006) .While the agricultural sectors in Canada and the U.S. are largely commercial, the Mexican farming population is comprised of a small number of commercial and medium-sized producers, and a large number of subsistence farmers (2.1 million), and agricultural workers (3.3 million) (Claridades Agropecuarias 2006).

The climate vulnerability of farming households is complex. For example, productivity declines induce higher commodity prices that increase food insecurity, but benefit farmers producing those crops (Hertel *et al.*, 2010)). Larger farms have more capital and credit but face the highest potential declines in asset value. High capital investments in certain technological improvements or commodities enhance productivity but limit opportunities for future innovation. Extreme weather is likely to be the climate impact to which farmers are most sensitive (Belliveau *et al.*, 2006); (Reid *et al.*, 2007)); successive extreme events can quickly surpass coping thresholds (Endfield and Tejedo, 2006). Key forms of social sensitivity include financial loss, inequitable distribution of impacts, multiple stressors, and social conflict.

Climate change impacts are very likely to impose increased input costs and/or income and asset losses, resulting from, for example, pest and disease outbreaks (925 Kiely, T. 2005) and lost efficacy of weed control practices (e.g. (860 Wolfe, D.W. 2008)(Hatfield *et al.*, 2008)). Using a Ricardian analysis, (Mendelsohn *et al.*, 2010) estimated that by 2100 agricultural land values in Mexico would decline 42-54% (range reflecting three models: PCM, MIMR, HADCM3). Farm values and water availability are also strongly correlated (Schlenker *et al.*, 2007)). In Mexico, 80% of weather-related financial losses over the past 20 years were borne by the agricultural sector (890 Saldaña-Zorrilla, S.O. 2008).

Vulnerability is related to degree of dependence on farm income (Eakin and Appendini, 2008); (Eakin and Bojorquez-Tapia, 2008), and extant levels of poverty. The North American agricultural sector exemplifies the high degree of socio-economic disparity characterizing this continent, translating into highly differentiated vulnerability.

20% of Mexicans live in extreme poverty, and the livelihood of 72% of these is in farming ((890 Saldaña-Zorrilla, S.O. 2008), and these are concentrated in the South (Araujo *et al*. 2002). Most subsistence farmers in Mexico have land bases so small that production options are limited. (Eakin, 2005) found that farmers plant maize for food security despite the climate sensitivty of this crop. Small Mexican farmers face limited access to credit and insurance (Saldaña-Zorilla and Sandberg, 2009); (951 Eakin, H. 2006); (Wehbe *et al.*, 2008).

(Feng *et al.*, 2010) estimated the emigration of an additional 1.4 to 6.7 million Mexicans by 2080 due to climate-induced declines in agricultural productivity. Lack of capital has been the key inducement for migration in response to historic droughts (Gilbert and McLeman, 2010); (Fraser, 2007). However, Mexican outmigration from regions experiencing recurrent disasters outpaces outmigration from regions with lower socio-economic status (892 Saldaña-Zorrilla, S.O. 2006).

Farming households face multiple sources of non-climatic stress that interact with climate vulnerability (Coles and Scott, 2009); Eakin 2006; (Eakin and Wehbe, 2009). Involvement in export markets expose producers to increased economic volatility (1272 Eakin, H. 2003) ; (951 Eakin, H. 2006); (Saldaña-Zorilla and Sandberg, 2009). Mexican farmers have experienced a 60% net drop in maize prices since 1980 through at least the middle of the 2000’s, due primarily to trade liberalization (892 Saldaña-Zorrilla, S.O. 2006).

Social conflict may emerge when and where water supply is reduced (United States Global Change Research Program (USGCRP), 2009); (836 Lal, P. 2011)), as access by junior rights holders will be likely be withheld first (1108 Vano, J. 2010; 867 Vano, J.A. 2010). The combined demands of rapid population growth and agricultural water demand in the Southwest U.S. are likely to conflict with projected water supply declines (MacDonald, 2010). The migration of Mexican farmers into cities in Mexico and the U.S. has the potential to induce conflict, particularly when opportunities for employment in cities are limited, and if farm employment in the U.S. declines due to climate impacts on productivity (889 Saldaña-Zorrilla, S.O. 2009).

26.6.3. Adaptation and Adaptive Capacity

Multiple adaptation options exist for North American agriculture (Belliveau *et al.*, 2006). Planting varieties better suited to future climate conditions has potential in many areas (Bootsma *et al.*, 2005); (Coles and Scott, 2009; Eakin and Appendini, 2008)). Economic and crop diversification have mediated the impacts of climate and market shocks in northeastern Mexico (Eakin and Appendini, 2008; Eakin and Bojorquez-Tapia, 2008).

High social capital enhances adaptive capacity (Wittrock and Kulshreshtha, 2011), particularly stronger ties among producers (Chiffoleau, 2009). Price increases due to climate-induced yield declines may motivate investment (Li *et al.*, 2011). A high proportion of farming families in all three countries derive some off-farm household income as an important supplement to household income.

Adaptation barriers are multiple, however, particularly access to capital. In Mexico, agricultural credit has decreased 80% in the past decade (ECLAC 2006) . Irrigation is an oft-cited adaptation mechanism, but levels of irrigation are low in some areas, with just 18% of cultivated land in Mexico irrigated (Skoufias *et al.*, 2011), and the costs of installation are high. Even when capital is available, technological improvements can increase yield under normal conditions but do not protect harvests from extreme events (United States Global Change Research Program (USGCRP), 2009). Irrigation was an insufficient buffer during the Canadian Prairie drought of 2001-2, as surface water sources had reduced flow (Wittrock and Kulshreshtha, 2011). In many regions high water demand by agriculture and other sectors limit options for expanding irrigation (Coles and Scott, 2009).

Farm-level decisions dictated by economic competitiveness also limit adaptive capacity. Heavy capital investments in crop-specific technologies constrain management decisions (Chhetri *et al.*, 2010). Crops introduced to enhance economic competitiveness can be more climate-sensitive. In Canada, cold-hardy French hybrid grapes have been replaced with higher-quality varieties that are more sensitive to winter injury (e.g., (Alayon-Gamboa and Ku-Vera, 2011; Belliveau *et al.*, 2006)). One study of small-holder farmers in Mexico ironically showed that subsistence-based farmers recovered from Hurricane Isidore (2002) sooner than commercial farmers due to higher labour investments and earlier sowing post-hurricane (Alayon-Gamboa and Ku-Vera, 2011).

Studies also indicate gaps in effective institutional support for adaptation (Bryant *et al*. 2008; (Jacques *et al.*, 2010); (1273 Tarnoczi, T.J. 2010).

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Box 26-3. Impacts and Adaptation in the Mexican Coffee Sector

Coffee is an important export for Mexico, supporting approximately a half-million primarily indigenous households, nearly two-thirds of which have one hectare or less of land (González Martínez, 2006)). Coffee production is projected to decline in response to climate change by as much as 34% by 2020 (Gay *et al.*, 2006); (Schroth *et al.*, 2009)). Losses associated with Hurricanes Stan (2005) and Agatha (2010) were especially detrimental , occurring at a time of falling commodity prices ((952 Eakin, H. 2006) . In one study, 40% of farmers interviewed in Chiapas planned to emigrate ((890 Saldaña-Zorrilla, S.O. 2008).

[INSERT FIGURE 26-6 HERE
Figure 26-6: Photo indicating damage caused by Hurricane Stan, courtesy of Hallie Eakin.]

Many current agro-ecological practices associated with sustainability enhancement may help smallholders adapt (918 Lin, B. B. 2008) (Schroth *et al.*, 2009). Research demonstrates that coffee farmers are aware of increases in the frequency and intensity of drought and torrential rainfall (Eakin *et* al., forthcoming) motivating some to plant different varietals, modify shade cover, and practice soil conservation. Some households are entering niche markets, joining coffee cooperatives, and adopting organic practices. Others, particularly those highly specialized in coffee, are exploring alternative crops, or diversifying into non-farm activities (Eakin *et al*. 2011).

International coffee retailers and non-governmental organizations are increasingly engaged in enhancing farmer adaptive capacity . Coffee cooperatives may also enhance adaptive capacity, although there are obstacles to participating (Eakin *et al*. 2006; (Frank *et al.*, 2011)).

_____ END BOX 26-3 HERE _____

26.6.4. Fisheries

Many fisheries in North America are already under stress from multiple factors. A study of freshwater fish in California found 26% of populations in danger of extinction in the near future (Moyle *et al.*, 2011)). Historical warm periods have coincided with low salmon abundance (486 Crozier, L. G., R.W. Zabel, and A. Hamlet 2008; 960 Crozier, L.G. 2008). The restriction of fisheries in Alaska has been attributed to climate change (United States Global Change Research Program (USGCRP), 2009)). Coral cover and complexity in the Caribbean Basin, important habitat for many species, has declined by an estimated 80% since the 1970s (1301 IPCC 2012).

Projected impacts include contraction of coldwater fish habitat and expansion of warm-water fish habitat (Janetos *et al.*, 2008)), which can function as invasive species threatening resident populations. Up to 40 % of Northwest salmon populations may be lost by 2050 due to climate change (Battin J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki, 2007)). Climatic effects on temperature and salinity may reduce nutrient availability, and acidifcation will be especially detrimental to shell fish and coral reefs (Barange and Perry, 2009). Further declines in coral cover and complexity in the Caribbean Basin are estimated to reduce fish production by 30-40% by 2015, resulting in losses of $95-140 million for over 100,000 fishers (Trotman *et al.*, 2009). Predicted impacts at long time scales are highly uncertain, but for rapid time scales (a few years) (Barange and Perry, 2009) express high confidence that increasing temperatures will “caus[e] significant limitations for aquaculture, changes in species distributions, and likely changes in abundance.”

26.6.4.1. Social Sensitivity

Alaska is home to the largest number of commercial and subsistence fishers in the U.S. (836 Lal, P. 2011), and Alaska's rural residents harvest an average of 225 pounds of fish per person (USFWS 2010). Fishing is also important in Northwestern Mexico, where fishers catch on average 1.5 million tons per year (Arroyo *et al.*, 2010). Families engaged in fishing livelihoods in North America represent an especially vulnerable group. Fish provide both income and food security (Badjek *et al.*, 2010). Coastal fishing communities face the combined threats of direct exposure to rising sea level and increased frequency and intensity of storms, affecting both community and fishing infrastructure (Badjek *et al.*, 2010); (Daw *et al.*, 2009); livelihood sensitivity to fish population shifts; and erosion of tourist amenities (Daw *et al.*, 2009). Increased intensity and severity of storms also translates into reduced harvest time or increased personal hazard risk.

Inter-related factors affecting vulnerability include overfishing, and land use activities such as logging that contribute to declines in stocks. In Alert Bay, British Columbia, historic catches of up to one million salmon dropped to 5,800 by 2000 (Brklacich *et al.*, 2008). (Badjek *et al.*, 2010) note that efforts to adapt in other sectors (e.g. irrigation or flood control infrastructure) may exacerbate declines in fisheries.

26.6.4.2 Adaptive Capacity

Fisher-people have historical experience with adaptation. Climate change poses a threat to some species, but the potential for other species to expand. Small-scale fishers are less able to adapt to shifting fish distribution patterns than large-scale operations due to limited mobility. Access to capital for adoption of new harvesting techniques is an important source of adaptive capacity ((954 Daw, T. 2009)).

26.7. Rural Communities

North America's rural population is proportionally small (U.S. 17%; Canada 20%, Mexico 23%) but has distinct vulnerability characteristics. Most rural communities depend in some way on local ecosystems, and are therefore especially sensitive to climate change (Molnar, 2010); (Johnston *et al.*, 2008). Single-sector economic dependence in particular has been shown to contribute significantly to disaster vulnerability in a national-level study of the U.S. (1274 Cutter, S.L. 2003). Because of limited economic diversity, irreversible climate changes are a particular concern. Recent extreme events affecting rural communities include drought in the Canadian Prairies (2001-2); drought in Southwestern U.S. (2010-2011) (argued to be the most severe in history (MacDonald, 2010) and subsequent wildfires; flooding in the U.S. Midwest (2011), and hurricanes in Mexico (2004-5). Communities in coastal and water-scarce interior locations are of particular concern. Droughts have decreased in occurrence historically in the U.S.(1301 IPCC 2012), but several regions have experienced increases (United States Global Change Research Program (USGCRP), 2009). Forecasts of increased water scarcity, and intensification of drought (1301 IPCC 2012), medium confidence) are particular concerns due to dependence on drought-sensitive sectors (forestry, agriculture, water-based recreation) (836 Lal, P. 2011).

Other sensitivity characteristics include high poverty and unemployment (particularly in Mexico) ((836 Lal, P. 2011)); (Whitener and Parker, 2007); (Skoufias *et al.*, 2011); (Exposed: Social Vulnerability and Climate Change in the US Southeast, 2009)); aging populations (U.S. and Canada) (831 McLeman, R.A. 2010) and lower education levels (836 Lal, P. 2011); limited extreme event response capacity (836 Lal, P. 2011)); physical infrastructure (Krishnamurthy *et al.*, 2011); (McLeman and Gilbert, 2008)); and limited health care access (836 Lal, P. 2011). Mexico is one of five developing countries globally that is estimated to experience the highest increases in poverty due to climate change-induced extreme events (52% increase in rural households; 95.4% in urban wage-labor households) (A2 scenario) (Ahmed *et al.*, 2009).

The consequences of extreme events for communities that are very small (less than 1,000) and/or isolated (several hours' commute from large population centre) are more severe due to limited local services; non-redundant transportation corridors that can be compromised; and difficulties accessing external government resources (Cervantes-Godoy, 2009);(Chouinard *et al.*, 2008).

Rural communities have developed adaptive capacity throughout history, and studies indicate high levels of climate change awareness among residents ((1069 Matthews, R.);(McLeman and Gilbert, 2008). Rural communities face many adaptation constraints, however--particularly limited revenues combined with higher costs of supplying adaptation services--warranting state and national investments into rural adaptive capacity (Williamson *et al.*, 2008). (Posey, 2009) found a direct relationship between the socio-economic status of a municipal population and engagement in adaptation. Building adaptive capacity can also address poverty and sustainability (Badjek *et al.*, 2010).

Indigenous, tourism- and forest-based communities are discussed below. Agricultural and fishing communities were discussed previously. Northern Aboriginal communities are discussed in Chapter 28: Polar Regions.

26.7.1. Indigenous Communities

26.7.1.1. Social Sensitivity

Indigenous-dominant rural communities are located throughout North America and thus the types of climate change impacts to which they are exposed vary greatly. Other factors contributing to vulnerability are held in common, however, including social factors influencing sensitivity and adaptive capacity. Sources of climate sensitivity for Indigenous communities include reliance on natural-resource-based sectors; dependence on local hunting and harvesting of climate-sensitive resources for food security (Impacts of Climate Change on Tribes in the United States, 2009); (Hardess *et al.*, 2011); (*Climate Change Impacts on Abundance and Distribution of Traditional Foods and Medicines—Effects on a First Nation and their Capacity to Adapt Final Report*, 2007)); high extreme poverty (Downing and Cuerrier, 2011);(Climate Risks and Adaptive Capacity in Aboriginal Communities Final Report, 2009); significant infrastructure deficits; high rates of substance abuse and other social problems (Hardess *et al.*, 2011);(1069 Matthews, R.); (Brklacich *et al.*, 2008); and the cultural significance of traditional foods in decline, like salmon (Jacob *et al.*, 2010); (*Climate Change Impacts on Abundance and Distribution of Traditional Foods and Medicines—Effects on a First Nation and their Capacity to Adapt Final Report*, 2007). For many, local livelihoods are doubly threatened by the combined impacts of climate change and industrial development (*Climate Change Impacts on Abundance and Distribution of Traditional Foods and Medicines—Effects on a First Nation and their Capacity to Adapt Final Report*, 2007). Water supply and quality are of special concern for Canadian First Nations communities (*Climate Change and Water: Impacts and Adaptations for First Nations Communities*, 2008), and Native American communities in Southwestern U.S.(836 Lal, P. 2011). Drinking water available to 85 out of 615 First Nation reserves was recently identified as high-risk (*Climate Change and Water: Impacts and Adaptations for First Nations Communities*, 2008; Plan of Action for Drinking Water in First Nation Communities, 2008). Many Indigenous people have limited relocation options given their residential status on reserves, rendering them especially vulnerable to regional impacts (836 Lal, P. 2011).

26.7.1.2. Adaptive Capacity

Indigenous peoples have centuries-long relationships with the land, generating high acceptance of change and extensive local knowledge. Indigenous peoples also express high awareness of recent changes in weather, wildlife, water and ice conditions, and winter roads (Climate Change Impacts on Ice, Winter Roads, Access Trails, and Manitoba First Nations Final Report, 2006). Adaptive capacity is higher among communities able to integrate traditional culture with contemporary forms of knowledge, education and economic development (Hardess *et al.*, 2011). The legacy of their colonial history, however, has stripped Indigenous communities of many of their sources of social and human capital, introduced insecurity in land tenure, and contentious inter-governmental relations, all of which constrain adaptive capacity.

26.7.2. Tourism-based Communities

26.7.2.1. Observed and Projected Impacts

Nature tourism is concentrated in alpine regions and along coastlines and inland water bodies, all of which are exposed to climate impacts with implications for tourist amenities. Impacts will be highly differentiated by region and type of tourist activity.

Observed shifts in spring temperatures have been linked to a shift in the timing of peak attendance in US National Parks (Buckley and Foushee, 2011). Increased mountain park visitation (up to 29% by 2050 in Canada, e.g.) are projected as a result of forecasted increasing in warm degree days (186 Scott, D. 2007), but fires, loss of desired fishing species and mega-fauna, and loss of glaciers may counter this trend (Scott *et al.*, 2007a). Winter sports face shorter seasons, with snowfall declines forecast for the Northeast U.S., leading to 8-100% reductions in length of snowmobile season, and 6-21% reduction in length of ski season by 2039 (B1 and A1Fi), range depicting regional variations (Scott *et al.*, 2008). Findings for Canada are similar: declines in season length by 11-44% in different regions (low-emission scenario), and 39-68% (high emission scenario) by 2020 (McBoyle *et al.*, 2007). The popularity of other tourist destinations, such as Mexican beach resorts, has been found to be less affected by environmental change (Buzinde *et al.*, 2010a; Buzinde *et al.*, 2010b).

Increased occurrence of extreme events introduces high economic volatility that many small tourism communities will likely have difficulty absorbing. 2008). In forested regions, extreme events of concern include wildfires and pest outbreaks, discussed below and in Box 26-2.

26.7.2.2. Social Sensitivity

Tourism communities are dominated by low-wage, service-based employment, and small businesses. Adjustments in tourism employment due to climate change will be inevitable as some opportunities shrink (skiing) and others emerge (summer recreation), but social insurance programs are not well suited to this sector translating into high vulnerability for employees (Tufts, 2010).

Extreme events are of particular concern due to infrastructure damage potential, and the predominance of small businesses that lack resources for effective emergency preparation and recovery. Recent fires in the Okanagan, British Columbia caused total losses of 10-20% in revenues; some businesses lost 90%. Smaller businesses were less likely to invest in emergency planning, even following the event (Hystad and Keller, 2006; Hystad and Keller, 2008).

26.7.2.3. Adaptive Capacity

Snow-making equipment may mediate climate impacts in ski regions, although the expense, and high water and energy requirements could be prohibitive, especially if revenues fall due to shorter seasons or if water is not available (Scott *et al.*, 2007b). Some communities are engaged in adaptation innovation. Several coastal tourism communities in eastern Canada, for example, are experimenting with saltwater marsh restoration as an adaptation to rising sea levels, which also has ecological benefits (Marlin *et al.*, 2007).

26.7.3. Forest-based Communities

The effect of climate change on forests is addressed in Section 26.3. This analysis examines the socioeconomic consequences of such changes.

26.7.3.1. Social Sensitivity

Contraction of the forestry sector has hit Canadian communities especially hard. The Canadian forest sector shed 100,000 jobs since 2005, due to structural change in the industry and the mountain pine beetle epidemic (Holmes, 2010). Projected climate-induced increases in global supplies may lower prices, further reducing the competitiveness of some North American regions (Brown, 2009). (Sohngen and Sedjo, 2005) estimate average annual producers' surplus losses from climate change in the Canadian/U.S. timber sector of $1.4 – $2.1 billion per year over the next century. Extreme events pose an additional layer of vulnerability, threatening directly local ecosystems, timber inventories, infrastructure and lives in forest-based communities. For instance, the Mountain Pine Beetle infestation encouraged increased harvests as companies removed merchantable timber ahead of the path of the outbreak, but regional economies face a long term net decline in forestry income levels of 25% or more (British Columbia's Mountain Pine Beetle Action Plan 2006-2011: Sustainable Forests, Sustainable Communities, 2006). Anticipated future supply reductions vary from -10 to -62% (Patriquin *et al.*, 2007). (Parkins and MacKendrick, 2007);(MacKendrick and Parkins);(Parkins, 2008) identified more than 30 communities and 25,000 families directly affected, but vulnerability varied by degree of economic dependency and socio-economic conditions. Since the outbreak, several community-level adaptation initiatives have emerged.

26.7.3.2. Adaptive Capacity

One adaptation option is the assisted migration of tree species more tolerant to anticipated future conditions, currently receiving attention in British Columbia. Mitigation innovations, including carbon sequestration plantations and biofuels, may temper declines in production or competitiveness (Holmes, 2010). Economic diversification is an oft-promoted adaptation strategy for resource-based communities, however there are several constraints to doing so (Joseph and Krishnaswamy, 2010).

Financial stressors command more attention in forest-based communities than climate change (Ogden and Innes, 2007), limiting motivation and resources available for municipal adaptation planning. Studies indicate that attention to adaptation among companies and government is limited as well, which is concerning given the large proportion of public and industrial tenure of forestlands (Brown, 2009); (Spittlehouse, 2008); (Johnston *et al.*, 2008).

26.8. Human Health: Observed and Projected Impacts

Climate-related impacts and vulnerability related to population health and the systems that promote health has been the focus of considerable research and assessment in North America since AR4. In particular, large national assessments of climate and health have been carried out in both the US and Canada (cite 2008 Canada report and US Synthesis and Assessment Report 4.6 from 2008). There is also a growing literature addressing climate-related health risks in Mexico. The national assessments have highlighted the potential for changes in impacts of extreme storm and heat events, air pollution, pollen, and infectious diseases, drawing from a growing NA research base analyzing observed and projected relationships among weather variables, vulnerability factors and health outcomes. The causal pathways leading from climate to health are complex, and are often modified by intervening factors including economic status, pre-existing illness, age, other health risk factors, access to health care, built and natural environments, adaptation actions and others. This complexity makes it extremely difficult to detect and attribute climate change-related health impacts. Health impacts of wildfire are discussed in Section 26.X

26.8.1. Extreme Storms, Floods, Drought

WGI chapter X and SREX discuss evidence for observed and predicted trends in extreme storms (SREX). Hurricanes can cause extensive direct losses of life as well as longer term, more indirect health impacts, particularly in Mexico and the Southern US. However, the magnitude of health impacts of extreme storms depends on the interaction between hazard exposure and characteristics of the affected communities ((1275 Keim, M.E. 2008). Coastal and other low-lying infrastructure and populations can create vulnerabilities related to communications, healthcare delivery, and evacuation. Health impacts include direct effects (eg: death and injury) and indirect, long-term effects on contamination of water and soil, vector-borne diseases, respiratory health and mental health (Gamble *et al.*, 2008). Infectious disease impacts from flooding include creation of breeding sites for vectors (1276 Ivers, L.C. 2006) and bacterial transmission through contaminated water sources causing gastrointestinal disease. Impacts on diarrheal disease morbidity and mortality are particularly relevant in Mexico, where these diseases are more prevalent in general. Additionally, chemical toxins can be mobilized from industrial or contaminated sites (1277 Euripidou, E. 2004) . Elevated indoor mold levels associated with flooding of buildings and standing water have been identified as risk factors for cough, wheeze and childhood asthma (1279 Jaakkola, J.J.K. 2005; 1278 Bornehag, C.G. 2001). Mental health impacts may be among the most common and long-lasting impacts of extreme storms as well as draughts; however to date they have received relatively little study (Berry *et al.*, 2010). Stress of evacuation, property damage, economic loss, and household disruption are some of the triggers that have identified through recent work with populations in the Gulf Coast and Midwest region (Weisler *et al.*, 2006); (Gamble *et al.*, 2008).

26.8.2. Extremes of Temperature

A large body of literature in North America has associated high temperatures with increased mortality and morbidity (e.g., (O'Neill and Ebi, 2009); (Anderson and Bell, 2009). During a recent severe heat wave in California, more than 140 deaths and 1000 hospitalizations were documented (CDHS, 2007); (42 Knowlton, K. 2007). Most available NA evidence derives from the US and Canada. However one recent study reported significant heat- and cold-related mortality impacts in Mexico City ((1280 McMichael, A.J. 2008). Urban areas are especially vulnerable because of the high concentrations of susceptible populations and enhanced heating. However, projecting future public health consequences of gradual climate warming is challenging, due in large part to uncertainties in the nature and pace of adaptations that populations and societal infrastructure will undergo in response to long-term climate change (Kinney *et al.*, 2008). Additional uncertainties arise from changes over time in population demographics, economic well-being, and underlying disease risk, as well as in the model-based predictions of future climate and our understanding of the exposure-response relationship for heat-related mortality. In spite of these complications, one can state with high confidence that climate warming will lead to additional health stresses related to extreme high temperatures, particularly for the northern parts of NA. The magnitude of health impacts will depend on the pace and extent of adaptation/acclimatization to high temperatures (1302 Romero Lankao, P., Qin, H., and Dickinson, K., Forthcoming), which will tend to reduce health risks. The health implications of warming winters remain uncertain. While it is possible that acute cold-snap related health effects could diminish, adaptation to warmer winters may lead to higher susceptibility to more rare cold events. Well-documented winter season increases in respiratory and cardiovascular deaths do not show evidence of direct response to warming winter temperatures (1281 Kinney, P.L. 2012).

26.8.3. Air Pollution

Poor air quality results from a combination of unfavorable weather conditions and high emissions of criteria pollutants (Jacob and Winner, 2009). Urbanization tends to concentrate emission sources, leading to higher air pollution levels, often in close proximity to vulnerable populations. Ozone and particulate matter (e.g., PM2.5 and PM10) have been associated with adverse health effects in many locations in NA (1302 Romero Lankao, P., Qin, H., and Dickinson, K., Forthcoming). Weather and climate play important roles in determining concentrations of air pollution over multiple scales in time and space. Emissions, transport, dilution, chemical transformation, and eventual deposition of air pollutants all can be influenced by meteorological variables such as temperature, humidity, wind speed and direction, and mixing height (Kinney, 2008).

Since AR4 there has been a substantial expansion of the modeling literature examining climate influences on air quality in North America, particularly for ozone (Tao *et al.*, 2007); (Kunkel *et al.*, 2007); (Holloway *et al.*, 2008); (Lin *et al.*, 2008); (Nolte *et al.*, 2008); (Wu *et al.*, 2008); (Avise *et al.*, 2009); (Chen *et al.*, 2009); Dawson et al. 2009 (Liao *et al.*, 2009); (Racherla and Adams, 2009); (Lin *et al.*, 2010); Tai et al. 2010. This work suggests with medium confidence that ozone concentrations in NA would increase slightly (under 15%) under future climate change scenarios if pollution precursor emissions were held constant at historical levels. However, there is little consistency in regional changes projected from models, and emissions controls on precursors can overcome the “climate penalty” for air quality (Jacob and Winner, 2009). The literature for PM2.5 is smaller and less consistent (Liao *et al.*, 2007); (Tagaris *et al.*, 2008); (Avise *et al.*, 2009); Dawson et al. 2009; (Pye *et al.*, 2009); (Mahmud *et al.*, 2010)). One study projected decreases in both ozone and PM2.5 concentrations in N. Mexico and S. Canada when the A1B scenario was modeled along with projected decreases in air pollution emissions in the US and Canada (Tagaris *et al.*, 2008). Several recent studies have projected future health impacts due to air pollution in a changing climate (Bell *et al.*, 2007); (Tagaris *et al.*, 2009); (Tagaris *et al.*, 2010); (Chang *et al.*, 2010)). Results of these studies follow directly from the underlying climate/chemistry modeling outputs, and generally do not take into account future changes in population demographics, underlying disease risk, or sensitivity to air pollution.

26.8.4. Pollen

Exposure to pollen has been associated with a range of allergic outcomes, including exacerbations of allergic rhinitis (Cakmak *et al.*, 2002), (Villeneuve *et al.*, 2006)), exacerbations of allergic asthma (1282 Delfino, R.J. 2002) , and allergic sensitization (BjÃ¶rkstÃ©n and Suoniemi, 1981), Porsbjerg et al. 2002). Higher temperature and greater precipitation, in the months prior to the pollen season, lead to increased production of many types of tree and grass pollen(1283 Lo, E. 2007), (Reiss and Kostic, 1976), (1285 Minero, F.J.G. 1998), USEPA 2008). Furthermore, ragweed pollen production has been observed to increase in response to increased temperatures and concentrations of atmospheric carbon dioxide (Singer *et al.*, 2005), (Wayne *et al.*, 2002), (Ziska and Caulfield, 2000), (Ziska *et al.*, 2003). Because pollen production and release can be affected by temperature, precipitation, and CO2 concentrations, it is possible that future patterns of pollen exposure and allergic disease morbidity could change in response to climate change. However, to date, the only evidence for observed climate-related impacts are for the timing of the pollen season. Many studies have indicated that pollen seasons are beginning earlier (Ariano *et al.*, 2010), (1284 Clot, B. 2003), (1286 Emberlin, J. 2002) (1287 Frei, T. 2008), (Levetin and Van, 2008), (1288 Rasmussen, A. 2002), (1289 Teranishi, H. 2006). These changes have been described most thoroughly in Europe, although evidence of an earlier start to the pollen season has also been documented in the United States and Asia. Some pollen types, such as ragweed, also have shown an increase in season length (Ziska *et al.*, 2011), (Ariano *et al.*, 2010). However, research on trends in NA has been hampered by the lack of long-term, consistently collected pollen records (USEPA 2008).

26.8.5. Waterborne Diseases

Waterborne infections remain an important source of morbidity and mortality in NA. Infections may be contracted through consumption of drinking water, by inhalation of aerosols containing bacteria, and by direct contact with recreational or floodwaters. Commonly reported infectious agents in recent US and Canadian outbreaks include legionella bacterium, the cryptosporidium parasite, campylobacter, and giardia (CDC, 2011), Séguin 2008. Along with these, cholera remains an important agent in Mexico (Greer *et al.*, 2008). Risk of waterborne illness is to be greater among infants, elderly, pregnant women, and immunocompromised individuals (Rose *et al.*, 2001);(Gamble *et al.*, 2008). In 1993, 85% (46) of the deaths from a cryptosporidiosis outbreak in Wisconsin occurred among patients suffering from AIDS (Craun *et al.*, 2006).

Changes in the temperature and the hydrological cycle can influence the risk of waterborne diseases (Curriero *et al.*, 2001), (Greer *et al.*, 2008), (Harper *et al.*, 2011)). Floods also enhance the potential for runoff to carry sediment and pollutants to water supplies (Karl *et al.*, 2009)). Disparities in access to treated water were identified as a key determinant of under age-5 morbidity due to water borne illnesses in the central State of Mexico (JimÃ©nez-MoleÃ³n and GÃ³mez-Albores, 2011)).

[INSERT FIGURE 26-7 HERE
Figure 26-7: 2005 waterborne disease incidence for <age 5 in the State of Mexico. Source: Jiménez-Moléon and Goméz-Albores, 2011.]

26.8.6. Vectorborne Diseases

The extent to which climate change has altered, and will alter, the geographic distribution of vectors of infectious disease remains uncertain because of the inherent complexity of the ecological system. Spatial and temporal distribution of disease vectors depend not only on climate factors, but also on land use/change, socio-economic and socio-cultural factors, prioritization of vector control, access to health care and human behavioral responses to perception of disease risk, among other factors (Lafferty, 2009); (Wilson, 2009). Although temperature drives important biological processes in these organisms, variability in climate on a daily, seasonal or interannual scale may result in organism adaptation and a shift in geographic range, not necessarily an expansion in range (Lafferty, 2009); (Tabachnick, 2010); (McGregor, 2011)). This shift may alter the incidence of disease depending on host receptiveness and immunity, as well as the ability of the pathogen to evolve so that strains are more effectively and efficiently acquired (1290 Beebe, N.W. 2009); (Epstein, 2010; Reiter, 2008); (Reiter, 2008); (Rosenthal, 2009); (Russell, 2009).

North Americans are currently at risk from a number of vector-borne diseases, including Lyme disease (Diuk-Wasser *et al.*, 2010; Ogden *et al.*, 2008); (Diuk-Wasser *et al.*, 2010)), dengue fever (Jury, 2008);(Ramos *et al.*, 2008); (Johansson *et al.*, 2009); (Kolivras, 2010); (1291 Degallier, N. 2010) ; (Lambrechts *et al.*, 2011), and Rocky Mountain spotted fever, to name a few; this population is also increasingly at risk from invasive vector-borne pathogens, such as chikungunya and Rift Valley fever viruses 8(Greer *et al.*, 2008). Mexico is the sole NA country listed as high risk for dengue fever by the WHO. Whether warmer winter temperatures in the United States and Canada will result in locally acquired transmission of diseases like dengue and malaria is uncertain, in part, because of access to amenities such as air-conditioning that provide barriers to human-vector contact. Better longitudinal datasets and empirical models are needed to address knowledge gaps in research on climate-sensitive infectious diseases, as well as to provide a better mechanism for weighting the roles of external drivers such as climate change on a macro/micro scale, human-environmental changes on a regional to local scale and extrinsic factors (such as immunity, phenotype plasticity and evolution) in the transmission of vector-borne infectious diseases (Wilson, 2009); (McGregor, 2011).

26.9. Infrastructure

Infrastructure provides critical services including water supply, sanitation, flood control, electricity, natural gas, transportation, and communications that can be disrupted in manifold ways by climate variability and change although detailed assessments of existing and projected damages are mostly limited to US and Canada (Handmer, J., Y. Honda, Z.W. Kundzewicz, N. Arnell, G. Benito, J. Hatfield, I.F. Mohamed, P. Peduzzi, S. Wu, B. Sherstyukov, K. Takahashi, and Z. Yan, 2012). For example, while infrastructures on the East Coast could be affected by SLR ((114 Kirshen, P. 2008)) in the Gulf of Mexico area they can and are already affected by hurricane and flood damages (Conrad, 2010). The Gulf Coast is among the highest disaster loss regions in the United States (19 Cutter, S.L. 2008). However, rather than to increased intensity or frequency of hazards (e.g., hurricanes) trends in loses are due both to the increasing value of infrastructure at risk (e.g., along the coast (1300 Field, C. B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott 2007), (19 Cutter, S.L. 2008)and to increasing social vulnerability (Pielke Jr *et al.*, 2003; Pielke Jr *et al.*, 2008).

Damage to or disruption of infrastructure affects not only the infrastructure itself, but also the services infrastructure provides. Disruption of service in one infrastructure can affect other infrastructures, particularly in urban areas (Wilbanks *et al.*, 2008). The risks from climate change to infrastructure should be put in context of the state of infrastructure. Infrastructure in good condition (or that is climate proofed) will be more resistant to climate change impacts than aging or deficient infrastructure. The ability of a society to build and maintain its infrastructure is an indicator of its adaptive capacity.

Pubic infrastructure across North America appears to be aging, or - in the case of Mexico - lacking, and is vulnerable to climate extremes. The American Society for Civil Engineers notes that of the more than 81,000 dams in the U.S., more than 4,000 are deficient. The reliability of 85% of the 100,000 miles of levees is unknown. More than one-fourth of the nation's bridges are structurally deficient or functionally obsolete (513 American Society for Civil Engineers 2009).

There are hundreds of billions to trillions of dollars of needed investment in public infrastructure in the United States alone. The American Society for Civil Engineers estimates that more than $2 trillion are needed to bring infrastructure in the US up to "good condition" (513 American Society for Civil Engineers 2009; p. 6.) As of 2008, $298 billion was identified by the U.S. Environmental Protection Agency (USEPA) as being needed for wastewater pipes and treatment facilities; combined sewer overflow (CSO) correction; and stormwater management through 2028 to rehabilitate aging infrastructure, to meet higher water quality standards, and serve population growth. (511 U.S. Environmental Protection Agency 2008) . In addition, USEPA found that $334.8 billion is needed over the next 20 years to expand, replace or rehabilitate existing pipes, treatment facilities, storage tanks, or other assets to provide clean drinking water (510 U.S. Environmental Protection Agency Office of Water 2009). The U.S. Department of Transportation estimated that between $100 and $175 billion would be needed in the next 20 years to upgrade U.S. highways (514 Federal Transit Administration 2008). Based on infrastructure surveys from the 1980s and '90s Mirza and Haider (2003) report an investment deficit in Canadian infrastructure of $125 billion (517 Mirza, M. Saeed 2003).

Climate change can threaten infrastructure through sea level rise, changes in extreme temperatures, winds, and flooding. (749 Wilbanks, T. 2012) (520 Wilbanks, TJ 2008)note that disruption of infrastructure can have significant consequences for social well-being and the economy. The greatest climate risks to infrastructure arise from extreme events. Impacts on one infrastructure can affect other infrastructure.

26.9.1. Transportation

Transportation infrastructure is crucial for economic activity (e.g., 7 and 3 of the Gulf of Mexico region ports account for about 70% of waterborne commerce ton-miles in the United States and 75% of the tonnage of Mexican imports and exports respectively (Conrad, 2010).The Transportation Research Board found that increases in high temperature events, intense precipitation, drought, sea level, and storm surge can affect transportation across the US. They concluded the greatest risks would be to coastal transportation infrastructure. There also can be benefits, e.g., to marine and lake transportation in high latitudes from shorter period with ice cover (Transportation Research Board, 2008).

(Savonis *et al.*, 2008) estimated that rise in sea level of 1.2 meters would risk inundating 27% of major roads, 9% of rail lines, and 72% of ports in the U.S. Gulf Coast. They estimated a storm surge at 7 meter could inundate 64% of interstate highways andv57% of arterials, almost half of the rail miles, 29 airports, and virtually almost all of the ports in the central Gulf. Higher temperatures and changes in precipitation could also necessitate changes in materials and construction of transportation infrastructure (Savonis *et al.*, 2008)

Mills et al. 2009 projected that in southern Canada by the 2050s, low temperature cracking would decrease, structures would freeze later and thaw earlier, and higher extreme temperatures would increase the potential for rutting (Mills *et al.*, 2009). Overall, they found the effects of climate change to be "modest."

(519 Chinowsky, P. Submitted) estimated that a scenario corresponding to a 1.5oC increase in global mean temperature would increase the costs of keeping paved and unpaved roads in the United States in service by $2.8 billion per year by 2050. Under a scenario corresponding to a 1.0oC increase in global mean temperature, the costs would be about $1.9 billion per year (Chinowsky *et al.*, Submitted).

(518 Wright, L. 2012) projected that up to 100,000 bridges in the U.S. crossing rivers and streams could be made vulnerable by increasing peak flows in the mid- and late-21st Century. Currently deficient bridges, about one-fourth of the current bridges, would be most vulnerable. Strengthening the vulnerable bridges in response to climate change is estimated to cost $138 to 247 billion, but the costs could be reduced by 27 to 28% if currently deficient bridges are strengthened (Wright *et al.*, 2012)

26.9.2. Energy

Energy systems are particularly sensitive to climate change, as energy requirements for cooling and heating are expected, refineries in dry areas can face water availability problems (971 Boyd, R. 2009) and energy demand for different energy sources will be differently affected by extremes (e.g., heat waves). Some energy sectors (hydroelectricity, solar and wind power) are particularly sensitive to climate variability (section 26.2). The potential impacts of climate change in Canada include significant increase in electricity requirements for cooling; adverse effects on hydroelectric potential in both western and eastern Canada; combining demand and supply impacts, increased number of blackout/brownout events (Minville *et al.*, 2009) estimate that annual mean hydropower in the St. Lawrence and Great Lakes region of Canada would decrease by 1.8% in the period 2010–2039 and then increase by 9.3% and 18.3% during the periods 2040–2069 and 2070–2099, respectively.

According to specific studies assessed by (520 Wilbanks, TJ 2008)the net change in energy demand by 2080 is estimated to range from -15 to +4% (520 Wilbanks, TJ 2008). (Mansur *et al.*, 2008) used cross-section data of current energy demand and develop a base case of population and economic activity in 2100 for the US. They estimate that oil and gas consumption will decrease with higher temperatures and net electricity consumption will increase. They estimate that 2.5oC increase in mean US temperature would reduce welfare by $26 billion per year (1990$), with $16.2 billion from residential and $9.9 billion from the commercial sector. A 5.0oC warming and a 15% increase in precipitation would increase the welfare loss to $56.7 billion per year, with $35.1 billion in welfare loss coming from the residential sector (526 Mansur, Erin T. 2008). (Wilbanks *et al.*, 2012) conclude that peak demand for electricity may increase more than average demand for electricity, necessitating capacity expansion in many areas.

Other impacts are likely as well, including effects on energy production of rising temperatures (which reduce thermal power plant efficiencies) and limited water supplies in many regions (which can affect power plant cooling) and effects on renewable energy sources other than hydropower. For example changing cloud cover affects solar energy resources, changes in winds affect wind power potentials, and temperature change and water availability can affect biomass production (for instance, water requirements for biofuel production) (520 Wilbanks, TJ 2008).

Regional differences exist in the energy impacts of warming. Regionally in the US, major concerns include effects of increased cooling demands and water scarcity in the west; effects of extreme weather events, sea-level rise, and seasonal droughts in the southeast; effects of increased cooling demands in the northern regions; effects of warming on energy production and transportation in Alaska; and effects of climate policy on regions whose economies are closely tied to fossil energy production and conversion (520 Wilbanks, TJ 2008).

Other types of infrastructure such as water resources, coastal protection, and communications will also likely be affected directly or indirectly by climate change (520 Wilbanks, TJ 2008).

26.10. Urban

In North American urban areas, the concentration of populations, economic activities, cultural amenities and built environments creates higher risks from hazards (floods, heat waves) that climate change is expected to aggravate. At the same time, factors such as economies of scale and cities' role as development hubs and centers of innovation, endow cities with opportunities to play pivotal roles in adaptation efforts (UN-HABITAT United Nations Human Settlements Programme, 2011); (Romero-Lankao and Dodman, 2011)).

26.10.1. Multilevel Hazards and Stresses

Cities are currently being faced with a multilevel array of hazards, some related to climate change and others that are not (e.g., industrial, technological, (McGranahan *et al.*, 2007), (De Sherbinin *et al.*, 2007), Satterthwaite et al., 2009; (Romero-Lankao and Dodman, 2011)). However, as these hazards interact, they may present complexity and greater societal challenges. For instance, factors such as urban growth on cities' perimeters, forest fuel build-up, and cultural practices produce an elevated risk from wildfires (Brenkert-Smith, 2010); (Collins and Bolin, 2009). Increasing salinity levels (e.g., the Delaware River in Philadelphia US) is an example of how sea level rise can negatively impact power stations, water treatment plants, food and beverage manufacturers and oil refineries (183 Sharp, J.H. 2010).

In the absence of effective policies, the concentration of populations and economic activities can result in poor air quality, particularly when coupled with unfavorable weather conditions ((723 Romero-Lankao, P. 2012); section 26.7). Urbanization changes land-use and land-surface physical characteristics (e.g., surface albedo (718 Chen, F. 2011). Cities also affect atmospheric and hydrological conditions through dynamic effects (e.g., distorting synoptic systems) (Bornstein and Lin, 2000); aerosol effects (e.g., cloud condensation); and thermo-dynamical effects (e.g., the heat island effect, UHI). The UHI, which varies across and within cities (Miao *et al.*, 2011); (Harlan *et al.*, 2008) also increases health risks from heat (section 26.7)

The warming of the atmosphere and ocean can result not only in sea level rise and storms affecting North American coastal cities (Nicholls *et al.*, 2008); (102 Kirshen, P. 2008) (Weiss, J.L., J.T. Overpeck, and B. Strauss., 2011);, but also in an acceleration of the hydrologic cycle that would bring both increased precipitation intensity and higher flood risks and more prolonged dry periods (section 26.3). Urbanization, therefore, may enhance or reduce precipitation depending on the climate regime, geographical location and patterns of land, energy and water use in a city's region (720 Cuo, L. 2009).

26.10.2. Observed and Predicted Social and Economic Impacts

Climate variability and change already have a variety of implications for urban populations, buildings, economic sectors (e.g., industry, retail and commercial services) and on infrastructures such as energy, waste water and transportation (Gasper and Ruth 2011, Table 26-1)(Gasper *et al.*, 2011). Not only SLR has been observed affecting 17 Mexican cities (Zavala et al., 2010(Zavala-Hidalgo, J., R. de Buen, R. Romero-Centeno, and F. Hernández, 2010)), but also severe weather events including heavy precipitation, storm surges, flash-floods and wind creating risks to the built environment, including homes and places of business ((331 Jonkman, S.N. 2009)(Collins *et al.*, 2009), (Comfort, 2006), (41 Kirshen, P. 2008), (6 Romero-Lankao, P 2010). Impacts on water supply, sanitation and energy provision can increase the costs of insurance coverage (section 26.9; (Mills, 2005). Retail and commercial services, or tourism ((186 Scott, D. 2007); (1027 Manuel-Navarrete, David 2011), and industrial facilities may also be affected, especially if they are located in risk prone areas, depend on climate sensitive inputs (Mendelsohn and Neumann, 2004);(Bin *et al.*, 2007) or foster mass tourism increasing social inequalities, degrading ecosystems, and amplifying overall exposure to extreme events (e.g., Cancun; (1027 Manuel-Navarrete,David 2011)).

[INSERT TABLE 26-1 HERE
Table 26-1: Dimensions and determinants of urban adaptive capacity. Source: Romero-Lankao, 2012.]

Although case studies sometimes focus on economic, social or ecological impacts individually, research increasingly emphasizes their interrelated nature (Gasper *et al.*, 2011). For instance, under current financial constraints at the local level, economic losses from adverse climate events can reduce resources available to address social issues and, by doing so, pose a serious threat to local institutional capacity and urban livelihoods ((368 Kundzewicz, ZW 2008)).

Scholarship on the future impacts of climate change on cities has found that populations and significant portions of the built environment, economic activities and infrastructures are at risk from climate related changes and hazards on the Pacific coast (48 Miller, N.L. 2009)); US-Mexico Gulf coast (Sobel *et al.*, 2010); (Conrad, 2010); ("U.S. Government Accountability Office, http://www.gao.gov", 2007; Wittrock and Kulshreshtha, 2011)); Canadian prairie cities (Wittrock and Kulshreshtha, 2011)); US-Mexico border cities (Collins, 2008); (Collins *et al.*, 2009)) as well as in Boston, New York, Chicago, Washington, DC, Maryland, Virginia, North Carolina, Mexico City (Bin *et al.*, 2007);(102 Kirshen, P. 2008; 41 Kirshen, P. 2008); (Hayhoe *et al.*, 2010);(Gallivan *et al.*, 2011).

26.10.3. Urban Vulnerability and Resilience

Hurricanes, heat waves and other hazards do not exclusively create negative effects, however. The existence of insurance, emergency response systems and water conservation strategies illustrate that urban actors can have the ability to recover from and even take advantage of some stresses (Collins and Bolin, 2009); (Coffee *et al.*, 2010); (6 Romero-Lankao, P 2010); (Aguilar and Santos, 2011). Multiple interacting factors explain differences in adaptive capacity: e.g., differences in the use of information and flexibility for learning and innovation (e.g., Chicago, New York, Mexico City, Canadian prairie cities). Urban capacity to respond is also shaped by long-term processes (e.g., water overexploitation limits Mexico City capacity to manage flood risks, (6 Romero-Lankao, P 2010); and short-term triggers (e.g., droughts in Canadian prairie cities led to conservation imposed on urban water users (Wittrock and Kulshreshtha, 2011).

For urban populations, class and socio-spatial segregation are key determinants of urban risks and vulnerabilities through two mechanisms: First, economic elites are able to monopolize the best land and enjoy the rewards of environmental amenities such as clean air, safe drinking water, open space, and tree shade (Morello-Frosch *et al.*, 2002); (Harlan *et al.*, 2006; Harlan *et al.*, 2008); (Ruddell *et al.*, 2009); second, although wealthy sectors are moving into risk prone coastal and forested areas (Collins, 2008), and although certain hazards such as air pollution can affect both rich and poor alike (723 Romero-Lankao, P. 2012), climate risks tend to be disproportionally borne by the poor or otherwise marginalized populations, such as ethnic minority groups (Cutter *et al.*, 2008);(Collins *et al.*, 2009); (6 Romero-Lankao, P 2010); (Wittrock and Kulshreshtha, 2011). Some peri-urban areas are being inhabited by marginalized populations, with inadequate services, a portfolio of precarious livelihood mechanisms, and inappropriate risk-management institutions [for US(Collins *et al.*, 2009) and(Colten *et al.*, 2008); for Canada Iqaluit: for Mexico (Aragón-Durand, 2007); (Eakin *et al.*, 2010); (Monkkonen, 2011). Equally important determinants, however, are individual levels of social trust, participation in networks and family support in reducing vulnerabilities (Pelling and High, 2005);(1302 Romero Lankao, P., Qin, H., and Dickinson, K., Forthcoming).

Such other characteristics as housing stock, urban form, built environment and availability of urban and ecologic services also affect urban vulnerability. For example, the large, impermeable surfaces and concentration of buildings characteristic of cities can disrupt natural drainage channels and accelerate run-off (Walsh *et al.*, 2005). The resulting damage from floods can be much more catastrophic if settlements lack drainage or waste collection systems, or if these are not sufficient to deal with recent and expected peak flows. While infrastructures in many Canadian and US cities are in need of major upgrades or repairs (Doyle *et al.*, 2008); (Conrad, 2010)), Mexican urban areas are additionally faced with deficits in roads, water and sanitation provision (Niven *et al.*, 2010); (Hardoy and Romero Lankao, 2011)), as well as with high levels of socio-spatial exclusion and informality (Smolka and Larangeira, 2008)). Hence, while adequately served cities mostly face the challenge of repairing or expanding their infrastructures and buildings, or enhancing their capacity to anticipate and manage extreme-weather events, many Mexican cities have the additional burden of overcoming development deficits.

The evolution of cities as economic hubs is also of relevance for understanding vulnerability and resilience (Leichenko, 2011). Because of lifestyles, economic or geopolitical considerations, urban centers expand onto mountain, agricultural, protected and otherwise risk-prone areas ((1292 Boruff, B.J. 2005) ;(McGranahan *et al.*, 2007); (16 Collins, T.W. 2009) ; (Conrad, 2010). These socio-ecological systems invariably alter their and their hinterlands' environments. Depending, at least partially, on their socioeconomic and environmental histories, paths are open going from increasing reduced resilience (e.g., irreversible overexploitation and degradation of groundwater resources, inflexibility and ineffectiveness of management systems) to an increasing ability of urban populations and urban-relevant decision makers' to repair damage, sustain the environment and foster urban actors' capacity for learning and adaptation (Collins *et al.*, 2009); (6 Romero-Lankao, P 2010) ; (Aguilar and Santos, 2011)).

26.10.4. Urban Climate Responses

Urban populations have long had to cope with a wide range of climatic and non-climatic risks to their economic activities, lives and livelihoods (1293 Romero-Lankao, P. 2011). Measures such as green roofs, forest thinning and urban agriculture (Chicago, New York, Kamloops, Mexico City, Toronto), flood protection (New Orleans, Chicago), private or governmental insurance (Browne and Hoyt, 2000); (Ntelekos *et al.*, 2010a, section 26.10); (418 Toronto 2008;)), safe saving schemes (common in Mexico), reinforcing homes to withstand extreme weather (740 Simmons, K.M. 2007), air pollution controls (Mexico City), warning systems or diversifying livelihoods, for instance, through circular (or temporary) migration (Newland *et al.*, 2008); (Rose and Shaw, 2008)) become the most frequent types of response to climate hazards.

Urban authorities are starting to assess their climate change vulnerabilities and designing their adaptation programs (table to be developed).(Ford *et al.*, 2011)found that two-thirds of adaptations in developed countries are happening at the municipal level. Some of these responses have involved the development of “integrated” climate change strategies, e.g., New York and Chicago ((108 Rosenzweig, C. 2010);(Perkins *et al.*, 2007), and myriad “projects” for reducing climate risk to specific sectors (e.g., water conservation in Phoenix, US and Regina Canada; wildfire protection in Kamloops, Canada and Boulder, US). For example, New York adopted “plaNYC” in 2007, which incorporates climate change into sustainable development of housing and neighborhoods, parks and public spaces, brownfields, waterways, water supplies, transportation, energy, air quality, and solid waste (421 New 2011). However many cities have not yet moved into the implementation stage, and most of the adaptation programs are in the process of problem diagnosis and adaptation planning (Perkins *et al.*, 2007); Dodman et al., 2011; (Moser and Ekstrom, 2011); (Carmin *et al.*, 2012);(724 Romero-Lankao, P. 2012).

Some smaller municipalities have initiated adaptation efforts. In Mexico, the “*Safe Municipality*” (SIAT-CT) has been adopted by cities such as Acapulco, Tijuana, Tuxtla Gutierrez y Monterrey, while other cities such as Hermosillo (Sonora) and Villahermosa (Tabasco) are trying various strategies to manage water-related stresses, including floods and droughts. The city of Keene, New Hampshire with a population around 20,000, has an adaptation plan which addresses reducing a number of risks including flooding and extreme heat (420 Keene 2007). Dawson City in the Yukon is exploring technologies that will promote permafrost conservation; assessing the need to increase the level of an existing dyke; and educating and advocating local food consumption and sustainable fishing methods to present and future generations (417 Jones 2010).

Engaging stakeholders in urban adaptation has proved effective in getting legitimacy for public decisions and helping capture local realities (e.g., Mexico City, (195 Aguilar, A.G. 2011)). However, potential issues might arise: delays in decision making; tensions and conflicts among stakeholder groups embedded in power relationships that can constrain the access of the general population to decision making processes (Few *et al.*, 2007); (Colten *et al.*, 2008).

Adapting urban areas to climate change is complicated by the fact that it is undertaken at different temporal, spatial and sectoral scales (724 Romero-Lankao, P. 2012), thus requiring a careful assessment of the different layers involved in land-use planning, emergency responses, housing, health and other sectoral policies and their effects on the determinants of urban vulnerability at the city, neighborhood and individual levels (Table 26-1). Traditionally, environmental or engineering agencies are frequently made responsible for managing climate issues (e.g., Mexico City, or Edmonton and London, Canada), but do not have the decision making power nor the resources available to address all the dimensions involved. Planning requires not only shorter term actions at the governmental level, but also longer term measures by businesses, grassroots organizations and individuals to adapt to climate change (e.g., Vancouver and Halifax, Canada; New York and Chicago (Romero-Lankao, 2007); (Croci *et al.*, 2010); (Burch, 2010).

26.10.5. Adaptation, Mitigation, and Urban Development

Climate change impacts can hamper current progress towards sustainability (UN-HABITAT United Nations Human Settlements Programme, 2011)) and have the potential to exacerbate existing challenges such as deficits in infrastructure (e.g., insufficient coverage, need of major upgrades and climate proofing), or in institutional capacity to prevent climate effects (e.g., hot weather) on the health of their populations (O'Neill and Ebi, 2009). Hence, cities require adaptations that create synergies and overcome conflicts with mitigation and other development goals. For instance, painting roofs white (Akbari *et al.*, 2009) can reduce the effects of heat waves and local energy demand for cooling, presenting a possible mitigation-adaptation co-benefit. Conversely, sea walls can protect coastal properties, yet they negatively affect the structure and functioning of coastal ecosystems. Therefore, both synergies and trade-offs exist between actions addressing the mitigation challenge and other policy dimensions (industrial development, energy security, health; (Hamin and Gurran, 2009); (Laukkonen *et al.*, 2009)). As illustrated by Mexico City, Denver, New York and Los Angeles, climate change policies are an outcome of efforts driven by economic security and local concerns, but also by the drive to be at the forefront of initiatives among a cohort of city leaders ((160 Rosenzweig, C. 2010) ; (Anguelovski and Carmin, 2011);(724 Romero-Lankao, P. 2012). Policies addressing other environmental and social problems, such as air pollution (Harlan and Ruddell, 2011)), or the provision of adequate shelter to the poor (Colten *et al.*, 2008) can often be adapted at low or no cost in order to fulfill sustainability goals and improve human wellbeing simultaneously.

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Box 26-4. Climate Change: Additional Challenges on the Water System of Mexico City Metropolitan Area (MCMA)

MCMA has 21.4 million people, over four million vehicles, intricate energy and water systems, transportation infrastructures and populations vulnerable to extreme weather (1294 Tortajada, C 2006) ;(724 Romero-Lankao, P. 2012). In 1900-2005, there has been a 66% increase in precipitation with a temperature rise of around 1.5^{o}C, both not thought to be associated with climate change but mainly with an increasing heat-island effect ((1217 Galindo, I. 2009). Of the 85.7 m3/s of water used, 67% comes from the aquifer, 31%, from the Lerma and Cutzamala Basins and 2% from local rivers and wells. 90% of wastewater from MCMA is not treated, but is used for agricultural irrigation.

While it has one of the highest coverage levels nationally, in terms of population receiving piped water and sanitation, MCMA water system is faced with many sustainability challenges. The local aquifer is overexploited by between 19.1 and 22.2 m3/s. Not even its sophisticated drainage system has been effective at controlling the floods that continue to affect different sectors and areas. Problems of water availability make water users (especially poor sectors, Figure 26-8) vulnerable to existing and future changes in availability. Groundwater levels have continuously fallen and caused subsidence, thus undermining the foundations of buildings and infrastructure and increasing the vulnerability of these areas' populations to earthquakes and heavy rains ((6 Romero-Lankao, P 2010). According to projections, giving no consideration to global warming, between 2005 and 2030 the population of MCMA will increase by 17.5%, while between 2007 and 2030 available water will diminish by 11.2%.

[INSERT FIGURE 26-8 HERE
Figure 26-8: Woman fetching water in a periurban area southwest of Mexico City. Mexico City has made important strides in the provision of water and sanitation; however, in some urban neighborhoods, fetching water from outside of the home is common. Source: Courtesy of Patricia Romero-Lankao (September 2011).]

The situation is likely to be exacerbated by climate change. While past increases in intense rain events are thought to be linked to the heat-island effect (Magaña, 2008), projections for 2046-2085 using the B1 scenario and the GFDLCM2 model indicate that rainfall events of greater than 60 mm over 24 h will increase between 150 and 200% (Soto et al., 2010). An increased number of summer droughts is also predicted (1218 Carabias, J. 2005; 1219 Legorreta, J. 2005) which will disproportionately affect those water users who already face recurrent shortages during the dry season or in drought periods. For example, 81.2 per cent of people affected by droughts during 1980 to 2006 live in Netzahualcoyotl, one of the poorer municipalities of the city.

State authorities of Mexico City's Federal District have undertaken efforts to address water and climate change and to build synergies with other state agencies. Policy networks such as ICLEI, political leaders (e.g., Mayor Marcelo Ebrard) and research groups, such as the Molina Center, have been critical in launching a climate agenda. However, policy making has been constrained by insufficient financial and human resources to address the underlying processes of environmental deterioration and the lack of coordination and institutional fragmentation of the different tiers of government (Romero-Lankao, 2007).

Any policy aimed at solving MCMAs water sustainability issues and adapting to climate change will need to grapple with these constraints. However, opportunities may also be created. Infrastructural upgrades that take climate change into consideration can be made with an eye toward correcting current shortfalls while introducing water conservation measures and storm and wastewater collection and treatment across the entire system. The service to areas and populations currently underserved or not served at all enhances their safety and quality of life, and costs for disaster response and management can be decreased. For this to work, the institutional fragmentation of the multiple layers and spatial jurisdictions of government and civil society will need to be lessened (1220 Romero Lankao, P. 2011).

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Adaptation by states, provinces, and the three national governments in North America is discussed in Box 26-5.

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Box 26-5. Adaptation at the State/Provincial and National Levels in North America

State and Provincial Level

Some states and provinces in all three countries have developed adaptation plans and taken other measures. Nunavut was the first territory, province or state in North America to develop a climate change strategy in 2003 (Nunavut Department of Sustainable Development, 2003). Among the states and provinces developing adaptation plans are California, Maryland. Alaska, Washington, British Columbia, Ontario, Veracruz, Mexico City, Nuevo Leon, Guanajuato, Puebla, Tabasco, and Chiapas. Table 26-2 identifies some of the adaptation activities at the state and provincial level.

[INSERT TABLE 26-2 HERE
Table 26-2: Examples of state and provincial adaptation activities in North America.]

Federal Level

All three national governments are addressing adaptation to some extent. Mexico is developing a national strategy, Canada a national policy, and the United States is having all federal agencies develop adaptation plans.

In 2005, the *Inter-Secretarial Commission to Climate Change* (CICC – Comisión Inter-Secretarial de Cambio Climático) was created by the Mexican government as a cross-sectoral government structure to coordinate adaptation activities across eleven ministries (Comisión Inter-Secretarial de Cambio Climático, 2005)(SEMARNAT, 2010). The *National Plan for Development 2007-2012* is attempting to 1) design and develop capacities for adaptation; 2) develop climate scenarios at regional scale; 3) assess impacts, vulnerabilities and adaptation to climate change in various socioeconomic sectors and ecological systems, and 4) promote the dissemination of information about those impacts, vulnerabilities, and adaptation measures (Presidencia de la República, 2007). The *National Strategy for Climate Change 2007-2012* identifies priorities in climate change adaptation research and capacity development at various levels of government and society(Intersecretarial Commission on Climate Change, 2007).

The *Special Programme on Climate Change 2009-2012* (CICC, 2009) seeks to build synergy with other federal government agencies and programmes. So far, strategies on adaptation consist of setting up early warning systems, developing shared-risk schemes for agriculture and livestock activities, and creating insurance schemes against disasters. They also include campaigns for raising public awareness on various topics, including climate impacts on health, and natural resource degradation. Moreover, other sorts of strategies have also tried to support adaptation by opening up new opportunities for green investments (i.e. PES, alternative energy, and ecotourism).

The *Policy Framework for Medium Term Adaptation* (CICC, 2009) aims at framing national initiatives, such as the ones above mentioned, into a single national public policy approach on adaptation with a time-horizon up to 2030. It provides principles and guidelines for the integration of climate change adaptation across government departments. The four general principles are: 1) integrated land planning approach; 2) guaranteed human rights and equity; 3) public participation; and 4) access to information.

The Canadian Federal Government is working towards creating an Adaptation Policy Framework that is intended to mainstream climate risks and impacts into programs and activities to help frame government priorities (Environment Canada, 2011). In 2011, the Canadian Government announced continued adaptation funding for of $148.8 million for five years, to be distributed among several government departments and programs. The funding includes renewed financial support for Environment Canada's Climate Change Prediction and Scenarios Program (Canada’s state-of-the-art network that has contributed to the IPCC Assessment Reports) and Canada’s Heat Alert and Response System, and provides new funding to create a Climate Adaptation and Resilience Program for Aboriginals and Northerners, and to finance the integration of adaptation into National Codes and Standards (Environment Canada, 2011).

Following the release of the 2007 assessment, the Government of Canada made a four-year commitment to climate change adaptation by providing domestic funding of $85.9 million, of which NRCan received $35 million to develop the Regional Adaptation Collaborative (RAC) in provinces across Canada. The collaboratives (six in total) range in size and scope, focusing on issues from flood protection and drought planning, to extreme weather risk management and assessing the vulnerability of Nunavut’s mining sector to climate change(Natural Resources Canada, 2011).

In the U.S. government, the Interagency Climate Change Adaptation Task Force is led by the White House Council on Environmental Quality (CEQ), the White House Office of Science and Technology Policy (OSTP), and the National Oceanic and Atmospheric Administration (NOAA) (1239 The White House 2009). CEQ released “Instructions for Implementing Climate Change Adaptation Planning in Accordance with Executive Order 13514” (Executive Order 13514, 2011a) and a Support Document (Executive Order 13514, 2011b) to establish an agency climate change adaptation policy; to increase agency understanding of how the climate is changing; to apply understanding of climate change to agency missions and operations; to develop, prioritize, and implement actions; and to evaluate adaptations and learn from experience. The task force is requiring federal agencies to prepare adaptation plans by the middle of 2012.

Some federal agencies have already taken steps to address climate change adaptation prior to this broader interagency effort. In 2010, the U.S. Department of Interior created Climate Science Centers to integrate climate change information and management strategies in eight regions and 21 Landscape Conservation Cooperatives. These institutions are designed to inform science-based adaptation and mitigation strategies and adaptive management techniques at the state and local level (Secretary of the Interior, 2010). There are other, less comprehensive federal agency strategies that also predate the interagency efforts, such as the EPA’s office of water’s strategy (U.S. Environmental Protection Agency National Water Program, 2011).

The US Government provides technical and information support for adaptation by non-federal actors, but does not provide direct financial support for adaptation. Among the technical support mechanisms by the US Government are the National Oceanographic and Atmospheric Administration’s Regional Integrated Science and Assessment (RISA) program centers (Parris *et al.*, 2010) and the U.S. Geological Survey’s Science Centers. Both provide information on climate trends and projections (413 Geological 2011;).

Discussion

Most adaptation activities have only involved planning for climate change (Preston *et al.*, 2010) (Carmin *et al.*, 2012) surveyed more than 300 urban areas in the US, Canada, and Mexico (and 498 internationally). About three-fifths stated they are engaging in planning for climate change, mostly involving generating an adaptation plan, not sector-specific or detailed implementation plans. Many cities have not yet moved into the implementation stage, and most of the adaptation programs are in the process of problem diagnosis and adaptation planning ((Perkins *et al.*, 2007);(128 Romero-Lankao, P. 2011); (Moser and Satterthwaite, 2009). Most Canadian cities have created adaptation commissions and are inventorying adaptation activities. Most US cities engaged in adaptation are planning for climate change, but a lower share of US cities are conducting assessments or planning relative to other regions (Carmin *et al.*, 2012). None of the three national governments requires that provinces, states, or municipalities develop adaptation plans.

The most important barriers to adaptation identified by the cities were funding and staff availability (Moser and Satterthwaite, 2009))(Carmin *et al.*, 2012). Obtaining accurate scientific data was ranked less important (Carmin *et al.*, 2012).(Eakin and Patt, 2011) concluded that adaptation activities in the U.S. tended to address hazards and propose adaptations that tend to protect current activities rather than facilitate long term change. In addition, the adaptation plans generally do not attempt to increase adaptive capacity (Eakin and Patt, 2011).

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26.11. Key Economic Sectors

26.11.1. Manufacturing and Mining

26.11.1.1. Manufacturing

There is little literature focused on climate change and manufacturing, although one study found that manufacturing could be among the most sensitive sectors to weather in the United States (Lazo *et al.*, 2011) Figure 26-9). Climatic sensitivities of the sector, however, could be exacerbated by projected changes in climate. For example, a reliable supply of water is necessary for many manufacturers, with water availability affecting site selection and day-to-day operations. The drier conditions projected for many regions of North America (Seager, R., and G. Vecchi, 2010; Sun, G., McNulty, S. G., Moore Myers, J. A., & Cohen, E. C., 2008; Wehner *et al.*, 2011)) would present challenges, especially for manufacturers located in regions already experiencing water stress. Increased conflicts over water between sectors and regions are likely. There is also the concern that certain regions would become less desirable to new manufacturing facilities if water stress becomes a recurrent issue.

[INSERT FIGURE 26-9 HERE
Figure 26-9: The most weather-sensitive sectors U.S. production and weather data, 1930-2008. This figure shows the interannual aggregate dollar variation in U.S. economic activity that is attributable to weather variability of the 2008 gross domestic product. Source: Lazo, 2011.]

Delays or disruptions in supply related to weather events can be costly for manufacturers. In 2011, automobile manufacturers in North America experienced production losses associated with shortages of components due to flooding in Thailand (Newswire, 2011). For food manufacturing, climate impacts on agricultural production could be significant. In addition to climate extremes, gradual changes are also important to the supply chain. Declining water levels in the Great Lakes, for instance, would increase shipping costs by restricting vessel drafts, reducing vessel cargo volume (Millerd, 2011). For manufacturers dependent on raw materials from mining, the impacts on transportation (*see* section 26.10.1.2) could be expensive.

Another potential concern for manufacturing relates to impacts of heat on worker safety and productivity. Several studies suggest that higher temperatures and humidity would lead to decreased productivity and increased health risks (e.g., (Hanna *et al.*, 2011; Kjellstrom *et al.*, 2009; Kjellstrom and Crowe, 2011). Manufacturers may also experience increased air conditioning demands, though in more northern regions, these may be partially offset by decreased heating costs in colder months.

There is evidence that some companies are beginning to recognize the risks climate change presents to their manufacturing operations, and consider strategies to build resilience to these risks (National Round Table on the Environment and the Economy, 2012)). Coca Cola, for example, has a water stewardship strategy, that focuses, among other things, on improving water use efficiency at its manufacturing plants, while Rio Tinto Alcan is assessing climate change risks for their operations and infrastructure, which include, among other issues, vulnerability of transport systems, increased maintenance costs, and disruptions due to extreme events (National Round Table on the Environment and the Economy, 2012).

26.11.1.2. Mining

Climatic sensitivities of mining activities (including exploration, extraction, processing, transportation and site remediation) have been noted in the limited literature on climate and mining (e.g.,;(1206 Locke, P. 2011);;(753 Ford, J.D. ,Pearce, T. , Prno, J. , Duerden, F. , Ford, L.B. , Beaumier, M. , Smith, T. 2010; 754 Ford, J.D., Pearce, T., Prno, J., Duerden, F., Ford, L.B. , Smith, T.R. , Beaumier, M. 2011); (Chiotti and Lavender, 2008; Furgal and Prowse, 2008; Gómez-álvarez, A., Valenzuela-García, J. L., Meza-Figueroa, D., de la O-Villanueva, M., Ramírez-Hernández, J., Almendariz-Tapia, J., 2011; Kirchner, J. W., Austin, C. M., Myers, A., & Whyte, D. C., 2011; Meza-Figueroa, D., Maier, R. M., de la O-Villanueva, M., Gómez-Alvarez, A., Moreno-Zazueta, A., Rivera, J., 2009; Pearce, T.D., Ford, J.D. , Prno, J. , Duerden, F. , Pittman, J. , Beaumier, M. , Berrang-Ford, L. , Smit, B., 2011)). Drought-like conditions have affected the mining sector by limiting water supply for operations ((Pearce, T.D., Ford, J.D. , Prno, J. , Duerden, F. , Pittman, J. , Beaumier, M. , Berrang-Ford, L. , Smit, B., 2011)), enhancing dust emissions from quarries ((Pearce, T.D., Ford, J.D. , Prno, J. , Duerden, F. , Pittman, J. , Beaumier, M. , Berrang-Ford, L. , Smit, B., 2011)) and increasing concentrations of heavy metals in sediments ((758 Gómez-álvarez, A., Valenzuela-García, J. L., Meza-Figueroa, D., de la O-Villanueva, M., Ramírez-Hernández, J., Almendariz-Tapia, J., 2011)). Heavy precipitation events have caused untreated mining wastewater to be flushed into river systems (Pearce et al., 2011(Pearce, T.D., Ford, J.D. , Prno, J. , Duerden, F. , Pittman, J. , Beaumier, M. , Berrang-Ford, L. , Smit, B., 2011)). High loads of contamination (metals, sulfate and acid) at three mine sites in the US were measured during rainstorm events following dry periods ((Nordstrom, 2009)). An increase in heavy precipitation events and more intense and/or frequent droughts are projected for much of North America (e.g., (Gutzler and Robbins, 2011); (Nordstrom, 2009; Warren and Egginton, 2008).

Interviews conducted with mine practitioners in Canada found that heavy rainfall, heavy snowfall and storm events currently affect operations, and climate change is perceived as an emerging risk, and in some cases, a potential opportunity(753 Ford, J.D. ,Pearce, T. , Prno, J. , Duerden, F. , Ford, L.B. , Beaumier, M. , Smith, T. 2010; 754 Ford, J.D., Pearce, T., Prno, J., Duerden, F., Ford, L.B. , Smith, T.R. , Beaumier, M. 2011); (National Round Table on the Environment and the Economy, 2012; Pearce, T.D., Ford, J.D. , Prno, J. , Duerden, F. , Pittman, J. , Beaumier, M. , Berrang-Ford, L. , Smit, B., 2011)). Impacts on transportation were found to represent a key issue for Canadian mines(754 Ford, J.D., Pearce, T., Prno, J., Duerden, F., Ford, L.B. , Smith, T.R. , Beaumier, M. 2011). Transportation by road (including ice roads), air, and water will be affected by extreme events (e.g., heavy rainfall, snow storms, flooding) and gradual changes (e.g., higher temperatures, sea level rise). Resultant disruptions to the supply chains could be costly.

Limited water availability is a key concern for mining companies (Acclimatise, 2009)), which would be exacerbated by the drier conditions projected for many regions of North America (Seager, R., and G. Vecchi, 2010; Sun, G., McNulty, S. G., Moore Myers, J. A., & Cohen, E. C., 2008). Adjustments to management practices to deal with short-term water shortages, including reducing water intake, increasing water recycling and establishing infrastructure to move water from tailings ponds, pits and quarries, have worked successfully in the past (Chiotti and Lavender, 2008). Despite awareness of the potential role of adaptation within the mining industry there is presently little evidence of proactive planning for climate change impacts within the mining sector(753 Ford, J.D. ,Pearce, T. , Prno, J. , Duerden, F. , Ford, L.B. , Beaumier, M. , Smith, T. 2010; 754 Ford, J.D., Pearce, T., Prno, J., Duerden, F., Ford, L.B. , Smith, T.R. , Beaumier, M. 2011); (Acclimatise, 2009).

26.11.2. Construction and Housing

The risk of damage from climate perils is a significant issue for the housing and construction industries, though little research has systematically explored the topic (Morton, T., Bretschneider, P., Coley, D. and Kershaw, T., 2011)). Engineering and construction knowledge exists to design and construct new buildings to accommodate the risk of damage from historic extremes and anticipated changes in severe weather (Institute for Business and Home Safety, 2012; Kelly, 2010; Ministry of Municipal Affairs and Housing, 2011). Older buildings may be retrofit to increase resilience, but these changes are often more expensive to introduce into an existing structure than if they were including during initial construction.

The housing and construction industries have made advances toward climate change mitigation by incorporating energy efficiency in building design (Heap, 2007). Less progress has been made in addressing the risk of damage from extreme weather events (Kenter, 2010). In some markets, like the US Gulf Coast, change is underway in the design and construction of new homes in reaction to recent hurricanes, but in most markets across North America there has been little change in building practices. The cost of adaptation measures combined with limited long-term liability for future buildings influenced some builders to take a wait and see attitude (Morton, T., Bretschneider, P., Coley, D. and Kershaw, T., 2011).

Adaptation strategies for the industry include avoiding building in hazardous areas (e.g. in a floodplain) and safer building design (e.g. wind-resistant roof fastenings). Both strategies are influenced by government through land use planning and building codes. A builder can choose to surpass the minimum requirements in response to consumer demand, insurer incentives or the builder's desire to offer a premium product. Exploratory work is underway to consider implementation of building codes that would focus on historic weather experience and also introduce expected future weather risks(1236 Ontario Ministry of Environment 2011); (Kelly, 2010).

26.11.3. Agriculture, Forestry, Energy, and Other Goods Industries

Impacts and adaptation in the other goods producing industries are addressed elsewhere in this chapter.

26.11.4. Insurance and Other Service Industries

26.11.4.1. Insurance

Insurance is one of the most studied sectors with respect to weather and climate impact and adaptation. There is extensive evidence of adaptation in insurance practices, particularly over the past decade, and an expectation of further adaptation ((779 Mills, E. 2009; 1208 Leurig, S. 2011); (Autorite des Marches Financiers, 2011; Mills and Lecomte, 2006; Mills, 2007)). Most adaptation in the insurance industry has been in response to an increase in severe weather damage and there is little evidence of proactive adaptation in anticipation of expected future change in the climate.

Property insurance and reinsurance companies across North America experienced a significant increase in severe weather damage claims paid over the past three or four decades(Cutter and Emrich, 2005);(1232 Munich Re 2011);;(1222 Bresch, D. 2011). Most of the increase in insurance costs has been attributed to increasing exposure of people and assets in areas of risk (Barthel and Neumayer, 2010; Pielke Jr *et al.*, 2008). A role for climate change has not been excluded, but the increase to date in damage claims is largely due to growth in wealth and population(790 Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley 2012).

Without adaptation, there is an expectation that severe weather insurance damage claims will increase significantly over the next several decades across North America (World Bank, 2010). The risk of damage is expected to rise due to continuing growth in wealth, the population living at risk, and climate change. There is also an expectation that some weather perils in North America will increase in severity, including Atlantic hurricanes and the area burned by wildfire (Karl *et al.*, 2008), and frequency, including intense rainfall events(790 Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley 2012).

Severe weather and climate risks have emerged over the past decade as the leading cost for property insurers across North America, resulting in significant change in industry practices. The price of insurance increased in regions where the risk of loss and damage has increased, and discounts were introduced where risks have been reduced. Catastrophe models were developed to help insurers manage the risk of insolvency, their capital needs and the appropriate use of reinsurance. In addition to pricing decisions based on an actuarial analysis of historic loss experience, many insurance companies now use model information to help determine the prices they charge and discounts they offer. And most insurance companies have established specialized claims handling procedures for responding to catastrophic events (Kovacs, 2005);(779 Mills, E. 2009).

Insurance companies are also working to influence the behavior of their policyholders, seeking to champion actions that reduce the risk of damage from climate extremes (Allianz and WWF, 2006);(Kovacs, 2005);(779 Mills, E. 2009). For example, the industry supports the work of the Insurance Institute for Business and Home Safety in the United States, and the Institute for Catastrophic Loss Reduction in Canada working to champion change in the building code and communicate best practices for reducing the risk of damage from extreme events to property owners, governments and other stakeholders.

In 2010, the per capita spending on property and casualty insurance was $2,112.80 in the United States, $1,870.60 in Canada and $92.90 in Mexico (1233 Bevere, L. 2012). Few homeowners and businesses in Mexico purchase insurance so there is an increased risk that the impact of severe weather may be catastrophic for those who experience loss (1234 A.M. Best 2012; 1235 Insurance Information Institute 2010; 1222 Bresch, D. 2011). There is a growing literature identifying policy options for introducing and expanding the role of insurance in developing markets (Warner *et al.*, 2009);(Bals *et al.*, 2006).

26.11.4.2. Other Service Industries

Service industries are continuously adapting to changing circumstances, with weather-related risks among many factors affecting performance. Most service industries are less climate-sensitive than goods-producing industries, except insurance and tourism(753 Ford, J.D. ,Pearce, T. , Prno, J. , Duerden, F. , Ford, L.B. , Beaumier, M. , Smith, T. 2010; 754 Ford, J.D., Pearce, T., Prno, J., Duerden, F., Ford, L.B. , Smith, T.R. , Beaumier, M. 2011), (Lazo *et al.*, 2011). Insurance and tourism are two sectors where there is extensive literature but there are few studies assessing most other service industries. Impacts and adaptation in the tourism industry is addressed elsewhere in this chapter. Three broad categories of impacts of climate extremes can affect tourism destinations, competitiveness, and sustainability. The first relates to direct impacts on hotels, access roads and other tourist infrastructures, on such operating costs as heating/cooling, snowmaking, irrigation, food and water supply, evacuation, and insurance, on emergency preparedness requirements, and on business disruption (e.g., sun-and-sea or winter sports holidays). The second category refers to indirect environmental change impacts of extreme events on biodiversity and landscape change (e.g., coastal erosion), which may negatively affect the quality and attractiveness of tourism destinations. Last but not least, particular touristic regions can suffer as a result of tourism-adverse perception after occurrence of the extreme event itself (1107 Scott, D., Amelung, B., Becken, S., Ceron, J-P., Dubois, G., Gössling, S., Peeters, P., Simpson, M. 2008).

_____ START BOX 26-6 HERE _____

Box 26-6. Adapting in a Transboundary Context: the Mexico-US Border Region

Extending over 3169 km (1969 miles), the border between the United States and Mexico is one of the longest between a high-income and middle income country (Figure 26-10), and offers both challenges and opportunities to respond to climate change in a transboundary context. Sharing common climate regimes, natural resources, regional economies and urban areas, in recent years the region has been subject to severe droughts, and floods, and these events are likely to become more frequent and intense as climate change progresses. Additionally, there is a prevalence of incipient or actual conflict, given by currently or historically contested land boundaries or natural resources (1298 Udall, S.N. 1993) and management of shared resources by distinct entities (1299 Megdal, S.B. 2011).Climate change, therefore, as it interplays with socio-economic changes in the area, will most likely bring significant consequences for water resources, ecosystems, human health, and rural and urban communities.

[INSERT FIGURE 26-10 HERE
Figure 26-10: The US-Mexico Border. Source: EPA, 2012.]

Changing Socio-Economic Conditions

The population of the Mexico-US Border Region is rapidly growing and urbanizing, with population increasing from just under 7 million in 1983 to over 15 million in 2012. Since 1994, rapid growth in the area has been fueled by a fast-paced economic change resulting from the passage of the North American Free Trade Agreement (NAFTA) (U.S. Environmental Protection Agency and Secretaría de Medio Ambiente y Recursos Naturales, 2011; U.S. Environmental Protection Agency, 2012). Since 1965, urbanization was driven by the promise of work in maquiladoras, or duty-free foreign owned manufacturing plants, but this urbanization increased substantially after NAFTA. Between 1990 and 2001 the number of maquiladoras in Mexico had more than doubled, from 1700 to nearly 3,800, *with* 2,700 in the border area. By 2004, it was estimated that more than one million Mexicans were employed in the more than 3,000 *maquiladoras* located along the border.

Notwithstanding this explosive growth in economic activity and population in the region, many infrastructural needs there remain unmet. For example, an estimated 98,600 households in the region lacked safe drinking water, and an estimated 690,700 homes lacked adequate wastewater collection and treatment services. Given this infrastructural deficit, any effort to increase regional adaptive capacity needs to take existing gaps into account.

Changing Climate and Water Resources

The region is characterized by high temperatures and aridity, with about half of its precipitation coming in the summer monsoon but has experienced particularly dry conditions in recent years. For example, the current drought, concentrated in Texas and extending into Mexico, is the most extreme in over a century of recorded precipitation patterns for the area (977 Cayan, D.R. 2010)(1167 Seager, R., and G. Vecchi 2010)(1059 Nielsen-Gammon, J.W. 2011), Figure 26-11). Streamflow in already oversubscribed rivers such as the Colorado and Rio Grande has also decreased, threatening water resources. In fact, climatological conditions for the area have been particularly unprecedented, with sustained high temperatures that may exceed any experienced for 1,200 years. While these changes cannot conclusively be attributed to anthropogenic climate change, they are consistent with climate change model projections (Woodhouse et al., 2010).

[INSERT FIGURE 26-11 HERE
Figure 26-11: Soil-Humidity anomaly during April 2011. Source: Magana, 2011.]

Ecosystems

Population growth, economic development and urbanization are already fragmenting and degrading the region’s highly diverse habitats, species and ecosystems, such as the California saga and chaparral, the Sonoran desert, the Chihuahuan desert, and the Tamaulipan mezquital. Of the region’s over 6,500 animal and plant species, 235 on the Mexican side are classified in a risk category and 85 are considered endangered under Mexico’s law. While on the U.S. side, 148 species are listed as endangered under the U.S. Endangered Species Act. (975 U.S. Environmental Protection Agency 2011;).

Human Health

In the absence of adequate policies and governance structures, upward trends in population growth and economic activity have brought with them more air pollution sources, including motor vehicles, industries and power plants. Heavy diesel trucking is also concentrated along several highways and border crossings, creating local hotspots for fine particle pollution. Border monitoring stations show that there were some days with violations of ozone or PM10 air quality standards in the past five years, but with variations from year to year(1303 World Health Organization 2007).

As climate change enters the equation, it may impact human health in the region in diverse ways: For instance, long-term draught in the region increases respiratory impacts from wind-blown dust. Rising temperatures increase ozone levels (U.S. Environmental Protection Agency and Secretaría de Medio Ambiente y Recursos Naturales, 2011). As climate change interacts with socio-economic factors in the region, the human health stressors may be compounded.

In the fragile ecosystems of this region, opportunities and challenges, resources and environmental and health impacts are shared across international borders, creating the need for cooperation in the governance between, local, national and international actors. In the SOD we will briefly discuss findings on these challenges and opportunities as they pertain to both sides of the border in the context of climate variability and change.

_____ END BOX 26-6 HERE _____

26.12. Concluding Remarks

(to be drafted)

Frequently Asked Questions

FAQ 26.1: What makes North America especially unique compared with other continents when it comes to climate vulnerabilities?

North America is unique in the very broad diversity of geography, climate, economic development, social fabric and governance systems which can be found across its broad landmass, and result in different vulnerabilities and capacities to adapt across sectors and regions. Layered on top of this broad diversity is a similarly broad range of climate trends and projections. For example rapid observed and projected further warming of northern NA will lead to major changes in transportation, agriculture, and native livelihoods. Meanwhile, strong drying trends in the western US and Mexico are leading to major stresses on water supplies, agriculture, and ecological services.

FAQ 26.2: Will changing patterns of precipitation be experienced in NA and if so, in what ways?

Future projections over NA suggest increases in annual precipitation in Canada and Alaska. However decreases in the southwestern US and much of Mexico are projected. These average trends will be accompanied by increasing intensity of precipitation events along with longer, more intense periods of draught. Thus, variability in precipitation appears to be a hallmark of future climate in NA. Extreme storm events can have significant impacts on local infrastructure and human health when they exceed the intensity for which these systems have been developed over many decades. The large concentration of human and infrastructure resources in the Gulf of Mexico and other coastal regions can exacerbate this vulnerability.

FAQ 26.3: What sectors/regions are more vulnerable? What factors/drivers contribute to a vulnerable situation?

- *Water supplies and quality in many regions*: Runoff throughout most of Mexico, except the south, much of the western United States and southwestern Canada is likely to decrease. These areas are already facing stress from limited water supply and lower future runoff is likely to result in increased competition for water supplies, decreased agricultural production, and harm to aquatic ecosystem.

- *Agriculture in Mexico*, particularly among smallholders: Higher temperatures, a decrease in runoff, and lower soil moisture, which are all considered to be likely for many agricultural-producing areas of Mexico, will likely decrease agricultural production. Only a small proportion of cultivated land is irrigated, furthermore, and the availability of insurance to small-holders in particular is limited. This risks reducing food security, and increasing social instability and migration. Mention something about the wet tropical south
- *Many ecosystems*: In particular, wildfire and pest outbreaks have increased in North America and both of these trends have been linked to climate change. Forest ecosystems, forest-based industries, and human settlements have been impacted negatively by recent wildfire and pest events. Forecasts indicating increasing frequency and intensity of both processes suggest a high likelihood for further reductions in biodiversity, loss of habitat, decreases in ecosystem services, challenges for forest-based industries, and increased economic and health consequences for local communities

FAQ 26.4: What lessons can be drawn from existing adaptation actions on the factors shaping effective responses?

Different economic and demographic sectors and tiers of government are starting to assess their climate change vulnerabilities and designing adaptation programs. Many responses are in diagnosis and planning stage and have not yet moved into the implementation.

Engaging stakeholders in adaptation has proved effective in gaining legitimacy for public decisions and helping capture local realities. The use of scientific information in participatory exercises has also been crucial. However, potential issues might arise: delays in decision making; tensions and conflicts among stakeholder groups embedded in power relationships that can constrain the access of the general population to decision making processes. In addition, adaptation may be constrained by a general unwillingness to address long-term changes (e.g., many decision makers have relatively short term planning and management horizons).

Adapting to climate change is complicated by the fact that it is undertaken at different temporal, spatial and sectoral scales, thus requiring a careful assessment of the different sectoral and spatial layers involved (e.g., land-use planning, emergency responses, housing, and health). Often, environmental or engineering agencies are responsible for managing climate issues, but do not have the decision making power nor the resources available to address all the dimensions involved. Adaptation requires not only shorter term actions, but also longer term measures and perspectives by the different tiers of governmental, businesses, grassroots organizations and individuals.

References

Adamo, S.B., 2010: Environmental migration and cities in the context of global environmental change. *Current Opinion in Environmental Sustainability*, .

Adams, R.M., B.H. Hurd, and J. Reilly, 1999: *Agriculture and Global Climate Change: A Review of Impacts to U.S. Agricultural Resources*, Pew Center for Global Change, Arlington, VA, .

Adams, H.D., M. Guardiola-Claramonte, G.A. Barron-Gafford, J.C. Villegas, D.D. Breshears, C.B. Zou, P.A. Troch, and T.E. Huxman, 2009: Temperature sensitivity of drought-induced tree mortality portends increased regional die-off under global-change-type drought. *Proceedings of the National Academy of Sciences*, **106(17)**, 7063-7066.

Adaptation Advisory Groups to the Alaska Climate Change Sub-Cabinet, 2010: Alaska's Climate Change Strategy: Addressing Impacts in Alaska, Alaska Department of Environmental Conservation, Juneau, Alaska, .

Adger, W.N., 2006: Vulnerability. *Global Environmental Change*, **16(3)**, 268-281.

Adler, J.H., 2008: Water marketing as an adaptive response to the threat of climate change. *Hamline L.Rev.*, **31**, 729.

AECOM, 2010: Colorado River Water Availability Study Phase I Report DRAFT. .

Aerts, J., 2009: *Connecting delta cities: Coastal cities, flood risk management and adaptation to climate change.* VU University Press, .

Afifi, T. and J. JäGER, 2010: *Environment, forced migration and social vulnerability.* Springer Verlag, .

Agrawala, S., A. Moehner, F. Gagnon-Lebrun, W.E. Baethgen, D.L. Martino, E. Lorenzo, M. Hagenstad, J. Smith, and M. van Aalst, 2004: *Development and Climate Change in Uruguay: Focus on Coastal Zones, Agriculture and Forestry*, .

Aguilar, A.G. and C. Santos, 2011: Informal settlements' needs and environmental conservation in mexico city: An unsolved challenge for land-use policy. *Land use Policy*, .

Ahmed, S.A., N.D. Diffenbaugh, and T. Hertel, 2009: Climate volatility deepens poverty vulnerability in developing countries. *Environmental Research Letters,* **4**.

Akbari, H., S. Menon, and A. Rosenfeld, 2009: Global cooling: Increasing world-wide urban albedos to offset CO 2. *Climatic Change,* **94(3)**, 275-286.

Alan Fuchs and Hendrik Wolff1, Drought and retribution: Evidence from a large scale rainfall-indexed insurance program in mexico.

Alber, G. and K. Kern, 2008: Governing climate change in cities: Modes of urban climate governance in multi-level systems. In: Proceedings of OECD conference on competitive cities and climate change, milan, october, pp. 9–10.

Alcántara-Ayala, I., 2008: On the historical account of disastrous landslides in mexico: The challenge of risk management and disaster prevention. *Advances in Geosciences,* **14**, 159-164.

Alcántara-Ayala, I., 2009: Disasters in mexico and central america:: A little bit more than a century of natural hazards. *Developments in Earth Surface Processes,* **13**, 75-97.

Alcántara-Ayala, I., O. Esteban-Chávez, and J. Parrot, 2006: Landsliding related to land-cover change: A diachronic analysis of hillslope instability distribution in the sierra norte, puebla, mexico. *Catena,* **65(2)**, 152-165.

Alexander et al., 2006: Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research,* **111**, D05109, doi:10.1029/2005JD006290.

Allen, C. D., A. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, P. Gonzales, T. Hogg, A. Rigling, and D.D. Breshears, 2010: A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *Forest Ecology and Management,* **259(4)**, 660-684.

Allianz and WWF, 2006: Climate Change and Insurance: An Agenda for Action in the United States, Allianz and WWF, .

Amato, A.D., M. Ruth, P. Kirshen, and J. Horwitz, 2005: Regional energy demand responses to climate change: Methodology and application to the commonwealth of massachusetts. *Climatic Change,* **71(1)**, 175-201.

American Society for Civil Engineers, 2009: 2009 Report Card for America's Infrastructure, American Society of Civil Engineers, Reston, Virginia, .

Amundsen, H., F. Berglund, and H. Westskogô, 2010: Overcoming barriers to climate change adaptationöa question of multilevel governance? *Environment and Planning C: Government and Policy,* **28**, 276-289.

Anderegg, W.R.L., J.A. Berry, D.D. Smith, J.S. Sperry, L.D.L. Anderegg, and C.B. Field, 2012: The roles of hydraulic and carbon stress in a widespread climate-induced forest die-off. *Proceedings of the National Academy of Sciences,* **109(1)**, 233-237.

Andersen, L., L. Lund, and D. Verner, 2010: Migration and climate change. *Reducing Poverty, Protecting Livelihoods, and Building Assets in a Changing Climate: Social Implications of Climate Change Latin America and the Caribbean,* , 195.

Andersen, L.E., A. Suxo, and D. Verner, 2009: Social impacts of climate change in peru: A district level analysis of the effects of recent and future climate change on human development and inequality, draft, february. *World,* .

Andersen, L.E. and D. Verner, 2009: Social impacts of climate change in bolivia. *A Municipal Level Analysis of the Effects of,* .

Andersen, L.E. and D. Verner, 2010: Social impacts of climate change in chile: A municipal level analysis of the effects of recent and future climate change on human development and inequality, draft, february. *World,* .

Anderson, B.C., Consumption smoothing responses to natural disasters: Evidence from a quasi-natural experiment in nicaragua.

Anderson, B.G. and M.L. Bell, 2009: Weather-related mortality: How heat, cold, and heat waves affect mortality in the united states. *Epidemiology,* **20(2)**, 205.

Anderson, R.G., J.G. Canadell, J.T. Randerson, R.B. Jackson, B.A. Hungate, D.D. Baldocchi, G.A. Ban-Weiss, G.B. Bonan, K. Caldeira, L. Cao, N.S. Diffenbaugh, K.R. Gurney, L.M. Kueppers, B.E. Law, and S. Luyssaert and T.L. O'Halloran, 2011: Biophysical considerations in forestry for climate protection. *Frontiers in Ecology and the Environment,* **9**, 174-182.

Andersson, E., 2006: Urban landscapes and sustainable cities.

Andrade, M.I. and O.E. Scarpati, 2007: Recent changes in flood risk in the gran la plata, buenos aires province, argentina: Causes and management strategy. *GeoJournal,* **70(4)**, 245-250.

Andrey, J. and B. Mills, 2003: Climate change and the canadian transportation system: Vulnerabilities and adaptations. *Weather and Transportation in Canada,* , 235-279.

Anguelovski, I. and M. Campbell, 2009: Building the resilience of vulnerable communities in quito: Adapting local food systems to climate change. *Urban Agriculture Magazine,* , 25-26.

Anguelovski, I. and J.A. Carmin, 2011: Something borrowed, everything new: Innovation and institutionalization in urban climate governance. *Current Opinion in Environmental Sustainability,* .

Anton, D.J., 1993: *Thirsty cities: Urban environments and water supply in latin america.* Idrc, .

Anzaldúa, G., 1987: *Borderlands/La frontera.* Aunt Lute Press, San Francisco, .

Aragón - Durand, F., 2007: Urbanisation and flood vulnerability in the peri - urban interface of mexico city. *Disasters,* **31(4)**, 477-494.

Ariano, R., G.W. Canonica, and G. Passalacqua, 2010: Possible role of climate changes in variations in pollen seasons and allergic sensitizations during 27 years. *Annals of Allergy, Asthma & Immunology : Official Publication of the American College of Allergy, Asthma, & Immunology,* **104(3)**, 215-22.

Aron, J.L., 2008: Outreach from the IAI collaborative research network on climate variability and human health impacts in the tropical americas. *Seasonal Forecasts, Climatic Change and Human Health,* , 189-201.

Arroyo, A.M., S.M. Naim, and J.S. Hidalgo, 2010: Vulnerability to climate change of marine and coastal fisheries in mexico *Atmósfera,* **24(1)**, 103-123.

Aukema, B.H., A.L. Carroll, J. Zhu, K.F. Raffa, T.A. Sickley, and S.W. Taylor, 2006: Landscape level analysis of mountain pine beetle in british columbia, canada: Spatiotemporal development and spatial synchrony within the present outbreak. *Ecography,* **29**, 427-441.

Autorite des Marches Financiers, 2011: Managing Climate Change Risk: Findings of 2010 Survey of Property and Casualty Insurers Operating in Quebec, AMF, .

Avise, J., J. Chen, B. Lamb, C. Wiedinmyer, A. Guenther, and E. Salath, 2009: Attribution of projected changes in summertime US ozone and PM 2.5 concentrations to global changes. *Atmospheric Chemistry and Physics,* **9**, 1111-1124.

Azumaya, T., T. Nagasawa, O.S. Temnykh, and G.V. Khen, 2007: Regional and seasonal differences in temperature and salinity limitations of pacific salmon. *North Pacific Anadromous Fish Commission,* **4**, 179-187.

Bacon, C., 2005: Confronting the coffee crisis: Can fair trade, organic, and specialty coffees reduce small-scale farmer vulnerability in northern nicaragua? *World Development,* **33(3)**, 497-511.

Badjeck, M.C., E.H. Allison, A.S. Halls, and N.K. Dulvy, 2009: Impacts of climate variability and change on fishery-based livelihoods *Marine Policy,* **34**, 375-383.

Badjek, M., E.H. Allison, A.S. Halls, and N.K. Dulvy, 2010: Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy,* **34**, 375-383.

Baethgen, W.E., 1997: Vulnerability of the agricultural sector of latin america to climate change. *Climate Research,* **9**, 1-7.

Baez, J. and A. Mason, 2008: Dealing with climate change: Household risk management and adaptation in latin america. *Background Paper for World Bank Flagship Report on Climate Change, World Bank Latin American and Caribbean Region,* .

Balbus, J.M. and C. Malina, 2009: Identifying vulnerable subpopulations for climate change health effects in the united states. *Journal of Occupational and Environmental Medicine,* **51(1)**, 33.

Balk, D., M.R. Montgomery, G. McGranahan, D. Kim, V. Mara, M. Todd, T. Buettner, and A. Dorélien, 2009: Mapping urban settlements and the risks of climate change in africa, asia and south america. *Population Dynamics and Climate Change,* , 80.

Balling, R.C. and R.S. Cerveny, 2003: Compilation and discussion of trends in severe storms in the united states: Popular perception v. climate reality. *Natural Hazards,* **29(2)**, 103-112.

Bals, C., K. Warner, and S. Butzengeiger, 2006: Insuring the uninsurable: Design options for a climate change funding mechanism. *Climate Policy,* **6(6)**, 637-647.

Barclay, E., 2008: Is climate change affecting dengue in the americas ? *Lancet,* **371**, 973-74.

Barnett, a.G., S. Hajat, a. Gasparrini, and J. RocklÃ¶v, 2012: Cold and heat waves in the united states. *Environmental Research,* .

Barnett, A.G., 2007: Temperature and cardiovascular deaths in the US elderly: Changes over time. *Epidemiology (Cambridge, Mass.),* **18(3)**, 369-72.

Barrieu, P. and H. Louberge, 2009: Hybrid cat bonds. *Journal of Risk and Insurance,* **76(3)**, 547-578.

Barros, V., 2008: Adaptation to climate trends: Lessons from the argentine experience. *Climate Change and Adaptation,* , 296.

Barros, V., A. Menéndez, C. Natenzon, R. Kokot, J. Codignotto, M. Re, P. Bronstein, I. Camilloni, S. Ludueña, and D. Rios, 2008: Storm surges, rising seas and flood risks in metropolitan buenos aires. *Climate Change and Vulnerability,* , 117–133.

Barthel, F. and E. Neumayer, 2010: A trend analysis of normalized insured damage from natural disasters. *Climatic Change,* .

Bartlett, S., D. Dodman, J. Hardoy, D. Satterthwaite, C. Tacoli, and A. y Desarrollo, 2009: Social aspects of climate change in urban areas in low and middle income nations. In: Proceedings of Contribution to the 5th symposium on urban research "Cities in climate change, pp. 28-30.

Barton, J.R., 2009: Adaptación al cambio climático en la planificación de ciudades-regiones. *Revista De Geografía Norte Grande,* **(43)**, 5-30.

Bassil, K.L., D.C. Cole, R. Moineddin, W. Lou, A.M. Craig, B. Schwartz, and E. Rea, 2011: The relationship between temperature and ambulance response calls for heat-related illness in toronto, ontario, 2005. *Journal of Epidemiology and Community Health,* **65(9)**, 829-31.

Basu, R., W.Y. Feng, and B.D. Ostro, 2008: Characterizing temperature and mortality in nine california counties. *Epidemiology,* **19(1)**, 138.

Bates, B.C., Z. Kundzewicz, S. Wu, and J. Palutikof, 2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, , 210 Pp. IPCC Secretariat, Geneva, .

Bates, B.C., Z. Kundzewicz, S. Wu, and J. Palutikof, 2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, .

Battin J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki, 2007: Projected impacts of climate change on salmon habitat restoration *Proceedings of the National Academy Sciences of the United States of America,* **104(16)**, 6720-6725.

Battin, J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K. Bartz, and H. Imaki, 2007: Projected impacts of climate change on salmon habitat restoration. *Proceedings of the National Academy of Sciences,* **104**, 6720-6725.

Bayentin, L., S. El Adlouni, T.B. Ouarda, P. Gosselin, B. Doyon, and F. Chebana, 2010: Spatial variability of climate effects on ischemic heart disease hospitalization rates for the period 1989-2006 in quebec, canada. *International Journal of Health Geographics,* **9(1)**, 5-5.

Beamish, R.J., 1993: Climate and exceptional fish production off the west-coast of north-america *Canadian Journal of Fisheries and Aquatic Sciences,* **50(10)**, 2270-2291.

Beebe, N.W., R.D. Cooper, P. Mottram, and A.W. Sweeney, 2009: Australia's dengue risk driven by human adaptation to climate change. *PLoS Neglected Tropical Diseases,* **3(5)**, e429.

Belanger, D., P. Berry, V. Bouchet, D. Charron, K. Clarke, B. Doyon, M. Fleury, C. Furgal, P. Gosselin, S. Lamy, L.R. Lindsay, G. McBean, N.H. Ogden, J. Seguin, C.J. Shuster, and C.L. Soskolne, 2008: *Human health in a changing climate : A canadian assessment of vulnerabilities and adaptive capacity.* Health Canada, Ottowa, Ontario, .

Bell, M.L., R. Goldberg, C. Hogrefe, P.L. Kinney, K. Knowlton, B. Lynn, J. Rosenthal, C. Rosenzweig, and J.A. Patz, 2007: Climate change, ambient ozone, and health in 50 US cities. *Climatic Change,* **82(1)**, 61-76.

Bell, M.L., M.S. O'Neill, N. Ranjit, V.H. Borja-Aburto, L.A. Cifuentes, and N.C. Gouveia, 2008: Vulnerability to heat-related mortality in latin america: A case-crossover study in sao paulo, brazil, santiago, chile and mexico city, mexico. *International Journal of Epidemiology,* **37(4)**, 796.

Bell, M.L., D.L. Davis, N. Gouveia, V. Borja-Aburto, and L.a. Cifuentes, 2006: The avoidable health effects of air pollution in three latin american cities: Santiago, SÃ£o paulo, and mexico city. *Environmental Research,* **100(3)**, 431-40.

Bell, M.L., R. Goldberg, C. Hogrefe, P.L. Kinney, K. Knowlton, B. Lynn, J. Rosenthal, C. Rosenzweig, and J.a. Patz, 2007: Climate change, ambient ozone, and health in 50 US cities. *Climatic Change,* **82(1-2)**, 61-76.

Belliveau, S., B. Smit, and B. Bradshaw, 2006: Multiple exposures and dynamic vulnerability: Evidence from the grape industry in the okanagan valley, canada. *Global Environmental Change,* **16(4)**, 364-378.

Bender, M.A., T.R. Knutson, R.E. Tuleya, J.J. Sirutis, G.A. Vecchi, S.T. Garner, and I.M. Held, 2010: Modeled impact of anthropogenic warming on the frequency of intense atlantic hurricanes. *Science,* **327(5964)**, 454-458.

Benotti, M.J., B.D. Stanford, and S.A. Snyder, 2010: Impact of drought on wastewater contaminants in an urban water supply. *Journal of Environmental Quality, 39 (4), Pp. 1196-1200,* .

Bentz, B., 2008: *Western US bark beetles and climate change* U.S. Department of Agriculture, Forest Service, Climate Change Resource Centre, .

Bentz, B.J., J. Régnière, C.F. Fettig, E.M. Hansen, J.L. Hayes, J.A. Hicke, R.G. Kelsey, J.F. Negrón, and S.J. Seybold, 2010: *Climate change and bark beetles of the western united states and canada: Direct and indirect effects. . Bioscience,* **60(8)**, 602-613.

Berry, H.L., K. Bowen, and T. Kjellstrom, 2010: Climate change and mental health: A causal pathways framework. *International Journal of Public Health,* **55(2)**, 123-32.

Best, A.M., 2012: *Special Report.* Mexico Non-Life & Life – Market Review. Economic Rebound, Market Innovation Drive Insurance Growth in Mexico, 7 pp.

Betsill, M.M., 2001: Mitigating climate change in US cities: Opportunities and obstacles. *Local Environment,* **6(4)**, 393-406.

Betsill, M.M. and H. Bulkeley, 2004: Transnational networks and global environmental governance: The cities for climate protection program. *International Studies Quarterly,* **48(2)**, 471-493.

Betsill, M.M. and H. Bulkeley, 2006: Cities and the multilevel governance of global climate change. *Global Governance: A Review of Multilateralism and International Organizations,* **12(2)**, 141-159.

Bevere, L., R. Enz, J. Mehlhorn, and T. Tamura, 2012: *Sigma.* Sigma no 2/2012: Natural Catastrophes and Man-made Disasters in 2011, Swiss Re, .

Bicknell, J., D. Dodman, and D. Satterthwaite, 2009: *Adapting cities to climate change: Understanding and addressing the development challenges.* Earthscan Publications, .

Bils, J., 2008: Wal-mart and the supermarket revolution in mexico. *Geographische Rundschau,* **4**, 44-49.

Bin, O., C. Dumas, B. Poulter, and J. Whitehead, 2007: Measuring the impacts of climate change on north carolina coastal resources. *Boone, NC: Department of Economics, Appalachian State University,* , 101.

Bin, O., J.B. Kruse, and C.E. Landry, 2008: Flood hazards, insurance rates, and amenities: Evidence from the coastal housing market. *Journal of Risk and Insurance,* **75(1)**, 63-82.

Birkmann, J., M. Garschagen, F. Kraas, and N. Quang, 2010: Adaptive urban governance: New challenges for the second generation of urban adaptation strategies to climate change. *Sustainability Science,* , 1-22.

BjÃ¶rkstÃ©n, F. and I. Suoniemi, 1981: Time and intensity of first pollen contacts and risk of subsequent pollen allergies. *Acta Medica Scandinavica,* **209(4)**, 299-303.

Blanco, J.T. and D. Hernández, 2009: The potential costs of climate change in tropical vector-borne Diseases–A case study of malaria and dengue in colombia. *Assessing the Consequences of Climate Destabilization in Latin America,* .

Blate, G.M., L.A. Joyce, J.S. Littell, S.G. McNulty, C.I. Millar, S.C. Moser, R.P. Neilson, and K.O. Halloran and D.L. Peterson, 2009: Adapting to climate change in united states national forest. *Unasylva,* **60(1-2 (231-232) Adapting to climate change)**, 57-62.

Bloem, M.W., R.D. Semba, and K. Kraemer, 2010: Castel gandolfo workshop: An introduction to the impact of climate change, the economic crisis, and the increase in the food prices on malnutrition. *The Journal of Nutrition,* **140(1)**, 132S-135S.

Bolin, B., M. Seetharam, and B. Pompeii, 2010: Water resources, climate change, and urban vulnerability: A case study of phoenix, arizona. *Local Environment,* **15(3)**, 261-279.

Bond, W. J. and J. E. Keeley, 2005: Fire as a global “herbivore”: The ecology and evolution of flammable ecosystems. *Trends in Ecology and Evolution,* **20**, 387-394.

Bootsma, A., S. Gameda, and D.W. McKenney, 2005: Potential impacts of climate change on corn, soybeans and barley yields in atlantic canada. *Canadian Journal of Soil Science,* **85**, 345-357.

Bornehag, C.G., G. Blomquist, F. Gyntelberg, B. Jarvholm, P. Malmberg, L. Nordvall, A. Nielsen, G. Pershagen, and J. Sundell, 2001: Dampness in buildings and health. *Indoor Air,* **11(2)**, 72-86.

Bornstein, R. and Q. Lin, 2000: Urban heat islands and summertime convective thunderstorms in atlanta: Three case studies. *Atmospheric Environment,* **34(3)**, 507-516.

Boruff, B.J., C. Emrich, and S.L. Cutter, 2005: Erosion hazard vulnerability of US coastal counties. *Journal of Coastal Research,* , 932-942.

Boruff, B.J., C. Emrich, and S.L. Cutter, 2009: Erosion hazard vulnerability of US coastal counties.

Boyd, E., L. Director, and M. Levitan, 2010: Improvements in flood fatality estimation techniques based on flood depths. *Wind Storm and Storm Surge Mitigation,* , 126.

Boyd, R. and M.E. Ibarraran, 2009: Extreme climate events and adaptation: An exploratory analysis of drought in mexico. *Environment and Development Economics,* **14**, 371-395.

Boyd, R. and M.E. Ibarrarán, 2009: Extreme climate events and adaptation: An exploratory analysis of drought in mexico. *Environment and Development Economics,* **14(03)**, 371-395.

Bradley, R.S., M. Vuille, H.F. Diaz, and W. Vergara, 2006: Threats to water supplies in the tropical andes. *Science,* **312(5781)**, 1755-1756.

Brassard, J. and B. Singh, 2008: Impacts of climate change and CO2 increase on agricultural production and adaptation options for southern québec, canada. *Mitigation and Adaptation Strategies for Global Change,* **13**, 241-265.

Breceda-Lapeyre, M., O. de Buen-Rodrígez, C. Hernández-Fernández, C. León-Diez, M.Á. Lino-Linares, I. López-López, J.A. Plauchú-Alcántara, R. Salcedo-Novella, S. Salinas-Álvarez, B. del Valle-Cárdenas, and Vázquez-Martínez Ó., 2008: Programa De Accion Climatica De La Cuidad De Mexico: 2008-2012, Gobierno del Distrito Federal, Secretario del Medeo Ambiente, Mexico City, .

Brenkert-Smith, H., 2010: Building bridges to fight fire: The role of informal social interactions in six colorado wildland-urban interface communities. *International Journal of Wildland Fire,* **19**, 689-697.

Brenkert-Smith, H., 2010: Building bridges to fight fire: The role of informal social interactions in six colorado wildland–urban interface communities. *International Journal of Wildland Fire,* **19(6)**, 689-697.

Bresch, D. and A. Spiegel, 2011: A Blueprint for Managing Climate Risks in Emerging Markets, Swiss Re, .

Breshears, D. D., N.S. Cobb, P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer, 2005: Regional vegetation die-off in response to global-change-type drought. *Proceedings of the National Academy of Sciences of the United States of America,* **102(42)**, 15144-15148.

Bridge, J.W., D.M. Oliver, D. Chadwick, H.C. Godfray, a.L. Heathwaite, D. Kay, R. Maheswaran, D.F. McGonigle, G. Nichols, R. Pickup, J. Porter, J. Wastling, and S.a. Banwart, 2010: Engaging with the water sector for public health benefits: Waterborne pathogens and diseases in developed countries. *Bulletin of the World Health Organization,* **88(11)**, 873-5.

British Columbia Ministry of the Environment, 2010: Preparing for Climate Change: British Columbia's Adaptation Strategy, British Columbia Ministry of the Environment, Victoria, British Columbia, .

Brklacich, M., M. Woodrow, R. McLeman, and K. Vodden, 2008: *Project no. A1397, June 30.* Enhancing the Capacity of Canadian Rural Communities to Adapt to Uncertain Futures, Canadian Climate Impacts and Adaptation Program, Ottawa: Natural Resources Canada, .

Brklacich, M., M. Woodrow, R. McLeman, and K. Vodden, 2008: *Canadian Climate Impacts and Adaptation Program Project no. A1397.* Enhancing the Capacity of Canadian Rural Communities to Adapt to Uncertainties Natural Resources Canada, Ottawa, Canada, .

Brody, S.D., S. Zahran, H. Grover, and A. Vedlitz, 2008: A spatial analysis of local climate change policy in the united states: Risk, stress, and opportunity. *Landscape and Urban Planning,* **87(1)**, 33-41.

Brown, M., T.A. Black, Z. Nesic, V.N. Foord, D.L. Spittlehouse, A.L. Fredeen, N.J. Grant, P.J. Burton, and J.A. Trofymow, 2010: Impact of mountain pine beetle on the net ecosystem production of lodgepole pine stands in british columbia. *Agricultural and Forest Meterorology,* **150**, 254-264.

Brown, P. J., R. S. Bradley, and F. T. Keimig, 2010: Changes in extreme climate indices for the northeastern united states, 1870-2005. *Journal of Climate,* **23**, 6555-6572.

Brown, P.M., E.K. Heyerdahl, S.G. Kitchen, and M.H. Weber, 2008: **Climate effects on historical fires (1630–1900) in utah**. *International Journal of Wildland Fire,* **17(1)**, 28-39.

Browne, M.J. and R.E. Hoyt, 2000: The demand for flood insurance: Empirical evidence. *Journal of Risk and Uncertainty,* **20(3)**, 291-306.

Brunkard, J.M., E. Cifuentes, and S.J. Rothenberg, 2008: Assessing the roles of temperature, precipitation, and ENSO in dengue re-emergence on the texas-mexico border region. *Salud pÃºblica De MÃ©xico,* **50(3)**, 227-34.

Buckley, L.B. and M.S. Foushee, 2011: Footprints of climate change in US national park visitation. *International Journal of Biometeorology,* .

Buechler, S., 2009: **Gender, water, and climate change in sonora, mexico: Implications for policies and programmes on agricultural income-generation**. *Gender & Development,* **17**, 51-66.

Bulkeley, H. and M.M. Betsill, 2003: *Cities and climate change: Urban sustainability and global environmental governance.* Psychology Press, .

Burch, S., 2010: Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in british columbia, canada. *Global Environmental Change,* **20(2)**, 287-297.

Bury, J.T., B.G. Mark, J.M. McKenzie, A. French, M. Baraer, K.I. Huh, M.A. Zapata Luyo, and R.J. Gómez López, 2011: Glacier recession and human vulnerability in the yanamarey watershed of the cordillera blanca, peru. *Climatic Change,* , 1-28.

Butrón Madrigal, L., B. Del Valle-Cárdenas, J. Escandón Calderón, B. Gutiérrez-Guzmán, M. López Pérez, V. Magaña-Rueda, I. Martínez-Gaytán, J. Medrano García, G. Montiel-García, E.R. Borrel-Escobedo, D. Rodríguez-Gutiérrez, D. Rosas-Flores, S. Salinas-Álvarez, Y. Sanginés Sayavedra, C. Sheinbaum-Pardo, E. Trujillo-Bolio, and O. Vázquez Martínez, 2006: Estrategia Local De Accion Climatica Del Distrito Federal, Secretaría del Medio Ambiente del Distrito Federal, Cuidad de Mexico, .

Buzinde, C.N., D. Manuel-Navarrete, D. Kerstetter, and M. Redclift, 2010: Representations and adaptation to climate change. *Annals of Tourism Research,* **37(3)**, 581-603.

Buzinde, C.N., D. Manuel-Navarrete, E.E. Yoo, and D. Morais, 2010: Tourists' perceptions in a climate of change: Eroding destinations. *Annals of Tourism Research,* **37(2)**, 333-354.

Cai, X., D. Wang, and R. Laurent, 2009: Impact of climate change on crop yield: A case study of rainfed corn in central illinois. *Journal of Applied Meteorology & Climatology,* **48**, 1868-1881.

Cakmak, S., R.E. Dales, R.T. Burnett, S. Judek, F. Coates, and J.R. Brook, 2002: Effect of airborne allergens on emergency visits by children for conjunctivitis and rhinitis. *Lancet,* **359(9310)**, 947-8.

California Natural Resources Agency, 2009: 2009 California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008, State of California, Sacramento, California, .

California, E.C., 2005: *Chapter eight: Integrating water and energy strategies. Integrated Energy Policy Report. 139-161.,* .

Campanella, T.J., 2006: Urban resilience and the recovery of new orleans. *Journal of the American Planning Association,* **72(2)**, 141-146.

Campbell, B.D., D.M. Smith, and GCTE Pastures and Rangelands Network Members, 2000: A synthesis of recent global change research on pasture and rangeland production: Reduced uncertainties and their management implications. *Agriculture, Ecosystems & Environment,* **82**, 39-55.

Campbell-Lendrum, D., A. Pruss-Ustun, and C. Corvalan, 2003: How much disease could climate change cause. *Climate Change and Human Health: Risks and Responses.Geneva: WHO,* .

Carabias, J., R. Landa, J. Collado, P. Martínez, and F. Tudela, 2005: *Agua, medio ambiente y sociedad: Hacia la gestión integral de los recursos hídricos en méxico.* Universidad Nacional Autónoma de México, .

Carabias, J., R. Landa, J. Collado, P. Martínez, and F. Tudela, 2005: *Agua, medio ambiente y sociedad: Hacia la gestión integral de los recursos hídricos en méxico.* Universidad Nacional Autónoma de México, .

Carey, M., 2005: Living and dying with glaciers: People's historical vulnerability to avalanches and outburst floods in peru. *Global and Planetary Change,* **47(2-4)**, 122-134.

Carey, M., 2010: Commodities, colonial science, and environmental change in latin american history. *Radical History Review,* **2010(107)**, 185.

Carlson, S. and A. Walburger , 2007: Energy Index Development for Benchmarking Water and Wastewater Utilities, AWWA Reserach Foundation, 2007. .

Carmen Lacambra, S., I. Möller, and T. Spencer, 2008: 2.3 the need for an ecosystem-inclusive vulnerability index for coastal areas in colombia. *Resilience and Social Vulnerability,* , 82.

Carmin, J., N. Nadkami, and C. Rhie, 2012: Progress and Challenges in Urban Climate Adaptation Planning: Results of a Global Survey, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA, .

Carmin, J.A. and I. Anguelovski, 2009: Planning climate resilient cities: Early lessons from early adapters.

Carrière, A., M. Prévost, A. Zamyadi, P. Chevalier, and B. and Barbeau, 2010.: Vulnerability of quebec drinking-water treatment plants to cyanotoxins in a climate change context. *Journal of Water and Health 8(3): 455-465.*

Carrière, A., M. Prévost, A. Zamyadi, P. Chevalier, and B. Barbeau, 2010: Vulnerability of quebec drinking-water treatment plants to cyanotoxins in a climate change context. *Journal of Water and Health 8(3): 455-465,* .

Carvajal-Escobal, Y. and M. Quintero-Angel, 2009: Capacity development for adapting to landslides associated with changes in the precipitation patterns caused by climate variability and change in manizales (colombia). *Strengthening the Capacities of Local Organisations and People,* , 147.

Cashman, A., L. Nurse, and C. John, 2010: Climate change in the caribbean: The water management implications. *The Journal of Environment & Development,* **19(1)**, 42-67.

Cayan, D. R., K. T. Redmond, and L. G. Riddle, 1999: ENSO and hydrologic extremes in the western united states. *Journal of Climate,* **12**, 2881-2893.

Cayan, D.R., T. Das, D.W. Pierce, T.P. Barnett, M. Tyree, and A. Gershunov, 2010: Future dryness in the southwest US and the hydrology of the early 21st century drought. *Proceedings of the National Academy of Sciences,* **107(50)**, 21271-21276.

CDC, 2011: Surveillance for waterborne disease outbreaks and other health events associated with recreational water â€” US, 2007 â€“ 2008 and surveillance for waterborne disease outbreaks associated with drinking water â€” US, 2007-2008. *Morbidity and Mortality Weekly Report,* **60(12)**, 1-80.

Centers for, D.C., *Rocky mountain spotted fever (RMSF)* .

Cervantes-Godoy, D., 2009: The Role of Agriculture and Farm Household Diversification in the Rural Economy of Mexico, Organization for Economic Cooperation and Development, Trade and Agriculture Directorate, .

Chambers, J.Q., J.I. Fisher, H. Zeng, E.L. Chapman, D.B. Baker, and G.C. Hurtt, 2007: Hurricane katrina's carbon footprint on U.S. gulf coast forests. *Science,* **318(5853)**, 1107-1107.

Chandel, M.K., L.F. Pratson, and R.B. Jackson, 2010: The potential impacts of climate-change policy on freshwater use in thermoelectric power generation. *Energy Policy, 39 (2011), 6234-6242,* .

Chang, W., V.A. Lantz, and D.A. MacLean, 2009: Public attitudes about forest pest outbreaks and control: Case studies in two canadian provinces. *Forest Ecology and Managment,* **257(4)**, 1333-1343.

Charvériat, C. and Inter-American Development Bank. Research Dept, 2000: *Natural disasters in latin america and the caribbean: An overview of risk.* Inter-American Development Bank, .

Chen, C.C. and B.A. McCarl, 2009: Hurricanes and possible intensity increases: Effects on and reactions from U.S. agriculture. *Journal of Agricultural and Applied Economics,* **41**, 125-144.

Chen, F., S. Miao, M. Tewari, J.W. Bao, and H. Kusaka, 2011: A numerical study of interactions between surface forcing and sea breeze circulations and their effects on stagnation in the greater houston area. *J.Geophys.Res,* **116**, D12105.

Chen, J., J. Avise, B. Lamb, and E. Salath, 2009: The effects of global changes upon regional ozone pollution in the united states. *Atmospheric Chemistry and Physics,* , 1125-1141.

Chen, J., J. Avise, B. Lamb, E. SalathÃ©, C. Mass, a. Guenther, C. Wiedinmyer, J.-. Lamarque, S. O'Neill, D. McKenzie, and N. Larkin, 2009: The effects of global changes upon regional ozone pollution in the united states. *Atmospheric Chemistry and Physics,* **9(4)**, 1125-1141.

Cheng, J. and B. Newbold, 2010: Mapping vulnerability to climate change and variability in hamilton, ontario using geographical information systems.

Chhetri, N.B., W.E. Easterling, E. Terandoc, and L. Mearns, 2010: Modeling path dependence in agricultural adaptation to climate variability and change. *Annals of the Association of American Geographers,* **100(4)**, 894-907.

Chiffoleau, Y., 2009: **From politics to co-operation: The dynamics of embeddedness in alternative food supply chains**. *Sociologia Ruralis,* **49(3)**, 218-235.

Chinowsky, P., J.C. Price, and J. Neumann, Submitted:
Assessment of climate change adaptation costs for the U.S. road network. *Global Environmental Change,* .

Chouinard, O., S. Plante, and G. Martin, 2008: The community engagement process: A governance approach in adaptation to coastal erosion and flooding in atlantic canada. *Canadian Journal of Regional Science,* **31(3)**, 507-520.

Christensen, J.H., 2010: *Summaries of likely climate change impacts, by country.* World Bank Publications, pp. 373.

Cifuentes, L., V. Borja-aburto, N. Gouveia, G. Thurston, and D.L. Davis, 2001: Assessing the health benefits of urban air pollution reductions associated with climate change mitigation (2000-2020): Santiago, SÃ£o paulo, MÃ©xico city, and new york city. *Environmental Health Perspectives,* **109 Suppl**, 419-25.

City of Keene, New Hampshire and ICLEI - Local Governments for Sustainability, 2007:
Adapting to Climate Change: Planning a Climate Resilient Community, ICLEI Local Governments for Sustainability, Oakland, California, .

Clot, B., 2003: Trends in airborne pollen: An overview of 21 years of data in neuchâtel (switzerland). *Aerobiologia,* **19(3)**, 227-234.

Coffee, J.E., J. Parzen, M. Wagstaff, and R.S. Lewis, 2010: Preparing for a changing climate: The chicago climate action plan's adaptation strategy. *Journal of Great Lakes Research,* **36**, 115-117.

Cohen, J.D., 2000: Preventing disaster: Home ignitability in the wildland-urban interface. *Journal of Forestry,* **98**, 15-21.

Coles, A.R. and C.A. Scott, 2009: Vulnerability and adaptation to climate change and variability in semi-arid rural southeastern arizona, USA. *Natural Resources Forum,* **33(4)**, 297-309.

Collins, B.M., P.N. Omi, and P.L. Chapman, 2006: Regional relationship between climate and wildfire-burned area in the interior west, USA. *Canadian Journal of Forest Research,* **36**, 699-709.

Collins, T.W., 2008: The political ecology of hazard vulnerability: Marginalization, facilitation and the production of differential risk to urban wildfires in arizona's white mountains. *Journal of Political Ecology*, **15**, 21-43.

Collins, T.W. and B. Bolin, 2009: Situating hazard vulnerability: People's negotiations with wildfire environments in the U.S. southwest. *Environmental Management,* **44**, 441-455.

Collins, T.W. and B. Bolin, 2009: Situating hazard vulnerability: People's negotiations with wildfire environments in the US southwest. *Environmental Management,* **44(3)**, 441-455.

Collins, T.W., S.E. Grineski, and de Lourdes Romo Aguilar, M., 2009: Vulnerability to environmental hazards in the ciudad juárez (mexico)-el paso (USA) metropolis: A model for spatial risk assessment in transnational context. *Applied Geography,* **29(3)**, 448-461.

Colombo, A.F., D. Etkin, and B.W. Karney, 2010: Climate variability and the frequency of extreme temperature events for nine sites across canada: Implications for power usage.

Colten, C., R. Kates, and S. Laska, 2008: Community resilience: Lessons from new orleans and hurricane katrina. *CARRI Research Report,* **3**.

Comfort, L.K., 2006: Cities at risk. *Urban Affairs Review,* **41(4)**, 501.

Comisión Inter-Secretarial de Cambio Climático, 2005: Government of Mexico, Mexico City, pp. 6.

CONAFOR (National Forestry Comission). (2011). Sistema nacional de información forestal. Informes históricos de incendios forestales. (National forest information system. Historical reports of forest fires). http://148.223.105.188:2222/gif/snif_portal/index.php?option=com_content&task=view&id=44&Itemid=54.

CONANP and TNC, 2009: *CONANP and TNC (national commission of natural protected areas and the nature conservancy) programa de manejo integral del fuego, reserva de la biosfera selva el ocote chiapas, méxico 2009-2012. program integrated fire management, biosphere reserve el ocote chiapas, mexico 2009-2012* [CONANP and TNC (ed.)]. www.camafu.org.mx, pp. 1-43.

Conde, C., D. Liverman, M. Flores, R. Ferrer, R. Araujo, E. Betancourt, G. Villarreal, and C. Gay, 1997: Vulnerability of rainfed maize crops in mexico to climate change. *Climate Research,* **9(1-2)**, 17-23.

Confalonieri, U., D. Marinho, and R. Rodriguez, 2009: Public health vulnerability to climate change in brazil. *Clim Res,* **40**, 175-186.

Conlon, K.C., N.B. Rajkovich, J. White-Newsome, L. Larsen, and M. O'Neill S., 2011: Preventing cold-related morbidity and mortality in a changing climate. *Maturitas,* **69(3)**, 197-202.

Conrad, E., 2010: Climate change and infrastructure in the gulf of mexico and caribbean basin: New risks to building blocks of resilience. *Letter of Introduction,* , 63.

Contreras et al., Spatial vulnerability indicators: "Measuring" recovery processes after earthquakes. *Proceedings of the 8th International ISCRAM Conference – Lisbon, Portugal, may 2011,* .

Cooper, D.C. and G. Sehlke, 2011: Sustainability and energy development: Influences of greenhouse gas emission reduction options on water use in energy production. *Environmental Science & Technology, A-J. *accepted 2012*,* .

Cooper, D.C. and G. Sehlke, 2012: Sustainability and energy development: Influences of greenhouse gas emission reduction options on water use in energy production. *Environmental Science & Technology,* .

Costello, C.J., O. Deschênes, and C.D. Kolstad, 2009: **Economic Impacts of Climate Change on California *Agriculture (*****CEC-500-2009-043-D.)** , California Energy Commission, .

Crabbe, P. and M. Robin, 2006: Institutional adaptation of water resource infrastructures to climate change in eastern ontario. *Climatic Change,* **78(1)**, 103-133.

Crabbé, P. and M. Robin, 2004: Adaptation of water resource infrastructure-related institutions to climate change in eastern ontario. *Community-University Reasearch Alliance Report, University of Ottawa, Ottawa, ON,* .

Craine, J.M., A.J. Elmore, K.C. Olson, and D. Tollesons, 2010: Climate change and cattle nutritional stress. *Global Change Biology,* **16**, 2901-2911.

Craun, G.F., M.F. Craun, R.L. Calderon, and M.J. Beach, 2006: Waterborne outbreaks reported in the united states. *Journal of Water and Health,* **04**, 19-19.

Crawford, C., S. Teles da Silva, and K. Morris, 2010: The challenges of climate change regulation for governments on the political left: A comparison of brazilian and united states promises and actions.

CRED, 2012: *EM-DAT: The international disaster data base* [Centre for Research on the Epidemeology of Disasters (ed.)].

Croci, E., S. Melandri, and T. Molteni, 2010: *A Comparative Analysis of Global City Policies in Climate Change Mitigation: London, New York, Milan, Mexico City and Bangkok,* .

Crozier, L. G., R.W. Zabel, and A. Hamlet, 2008: Predicting differential effects of climate change at the population level with life-cycle models of spring chinook salmon *Global Change Biology,* **14(2)**, 236-249.

Crozier, L.G., A.P. Hendry, P.W. Lawson, T.P. Quinn, N.J. Mantua, J. Battin, and R.B. Huey, 2008: Potential responses to climate change in organisms with complex life histories: Evolution and plasticity in pacific salmon. *Evolutionary Applications,* **1**, 252-270.

Cruz-Bello, G.M. and H. Eakin, 2011: Linking multi-temporal analysis and community consultation to evaluate the response to the impact of hurricane stan in coffee areas of chiapas, mexico. *Natural Hazards,* **58**, 103-116.

Cuo, L., D.P. Lettenmaier, M. Alberti, and J.E. Richey, 2009: Effects of a century of land cover and climate change on the hydrology of the puget sound basin. *Hydrological Processes,* **23(6)**, 907-933.

Cupp, O., D. Walker II, and J. Hillison, 2004: Agrobioterrorism in the U.S.: Key security challenge for the 21st century. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice and Science,* **2**, 97-105.

Curriero, F.C., K.S. Heiner, J.M. Samet, S.L. Zeger, L. Strug, and J.A. Patz, 2002: Temperature and mortality in 11 cities of the eastern united states. *American Journal of Epidemiology,* **155(1)**, 80.

Curriero, F.C., J.a. Patz, J.B. Rose, and S. Lele, 2001: The association between extreme precipitation and waterborne disease outbreaks in the united states, 1948-1994. *American Journal of Public Health,* **91(8)**, 1194-9.

Curry, J., M. Jelinek, B. Foskey, A. Suzuki, and P. Webster, 2009: Potential economic impacts of hurricanes in mexico, central america, and the caribbean, 2020–2025. *Sustainable Development Working Paper,* **32**, 18-34.

Curtis, F., 2009: Peak globalization: Climate change, oil depletion and global trade *Ecological Economics,* **69**, 427-434.

Cutter, S.L. and C. Emrich, 2005: Are natural hazards and disaster losses in the US increasing? *EOS, Transactions American Geophysical Union,* **86(41)**, 381.

Cutter, S.L., L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, and J. Webb, 2008: A place-based model for understanding community resilience to natural disasters. *Global Environmental Change,* **18(4)**, 598-606.

Cutter, S.L., B.J. Boruff, and W.L. Shirley, 2003: Social vulnerability to environmental hazards*. *Social Science Quarterly,* **84(2)**, 242-261.

Cynthia Rosenzweig · William D. Solecki · Reginald Blake · Malcolm Bowman· Craig Faris · Vivien Gornitz · Radley Horton · Klaus Jacob · Alice LeBlanc · Robin Leichenko · Megan Linkin · David Major · Megan O’Grady · Lesley Patrick · Edna Sussman · Gary Yohe · Rae Zimmerman, 2011: Developing coastal adaptation to climate change
in the new york city infrastructure-shed:
process, approach, tools, and strategies. *Climatic Change,* **106:93–127**.

da Costa Ferreira, L., F. Barbi, R.D.A. Martins, L.R. Teixeira, and A.M. Urbinatti, 2011: Governing climate change in brazilian coastal cities: Risks and strategies. *Journal of US-China Public Administration,* **8(1)**, 51-65.

da Costa Ferreira, L., R.D.A. Martins, F. Barbi, L. da Costa Ferreira, L.F. de Mello, A.M. Urbinatti, F.O. de Souza, and T.H.N. de Andrade, 2011: Governing climate change in brazilian coastal cities: Risks and strategies. *Journal of US-China Public Administration,* **8(1)**, 51-65.

Dai, A.G., 2011: Drought under global warming: A review. *Wiley Interdisciplinary Reviews: Climate Change,* **2**, 45-65.

Daigger, G., 2009: Urban water and wastewater management in 2050. *Proceedings ASCE World Environmental and Water Resources Congress, Kansas City, MO, 17-21 may 2009,* .

Daley, M.L., J.D. Potter, and W.H. McDowell, 2009: Salinization of urbanizing new hampshire streams and groundwater: Effects of road salt and hydrologic variability. *Journal of the North American Benthological Society, 28 (4), Pp. 929-940,* .

Darnton-Hill, I. and B. Cogill, 2010: Maternal and young child nutrition adversely affected by external shocks such as increasing global food prices. *The Journal of Nutrition,* **140(1)**, 162S-169S.

Daw, T., W.N. Adger, K. Brown, and M.C. Badjeck, 2009: *Climate Change Implications for Fisheries and Aquaculture: Overview of Current Scientific Knowledge. FAO Fisheries and Aquaculture Technical Paper, no. 530.* Climate Change and Capture Fisheries: Potential Impacts, Adaptation and Mitigation, FAO, Rome, Italy, 7-106 pp.

De la Torre, A., P. Fajnzylber, and J. Nash, 2009: *Low carbon, high growth: Latin american responses to climate change: An overview.* World Bank Publications, .

De La Torre, A., P. Fajnzylber, and J. Nash, 2009: *Low-carbon development: Latin american responses to climate change.* World Bank Publications, .

de Leeuw, S., I.F.A. Vis, and S.N. Jonkman, 2009: Logistics aspects of emergency preparedness in flood disaster prevention.

de Loë, R.C., 2011: 2011. Mainstreaming Climate Change in Drinking Water Source Protection in Ontario: Challenges and Opportunities. in *Climate Change Adaptation in Developed Nations: From Theory to Practice*. Eds. J. Ford and L Berrang-Ford. Springer. 439-448. New York: Spring. .

De Sherbinin, A., A. Schiller, and A. Pulsipher, 2007: The vulnerability of global cities to climate hazards. *Environment and Urbanization,* **19(1)**, 39.

DeGaetano, A.T., 2009: Time-dependent changes in extreme-precipitation return-period amounts in the continental united states. *Journal of Applied Meteorology and Climatology,* **48**, 2086-2099.

Degallier, N., C. Favier, C. Menkes, M. Lengaigne, W.M. Ramalho, R. Souza, J. Servain, and J.P. Boulanger, 2010: Toward an early warning system for dengue prevention: Modeling climate impact on dengue transmission. *Climatic Change,* **98(3)**, 581-592.

Degallier, N., C. Favier, C. Menkes, M. Lengaigne, W.M. Ramalho, R. Souza, J. Servain, and J. Boulanger, 2009: Toward an early warning system for dengue prevention: Modeling climate impact on dengue transmission. *Climatic Change,* **98(3-4)**, 581-592.

Delfino, R.J., 2002: Epidemiologic evidence for asthma and exposure to air toxics: Linkages between occupational, indoor, and community air pollution research. *Environmental Health Perspectives,* **110(Suppl 4)**, 573.

Delfino, R.J., S. Brummel, J. Wu, H. Stern, B. Ostro, M. Lipsett, A. Winer, D.H. Street, L. Zhang, T. Tjoa, and D.L. Gillen, 2009: The relationship of respiratory and cardiovascular hospital admissions to the southern california wildfires of 2003. *Occupational and Environmental Medicine,* **66(3)**, 189-97.

Delpla, I., A.-. Jung, E. Baures, M. Clement, and O. and Thomas, 2009: Impacts of climate change on surface water quality in relation to drinking water production. *Environment International,* **35**.

Delpla, I., A.-. Jung, E. Baures, M. Clement, and O. and Thomas, 2009.: Impacts of climate change on surface water quality in relation to drinking water production. *Environment International 35: 1225-1233.,* .

Delucchi, M.A., 2010: Impacts of biofuels on climate change, water use, and land use. *Annals of the New York Academy of Sciences,* **1195(1)**, 28-45.

Delucchi, M.A. and M.Z. Jacobson, 2011: Providing all global energy with wind, water, and solar power, part II: Reliability, system and transmission costs, and policies. *Energy Policy,* **39(3)**, 1170-1190.

Denault, C., R.G. Millar, and B.J. Lence, 2006: Assessment of possible impacts of climate change in an urban catchment. *Journal of the American Water Resources,* .

Diaz, J.D.G., A.I.M. Rivas, J.A.T. Rueda, and M.L.T. Medrano, 2011: Assessing current and potential patterns of 16 forest species driven by climate change scenarios in méxico. *Atmósfera,* **24(1)**, 31-52.

Diez, P.G., G.M.E. Perillo, and M.C. Piccolo, 2009: Vulnerability to sea-level rise on the coast of the buenos aires province.

Diffenbaugh, N.S, M. Ashfaq, and M. Scherer, 2011: Transient regional climate change: Analysis of the summer climate response in a high-resolution, century-scale, ensemble experiment over the continental united states. *Journal of Geophysical Research,* **116**, D24111, doi:10.1029/2011JD016458.

Diffenbaugh, N.S. and F. Giorgi, in review: Climate change hotspots in the CMIP5 global climate model ensemble. *Climatic Change,* .

Diffenbaugh, N.S. and M. Scherer, 2011: Observational and model evidence of global emergence of permanent, unprecedented heat in the 20th and 21st centuries. *Climatic Change,* **107(3-4)**, 615-624.

Diffenbaugh, N.S., M. Scherer, and M. Ashfaq, submitted: Continued global warming intensifies snow-dependent hydrologic extremes in the northern hemisphere. *Nature Climate Change,* .

Diuk-Wasser, M., G. Vourc'h, P. Cislo, A.G. Hoen, F. Melton, S.a. Hamer, M. Rowland, R. Cortinas, G.J. Hickling, J.I. Tsao, A.G. Barbour, U. Kitron, J. Piesman, and D. Fish, 2010: Field and climate-based model for predicting the density of host-seeking nymphal ixodes scapularis , an important vector of tick-borne disease agents in the eastern united states. *Global Ecology and Biogeography,* , 504-514.

Dodman, D., 2009: Blaming cities for climate change? an analysis of urban greenhouse gas emissions inventories. *Environment and Urbanization,* **21(1)**, 185.

Dombeck, M.P., J.E. Williams, and C.A. Wood, 2004: Wildfire policy and public lands: Integrating scientific understandings with social concerns across landscapes. *Conservation Biology,* **18(4)**, 883-889.

Doney, S.C., V.J. Fabry, R.A. Feely, and J.A. Kleypas, 2009: Ocean acidification: The other CO_2 problem *Annual Review of Marine Science,* **1**, 169-192.

Douglas, E., P. Kirshen, C.J. Watson, J. Wiggin, and A. Gontz, 2009: Coastal flooding and environmental justice: Identifying vulnerable communities in boston. In: Proceedings of Papers from the annual meeting of the association of american geographers- 2009, .

Dow, K., R.E. O’Connor, B. Yarnal, G.J. Carbone, and C.L. Jocoy, 2007: Why worry? community water system managers’ perceptions of climate vulnerability. *Global Environmental Change.,* .

Downing, A. and A. Cuerrier, 2011: A synthesis of the impacts of climate change on the first nations and inuit of canada. *Indian Journal of Traditional Knowledge,* **10(1)**, 57-70.

Downing, A. and A. Cuerrier, 2011: A synthesis of the impacts of climate change on the first nations and inuit of canada. *Indian Journal of Traditional Knowledge,* **10**, 57-70.

Doyle, M.W., E.H. Stanley, D.G. Havlick, M.J. Kaiser, G. Steinbach, W.L. Graf, G.E. Galloway, and J.A. Riggsbee, 2008: Aging infrastructure and ecosystem restoration. *Science,* **319(5861)**, 286.

Doyon, B., D. Bélanger, and P. Gosselin, 2008: The potential impact of climate change on annual and seasonal mortality for three cities in quebec, canada. *International Journal of Health Geographics,* **7(1)**, 23.

Doyon, B., D. BÃ©langer, and P. Gosselin, 2008: The potential impact of climate change on annual and seasonal mortality for three cities in QuÃ©bec, canada. *International Journal of Health Geographics,* **7**, 23-23.

Doyon, B., D. BÃ©langer, and P. Gosselin, 2008: The potential impact of climate change on annual and seasonal mortality for three cities in quebec, canada. *International Journal of Health Geographics,* **7**, 23-23.

Drake, B.G., L. Hughes, E.A. Johnson, B.A. Seibel, M.A. Cochrane, V.J. Fabry, D. Rasse, and L. Hannah, 2005: Synergistic effects. In: *Climate change and biodiversity.* [T.E. Lovejoy and L.J. Hannah (ed.)]. Yale University Press, New Haven, CT, pp. 296-316.

D'Souza, R.M., N.G. Becker, G. Hall, and K.B.A. Moodie, 2004: Does ambient temperature affect foodborne disease? *Epidemiology,* **15(1)**, 86-92.

Dumas, C., 2009: Measuring the impacts of climate change on north carolina coastal resources.

Dupuis, A.P. and B.J. Hann, 2009: Warm spring and summer water temperatures in small eutrophic lakes of the canadian prairies: Potential implications for phytoplankton and zooplankton. *Journal of Plankton Research 31(5): 489-502.,* .

Dupuis, A.P. and B.J. Hann, 2009.: Warm spring and summer water temperatures in small eutrophic lakes of the canadian prairies: Potential implications for phytoplankton and zooplankton. *Journal of Plankton Research 31(5): 489-502.,* .

Dvorin, D.J., J.J. Lee, G.a. Belecanech, M.F. Goldstein, and E.H. Dunsky, 2001: A comparative, volumetric survey of airborne pollen in philadelphia, pennsylvania (1991-1997) and cherry hill, new jersey (1995-1997). *Annals of Allergy, Asthma & Immunology : Official Publication of the American College of Allergy, Asthma, & Immunology,* **87(5)**, 394-404.

Eakin, H., 2003: The social vulnerability of irrigated vegetable farming households in central puebla. *The Journal of Environment & Development,* **12(4)**, 414-429.

Eakin, H., 2005: Institutional change, climate risk, and rural vulnerability: Cases from central mexico. *World Development,* **33(11)**, 1923-1938.

Eakin, H., 2006: *Weathering risk in rural mexico: Economic, climatic and institutional change.* University of Arizona Press, Tuscon, USA, .

Eakin, H.C. and A. Patt, 2011: Are adaptation studies effective, and what can enhance their practical impact? *WIREs Climatic Change,* **2**, 141-153.

Eakin, H., 2005: Institutional change, climate risk, and rural vulnerability: Cases from central mexico. *World Development,* **33(11)**, 1923-1938.

Eakin, H. and K. Appendini, 2008: Livelihood change, farming, and managing flood risk in the lerma valley, mexico. *Agriculture and Human Values,* **25(4)**, 555-566.

Eakin, H. and L.A. Bojorquez-Tapia, 2008: Insights into the composition of household vulnerability from multicriteria decision analysis. *Global Environmental Change-Human and Policy Dimensions,* **18(1)**, 112-127.

Eakin, H., A.M. Lerner, and F. Murtinho, 2010: Adaptive capacity in evolving peri-urban spaces: Responses to flood risk in the upper lerma river valley, mexico. *Global Environmental Change,* **20(1)**, 14-22.

Eakin, H. and C. Tucker, 2006: Responding to the coffee crisis: A pilot study of farmers' adaptations in mexico, guatemala and honduras. *The Geographical Journal,* **172(2)**, 156-171.

Eakin, H. and M. Wehbe, 2009: Linking local vulnerability to system sustainability in a resilience framework: Two cases from latin america. *Climatic Change,* .

Eakin, H., M. Wehbe, C. Ávila, G. SANCHEZ, and L. Bojórquez-Tapia, 2007: Social vulnerability of farmers in mexico y argentina. *Climate Change and Vulnerability,* .

Eakin, H.C. and M.B. Wehbe, 2009: Linking local vulnerability to system sustainability in a resilience framework: Two cases from latin america. *Climatic Change,* **93(3)**, 355-377.

Ebi, K.L., J. Balbus, P.L. Kinney, E. Lipp, D. Mills, M. O'Neill S., and M.L. Wilson, 2009: U.S. funding is insufficient to address the human health impacts of and public health responses to climate variability and change. *Environmental Health Perspectives,* **117(6)**, 857-62.

Economic Development Research Group Inc. and Downstream Strategies, 2011: American Society of Civil Engineers, Reston, Virginia, .

Ehrhart, A., 2011: Casualties of climate change. *Scientific American Magazine,* **304(1)**, 64-71.

El Adlouni, S., C. Beaulieu, T.B.M.J. Ouarda, P.L. Gosselin, and A. Saint-Hilaire, 2007: Effects of climate on west nile virus transmission risk used for public health decision-making in quebec. *International Journal of Health Geographics,* **6**, 40-40.

Elsner, M., and A. Hamlet, 2010: Chapter 5, *Macro-Scale Hydrologic Model Implementation,* of Final Report for the Columbia Basin Climate Change Scenarios Project, Hamlet, A., Et Al (Editors), Climate Impacts Group at the University of Washington, .

Elsner, M. and A. Hamlet, 2010: Chapter 5,*Macro-Scale Hydrologic Model Implementation,* in Hydrologic Climate Change Scenarios for the Pacific Northwest Columbia River Basin and Coastal Drainages, Hamlet Et Al (Editors), Climate Impacts Group of the University of Washington, .

Emberlin, J., M. Detandt, R. Gehrig, S. Jaeger, N. Nolard, and A. Rantio-Lehtimäki, 2002: Responses in the start of betula (birch) pollen seasons to recent changes in spring temperatures across europe. *International Journal of Biometeorology,* **46(4)**, 159-170.

Emdad Haque, C., 2000: Risk assessment, emergency preparedness and response to hazards: The case of the 1997 red river valley flood, canada. *Natural Hazards,* **21(2)**, 225-245.

Emelko, M.B., U. Silins, K.D. Bladon, and M. and Stone, 2011: Implications of land disturbance on drinking water treatability in a changing climate: Demonstrating the need for " source water supply and protection" strategies. *Water Research 45(2): 461-472.,* .

Enarson, E., 2001: What women do: Gendered labor in the red river valley flood. *Global Environmental Change Part B: Environmental Hazards,* **3(1)**, 1-18.

Enarson, E. and J. Scanlon, 1999: Gender patterns in flood evacuation: A case study in canada's red river valley. *Applied Behavioral Science Review,* **7(2)**, 103-124.

Endfield, G.H. and I.F. Tejedo, 2006: Decades of drought, years of hunger: Archival investigations of multiple year droughts in late colonial chihuahua. *Climatic Change,* **75**, 391-419.

Engelhaupt, E., 2007: Biofueling water problems, (2007). *Environmental Science and Technology, 41 (22), Pp. 7593-7595.,* .

Engle, N.L. and M.C. Lemos, 2010: Unpacking governance: Building adaptive capacity to climate change of river basins in brazil. *Global Environmental Change,* **20(1)**, 4-13.

Environment Canada, 2011: *Backgrounder: Canada’s ongoing commitment to climate change adaptation* Environment Canada, Ottawa, Canada, pp. 1.

EPA, U.S., 2004: **the *National Water Quality Inventory: Report to Congress* for the 2004 Reporting Cycle – A Profile** , Washington DC, .

Epp, T.Y., C.L. Waldner, and O. Berke, 2009: Predicting geographical human risk of west nile virus--saskatchewan, 2003 and 2007. *Canadian Journal of Public Health.Revue Canadienne De SantÃ© Publique,* **100(5)**, 344-8.

Epstein, P.R., 2001: West nile virus and the climate. *Journal of Urban Health : Bulletin of the New York Academy of Medicine,* **78(2)**, 367-71.

Epstein, P., 2010: The ecology of climate change and infectious diseases: Comment. *Ecology,* **91(3)**, 925-8; discussion 928-9.

Ericksen, P.J., 2008: Conceptualizing food systems for global environmental change research. *Global Environmental Change,* **18(1)**, 234-245.

Eriksen, S., P. Aldunce, C.S. Bahinipati, R.D.A. Martins, J.I. Molefe, C. Nhemachena, K. Obrien, F. Olorunfemi, J. Park, and L. Sygna, 2011: When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Climate and Development,* **3(1)**, 7-20.

Esqueda, G.S., J.E. Ospina-Norena, C. Gay-Garcia, and C. Conde, 2010: **Vulnerability of water resources to climate change scenarios. impacts on the irrigation districts in the guayalejo-tamesí river basin, tamaulipas, méxico**. *Atmósfera,* **24(1)**, 141-155.

Euripidou, E. and V. Murray, 2004: Public health impacts of floods and chemical contamination. *Journal of Public Health,* **26(4)**, 376-383.

FAO, 2012: ***Forests and Climate Change Working Paper 10.***. **Forest Management and Climate Change: A Literature Review.**, Food and Agriculture Organization of the United Nations, Rome, .

Feagin, R.A., D.J. Sherman, and W.E. Grant, 2005: Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats. *Frontiers in Ecology and the Environment,* **3(7)**, 359-364.

Federal Transit Administration, 2008: 2008 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, U.S. Department of Transportation, Washington DC, .

Federation of Canadian Municipalities and ICLEI - Local Governments for Sustainability, 2009: Partners for Climate Protection: Municipal Resources for Adapting to Climate Change, Federation of Canadian Municipalities, Ottawa, Ontario, .

Feng, S.Z., A.B. Krueger, and M. Oppenheimer, 2010: Linkages among climate change, crop yields and mexico-us cross-border migration. *Proceedings of the National Academy of Sciences of the United States of America,* **107(32)**, 14257-14262.

Fernandez, L., J. Karol, and N. Castillo, 2009: Decision support model to risk management and adaptation strategies to climate change in buenos aires coast, argentina. In: Proceedings of IOP conference series: Earth and environmental science, pp. 352010.

Ferreira, S., K. Hamilton, and J.R. Vincent, 2011: Nature, socioeconomics and adaptation to natural disasters: New evidence from floods. *World Bank Policy Research Working Paper no.5725,* .

Few, R., K. Brown, and E.L. Tompkins, 2007: Public participation and climate change adaptation: Avoiding the illusion of inclusion. *Climate Policy,* **7(1)**, 46-59.

Field, C. B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O. F. Canziani, J. P. Paulikof, P.J. Van Der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 617--652 pp.

Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley, 2012: Summary for Policymakers. in: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation Intergovernmental Panel on Climate Change, .

Field, R.V., M. Heimann, E. Jeffrey, P.R.L. Richey, E.D. Schulze, and C.T.A. Chen, 2004: The vulnerability of the carbon cycle in the 21st century: An assessment of carbon-climate-human interactions. *The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World,* **62**, 45.

Findell, K. L., and T. L. Delworth, 2010: Impact of common sea surface temperature anomalies on global drought and pluvial frequency. *Journal of Climate,* **23**, 485-503.

Fischlin, A., G.F. Midgley, J.T. Price, R. Leemans, B. Gopal, C. Turley, M.D.A. Rounsevell, O.P. Dube, J. Tarazona, A.A. Velichko, 2007: Ecosystems, their properties, goods, and services. In: *Climate change 2007: Impacts, adaptation and vulnerability. contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change.* [M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (ed.)]. Cambridge University Press, Cambridge, pp. 211-272.

Flannigan, M.D. and C.E. . Van Wagner, 1990: Climate change and wildfire in canada. *Canadian Journal of Forest Research,* **21(1)**, 66-72.

Flannigan, M.D., K.A. Logan, B.D. Amiro, W.R. Skinner, and B.J. Stocks, 2005: Future area burned in canada. *Climatic Change,* **72**, 1-16.

Fleury, M., D. Charron, J. Holt, O. Allen, and A. Maarouf, 2006: A time series analysis of the relationship of ambient temperature and common bacterial enteric infections in two canadian provinces. *International Journal of Biometeorology,* **50(6)**, 385-391.

Flint, C.G., B. McFarlane, and M. Miller, 2008: Human dimensions of forest disturbance by insects: An international synthesis. *Environmental Management,* **43(6)**, 1174-1186.

Flood, J.F. and L.B. Cahoon, 2011: Risks to coastal wastewater collection systems from sea-level rise and climate change. *Journal of Coastal Research: Volume 27, Issue 4: Pp. 652 – 660.,* .

Flores Verdugo, F.J., P. Moreno-Casasola, G. De La Lanza-Espino, and C. Agraz Hernández, 2010: El manglar, otros humedales costeros y el cambio climático [the mangrove, other coastal wetlands and climate change]. In: *Vulnerabilidad de las zonas costeras mexicanas ante el cambio climático [mexican coastal vulnerability to climate change]*. [A. V. Botello, S. Villanueva, J. Gutiérrez, J. L. Rojas Galaviz (ed.)]. Gobierno del Estado de Tabasco, SEMARNAT-INE, UNAM-ICMyL, Universidad Autónoma de Campeche, Campeche, México, pp. 165-188.

Flory, J.E. and T. Panella, 1994: Long-term water conservation & shortage management practices: Planning that includes demand hardening. *Tabors Caranianis & Associates.*, .

Ford, J.D. and L. Berrang-Ford, 2009: Food security in igloolik, nunavut: An exploratory study. *Polar Record,* **45(234)**, 225-236.

Ford, J.D. and T. Pearce, 2010: What we know, do not know, and need to know about climate change vulnerability in the western canadian arctic: A systematic literature review. *Environmental Research Letters,* **5**, 1-9.

Ford, J.D. ,Pearce, T. , Prno, J. , Duerden, F. , Ford, L.B. , Beaumier, M. , Smith, T., 2010: Perceptions of climate change risks in primary resource use industries: A survey of the canadian mining sector. *Regional Environmental Change,* **10(1)**, 65.

Ford, J.D., Pearce, T., Prno, J., Duerden, F., Ford, L.B. , Smith, T.R. , Beaumier, M., 2011: Canary in a coal mine: Perceptions of climate change risks and response options among canadian mine operations. *Climatic Change,* **109(3-4)**, 399-415.

Ford, J.D., L. Berrang-Ford, and J. Paterson, 2011:
A systematic review of observed climate change
adaptation in developed nations. *Climatic Change,* **106**, 327.

Ford, J.D., T. Pearce, F. Duerden, C. Furgal, and B. Smit, 2010: Climate change policy responses for canada's inuit population: The importance of and opportunities for adaptation. *Global Environmental Change,* **20(1)**, 177-191.

Frank, E., H. Eakin, and D. Carr, 2011: Social identity, perception and motivation in adaptation to climate risk in the coffee sector of chiapas, mexico. *Global Environmental Change,* **21**, 66-76.

Fraser, E.D.G., 2007: Travelling in antique lands: Using past famines to develop an adaptability/resilience framework to identify food systems vulnerable to climate change. *Climatic Change,* **83**, 495-514.

Frei, T. and E. Gassner, 2008: Climate change and its impact on birch pollen quantities and the start of the pollen season an example from switzerland for the period 1969–2006. *International Journal of Biometeorology,* **52(7)**, 667-674.

Freudenburg, W.R., 1992: Addictive economies: Extractive industries and vulnerable localities in a changing world economy. *Rural Sociology,* **57(3)**, 305-332.

Fried, J.S., J.K. Gilless, W.J. Riley, T.J. Moody, C. Simon de Blas, K. Hayhoe, M. Moritz, S. Stephens, and M. Torn, 2008: Predicting the effect of climate change on wildfire behavior and initial attack success. *Climatic Change,* **87**, 251-264.

Fuentes, Y.M. and J.C.V. de Leon, 2010: Guatemala: A review of historic and recent relocation processes provoked by disasters of natural origin. *Environment, Forced Migration and Social Vulnerability,* , 157.

Fünfgeld, H., 2010: Institutional challenges to climate risk management in cities. *Current Opinion in Environmental Sustainability,* .

Furgal, C. and T. Prowse, 2008: Northern Canada *in* from Impacts to Adaptation: Canada in a Changing Climate 2007, Government of Canada, Ottawa, 57-118 pp.

Fussel, H.M., 2007: Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change,* **17(2)**, 155-167.

Füssel, H.M. and R.J.T. Klein, 2006: Climate change vulnerability assessments: An evolution of conceptual thinking. *Climatic Change,* **75(3)**, 301-329.

Galindo, I., S. Castro, and M. Valdés, 2009: Satellite derived solar irradiance over mexico. *Atmósfera,* **4(3)**.

Galindo, I., S. Castro, and M. Valdés, 2009: Satellite derived solar irradiance over mexico. *Atmósfera,* **4(3)**.

Gallivan, F., J. Ang-Olson, and D. Turchetta, 2011: Towards a better state climate action plan: A review and assessment of proposed transportation strategies. In: Proceedings of Transportation research board 90th annual meeting, .

Gallivan, F., K. Bailey, and L. O'Rourke, 2009: Planning for impacts of climate change at US ports. *Transportation Research Record: Journal of the Transportation Research Board,* **2100(-1)**, 15-21.

Gamble, J.L., K.L. Ebi, A.E. Grambsch, F.G. Sussman, and T.J. Wilbanks, 2008: Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems, Washington, DC, .

Garcia, N.O., R.N. Ferreira, and E.M. Latrubesse, 2009: Climate and geomorphologic-related disasters in latin america. *Developments in Earth Surface Processes*, **13**, 1-27.

Gasper, R., A. Blohm, and M. Ruth, 2011: Social and economic impacts of climate change on the urban environment. *Current Opinion in Environmental Sustainability,* .

Gavin, D.G., D.J. Hallett, F. Sheng Hu, K.P. Lertzman, S.J. Prichard, K.J. Brown, J.A. Lynch, P. Bartlein, and D.L. Peterson, 2007: Forest fire and climate change in western north america: Insights from sediment charcoal records. *Frontiers in Ecology and the Environment*, **5(9)**, 499-506.

Gay, C., F. Estrada, C. Conde, H. Eakin, and L. Villers, 2006: Potential impacts of climate change on agriculture: A case of study of coffee production in veracruz, mexico. *Climatic Change,* **79(3-4)**, 259-288.

Gedalof, Z., D.L. Peterson, and N.J. Mantua, 2005: Atmospheric, climatic, and ecological controls on extreme wildfire years in the northwestern united states. *Ecological Applications*, **15(1)**, 154-174.

Gerald, C.A., 2010: *Public Perception of Wildfire Risk and Prescribed Burning in the Wildland/Urban Interface of the Louisiana Florida Parishes,* .

Gilbert, G. and R. McLeman, 2010: Household access to capital and its effects on drought adaptation and migration: A case study of rural alberta in the 1930s. *Population & Environment,* **32**, 3-26.

Githeko, a.K., S.W. Lindsay, U.E. Confalonieri, and J.a. Patz, 2000: Climate change and vector-borne diseases: A regional analysis. *Bulletin of the World Health Organization,* **78(9)**, 1136-47.

Gleick, P., 2010: Roadmap for sustainable water resources in southwestern north america, 21300–21305. *PNAS, December 14, 2010.,* .

Gober, P. and C.W. Kirkwood, 2010: Vulnerability assessment of climate-induced water shortage in phoenix. *Proceedings of the National Academy of Sciences,* **107(50)**, 21295.

Gómez-álvarez, A., Valenzuela-García, J. L., Meza-Figueroa, D., de la O-Villanueva, M., Ramírez-Hernández, J., Almendariz-Tapia, J., 2011: Impact of mining activities on sediments in a semi-arid environment: San pedro river, sonora, mexico *Applied Geochemistry,* **26(12)**, 2101-2112.

Gómez-Mendoza, L. and L. Arriaga, 2007: Modeling the effect of climate change on the distribution of oak and pine species of mexico. *Conservation Biology,* **21(6)**, 1545-1555.

González Martínez, E., 2006: Plan Rector De La Cafeticultura Nacional, Sistema Producto Cafe Nacional, SAGARPA, México, DF, .

Goujon, A. and W. Lutz, 2004: Future human capital: Population projections by level of education. *The End of World Population Growth in the 21st Century.New Challenges for Human Capital Formation and Sustainable Development,* , 121-141.

Greer, A., V. Ng, and D. Fisman, 2008: Climate change and infectious diseases in north america: The road ahead. *Canadian Medical Association Journal,* **178(6)**, 715.

Greer, Amy, Victoria Ng,David Fisman, 2008: Climate change and infectious diseases in north america: The road ahead. *Public Health,* **178(6)**.

Greer, A., V. Ng, and D. Fisman, 2008: Climate change and infectious diseases in north america: The road ahead. *Canadian Medical Association Journal,* **178(6)**, 715-22.

Grimmond, C., T. King, F. Cropley, D. Nowak, and C. Souch, 2002: Local-scale fluxes of carbon dioxide in urban environments: Methodological challenges and results from chicago. *Environmental Pollution,* **116**, S243-S254.

Grineski, S.E. and T.W. Collins, 2008: Exploring patterns of environmental injustice in the global south: Maquiladoras in ciudad juárez, mexico. *Population & Environment*, **29(6)**, 247-270.

Gronlund, C., M. O'Neill, J. Schwartz, D. Brown, and S. Brines, 2009: Heat waves, impervious surfaces, and hospital admissions among the elderly in US cities. *Epidemiology,* **20(6)**, S145.

Gude, P., R. Rasker, and J. van den Noort, 2008: Potential for future development on fire-prone lands. *Journal of Forestry,* **106(4)**, 198-205.

Gurley, K.R. and F.J. Masters, 2011: Post-2004 hurricane field survey of residential building performance. *Natural Hazards Review,* **12(4)**, 177-183.

Gutzler, D.S. and T.O. Robbins, 2011: Climate variability and projected change in the western united states: Regional downscaling and drought statistics. *Climate Dynamics,* **37(5)**, 835-849.

Hales, S., N. de Wet, J. Maindonald, and A. Woodward, 2002: Potential effect of population and climate changes on global distribution of dengue fever: An empirical model. *Lancet,* **360(9336)**, 830-4.

Hall, J.V. and V. Brajer, 2008: The Benefits of Meeting Federal Clean Air Standards in the South Coast and San Joaquin Valley Air Basins, Fullerton, CA, .

Hallegatte, S., V. Przyluski, and A. Vogt-Schilb, 2011: Building world narratives for climate change impact, adaptation and vulnerability analyses. *Nature Climate Change*, **1(3)**, 151-155.

Hallegatte, S., N. Ranger, O. Mestre, P. Dumas, J. Corfee-Morlot, C. Herweijer, and R.M. Wood, 2011: Assessing climate change impacts, sea level rise and storm surge risk in port cities: A case study on copenhagen. *Climatic Change*, **104(1)**, 113-137.

Hamin, E.M. and N. Gurran, 2009: Urban form and climate change: Balancing adaptation and mitigation in the US and australia. *Habitat International*, **33(3)**, 238-245.

Hamlet, A.F., 2011: Assessing water resources adaptive capacity to climate change impacts in the pacific northwest region of north america. *Hydrology and Earth System Sciences 15(5): 1427-1443.*, .

Hamlet, A., S.Y. Lee, K. Mickelson, and M. Elsner, 2010: Effects of projected climate change on energy supply and demand in the pacific northwest and washington state. *Climatic Change, 102, 103-128.*, .

Hammer, R.B., S.I. Stewart, and V.C. Radeloff, 2009: Demographic trends, the wildland-urban interface, and wildfire management. *Society and Natural Resources*, **22**, 777-782.

Handmer, J., Y. Honda, Z.W. Kundzewicz, N. Arnell, G. Benito, J. Hatfield, I.F. Mohamed, P. Peduzzi, S. Wu, B. Sherstyukov, K. Takahashi, and Z. Yan, 2012: *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC).* Changes in Impacts of Climate Extremes: Human Systems and Ecosystems. in: Managing the
Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Cambridge University Press, Cambridge, UK, and New York, NY, USA, 231-290 pp.

Hanna, E.G., T. Kjellstrom, C. Bennett, and K. Dear, 2011:
Climate change and rising heat: Population health implications for working people in australia. *Asia-Pacific Journal of Public Health,* **23(2 SUPPL.)**, 14S-26S.

Hanson, S., R. Nicholls, N. Ranger, S. Hallegatte, J. Corfee-Morlot, C. Herweijer, and J. Chateau, 2011: A global ranking of port cities with high exposure to climate extremes. *Climatic Change,* , 1-23.

Hardess, L., A. Karst, M. M'Lot, S. Morgan, S. Wolfe, R. Matthews, and R. Sydneysmith, 2011: Climate Change and Adaptive Capacity in Aboriginal Communities South of 60 Assessment Report, Centre for Indigenous Environmental Resources, Winnipeg, Manitoba, .

Hardoy, J. and G. Pandiella, 2009: Urban poverty and vulnerability to climate change in latin america. *Environment and Urbanization,* **21(1)**, 203.

Hardoy, J. and P. Romero Lankao, 2011: Latin american cities and climate change: Challenges and options to mitigation and adaptation responses. *Current Opinion in Environmental Sustainability,* .

Hare, S. R. and R.C. Francis, 1995: Climate change and salmon production in the northeast pacific ocean. In: *Ocean climate and northern fish populations.* [R.J. Beamish (ed.)]. Canadian Special Publication of Fisheries and Aquatic Sciences, Canada, pp. 357-372.

Harlan, S.L., A.J. Brazel, G.D. Jenerette, N.S. Jones, L. Larsen, L. Prashad, and W.L. Stefanov, 2008: In the shade of affluence: The inequitable distribution of the urban heat island. *Research in Social Problems and Public Policy,* **15**, 173-202.

Harlan, S.L., A.J. Brazel, L. Prashad, W.L. Stefanov, and L. Larsen, 2006: Neighborhood microclimates and vulnerability to heat stress. *Social Science & Medicine,* **63(11)**, 2847-2863.

Harlan, S.L. and D.M. Ruddell, 2011: Climate change and health in cities: Impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. *Current Opinion in Environmental Sustainability,* .

Harper, A., A. Shattuck, E. Holt-Gimenez, A. Alkon, and F. Lambrick, 2009: Food Policy Councils: Lessons Learned, Food First/Institute for Food and Development Policy. .

Harper, S.L., V.L. Edge, C. Schuster-Wallace, O. Berke, and S.a. McEwen, 2011: Weather, water quality and infectious gastrointestinal illness in two inuit communities in nunatsiavut, canada: Potential implications for climate change. *EcoHealth,* **8(1)**, 93-108.

Hatfield, J.R., K.J. Boote, B.A. Kimball, D.W. Wolfe, D.R. Ort, R.C. Izaurralde, and G.L. Hahn, 2008: ***the Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States.*** *Synthesis and Assessment Product 4.3.* Agriculture, U.S.Climate Change Science Program, Washington, DC, USA, 21-74 pp.

Hattis, D., Y. Ogneva-Himmelberger, and S. Ratick, 2012: The spatial variability of heat-related mortality in massachusetts. *Applied Geography,* **33**, 45-52.

Hausermann, H. and H. Eakin, 2008: Producing 'viable' landscapes and livelihoods in central veracruz, mexico: Institutional and producer responses to the coffee commodity crisis. *Journal of Latin American Geography,* **7(1)**, 109-131.

Hayhoe, K., D. Cavan, C. Field, P. Frumhoff, E. Maurer, M.N. Miller, S. Moser, S. Schneider, K.N. Cahill, E. Cleland, L. Dale, and J. Verville, 2004: **Emissions pathways, climate change and impacts on california**. *PNAS,* **101**, 12422-12427.

Hayhoe, K., S. Sheridan, L. Kalkstein, and S. Greene, 2010: Climate change, heat waves, and mortality projections for chicago. *Journal of Great Lakes Research,* **36, Supplement 2(0)**, 65-73.

Hayhoe, K., S. Sheridan, L. Kalkstein, and S. Greene, 2010: Climate change, heat waves, and mortality projections for chicago. *Journal of Great Lakes Research,* **36**, 65-73.

Heap, N., 2007: Hot Properties: How Global Warming could Transform B.C.'s Real Estate Sector, David Suzuki Foundation, Vancouver, .

Heejun Chang,∗ Martin Lafrenz,∗ Il-Won Jung,∗ Miguel Figliozzi,† Deena Platman,‡ and Cindy Pederson‡, 2010: Potential impacts of climate change on flood-induced travel disruptions: A case study of portland, oregon, USA. *Potential Impacts of Climate Change on Flood-Induced Travel Disruptions: A Case Study of Portland, Oregon, USA, Annals of the Association of American Geographers,* **100:4, 938-952**.

Heemann, R., J.M.M. Ketzer, G. Hiromoto, and A. Scislewski, 2011: Assessment of the geological disposal of carbon dioxide and radioactive waste in brazil, and some comparative aspects of their disposal in argentina. *Geological Disposal of Carbon Dioxide and Radioactive Waste: A Comparative Assessment,* , 589-611.

Hegglin, E. and C. Huggel, 2008: An integrated assessment of vulnerability to glacial hazards. *Mountain Research and Development,* **28(3)**, 299-309.

Hejazi, M.I. and M. Markus, 2009: Impacts of urbanization and climate variability on floods in northeastern illinois. . *Journal of Hydrologic Engineering, 14(6), 606-616,* .

HELLEBRANDT, D. and L. HELLEBRANDT, 2010: Representations in the brazilian media of the impacts of climate change in the coastal zone. *Pan-American Journal of Aquatic Sciences,* **5(2)**, 126-137.

Henderson, S.B., M. Brauer, Y.C. Macnab, and S.M. Kennedy, 2011: Three measures of forest fire smoke exposure and their associations with respiratory and cardiovascular health outcomes in a population-based cohort. *Environmental Health Perspectives,* **119(9)**, 1266-71.

Hernandez, A., B. Dominguez, P. Cervantes, S. Munoz-Melgarejo, S. Salazar-Lizan, and A. Tejeda-Martinez, 2011: **Temperature-humidity index (*THI*) 1917-2008 and future scenarios of livestock comfort in veracruz, méxico**. *Atmósfera,* **24(1)**, 89-102.

Hernández, L., H. Reyes-Bonilla, and E.F. Balart, 2010: Efecto del blanqueamiento del coral por baja temperatura en los crustáceos decápodos asociados a arrecifes del suroeste del golfo de california. *Revista Mexicana De Biodiversidad,* **81**, S113-S119.

Hertel, T.W., M.B. Burke, and D.B. Lobell, 2010: *GTAP Working Paper no. 59. the Poverty Implications of Climate-Induced Crop Yield Changes by 2030,* Purdue/Stanford University, Global Trade Analysis Project, .

Heyerdahl, E. K., D. McKenzie, L. D. Daniels, A. E. Hessl, J. S. Littell, N. J. Mantua., 2008: **Climate drivers of regionally synchronous fires in the inland northwest (1651–1900)**. *International Journal of Wildland Fire,* **17(1)**, 40-49.

Hogg, E. H. and P. Y. Bernier, 2005: Climate change impacts on drought-prone forest in western canada. *The Forestry Chronicle,* **81(5)**, 675-682.

Hogg, E. H., J.P. Brandt, and B. Kochtubajda, 2002: Growth and dieback of aspen forest in northwestern alberta, canada, in relation to climate and insects. *Canadian Journal of Forest Research,* **32(5)**, 823-832.

Hogg, E.H. and P.Y. Bernier, 2005: Climate change impacts on drought-prone forests in western canada. *The Forestry Chronicle,* **81(5)**, 675-682.

Hogg, E.H.T.e.d., J.P. Brandt, and M. Michaelian, 2008: Impacts of a regional drought on the productivity, dieback, and biomass of western canadian aspen forests. *Canadian Journal of Forest Research,* **38(6)**, 1373-1384.

Hogrefe, C., 2004: Simulating changes in regional air pollution over the eastern united states due to changes in global and regional climate and emissions. *Journal of Geophysical Research,* **109**, 1-13.

Hogrefe, C., 2004: Simulating changes in regional air pollution over the eastern united states due to changes in global and regional climate and emissions. *Journal of Geophysical Research,* **109**, 1-13.

Hogrefe, C., J. Biswas, B. Lynn, K. Civerolo, J.-. Ku, J. Rosenthal, C. Rosenzweig, R. Goldberg, and P.L. Kinney, 2004: Simulating regional-scale ozone climatology over the eastern united states: Model evaluation results. *Atmospheric Environment,* **38(17)**, 2627-2638.

Hogrefe, C., J. Biswas, B. Lynn, K. Civerolo, J.-. Ku, J. Rosenthal, C. Rosenzweig, R. Goldberg, and P.L. Kinney, 2004: Simulating regional-scale ozone climatology over the eastern united states: Model evaluation results. *Atmospheric Environment,* **38(17)**, 2627-2638.

Holden, Z.A., P. Morgan, M.A. Crimmins, R.K. Steinhorst, and A.M. Smith, 2007: Fire season precipitation variability influences fire extent and severity in a large southwestern wilderness area, united states. *Geophysical Research Letters,* **34(L16708)**.

Holloway, T., S.N. Spak, D. Barker, M. Bretl, C. Moberg, K. Hayhoe, J. Van Dorn, and D. Wuebbles, 2008: Change in ozone air pollution over chicago associated with global climate change. *Journal of Geophysical Research,* **113**, 1-14.

Holloway, T., S.N. Spak, D. Barker, M. Bretl, C. Moberg, K. Hayhoe, J. Van Dorn, and D. Wuebbles, 2008: Change in ozone air pollution over chicago associated with global climate change. *Journal of Geophysical Research,* **113**, 1-14.

Holmes, J., 2010: The forestry industry. In: *What do we know? what do we need to know? the state of canadian research on work, employment and climate change.* [Lipsig-Mummé , C. (ed.)]. Work in a Warming World Research Programme, York University, Toronto, pp. 149-167.

Holtz-Giménez, E., 2002: Measuring farmers' agroecological resistance after hurricane mitch in nicaragua: A case study in participatory, sustainable land management impact monitoring. *Agriculture, Ecosystems and Environment,* **93**, 87-105.

Homer-Dixon, T.F., 1991: On the threshold: Environmental changes as causes of acute conflict. *International Security,* **16(2)**, 76-116.

Hori, M. E., D. Nohara, and H. L. Tanaka, 2007: Influence of arctic oscillation towards the northern hemisphere surface temperature variability under the global warming scenario. *Journal of the Meteorological Society of Japan,* **85**, 847859.

Huang, G., W. Zhou, and M. Cadenasso, 2011: Is everyone hot in the city? spatial pattern of land surface temperatures, land cover and neighborhood socioeconomic characteristics in baltimore, MD. *Journal of Environmental Management, .*

Hunt, A. and P. Watkiss, 2007: Literature review on climate change impacts on urban city centers: Initial findings. *France: OECD, .*

Hunter, L.M., S. Murray, and F. Riosmena, 2011: The environmental dimensions of emigration from rural mexico.

Hurd, B. and J. Coonrod, 2012: **Hydro-economic consequences of climate change in the upper rio grande, in press,** . *Climate Research, 2012.,* .

Hurteau, M.D. and M. North, 2010: Carbon recovery rates following different wildfire risk mitigation treatments. *Forest Ecology and Management,* **260**, 930-937.

Hurteau, M.D., M.T. Stoddard, and P.Z. Fulé, 2011: The carbon costs of mitigating high-severity wildfire in southwestern ponderosa pine. *Global Change Biology,* **17**, 1516-1521.

Hystad, P.W. and P.C. Keller, 2006: Disaster management: Kelowna tourism industry's preparedness, impact and response to a 2003 major forest fire. *Journal of Hospitality and Tourism Management,* **13(1)**, 44-58.

Hystad, P.W. and P.C. Keller, 2008: Towards a destination tourism disaster management framework: Long-term lessons from a forest fire disaster. *Tourism and Management,* **29**, 151-162.

Ibarraran, M.E., E.L. Malone, and A.L. Brenkert, 2010: Climate change vulnerability and resilience: Current status and trends for mexico. *Environment, Development and Sustainability,* **12(3)**, 365-388.

ICES (The International Council for the Exploration of the Sea), 2011: Report of the Study Group on Designing Marine Protected Area Networks in a Changing Climate (SGMPAN), 15-19 November 2010, Woods Hole, Massachusetts, USA ICES CM 2011/SSGSUE:01, Copenhagen, Denmark, 155 pp.

ICLEI Local Governments for Sustainability, 2011: ICLEI's Adaptation Initiative: Adaptation Initiative Second Cohort, ICLEI.

Institute for Business and Home Safety, 2012: Fortified for Safer Living: Builders' Guide, IBHS, Tampa, Florida, .

Instituto Nacional de Ecologia, 2012: *Avances de los programas estatales de acción ante el cambio climático*
Instituto Nacional de Ecologia, Mexico City, Instituto Nacional de Ecología, 2009:
México Cuarta Comunicación Nacional
Ante La Convención Marco

De Las Naciones Unidas Sobre El Cambio Climático, Secretaría de Medio Ambiente y Recursos Naturales, Cuidad Mexico, .

Instituto Nacional de Ecología, 2009: México Cuarta Comunicación Nacional Ante La Convención Marco De Las Naciones Unidas Sobre El Cambio Climático, Secretaría de Medio Ambiente y Recursos Naturales, Mexico City, .

Insurance Information Institute, 2010: The Insurance Fact Book 2010, Insurance Information Institute, .

Insurance Information Institute, 2011: Insurance Fact Book 2011, .

Intersecretarial Commission on Climate Change, 2007: National Strategy on Climate Change: Mexico, Government of Mexico, Mexico City, .

Ionescu, C., R.J.T. Klein, J. Hinkel, K. Kavi Kumar, and R. Klein, 2009: Towards a formal framework of vulnerability to climate change. *Environmental Modeling and Assessment*, **14(1)**, 1-16.

IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge U.K. and New York, USA, .

IPCC [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)], 2012: Summary for Policymakers. in: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA, 1-19 pp.

Ivers, L.C. and E.T. Ryan, 2006: Infectious diseases of severe weather-related and flood-related natural disasters. *Current Opinion in Infectious Diseases*, **19(5)**, 408.

Jaakkola, J.J.K., B.F. Hwang, and N. Jaakkola, 2005: Home dampness and molds, parental atopy, and asthma in childhood: A six-year population-based cohort study. *Environmental Health Perspectives*, **113(3)**, 357.

Jack, D.W. and P.L. Kinney, 2010: Health co-benefits of climate mitigation in urban areas. *Current Opinion in Environmental Sustainability*, **2(3)**, 172-177.

Jack, D.W. and P.L. Kinney, 2010: Health co-benefits of climate mitigation in urban areas. *Current Opinion in Environmental Sustainability*, **2(3)**, 172-177.

Jackson, L., F. Santos-Martin, A. Hollander, W. Horwath, R. Howitt, J. Kramer, A. O'Geen, B. Orlove, J. Six, and S. Sokolow, 2009: *Potential for Adaptation to Climate Change in an Agricultural Landscape in the Central Valley of California*, .

Jacob, C., T. McDaniels, and S. Hinch, 2010: Indigenous culture and adaptation to climate change: Sockeye salmon and the St'át'imc people. *Mitigation and Adaptation Startegies for Global Change*, **15**, 859-876.

Jacob, D.J. and D.A. Winner, 2009: Effect of climate change on air quality. *Atmospheric Environment*, **43(1)**, 51-63.

Jacob, D. and D. Winner, 2009: Effect of climate change on air quality. *Atmospheric Environment*, **43(1)**, 51-63.

Jacob, D. and D. Winner, 2009: Effect of climate change on air quality. *Atmospheric Environment*, **43(1)**, 51-63.

Jacobson, M.Z. and M.A. Delucchi, 2011: Providing all global energy with wind, water, and solar power, part I: Technologies, energy resources, quantities and areas of infrastructure, and materials. *Energy Policy*, **39(3)**, 1154-1169.

Jacques, L., C. De Vit, and F. Gagnon-Lebrun, 2010: Status of Climate Change Adaptation in Canada's Agricultural Sector, Government of Canada Policy Research Initiative, .

Jaffe, D., D. Chand, W. Hafner, A. Westerling, and D. Spracklen, 2008: Influence of fires on O3 concentrations in the western U.S. *Environmental Science & Technology*, **42(16)**, 5885-91.

Janetos, A., L. Hansen, D. Inouye, B.P. Kelly, L. Meyerson, W. Peterson, and R. Shaw, 2008: ***the Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States.*** *Synthesis and Assessment Product 4.3.* Biodiversity, U.S. Climate Change Science Program, Washington, DC, 21-74 pp.

Jenkins, E.J., J.M. Schurer, and K.M. Gesy, 2011: Old problems on a new playing field: Helminth zoonoses transmitted among dogs, wildlife, and people in a changing northern climate. *Veterinary Parasitology*, **182(1)**, 54-69.

JimÃ©nez-MoleÃ³n, ,M.C. and GÃ³mez-Albores M.A., 2011: Waterborne diseases in the state of mexico, mexico (2000-2005). *Journal of Water and Health*, **9(1)**, 200-7.

Johansson, M.a., D.a.T. Cummings, and G.E. Glass, 2009: Multiyear climate variability and dengue--el NiÃ±o southern oscillation, weather, and dengue incidence in puerto rico, mexico, and thailand: A longitudinal data analysis. *PLoS Medicine,* **6(11)**, e1000168-e1000168.

Johnson, D.P., J.S. Wilson, and G.C. Luber, 2009: Socioeconomic indicators of heat-related health risk supplemented with remotely sensed data. *International Journal of Health Geographics,* **8(1)**, 57.

Johnston, M., T. Williamson, A. Munson, A.Ogden, M. Moroni, R. Parsons, D. Price, and J. Stadt, 2010: Climate Change and Forest Management in Canada: Impacts, Adaptive Capacity and Adaptation Options. A State of Knowledge Report. Sustainable Forest Management Network, , Edmonton, Alberta, 16-35 pp.

Johnston, M., T. Williamson, E. Wheaton, V. Wittrock, H. Nelson, H. Hesseln, L. Vandamme, J. Pittman, and M. Lebel, 2008: *Climate Change Impacts and Adaptation Program Project A1383.* Limited Report: Climate Change Adaptive Capacity of Forestry Stakeholders in the Boreal Plains Ecozone, Saskatchewan Research Council, Saskatoon, SK, .

Jones, G.V., M.A. White, O.R. Cooper, and K. Storchmann, 2005: Climate change and global wine quality. *Climatic Change,* **73**, 319-343.

Jones, P., D. Comfort, and D. Hillier, 2008: Moving towards sustainable food retailing? *International Journal of Retail and Distribution Management,* **36**, 995-1001.

Jones, S., 2010:
Dawson climate change adaptation project:
final project report
The Northern Climate Exchange, Dawson City, Yukon, pp. 14-5.

Jongejan, R.B., S.N. Jonkman, T. Aven, and B.J.M. Ale, 2011: Propositions for using risk acceptance criteria. *International Journal of Business Continuity and Risk Management,* **2(1)**, 79-90.

Jonkman, S.N., B. Maaskant, E. Boyd, and M.L. Levitan, 2009: Loss of life caused by the flooding of new orleans after hurricane katrina: Analysis of the relationship between flood characteristics and mortality. *Risk Analysis,* **29(5)**, 676-698.

Jonkman, S., M. Kok, M. Van Ledden, and J. Vrijling, 2009: Risk - based design of flood defence systems: A preliminary analysis of the optimal protection level for the new orleans metropolitan area. *Journal of Flood Risk Management,* **2(3)**, 170-181.

Jonkman, S., A. Lentz, and J. Vrijling, 2010: A general approach for the estimation of loss of life due to natural and technological disasters. *Reliability Engineering & System Safety,* .

Joseph, C. and A. Krishnaswamy, 2010: Factors of resiliency for forest communities in transition in british columbia. *British Journal of Ecosystems and Management,* **10(3)**, 127-144.

Juarez, B. and C. Gonzalez, 2010: Food Security and Nutrition in Mexico, U. S. Department of Agriculture, Foreign Agriculture Service, USA, .

Jury, M.R., 2008: Climate influence on dengue epidemics in puerto rico. *International Journal of Environmental Health Research,* **18(5)**, 323-34.

KÃ¼nzli, N., E. Avol, J. Wu, W.J. Gauderman, E. Rappaport, J. Millstein, J. Bennion, R. McConnell, F.D. Gilliland, K. Berhane, F. Lurmann, A. Winer, and J.M. Peters, 2006: Health effects of the 2003 southern california wildfires on children. *American Journal of Respiratory and Critical Care Medicine,* **174(11)**, 1221-8.

Kalkstein, A.J. and S.C. Sheridan, 2007: The social impacts of the heat–health watch/warning system in phoenix, arizona: Assessing the perceived risk and response of the public. *International Journal of Biometeorology,* **52(1)**, 43-55.

Karl, T.R., G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray, 2008: *Synthesis and Assessment Product 3.3: Report by the US Climate Change Science Program and the Subcommittee on Global Change Research.* Weather and Climate Extremes in a Changing Climate: Regions of Focus: North America, Hawaii, Caribbean and US Pacific Islands, Washington DC, .

Karl, T.R., J.M. Melillo, and T.C. Peterson, 2009: *Global climate change impacts in the united states.* Cambridge Univ Pr, .

Karpechko, A.Y., 2010: Uncertainties in future climate attributable to uncertainties in future northern annular mode trend. *Geophysical Research Letters,* **37**, L20702, doi:10.1029/2010GL044717.

Keel, B.G. (ed.), 2007: *Assisted Migration as a Conservation Strategy for Rapid Climatic Change: Investigating Extended Photoperiod and Mycobiont Distribution for Habenaria Repens Nuttall (Orchidaceae) as a Case Study.* 160 p pp.

Keeley, J.E., 2004: Impact of antecedent climate on fire regimes in coastal california. *International Journal of Wildland Fire,* **13**, 173-182.

Keeley, J. E. and P. H. Zedler, 2009: Large, high-intensity fire events in southern california shrublands: Debunking the fine-grain age patch model. *Ecological Applications,* **19(1)**, 64-94.

Keim, M.E., 2008: Building human resilience: The role of public health preparedness and response as an adaptation to climate change. *American Journal of Preventive Medicine,* **35(5)**, 508-516.

Kelly, G., 2010: Built to a new code. *Canadian Underwriter,* **August 2010(8)**, 48-50.

Kelly, A.E. and M.L. Goulden, 2008: Rapid shifts in plant distribution with recent climate change. *Proceedings of the National Academy of Sciences,* **105(33)**, 11823-11826.

Kemp, A., B.P. Horton, S.J. Culver, D.R. Corbett, O. Van De Plassche, and R. Edwards, 2008: Early onset of accelerated relative sea-level rise in north carolina, USA. *Geological Society of America Annual Meeting,* **Abstract No. 148597 (October)**.

Kenny, J.F., N.L. Barber, S.S. Hutson, K.S. Linsey, J.K. Lovelace, and M.A. Maupin, 2009: Estimated use of water in the united states in 2005. *U.S. Geological Survey Circular 1344, 52 Pp.,* .

Kenny, J.F., N.L. Barber, S.S. Hutson, K.S. Linsey, J.K. Lovelace, and M.A. Maupin, 2009: Estimated use of Water in the United States in 2005. U.S. Geological Survey Circular 1344, 52 Pp. .

Kenter, P., 2010: Climate change adaptation missing. *Daily Commercial News and Construction Record,* **83(97)**.

Kestens, Y., A. Brand, M. Fournier, S. Goudreau, T. Kosatsky, M. Maloley, and A. Smargiassi, 2011: Modelling the variation of land surface temperature as determinant of risk of heat-related health events. *International Journal of Health Geographics,* **10(1)**, 7-7.

Kiely, T., D. Donaldson, and A. Grube, 2005: Pesticides Industry Sales and Usage: 2000 and 2001 Market Estimates, U.S Environmental Protection Agency, Washington, DC, USA, .

Kinney, P.L., 2012: Health: A new measure of health effects. *Nature Climate Change,* **2(4)**, 233-234.

Kinney, P., M. Oneill, M. Bell, and J. Schwartz, 2008: Approaches for estimating effects of climate change on heat-related deaths: Challenges and opportunities. *Environmental Science & Policy,* **11(1)**, 87-96.

Kinney, P.L., 2008: Climate change, air quality, and human health. *American Journal of Preventive Medicine,* **35(5)**, 459-67.

Kinney, P.L., 2008: Climate change, air quality, and human health. *American Journal of Preventive Medicine,* **35(5)**, 459-67.

Kinney, P.L., 2008: Climate change, air quality, and human health. *American Journal of Preventive Medicine,* **35(5)**, 459-67.

Kirchner, J. W., Austin, C. M., Myers, A., & Whyte, D. C., 2011: Quantifying remediation effectiveness under variable external forcing using contaminant rating curves. *Environmental Science and Technology,* **45(18)**, 7874-7881.

Kirilenko, A.P. and R.A. Sedjo, 2007: Climate change impacts on forestry. *Proceedings of the National Academy of Sciences,* **104(50)**, 19697-19702.

Kirshen, P., K. Knee, and M. Ruth, 2008: Climate change and coastal flooding in metro boston: Impacts and adaptation strategies. *Climatic Change,* **90(4)**, 453-473.

Kirshen, P., M. Ruth, and W. Anderson, 2006: **Climate's long-term impacts on urban infrastructures and services: The case of metro boston, chapter 7 of ruth, M., donaghy, K., and kirshen, P.H., (eds.)** . *Climate Change and Variability: Local Impacts and Responses, Edward Elgar Publishers, Cheltenham, England.,* .

Kirshen, P., M. Ruth, and W. Anderson, 2008: Interdependencies of urban climate change impacts and adaptation strategies: A case study of metropolitan boston USA. *Climatic Change,* **86(1)**, 105-122.

Kirshen, P., R. Vogel, and K. Strzepek, 2011: Guidance tools for planning and management of urban drainage under a changing climate. *Final Report to NOAA SARP Program, Grant NA07OAR4310373, Silver Spring MD, August 31, 2011.,* .

Kirshen, P., C. Watson, E. Douglas, A. Gontz, J. Lee, and Y. Tian, 2008: Coastal flooding in the northeastern united states due to climate change. *Mitigation and Adaptation Strategies for Global Change,* **13(5)**, 437-451.

Kitzberger, T., P.M. Brown, E.K. Heyerdahl, T.W. Swetnam, and T.T. Veblen, 2007: Contingent pacific-atlantic ocean influence on multicentury wildfire synchrony over western north america. *Proceedings of the National Academy of Sciences of the United States of America,* **104(2)**, 543-548.

Kjellstrom, T. and J. Crowe, 2011:
Climate change, workplace heat exposure, and occupational health and productivity in central america. *International Journal of Occupational and Environmental Health,* **17(3)**, 270-281.

Kjellstrom, T., R.S. Kovats, S.J. Lloyd, T. Holt, and R.S.J. Tol, 2009: The direct impact of climate change on regional labor productivity. *Archives of Environmental and Occupational Health,* **64(4)**, 217-227.

Klinenberg, E., 2003: *Heat wave: A social autopsy of disaster in chicago.* University of Chicago Press, .

Knowlton, K., B. Lynn, R.A. Goldberg, C. Rosenzweig, C. Hogrefe, J.K. Rosenthal, and P.L. Kinney, 2007: Projecting heat-related mortality impacts under a changing climate in the new york city region. *American Journal of Public Health,* **97(11)**, 2028.

Knowlton, K., B. Lynn, R.a. Goldberg, C. Rosenzweig, C. Hogrefe, J.K. Rosenthal, and P.L. Kinney, 2007: Projecting heat-related mortality impacts under a changing climate in the new york city region. *American Journal of Public Health,* **97(11)**, 2028-34.

Knowlton, K., B. Lynn, R.a. Goldberg, C. Rosenzweig, C. Hogrefe, J.K. Rosenthal, and P.L. Kinney, 2007: Projecting heat-related mortality impacts under a changing climate in the new york city region. *American Journal of Public Health,* **97(11)**, 2028-34.

Knowlton, K., J.E. Rosenthal, C. Hogrefe, B. Lynn, S. Gaffin, R. Goldberg, C. Rosenzweig, K. Civerolo, J. Ku, and P.L. Kinney, 2004: Assessing ozone-related health impacts under a changing climate. *Environmental Health Perspectives,* **112(15)**, 1557-1563.

Kolden, C.A. and T.J. Brown, 2010: Beyond wildfire: Perspectives of climate, managed fire, and policy in the USA. *International Journal of Wildland Fire,* **19**, 364-373.

Kolivras, K., 2010: Changes in dengue risk potential in hawaii, USA, due to climate variability and change. *Climate Research,* **42(1)**, 1-11.

Kousky, C. and S.H. Schneider, 2003: Global climate policy: Will cities lead the way? *Climate Policy,* **3(4)**, 359-372.

Kovacs, J. M., J. Malczewski, and F. Flores-Verdugo, 2004: Examining local ecological knowledge of hurricane impacts in a mangrove forest using an analytical hierarchy process (AHP) approach. *Journal of Coastal Research,* **20(3)**, 792-800.

Kovacs, P., 2005: Promoting resilient homes. *Canadian Underwriter,* **May 2005**, 36-40.

Kovats, R.S., S.J. Edwards, S. Hajat, B.G. Armstrong, K.L. Ebi, and B. Menne, 2004: The effect of temperature on food poisoning: A time-series analysis of *salmonellosis* in ten european countries. *Epidemiology and Infection,* **132(03)**, 443-453.

Krishnamurthy, P.K., J.B. Fisher, and C. Johnson, 2011: Mainstreaming local perceptions of hurricane risk into policymaking: A case study of community GIS in mexico. *Global Environmental Change,* **21**, 143-153.

Krupnik, I. and D. Jolly, 2002: The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. A.R.C.o.t.U. States, Fairbanks, Alaska, .

Kuchcik, M., 2004: Weather and transportation in canada, edited by jean andrey and christopher knapper, department of geography publication series, university of waterloo, 2003, 289 pp. *GEOGRAPHIA POLONICA,* **77(1)**, 97-99.

Kulshreshtha, S., 2011: Climate change, prairie agriculture, and prairie economy: The new normal *Canadian Journal of Agricultural Economics,* **59**, 19-44.

Kundzewicz, Z., L. Mata, N.W. Arnell, P. Döll, B. Jimenez, K. Miller, T. Oki, Z. Sen, and I. Shiklomanov, 2008: The implications of projected climate change for freshwater resources and their management. *Hydrological Sciences Journal,* **53(1)**, 3-10.

Kunkel, K.E., K.E. Bromirski, H.E. Brooks, T. Cavazos, A.V. Douglas, D.R. Easterling, K.A. Emanuel, P.Y. Groisman, G.J. Holland, T.R. Knutson, J.P. Kossin, P.D. Komar, P.D. Levinson, and R.L. Smith, 2008: Observed Changes in Weather and Climate Extremes in Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Washington, DC, .

Kunkel, K.E., P.D. Bromirski, H.E. Brooks, T. Cavazos, A.V. Douglas, D.R. Easterling, K.A. Emanuel, P.Y. Groisman, G.J. Holland, T.R. Knutson, J.P. Kossin, P.D. Komar, D.H. Levinson, and R.L. Smith, 2008: Observed Changes in Weather and Climate Extremes in Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands, U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Washington, DC, .

Kunkel, K.E., P.D. Bromirski, H.E. Brooks, T. Cavazos, A.V. Douglas, D.R. Easterling, K.A. Emanuel, P.Ya. Groisman, G.J. Holland, T.R. Knutson, J.P. Kossin, P.D. Komar, D.H. Levinson, and R.L. Smith, 2008: Observed changes in weather and climate extremes. In: *Weather and climate extremes in a changing climate.*

regions of focus: North america, hawaii, caribbean, and U.S. pacific islands. A report by the U.S. climate change science program and the subcommittee on global change research. [T.R. Karl, G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and and W.L. Murray(eds.)]. U.S. Climate Change Science Program, Washington, DC, pp. 35-80.

Kunkel, K.E., H.-. Huang, X.-. Liang, J.-. Lin, D. Wuebbles, Z. Tao, A. Williams, M. Caughey, J. Zhu, and K. Hayhoe, 2007: Sensitivity of future ozone concentrations in the northeast USA to regional climate change. *Mitigation and Adaptation Strategies for Global Change,* **13(5-6)**, 597-606.

Kunreuther, H. and E. Michel-Kerjan, 2007: Climate change, insurability of large-scale disasters and the emerging liability challenge. *The University of Pennsylvania Law Review,* **155**, 1795.

Künzli, N., E. Avol, J. Wu, W.J. Gauderman, E. Rappaport, J. Millstein, J. Bennion, R. McConnell, F.D. Gilliland, and K. Berhane, 2006: Health effects of the 2003 southern california wildfires on children. *American Journal of Respiratory and Critical Care Medicine,* **174(11)**, 1221-1228.

Kurz, W.A., C.C. Dymond, G. Stinson, G.J. Rampley, E.T. Neilson, A.L. Carroll, T. Ebata, and L. Safranyik, 2008: Mountain pine beetle and forest carbon feedback to climate change. *Nature,* **452(24)**, 987-990.

Kurz, W.A., G. Stinson, G.J. Rampley, C.C. Dymond, and E.T. Neilson, 2008: Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain. *Proceedings of the National Academy of Sciences,* **105(5)**, 1551-1555.

Kurz, W.A., C.C. Dymond, G. Stinson, G.J. Rampley, E.T. Neilson, A.L. Carroll, T. Ebata, and L. Safranyik, 2008: Mountain pine beetle and forest carbon feedback to climate change. *Nature*, **452(7190)**, 987-990.

L. Perch-Nielsen, S., M. B. Bättig, and D. Imboden, 2008: Exploring the link between climate change and migration. *Climatic Change,* **91(3)**, 375-393.

Lafferty, K.D., 2009: The ecology of climate change and infectious diseases. *Ecology,* **90(4)**, 888-900.

Lal, P., J. Alavalapati, and D.E. Mercer, 2011: *Effects of Climate Change on Natural Resources and Communities: A Compendium of Briefing Papers* . Chapter 3: Socioeconomic Impacts of Climate Change on Rural Communities in the United States, US Department of Agriculture, Forest Service, PNW Research Station, Portland, OR, 73-118 pp.

Lal, P., J. Alavalapati, and D.E. Mercer, 2011: Socio-economic impacts of climate change on rural united states. *Mitigation and Adaptation Strategies for Global Change,* **16**, 819-844.

Lal, P., J.R.R. Alavalapati, and E.D. Mercer, 2011: **Socio-economic impacts of climate change on rural united states**. *Mitigation and Adpatation Strategies for Global Change,* **16**, 819-844.

Lambrechts, L., K.P. Paaijmans, T. Fansiri, L.B. Carrington, and L.D. Kramer, 2011: Impact of daily temperature fluctuations on dengue virus transmission by aedes aegypti. *PNAS,* **108(21)**, 7460-7465.

Lanciotti, R.S., 1999: Origin of the west nile virus responsible for an outbreak of encephalitis in the northeastern united states. *Science,* **286(5448)**, 2333-2337.

Lane, M., P.H. Kirshen, and R.M. and Vogel, 1999: Indicators of impacts of global climate change on U.S. water resources. *Journal of Water Resources Planning and Management,* **July/August**.

Lankao, R., 2007: Are we missing the point? *Environment and Urbanization,* **19(1)**, 159.

Laugharne, J., d.W. van, d.W. Van, and A. Janca, 2011: After the fire: The mental health consequences of fire disasters. *Current Opinion in Psychiatry,* **24(1)**, 72-7.

Laukkonen, J., P.K. Blanco, J. Lenhart, M. Keiner, B. Cavric, and C. Kinuthia-Njenga, 2009: Combining climate change adaptation and mitigation measures at the local level. *Habitat International,* **33(3)**, 287-292.

Layton, M., M.E. Parise, C.C. Campbell, R. Advani, J.D. Sexton, E.M. Bosler, and J.R. Zucker, 1995: Mosquito-transmitted malaria in new york city, 1993. *Lancet,* **346(8977)**, 729-31.

Lazo, J.K., M. Lawson, P.H. Larsen, and D.M. Waldman, 2011: U.S. economic sensitivity to weather variability. *Bulletin of the American Meteorological Society,* **(June 2011)**, 709-720.

Leadbetter, D. and S. Dibra, 2008: Why insurers fail: The dynamics of property and casualty insurance insolvency in canada. *The Geneva Papers on Risk & Insurance,* **33**, 464-488.

Leal Asencio, M.T., D.V. Millán Gómez, C.G. Méndez Jaime, and C.A. Servín Jungdorf, 2008: **Evaluación De La Afectación De La Calidad Del Agua En Cuerpos De Agua Superficiales y Subterráneos Por Efecto De La Variabilidad y El Cambio Climático y Su Impacto En La Biodiversidad, Agricultura, Salud, Turismo e Industria, INE-IMTA-SEMARNAT, Mexico.**, .

Leal, A.T., G.V. Millán, J.C. Méndez, and J.C. Servín, 2008: Assessment of the impacts on surface and groundwater due to climate change and the cliamte variability and effects on biodiversity, agriculture, health tourims and the industry. IMTA-INE, Mexico, 123 Pp Available at : Http://www.Ine.Gob.Mx., .

Legorreta, J., 2005: Inundaciones recientes presagian una catástrofe en el DF. *Agua, La Jornada, Edición Especial, México,* .

Lei, W., M. Zavala, B. de Foy, R. Volkamer, and L.T. Molina, 2008: Characterizing ozone production and response under different meteorological conditions in mexico city. *Atmospheric Chemistry and Physics,* **8(24)**, 7571-7581.

Leichenko, R., 2011: Climate change and urban resilience. *Current Opinion in Environmental Sustainability,* .

Leichenko, R.M. and K.L. O'Brien, 2008: *Environmental change and globalization: Double exposures.* Oxford University Press, USA, .

Lempert, R.J. and D.G. Groves, 2010: Identifying and evaluating robust adaptive policy responses to climate change for water management agencies in the american west. . *Technological Forecasting and Social Change, 77(6), 960-974.,* .

Leonard, L., J. Dorton, S. Culver, and R. Christian, 2009: *Coastal and estuarine observing in north carolina: Integrating observations and science to understand our coastal environment.* East Carolina University Press, Carolina, USA, pp. 30.

Leurig, S., 2010: The ripple effect: Water risk in the municipal bond market. *Ceres.,* .

Leurig, S., 2011: Climate Risk Disclosure by Insurers: Evaluating Insurer Responses to the NAIC Climate Disclosure Survey, Ceres, Boston, MA, .

Levetin, E. and d.W. Van, 2008: Changing pollen types/concentrations/distribution in the united states: Fact or fiction? *Current Allergy and Asthma Reports,* **8(5)**, 418-24.

Levy, M.A., S.R. Baptista, M. Muñiz, S. Adamo, T.M. Aide, M.J.A. Núñez, M.L. Clark, G. Yetman, M.E. Lukang, and T. Chai-Onn, 2010: Multi-hazard risks and vulnerable populations in the caribbean and gulf of mexico region: Implications of spatial population and land cover Dynamics1. *Letter of Introduction,* , 28.

Lewis, C., A. McGahan, S. Peterson, and K. Quackenbush, 2008: Carbon dioxide, climate change, and the boston region MPO A discussion paper.

Li, X., T. Takahashi, N. Suzuki, and H.M. Kaiser, 2011: The impact of climate change on maize yields in the united states and china. *Agricultural Systems,* **104**, 348-353.

Liao, K., E. Tagaris, K. Manomaiphiboon, C. Wang, J. Woo, P. Amar, S. He, and A.G. Russell, 2009: And physics quantification of the impact of climate uncertainty on regional air quality. *Atmospheric Chemistry and Physics,* **(2006)**, 865-878.

Liao, K., E. Tagaris, K. Manomaiphiboon, S.L. Napelenok, J. Woo, S. He, P. Amar, and A.G. Russell, 2007: Sensitivities of ozone and fine particulate matter formation to emissions under the impact of potential future climate change. *Environmental Science & Technology,* **41(24)**, 8355-61.

Lin, B.B., I. Perfecto, and J. Vandermeer, 2008: Synergies between agricultural intensification and climate change could create surprising vulnerabilities for crops. *Bioscience,* **58(9)**, 847-854.

Lin, B.B., 2007: Agroforestry management as an adaptive strategy against potential microclimate extremes in coffee agriculture. *Agricultural and Forest Meterorology,* **144(1-2)**, 85-94.

Lin, N., K. Emanuel, J. Smith, and E. Vanmarcke, 2010: Risk assessment of hurricane storm surge for new york city. *J.Geophys.Res,* **115**.

Lin, J., K.O. Patten, K. Hayhoe, X. Liang, and D.J. Wuebbles, 2008: Effects of future climate and biogenic emissions changes on surface ozone over the united states and china. *Journal of Applied Meteorology and Climatology,* **47(7)**, 1888-1909.

Lin, J., D.J. Wuebbles, H. Huang, Z. Tao, M. Caughey, X. Liang, J. Zhu, and T. Holloway, 2010: Potential effects of climate and emissions changes on surface ozone in the chicago area. *Journal of Great Lakes Research,* **36**, 59-64.

Lin, J., D.J. Wuebbles, H. Huang, Z. Tao, M. Caughey, X. Liang, J. Zhu, and T. Holloway, 2010: Potential effects of climate and emissions changes on surface ozone in the chicago area. *Journal of Great Lakes Research,* **36**, 59-64.

Linnerooth-Bayer, J., K. Warner, C. Bals, P. Hoppe, I. Burton, T. Loster, and A. Haas, 2009: Insurance, developing countries, and climate change. *The Geneva Papers on Risk & Insurance,* **34**, 381-400.

Liverman, D. and K. Kapadia, 2010: Chapter 1: Food systems and the global environment: An overview. In: *Food security and global environmental change.* [Ingram, J., P. Erickson, and D. Liverman(eds.)]. Earthscan, London, UK, pp. 3-24.

Liverman, D.M., R.G. Varady, O. Chavez, and R. Sanchez, 1999: Environmental issues along the united states-mexico border: Drivers of change and responses of citizens and institutions. *Annual Review of Energy and the Environment,* **24(1)**, 607-643.

Liverman, D.M. and S. Vilas, 2006: Neoliberalism and the environment in latin america. *Annu.Rev.Environ.Resour.,* **31**, 327-363.

Lloyd's, 2006: *360 Risk Project.* Climate Change: Adapt Or Bust, Lloyd's, London, .

Lo, E. and E. Levetin, 2007: Influence of meteorological conditions on early spring pollen in the tulsa atmosphere from 1987-2006. *Journal of Allergy and Clinical Immunology,* **119(1)**, S101-S101.

Lo, E. and E. Leviten, 2005: Influence of meteorological conditions on early spring pollen in the tulsa atmosphere from 1987-2006. *Clinical Immunology,* **119(1)**, 2006-2006.

Loarie, S.R., P.B. Duffy, H. Hamilton, G.P. Asner, C.B. Field, and D.D. Ackerly, 2009: The velocity of climate change. *Nature,* **462(7276)**, 1052-1055.

Lobell, D.B. and M.B. Burke, 2010: On the use of statistical models to predict crop yield responses to climate change. *Agricultural and Forest Meterorology,* **150(11)**, 1443-1452.

Lobell, D.B., K.G. Cassman, and C.B. Field, 2009: Crop yield gaps: Their importance, magnitudes, and causes. *Annual Review of Environment and Resources,* **34(1)**, 179.

Lobell, D.B., C.B. Field, K.N. Cahill, and C. Bonfils, 2006: **Impacts of future climate change on california perennial crop yields: Model projections with climate and crop uncertainties**. *Agricultural and Forest Meterorology,* **141**, 208-218.

Lobell, D.B., S. Wolfram, and J. Costa-Roberts, 2011: Climate trends and global crop production since 1980. *Science,* **333**, 616-620.

Locke, P., C. Clifton, and S. Westra, 2011: Extreme weather events and the mining industry. *Engineering and Mining Journal,* **212(3)**, 58.

Long, S.P., E.A. Ainsworth, A.D.B. Leakey, J. Nosberger, and D.R. Ort, 2006: Food for thought: Lower-then-expected crop yield simulations with rising CO2 concentrations. *Science,* **312(5782)**, 1918-1921.

Lopez-Calva, L.F. and E. Ortiz-Juarez, 2009: Evidence and policy lessons on the links between disaster risk and poverty in latin america.

Lund, J., E. Hanak, W. Fleenor, R. Howitt, J. Mount, and P. Moyle, 2007: *Envisioning futures for the sacramento-san joaquin delta.* San Francisco, USA, Public Policy Institute of California, San Francisco ed., pp. 285.

Lutz, W., A. Goujon, and A. Wils, 2008: The population dynamics of human capital accumulation. *Population and Development Review,* **34**, 149-187.

Lutz, W., W. Sanderson, and S. Scherbov, 2008: The coming acceleration of global population ageing. *Nature,* **451(7179)**, 716-719.

Lynn, B.H., C. Rosenzweig, R. Goldberg, D. Rind, C. Hogrefe, L. Druyan, R. Healy, J. Dudhia, J. Rosenthal, and P. Kinney, 2009: Testing GISS-MM5 physics configurations for use in regional impacts studies. *Climatic Change,* **99(3-4)**, 567-587.

Maantay, J. and A. Maroko, 2009: Mapping urban risk: Flood hazards, race, & environmental justice in new york. *Applied Geography,* **29(1)**, 111-124.

MacDonald, G.M., 2010: Water, climate change, and sustainability in the southwest. *Proceedings of the National Academy of Sciences,* **107(50)**, 21256-21262.

MacDonald, G.M., 2010: Water, climate change, and sustainability in the southwest. *Proceedings of the National Academy of Sciences,* **107(50)**, 21256-21262.

MacDonald, G.M., 2010: Water, climate change, and sustainability in the southwest. *Proceedings of the National Academy of Sciences,* **107(50)**, 21256-21262.

Macfarlane, R., 2007: Anatomy of heat waves and mortality in toronto. *REVUE CANADIENNE DE SANTÉ PUBLIQUE,* **98(5)**.

Machado-Machado, E., 2012: Empirical mapping of suitability to dengue fever in mexico using species distribution modeling. *Applied Geography,* **33**, 82-93.

Macias Fauria, M. and E. A. Johnson, 2006: Large-scale climatic patterns control large lightning fire occurrence in canada and alaska forest regions. *Journal of Geophysical Research,* **111(G04008)**.

Macias Fauria, M. and E. A. Johnson, 2008: Climate and wildfires in the north american boreal forest. *Philosophical Transactions of the Royal Society B*, **363**, 2317-2329.

MacKendrick, N. and J. Parkins, *Mountain Pine Beetle Initiative Working Paper 2005-26.* Social Dimensions of Community Vulnerability to Mountain Pine Beetle, Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, .

Magana, V., 2011: *Una reflexión climática sobre los incendios forestales en coahuila* UNAM, Mexico City, pp. 7.

Magaña, V., 2011: *Una reflexión climática sobre los incendios forestales en coahuila* UNAM, Mexico City, pp. 7.

Magrin, G., Gay, C. with Cruz Choque, D. Jiménez, J.C. Moreno, A.R. Nagy, G., Nobre, C. Villamizar, A., 2007: Chapter 13 - Latin America, IPCC WGII Fourth Assessment Report, 63 pp.

Magrin, G.O., M.I. Travasso, and G.R. Rodríguez, 2005: Changes in climate and crop production during the 20th century in argentina. *Climatic Change*, **72(1)**, 229-249.

Mahmud, a., M. Hixson, J. Hu, Z. Zhao, S.-. Chen, and M.J. Kleeman, 2010: Climate impact on airborne particulate matter concentrations in california using seven year analysis periods. *Atmospheric Chemistry and Physics,* **10(22)**, 11097-11114.

Mahmud, a., M. Hixson, J. Hu, Z. Zhao, S.-. Chen, and M.J. Kleeman, 2010: Climate impact on airborne particulate matter concentrations in california using seven year analysis periods. *Atmospheric Chemistry and Physics,* **10(22)**, 11097-11114.

Mailhot, A. and S. Duchesne, 2010: "Design criteria of urban drainage infrastructures under climate change.". *Journal of Water Resources Planning and Management 136.2 2010: Pp. 201-208. Web of Science. Web. 1 July 2010.,* .

Mansourian, S. and A. Belokurov and P.J. Stephenson, 2009: The role of forest protected areas in adaptation to climate change. *Unasylva,* **60(1-2 (231-232) Adapting to climate change)**, 63-68.

Mansur, E.T., R. Mendelsohn, and W. Morrison, 2008: Climate change adaptation: A study of fuel choice and consumption in the US energy sector. *Journal of Environmental Economics and Management,* **55**, 175.

Mantua, N. J., I. Tohver, and A.F. Hamlet, 2010: Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in washington state. *Climatic Change*, **102(1-2)**, 187-223.

Mantua, N. J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis, 1997: A pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society,* **78(6)**, 1069-1079.

Manuel-Navarrete, D., J.J. Gomez, and G. Gallopin, 2007: Syndromes of sustainability of development for assessing the vulnerability of coupled human-environmental systems. the case of hydrometeorological disasters in central america and the caribbean. *Global Environmental Change,* **17(2)**, 207-217.

Manuel-Navarrete, D., M. Pelling, and M. Redclift, 2011: Critical adaptation to hurricanes in the mexican caribbean: Development visions, governance structures, and coping strategies. *Global Environmental Change,* **21(1)**, 249-258.

Marengo, J., M. Rusticucci, O. Penalba, M. Renom, and R. Laborbe, 2009: An intercomparison of model-simulated in extreme rainfall and temperature events during the last half of XX century. part 2: Historical trends. *Clim Change.Doi,* **10**.

Marengo, J., R. Jones, L.M. Alves, and M. Valverde, 2009: Future change of temperature and precipitation extremes in south america as derived from the PRECIS regional climate modeling system. *International Journal of Climatology*, **29(15)**, 2241-2255.

Marie S. O'Neill, Dana K. Jackman, Michelle Wyman, Xico Manarolla, Carina J. Gronlund, Daniel G. Brown, Shannon J. Brines, Joel Schwartz and Ana V. Diez-Roux, **US local action on heat and health: Are we prepared for climate change?** . *International Journal of Public Health,* **Volume 55, Number 2, 105-112**.

Mark, B.G., J. Bury, J.M. McKenzie, A. French, and M. Baraer, 2010: Climate change and tropical andean glacier recession: Evaluating hydrologic changes and livelihood vulnerability in the cordillera blanca, peru. *Annals of the Association of American Geographers,* **100(4)**, 794-805.

Marlin, A., L. Olsen, D. Bruce, J. Ollerhead, K. Singh, J. Heckman, B. Walters, D. Meadus, and A. Hanson, 2007: Examining Community Adaptive Capacity to Address Climate Change, Sea Level Rise, and Salt Marsh Restoration in Maritime Canada, Rural and Small Town Program, Sackville, NB, .

Marlon, J.R., P.J. Bartlein, D.G. Gavin, C.J. Long, R.S. Anderson, C.E. Briles, K.J. Brown, D. Colombaroli, D.J. Hallett, and M.J. Power, 2012: Long-term perspective on wildfires in the western USA. *Proceedings of the National Academy of Sciences*, **109(9)**, E535-E543.

Márquez, R. and Jiménez, Ma. del C., 2010: El posible efecto del cambio climático en las tortugas marinas. [the possible effect of climate change on sea turtles]. In: *Vulnerabilidad de las zonas costeras mexicanas ante el cambio climático.* [Botello, A. V., Villanueva,S., Gutiérrez, J., Rojas Galaviz, J. L. (ed.)]. Gobierno del Estado de Tabasco, SEMARNAT-INE, UNAM-ICMyL, Universidad Autónoma de Campeche, Mexico, pp. 97-112.

Marshall, E. and T. Randhir, 2008: Effect of climate change on watershed system: A regional analysis. *Climatic Change, 89 (3-4), Pp. 263-280., .*

Marshall, G., T. Schell, M. Elliott, N. Rayburn, and L. Jaycox, 2007: Psychiatric disorders among adults seeking emergency disaster assistance after a wildland-urban interface fire. *Psychiatric Services*, **58(4)**, 509-514.

Martiello, M.A. and M.V. Giacchi, 2010: Review article: High temperatures and health outcomes: A review of the literature. *Scandinavian Journal of Public Health,* **38(8)**, 826-837.

Martin, C.A., 2008: Landscape sustainability in a sonoran desert city. *Cities and the Environment (CATE),* **1(2)**, 5.

Martin, W.E., I.M. Martin, and B. Kent, 2009: The role of risk perceptions in the risk mitigation process: The case of wildfire in high risk communities. *Journal of Environmental Management,* **91**, 489-498.

Martins, R.D.A. and L.D.C. Ferreira, 2011: Opportunities and constraints for local and subnational climate change policy in urban areas: Insights from diverse contexts. *International Journal of Global Environmental Issues,* **11(1)**, 37-53.

Martins, R.D.A. and L.D.C. Ferreira, 2011: Opportunities and constraints for local and subnational climate change policy in urban areas: Insights from diverse contexts. *International Journal of Global Environmental Issues,* **11(1)**, 37-53.

Marulanda, M.C., O.D. Cardona, and A.H. Barbat, 2008: 3.2 the economic and social effects of small disasters revision of the local disaster index and the case of study of colombia. *Resilience and Social Vulnerability,* , 110.

Maryland Commission on Climate Change Adaptation and Response Working Group, 2008: Comprehensive Strategy for Reducing Maryland\'s Vulnerability to Climate Change: Phase I: Sea-Level Rise and Coastal Storms, Maryland Department of Natural Resources, Annapolis, Maryland, .

Maryland Department of the Environment on behalf of the Maryland Commission on Climate Change, 2010: Update to Governor and General Assembly, Maryland Department of the Environment, Annapolis, Maryland, .

Massey, D.S., W.G. Axinn, and D.J. Ghimire, 2007: *Environmental change and out-migration: Evidence from nepal.* University of Michigan. Institute for social research. Population studies center (PSC), .

Matthews, R., T. Satterfield, R. Sydneysmith, and N. Young, The Co-Management of Climate Change in Coastal Communities of British Columbia: Social Capital, Trust and Capacity: Final Report. Canadian Climate Impacts and Adaptation Program Project A1115, .

McAdam, J., 2010: *Climate change and displacement : Multidisciplinary perspectives.* Hart Pub., Oxford ;Portland, Or., pp. 258.

McAndrews, C., E. Deakin, and L. Schipper, 2010: Climate change and urban transportation in latin america. *Transportation Research Record: Journal of the Transportation Research Board,* **2191(-1)**, 128-135.

McAndrews, C., E. Deakin, and L. Schipper, 2010: Climate change and urban transportation in latin america: An analysis of recent projects. *Transportation Research Record, Forthcoming,* .

McBoyle, G.D., Scott, and B. Jones, 2007: Climate change and the future of snowmobiling in non-mountainous regions of canada. *Managing Leisure,* **12**, 237-250.

McCarthy, J.J., 2001: *Climate change 2001: Impacts, adaptation, and vulnerability: Contribution of working group II to the third assessment report of the intergovernmental panel on climate change.* Cambridge Univ Pr, .

McEntire, D., C.G. Crocker, and E. Peters, 2010: Addressing vulnerability through an integrated approach. *International Journal of Disaster Resilience in the Built Environment,* **1(1)**, 50-64.

McFarlane, B.L., 2006: *Canadian Wildland Fire Strategy: Background, Syntheses, Analyses, and Perspectives.* Human Dimensions of Fire Management in the Wildland-Urban Interface: A Literature Review, Canadian Council for Forest Ministries, Edmonton, Alberta, CA, 27-34 pp.

McGranahan, G., D. Balk, and B. Anderson, 2007: The rising tide: Assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and Urbanization,* **19(1)**, 17.

McGraw, J., P. Haas, L. Young, and A. Evens, 2010: Greenhouse gas emissions in chicago: Emissions inventories and reduction strategies for chicago and its metropolitan region. *Journal of Great Lakes Research,* **36, Supplement 2(0)**, 106-114.

McGregor, G.R., 2011: Human biometeorology. *Progress in Physical Geography,* **36(1)**, 93-109.

McKenney, D.W., J.H. Pedlar, K. Lawrence, K. Campbell, and M.F. Hutchinson, BioScience: Potential impacts of climate change on the distribution of north american trees. *2007,* **57(11)**, 939-948.

McKenzie, D., Z. Gedalof, D.L. Peterson, and P. Mote, 2004: Climatic change, wildfire, and conservation. *Conservation Biology,* **18(4)**, 890-902.

McKenzie, D., Z. Gedalof, D.L. Peterson, and P. Mote, 2004: Climatic change, wildfire, and conservation. *Conservation Biology,* **18(4)**, 890-920.

McLauchlan, K.K., C.S. Barnes, and J.M. Craine, 2010: Interannual variability of pollen productivity and transport in mid-north america from 1997 to 2009. *Aerobiologia,* **27(3)**, 181-189.

McLeman, R. and G. Gilbert, 2008: *Final Scientific Report for Natural Resources Canada, Project A1319.* Economic and Social Adaptation to Climate Change in Canadian Seasonal-Economy Communities, University of Ottawa, Ottawa, CAN, .

McLeman, R.A., 2010: Impacts of population change on vulnerability and the capacity to adapt to climate change and variability: A typology based on lessons from ‘a hard country.’ *Population & Environment,* **31**, 286-316.

McLeman, R.A. and L.M. Hunter, 2010: Migration in the context of vulnerability and adaptation to climate change: Insights from analogues. *Wiley Interdisciplinary Reviews: Climate Change,* **1(3)**, 450-461.

McMahon, J.E. and S.K. Price, 2011: Water and energy interactions. *Annual Review of Environment and Resources Vol. 36: 163-191, 28 Pp,* .

McMichael, A.J., P. Wilkinson, R.S. Kovats, S. Pattenden, S. Hajat, B. Armstrong, N. Vajanapoom, E.M. Niciu, H. Mahomed, and C. Kingkeow, 2008: International study of temperature, heat and urban mortality: The ‘ISOTHURM’project. *International Journal of Epidemiology,* **37(5)**, 1121-1131.

McSweeney, K. and O.T. Coomes, 2011: Climate-related disaster opens a window of opportunity for rural poor in northeastern honduras. *Proceedings of the National Academy of Sciences,* **108(13)**, 5203.

Mearns, R., A. Norton, and E. Cameron, 2009: *The social dimensions of climate change: Equity and vulnerability in a warming world.* World Bank, .

Medina-RamÃ³n, M. and J. Schwartz, 2007: Temperature, temperature extremes, and mortality: A study of acclimatization and effect modification in 50 united states cities. *Occupational and Environmental Medicine,* .

Meehl, G. A., C. Tebaldi, G. Walton, D. Easterling, and L. McDaniel, 2009: Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S. *Geophysical Research Letters,* **36**, L23701, doi:10.1029/2009GL040736.

Megdal, S.B. and C.A. Scott, 2011: The importance of institutional asymmetries to the development of binational aquifer assessment programs: The arizona-sonora experience. *Water,* **3(3)**, 949-963.

Mendelsohn, R., J. Arellano-Gonzalez, and P. Christensen, 2010: A ricardian analysis of mexican farms *Environment and Development Economics,* **15**, 153-171.

Mendelsohn, R. and J.E. Neumann, 2004: The impact of climate change on the united states economy. *The Impact of Climate Change on the United States Economy, Edited by Robert Mendelsohn and James E.Neumann, Pp.343.ISBN 0521607698.Cambridge, UK: Cambridge University Press, August 2004.,* **1**.

Mendoza, V.M., E.E. Villanueva, and J. Adame, 1997: Vulnerability of basins and watersheds in mexico to global climate change. *Climate Research, 9: 139-145,* .

Mercer, J., 2010: Disaster risk reduction or climate change adaptation: Are we reinventing the wheel? *Journal of International Development,* **22(2)**, 247-264.

Mercer, K., A. Martinez-Vasquez, and H.R. Perales, 2008: Asymmetrical local adaptation of maize landraces along an altitudinal gradient. *Evolutionary Applications,* **1(3)**, 489-500.

Meza-Figueroa, D., Maier, R. M., de la O-Villanueva, M., Gómez-Alvarez, A., Moreno-Zazueta, A., Rivera, J., 2009: The impact of unconfined mine tailings in residential areas from a mining town in a semi-arid environment: Nacozari, sonora, mexico. *Chemosphere,* **77(1)**, 140-147.

Miao, S., F. Chen, Q. Li, and S. Fan, 2011: Impacts of urban processes and urbanization on summer precipitation: A case study of heavy rainfall in beijing on 1 aug 2006. *Journal of Applied Meteorology and Climatology,* .

Michaelian, M., E.H. Hogg, R.J. Hall, and E. Arsenault, 2010: Massive mortality of aspen following severe drought along the southern edge of the canadian boreal forest. *Global Change Biology,* .

Michel-Kerjan, E. and F. Morlaye, 2008: Extreme events, global warming, and insurance-linked securities: How to trigger the "tipping point". *The Geneva Papers on Risk & Insurance,* **33**, 153-176.

Millar, C.I., N.L. Stephenson, and S.S. Stephens, 2007: Climate change and forests of the future: Managing in the face of uncertainty. *Ecological Applications,* **17(8)**, 2145-2151.

Miller, N.L., K. Hayhoe, J. Jin, and M. Auffhammer, 2009: Climate, extreme heat, and electricity demand in california.

Millerd, F., 2011:
The potential impact of climate change on great lakes international shipping. *Climatic Change,* **104(3-4)**, 629-652.

Mills, B.N., S.L. Tighe, J. Andrey, J.T. Smith, and K. Huen, 2009: Climate change implications for flexible pavement design and performance in southern canada. *Journal of Transportation Engineering,* **135(10)**, 773-782.

Mills, E., 2005: Insurance in a climate of change. *Science,* **309(5737)**, 1040.

Mills, E., 2007: From Risk to Opportunity 2007: Insurer Responses to Climate Change, Ceres, .

Mills, E., 2009: From Risk to Opportunity: Insurer Responses to Climate Change 2008, Ceres, .

Mills, E., 2009: A global review of insurance industry responses to climate change. *Geneva Papers on Risk & Insurance,* **34(3)**, 323-359.

Mills, E. and E. Lecomte, 2006: From Risk to Opportunity: How Insurers can Proactively and Profitably Manage Climate Change, Ceres, .

Minero, F.J.G., P. Candau, J. Morales, and C. Tomas, 1998: Forecasting olive crop production based on ten consecutive years of monitoring airborne pollen in andalusia (southern spain). *Agriculture, Ecosystems & Environment,* **69(3)**, 201-215.

Ministry of Municipal Affairs and Housing, 2011: *Potential Changes for the Next Edition of the Building Code: Second Round of Consultation (February-April 2011),* Queen's Printer for Ontario, Toronto, 46 pp.

Minville, M., F. Brissette, S. Krau, and R. Leconte, 2009: Adaptation to climate change in the management of a canadian water-resources system exploited for hydropower. *Water Resources Management 23(14): 2965-2986.*

Miranda, M., I. Porras, and M.L. Moreno, 2003: The social impacts of payments for environmental services in costa rica. A quantitative field survey and analysis of the virilla watershed. *International Institute for Environment and Development, London,* .

Mirza, M.S. and M. Haider, 2003: The State of Infrastructure in Canada: Implications for Infrastructure Planning and Policy, McGill University, Montreal, .

Molnar, J.J., 2010: Climate change and societal response: Livelihoods, communities, and the environment. *Rural Sociology,* **75(1)**, 1-16.

Monica, S., 2007: After a wildland-urban interface fire. *Methods,* **58(4)**.

Monkkonen, P., 2011: The housing transition in mexico: Expanding access to housing finance. *Urban Affairs Review,* .

Monterroso Rivas, A.I., C.C. Álvarez, G.R. Dorantes, J.D. Gomez Diaz, and C.G. Garcia, 2011: **Assessing current and potential rainfed maize suitability under climate change scenarios in méxico** . *Atmósfera,* **24(1)**, 53-67.

Morello-Frosch, R., M. Pastor Jr, C. Porras, and J. Sadd, 2002: *Environmental Health Perspectives,* **110(Suppl 2)**, 149.

Morello-Frosch, R., M. Pastor, and J. Sadd, 2001: Environmental justice and southern California's "Riskscape". *Urban Affairs Review,* **36(4)**, 551.

Moreno, A.R., 2006: Climate change and human health in latin america: Drivers, effects, and policies. *Regional Environmental Change,* **6(3)**, 157-164.

Morin, C.W. and A.C. Comrie, 2010: Modeled response of the west nile virus vector culex quinquefasciatus to changing climate using the dynamic mosquito simulation model. *International Journal of Biometeorology,* **54(5)**, 517-29.

Moritz, C., C. Hoskin, J. MacKenzie, B. Phillips, M. Tonione, N. Silva, J. VanDerWal, S. Williams, and C. Graham, 2009: Identification and dynamics of a cryptic suture zone in tropical rainforest. *Proceedings of the Royal Society B: Biological Sciences,* **276(1660)**, 1235-1244.

Moritz, C., J.L. Patton, C.J. Conroy, J.L. Parra, G.C. White, and S.R. Beissinger, 2008: Impact of a century of climate change on small-mammal communities in yosemite national park, USA. *Science,* **322(5899)**, 261-264.

Moritz, C., J.L. Patton, C.J. Conroy, J.L. Parra, G.C. White, and S.R. Beissinger, 2008: Impact of a century of climate change on small-mammal communities in yosemite national park, USA. *Science,* **322(5899)**, 261-264.

Morton, T., Bretschneider, P., Coley, D. and Kershaw, T., 2011: Building a better future: An exploration of beliefs about climate change and perceived need for adaptation within the building industry. *Building and Environment,* **46**, 1151-1158.

Moser, C. and D. Satterthwaite, 2009: Towards pro-poor adaptation to climate change in the urban centres of low- and middle-income countries. *The Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World,* , 231.

Moser, S.C. and J.A. Ekstrom, 2010: A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences,* **doi: 10.1073/pnas.1007887107**.

Moser, S.C. and J.A. Ekstrom, 2011: Taking ownership of climate change: Participatory adaptation planning in two local case studies from california. *Journal of Environmental Studies and Sciences,* , 1-12.

Mote, P.W., 2006: Climate-driven variability and trends in mountain snowpack in western north america. *Journal of Climate,* **19**, 6209-6220.

Mote, P.W., and E. Salathé, 2010: Future climate in the pacific northwest *Climatic Change,* **DOI: 10.1007/s10584-010-9848**.

Mote, P.W. and E.P. Salathe, 2010: Future climate in the pacific northwest. *Climatic Change,* **102(1)**, 29-50.

Moyle, P.B., J.V.E. Katz, and R.M. Quinones, 2011: Rapid decline of California's native inland fishes: A status assessment *Biological Conservation,* **144**, 2414-2423.

Mueller, S.F. and J.W. Mallard, 2011: Contributions of natural emissions to ozone and PM2.5 as simulated by the community multiscale air quality (CMAQ) model. *Environmental Science & Technology,* **45(11)**, 4817-23.

Mumby, P.J., I.A. Elliott, C.M. Eakin, W. Skirving, C.B. Paris, H.J. Edwards, S. Enríquez, R. Iglesias-Prieto, L.M. Cherubin, and J.R. Stevens, 2011: Reserve design for uncertain responses of coral reefs to climate change. *Ecology Letters,* **14**, 132-140.

Mumme, S.P. and O. Ibanez, 2009: US-mexico environmental treaty impediments to tactical security infrastructure along the international boundary. *Nat.Resources J.,* **49**, 801-883.

Munich Re, 2011: *Topics Geo.* Topics Geo Natural Catastrophes 2010, Munich Re, .

Murazaki, K. and P. Hess, 2006: How does climate change contribute to surface ozone change over the united states? *Journal of Geophysical Research,* **111**, 1-16.

Murazaki, K. and P. Hess, 2006: How does climate change contribute to surface ozone change over the united states? *Journal of Geophysical Research,* **111**, 1-16.

Myers, N., 2002: Environmental refugees: A growing phenomenon of the 21st century. *Philosophical Transactions of the Royal Society of London.Series B: Biological Sciences,* **357(1420)**, 609.

Nadler, A.J. and P.R. Bullock, 2011: Long-term changes in heat and moisture related to corn production on the canadian prairies. *Climatic Change,* **104**, 339-352.

Naeher, L.P., M. Brauer, M. Lipsett, J.T. Zelikoff, C.D. Simpson, J.Q. Koenig, and K.R. Smith, 2007: Woodsmoke health effects: A review. *Inhalation Toxicology,* **19(1)**, 67-106.

Nagy, G., M.G. Erache, and V. Fernández, 2007: El aumento del nivel del mar en la costa uruguaya del río de la plata. tendencias, vulnerabilidades y medidas para la adaptación. *Medio Ambiente y Urbanización,* **67(1)**, 77-93.

National Center for, E.A. and a.D. Office of Research, 2008: A Review of the Impacts of Climate Variability and Change on Aeroallergens and their Associated Effects, Washington, DC 20460, .

National Center for, E.H., *Health effects - waterborne diseases* .

National Round Table on the Environment and the Economy, 2012: Facing the Elements: Building Business Resilience in a Changing Climate (Case Studies), National Round Table on the Environment and the Economy, Ottawa, .

Natural Resources Canada, 2011: **Canada's Regional Adaptation Collaborative ProgramHelping Canadians Prepare for and Adapt to Climate changeThe** , Natural Resources Canada, .

Nelson, G.C., M.W. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, C. Ringler, S. Msangi, A. Palazzo, M. Batka, M. Magalhaes, R. Valmonte-Santos, M. Ewing, and D. Lee, 2009: Climate Change: Impact on Agriculture and Costs of Adaptation, International Food Policy Research Institute, Washington, DC, USA, .

Neumayer, E. and F. Barthel, 2011: Normalizing economic loss from natural disasters: A global analysis. *Global Environmental Change,* **21(1)**, 13-24.

Newland, K., D.R. Agunias, and A. Terrazas, 2008: Learning by doing: Experiences of circular migration. *Insight.Program on Migrants, Migration and Development,* .

Newman, P., T. Beatley, and H. Boyer, 2009: *Resilient cities: Responding to peak oil and climate change.* Island Pr.

Newswire, 2011: Thai flooding impact spreads across world for toyota. *Reuters,* (http://www.asiaworks.com/news/2011/10/27/thai-flooding-impact-spreads-across-world-for-toyota-reuters/), .

Nicholls, R., S. Hanson, C. Herweijer, N. Patmore, S. Hallegatte, J. Corfee-Morlot, J. Château, and R. Muir-Wood, 2008: Ranking port cities with high exposure and vulnerability to climate extremes. *Organization for Economic Development,* **19**.

Nicholls, N., 2009: Estimating changes in mortality due to climate change. *Climatic Change,* **97(1-2)**, 313-320.

Nielsen, S.T., 2010: Coastal livelihoods and climate change. *Reducing Poverty, Protecting Livelihoods, and Building Assets in a Changing Climate: Social Implications of Climate Change Latin America and the Caribbean,* , 123.

Nielsen-Gammon, J.W., 2011: The 2011 Texas Drought. A Briefing Packet for the Texas Legislature, The Office of the State Climatologist Report, Texas A&M University, College Station, .

Niven, R.V., N.M. Hutson, L. Loftus-Otway, and L.B. Boske, 2010: Transportation infrastructure planning in mexico. In: Proceedings of Transportation research board 89th annual meeting, .

Nobre, C.A., 2011: Brazilian model of the global climate system.

Nolte, C.G., A.B. Gilliland, C. Hogrefe, and L.J. Mickley, 2008: Linking global to regional models to assess future climate impacts on surface ozone levels in the united states. *Journal of Geophysical Research,* **113**, 1-14.

Nolte, C.G., A.B. Gilliland, C. Hogrefe, and L.J. Mickley, 2008: Linking global to regional models to assess future climate impacts on surface ozone levels in the united states. *Journal of Geophysical Research,* **113**, 1-14.

Nord, M., A. Coleman-Jensen, M. Andrews, and S. Carlson, 2010: Household Food Security in the United States, 2009, United States Department of Agriculture, Washington, DC, Economic Research Service., .

Nord, M., M.D. Hopper, and H. Hopwood, 2008: Household-level income-related food insecurity is less prevalent in canada than in the united states. *Journal of Hunger and Environmental Nutrition,* **3(1)**, 17-35.

Nordstrom, D.K., 2009: Acid rock drainage and climate change. *Journal of Geochemical Exploration,* **100(2-3)**, 97-104.

Noss, R.F., 2001: Beyond kyoto: Forest management in a time of rapid climate change. *Conservation Biology,* **15(3)**, 578-590.

Novotny, E.V. and H.G. Stefan, 2007: Streamflow in minnesota: Indicator of climate change. *Journal of Hydrology (2007) 334, 319– 333.,* .

Novotny, V. and P. Brown , 2007: **Cities of the future: Towards integrated sustainable water and landscape, proceedings of an international workshop held july 12-14, 2006 in wingspread conference center, racine, WI.**. *IWA Publishing, London, 2007.,* .

Ntelekos, A.A., M. Oppenheimer, J.A. Smith, and A.J. Miller, 2010: Urbanization, climate change and flood policy in the united states. . *Climatic Change, 103(3), 597-616.,* .

Ntelekos, A.A., M. Oppenheimer, J.A. Smith, and A.J. Miller, 2010: Urbanization, climate change and flood policy in the united states. *Climatic Change,* **103(3)**, 597-616.

Nunavut Department of Sustainable Development, 2003: Nunavut Climate Change Strategy, Nunavut Department of Sustainable Development, Iqaluit, Nunavut, .

Nunavut Department of the Environment, 2011: Upagiaqtavut setting the course: Climate change impacts and adaptation in nunavut.

Obeysekera, J., M. Irizarry, J. Park, J. Barnes, and T. Dessalegne, 2011: Climate change and its implications for water resources management in south florida. . *Stochastic Environmental Research and Risk Assessment, 25(4), 495-516,* .

OBrien, K., S. Eriksen, L.P. Nygaard, and A. Schjolden, 2007: Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy,* **7(1)**, 73-88.

OECD, 2009: The Role of Agriculture and Farm Household Diversification in the Rural Economy of Mexico, Trade and Agriculture Directorate, Working Party on Agricultural Policies and Markets, .

OECD, 2010: *OECD economic outlook, volume 2010 issue 1.* Organisation for Economic Co-operation and Development, .

OECD, 2010: *OECD economic outlook, volume 2010 issue 1.* Organisation for Economic Co-operation and Development, .

OECD, Volume 2010/2: Chapter 1. General Assessment of the Macroeconomic Situation” in OECD Economic Outlook

Office of the United States Trade Representative, 2012: ***North american free trade agreement (NAFTA)*** Executive Office of the President, Washington DC, .

Ogden, A.E. and J.L. Innes, 2007: Perspectives of forest practitioners on climate change adaptation in the yukon and northwest territories of canada. *The Forestry Chronicle,* **83(4)**, 557-569.

Ogden, N.H., C. Bouchard, K. Kurtenbach, G. Margos, L.R. Lindsay, L. Trudel, S. Nguon, and F. Milord, 2010: Active and passive surveillance and phylogenetic analysis of borrelia burgdorferi elucidate the process of lyme disease. *Environmental Health Perspectives,* **118(7)**, 909-914.

Ogden, N.H., L.R. Lindsay, M. Morshed, and P.N. Sockett, 2009: The emergence of lyme disease in canada review. *CMAJ,* **180(12)**, 1221-1224.

Ogden, N.H., L. St-Onge, I.K. Barker, S. Brazeau, M. Bigras-Poulin, D.F. Charron, C.M. Francis, A. Heagy, L.R. Lindsay, A. Maarouf, P. Michel, F. Milord, C. O'Callaghan J., L. Trudel, and R.A. Thompson, 2008: Risk maps for range expansion of the lyme disease vector, ixodes scapularis, in canada now and with climate change. *International Journal of Health Geographics,* **7**, 24-24.

O'HARE, G. and S. Rivas, 2005: The landslide hazard and human vulnerability in la paz city, bolivia. *Geographical Journal,* **171(3)**, 239-258.

ONeill, K., T.K. Rudel, and M.H. McDermott, 2009: Why the growth machine goes green in environmentally constrained communities.

O'Neill, M.S. and K.L. Ebi, 2009: Temperature extremes and health: Impacts of climate variability and change in the united states. *Journal of Occupational and Environmental Medicine,* **51(1)**, 13.

Ontario Ministry of Environment, 2011: Climate Ready: Ontario's Adaptation Strategy and Action Plan 2011-2014, Queen's Printer for Ontario, 124 pp.

Ontario Ministry of the Environment, 2011: Climate ready: Ontario’s adaptation strategy and action plan 2011-2014.

Ostro, B.D., L.A. Roth, R.S. Green, and R. Basu, 2009: Estimating the mortality effect of the july 2006 california heat wave. *Environmental Research,* **109(5)**, 614-619.

Ostry, A., M. Ogborn, K.L. Bassil, T.K. Takaro, and D.M. Allen, 2010: Climate change and health in british columbia: Projected impacts and a proposed agenda for adaptation research and policy. *International Journal of Environmental Research and Public Health,* **7(3)**, 1018-35.

Overpeck, J. and B. Udall, 2010: Dry times ahead. *Science,* **328(5986)**, 1642-1643.

Palacios, J.D. and L. Miranda, 2005: ‘Concertación’(reaching agreement) and planning for sustainable development in ilo, peru. *Reducing Poverty and Sustaining the Environment.Edited by Bass S, Reid H, Satterthwaite D, Steele P.London: Earthscan,* , 255-279.

Palloni, A., G. Pinto-Aguirre, and M. Pelaez, 2002: Demographic and health conditions of ageing in latin america and the caribbean. *International Journal of Epidemiology,* **31(4)**, 762.

Pan, Y., R.A. Birdsey, J. Fang, R. Houghton, P.E. Kauppi, W.A. Kurz, O.L. Phillips, A. Shvidenko, S.L. Lewis, J.G. Canadell, P. Ciais, R.B. Jackson, S.W. Pacala, A.D. McGuire, S. Piao, A. Rautiainen, S. Sitch, and D. Hayes, 2011: A large and persistent carbon sink in the World’s forests. *Science,* **333(6045)**, 988-993.

Parkins, J.R., 2008: The metagovernance of climate change: Institutional adaptation to the mountain pine beetle epidemic in british columbia. *Journal of Rural and Community Development,* **3(2)**, 7-26.

Parkins, J.R. and N.A. MacKendrick, 2007: Assessing community vulnerability: A study of the mountain pine beetle outbreak in british columbia, canada. *Global Environmental Change,* **17**, 460-471.

Parmesan, C., 2006: Ecological and evolutionary responses to recent climate change. *Annual Review of Ecology Evolution and Systematics,* **37**, 637-669.

Parnell, S., D. Simon, and C. Vogel, 2007: Global environmental change: Conceptualising the growing challenge for cities in poor countries. *Area,* **39(3)**, 357-369.

Parris, A., C. Simpson, and S. Abdelrahim, 2010: RISA Workshop Report: Looking Ahead at Climate Service, Assessment, and Adaptation, National Oceanographic and Atmospheric Administration, Climate Program Office, Silver Spring, Maryland, .

Parshall, L., K. Gurney, S.A. Hammer, D. Mendoza, Y. Zhou, and S. Geethakumar, 2010: Modeling energy consumption and CO2 emissions at the urban scale: Methodological challenges and insights from the united states. *Energy Policy,* **38(9)**, 4765-4782.

Pataki, D., R. Alig, A. Fung, N. Golubiewski, C. Kennedy, E. McPherson, D. Nowak, R. Pouyat, and P. Romero Lankao, 2006: Urban ecosystems and the north american carbon cycle. *Global Change Biology,* **12(11)**, 2092-2102.

Patriquin, M.N., A.M. Wellstead, and W.A. White, 2007: Beetles, trees and people: Regional economic impact sensitivity and policy considerations related to the mountain pine beetle infestation in british columbia, canada. *Forest Policy and Economics,* **9**, 938-946.

Payne, J.T., A. Wood, A. Hamlet, R. Palmer, and D. Lettenmaier, 2004: Mitigating the effects of climate change on the water resources of the columbia river basin *Climatic Change,* **62(1–3):233–256**.

Payne, J.T., A.W. Wood, A.F. Hamlet, R.N. Palmer, and D.P. Lettenmaier, 2004: Mitigating the effects of climate change on the water resources of the columbia river basin. *Climatic Change,* **62(1)**, 233-256.

Peach, J. and J. Williams, 2007: Population and economic dynamics on the U.S.-mexican border: Past, present, and future. In: *The U.S.-mexican border environment: A road map to a sustainable 2020.* [Ganster, P. (ed.)]. SCERP and SDSU Press, San Diego, .

Pearce, T., J.D. Ford, F. Duerden, B. Smit, M. Andrachuk, L. Berrang-Ford, and T. Smith, 2011: Advancing adaptation planning for climate change in the inuvialuit settlement region (isr): A review and critique. *Regional Environmental Change,* **11**, 1-17.

Pearce, T.D., Ford, J.D. , Prno, J. , Duerden, F. , Pittman, J. , Beaumier, M. , Berrang-Ford, L. , Smit, B., 2011: Climate change and mining in canada. *Mitigation and Adaptation Strategies for Global Change,* **16(3)**, 347-368.

Pearson, C.J., D. Bucknell, and G.P. Laughlin, 2008: Modelling crop productivity and variability for policy and impacts of climate change in eastern canada. *Environmental Modelling & Software,* **23**, 1345-1355.

Pelling, M., 2011: Urban governance and disaster risk reduction in the caribbean: The experiences of oxfam GB. *Environment and Urbanization,* **23(2)**, 383-400.

Pelling, M. and K. Dill, 2010: Disaster politics: Tipping points for change in the adaptation of sociopolitical regimes. *Progress in Human Geography,* **34(1)**, 21.

Pelling, M. and C. High, 2005: Understanding adaptation: What can social capital offer assessments of adaptive capacity? *Global Environmental Change Part A,* **15(4)**, 308-319.

Pelling, M. and L. Schipper, Climate adaptation as risk manage-ment: Limits and lessons from disas-ter risk reduction. *GECHS Synthesis Human Security in an Era of Global Change,* , 29.

Peng, C., Z. Ma, X. Lei, Q. Zhu, H. Chen, W. Wang, S. Liu, W. Li, X. Fang, and X. Zhou, 2011: A drought-induced pervasive increase in tree mortality across canada's boreal forests. **1(9)**, 467-471.

Peredo-Videa, B., 2008: Climate change, energy and biodiversity conservation in Bolivia–roles, dynamics and policy responses. *Policy Matters,* **16**, 163-174.

Perkins, B., D. Ojima, and R. Corell, 2007: A survey of climate change adaptation planning. *Environment,* , 1-52.

Peter, B., S. Want, T. Mogus, and B. Wilson, 2006: *Canadian Wildland Fire Strategy: Background, Syntheses, Analyses, and Perspectives.* Fire Risk and Population Trends in Canada’s Wildland-Urban Interface Canadian Council for Forest Ministries, Edmonton, Alberta, CA, 37-48 pp.

Peterson, T.C.e.a., 2009: State of the climate in 2008. *Bulletin of the American Meteorological Society,* **90**, S13.

Pfister, G.G., C. Wiedinmyer, and L.K. Emmons, Impacts of the fall 2007 california wildfires on surface ozone: Integrating local observations with global model simulations.

Pfister, G.G., C. Wiedinmyer, and L.K. Emmons, 2008: Impacts of the fall 2007 california wildfires on surface ozone: Integrating local observations with global model simulations. *Geophysical Research Letters,* **35(19)**, 1-5.

Phillips, O. L., L. Aragao, S.L. Lewis, J.B. Fisher, J. Lloyd, G. Lopez-Gonzalez, Y. Malhi, A. Monteagudo, J. Peacock, and C.A. Quesada, 2009: Drought sensitivity of the amazon rainforest. *Science,* **323(5919)**, 1344-1347.

Phillips, M.L., 2008: Dengue reborn: Widespread resurgence of a resilient vector. *Environmental Health Perspectives,* **116(9)**, 382-388.

Philpott, S.M. and B.B. Lin, 2008: A multi-scale assessment of hurricane impacts on agricultural landscapes based on land use and topographic features. *Agriculture, Ecosystems and Environment,* **128**, 12-20.

Pielke Jr, R.A., J. Gratz, C.W. Landsea, D. Collins, M.A. Saunders, and R. Musulin, 2008: Normalized hurricane damage in the united states: 1900-2005. *Natural Hazards Review,* **9(1)**, 29.

Pielke Jr, R.A., J. Rubiera, C. Landsea, M.L. Fernández, and R. Klein, 2003: Hurricane vulnerability in latin america and the caribbean: Normalized damage and loss potentials. *Natural Hazards Review,* **4**, 101.

Pierce, J. and G. Meyer, 2008: Long-term fire history from alluvial fan sediments: The role of drought and climate variability, and implications for management of rocky mountain forests. *International Journal of Wildland Fire,* **17(1)**, 84-95.

Piguet, E., 2010: Climate and migration: A synthesis. *Environment, Forced Migration and Social Vulnerability,* , 73.

Pistrika, A.K. and S.N. Jonkman, 2010: Damage to residential buildings due to flooding of new orleans after hurricane katrina. *Natural Hazards*, , 1-22.

Pittman, J., V. Wittrock, S. Kulshreshtha, and E. Wheaton, 2011: Vulnerability to climate change in rural saskatchewan: Case study of the rural municipality of rudy no. 284. *Journal of Rural Studies*, **27**, 83-94.

Plaza, G.D.C. and M. Pasculli, 2005: Gestión integral de residuos sólidos municipales para mitigar el cambio climático en la provincia de salta. In: Proceedings of Congreso munidal ISWA, argentina, pp. 19-27.

Poirier, B. and R.C. de Loë, 2012: Protecting aquatic ecosystems in heavily-allocated river systems: The case of the oldman river basin, alberta. *The Canadian Geographer 55(2): 243-61.*, .

Porter, J.R. and M.A. Semenov, 2005: Crop responses to climatic variation. *Philosophical Transactions of the Royal Society B-Biological Sciences*, **360**, 2021-2035.

Posey, J., 2009: The determinants of vulnerability and adaptive capacity at the municipal level: Evidence from floodplain management programs in the united states. *Global Environmental Change*, **19(4)**, 482-493.

Posey, J., 2009: The determinants of vulnerability and adaptive capacity at the municipal level: Evidence from floodplain management programs in the united states. *Global Environmental Change*, **(19)**, 482-493.

Powers, S.E., J.C. Ascough II, R.G. Nelson, and G.R. Larocque, 2011: Modeling water and soil quality environmental impacts associated with bioenergy crop production and biomass removal in the midwest USA. *Ecological Modeling 222 (2011) 2430-2447.*, .

Praskievicz, S. and H. Chang, 2011: Impacts of climate change and urban development on water resources in the tualatin river basin, oregon. *Annals of the Association of American Geographers, 101 (2), Pp. 249-271.*, .

Pratchett, M.S., P.L. Munday, S.K. Wilson, N.A.J. Graham, J.E. Cinner, D.R. Bellwood, G.P. Jones, N.V.C. Polunin, and T.R. McClanahan, 2008: Effects of climate-induced coral bleaching on coral-reef fishes-ecological and economic consequences. *Oceanography and Marine Biology: An Annual Review*, **46**, 251-296.

Preston, B.L., R.M. Westaway, and E.J. Yuen, 2010: Climate adaptation planning in practice: An evaluation of adaptation plans from three developed nations. *Mitigation and Adaptation Strategies for Global Change*, **16(4)**, 407.

Prodanovic, P. and S. Simonovic, 2007: Development of rainfall intensity duration frequency curves for the city of london under the changing climate. *University of Western Ontario, Department of CEE, Water Resources Research Report, Report no: 058, November 2007*, .

Pryor, S. C., R. J. Barthelmie, D. T. Young, E. S. Takle, R. W. Arritt, D. Flory, W. J. Gutowski Jr., A. Nunes, and J. Roads, 2009: Wind speed trends over the contiguous united states. *Journal of Geophysical Research*, **114**, D14105, doi:10.1029/2008JD011416.

PT McPhearson, 2011: **Toward a sustainable new york city: Greening through urban forest restoration**. *Sustainability in America's Cities*, .

Pulver, S., 2009: Climate change politics in mexico. *Changing Climates in North American Politics: Institutions, Policymaking, and Multilevel Governance*, , 25.

Pye, H.O.T., H. Liao, S. Wu, L.J. Mickley, D.J. Jacob, D.K. Henze, and J.H. Seinfeld, 2009: Effect of changes in climate and emissions on future sulfate-nitrate-ammonium aerosol levels in the united states. *Journal of Geophysical Research*, **114**, 1-18.

Pye, H.O.T., H. Liao, S. Wu, L.J. Mickley, D.J. Jacob, D.K. Henze, and J.H. Seinfeld, 2009: Effect of changes in climate and emissions on future sulfate-nitrate-ammonium aerosol levels in the united states. *Journal of Geophysical Research*, **114**, 1-18.

Qi, H. and M. Altinakar, 2011: Short communication: A GIS-based decision support system for integrated flood management under uncertainty with two dimensional numerical simulations. *Environmental Modelling & Software*, **26(6)**, 817-821.

Rabassa, J., 2009: Impact of global climate change on glaciers and permafrost of south america, with emphasis on patagonia, tierra del fuego, and the antarctic peninsula. *Developments in Earth Surface Processes*, **13**, 415-438.

Racherla, P.N. and P.J. Adams, 2009: U.S. ozone air quality under changing climate and anthropogenic emissions. *Environmental Science & Technology*, **43(3)**, 571-7.

Radel, C., B. Schmook, and S. McCandless, 2010: Environment, transnational labor migration, and gender: Case studies from southern yucatán, mexico and vermont, USA. *Population & Environment*, , 1-21.

Radeloff, V.C., R.B. Hammer, S.I. Stewart, J.S. Fried, S.S. Holcomb, and J.S. McKeefry, 2005: The wildland-urban interface in the united states. *Ecological Applications*, **15(3)**, 799-805.

Raffa, K.F., B.H. Aukema, B.J. Bentz, A.L. Carroll, J.A. Hicke, M.G. Turner, and W.H. Romme, 2008: Cross-scale drivers of natural disturbances prone to anthropogenic amplification: The dynamics of bark beetle eruptions. *Bioscience,* **58(6)**, 501-517.

Raleigh, C. and L. Jordan, 2009: Climate change and migration: Emerging patterns in the developing world. *The Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World,* , 103.

Ramanathan, V. and Y. Feng, 2009: Air pollution, greenhouse gases and climate change: Global and regional perspectives. *Atmospheric Environment,* **43(1)**, 37-50.

Ramos, M.M., H. Mohammed, E. Zielinski-Gutierrez, M.H. Hayden, J.L.R. Lopez, M. Fournier, A.R. Trujillo, R. Burton, J.M. Brunkard, L. Anaya-Lopez, A.A. Banicki, P.K. Morales, B. Smith, J. MuÃ±oz L., and S.H. Waterman, 2008: Epidemic dengue and dengue hemorrhagic fever at the texas-mexico border: Results of a household-based seroepidemiologic survey, december 2005. *The American Journal of Tropical Medicine and Hygiene,* **78(3)**, 364-9.

RAMSAR STRP10 Bureau's Deputy Secretary General, 2002: "Wetlands: Water, life, and culture" 8th meeting of the conference of the contracting parties to the convention on wetlands (ramsar, iran, 1971) valencia, spain, 18-26 november 2002. In: *Climate change and wetlands: Impacts, adaptation and mitigation* [Gitay, H., R. Van Dam, and M. Finlayson (ed.)]. Gland, Switzerland, pp. 18-26.

Rappold, A.G., S.L. Stone, W.E. Cascio, L.M. Neas, V.J. Kilaru, M.S. Carraway, J.J. Szykman, A. Ising, W.E. Cleve, J.T. Meredith, H. Vaughan-Batten, L. Deyneka, and R.B. Devlin, 2011: Peat bog wildfire smoke exposure in rural north carolina is associated with cardiopulmonary emergency department visits assessed through syndromic surveillance. *Environmental Health Perspectives,* **119(10)**, 1415-20.

Rasmussen, A., 2002: The effects of climate change on the birch pollen season in denmark. *Aerobiologia,* **18(3)**, 253-265.

Reardon, T. and J.A. Berdegué, 2002: The rapid rise of supermarkets in latin america: Challenges and opportunities for development. *Development Policy Review,* **20**, 371-388.

Reid, C.E., M.S. O'Neill, C.J. Gronlund, S.J. Brines, D.G. Brown, A.V. Diez-Roux, and J. Schwartz, 2009: Mapping community determinants of heat vulnerability. *Environmental Health Perspectives,* **117(11)**, 1730.

Reid, S., B. Smit, W. Caldwell, and S. Belliveau, 2007: Vulnerability and adaptation to climate risks in ontario agriculture. *Mitigation and Adaptation Strategies for Global Change,* **12**, 609-637.

Reisen, F. and S.K. Brown, 2009: Australian firefighters' exposure to air toxics during bushfire burns of autumn 2005 and 2006. *Environment International,* **35(2)**, 342-352.

Reisen, F., D. Hansen, and C. Meyer, 2011: Exposure to bushfire smoke during prescribed burns and wildfires: Firefighters' exposure risks and options. *Environment International,* **37(2)**, 314-321.

Reiss, N.M. and S.R. Kostic, 1976: Pollen season severity and meteorologic parameters in central new jersey. *The Journal of Allergy and Clinical Immunology,* **57(6)**, 609-14.

Reiter, P., 2008: Climate change and mosquito-borne disease : Knowing the horse before hitching the cart. *Revue Scientifique Et Technique - Office International Des Epizooties,* **27(2)**, 383-398.

Repetto, R., 2008: *Working Paper Number 13.* The Climate Crisis and the Adaptation Myth, Yale School of Forestry and Environmental Studies, 1-20 pp.

Reynolds, K.a., K.D. Mena, and C.P. Gerba, 2008: Risk of waterborne illness via drinking water in the united states. *Reviews of Environmental Contamination and Toxicology,* **192**, 117-58.

Rinner, C., D. Patychuk, K. Bassil, S. Nasr, S. Gower, and M. Campbell, 2010: The role of maps in neighborhood-level heat vulnerability assessment for the city of toronto. *Cartography and Geographic Information Science,* **37(1)**, 31-44.

Rivas, A.I.M., C.C. Alvarez, G.R. Dorantes, J.D.G. Diaz, and C.G. Garcia, 2011: Assessing current and potential rainfed maize suitability under climate change scenarios in mexico. *Atmosfera,* **24(1)**, 53-67.

Roberts, J.T. and B.C. Parks, 2007: Fueling injustice: Globalization, ecologically unequal exchange and climate change. *Globalizations,* **4(2)**, 193.

Roberts, N., 2009: Culture and landslide risk in the central andes of bolivia and peru. *Studia Universitatis Babes-Bolyai, Geologia,* **54(1)**, 11.

Robertson, R., D. Brown, G. Pierre, and L.(.). Sanchez-Puerta, 2009: Globalisation, Wages, and the Quality of Jobs Five Country Studies, The World Bank, Washington, D.C., .

Robinson, P.J. and C.D. Gore, 2005: Barriers to canadian municipal response to climate change. *Canadian Journal of Urban Research,* **14(1)**, 102-121.

Rodríguez, H. and W. Donner, 2009: Population composition, migration and inequality: The influence of demographic changes on disaster risk and vulnerability. *Social Forces,* **87(2)**, 1089-1114.

Rodriguez-Oreggia, E., A. de la Fuente, and R. de la Torre, 2008: The impact of natural disasters on human development and poverty at the municipal level in mexico. *Background Paper of the ISDR/RBLAC-UNDP Project on Disaster Risk and Poverty in Latin America,* .

Romero Lankao, P., 2011: Missing the multiple dimensions of water? neoliberal modernization in mexico city and buenos aires. *Policy and Society,* **30(4)**, 267-283.

Romero Lankao, P., Qin, H., and Dickinson, K., Forthcoming: **Urban vulnerability to temperature-related hazards: A meta-analysis and meta-knowledge approach**. *Global Environmental Change,* .

Romero Lankao, P. and G. Gunter, 2011: Missing the multiple dimensions of water? neoliberal modernization in mexico city and buenos aires. *Policy and Society,* **30(4)**, 267-283.

Romero-Lankao, P., 2010: Water in mexico city: What will climate change bring to its history of water-related hazards and vulnerabilities? *Environment and Urbanization,* **22(1)**, 157.

Romero-Lankao, P., 2007: How do local governments in mexico city manage global warming. *Local Environment,* **12(5)**, 519-535.

Romero-Lankao, P., 2007: How do local governments in mexico city manage global warming? *Local Environment,* **12(5)**, 519-535.

Romero-Lankao, P., 2008: Urban areas and climate change: Review of current issues and trends issues paper for the 2011 global report on human settlements.

Romero-Lankao, P., 2012: Governing carbon and climate in the cities: An overview of policy and planning challenges and options. *European Planning Studies,* **20(1)**, 7-26.

Romero-Lankao, P., 2012: Governing carbon and climate in the cities: An overview of policy and planning challenges and options. *European Planning Studies,* **20(1)**, 7-26.

Romero‐Lankao, P., 2011: Urban responses to climate change in latin america: Reasons, challenges and opportunities. *Architectural Design,* **81(3)**, 76-79.

Romero-Lankao, P., M. Borbor-Cordova, R. Abrutsky, G. Günther, E. Behrenz, and L. Dawidowsky, 2012: ADAPTE: A tale of diverse teams coming together to do issue-driven interdisciplinary research. *Environmental Science & Policy,* .

Romero-Lankao, P. and D. Dodman, 2011: Cities in transition: Transforming urban centers from hotbeds of GHG emissions and vulnerability to seedbeds of sustainability and resilience:: Introduction and editorial overview. *Current Opinion in Environmental Sustainability,* .

Romero-Lankao, P. and D. Gnatz, 2011: Introduction. urbanization and the challenge of climate change. *UN-Habitat, UN-Habitat Report on Cities and Climate Change,* , 1-16.

Romero-Lankao, P., D. Nychka, and J. Tribbia, 2008: Development and greenhouse gas emissions deviate from the'modernization' theory and'convergence' hypothesis. *Climate Research,* **38(1)**, 17-29.

Romme, W.H., J. Clement, J. Hicke, D. Kulakowski, L.H. MacDonald, T.L. Schoennagel, and T.T. Veblen, 2006: Recent Forest Insect Outbreaks and Fire Risk in Colorado Forests: A Brief Synthesis of Relevant Research, Colorado Forest Restoration Institute, Fort Collins, CO, .

Root, T., 1988: Energy constraints on avian distributions and abundances. *Ecology,* **69(2)**, pp. 330-339.

Root, T.L., D.P. MacMynowski, M.D. Mastrandrea, and S.H. Schneider, 2005: Human-modified temperatures induce species changes: Joint attribution. *Proceedings of the National Academy of Sciences of the United States of America,* **102(21)**, 7465-7469.

Rose, S. and R. Shaw, 2008: The gamble: Circular mexican migration and the return on remittances. *Mexican Studies/Estudios Mexicanos,* , 79-111.

Rose, J.B., P.R. Epstein, E.K. Lipp, B.H. Sherman, S.M. Bernard, and J.a. Patz, 2001: Climate variability and change in the united states: Potential impacts on water- and foodborne diseases caused by microbiologic agents. *Environmental Health Perspectives,* **109 Suppl**, 211-21.

Roseen, R., T. Janeski, J. Houle, M. Simpson, and J. Gunderson, 2011: **FORGING THE LINK**
Linking the Economic Benefits of Low Impact Development and Community Decisions
the UNH Stormwater Center, University of New Hampshire, July 2011. .

Rosenberg, E.A., P.W. Keys, D.B. Booth, D. Hartley, J. Burkey, A.C. Steinemann, and D.P. Lettenmaier, 2010: Precipitation extremes and the impacts of climate change on stormwater infrastructure in washington state. *Climatic Change, 102, 319-349.,* .

Rosenthal, J., 2009: Climate change and the geographic distribution of infectious diseases. *EcoHealth,* **6(4)**, 489-95.

Rosenthal, J.K., E.D. Sclar, P.L. Kinney, K. Knowlton, R. Crauderueff, and P. Brandt-Rauf, 2007: Links between the built environment, climate and population health: Interdisciplinary environmental change research in new york city. *Annals of the Academy of Medicine, Singapore,* **36(10)**, 834-46.

Rosenthal, J.K., E.D. Sclar, P.L. Kinney, K. Knowlton, R. Crauderueff, and P. Brandt-Rauf, 2007: Links between the built environment, climate and population health: Interdisciplinary environmental change research in new york city. *Annals of the Academy of Medicine, Singapore,* **36(10)**, 834-46.

Rosenzweig, , 2007: Assessment of observed changes and responses in natural and managed systems. In: *Climate change 2007: Impacts, adaptation and vulnerability. contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change,*. [M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson (ed.)]. Cambridge University Press, .

Rosenzweig, C. and D. Hillel, 1998: *Climate change and the global harvest: Potential impacts of the greenhouse effect on agriculture.* Oxford University Press, New York, NY, .

Rosenzweig, C. and R. Horton, 2009: Climate change scenarios for the new york metropolitan region. In: Proceedings of Fourth symposium on policy and Socio—Economic research, .

Rosenzweig, C., D.C. Major, K. Demong, C. Stanton, R. Horton, and M. Stults, 2007: Managing climate change risks in new york city's water system: Assessment and adaptation planning. . *Mitigation and Adaptation Strategies for Global Change, 12(8), 1391-1409., .*

Rosenzweig, C., D.C. Major, K. Demong, C. Stanton, R. Horton, and M. Stults, 2007: Managing climate change risks in new york City’s water system: Assessment and adaptation planning. *Mitigation and Adaptation Strategies for Global Change,* **12(8)**, 1391-1409.

Rosenzweig, C., D.C. Major, K. Demong, C. Stanton, R. Horton, and M. Stults, 2007: Managing climate change risks in new york City’s water system: Assessment and adaptation planning. *Mitigation and Adaptation Strategies for Global Change, 12, 1391–1409, .*

Rosenzweig, C., D.C. Major, K. Demong, C. Stanton, R. Horton, and M. Stults, 2007.: Managing climate change risks in new york City’s water system: Assessment and adaptation planning. *Mitigation and Adaptation Strategies for Global Change, 12, 1391–1409, .*

Rosenzweig, C. and W. Solecki, 2010: Introduction to climate change adaptation in new york city: Building a risk management response. *Annals of the New York Academy of Sciences,* **1196(1)**, 13-18.

Rosenzweig, C., W. Solecki, S.A. Hammer, and S. Mehrotra, 2010: Cities lead the way in climate-change action. *Nature,* **467(7318)**, 909-911.

Rosenzweig, C., W.D. Solecki, R. Blake, M. Bowman, C. Faris, V. Gornitz, R. Horton, K. Jacob, A. LeBlanc, and R. Leichenko, 2011: Developing coastal adaptation to climate change in the new york city infrastructure-shed: Process, approach, tools, and strategies. *Climatic Change,* , 1-35.

Rosenzweig, C., W.D. Solecki, L. Parshall, M. Chopping, G. Pope, and R. Goldberg, 2005: Characterizing the urban heat island in current and future climates in new jersey. *Global Environmental Change Part B: Environmental Hazards,* **6(1)**, 51-62.

Roveta, R.J. and International Institute for Environment and Development, 2008: *Resilience to climate change in patagonia, argentina.* Citeseer, .

Ruddell, D.M., S.L. Harlan, S. Grossman-Clarke, and A. Buyantuyev, 2010: Risk and exposure to extreme heat in microclimates of phoenix, AZ. *Geospatial Techniques in Urban Hazard and Disaster Analysis,* , 179-202.

Ruddell, D.M., S. Harlan, S. Grossman-Clarke, and G. Chowell, 2009: Scales of perception: Public awareness of neighborhood and regional temperature differences. In: Proceedings of Fourth symposium on policy and Socio—Economic research, .

Rudel, T.K., 2008: Meta-analyses of case studies: A method for studying regional and global environmental change. *Global Environmental Change,* **18(1)**, 18-25.

Rudel, T.K., 2009: How do people transform landscapes? A sociological perspective on suburban sprawl and tropical Deforestation1. *American Journal of Sociology,* **115(1)**, 129-154.

Russell, R.C., 2009: Mosquito-borne disease and climate change in australia: Time for a reality check. *Australian Journal of Entomology,* **48(1)**, 1-7.

Ruth, M. and P. Kirshen, 2001: Integrated impacts of climate change upon infrastructure systems and services in the boston metropolitan area. *World Resource Review,* **13(1)**, 106-122.

Sabine, C.L., M. Heimann, P. Artaxo, D.C.E. Bakker, C.T.A. Chen, C.B. Field, N. Gruber, C. Le Quéré, R.G. Prinn, and J.E. Richey, 2004: *Current status and past trends of the global carbon cycle.* Island Press, Washington, DC, USA, .

Saha, D. and R.G. Paterson, 2008: Local government efforts to promote the “Three es” of sustainable development. *Journal of Planning Education and Research,* **28(1)**, 21.

Sahoo, G., S.G. Schladow, J.E. Reuter, and R. Coats, 2010: Effects of climate change on thermal properties of lakes and reservoirs, and possible implications. *Stoch Environ Res Risk Assess (2011) 25:445–456.,* .

Sakurai, G., T. Iizumi, and M. Yokozawa, 2011: Varying temporal and spatial effects of climate on maize and soybean affect yield prediction. *Climate Research,* **49**, 143-154.

Sala, O.E., F.S. Chapin, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, and D.H. Wall, 2000: Global biodiversity scenarios for the year 2100. *Science,* **287(5459)**, 1770-1774.

Saldaña-Zorilla, S. and S. Sandberg, 2009: Impact of climate-related disasters on human migration in mexico: A spatial model. *Climatic Change,* **96**, 97-118.

Saldaña-Zorrilla, S.O. (ed.), 2006: *Reducing Economic Vulnerability in Mexico: Natural Disasters, Trade Liberalization and Poverty.* Wirtschaftsuniversität Wien, Vienna, Austria, .

Saldaña-Zorrilla, S.O., 2008: Stakeholders’ views in reducing rural vulnerability to natural disasters in southern mexico: Hazard exposure and coping and adaptive capacity. *Global Environmental Change,* **18**, 583-597.

Saldaña-Zorrilla, S.O. and K. Sandberg, 2009: Spatial econometric model of natural disaster impacts on human migration in vulnerable regions of mexico. *Disasters,* **33(4)**, 591-607.

Sanchez-Rodriguez, R., 2009: Learning to adapt to climate change in urban areas. A review of recent contributions. *Current Opinion in Environmental Sustainability,* **1(2)**, 201-206.

Sarah, B., 2010: Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in british columbia, canada. *Global Environmental Change,* **20(2)**, 287-297.

Saskatchewan Pulse Growers, 2000: Pulse Production Manual, 2nd Ed. Saskatchewan Pulse Growers, Saskatoon, SK, .

Satterthwaite, D., 2003: The links between poverty and the environment in urban areas of africa, asia, and latin america. *The Annals of the American Academy of Political and Social Science,* **590(1)**, 73.

Satterthwaite, D., S. Huq, H. Reid, M. Pelling, and P. Romero-Lankao, 2007: Adapting to climate change in urban areas. *London: IIED,* .

Satterthwaite, D. and International Institute for Environment and Development, 2007: *Adapting to climate change in urban areas: The possibilities and constraints in low-and middle-income nations.* International Institute for Environment and Development, .

Savonis, M.J., V.R. Burkett, and J.R. Potter, 2008: *U.S. Climate Change Science Program Synthesis and Assessment Product 4.7.* **Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I**, U.S. Climate Change Science Program, Washington DC.

Sayago, J.M., M.M. Collantes, L.V. Neder, and J. Busnelli, 2010: Cambio climático y amenazas ambientales en el área metropolitana de tucumán. *Revista De La Asociación Geológica Argentina,* **66(4)**, 544-554.

Schlenker, W., W.M. Hanemann, and A.C. Fisher, 2007: Water availability, degree days, and the potential impact of climate change on irrigated agriculture in california. *Climatic Change,* **81**, 19-38.

Schlenker, W. and M.J. Roberts, 2009: Nonlinear temperature effects indicate severe damages to us crop yields under climate change
. *Proceedings of the National Academy of Sciences of the United States of America,* **106(37)**, 15594-15598.

Schmidhuber, J. and F.N. Tubiello, 2007: Global food security under climate change. *Proceedings of the National Academy Sciences of the United States of America,* **104(50)**, 19703-19708.

Schmidtlein, M.C., R.C. Deutsch, W.W. Piegorsch, and S.L. Cutter, 2008: A sensitivity analysis of the social vulnerability index. *Risk Analysis,* **28(4)**, 1099-1114.

Schoennagel, T., T.T. Veblen, and W.H. Romme, 2004: The interaction of fire, fuels, and climate across rocky mountain forests. *Bioscience,* **54(7)**, 661-676.

Scholze, M., W. Knorr, N.W. Arnell, and I.C. Prentice, 2006: A climate-change risk analysis for world ecosystems. *Proceedings of the National Academy of Sciences,* **103(35)**, 13116-13120.

Schroeder, H. and H. Bulkeley, 2008: Governing climate change post-2012: The role of global cities case-study: Los angeles. *Tyndall Centre for Climate Change Research Working Paper,* **122**.

Schroth, G., P. Laderach, J. Dempewolf, S.M. Philpott, J. Haggar, H. Eakin, T. Castillejos, J. Garcia Moreno, L. Soto Pinto, R. Hernandez, A. Eitzinger, and J. Ramirez-Villegas, 2009: Schroth, G., P. laderach, J. dempewolf, S. M. philpott, J. haggar, H. eakin, T. castillejos, J. garcia moreno, L. soto pinto, R. hernandez, A. eitzinger and

J. ramirez-villegas, 2009: Towards a climate change adaptation strategy for coffee communities and ecosystems in the sierra madre de chiapas, mexico. mitigation and adaptation strategies for global change, 14(7), 605-625. *Mitigation and Adaptation Strategies for Global Change,* **14(7)**, 605-625.

Schwentesius, R. and M.A. Gómez, 2002: Supermarkets in mexico: Impacts on horticulture systems. *Development Policy Review,* **20(4)**, 487-502.

Scnhepf, R. and R.M. Chite, 2005: U.S. Agriculture After Hurricane Katrina: Status and Issues. C.R. Service, Washington, DC. The Library of Congress, .

Scott, B.R., 2008: It's time for a new low-dose-radiation risk assessment paradigm—one that acknowledges hormesis. *Dose-Response,* **6(4)**, 333-351.

Scott, C.A. and J.M. Banister, 2008: The dilemma of water management 'Regionalization'in mexico under centralized resource allocation. *Water Resources Development,* **24(1)**, 61-74.

Scott, D.J., Dawson, and B. Jones, 2008: Climate change vulnerability of the US northeast winter recreation-tourism sector. *Mitigation and Adaptation Strategies for Global Change,* **13**, 577-596.

Scott, D., Amelung, B., Becken, S., Ceron, J-P., Dubois, G., Gössling, S., Peeters, P., Simpson, M., 2008: Technical Report. in: Climate Change and Tourism: Responding to Global Challenges. Madrid: United Nations World Tourism Organization; Paris: United Nations Environment Program; Geneva: World Meteorological Organization. 23-250, .

Scott, D. and B. Jones, 2008: *Climate change and nature-based tourism: Implications for park visitation in canada.* Univeristy of Waterloo, Ontario, CAN, .

Scott, D. and G. McBoyle, 2007: Climate change adaptation in the ski industry. *Mitigation and Adaptation Strategies for Global Change,* **12(8)**, 1411-1431.

Scott, D.B., Jones, and J. Konopek, 2007: Implications of climate and environmental change for nature-based tourism in the canadian rocky mountains: A case study of waterton lakes national park. *Tourism Management,* **28**, 570-579.

Scott, D.G., McBoyle, and A. Minogue, 2007: Climate change and quebec's ski industry. *Global Environmental Change,* **17**, 181-190.

Scott, J., 2007: *Agricultural policy and rural poverty in mexico.* CIDE, .

Scott, J., 2007: Agricultural Policy and Rural Poverty in Mexico, Centro de Investigación y Docencia Económicas, Working Papers. Economics Department, .

Seager, R., and G. Vecchi, 2010: Greenhouse warming and the 21st century hydroclimate of southwestern north america. *Proceedings of the National Academy of Sciences of the United States of America,* **(107)**, 21277-21282.

Seager, R. and G.A. Vecchi, 2010: Greenhouse warming and the 21st century hydroclimate of southwestern north america. *Proceedings of the National Academy of Sciences of the United States of America,* **107(50)**, 21277-21282.

Seager, R., M. Ting, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H. Huang, N. Harnik, A. Leetmaa, N. Lau, C. Li, J. Velez, and N. Naik, 2007: Model projections of an imminent transition to a more arid climate in southwestern north america. *Science,* **316(5828)**, 1181-1184.

Searchinger, T., R. Heimlich, R.A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T. Yu, 2008: Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change. *Science,* **319**, 1238-1240.

Secretary of the Interior, 2010: *Addressing the impacts of climate change on America's water, land, and other natural and cultural resources* Washington DC, .

SEMARNAT, 2010: *Comisión intersecretarial de cambio climático* Government of Mexico, Secretary of the Environment and Natural Resources (SEMARNAT), Mexico City, .

Shaman, J. and M. Kohn, 2009: Absolute humidity modulates influenza survival, transmission, and seasonality. *Proceedings of the National Academy of Sciences of the United States of America,* **106(9)**, 3243-8.

Sharkey, P., 2007: Survival and death in new orleans: An empirical look at the human impact of katrina. *Journal of Black Studies,* **37(4)**, 482.

Sharp, J.H., 2010: Estuarine oxygen dynamics: What can we learn about hypoxia from long-time records in the delaware estuary? *Limnology and Oceanography,* **55(2)**, 535-548.

Shashua-Bar, L., D. Pearlmutter, and E. Erell, 2009: The cooling efficiency of urban landscape strategies in a hot dry climate. *Landscape and Urban Planning,* **92(3-4)**, 179-186.

Sheffield, P.E., K.R. Weinberger, and P.L. Kinney, 2011: Climate change , aeroallergens , and pediatric allergic disease. *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine,* **78(1)**, 78-84.

Sheffield, P.E., K.R. Weinberger, and P.L. Kinney, 2011: Climate change , aeroallergens , and pediatric allergic disease. *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine,* **78(1)**, 78-84.

Sheffield, P.E., K. Knowlton, J.L. Carr, and P.L. Kinney, 2011: Modeling of regional climate change effects on ground-level ozone and childhood asthma. *American Journal of Preventive Medicine,* **41(3)**, 251-7.

Sheffield, P.E., K. Knowlton, J.L. Carr, and P.L. Kinney, 2011: Modeling of regional climate change effects on ground-level ozone and childhood asthma. *American Journal of Preventive Medicine,* **41(3)**, 251-7.

Sheffield, P.E., K.R. Weinberger, K. Ito, T.D. Matte, R.W. Mathes, G.S. Robinson, and P.L. Kinney, 2011: The association of tree pollen concentration peaks and allergy medication sales in new york city: 2003â€“2008. *ISRN Allergy,* **2011**, 1-7.

Shepherd, A., K.M. Gill, and S.B. Rood, 2010.: Climate change and future flows of rocky mountain rivers: Converging forecasts from empirical trend projection and down-scaled global circulation modelling. *Hydrological Processes 24(26): 3864-3877.*, .

Sheridan, S.C., 2007: A survey of public perception and response to heat warnings across four north american cities: An evaluation of municipal effectiveness. *International Journal of Biometeorology,* **52(1)**, 3-15.

Sherriff, R.L. and T.T. Veblen, 2008: Variability in fire-climate relationships in ponderosa pine forests in the colorado front range. *International Journal of Wildland Fire,* **17**, 50-59.

Shrubsole, D., 2000: Flood management in canada at the crossroads. *Global Environmental Change Part B: Environmental Hazards,* **2(2)**, 63-75.

Simmons, K.M. and D. Sutter, 2007: Tornado shelters and the housing market. *Construction Management and Economics,* **25(11)**, 1119-1126.

Simmons, K.M. and D. Sutter, 2007: Tornado shelters and the manufactured home parks market. *Natural Hazards,* **43(3)**, 365-378.

Sinervo, B., F. Méndez-de-la-Cruz, D.B. Miles, B. Heulin, E. Bastiaans, M. Villagrán-Santa Cruz, R. Lara-Resendiz, N. Martínez-Méndez, M.L. Calderón-Espinosa, R.N. Meza-Lázaro, H. Gadsden, L.J. Avila, M. Morando, I.J. De la Riva, P.V. Sepulveda, C.F.D. Rocha, N. Ibargüengoytía, C.A. Puntriano, M. Massot, V. Lepetz, T.A. Oksanen, D.G. Chapple, A.M. Bauer, W.R. Branch, J. Clobert, and J.W. Sites, 2010: Erosion of lizard diversity by climate change and altered thermal niches. *Science,* **328(5980)**, 894-899.

Singer, B.D., L.H. Ziska, D.A. Frenz, D.E. Gebhard, and J.G. Straka, 2005: Research note : Increasing amb a 1 content in common ragweed (ambrosia artemisiifolia) pollen as a function of rising atmospheric CO 2 concentration. **(2000)**, 667-670.

Sippel, M. and T. Jenssen, 2009: What about local climate governance? A review of promise and problems.

Skinner, W.R., E. Shabbar, M.D. Flannigan, and K. Logan, 2006: Large forest fires in canada and the relationship to global sea surface temperatures. *Journal of Geophysical Research,* **111(D14106)**.

Skinner, W.R., E. Shabbar, M.D. Flannigan, and K. Logan, 2006: Large forest fires in canada and the relationship to global sea surface temperatures. *Journal of Geophysical Research,* **111(D14106)**.

Skoufias, E., K. Vinha, and H.V. Conroy, 2011: *Policy Research Working Paper 5555.* The Impacts of Climate Variability on Welfare in Rural Mexico, The World Bank, Poverty Reduction and Economic Management Network, Poverty Reduction and Equity Unit, .

Skoufias, E., K. Vinha, and H.V. Conroy, 2011: *Policy Research Working Paper 5555.* The Impacts of Climate Variability on Welfare in Rural Mexico, World Bank Poverty Reduction and Equity Unit, .

Slocum, R., 2004: Consumer citizens and the cities for climate protection campaign. *Environment and Planning A,* **36(5)**, 763-782.

Smargiassi, A., M.S. Goldberg, C. Plante, M. Fournier, Y. Baudouin, and T. Kosatsky, 2009: Variation of daily warm season mortality as a function of micro-urban heat islands. *Journal of Epidemiology and Community Health,* **63(8)**, 659.

Smith, B.R., 2009: Re-thinking wastewater landscapes: Combining innovative strategies to address tomorrow's urban wastewater treatment challenges. . *Water Science and Technology, 60(6), 1465-1473,* .

Smoke, V. and H. Health, 2011: Flames. *Environmental Health,* **119(9)**.

Smoke, V. and H. Health, 2011: Flames. *Environmental Health,* **119(9)**.

Smolka, M.O. and A.A. Larangeira, 2008: Informality and poverty in latin american urban policies. *The New Global Frontier: Urbanization, Poverty and Environment in the 21st Century,* , 99.

Smoyer, K.E., D.G.C. Rainham, and J.N. Hewko, 2000: Heat-stress-related mortality in five cities in southern ontario: 1980–1996. *International Journal of Biometeorology*, **44(4)**, 190-197.

Sobel, A.H., M. Biasutti, S.J. Camargo, and T.T. Creyts, 2010: Projected changes in the physical climate of the gulf coast and caribbean. *Letter of Introduction,* .

Sohngen, B. and R. Sedjo, 2005: Impacts of climate change on forest product markets: Implications for north american producers. *The Forestry Chronicle,* **81(5)**, 669-674.

Soja, A.J., N.M. Tchebakova, N.H.F. French, M.D. Flannigan, H.H. Shugart, B.J. Stocks, A.I. Sukhinin, E.I. Parfenova, F.S. Chapin III, and P.W. Stackhouse Jr., 2006: Climate-induced boreal forest change: Predictions versus current observations. *Global and Planetary Change,* **5**, 274-296.

Solecki, W.D. and R.M. Leichenko, 2006: Urbanization and the metropolitan environment: Lessons from new york and shanghai. *Environment: Science and Policy for Sustainable Development,* **48(4)**, 8-23.

Soto-Pinto, L. and M. Anzueto, 2010: Carbon sequestration through agroforestry in indigenous communities of chiapas, mexico. *Agroforestry Systems,* **78(1)**, 39-51.

Spittlehouse, D.L., 2008: *Technical Report no. 045. Climate Change, Impacts and Adaptation Scenarios: Climate Change and Forest and Range Management in British Columbia*, British Columbia Ministry of Forests, Victoria, BC, .

Stefanidou, M., S. Athanaselis, and C. Spiliopoulou, 2008: Health impacts of fire smoke inhalation. *Inhalation Toxicology,* **20(8)**, 761-6.

Steiner, A.L., S. Tonse, R.C. Cohen, A.H. Goldstein, and R.a. Harley, 2006: Influence of future climate and emissions on regional air quality in california. *Journal of Geophysical Research,* **111**, 1-22.

Stern, N. and G. Britain, 2006: *Stern review: The economics of climate change.* HM treasury London, .

Stewart, I.T., D.R. Cayan, and M.D. Dettinger, 2005: Changes toward earlier streamflow timing across western north america. *Journal of Climate,* **18**, 1136-1155.

Stewart, I.T., D.R. Cyan, and M.D. Dettinger, 2005: Changes toward earlier streamflow timing across western north america. *Journal of Climate,* **18**, 1136-1155.

Stewart, S.I., V.C. Radeloff, R.B. Hammer, and T.J. Hawbaker, 2006: Defining the wildland-urban interface. *Journal of Forestry,* **105**, 201-207.

Stiles, M., 2012: On the records. In: *Census map shows population growth by county* The Texas Tribune, .

Stocks, B.J., A. Fosberg, T.J. Lynham, L. Mearns, B.M. Wotton, Q. Yang, J. Jin, K. Lawrence, G.R. Hartley, J.A. Mason, and D.W. McKenney, 1998: Climate change and forest fire potential in russian and canadian boreal forests. *Climatic Change,* **38**, 1-13.

Stone, K.C., P.G. Hunt, K.B. Cantrell, and K.S. Ro, 2010: The potential impacts of biomass feedstock production on water resource availability (2010). *Bioresource Technology, 101 (6), Pp. 2014-2025,* .

Stralberg, D., M. Brennan, J.C. Callaway, J.K. Wood, L.M. Schile, D. Jongsomjit, M. Kelly, T. Parker, and S. Crooks, 2011: Evaluating tidal marsh sustainability in the face of sea-level rise: A hybrid modeling approach applied to san francisco bay. *PLoS ONE,* **6(11)**, e27388.

Stren, R., Governance and climate change: Assessing and learning from canadian cities.

Suarez, P., W. Anderson, V. Mahal, and T. Lakshmanan, 2005: Impacts of flooding and climate change on urban transportation: A systemwide performance assessment of the boston metro area. *Transportation Research Part D: Transport and Environment,* **10(3)**, 231-244.

Sun, G., McNulty, S. G., Moore Myers, J. A., & Cohen, E. C., 2008: Impacts of multiple stresses on water demand and supply across the southeastern united states. *Journal of the American Water Resources Association,* **44(6)**, 1441-1457.

Sun, G., S.G. McNulty, J.A. Moore Myers, and E.C. Cohen, 2008: Impacts of multiple stresses on water demand and supply across the southeastern united states. . *Journal of the American Water Resources Association, 44(6), 1441-1457,* .

Tabachnick, W.J., 2010: Challenges in predicting climate and environmental effects on vector-borne disease episystems in a changing world. *The Journal of Experimental Biology,* **213(6)**, 946-54.

Tagaris, E., K. Liao, K. Manomaiphiboon, S. He, J. Woo, P. Amar, and A.G. Russell, 2008: The role of climate and emission changes in future air quality over southern canada and northern mexico. *Atmospheric Chemistry and Physics,* **(2006)**, 3973-3983.

Tagaris, E., K. Liao, A.J. Delucia, L. Deck, P. Amar, and A.G. Russell, 2009: Potential impact of climate change on air pollution-related human health effects. *Environmental Science & Technology,* **43(13)**, 4979-88.

Tagaris, E., K. Liao, A.J. DeLucia, L. Deck, P. Amar, and A.G. Russell, 2010: Sensitivity of air pollution-induced premature mortality to precursor emissions under the influence of climate change. *International Journal of Environmental Research and Public Health,* **7(5)**, 2222-37.

Tagaris, E., K. Liao, A.J. DeLucia, L. Deck, P. Amar, and A.G. Russell, 2010: Sensitivity of air pollution-induced premature mortality to precursor emissions under the influence of climate change. *International Journal of Environmental Research and Public Health,* **7(5)**, 2222-37.

Tagaris, E., K. Manomaiphiboon, K. Liao, L.R. Leung, J. Woo, S. He, P. Amar, and A.G. Russell, 2007: Impacts of global climate change and emissions on regional ozone and fine particulate matter concentrations over the united states. *Journal of Geophysical Research,* **112**.

Tai, A.P.K., L.J. Mickley, and D.J. Jacob, 2010: Correlations between fine particulate matter (PM2.5) and meteorological variables in the united states: Implications for the sensitivity of PM2.5 to climate change. *Atmospheric Environment,* **44(32)**, 3976-3984.

Tai, A.P.K., L.J. Mickley, and D.J. Jacob, 2010: Correlations between fine particulate matter (PM2.5) and meteorological variables in the united states: Implications for the sensitivity of PM2.5 to climate change. *Atmospheric Environment,* **44(32)**, 3976-3984.

Takasaki, Y., 2009: Do local elites capture natural disaster reconstruction funds? *Tsukuba Economics Working Papers no. 2009-012,* .

Tan, J., Y. Zheng, X. Tang, C. Guo, L. Li, G. Song, X. Zhen, D. Yuan, A.J. Kalkstein, and F. Li, 2010: The urban heat island and its impact on heat waves and human health in shanghai. *International Journal of Biometeorology,* **54(1)**, 75-84.

Taner, M.T., J.N. Carleton, and M. Wellman, 2011: Integrated model projections of climate change impacts on a north american lake. . *Ecological Modelling, 222(18), 3380-3393.,* .

Tao, Z., A. Williams, H. Huang, M. Caughey, and X. Liang, 2007: Sensitivity of U.S. surface ozone to future emissions and climate changes. *Geophysical Research Letters,* **34(8)**, 1-5.

Tao, Z., A. Williams, H. Huang, M. Caughey, and X. Liang, 2007: Sensitivity of U.S. surface ozone to future emissions and climate changes. *Geophysical Research Letters,* **34(8)**, 1-5.

Tarnoczi, T.J. and F. Berkes, 2010: Sources of information for farmers' adaptation practices in Canada's prairie agro-ecosystem. *Climatic Change,* **98(1)**, 299-305.

Teranishi, H., T. Katoh, K. Kenda, and S. Hayashi, 2006: Global warming and the earlier start of the japanese-cedar (cryptomeria japonica) pollen season in toyama, japan. *Aerobiologia,* **22(2)**, 90-94.

THE H. JOHN HEINZ III CENTER FOR SCIENCE, ECONOMICS AND THE ENVIRONMENT Washington, D.C., A survey of climate change adaptation planning.

The White House, 2009: *Executive order. federal leadership in environmental, energy, and economic performance.* Executive Office of the President, Washington DC, .

Theobald, D.M. and W.H. Romme, 2007: Expansion of the US wildland-urban interface. *Landscape and Urban Planning,* **83**, 340-354.

Thompson, I.D., B. Mackey, A. Mosseler, and S. McNulty, 2010: **The relationship between biodiversity and forest ecosystem resilience and relationship to climate change.** . In: *The International Forestry Review Vol.12(5), 2010* [Parrotta, J. A., and M. A. Carr (ed.)]. Proceedings of XXIII IUFRO world congress forests for the future: Sustaining society and the environment, 23-28 August 2010, Seoul, Republic of Korea, pp. 6.

Tingley, M.W., W.B. Monahan, S.R. Beissinger, and C. Moritz, 2009: Birds track their grinnellian niche through a century of climate change. *Proceedings of the National Academy of Sciences,* **106(Supplement 2)**, 19637-19643.

Tipple, G., 2005: Housing and urban vulnerability in Rapidly - Developing cities. *Journal of Contingencies and Crisis Management,* **13(2)**, 66-75.

Tompkins, E.L., M.C. Lemos, and E. Boyd, 2008: A less disastrous disaster: Managing response to climate-driven hazards in the cayman islands and NE brazil. *Global Environmental Change,* **18(4)**, 736-745.

Tong, S.T.Y., Y. Sun, T. Ranatunga, J. He, and Y.J. Yang, 2012: Predicting plausible impacts of sets of climate and land use change scenarios on water resources. *Applied Geography 32 (2012) 477-489,* .

Toni, F. and E. Holanda Jr, 2008: The effects of land tenure on vulnerability to droughts in northeastern brazil. *Global Environmental Change,* **18(4)**, 575-582.

Toronto Environment Office, 2008: Ahead of the Storm: Preparing Toronto for Climate Change, Toronto Environment Office, Toronto, Ontario, .

Tortajada, C., 2006: Who has Access to Water? Case Study of Mexico City Metropolitan Area Thematic Paper for Human Development Report 2006, .

Trainor, S.F., M. Calef, D. Natcher, F.S. Chapin III, A.D. McGuire, O. Huntington, P. Duffy, T.S. Rupp, L. DeWilde, M. Kwart, N. Fresco, and A.L. Lovecraft, 2009: Vulnerability and adaptation to climate-related fire impacts in rural and urban interior alaska. *Polar Research,* **28**, 100-118.

Trainor, S.F., M. Calef, D. Natcher, F.S. Chapin III, A.D. McGuire, O. Huntington, P. Duffy, T.S. Rupp, L. DeWilde, M. Kwart, N. Fresco, and A.L. Lovecraft, 2009: Vulnerability and adaptation to climate-related fire impacts in rural and urban interior alaska. *Polar Research,* **28**, 100-118.

Trainor, S.F., M. Calef, D. Natcher, F.S. Chapin III, A.D. McGuire, O. Huntington, P. Duffy, T.S. Rupp, L.O. DeWilde, and M. Kwart, 2009: Vulnerability and adaptation to climate - related fire impacts in rural and urban interior alaska. *Polar Research,* **28(1)**, 100-118.

Transportation Research Board, 2008: *#290.* Potential Impact of Climate Change on Us Transportation National Research Council, Washington DC, USA, .

Transportation Research Board, 2008: Potential Impacts of Climate Change on U.S. Transportation, National Research Council of the National Academy of Sciences, Washington DC, .

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

Trejo, I., E. Martínez-Meyer, E. Calixto-Pérez, S. Sánchez-Colón, R. Vázquez de La Torre and L. Villers-Ruiz, 2011: Analysis of the effects of climate change on plant communities and mammals in méxico. *Atmosfera,* **24(1)**, 1-14.

Trotman, A., R.M. Gordon, S.D. Hutchinson, R. Singh, and D. McRae-Smith, 2009: Policy responses to GEC impacts on food availability and affordability in the caribbean community. *Environmental Science & Policy,* **12(4)**, 529-541.

Trumpickas, J., B.J. Shuter, and C.K. and Minns, 2009: Forecasting impacts of climate change on great lakes surface water temperatures. *Journal of Great Lakes Research 35(3): 454-463,* .

Tsai, Y.S. and R.M. Vogel, 2010: Climatic and anthropogenic influences on freshwater availability in the eastern united states. In: Proceedings of Proceedings of the world environmental and water resources congress, 16-20 May, Providence, Rhode Island, USA, pp. 4520-4536.

Tu, J., 2009: Combined impact of climate and land use changes on streamflow and water quality in eastern massachusetts, USA (2009) . *Journal of Hydrology, 379 (3-4), Pp. 268-283,* .

Tufts, S., 2010: Tourism, climate change and the missing worker: Uneven impacts, institutions and response. In: *What do we know? what do we need to know? the state of canadian research on work, employment and climate change.* [Lipsig-Mummé, C. (ed.)]. Work in a Warming World Research Programme, York University, Toronto, pp. 80-108.

U.S Global Change Research Program (USGCRP), 2009: Global Climate Change Impacts in the United States, Cambridge University Press, Cambridge, UK, .

U.S. Environmental Protection Agency, 2008:
Clean Watersheds Needs Survey 2008
Report to Congress, U.S. Environmental Protection Agency, Washington DC USA, .

U.S. Environmental Protection Agency, 2008: Clean Water Needs Survey: 2008 Report to Congress, U.S. Environmental Protection Agency, Washington DC, USA, .

U.S. Environmental Protection Agency, 2012: U.S.-Mexico Environmental Program: Border 2012: A Mid-Course Refinement (2008-2012), U.S. Environmental Protection Agency, Washington DC, .

U.S. Environmental Protection Agency National Water Program, 2011: U.S. EPA National Water Program Strategy: Response to Climate Change 2010 - 2011 National and Regional Highlights of Progress, U.S. Environmental Protection Agency, Washington DC, .

U.S. Environmental Protection Agency Office of Water, 2009:
Drinking Water Infrastructure Needs Survey and Assessment: Fourth Report to Congress, U.S. Environmental Protection Agency, Washington DC, .

U.S. Environmental Protection Agency and Secretaría de Medio Ambiente y Recursos Naturales, 2011: State of the Border Region Indicators Report 2010, SEMARNAT, Tlalpan, Mexico, .

Udall, S.N. and R.G. Varady, 1993: Environmental conflict and the world's new international borders. *Transboundary Resources Report,* **7(3)**, 5-6.

Unger, N., T.C. Bond, J.S. Wang, D.M. Koch, S. Menon, D.T. Shindell, and S. Bauer, 2010: Attribution of climate forcing to economic sectors. *Proceedings of the National Academy of Sciences of the United States of America,* **107(8)**, 3382-7.

UN-HABITAT United Nations Human Settlements Programme, 2011: Cities and Climate Change — Global Report on Human Settlements 2011, http://www.unhabitat.org, .

United Nations Department of Economic and Social Affairs, Population Division, 2010: *World Population Ageing 2009*. ST/SEA/SER.A/295, .

United Nations Development Programme, 2011: *Human development report: Sustainability and equity: A better future for all* .

United States Department of Agriculture, 2010: Food Marketing System in the U.S. Food and Beverage Manufacturing, Economic Research Service, USA, .

United States Department of Agriculture, 2011: NAFTA, Canada, and Mexico: Mexico Trade, Economic Research Service, USA, .

United States Department of Agriculture, Economic Research Service, 2012: *ERS/USDA data sets* .

United States Global Change Research Program (USGCRP), 2009: *Climate change impacts in the united states.* Cambridge University Press, New York, USA, .

Vadean, F. and M. Piracha, 2009: *Circular migration or permanent return: What determines different forms of migration?* IZA, .

Vale, L.J. and T.J. Campanella, 2005: *The resilient city: How modern cities recover from disaster.* Oxford University Press, USA, .

Valero-Gil, J.N. and M. Valero, 2008: The effects of rising food prices on poverty in mexico. *Agricultural Economics,* **39**, 485-496.

Van den Berg, M., R. Fort, and K. Burger, 2009: Natural hazards and risk aversion: Experimental evidence from latin america. *Unpublished Paper,* .

van Lieshout, M., R. Kovats, M. Livermore, and P. Martens, 2004: Climate change and malaria: Analysis of the SRES climate and socio-economic scenarios. *Global Environmental Change,* **14(1)**, 87-99.

van Mantgem, P.J., N.L. Stephenson, J.C. Byrne, L.D. Daniels, J.F. Franklin, P.Z. Fulé, M.E. Harmon, A.J. Larson, J.M. Smith, A.H. Taylor, and T.T. Veblen, 2009: Widespread increase of tree mortality rates in the western united states. *Science,* **323(5913)**, 521-524.

Vano, J., N. Voisin, L. Cuo, A. Hamlet, M. Elsner, R. Palmer, A. Polebitski, and D. Lettenmaier, 2010: Climate change impacts on water management in the puget sound region, washington state, USA. *Climatic Change, 102, 261-286,* .

Vano, J.A., M.J. Scott, N. Voisin, C.O. Stöckle, A.F. Hamlet, K. Mickelson, and D.P. Lettenmaier, 2010: **Climate change impacts on water management and irrigated agriculture in the yakima river basin, washington, US A**. *Climatic Change,* **102**, 287-317.

Varady, R., P. Romero-Lankao, and K. Hankins, 2001: Managing hazardous materials along the US-mexico border. *Environment: Science and Policy for Sustainable Development,* **43(10)**, 22-36.

Vásquez, A., M. Salgado, and P. Smith, 2008: Socio-economic inequalities and the inequitable distribution of environmental risks in chilean metropolis local spaces: A perspective of environmental justice. .

Vasquez-Leon, M., C.T. West, and T.J. Finan, 2003: A comparative assessment of climate vulnerability: Agriculture and ranching on both sides of the US-mexico border. *Global Environmental Change,* **13(3)**, 159-173.

Vázquez Silva, L., J.C. Tamarit Urias, J. Quintanar Olguín, and L. Varela Fregoso, 2004: Caracterización de la declinación de bosques de encinos en "Sierra de lobos" guanajuato, méxico. *Polibotánica,* **017**, 1-14.

Veblen, T.T., T. Kitzberger, and J. Donnegan, 2000: Climatic and human influences on fire reimes in ponderosa pine forests in the colorado front range. *Ecological Applications,* **10(4)**, 1178-1195.

Velásquez, L.S., 2005: The bioplan: Decreasing poverty in manizales, colombia, through shared environmental management. *Reducing Poverty and Sustaining the Environment,* , 44-72.

Vellinga, P. and E. Mills, 2001: Chapter 8: Insurance and Other Financial Services of IPCC WGII TAR, .

Vergara, W., 2007: The impacts of climate change in latin america. *Visualizing Future Climate in Latin America: Results from the Application of the,* , 1.

Vergara, W., 2009: Assessing the potential consequences of climate destabilization in latin america. *Sustainable Development Working Paper,* **32**.

Vergara, W., 2009: Climate hotspots: Climate-induced ecosystem damage in latin america. *Sustainable Development Working Paper,* **32**, 5-17.

Verner, D., 2010: *Reducing poverty, protecting livelihoods, and building assets in a changing climate: Social implications of climate change latin america and the caribbean.* World Bank Publications, .

Veron, J.E.N., O. Hoegh-Guldberg, T.M. Lenton, J.M. Lough, D.O. Obura, P. Pearce-Kelly, C.R.C. Sheppard, M. Spalding, M.G. Stafford-Smith, and A.D. Rogers, 2009: The coral reef crisis: The critical importance of <350 ppm CO_2. *Marine Pollution Bulletin,* **58**, 1428-1436.

Vicuna, S., F. Meza, M. Jelinek, E. Bustos, and S. Bonelli, 2010: Vulnerability of a municipal water supply system in central chile to climate change impacts. In: Proceedings of AGU fall meeting abstracts, pp. 05.

Villeneuve, P.J., M. Doiron, D. Stieb, R. Dales, R.T. Burnett, and R. Dugandzic, 2006: Is outdoor air pollution associated with physician visits for allergic rhinitis among the elderly in toronto, canada? *Allergy,* **61(6)**, 750-8.

Villers-Ruíz, L., y Hernández-Lozano, J., 2007: Incendios forestales y el fenómeno de el niño en méxico. In: Proceedings of IV conferencia internacional sobre incendios forestales, 13-17 mayo, Sevilla, España, pp. 1-10.

Viola, E., 2008: Brazil and global governance: The case of climate change. *Cadernos De Pesquisa Interdisciplinar Em Ciências Humanas,* **2(15)**, 2-24.

Vojinovic, Z. and J. Van Teeffelen, 2007: An integrated stormwater management approach for small islands in tropical climates. *Urban Water Journal,* **4(3)**, 211-231.

Volney, W.J.A. and K.G. Hirsch, 2005: Disturbing forest disturbances. *The Forestry Chronicle,* **81(5)**, 662-668.

Vora, C., M.J. Renvall, P. Chao, P. Ferguson, and W. Ramsdell, 2011: 2007 san diego wildfires and asthmatics. *J Asthma,* **48(1)**, 75-78.

Wade, T.J., 2004: Did a severe flood in the midwest cause an increase in the incidence of gastrointestinal symptoms? *American Journal of Epidemiology,* **159(4)**, 398-405.

Walker, C.F., 2010: The nature of disaster in latin america: Recent perspectives on catastrophe and risk, the legacy of hurricane mitch: Lessons from Post‐Disaster reconstruction in honduras by marisa ensor, ed., living under the shadow: The cultural impacts of volcanic eruptions by john grattan and robin torrence, eds. and capitalizing on catastrophe: Neoliberal strategies in disaster reconstruction by nandini gunewardena and mark schuller, eds. foreword by alexander de waal. *The Journal of Latin American and Caribbean Anthropology,* **15(2)**, 533-537.

Walsh, C.J., T.D. Fletcher, and A.R. Ladson, 2005: Stream restoration in urban catchments through redesigning stormwater systems: Looking to the catchment to save the stream. *Journal Information,* **24(3)**.

Wang, R., 2010: Leaders, followers and laggards: Adoption of the U.S. conference of mayors climate protection agreement in california. *Faculty Research, University of California Transportation Center, UC Berkeley,* .

Wang, X. L. L., V. R. Swail, and F. W. Zwiers, 2006: Climatology and changes of extratropical cyclone activity: Comparison of ERA-40 with NCEP-NCAR reanalysis for 1958-2001. *Journal of Climate,* **19**, 3145-3166.

Wang, G., R.B. Minnis, J.L. Belant, and C.L. Wax, 2010: Dry weather induces outbreaks of human west nile virus infections. *BMC Infectious Diseases,* **10**, 38-38.

Waring, K. M., D.M. Reboletti, L.A. Mork, Ch. Huang, R.W. Hofstetter, A.M. Garcia, P.Z. Fulé, and T.S. Davis, 2009: Modeling the impacts of two bark beetle species under a warming climate in the southwestern USA: Ecological and economic consequences *Environmental Management*, **44**, 824-835.

Warner, K., N. Ranger, S. Surminski, M. Arnold, J. Linnerooth-Bayer, E. Michel-Kerjan, P. Kovacs, and C. Herweijer, 2009: Adaptation to Climate Change: Linking Disaster Risk Reduction and Insurance, UNISDR, .

Warren, F.J. and P. Egginton, 2008: Chapter 2: Background Information - Concepts, Overviews and Approaches; *in* From Impacts to Adaptation: Canada in a Changing Climate 2007, Government of Canada, Ottawa, 27-56 pp.

Washington State Built Environment: Infrastructure & Communities Topic Advisory Group (TAG), 2011: Washington State Climate Change Response Strategy: Interim Recommendations of the Built Environment: Infrastructure & Communities Topic Advisory Group (TAG) , State of Washington, .

Washington State TAG 4 Natural Resources Working Lands and Waters, 2011: Washington State Climate Change Response Strategy Interim Recommendations of the Natural Resources: Working Lands and Waters Topic Advisory Group, State of Washington, Olympia, WA, .

Washington State Topic Advisory Group (TAG) Report- TAG 2 Human Health and Security, 2011: Washington State Climate Change Response Strategy Topic Advisory Group (TAG) Report- TAG 2 Human Health and Security , State of Washington, Olympia,

Washington State Topic Advisory Group 3 Species, Habitats and Ecosystems, 2011:
Washington State Integrated Climate Change
Response Strategy
Interim Recommendations from
Topic Advisory Group 3
Species, Habitats and Ecosystems , State of Washington, Olympia, .

Washington State Topic Advisory Group 3 Species, Habitats and Ecosystems, 2011:
Washington State Integrated Climate Change
Response Strategy
Interim Recommendations from
Topic Advisory Group 3
Species, Habitats and Ecosystems
(TAG3) , State of Washington, Olympia, .

Water Utility Climate Alliance, 2012: *Water utility climate alliance* .

Waters, N., 2004: Weather and transportation in canada. *The Canadian Geographer,* **48(3)**, 380-383.

Waylen, P., D. Keellings, and Y. Qiu, 2012: Climate and health in florida: Changes in risks of annual maximum temperatures in the second half of the twentieth century. *Applied Geography,* **33**, 73-81.

Wayne, P., S. Foster, J. Connolly, F. Bazzaz, and P. Epstein, 2002: Production of allergenic pollen by ragweed (ambrosia artemisiifolia L.) is increased in CO2-enriched atmospheres. *Annals of Allergy, Asthma & Immunology : Official Publication of the American College of Allergy, Asthma, & Immunology,* **88(3)**, 279-82.

Weaver, C.P., E. Cooter, R. Gilliam, a. Gilliland, a. Grambsch, D. Grano, B. Hemming, S.W. Hunt, C. Nolte, D. Winner, X. Liang, J. Zhu, M. Caughey, K. Kunkel, J. Lin, Z. Tao, a. Williams, D.J. Wuebbles, P.J. Adams, J.P. Dawson, P. Amar, S. He, J. Avise, J. Chen, R.C. Cohen, a.H. Goldstein, R. Harley, a.L. Steiner, S. Tonse, a. Guenther, J. Lamarque, C. Wiedinmyer, W.I. Gustafson, L.R. Leung, C. Hogrefe, H. Huang, D.J. Jacob, L.J. Mickley, S. Wu, P.L. Kinney, B. Lamb, N.K. Larkin, D. McKenzie, K. Liao, K. Manomaiphiboon, a.G. Russell, E. Tagaris, B.H. Lynn, C. Mass, E. SalathÃ©, S.M. O'neill, S.N. Pandis, P.N. Racherla, C. Rosenzweig, and J. Woo, 2009: A preliminary synthesis of modeled climate change impacts on U.S. regional ozone concentrations. *Bulletin of the American Meteorological Society,* **90(12)**, 1843-1863.

Wegesser, T.C., K.E. Pinkerton, and J.a. Last, 2009: California wildfires of 2008: Coarse and fine particulate matter toxicity. *Environmental Health Perspectives,* **117(6)**, 893-7.

Wehbe, M., H. Eakin, R. Seiler, M. Vinocur, C. Avila, and C. Marutto, 2008: Local perspectives on adaptation to climate change: Lessons from mexico and argentina. In: *Climate change and adaptation.* Earthscan, London, UK, .

Wehbe, M., H. Eakin, R. Seiler, M. Vinocur, C. Ávila, and C. Marutto, 2008: Local perspectives on adaptation to climate change: Lessons from mexico and argentina. *Climate Change and Adaptation,* , 315.

Wehner, M., D.R. Easterling, J.H. Lawrimore, R.R. Heim, R.S. Vose, and B.D. Santer, 2011: Projections of future drought in the continental united states and mexico *Journal of Hydrometeorology,* **12(6)**, 1359-1377.

Weisler, R.H., J.G. Barbee, and M.H. Townsend, 2006: Mental health and recovery in the gulf coast after hurricanes katrina and rita. *JAMA : The Journal of the American Medical Association,* **296(5)**, 585-8.

Weiss, J.L., J.T. Overpeck, and B. Strauss., 2011: Implications of recent sea level rise science for low-elevation areas in coastal cities of the conterminous U.S.A. *Climatic Change,* **105**, 635-645.

Weiss, J.L. and Overpeck J.T. and Strauss, B., 2011: Implications of recent sea level rise science for low-elevation areas in coastal cities of the conterminous U.S.A. **105**, 635-645.

Weiss, J.L., J.T. Overpeck, and B. Strauss, 2011: Implications of recent sea level rise science for low-elevation areas in coastal cities of the conterminous USA. *Climatic Change,* , 1-11.

Welch, D. W., A.I. Chigirinsky, and Y. Ishida, 1995: Upper thermal limits on the oceanic distribution of pacific salmon (*oncorhynchus spp*.) in the spring. *Canadian Journal of Fisheries and Aquatic Sciences,* **52(3)**, 489-503.

Welch, D. W., Y. Ishida, and K. Nagasawa, 1998a: Thermal limits and ocean migrations of sockeye salmon (*oncorhynchus nerka*): Long-term consequences of global warming. *Canadian Journal of Fisheries and Aquatic Sciences,* **55(4)**, 937-948.

Welch, D. W., Y. Ishida, K. Nagasawa, and J.P. Eveson, 1998b: Thermal limits on the ocean distribution of steelhead trout (*oncorhynchus mykiss*). *North Pacific Anadromous Fish Commission,* **Bulletin 1**, 396-404.

Wesche, S. and H.M. Chan, 2010: Adapting to the impacts of climate change on food security among inuit in the western canadian arctic. *EcoHealth,* **7**, 361-373.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam, 2006: Warming and earlier spring increase western U.S. forest wildfire activity. *Science Express,* **313(5789)**, 940-943.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam, 2006: Warming and earlier spring increase western US forest wildfire activity. *Science,* **313(5789)**, 940.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam, 2007: Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. .

Wheaton, E., G. Koshida, B. Bonsal, T. Johnston, W. Richards, and V. Wittrock, 2007: *SRC Publication no. 11927-1E07.* ***Agricultural Adaptation to Drought (ADA) in Canada: The Case of 2001 and 2002*** Saskatchewan Research Council, Saskatoon, SK, .

Wheaton, E., S. Kulshreshtha, W. Eilers, and V. Wittrock, 2010: Environmental sustainability of agriculture in the context of adapting to a changing climate. In: Proceedings of OECDINEA-FAO workshop, Rome, Italy, .

White, R. and D. Etkin, 1997: Climate change, extreme events and the canadian insurance industry. *Natural Hazards,* **16(2)**, 135-163.

Whitener, L.A. and T. Parker, 2007: Policy options for a changing rural america. *Perspectives on Food and Farm Policy: Rural Development & Energy,* **5**, 58-65.

White-Newsome, J.L., B.N. Sánchez, O. Jolliet, Z. Zhang, E.A. Parker, J. Timothy Dvonch, and M.S. O'Neill, 2011: Climate change and health: Indoor heat exposure in vulnerable populations. *Environmental Research,* .

Wiedinmyer, C. and M.D. Hurteau, 2010: Prescribed fire as a means of reducing forest carbon emissions in the western united states. *Environment, Science and Technology,* **44**, 1926-1932.

Wilbanks, T., S. Fernandez, G. Backus, P. Garcia, K. Jonietz, P. Kirshen, M. Savonis, B. Solecki, and L. and Tool, 2012: Climate Change and Infrastructure, Urban Systems, and Vulnerabilities: Technical Report to the U.S. Department of Energy in Support of the U.S. Climate Change Assessment, Oak Ridge National Laboratory, Oak Ridge, Tennessee, .

Wilbanks, T., V. Bhatt, D.E. Bilello, S.R. Bull, J. Ekmann, W.C. Horak, Y.J. Huang, M.D. Levine, M.J. Sale, D.K. Schmalzer, and M.J. Scott, 2008:
Report by the U.S. Climate Change Science Program
and the Subcommittee on Global Change Research.
***Effects of Climate Change on Energy Production and use in the United States*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research.**, Department of Energy, Office of Biological & Environmental Research, Washington, DC, .

Wilbanks, T., P. Romero Lankao, M. Bao, F. Berkhout, S. Cairncross, J.P. Ceron, M. Kapshe, R. Muir-Wood, and R. Zapata-Marti, 2007: Industry, settlement and society. *Climate Change,* , 357-390.

Wilbanks, T., P. Romero Lankao, M. Bao, F. Berkhout, S. Cairncross, J.P. Ceron, M. Kapshe, R. Muir-Wood, and R. Zapata-Marti, 2007: Industry, settlement and society. *Climate Change,* , 357-390.

Wilby, R.L., 2008: Constructing climate change scenarios of urban heat island intensity and air quality. *Environment and Planning B: Planning and Design,* **35(5)**, 902-919.

Wilder, M. and P. Romero Lankao, 2006: Paradoxes of decentralization: Water reform and social implications in mexico. *World Development,* **34(11)**, 1977-1995.

Wilder, M., C.A. Scott, N.P. Pablos, R.G. Varady, G.M. Garfin, and J. McEvoy, 2010: Adapting across boundaries: Climate change, social learning, and resilience in the US–Mexico border region. *Annals of the Association of American Geographers,* **100(4)**, 917-928.

Wilhelmi, O.V. and M.H. Hayden, 2010: Connecting people and place: A new framework for reducing urban vulnerability to extreme heat. *Environmental Research Letters,* **5**, 014021.

Williams, A.P., C.D. Allen, C.I. Millar, T.W. Swetnam, J. Michaelson, C.J. Still, and S.W. Leavitt, 2010: Forest responses to increasing aridity and warmth in the southwestern united states. *Proceedings of the National Academy of Sciences,* **107(50)**, 21289-21294.

Williams, A.P., C.D. Allen, C.I. Millar, T.W. Swetnam, J. Michaelsen, C.J. Still, and S.W. Leavitt, 2010: Forest responses to increasing aridity and warmth in the southwestern united states. *Proceedings of the National Academy of Sciences,* .

Williamson, T.B., S.J. Colombo, P.N. Duinker, P.A. Gray, R.J. Hennessey, D. Houle, M.H. Johnston, A.E. Ogden, and D.L. Spittlehouse, 2009: *Climate change and Canada’s forests: From impacts to adaptation.* Edmonton, Canada, Sustainable Forest Management Network and Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre ed., pp. 104.

Williamson, T.B., S.J. Colombo, P.N. Duinker, P.A. Gray, R.J. Hennessey, D. Houle, M.H. Johnston, A.E. Ogden, and D.L. Spittlehouse, 2009: *Climate change and Canada's forests: From impacts to adaptation.* Edmonton, Canada, Sustainable Forest Management Network and Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre ed., pp. 104.

Williamson, T.B., M. Patriquin, and V. Wittrock, 2008: *Limited Report: Climate Change Adaptive Capacity of Forestry Stakeholders in the Boreal Plains Ecozone. Climate Change Impacts and Adaptation Program Project A1383.* Chapter 5: Adaptive Capacity Deficits of Human Populations in the Canadian Boreal Plains Ecozone: Assessment and Issues, Saskatchewan Research Council, Saskatoon, SK, 46-81 pp.

Wilson, C.O. and Q. Weng, 2011: Simulating the impacts of future land use and climate changes on surface water quality in the des plaines river watershed, chicago metropolitan statistical area, illinois. *Science of the Total Environment 409 (2011) 4387–4405.*, .

Wilson, K., 2009: Climate change and the spread of infectious ideas. *Ecology,* **90(4)**, 901-2.

Winchester, L., 2008: Harmony and dissonance between human settlements and the environment in latin america and the caribbean.

Winchester, L., 2008: Harmony and dissonance between human settlements and the environment in latin america and the caribbean.

Winchester, L. and R. Szalachman, THE URBAN POOR'S VULNERABILITY TO THE IMPACTS OF CLIMATE CHANGE IN LATIN AMERICA AND THE CARIBBEAN. APolicy AGENDA. In: Proceedings of World bank fifth urban research symposium, .

Winchester, L. and R. Szalachman, 2009: THE URBAN POOR'S VULNERABILITY TO THE IMPACTS OF CLIMATE CHANGE IN LATIN AMERICA AND THE CARIBBEAN. APolicy AGENDA. In: Proceedings of World bank fifth urban research symposium, .

Winder, R., Nelson E. A., and Beardmore, T., 2011: **Ecological implications for assisted migration in canadian forests** . *The Forestry Chronicle,* **87(6)**, 731-744.

Winder, R. and E.A. Nelson and T. Beardmore, 2011: Ecological implications for assisted migration in canadian forest. *The Forestry Chronicle,* **87(6)**, 731-744.

Witt, V.M. and F.M. Reiff, 1991: Environmental health conditions and cholera vulnerability in latin america and the caribbean. *Journal of Public Health Policy,* **12(4)**, 450-463.

Wittig, V., S. Williams, and S.B. DuTeaux, 2008: *Public health impacts of residential wildfires: Analysis of ash and debris from the 2007 southern california fires* .

Wittig, V., S. Williams, and S.B. DuTeaux, Public health impacts of residential wildfires: Analysis of ash and debris from the 2007 southern california fires.

Wittrock, V. and S.N. Kulshreshtha, 2011: Canadian prairie rural communities: Their vulnerabilities and adaptive capacities to drought *Mitigation and Adaptation Strategies for Global Change,* **16**, 267-290.

Wittrock, V., S.N. Kulshreshtha, and E. Wheaton, 2011: Canadian prairie rural communities: Their vulnerabilities and adaptive capacities to drought. *Mitigation and Adaptation Strategies for Global Change,* , 1-24.

Wittrock, V. and E. Wheaton, 2007: *SRC Publication no. 11927-2E07. Towards Understanding the Adaptation Process for Drought in the Canadian Prairie Provinces: The Case of the 2001 to 2002 Drought and Agriculture*. Saskatchewan Research Council, Saskatoon, SK, .

Wolfe, D.W., L. Ziska, C. Petzoldt, A. Seaman, L. Chase, and K. Hayhoe, 2008: Projected change in climate thresholds in the northeastern U.S.: Implications for crops, pests, livestock, and farmers. *Mitigation and Adaptation Strategies for Global Change,* **13**, 555-575.

Wood, N.J., C.G. Burton, and S.L. Cutter, 2010: Community variations in social vulnerability to cascadia-related tsunamis in the US pacific northwest. *Natural Hazards,* **52(2)**, 369-389.

World Bank, 2010: Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention, The International Bank for Reconstruction and Development, Washington DC, .

Worral, J. J., L. Egeland, T. Eager, E.R. Mask, E.W. Johnson, P.A. Kemp, and W.D. Shepperd, 2008: Rapid mortality of *populus tremuloides* in southwestern colorado, USA. *Forest Ecology and Management,* **255**, 686-696.

Wright, L., P. Chinowsky, K. Strzepek, R. Jones, R. Streeter, J.B. Smith, J.-. Mayotte, A. Powell, L. Jantarasami, and W. Perkins, 2012:

Estimated effects of climate change on flood vulnerability of U.S. bridges . *Mitigation and Adaptation Strategies for Global Change,* **DOI 10.1007/s11027-011-9354-2**.

Wu, S., 2010: Potential impact of climate change on flooding in the upper great miami river watershed, ohio, USA: A simulation-based approach. [impact potentiel du changement climatique sur les inondations dans le bassin supérieur de la rivière great miami, ohio, etats-unis: Une approche basée sur la simulation]. *Hydrological Sciences Journal, 55(8), 1251-1263,* .

Wu, S., L.J. Mickley, E.M. Leibensperger, D.J. Jacob, D. Rind, and D.G. Streets, 2008: Effects of 2000â€“2050 global change on ozone air quality in the united states. *Journal of Geophysical Research,* **113**, 1-12.

Wu, S., L.J. Mickley, E.M. Leibensperger, D.J. Jacob, D. Rind, and D.G. Streets, 2008: Effects of 2000â€“2050 global change on ozone air quality in the united states. *Journal of Geophysical Research,* **113**, 1-12.

Yanchuk, A. and G. Allard, 2009: Tree improvement programmes for forest health - can they keep pace with climate changes? *Unasylva,* **60(1-2 (231-232) Adapting to climate change)**, 50-56.

Yin, J., M.E. Schlesinger, and R.J. Stouffer, 2009: Model projections of rapid sea-level rise on the northeast coast of the united states. *Nature Geoscience,* **2(4)**, 262-266.

Yin, J.H., 2005: A consistent poleward shift of the storm tracks in simulations of 21st century climate. *Geophysical Research Letters,* **32**, L18701, doi:10.1029/2005GL023684.

Yohe, G., R. Lasco, Q.K. Ahmad, S. Cohen, T. Janetos, R. Perez, K. Ebi, P. Romero-Lankao, E. Malone, and T. Malone, Perspectives on climate change and sustainability 3. *Change,* **25(48)**, 49.

Young, G., H. Zavala, J. Wandel, B. Smit, S. Salas, E. Jimenez, M. Fiebig, R. Espinoza, H. Diaz, and J. Cepeda, 2010: Vulnerability and adaptation in a dryland community of the elqui valley, chile. *Climatic Change,* **98(1)**, 245-276.

Young, K.R. and B. León, 2009: Natural hazards in peru:: Causation and vulnerability. *Developments in Earth Surface Processes,* **13**, 165-180.

Young, K.R. and J.K. Lipton, 2006: Adaptive governance and climate change in the tropical highlands of western south america. *Climatic Change,* **78(1)**, 63-102.

Zahran, S., S.D. Brody, A. Vedlitz, H. Grover, and C. Miller, 2008: Vulnerability and capacity: Explaining local commitment to climate-change policy. *Environment and Planning C: Government & Policy,* **26(3)**, 544-562.

Zanobetti, A. and J. Schwartz, 2008: Temperature and mortality in nine US cities. *Epidemiology,* **19(4)**, 563.

Zavala-Hidalgo, J., R. de Buen, R. Romero-Centeno, and F. Hernández, 2010: Tendencias del nivel del mar en las costas mexicanas [trends in sea level on the mexican coast]. In: *Vulnerabilidad de las zonas costeras mexicanas ante el cambio climático [mexican coastal vulnerability to climate change].* [A. V. Botello, S. Villanueva, J. Gutiérrez, J. L. Rojas Galaviz (ed.)]. Gobierno del Estado de Tabasco, SEMARNAT-INE, UNAM-ICMyL, Universidad Autónoma de Campeche, Campeche, México, pp. 249-268.

Zhao, M. and S.W. Running, 2010: Drought-induced reduction in global terrestrial net primary production from 2000 through 2009. *Science,* **329(5994)**, 940-943.

Zhu, Y. L., and H. J. Wang, 2010: The arctic and antarctic oscillations in the IPCC AR4 coupled models. *Acta Meteorologica Sinica,* **24**, 176-188.

Zimmerman, R. and C. Faris, 2011: Climate change mitigation and adaptation in north american cities. *Current Opinion in Environmental Sustainability,* .

Ziska, L.H. and F.A. Caulfield, 2000: Rising CO2 and pollen production of common ragweed (ambrosia artemisiifolia), a known allergy-inducing species: Implications for public health. *Australian Journal of Plant Physiology,* **27**, 893-898.

Ziska, L.H., D.E. Gebhard, D.a. Frenz, S. Faulkner, B.D. Singer, and J.G. Straka, 2003: Cities as harbingers of climate change: Common ragweed, urbanization, and public health. *Journal of Allergy and Clinical Immunology,* **111(2)**, 290-295.

Ziska, L., K. Knowlton, C. Rogers, D. Dalan, N. Tierney, M. Ann, W. Filley, J. Shropshire, L.B. Ford, C. Hedberg, P. Fleetwood, K.T. Hovanky, and T. Kavanaugh, 2011: Recent warming by latitude associated with increased length of ragweed pollen season in central north america. *PNAS,* **108(10)**, 4248-4251.

Zoltay, V., R. Vogel, P. Kirshen, and K. Westphal, 2010: Integrated watershed management modeling: A generic optimization model applied to the ipswich river basin, September/October. *Journal of Water Resources Planning and Management, 2010.,* .

Zucker, J.R., 1996: Changing patterns of autochthonous malaria transmission in the united states: A review of recent outbreaks. *Emerging Infectious Diseases,* **2(1)**, 37-43.

To be integrated

C40 cities - climate leadership group - best practices .

CSR_Mexico_090126.pdf

EM-DAT .

GEPs - full text: Global economic Prospects—Summer 2011 .

LessonsLearned.pdf

Ovid: Public health impacts of residential wildfires: Analysis of ash and debris from the 2007 southern california fires .

United nations population division home page .

World population prospects, the 2010 revision .

Zimmerman, R. (2010). infrastructure impacts and adaptation challenges. annals of the new york academy of sciences, 1196(1), 63. .

Committee on Flood Control Alternatives in the American River Basin, 1995: National Research Council, .

Committee on Flood Control Alternatives in the American River Basin, National Research Council. 1995. *Flood Risk Management and the American River Basin:An Evaluation*. the National Academies Press. 1995: .

Drought in the united states 1998: National Drought Mitigation Center, .

Aboriginal people and other canadians. 2001: University of Ottawa Press, Ottawa, .

British Columbia’s Mountain Pine Beetle Action Plan 2006-2011: Sustainable Forests, Sustainable Communities, 2006: British Columbia (BC) Ministry of Forests, Victoria, BC: Government of British Columbia, .

Climate Change Impacts on Ice, Winter Roads, Access Trails, and Manitoba First Nations Final Report, 2006: Centre for Indigenous Environmental Resources (CIER), Winnipeg, Manitoba, .

Climate Change Impacts on Abundance and Distribution of Traditional Foods and Medicines—Effects on a First Nation and their Capacity to Adapt Final Report, 2007: Centre for Indigenous Environmental Resources (CIER), Winnipeg, Manitoba, .

Climate change and water. technical paper of the intergovernmental panel on climate change. In: 2008: [Bates, B.C., Z.W. Kundzewicz, S. Wu, and P. J.P.(eds.)]. IPCC Secretariat, Geneva, Switzerland, .

Climate Change and Water: Impacts and Adaptations for First Nations Communities, 2008: Assembly of First Nations (AFN), Environmental Stewardship Unit, Ottawa, .

King County Department of Natural Resources and Parks, 2008. Vulnerability of Major Wastewater Facilities to Flooding from Sea-
Level Rise. Seattle, Washington: King County (WA) Department of Natural Resources and Parks, Wastewater Treatment Division, 13p, 2008: .

New York City Department of Environmental Protection. 2008. *the NYCDEP Climate Change Program,* DEP with Contributions by Columbia University Center for Climate Systems Research and HydroQual Environmental Engineers and Scientists, P.C., New York, NY,
Http://www.Nyc.gov/dep, 2008: .

Plan of Action for Drinking Water in First Nation Communities, 2008: *Progress Report, January 17, 2008.* Indian and Northern Affairs Canada (INAC), Ottawa, Government of Canada, .

Síntesis Regional: Fomento De Las Capacidades Para La Etapa II De Adaptación Al Cambio Climático En Centroamérica, México y Cuba. Centro De Agua Del Trópico Húmedo Para América Latina y El Caribe, Panamá, 2008: CATHALAC, .

Síntesis Regional: Fomento De Las Capacidades Para La Etapa II De Adaptación Al Cambio Climático En Centroamérica, México y Cuba. Centro De Agua Del Trópico Húmedo Para América Latina y El Caribe, Panamá. 2008: CATHALAC, .

U.S. EPA. 2008. Ensuring a Sustainable Future: An Energy Management Guidebook for Water and Wastewater Utilities. 113pp. 2008: .

Exposed: Social Vulnerability and Climate Change in the US Southeast, 2009: Oxfam America, .

California Department of Water Resources. 2009. *Bulletin 160-09 California Water Plan Update 2009*. State of California. 2009: .

Climate Risks and Adaptive Capacity in Aboriginal Communities Final Report, 2009: Centre for Indigenous Environmental Resources (CIER), Winnipeg, Manitoba, .

FAOstat exports: Countries by commodity, wheat 2009: FAO, .

Impacts of Climate Change on Tribes in the United States, 2009: National Tribal Air Association (NTAA), .

Kenny, J.F., N.L. Barber, S.S. Hutson, K.S. Linsey, J.K. Lovelace, and M.A. Maupin, 2009: Estimated use of Water in the United States in 2005. U.S. Geological Survey Circular 1344, 52 Pp. 2009: .

National Association of Clean Water Agencies and National Association of Metropolitan Water Agencies, 2009: Confronting Climate Change: An Early Analysis of Water and Wastewater Adaptation Costs, Prepared by CH2M Hill, Inc. 103 Pp.), 2009: .

Climate change and displacement: Multidisciplinary perspectives 2010: Hart Pub, pp. 258.

IMTA, 2010, Efectos Del Cambio Climático En Los Recursos Hídricos De México, Volumen III. Atlas De Vulnerabilidad Hídrica En México Ante El Cambio Climático. Instituto Mexicano De Tecnología Del Agua, México. Available at Http://www.Atl.Org.mx/atlas-Vulnerabilidad-Hidrica-Cc/ , 2010: .

National Water Commission of Mexico, Statistics on Water in Mexico, 2010 Edition, June 2010. 2010: .

Top 10 weather stories of 2011: From manitoba flooding to goderich's tornado 2010: Canadian Broadcasting Corporation (CBC), .

Comisión Nacional Del Agua (CONAGUA), 2011. Atlas Del Agua En México. México, D.F.: CONAGUA-SEMARNAT, 2011: .

Drought causes mexico food shortages. earth observatory image 2011: National Aeronautics and Space Administration (NASA), .

Processed food and beverages 2011: Agriculture and Agrifood Canada, Government of Canada, .

2012: California Department of Forestry and Fire Protection (CDFFP), .

Total wildland fires and acres. 2012: National Interagency Fire Centre, .

"U.S. Government Accountability Office, http://www.gao.gov", 2007: GAO-07-412 Port Risk Management: Additional Federal Guidance would Aid Ports in Disaster Planning and Recovery, .

Table 26-1: Dimensions and determinants of urban adaptive capacity. Source: Romero-Lankao, 2012.

Hazards	**Systems**	**Impacts (changes in)**	**Determinants of adaptive capacity/resilience**	
			City wide	**Individual level**
Sea level rise	Health	Disease	Land use planning	Age
Temperature	Energy	Mortality	Urban design	Gender
Precipitation	Built environment	Water availability	Transportation	Ethnicity
Heat waves	Economic sector	Air & water quality	Water, sanitation, energy, waste	Migration status
Surges	Demographic group	Economic disruptions	Housing	Income
	Infrastructure	Migration	Social networks	Education
	Transport	Infrastructures damages	Community base organizations	Health condition
	Hinterland	Livelihoods	Policy (emergency) responses	Knowledge, experience
	Ecosystems services		Governance	Savings
				Insurance

Table 26-2: Examples of state and provincial adaptation activities in North America.

State or Province	Activities
British Columbia	Initiatives include community based adaptation to water allocation and forestry management. BC is modernizing its *Water Act* to alter water allocation during drought to reduce agricultural crop, livestock loss and community conflict, while protecting aquatic ecosystems.(British Columbia Ministry of the Environment, 2010)
California	Statewide adaptation plan calls for a 20% reduction in per capita water use by 2020 (California Natural Resources Agency, 2009)
Maryland	Developed a plan focusing on coastal adaptation and then developed a more comprehensive adaptation plan (Maryland Commission on Climate Change Adaptation and Response Working Group, 2008).In Phase II, Maryland developed adaptation plans for a number of sectors (Maryland Department of the Environment on behalf of the Maryland Commission on Climate Change, 2010)
Mexico City	Developed *Climate Action Programme for Mexico City 2008-2012* (SMA, 2006; 2008).
Nunavut	Developed Permafrost Monitoring Network in 2008 with eleven monitoring stations collecting data on permafrost temperature and change. (Nunavut Department of the Environment, 2011)
Ontario	2011-2014 Adaptation Strategy and Action Plan contains 37 adaptation actions including requirement that provincial legislation, policies and programs take climate change impacts into consideration. Provincial Ministry of Municipal Affairs and Housing required to update the building code to ensure that new buildings in Ontario take climate change into account to increase resilience and increase water and energy conservation. (Ontario Ministry of the Environment, 2011)
Washington	Advisory groups on built environment, infrastructure, and communities; human health and security; ecosystems, species, and habitat; and natural resources (Washington State Built Environment: Infrastructure & Communities Topic Advisory Group (TAG), 2011; Washington State TAG 4 Natural Resources Working Lands and Waters, 2011; Washington State Topic Advisory Group (TAG) Report- TAG 2 Human Health and Security, 2011; Washington State Topic Advisory Group 3 Species, Habitats and Ecosystems, 2011)

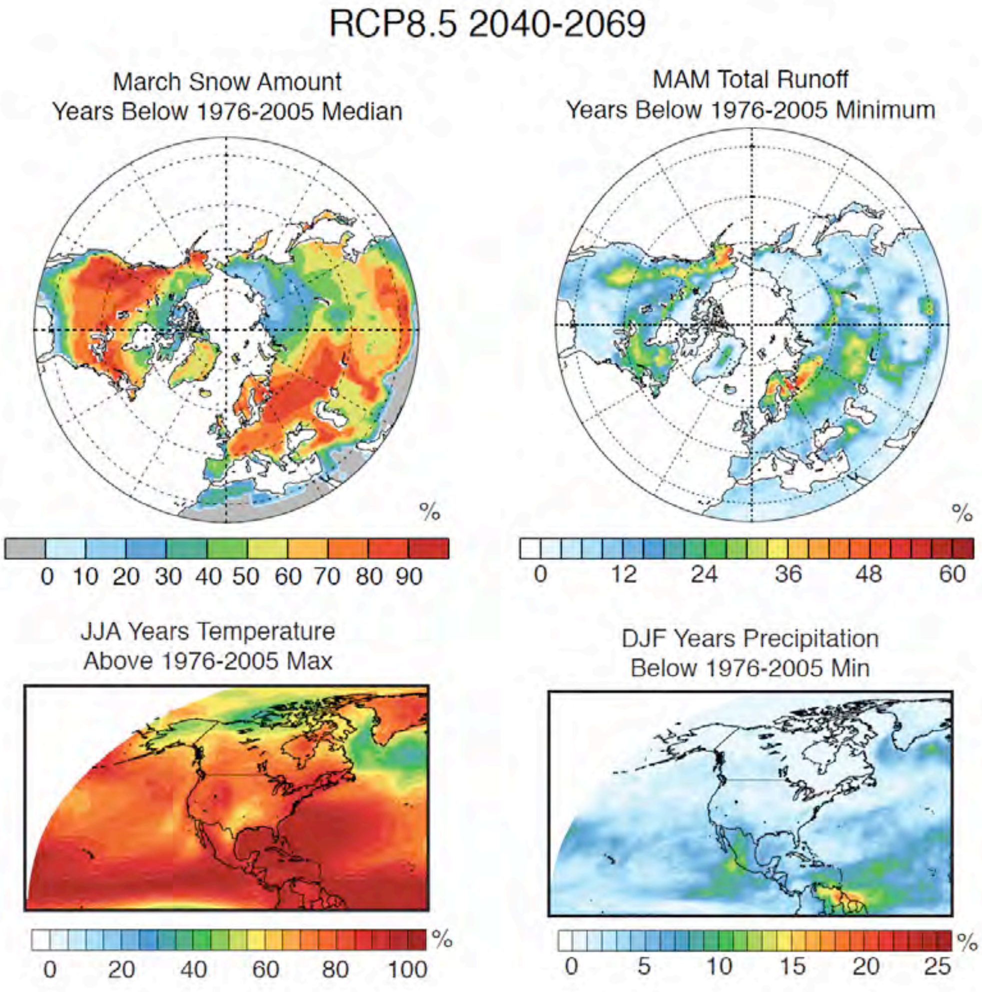
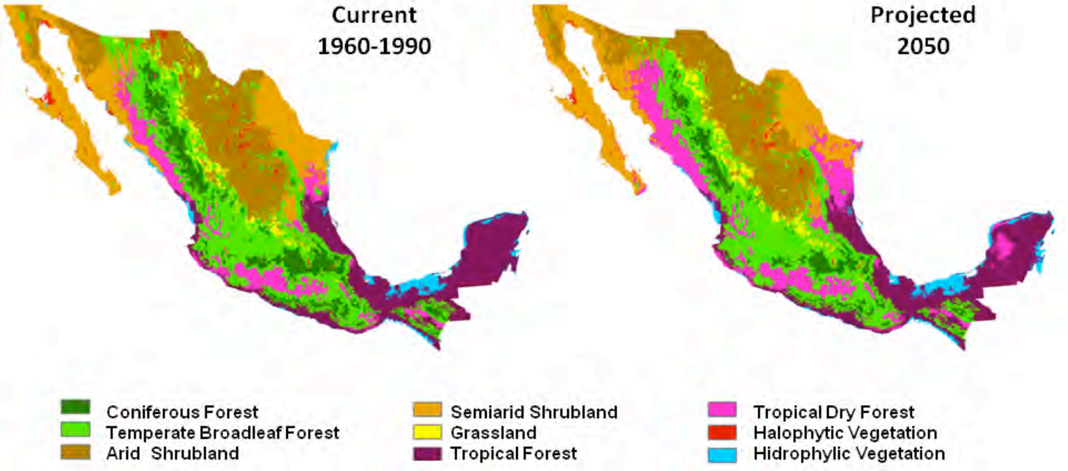


Figure 26-1: Projected changes in the extremes of seasonal temperature, precipitation, snow accumulation and runoff. The panels show the percentage of years exceeding respective thresholds in the 2040-2069 period of the CMIP5 RCP8.5 realizations. The upper left panel shows the percentage of years in which the March accumulated snow amount falls below the 1976-2005 median value. The upper right panel shows the percentage of years in which the March-April-May (MAM) total surface runoff falls below the 1976-2005 minimum value. The lower left panel shows the percentage of years in which the June-July-August (JJA) surface air temperature falls above the 1976-2005 maximum value. The lower right panel shows the percentage of years in which the December-January-February (DJF) precipitation falls below the 1976-2005 minimum value. The top panels are from Diffenbaugh et al. (submitted to Nature Climate Change). The bottom panels are from Diffenbaugh and Giorgi (in review, Climatic Change Letters), with the field of view zoomed over the North American region.



The maps show the actual and projected potential vegetation for Mexico according to the GCM UKHADGEM1 and A2 scenario. The most remarkable changes are the decrease of coniferous forests and the expansion of the tropical dry forest. This projection considers the soil conditions of the vegetation types considered as a constraint for changes.

Figure 26-2: Climate-induced species migration in Mexico. Source: Trejo et al., 2011.

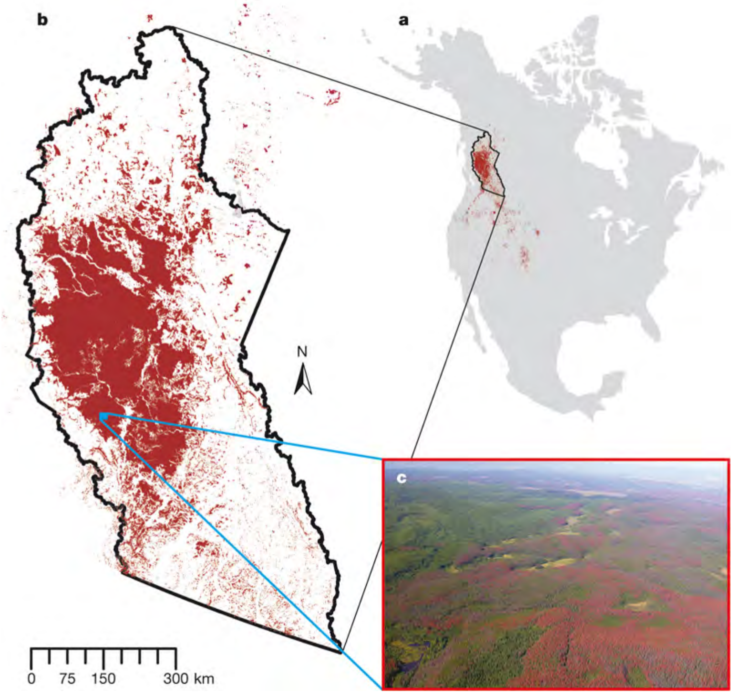


Figure 26-3: Geographic extent of mountain pine beetle outbreak in North America. Source: Kurz et al., 2008.

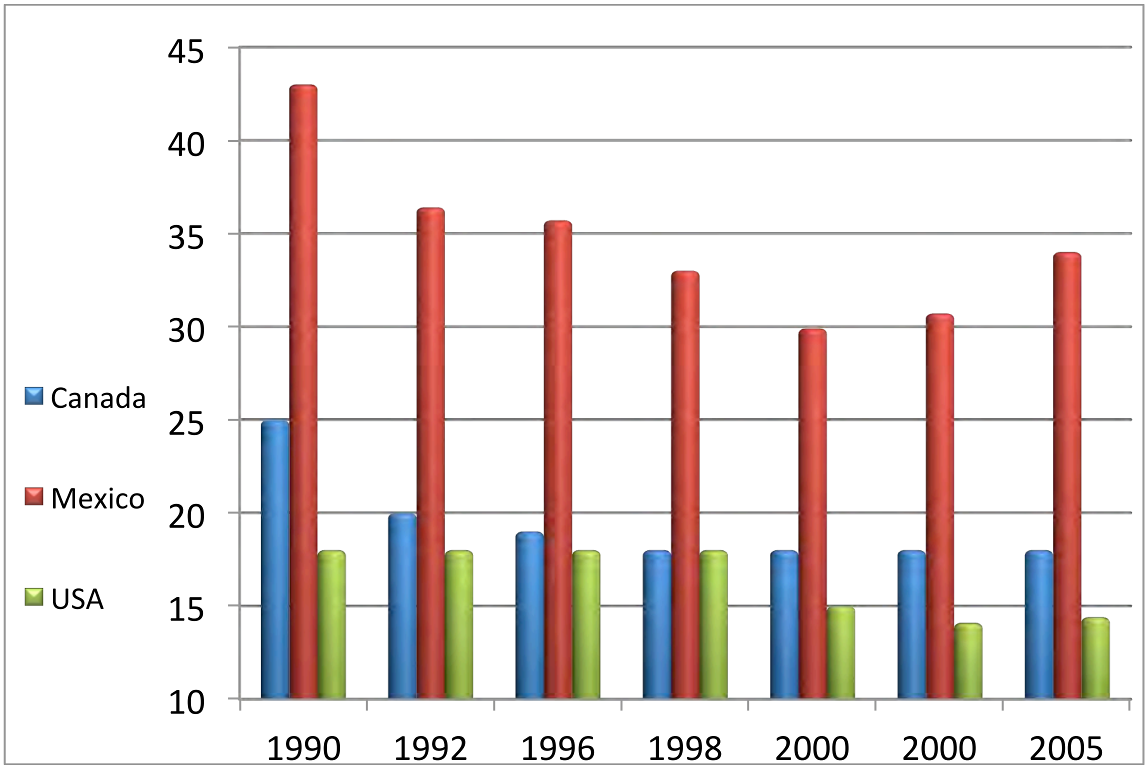


Figure 26-4: Household Budget Share of Food Comparison. Compiled by Gerardo Otero, Simon Fraser University.

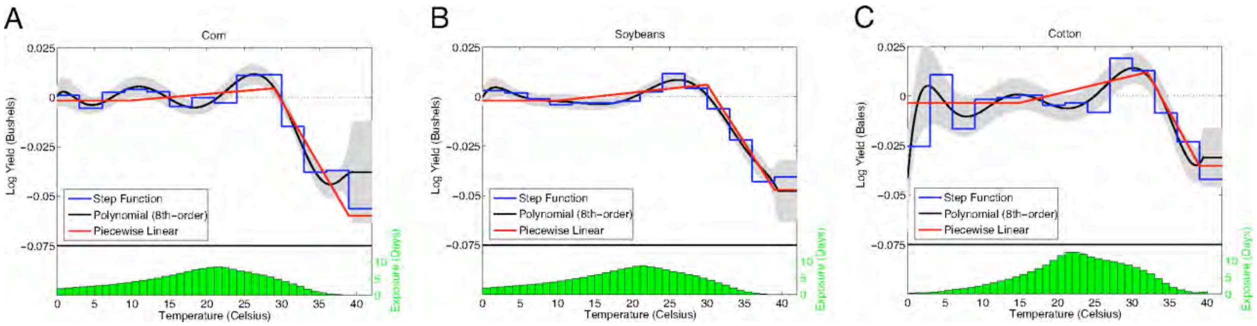


Figure 26-5: Nonlinear relation between temperature and yields. Source: Schlenker and Roberts, 2009.

Figure 26-6: Photo indicating damage caused by Hurricane Stan, courtesy of Hallie Eakin.

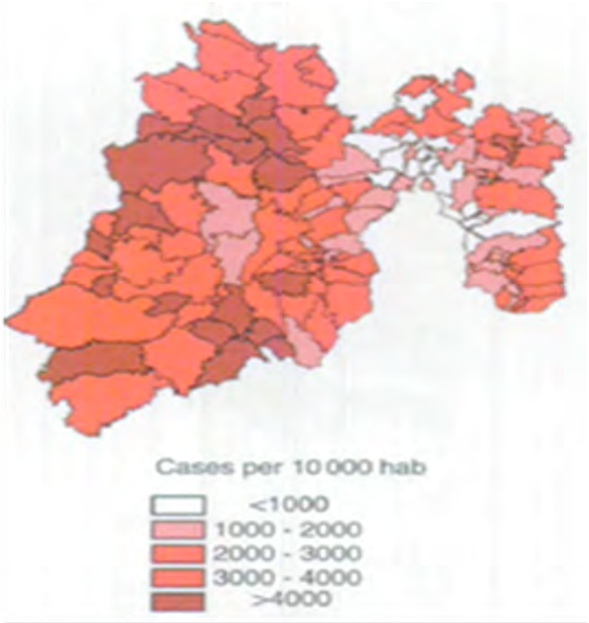


Figure 26-7: 2005 waterborne disease incidence for <age 5 in the State of Mexico. Source: Jiménez-Moléon and Goméz-Albores, 2011.

Figure 26-8: Woman fetching water in a periurban area southwest of Mexico City. Mexico City has made important strides in the provision of water and sanitation; however, in some urban neighborhoods, fetching water from outside of the home is common. Source: Courtesy of Patricia Romero-Lankao (September 2011).

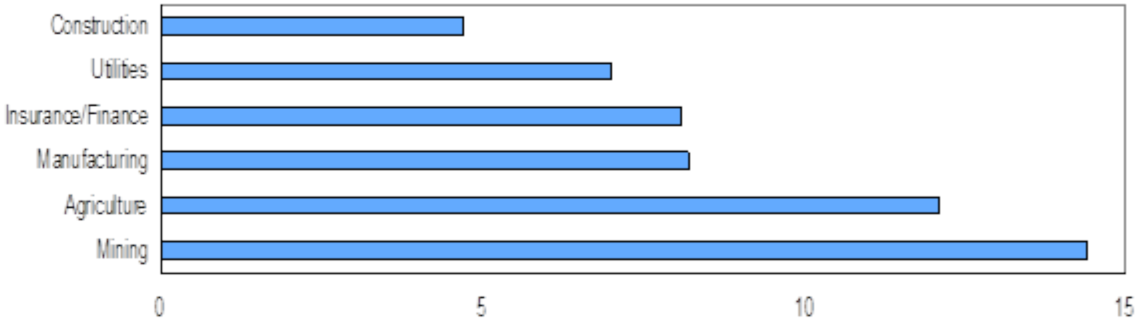


Figure 26-9: The most weather-sensitive sectors U.S. production and weather data, 1930-2008. This figure shows the interannual aggregate dollar variation in U.S. economic activity that is attributable to weather variability of the 2008 gross domestic product. Source: Lazo, 2011.

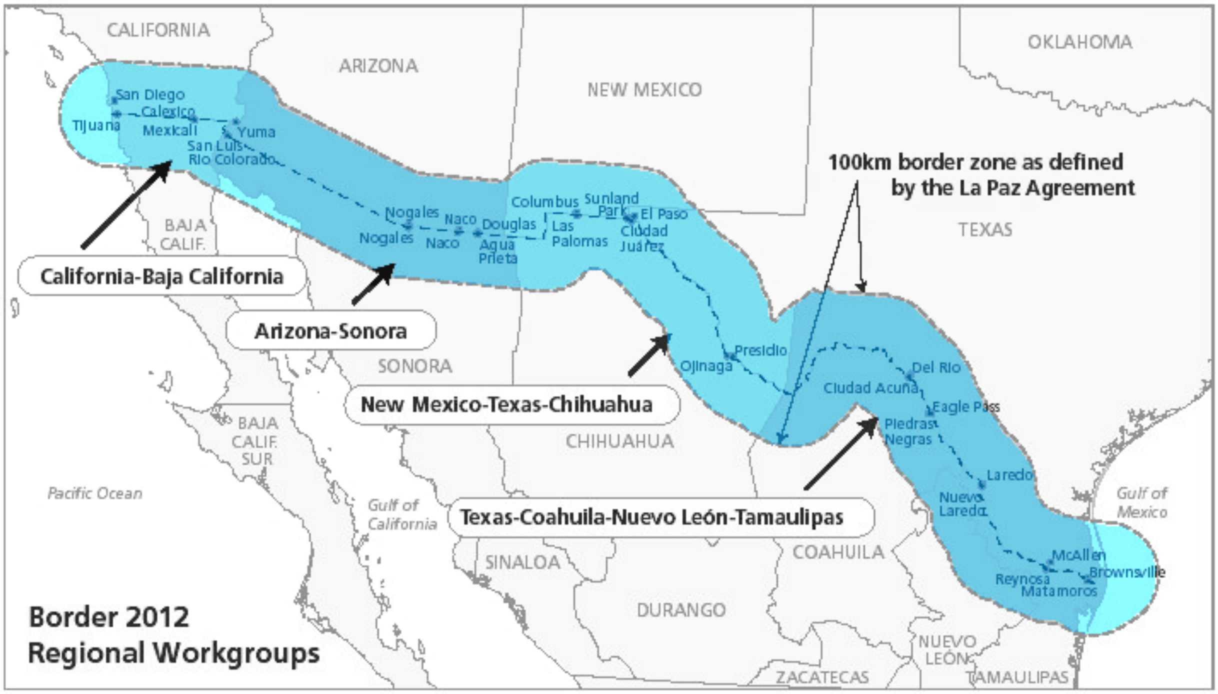


Figure 26-10: The US-Mexico Border. Source: EPA, 2012.

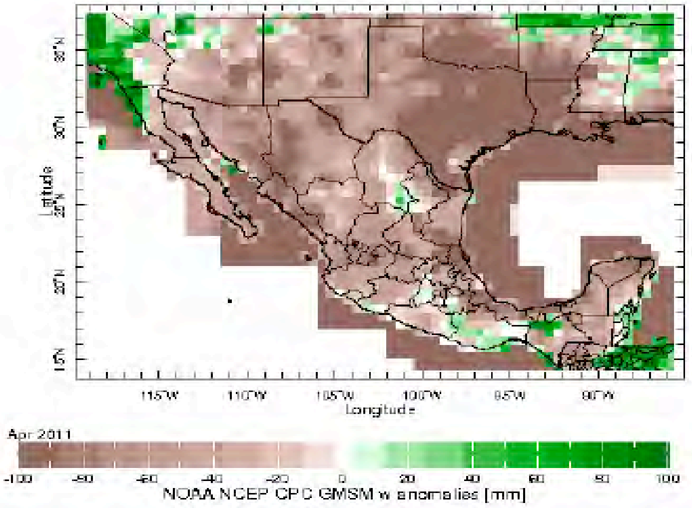


Figure 26-11: Soil-Humidity anomaly during April 2011. Source: Magana, 2011.