

**A PLACE FOR BUSINESS:
AN EXPLORATION OF BUSINESS LOCATION
AS A TOOL IN CLIMATE CHANGE
MITIGATION AND ADAPTATION**

A thesis

submitted by

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Abstract

Climate change will result in some regions suffering from unsustainable impacts, leading to outward human migration. This thesis examines the idea that relocation could preempt the worst impacts and be done in a planned way that mitigates greenhouse gas (GHG) emissions. Specifically, it explores the potential for businesses to relocate as a means to facilitate population movement. Extensive literature reviews were performed to establish how, who, where and why a firm would relocate. Climate and temperature data were analyzed to determine the emissions savings for a given firm to relocate between a low and high risk location. The results show GHG savings are possible through relocation, although there are significant caveats and assumptions. This thesis demonstrates the need for additional research to explore climate change impacts on locational risk and energy use. Furthermore, it highlights the need for purposeful and considered national spatial planning.

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Executive Summary

The scientific consensus that climate change is occurring and caused by human emissions of greenhouse gases [GHGs] is overwhelming. We will face continuing and increasing short-term impacts from climate change regardless of future emissions, due to the inertia in the climate system. The major impacts for the United States [U.S.] will be from increasing average temperature, changes in precipitation, sea level rise and increases in the power of tropical storm systems. Without action, consequences for biological and social systems will be severe. Mitigation will have to reduce emissions to 80% of present levels, and can help to avoid catastrophe in the long-term. In the short-term, adaptation will be vital in reducing the impacts on human systems. Migration will be one of the major human consequences, with poor, sick and elderly people, particularly in the developing world, being the hardest hit. Human migration can be a planned part of the adaptive process, moving people to less vulnerable places. Central to this thesis is the idea that human movement could also be an act of mitigation, moving people to places where they require and use less energy due to lower requirements for cooling and heating. Combining adaptation and mitigation is called synergy and is identified as a key strategy by the Intergovernmental Panel on Climate Change [IPCC].

One of the drivers of population movement since the industrial revolution has been the availability of jobs, which leads to the driving question of this thesis: Can business location be used as a tool in climate change mitigation and adaptation, pulling people to desirable locations and away from undesirable locations? Given the impacts of climate change, could some companies save on

Heating Ventilation and Air Conditioning [HVAC] energy use and reduce their physical risk to climate change impacts by relocating? To try and answer this, leads to an array of questions, which form the backbone of the chapters in this thesis, including: What are businesses doing about climate change? What drives business location? Are any businesses already moving due to climate change? Which places are most and least vulnerable to climate change? Which companies are most likely to relocate for the synergistic purposes of this thesis? What are the synergistic benefits of moving? How could such movement be implemented and is it desirable? The method for pursuing these questions is mainly through extensive literature reviews, pulling from a multi-disciplinary selection of sources. Analysis is also performed on available data from the Energy Information Administration [EIA], IPCC and the United States Global Change Research Program [USGCRP].

What are businesses doing about climate change?

A review of the literature on corporate responses to climate change reveals that overall, businesses are slow to adapt and mitigate and will need help to scale up their efforts. Most businesses acknowledge the importance of climate change but are failing to integrate it into their core strategy. Mitigation efforts vary, but include strategies of compensation, reduction and independence. Few businesses are adapting to the physical threats and those that are, often do so in ways which increase fossil fuel use and dependency. Adaptation is seen as an environmental problem and not a core issue and opportunity. Unfortunately, firms that do adapt often use historical norms as a guide, rather than the shifting baseline conditions of climate change. Also, there is a problem with the signaling

and interpretation of climate impacts. Studies find little sign of innovation in adaptation strategies, nor is there evidence of their codification. Emerging literature suggests that a resilience building approach may be more suitable given the uncertainties. Resilience strategies are more systems focused, involving the development of new competencies and slack resources. Location can be a core element of a resilient business as it is a multiplier of most factors of GHG emissions and has obvious implications for risk.

What drives business location?

Most businesses do not consider climate change, either the physical risk or legislative risk, when making location decisions. There is a difference between location and relocation decisions, with location decisions involving just pull factors, whereas relocation also includes push factors. Theories of relocation are rare but some theories of location can be used. Most firms do not occupy the optimal location and stay where they are unless profits are considerably higher elsewhere. Adjustment may also be sought through reorganization or investment. The location decision is firm specific and highly complex, with many researchers finding location incentives to be a waste of money. In fact, relocation is caused by the right combination of push and pull factors and is most often for firm internal reasons such as growth.

Which places are most and least vulnerable to climate change?

All firms will be affected, but climate change will cause particular problems for businesses facing competence-destroying consequences. Sectoral clustering could be a problem, with industries such as chemicals, oil and tourism clustering

at the coast. According to the literature, the Gulf Coast and Florida are particularly at risk and the Northeast, Northwest and Great Lakes are less prone to climate change. There were considerable gaps in the literature. First, climate models are not accurate enough yet to make accurate predictions at the city scale. Second, most studies of city sustainability do not fully account for climate risk. The goal was to choose two cities to carry forward for analysis in Chapter 7. From the studied literature, it was possible to choose Miami as a more at risk location. Cleveland was picked for its combination of low risk and potential to absorb new growth.

Which companies are most likely to relocate for synergistic purposes?

Finding the kinds of business most likely to move was more problematic than exploring location. Data showed that the commercial sector uses both a higher amount and a larger proportionate amount of energy for HVAC than the industrial sector. This makes commercial sector businesses most likely to move if HVAC energy savings are significant enough at another location. Using data gleaned from Chapter 4 it seems that innovative, growing firms would be most likely to relocate for synergistic purposes, particularly commercial sector, high-energy users.

What are the synergistic benefits of moving?

We compared present energy use and GHG emissions for HVAC between a typical commercial building in Miami and one in Cleveland. We also projected these figures into the future to compare the impact that a high and low emissions scenario could have on these figures. Total energy use for HVAC was

found to still be higher in Cleveland regardless of the emission scenario. We found that there is potential for GHG savings in Cleveland when typical fuels and national averages were used in the calculations. There were many caveats. Most importantly, the viability of cutting emissions by relocating relies upon the energy portfolio at destination and origin. Along with many other aspects of the shifting baseline, it is impossible to predict how the energy portfolio for each location will look in the future.

How could such movement be affected and is it desirable?

Insurance, if managed properly by government regulation, can provide a valuable incentive for low risk behavior. The removal of market distortions such as state subsidized insurance and FEMA funding, which does not account for risk, are two steps which would encourage low risk behavior, but also be hugely unpopular. Carbon pricing and environmental taxes will be an integral part of any climate change policy, with the potential to create both push and pull factors. Probably the most promising policy to affect business location is investment in infrastructure such as high-speed rail [HSR]. HSR will undoubtedly create growth around its location and we theorize that, done strategically, investment could pull growth away from risk prone areas.

Much research is needed, particularly in the area of risk assessment and climate modeling, before location can be used as an effective tool for adaptation, let alone mitigation. In the absence of stronger models businesses and governments should start to take no regrets actions over the location of people, businesses and infrastructure. Doing so will require a reassessment of the role of the federal government in national spatial planning.

1. The Context of Climate Change

1.1 Climate Science

1.1a Scientific consensus

The IPCC's second assessment report in 1995 stated that "the balance of evidence suggests a discernable human influence on global climate" (Santer and Wigley 2010, 28). Subsequent reports have strengthened the language. The USGCRP concluded that "the global warming of the past 50 years is due primarily to human-induced increases in heat-trapping gases" (USGCRP 2009, 19). The 2007 IPCC report suggests that "warming of the climate system is unequivocal," and "most of the observed increase in global average temperature since the mid-20th century is very likely due to the observed increase in anthropogenic GHG [Greenhouse Gas] concentrations" (IPCC 2007a, 30).

1.1b Observed Climate Changes

Atmospheric GHGs are now equivalent to approximately 430 parts per million (ppm) CO₂, compared to 280ppm prior to the Industrial Revolution (Stern 2006a, 3). Temperature increases are greatest towards the North Pole and it is "very likely" that the Northern Hemisphere just experienced the warmest 50 year period in the last 500 years, and "likely" that it was the warmest in the past 1300 years (IPCC 2007a, 30). The first decade of the 21st century was "0.69 °C above the pre-industrial average" (Met Office 2010, 4) and from 1995 to 2006 we experienced eleven of the twelve warmest years on record (IPCC 2007a, 30).

Along with average temperature increase, The Met Office (2010, 5) found

substantial increases in water temperature, humidity and sea-level, plus reductions in arctic sea ice, glaciers and spring snow cover. The IPCC (2007a, 30) found sea level rise [SLR] at an average rate of 1.8mm per year from 1961 to 2003 and 3.1mm per year from 1993 to 2003. Thermal expansion of the oceans has resulted in 57% of the SLR since 1993, with the remainder attributable to melting ice (30). Decreases in snow and ice cover are also linked to warming with the average extent of Arctic sea ice since 1970 reduced by 2.7% per decade in winter and 7.4% per decade in summer (30). We are seeing, “increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers, and warming of lakes and rivers in many regions” (31). There is also “high confidence” that higher water temperatures have led to “observed changes in marine and freshwater biological systems” and “very high confidence” that terrestrial biological systems have also been impacted, including earlier “spring events” and “poleward and upward shifts in ranges in plant and animal species” (IPCC 2007a, 33).

1.1c Observed Climate Changes in North America

From 1955 to 2005 the mean annual temperature increased in North America “with the greatest warming in Alaska and north-western Canada, substantial warming in the continental interior and modest warming in the south-eastern U.S. and eastern Canada” (IPCC 2007b, 620). The last 30 years has seen the most rapid changes in winter “with average winter temperatures in the Midwest and northern Great Plains increasing more than 7°F” (USGCRP 2009, 9). Some coastal areas have seen SLR of up to 8 inches in the last 50 years (USGCRP 2009, 37). Increasing temperatures are leading to changing precipitation

patterns on a regional scale. “Annual precipitation has increased for most of North America with large increases in northern Canada, but with decreases in the south-west U.S., the Canadian Prairies and the eastern Arctic” (IPCC 2007b, 621). Most of the increased precipitation in the last 50 years is attributable to the increased “frequency and intensity of heavy downpours” (USGCRP 2009, 32). In dryer areas, such as the U.S. Southeast and West, drought frequency has increased over the past 50 years, whereas the Midwest and Great Plains have seen reduced occurrence of drought (USGCRP 2009, 33).

Average sea surface temperatures have also increased, possibly leading to more powerful and frequent Atlantic hurricanes (USGCRP 2009, 32). “During the past 30 years, annual sea surface temperatures in the main Atlantic hurricane development region increased nearly 2°F”, coinciding with an increase in the destructive energy storms (35). Winter storm tracks have been pushed north, with an increase in the intensity of the strongest storms (33).

1.2 Climate Change Projections

According to Stern (2006a, 3), “scientific evidence points to increasing risks of serious, irreversible impacts from climate change associated with business-as-usual (BAU) paths for emissions.” Warming and SLR would not stabilize for centuries even with a leveling off of emissions (IPCC 2007a, 46). Historical emissions of GHGs “have already caused the world to warm by more than half a degree Celsius and will lead to at least a further half degree warming over the next few decades, because of the inertia in the climate system” (Stern 2006a, 3). For a BAU scenario, GHGs could increase threefold by 2100, leading to “at least a

50% risk of exceeding 5°C global average temperature change during the following decades,” an amount which differentiates temperatures today from the last ice age (4). Under the most likely emission scenario, the IPCC (2007a, 44) projects a global emissions increase of 25 to 90% between 2000 and 2030.

An increase in temperature of 0.2°C per decade is projected (IPCC 2007a, 45) for the next two decades, given the most likely emission scenarios. Beyond then projections are increasingly reliant on emissions and without a reduction in the 21st Century, further temperature increases would “very likely” result in greater changes to the world than those observed in the 20th century (45). The economic damage of the most likely scenarios is “around a 20% reduction in consumption per head, now and into the future” (Stern 2006a, 10).

For North America, the IPCC predicts warming of 1 to 3 °C from 2010 to 2039 (2007b, 626). The USGCRP predicts an increase to U.S. average temperature by the year 2100 of “approximately 7 to 11°F under the higher emissions scenario and by approximately 4 to 6.5°F under the lower emissions scenario” (2009, 29). Greater warming is projected for the contiguous U.S. states during summer, whereas in Alaska and other arctic regions winter will warm more (USGCRP 2009, 28). Most of the U.S. will see further increases in precipitation, mostly during heavier downpours, whereas the U.S. Southwest will see falling average precipitation (IPCC 2007b, 627). As with most of climate predictions, “future trends in hurricane frequency and intensity remain very uncertain” (627). Increasing temperatures are likely to affect the intensity of hurricanes, increasing their potential impact (USGCRP 2009, 36; IPCC 2007b, 627).

1.3 Mitigation

Climate projections become more difficult for dates further into the future. As Stern (2006a, 1) points out, “the effects of our actions now on future changes in the climate have long lead times,” with only a limited opportunity for effect “over the next 40 or 50 years,” but the opportunity for “a profound effect on the climate in the second half of this century and in the next.” Mitigation of GHG emissions needs “to account for inertia in the climate and socio-economic systems,” with for example, thermal expansion of the oceans continuing for many centuries after stabilization, for any of the given scenarios (IPCC 2007a, 66-67). Stern (2006a, 11) suggests stabilization requires annual emissions to be reduced to a level that can be absorbed by the earth’s sinks, with a long term goal of five gigatons of CO₂-eq per year, 80% below current levels. Achieving such a goal “would require global emissions to peak in the next 10 - 20 years, and then fall at a rate of at least 1 - 3% per year” (11).

The IPCC (2007a, 68) assesses a range of stabilization scenarios from 445 to 1130 ppm CO₂-eq. Any given scenario in this range could be achieved through existing, or soon to be available technologies (68). Economic and health benefits associated with GHG mitigation could offset substantial amounts of the cost (58-59), although both the IPCC and Stern agree that to achieve a more desirable stabilization level by 2050, a small net decrease of global GDP is likely.

1.4 Vulnerability

Given that climate change will continue to accelerate in the short to medium term, regardless of our mitigation efforts, society will have to address certain

vulnerabilities. “The vulnerability of North America depends on the effectiveness and timing of adaptation and the distribution of coping capacity, which vary spatially and among sectors” (IPCC 2007b, 619). Some of the most vulnerable groups include indigenous peoples and the socially or economically disadvantaged, with variations in wealth and regional capacity leading “to an uneven distribution of likely impacts” (619). Groups with few resources often live in conditions that increase their vulnerability and cluster in certain regions with, for example, the elderly more often making up a “larger share of the population in warmer areas” (USGCRP 2009, 101). The “disproportionate impacts of Hurricane Katrina on the poor, infirm, elderly, and other dependent populations,” illustrated this unfortunate reality (625).

North America has seen an increase of insured losses since the 1970s “reflecting growing affluence and movement into vulnerable areas” (IPCC 2007b, 620), a trend that is likely to continue (626). Other factors increasing exposure include urbanization in storm-prone areas, ageing infrastructure, substandard structures and inadequate building codes (626).

Water resources for many growing urban areas will become increasingly unstable, creating risks for people and industry, particularly in the western U.S. (IPCC 2007b, 633). Although most acute in the west, “vulnerability to extended drought is increasing across North America as population growth and economic development create more demands from agricultural, municipal and industrial uses, resulting in frequent over-allocation of water resources” (622). Urban water management will struggle with reliability of supply in some cases and flood risks and stormwater management in others (633).

1.5 Adaptation

International negotiations have largely focused on mitigation, until recently when adaptation was placed on a more equal footing by the 2007 meeting of the United Nations Framework Convention on Climate Change (Forfas 2010, 2).

“Adaptation is the only response available for the impacts that will occur over the next several decades before mitigation measures can have an effect,” yet it has not received sufficient attention in many countries (Stern 2006a, 21).

“Adaptive capacity is intimately connected to social and economic development, but it is not evenly distributed across and within societies” (IPCC 2007a, 56).

Wealthier countries and regions within countries “have greater access to technology, information, developed infrastructure, and stable institutions” (IPCC 2007b, 637). Given that the benefits of adaptation are felt locally, Stern (2006a, 21) suggests that some adaptation will occur autonomously. Conversely, major infrastructure and certain public goods will require a proactive planning approach (21). Adaptation options are plentiful but often hindered by “barriers, limits and costs, which are not fully understood” (IPCC 2007a, 56).

Governments in North America have focused the public discourse on mitigation rather than adaptation, with the result that none have a formal adaptation strategy (IPCC 2007b, 637-638). Furthermore, “information about climate change is usually not ‘mainstreamed’ or explicitly considered in the overall decision-making process” resulting in actions that are “maladapted” (638). Efforts to adapt urban areas encounter problems of ageing infrastructure, air pollution, population growth, population ageing and inertia in the political, economic and cultural system (619). Historical experience with climate “has

been institutionalized through building codes, flood management infrastructure, water systems and a variety of other programs” (637).

Quantitative information on the costs and benefits of economy-wide adaptation is currently limited (IPCC 2007a, 56). Adaptive strategies in the U.S. have been shown to provide multiple benefits, with one study reporting social benefits of \$14 billion from \$3.5 billion spent on flood, wind and earthquake adaptation between 1993 and 2003 (IPCC 2007b, 638). Looking forward, some studies in sectors sensitive to climate change predict benefits in excess of cost for adaptation, although under higher emission scenarios costs rise rapidly (Stern 2006a, 21). Adaptation will be particularly difficult in developing countries, where vulnerability and poverty will limit capacity (21).

“Integrating perspectives on climate change into legislation and regulations has the potential to promote or constrain adaptive behaviour” (IPCC 2007b, 637-638). Stern (2006a, 21-22) suggests four key areas for Governments to guide effective adaptation:

- Develop climate information and tools for risk management
- Incorporate climate change into land-use planning and building codes
- Invest in climate-sensitive public goods such as emergency preparedness and natural resource protection
- Provide financial safety nets for the poorest and most vulnerable

Many aspects of sustainable development provide the “diversification, flexibility and human capital which are crucial components of adaptation” therefore adaptation often can be an “extension of good development practice” (Stern 2006a, 22). Crucially, proactive adaptation calls for “technological and social innovation, areas where Canada and the U.S. have abundant capacity” (IPCC 2007b, 639).

1.6 Opportunities for Synergy of Mitigation and Adaptation

Chapter 18 of the 2007 IPCC Report outlines four inter-relationships between adaptation and mitigation (Klein et al. 2007, 747):

- Adaptation actions that have consequences for mitigation
- Mitigation actions that have consequences for adaptation
- Decisions that include trade-offs or synergies between adaptation and mitigation
- Processes that have consequences for both adaptation and mitigation

There are important differences between decision making for mitigation and adaptation, due to mitigation benefits being enjoyed globally, while costs are borne locally. Effective mitigation requires global policy, whereas adaptation is a local issue, with the costs and benefits felt at the local level (Klein et al. 2007,747). “Creating synergies between adaptation and mitigation can increase the cost effectiveness of actions and make them more attractive to stakeholders, including potential funding agencies” (747). Policies with both local and global benefits would be a powerful strategy. Sectors such as agriculture, forestry, buildings and urban infrastructure offer greater opportunity for synergy than others, such as health and energy (747).

What about opportunities for synergy between mitigation and adaptation in our social systems? The IPCC (Klein et al. 2007, 747) suggests with high confidence that “people’s capacities to adapt and mitigate are driven by similar sets of factors.” A general response capacity is vital to both adaptation and mitigation and therefore policies that enhance a “society’s response capacity through the pursuit of sustainable development” should be prioritized (747). Social response capacity can also be described as resiliency.

2. Human Movement as a Result of Climate Stress

“The United States (U.S.) and Canada will experience climate changes through direct effects of local changes, as well as through indirect effects, transmitted among regions by interconnected economies and migrations of humans and other species” (IPCC 2007b, 619).

2.1 Background

2.1a Migrant or Refugee?

The International Organization for Migration (IOM) suggests resistance to the word refugee being used in the context of climate change (Brown 2008, 13–15). Refugees have certain rights under international law, which most countries and international organizations are unable or unwilling to afford to people affected by climate change. The IOM suggests the phrase “climate migrant” implies the pull factor of the destination was more significant in causing the displacement “than the push of the source”, offering the term “forced climate migrant” as an alternative (13–15).

2.1b Will climate change cause human migration?

The overwhelming consensus is that climate change will cause human migration. According to The IOM (Hugo 2008, 31), “stresses such as increased drought, water shortages and riverine and coastal flooding will affect many local and regional populations. This will lead in some cases to relocation within and between countries, exacerbating conflicts and imposing migration pressures.” Stern suggests “there is already evidence of the pressure that an adverse climate can impose for migration” (2006b, 129). Although Stern is non-committal in attributing recent droughts to human induced climate change, a United Nations report affirms that, “the impacts of climate change are already causing migration

and displacement” (Warner et al. 2009, iv-v). For example, the migration caused by decreasing rainfall due to climate change in Senegal, Mali, Burkina Faso and Niger, resulted in “rapid intra-country migration and a swelling of big cities” between the years 1960 and 2000 (Warner et al. 2009, 21). The IOM feels that despite a large amount of research into climate change and migration “the number of empirical studies of contemporary manifestations of the influence of climate on migration is surprisingly small” (Kniveton 2008, 33). The lack of hard evidence will increase the hesitancy of organizations to commit to the existence of forced climate migrants. Warner et al. (2009, 2) believe the difficulty lies in “isolating environmental factors from other migration drivers.” Quantification is difficult due to the “slow onset” of climate induced environmental change and because initially “environmental induced migration is mostly internal” (16-17).

2.1c How many people will be displaced by climate change?

Predictions as to the number of people displaced vary drastically, mainly due to uncertainty as to the severity of climate change. According to Stern (2006b, 129), “the exact number of people who will actually be displaced or forced to migrate will depend on the level of investment, planning and resources at a government’s disposal to defend these areas or provide access to public services and food aid.” Lovelock (2009, 229-250) suggests that initially places with temperate climates, such as Britain and New Zealand, will become “lifeboats”, but the only way for humanity to survive long term will be to move to northern parts of Canada, Russia and Scandinavia. Although Lovelock is at the extreme end of the predictions, the commonly accepted numbers are sobering. 200 million climate migrants by the year 2050 is the commonly accepted figure

(Stern 2006b, 129; Brown 2008, 11). The IOM hedges that the originator of the estimate, Professor Norman Myers, had to use “heroic extrapolations” and there is huge uncertainty as to the extent of climate migration, with estimates ranging from 25 million and 1 billion people by 2050 (Brown 2008, 11).

2.1d What are the consequences of climate migration?

There is a much clearer picture in the current literature of the possible consequences of forced climate migration, than there is regarding the onset of migration and the number of people displaced. Society has dealt with migration from various drivers before. However, as the Center for American Progress points out, “climate migration has multiple humanitarian, security, and legal implications and is a more complex issue than we’ve previously faced. Traditional methods of response may prove insufficient.” One of the main problems is that traditional refugees can return home over time, whereas climate migrants may be permanently displaced (Werz and Manlove 2009, 2-4).

Large numbers of permanent migrants will have costly effects on the receiving area or nation, which is often likely to be a poor neighbor or ethnically different area, risking tension and conflict. As the Center for American Progress (Werz and Manlove 2009, 2-4) suggests, “climate migration hotspots overlap with already volatile and unstable regions.” The IOM also points out that migrants often make a heavy environmental impact on their destination area (Hugo 2008, 43), which can again escalate conflict through competition for resources (Brown 2008, 38). Consequences for migrants can also be severe, including “cultural degradation, lost livelihoods, reduced access to social services, and the loss of employment networks” (Warner et al. 2009, 21).

The worst consequences of migration could be avoided through proper planning. “Policy decisions made today will determine whether migration becomes a matter of choice amongst a range of adaptation options, or merely a matter of survival” (Warner et al. 2009, iv). With foresight, it should be possible to create conditions in favorable places to “pull” people away from at risk areas. Better still, policies that build resiliency are suggested favorably in most seminal reports from the leading international authorities on migration, including the UNHCR (Warner et al. 2009, 5), The IOM (Brown 2008, 41) and national bodies such as the Norwegian Refugee Council (Kolmannskog 2008, 34). Improving mobility is a major factor in improving resilience.

2.2 Migration and the United States

2.2a Historical Perspective

The U.S. is no stranger to migration. Founded by immigrants and with a population continually in flux, migration is part of the culture. “Much of what is superficial about U.S. culture is designed to alleviate the disorienting effects of migration” and “much of what is profound in American Society is meant equally to duplicate familiarity” (Urgo 1995, 4).

Americans are also no stranger to forced climate migration. In the 1930's, below average rainfall caused the failure of many small farms on the Great Plains, particularly Oklahoma. During what became known as the Dust Bowl “up to 300,000 “Okies” left the region,” many moving to California (Brown 2008, 23). More recently Hurricane Katrina forced a million people from the Mississippi and Louisiana coasts to move inland, with nearly all planning to return, many

have not (41). Migration in the U.S. has obviously not always been due to such push factors, with the pull of jobs making the country increasingly urban since the 1920's. That trend continued until the 1990's "when, across the country, a growing number of households have moved outside of cities and either commute to work or work at home part of the time" (National Research Council 1999, 57). Increasing GHG emissions, caused by the move to the suburbs, will be important to consider when looking at migration due to climate change.

2.2b How will climate change affect migration in the United States?

According to the USGCRP (2009, 100), "overlaying projections of future climate change and its impacts on expected changes in U.S. population and development patterns reveals a critical insight: more Americans will be living in the areas that are most vulnerable to the effects of climate change." This includes the most populous states of California, Texas, Florida and New York, which "share significant vulnerability to coastal storms, severe drought, sea-level rise, air pollution, and urban heat island effects" (100). Unfortunately, "human and environmental systems do not respond to change in a smooth fashion" (Warner et al. 2008, 14-15). Research suggests that one primary driver of migration in the U.S. will be an increased rate of severe hurricanes such as Katrina, which "resulted in the largest displacement of Americans in the country's history" (Warner et al. 2008, 14-15). Brown (2006) poses that rising insurance premiums and falling property values will cause people and businesses to move inland or not return after a severe weather event.

2.3 Migration as Adaptation, Mitigation or Synergy

The IOM (Brown 2008, 38) suggest that “migration is typically seen as a failure of adaptation, not a form of it,” but the same report and others recommend that this need not be so. Warner et al. (2009, 2) propose that migration should be included in adaptation strategies. Seasonal migration will play a more important role in the lives of many families (2). Many pastoralists traditionally practice seasonal migration to lessen the impact that their herds have on the environment. Few people would migrate purely to reduce their carbon footprint and migration is currently not seen as a serious method of mitigation. The literature was very clear that most migration will occur within existing national borders and will be an adaptive response to climate change. Unfortunately, the slow onset of climate change could cause policymakers to not recognize the need to facilitate movement.

Most mitigation is likely to come from international agreements. As a result, in order for people to migrate for mitigation purposes, there will also have to be an adaptive reason, or a pull factor that draws people to a lower carbon use area. In other words, to reduce emissions through migration, policies should seek synergy between mitigation and adaptation. At the very least, due diligence should be given to the fact that some adaptive policies, such as increased air conditioning, can have negative effects on mitigation efforts.

The impact on world GHG emissions of people from developing nations migrating would be negligible or could even increase emissions if they moved to a more developed area or nation. Any policy that wishes to seriously reduce GHG emissions through migration must look at the developed world. This should not

be at the expense of fostering resiliency and allowing migration in and from the developing world. Instead it should be part of a suite of actions that facilitate human movement to avoid imminent danger and reduce future threats. Much of the studied literature highlighted the need to consider the social, environmental and economic consequences for the destination area. Through careful selection of location, is it possible to create mutually beneficial results where both source and destination of migration benefit? Finally would there be an opportunity for migration to create synergy between mitigation and adaptation?

2.4 Conclusions and Questions Moving Forward

It is highly likely human migration will occur due to climate change in North America. Additionally, those needing to move will be vulnerable populations. Could the next great migration be managed in such a way as to provide synergistic benefits and assist those unable to move? Even better than attempting to relocate fleeing people to areas that lower their GHG emissions, would be to proactively help them to relocate to lower emission areas before they are seriously impacted by climate change. With people moving businesses will follow. Many will be forced to relocate for the same reasons as their customers and employees. What are the possibilities for businesses to relocate in a proactive manner? Could such relocations be used to pull human populations to less at risk areas? Would it be possible to do so and move to areas where human populations have a lower carbon footprint? Before attempting to answer these questions in later chapters, we will first briefly explore present business attitudes and strategies to climate change.

3. Business Strategy and Climate Change

Climate change has become an increasingly salient issue for business. Many businesses wish to be ahead of future regulations and green their image, with “responsibility towards the environment . . . becoming a key battleground for competitive advantage” (Galbreath 2010, 335). Business leaders appear to have sensed these shifts. A McKinsey (2007, 2) survey of global executives found that 60% see climate change as an important factor in the overall strategy of their company and 70% view it as “an important consideration for managing corporate reputation and brands.” Over 80% of respondents expected “some form of climate change regulation to be enacted in their companies’ home country within five years” (9). However, only 44% felt it was a “significant item on their agendas” signifying that climate change is not being acted upon. Over a third of respondents felt that their company seldom or never account for climate change in overall strategy (2).

Although priorities may have changed since the global financial crisis, one result of the crisis could be a push for greater transparency in business operations. The Carbon Disclosure Project [CDP] (2008, 1) in the United Kingdom [UK] feels that “stakeholders will develop their own perceptions and expectations regarding the impacts of climate change and the responses they expect to see from the business sector.” The CDP notice increased policy and regulatory activity around adaptation with the financial community requesting more disclosure on climate risks and opportunities (1).

As Linnenluecke and Griffiths (2010, 479) recognize, “increasing exposure to extreme weather events generates significant and new challenges for

organizations.” Forfas (2010, 19-21), suggests the following climate change impacts on business:

- Markets: changing demand for goods and services
- Logistics: increasing vulnerability of supply chain, utilities and transport
- Premises: changes to building design, construction and management
- Finance: implications for investments, insurance and stakeholder reputation
- People: implications for workforce, customers and changing lifestyles
- Processes: impacts on production processes and service delivery

This chapter first explores the corporate dimensions of mitigation and adaptation, looking at how business is, or is not, attempting to meet these challenges. Finally, we examine alternative frameworks for dealing with climate change issues.

3.1 Mitigation

Despite the continued absence or weakness of laws and regulations regarding GHG emissions, many businesses have acted to reduce or mitigate their emissions. Strong corporate action to reduce emissions will be an essential component of any strategy to slow and stop future climate change.

3.1a Drivers of Business Mitigation of Climate Change

McKinsey (2007, 5) found that executives considering climate change in business decisions listed the most influential factors as “corporate reputation, media attention to climate change and customer preferences.” Weinhofer and Hoffmann (2010, 77) elaborate that “many companies are facing increasing pressure by governments, shareholders and other stakeholders to reduce their CO₂ emissions” although there is variation “between and within industries” (78). Reducing emissions represents an important signal to the market (Galbreath

2010, 336), showing that a business is efficient, responsible and proactive.

3.1b Frameworks for mitigating GHG emissions?

Weinhofer and Hoffmann (2010, 80) offer a framework to understand corporate mitigation, breaking strategy down into three types:

1. CO₂ Compensation
 - Acquisition of CO₂ capacity through trading or investment in offsets
2. CO₂ Reduction
 - Enhancements or improvement of CO₂ emitting production process
 - New or improved products with lower lifetime emissions
3. Carbon Independence
 - New or improved carbon free production processes
 - New or improved products that are carbon free lifetime

Corporate CO₂ strategy can then be “conceptualized as a focus on one or a combination of several CO₂ strategy types” (80).

3.1c How are companies mitigating GHG emissions?

As expected from the strategies outlined, businesses adopt a variety of strategies including carbon credits or offsets, exceeding regulatory requirements, requiring suppliers to reduce carbon footprints and by applying technology (Galbreath 2010, 336). In a study of electricity producers, Weinhofer and Hoffman (2010, 86-87) find that the proportion of companies from the European Union and Japan who focus on all three strategy types (Compensation, Reduction and Independence) is significantly higher than for the U.S. The difference is due to varying regional GHG regulations and stakeholder pressure (86-87). There was also “no indication that companies with larger relative emissions (relative to electricity output) follow a specific strategy” (88).

There are other issues with the uptake of mitigation strategies. Many low carbon technologies are too large in scope to be implemented by one company

and a balance must be found between cooperating and gaining a competitive advantage (Pinkse and Kolk 2010, 268). Risk sharing is highly desired so “cooperation with companies from other industries” is often sought (268). Large corporations have the power to create significant barriers to entry, for example if an innovation is seen to be competence destroying (268). For instance, the electricity grid “suffers from a ‘carbon lock-in’, as technological and market systems surrounding electricity favour generation from fossil fuels” (269).

Clearly, corporate mitigation of GHG emissions has progressed as far as government, shareholder and customer pressure have forced it. Most costs of mitigation are borne by the company with many, but not all, of the benefits being spatially dispersed. Only government intervention in the form of regulation will force companies to take the range of actions necessary for mitigation.

3.2 Adaptation

The CDP (2008,1) suggests that businesses addressing just mitigation “are only considering half the picture” and that “prudent businesses are preparing strategies to assess and manage the impacts of a changing climate.” Despite business knowledge and action on the risks and opportunities associated with mitigation, few businesses “are incorporating the risks and opportunities associated with the physical effects of climate change in their business planning” (Sussman and Freed 2008, 1). As we know, the world will experience considerable impacts from GHGs already emitted, regardless of mitigation. Government agencies are only just beginning to encourage business to adapt, with Forfas (2010, 2-3) suggesting that an “effective response to climate change

must combine both mitigation - avoiding the unmanageable - with adaptation, managing the unavoidable.”

With the improving clarity of climate models and projections, more businesses will consider adaptation measures, “reacting to and managing risks as well as taking advantage of opportunities” (Sussman and Freed 2008, 1). “Adaptation measures range from soft responses (policy, planning and integration) to hard (engineering) responses, with varying degrees of cost” (Forfas 2010, 23).

3.2a Drivers of Business Adaptation to Climate Change

The CDP (2008, 4) suggests “the key drivers for adaptation will be experienced through regulatory and legal liabilities, changes in cost profiles, market transformations, stakeholder interest and governance.” Despite strong signals to act, change will not be easy. As Sussman and Freed (2008, 3) point out, our “current economic structures, production processes, and supporting systems have all developed over time under relatively stable climate conditions” (3). Transformational change will be required, offering both opportunity and risk for some organizations (3). Early adapters will be better positioned to avoid and limit impacts, as they avoid locking expensive assets into areas at risk from climate change (4).

3.2b Early Actors

The physical impacts of climate change are considered by relatively few businesses (Sussman and Freed 2008, 3), so examples of adaptation “are largely absent from the literature” (IPCC 2007b, 637). Businesses prone to increasing

frequency of extreme events are more likely to respond early to the physical impacts of climate change (Sussman and Freed 2008, 7). In one study, the insurance, oil and gas, electric utilities, and food, beverage and tobacco sectors expressed the most concern about climate change with extreme events being the main factor (9). In the UK, insurance and water have moved beyond concern and developed a high level of awareness of the implications of climate change on their business (CDP 2008, 11), with the same true of the insurance industry in the U.S. (Sussman and Freed 2008, 7). The UK water industry has taken a lead on adaptation and a proactive stance towards the shifting baseline of climate change. Looking beyond extreme climate events they have realized that “incremental changes to our climate are more subtle and their impacts on business models may pass undetected until critical thresholds are breached” (CDP 2008, 11). Although some planned adaptation has been “taken by the engineering community, insurance companies, water managers, public health officials, forest managers and hydroelectric producers” (IPCC 2007b, 637), there is an inadequate balance between preparing for extreme events and the effects of long term changes to average conditions (Sussman and Freed 2008, 7).

Other early adapters include businesses relying on snow and ice such as winter recreation and diamond mines using temporary ice roads (Sussman and Freed 2008, 7). In these cases, adaptation tends to be reactive and increases GHG emissions and fossil fuel dependency through solutions such as snow making and airlifting equipment. Not all businesses are as susceptible to the physical effects of climate change, but most “face the possibility of property damage, business interruption, and changes or delays in services provided by public and

private electricity and water utilities, and transport infrastructure” (7).

3.2c Why are companies not adapting?

Although some organizations are driven to early adaptation, most are still preoccupied with the risk of regulation and higher costs from mitigation (Sussman and Freed 2008, 9). There is a perception that physical impacts are either irrelevant or too uncertain, with only sectors having a considerable stake in areas prone to extreme weather events consistently listing physical risks as a concern (9). Research by the CDP (2008, 6) on UK FTSE350 companies suggests that the physical impacts of climate change are seen as risks to bottom lines rather than as opportunities for increased profits, market share or goodwill. Adaptation is still considered an environmental rather than a core business issue (6).

Businesses face difficulties in considering adaptation due to the temporal and spatial ranges of climate impacts. Forfas (2010, 47) finds that businesses suffer from a lack of information regarding impacts and a lack of ability to respond due to financial, cultural and institutional constraints. Forfas (2010, 47-50) recommends: tools to help businesses adapt, support and leadership from sector organizations, improved training and encouragement of multi-disciplinary learning, improved financing for adaptation and support from development and planning bodies.

Most approaches to organizational adaptation focus on changes within the business environment and usually “emphasize ways in which adaptive fit between firm and business environment can be achieved, maintained, and restored in the case of change”, based on assumptions of a return to “equilibrium

and stability” (Linnenluecke and Griffiths 2010, 485). Still, the shifting and accelerating baseline of climate change implies that the “future climate will not be like the past,” that 100 year storms and floods may occur more frequently (Sussman and Freed 2008, 11).

In a study examining nine UK companies in the Housing and Water sectors, Berkhout, Hertin & Gann (2006, 144-149) found the following problems with organizational learning and climate change:

1. *Signaling and Interpretation* – Direct signals of climate change were rare, difficult to interpret and usually not attributed to climate change. Indirect signals occurred more frequently, often from regulatory bodies, but also from the press and trade associations.
2. *Experimentation and Search* – All companies demonstrated the capacity to identify suitable adaptation measures to climate issues. Responses tended to be those that minimized conflict with prevailing routines and which utilized existing competencies, resulting in little innovation. Despite opportunities for synergy, impact on GHG emissions was not considered in adaptation decisions.
- 3 & 4. *Knowledge Articulation/Codification & Feedback/Iteration*– Little evidence was found of the codification or adoption of adaptation strategies.

3.2d Moving forward

Companies are generally more aware of the risks than the opportunities of climate change (CDP 2008, 7), with the first step, a fundamental one for successful adaptation, being the quantification of risk and identification of responses (Sussman and Freed 2008, 11). Climate change will create “novel risks outside the range of previous experience” with the possibility that

continued adaptation becomes impossible for individual organizations, industries and even societies to maintain (486-487). In these circumstances, “organizations need to consider response mechanisms of a different nature and develop suitable capabilities that enable them to be resilient to such changes” (487). Climate resilience could be a real opportunity for business.

3.3 Towards a Climate Resilient Business

Adaptation to climate change will reduce risks, yet “resilience is required in situations that are triggered by distinctive, discontinuous events that create vulnerability and require an unusual response” (Linnenluecke and Griffiths 2010, 480). While “adaptation is a process of deliberate change in anticipation of or in reaction to certain environmental stimuli, the concept of resilience is more systems focused and takes a more dynamic view” (487). Despite recent popularity in light of catastrophic events, there are “few consistent conceptual insights into the concept of organizational resilience” (488).

The root of a resilient business is stability and reliability, or “the ability of organizations to rarely fail and maintain their performance despite encountering unexpected events” (Linnenluecke and Griffiths 2010, 488). “Speed of recovery” is also important in determining organizational resilience (495). Characteristics of long-lived companies, hence suggesting a high level of resilience include (489):

- Sensitive to business environment, respond quickly to changing conditions
- Developed sense of cohesion, identity, and community among employees
- Decentralized but experiment with peripheral ideas
- Conservative approach to financing/low risk

3.3a A Resilience Framework

A core concept of resilience is adaptive cycles, which emerged from ecosystem studies. The adaptive cycle framework suggests that dynamic systems do not default toward a steady state. Instead, they repeatedly pass through four phases: growth & exploitation, conservation, collapse & release, and renewal & reorganization (See Appendix, Figure 3a). These phases form a sequence of both gradual change, namely exploitation and conservation phases, as well as sequences of rapid changes, triggered by “endogenous disturbances” (Linnenluecke and Griffiths 2010, 491).

3.3b Challenges to Resilience

Organizational resilience can be hindered by barriers and inertia “which reinforces the status quo and limits the boundaries of response” (Linnenluecke and Griffiths 2010, 496). Rebuilding after extreme events, organizations often focus on avoiding similar occurrences rather than developing long-term resilience strategies, as evidenced by recurrent and often increasing vulnerabilities (502). The CDP (2008, 14-15) traces companies’ failure to understand and manage risk back to three significant issues: a focus on short-term return maximization, inappropriate levels of governance and inadequate levels of disclosure. Business should use lessons from the recent financial crisis, where short-term strategy was enabled through inadequate risk management and disclosure (CDP 2008, 12-13). Tendencies toward short-term profit maximizing at the expense of preparing for long-term changes, leave businesses susceptible and make developing resilience difficult due to the dichotomous competencies required for the two (Linnenluecke and Griffiths 2010, 497-498).

Organizations will need to develop capabilities to identify vulnerabilities and understand the physical effects of the environment on their business (Linnenluecke and Griffiths 2010, 497-498). The CDP (2008, 12) suggests that, “uncertainty should be a driver for analysis, rather than a reason for inaction.” A new paradigm or framework will be required. Linnenluecke and Griffiths (2010, 500) emphasize the importance of slack resources in building resilience, including backups for critical systems, diversifying access to inputs and slack financial resources. Having slack resources runs contrary to mainstream management practice, which aims to eliminate slack resources for efficiency (500). In a changing climate, the benefits of slack resources for innovation and responsiveness will outweigh the short-term cost savings of streamlining (500).

3.4 Synergistic Strategies

A full exploration of how businesses can develop resilience to Climate Change is beyond the scope of this paper. As the literature suggests, many organizations have yet to begin developing the resources to predict the impacts of climate change on their business, let alone begin identifying strategies for coping and flourishing. Companies will need to find a better balance of planning for extreme weather events and long range planning that accounts for the shifting baseline of climate change. This will require the development of new competencies and the assistance of government and sector associations.

As companies develop climate change competencies, synergistic strategies will be extremely important to cope with impending GHG legislation and the physical impacts of climate change. First, it will be important that adaptation

does not drastically increase GHG emissions. Second, actions undertaken for adaptive purposes offer an excellent opportunity for reassessing GHG emissions and looking for synergistic opportunities. Third, lower emission options will not only buffer a firm against carbon legislation and stakeholder pressure, but also against greater variability in fuel price and supply. Lastly, synergistic strategies offer opportunities for cost savings.

3.4a Business Location as a Synergistic Strategy

In the literature examined several actions were outlined to increase business resilience to climate change. These included having back-up locations for critical resources and diversifying the location and suppliers of critical inputs. The location of business infrastructure and key resources offers excellent synergistic opportunities. There are many factors that affect the GHG emissions of a business, but location can be a multiplier for many of them. For example, a business located in Maine will have lower emissions from air conditioning than an identical business located in Florida, with the converse true for heating. Likewise, emissions from transportation will vary geographically depending on the length of the supply chain and distance from markets. The potential for location to be used to reduce GHG emissions and reduce risk, is difficult to predict. Clearly, some regions of North America will bear more of the physical impacts of climate change than others. Could moving away from, or not locating in a risk prone region also offer opportunities for reducing GHG emissions? In Chapter 5 we examine the possible synergistic benefits of business location. First, chapter four will explore the current drivers of business location in order to provide context for the arguments in the following chapter.

4. Drivers of business location decisions

Industry was impossible for nomadic peoples due to the restrictions of a mobile life. “Settled agriculture creates a technology from which all physics, all science takes off” (Bronowski 1973, 74). The first settlements, farming and industry, formed around important resources with transportation technology eventually allowing resources to be brought to settlements.

The location of industry was still limited until the rapid changes brought about by the industrial revolution. “Before 1760, it was standard to take work to villagers in their own homes. By 1820, it was standard to bring workers into a factory and have them overseen” (Bronowski 1973, 260). The advancements in engineering which sparked the industrial revolution brought economies of scale by concentrating industry around sources of power for the new machinery. Early in the industrial revolution waterpower was dominant, along with water transportation (260) creating early clusters of industry where running water was plentiful. Improved access to power and energy defined the industrial revolution (280) and with the use of coal, steam engines and railways, industry was free from the constraints of water, opening up trade and communication with the world (285).

Chapter 4 will explore the factors that draw human industry to certain locations. We will also examine the characteristics that make a firm more likely to relocate, in order to inform policy options for moving businesses away from climate change prone areas.

4.1 Location Theory

4.1a Early Theories of Location

The factors considered by people making industrial location decisions became increasingly complicated as markets became more complex. Location theory developed in an attempt to rationalize the location choice process. Early pioneers included Johann Heinrich von Thünen, whose 1826 Isolated State Theory, is summarized by the Encyclopedia Britannica (2011a) as follows:

Heavy products and perishables would be produced close to the town, while lighter and more durable goods could be manufactured on the periphery. Because it would cost more to transport goods to areas distant from the city centre, the returns to the outlying areas land would diminish until, at a certain distance, land rent would become zero. Moreover, methods of cultivation would vary—with land cultivated more intensively near the city, because the more valuable land near the city would demand a high rate of return.

As transport became cheaper and faster and sources of power became mobile, particularly in the era of cheap oil, other factors became important to the location of industry. Recognizing that no market was as simple as von Thunen's model, Weber's 1929 Least Cost Theory attempted to triangulate the least expensive location for a plant based upon the transportation costs of two resources and the location of labor (Encyclopedia Britannica 2011b). Weber's least cost theory assumes that firms make profit maximizing decisions, that they examine all available locations and that information regarding those locations is freely available (Webber 1984, 42).

4.1b Contemporary Work on Business Location

In order to process the vast amounts of data for modern location decisions, complex econometric models have been developed. According to Guimarães,

Figueiredo and Woodward (2004, 2) the random utility maximization (RUM) framework, developed by McFadden in 1974, has been the most common method of empirical analysis. McFadden's approach views the "industrial location decision as a discrete choice problem in which profit (utility) maximizing firms select sites from a distinct set of regions and localities" (2). Guimarães, Figueiredo and Woodward (2) suggest that despite vast amounts of academic work on industrial location, it is evident that "a systematic approach to industrial location modeling has not been found."

Many researchers suggest that good location strategy should be a key part of corporate planning providing a difficult to emulate competitive advantage (Karakaya and Canel 1998, 2). The business literature offers several methods of assessing various locations including the center-of-gravity method, locational break-even analysis, factor ratings and transportation linear programming (see Shim and Siegel 1999, 159). "Corporations are changing the way they make decisions about where they locate and where they relocate", using complex software to handle the many variables (Cohen 2000, 2). It is beyond the scope of this paper to examine the various econometric models. The following section contains an overview of the most common factors in location decisions according to existing research.

4.2 Pull Factors in Firm Location Decisions

"The firm location literature highlights two broad categories of costs that vary with location: transportation and production costs" (Shadbegian and Wolverton 2010, 5).

4.2a Labor

According to research by Bartik (1985, 18) “a 10% increase in the percentage unionized of a state's labor force is estimated to cause a 30-45% reduction in the number of new branch plants.” Bartik concluded that in the early 1980's “differences in unionization across states are having a major impact on industrial location in the United States” (1985, 21). Studies on firm location reflect the concerns of the time, as we noted proximity to water was once essential. Similarly, the issue of unionization and the industrial move south held a prominent place in the discourse in the 1980's, becoming less relevant as firms increasingly chased lower labor rates overseas. As labor costs in the developing world inevitably increase, other factors will become more important to location.

Using data from KPMG, Van Arnum (2004, 2) suggests that, “labor is the most location-sensitive cost component, representing 56 to 72% of location-sensitive costs for manufacturing operations, and 75 to 85% for non-manufacturing operations.” Similarly, wages have been found to have a “significantly negative effect” with a 10% increase in wages leading to a 9% decrease in new plant location (Bartik 1985, 20). Karakaya and Canel (1998, 4) found that the availability of low-cost labor is more important the larger a firm and that medium-size firms are more interested in skilled labor than larger firms. Access to skilled labor has been found to positively affect the location of new plants (Shadbegian and Wolvertson 2010, 5).

4.2b Tax

Other research suggests that tax rates are a significant factor. A 10% increase in corporate income tax results in a 2-3% decline in new plants and the

same increase in business property tax causes a 1-2% decline (Bartik 1985, 19). Guimarães, Figueiredo and Woodward (2004, 15) “find strong evidence that higher property taxes deter investments in U.S. counties”, with a 1% increase in taxes leading to a 0.25% decrease in new plants (13). Some authors caution against heavy reliance on elasticity, suggesting that separating the effects of tax from the rest of the economy is impossible (Buss 2001, 95). Elasticity often does not translate into believable real life figures, with many studies falling victim to mistaking correlation for causation (95). These findings suggest that tax incentives are “costly, ineffective, and detrimental, essentially corporate welfare” (89), and although taxes should be important to states, “researchers cannot say how, when, and where with much certainty” (101).

4.2c Other Factors

Guimarães, Figueiredo and Woodward (2004, 13) suggest the most important determinant of location is the cost of land with a 0.81% decrease in new plant locations for a 15% increase in the cost of land. The same study finds “evidence that the county market size matters and that agglomeration economies . . . are associated with higher numbers of plant births” (13). Energy costs have been shown to have a large negative effect, whereas access to highways, unemployment and education levels have been found to have a positive effect (Shadbegian and Wolvertson 2010, 5).

4.2d Clusters and Agglomeration Economies

Agglomeration economies or external economies of scale and competitive advantages are often gained through co-location, with agglomeration “thought to

be more important than ever before in determining an area's economic fortunes" (Lee, Liu and Stafford 2000, 87). Earlier work by Bartik (1985, 20) concurs with the powerful effect of agglomeration finding that "a state with 10% greater existing manufacturing activity will have an 8% or 9% greater number of new plants." The benefits of agglomeration results in clusters which are "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions . . . in particular fields that compete but also cooperate" (Akoorie 2000, 134). Clustering "enhances flows of technical and market information, contributing to both innovation, and the diffusion of skills and competencies" (McNaughton 2000, 69). Clusters of economic activity are well documented in the literature (Black 2004, 4) and "are seen as important in that they create synergies, increasing production and leading to economic advantages" including a decrease in transportation costs (Steiner 2002, 208), job search costs and increased skill transfer (Aydogan and Chen 2008, 1-3).

According to Black (2004, 29-30) geographic proximity is especially important in the transfer of tacit knowledge, because knowledge is "sticky" and the "cost of transmitting knowledge rises with distance" (30). Black (30) further suggests that cities are "centers of idea creation and transmission" and "the breeding ground of knowledge spillovers." Many researchers point to the link between top research universities and high-tech industry (31). The presence of "flagship firms" for example IBM, Microsoft, or NEC can also create agglomeration economies leading to clustering (Cecil and Green 2000, 175). Benefits of agglomeration are more significant to some kinds of firms. US

manufacturing firms tend to “locate near similar firms using the same type of labor.” Labor agglomeration can be especially beneficial to high tech firms, but the local labor pool must be “relevant to the innovative activity of the firms” (Black 2004, 28-29). Cohen (2000, 11) suggests that software development companies seek out interactions with similar firms, whereas pharmaceutical companies that seek confidentiality “favor more isolated campus locations.”

4.3 Factors in Relocation Decisions

We must recognize that there is a significant difference between firms migrating or relocating and those deciding upon a new location (Pellenbarg, Wissen and Dijk 2002, 110-111). Whereas location theory only includes the pull, relocation theory also includes the push accounting for not only the choice of location, but also the decision to move. Unfortunately, theories specific to firm relocation are rare (111). Brouwer, Mariotti and Ommeren (2004, 336) suggest that studies of relocation distinguish between complete and partial relocation, with the former most often executed by smaller, single site firms on a local basis. According to Pellenbarg, Wissen and Dijk’s (2002, 110) review, location theory has three schools of thought, which can be applied to relocation:

Neoclassical theory is based on the cost minimizing and profit maximizing theories of economics. Most firms do not occupy an optimal location (110), but as long as an acceptable profit rate is maintained they will not try to move for three reasons: relocation costs, capital inertia and the cost or revenue elasticity of location being low (112-113). Firms only relocate when much higher profits are available and the most common spur is the need for growth (113).

Behavioral theories see relocation affected by the four key elements: limited information, limited ability to use information, perception or mental maps and uncertainty. These limitations lead to a spatial bias in decision-making and make onsite investments most likely (116). There are four phases of relocation: decision, search, evaluation and choice (114-115). Relocation is one possible outcome of adjustment to change and “adjustment may also be sought in reorganization or in other investment strategies” (115).

Institutional theories focus on institutional size. Small firms have to accept their business environment, whereas large firms can control it. Clusters are more important in the relocation decision for small to medium sized firms (117).

4.3a Push Factors

Brouwer, Mariotti and Ommeren (2004, 336) found the main drivers of firm relocation to be expansion and the need for more suitable premises, with cost saving coming second. Other important drivers include market strategy, access to raw materials and energy sources (336). Pellenbarg, Wissen and Dijk (2002, 116) suggest external factors for relocation include “limited accessibility, deterioration of the building, environmental considerations, limited labor supply, or high location costs.” Decisions to relocate are normally due to firm internal factors (139), with firm growth and lack of image or exposure common internal reasons for relocation (116). A study of firm relocation in California found that in-state relocations are much more common than moves either in or out of the state (Kolko and Neumark 2007). Short distance moves were most likely, usually to adjacent counties, the authors suggesting that firms are moving to be closer to attractive clusters, real estate or a moving market (1).

Cohen (2000, 3-6) summarizes the push factors of relocation as:

- **Technological change** allows previously impossible organizational structures
- **Organizational Change** from mergers, acquisitions or reorganization
- **Government Policy** including deregulation, environmental policy and spending programs

4.3b Relocation Trends

In a complex global economy, firms clearly have different needs to be met and different reasons for moving. Industrial firms are less likely to move than those in the service sector, as are large firms when compared to firms with less than 10 employees (Pellenbarg, Wissen and Dijk 2002, 136-137). For obvious reasons, renters are found to be more likely to move than those owning a site (138). Notably, there is a difference in the level of consideration given to location by firm size, with large firms much more likely to thoroughly evaluate more alternatives than small firms (120). Karakaya and Canel (1998, 2) found skilled and productive labor was essential for high-tech firms, although firms adopting a strategy of "differentiation" look for technical and ambiance advantages. Likewise, banking and insurance primarily seek skilled labor along with manufacturing, which also considers the state regulatory environment and transportation (4). For retail, land and construction costs are the two most important factors (4). Cohen (2000, 6-13) suggests that location decisions vary by business sector, unit and culture, product maturity and competitive strategy.

4.4 Environment as a Factor in Location Choice

The environment has long been a factor in the location of industry, although to varying degrees temporally, spatially, sectorally and even culturally. While industry once relied on nature for resources, Weber's (1929,39) Theory of Industrial Location demonstrates a change in attitude. His theory suggests factoring in "forces of nature" such as waterpower in terms of their locational influence, by accounting for them as if they were a very cheap deposit of coal. Environmental services were taken for granted, until environmental regulation was enacted, forcing firms to reconsider their value.

4.4a Running Away from Environmental Regulations

Environmental regulation would have no impact on firm location if it affected all locations equally (Shadbegian and Wolverton 2010,1). Enforcement is more stringent in some locations than others, with inconsistency due to factors such as the existence of regular thermal inversions and concentrations of economic activity (3). Given that states are responsible for monitoring and enforcing federal regulations, compliance costs can differ due to the level of variation between state and federal rules (3).

One of the arguments used to block the progress of pricing carbon in the U.S. prior to worldwide policy, is that it will lead to job losses. For example, Kamal-Chaoui and Robert (2009, 149) find that locational variance in the price of power or regulation may cause the relocation of industries to localities with looser environmental regulation or what is known as the "pollution haven hypothesis." Businesses most likely to relocate would not necessarily be "the

dirtiest” but the more “footloose” such as electronic and appliance manufacturers (149).

Early research suggested an insignificant link between environmental regulation and firm location. More recent studies using different statistical analysis show a significant link (Brunnermeier and Levinson 2004, 6; Shadbegian and Wolverton 2010, 42). The new studies also argue that the connection is strong whether examining countries, industries, states or counties (Brunnermeier and Levinson 2004, 37). There is no evidence that different jurisdictions compete to lower environmental regulations to attract polluting firms (Shadbegian and Wolverton 2010, 4). A growing concern is that energy rich countries in the Persian Gulf will attract energy intensive industries such as aluminum, petrochemicals and steel (Kalkman, Nordin and Yahia 2007, 95). Such movement away from regulation or taxes is called leakage. The WRI (2008, 9) estimates a \$10 per ton charge for CO₂ in the U.S., but not in other countries, would decrease the output of carbon intensive industries by 0.5 to 6%.

4.4b Running Away from the Environment

Companies facing repeated climate impacts may need to consider relocation (Marsh 2006, 17) if traditional adaptation does not suffice. After Hurricane Katrina, the energy company, Entergy, relocated important business units (Sussman and Freed 2008, 21). Entergy chose to geographically diversify based on information about climate risks, recognizing that “climate change poses potential long-term risks to the economic viability of Entergy’s franchise and asset base, both of which are located in an area that is vulnerable to flooding and hurricanes” (21). This example shows Entergy reacting to a crisis, although

ongoing climate change will demand a more proactive and considered approach.

Linnenluecke, Stathakis and Griffiths (2011) published one of the only articles to explore business relocation as adaptive response to climate change. They suggest a gap in the research on firm relocation, when compared with the relocation of communities or species (124). They also agree with this thesis that relocation will become strategically important and “will be framed around issues such as likely impacts on infrastructure, supporting services and resource scarcity” (124). This thesis seeks to add the potential for relocation to allow the mitigation of emissions and reduction of energy costs. Linnenluecke, Stathakis and Griffiths (2011, 126) suggest that climate change relocation fits into Pellenbarg, Wissen and Dijk’s (2002) three types of relocation theory in the following ways: a) in neoclassical theory firms will relocate to regions less affected, b) in behavioral theory relocation will be impeded by costs and uncertainty, c) in institutional theory government will play an important role in facilitating or hindering relocation.

4.5 Conclusions

We have painted a complex picture of the firm relocation process, varying greatly due to individual firm characteristics, with many points to consider in upcoming chapters. First, firms are reluctant to move unless profits are considerably larger, and when they do move there is a bias against more distant locations. Second, small firms are more likely to relocate, and the most common reasons include growth and mergers or acquisitions. Finally, service industry firms are more likely to relocate than industry.

5. Regional Differences in U.S. Climate Risk Vulnerability and Resiliency

As discussed, the U.S. can expect to see increases in average temperature, sea level, hurricane severity and humidity. There are also strong predictions regarding regional trends, such as decreasing rainfall in the southeast and above average temperature increases in Alaska, the Midwest and Northern Great Plains. Existing climate models offer less guidance on future impacts at the regional and local scale (Linnenluecke and Griffiths 2010, 499). In Chapter 5, we examine existing research to highlight U.S. regions most and least at risk from climate change, particularly looking for areas with compounding problems. We also look at which areas could absorb an increase in population as climate change impacts manifest. We do not intend to seek the best and worst places for business and population relocation in any systematic fashion, but merely to pull out some of the main issues and highlight locations that are more and less attractive. A low resilience and high resilience location will be examined and compared in more depth in Chapter 7. As we have seen, real life firm relocation decisions are complex and firm specific. Finding the optimal location is a task for government departments, industry associations, consultancy firms and corporations.

5.1 Regional Climate Impacts and Risks

5.1a Cities – the multiplier

Urban areas will feel the worst impacts of climate change due to their concentration of people, resources and infrastructure (World Bank 2009, xiv). Satterthwaite et al. (2007, 10) suggest that the “spatial concentration of hazards

and stressors” in urban areas, often with the potential to compound one another, is exacerbated by the tendency for cities to erode natural defenses such as wetlands and create areas with poor drainage. Urban heat island effect will also cause cities to experience longer, more intense and more frequent heat waves (IPCC 2007b, 52).

Physical and social infrastructure are co-dependent in urban areas and consequently more vulnerable to disruption resulting from breaches of critical weather thresholds (Kamal-Chaoui and Robert 2009, 51). The vulnerability of cities is rightly a growing concern, with not just a concentration of hazards and stressors, but of assets and wealth. Approximately 80% of people live in urban areas in North America (IPCC 2007b, 625). Many large cities in the developed world have the resources to interpret research, analyze their level of risk and begin to adapt. Smaller urban areas and many cities in the developing world are not able to do so, resulting in the need for international assistance (World Bank 2009, 41).

5.1b Temperature

One of the most comprehensive projections for U.S. temperature increases from climate change is the 2009 USGCRP report using IPCC figures (see Appendix, Figure 5a). Projections vary significantly, although increases are larger in the Midwest, Great Lakes and Alaska, and smaller in the Southeast and West Coast. Another report by the Natural Resources Defense Council (NRDC), again using IPCC figures, suggests regional temperature changes for U.S. regions as outlined in Table 5a.

Business-as-Usual Case: Increase in U.S. Annual Average Temperatures by Region Compared to Year 2000 Temperatures (in degrees Fahrenheit)				
	2025	2050	2075	2100
Alaska	4.4	8.8	13.2	17.6
U.S. Central	3.3	6.6	9.9	13.1
U.S. East	3.1	6.1	9.2	12.2
U.S. West	3.1	6.1	9.2	12.2
U.S. Gulf Coast and Florida	2.4	4.9	7.3	9.7
Hawaii and the Pacific	1.8	3.6	5.4	7.2
Puerto Rico and the Caribbean	1.8	3.6	5.4	7.2
Global Mean	2.2	4.3	6.5	8.6

Table 5a - Regional U.S. Temperature Increases (Source NRDC 2008, 3)

In 2100, this U.S. city (temperature increase in degrees Fahrenheit noted).....	..will have a climate similar to this city in 2008.
Anchorage (+18)	New York
Minneapolis (+13)	San Francisco
Milwaukee (+13), Albany (+13)	Charlotte
Boston (+12), Detroit (+13), Denver (+13)	Memphis
Chicago (+13), Omaha (+14)	Los Angeles
Columbus (+13), Seattle (+13), Indianapolis (+13), New York (+12), Portland (+12), Philadelphia (+12)	Las Vegas
Kansas City (+13), Washington DC (+12), Albuquerque (+12)	Houston
San Francisco (+12), Baltimore (+12)	New Orleans
Charlotte (+13), Oklahoma City (+13), Atlanta (+13)	Honolulu
Memphis (+13), Los Angeles (+12), El Paso (+12)	Miami
Las Vegas (+12), Houston (+11), Jacksonville (+10), New Orleans (+11)	San Juan
Honolulu (+7)	Acapulco, Mexico
Phoenix (+12)	Bangkok, Thailand
Miami (+10), San Juan (+7)	No comparable city

Table 5b - Change in Temperature in U.S. Cities as a Result of Global Warming (NRDC 2008, vi)

Such temperature increases will have profound impacts. The West will see an increase in wildfires (IPCC 2007b, 623), and Alaskan infrastructure will be at risk from the instability caused by melting permafrost (632). The resulting temperature in areas with the largest increases is still within tolerable margins for humans most of the year. When translated into actual temperature, the picture is less positive for the Gulf Coast and Florida (see Table 5b). These regions will face potentially catastrophic temperatures, especially when

combined with humidity, with areas that currently experience 60 days per year over 90°F, projected to experience 150 or more days per year above 90°F by 2100, under a higher emissions scenario” (USGCRP 2009, 34).

5.1c Sea Level Rise, Hurricanes and Coastal Areas

Along with cities, coastal areas are also especially vulnerable to climate change, due to sea-level-rise (SLR) and increasing hurricane intensity. Coastal communities will experience more severe and frequent flooding, especially in areas where SLR combines with increasingly powerful storm surges (630). Due to “historical geological forces” an estimated 2-foot rise in global sea level by 2100 would translate to a rise of “2.3 feet at New York City, 2.9 feet at Hampton Roads, Virginia, 3.5 feet at Galveston, Texas, and 1 foot at Neah Bay in Washington state” (USGCRP 2009, 37). Several major urban areas, including New Orleans, are below sea level, placing large populations at risk (IPCC 2007b, 623). Florida is at particular risk from sea-level rise, with 9% of its territory, 1.5 million people and large numbers of businesses and pieces of infrastructure vulnerable to a 27-inch rise (NRDC, 2008 4).

Although hurricanes are one of the more difficult variables to precisely account for, an accurate gauge is historical damage. If hurricanes become more intense as predicted, or if they become more frequent as some research has suggested, the areas impacted most will be the areas historically affected (see Appendix, Figure 5b). Hurricanes Ivan (2004) and Katrina, Rita and Wilma (2005), illustrate the vulnerability of infrastructure and urban systems not designed or maintained to an adequate level (IPCC 2007b, 625). If the frequency of hurricanes increases, the impacts in areas already experiencing regular

hurricanes will be severe. As the IPCC (2007b, 623) notes, impacts can be amplified when major storms occur in quick succession, due to limited opportunity for regeneration in both human and natural systems.

Entergy (2010, 1) estimates the Gulf Coast could face total damages of \$350 billion in the next 20 years, or 3% of area GDP. By 2030, years with damage on par with 2005 will be a once in a generation event instead of once in every 100 years (1). Stern (2006a, 8) predicts that a 5 or 10% increase in average hurricane wind speeds would double annual damage costs in the U.S. (See Appendix, Figure 5c for the location of billion dollar weather events). A compounding problem is that many cities, and particularly in the U.S. large cities, are located in coastal areas, along with a large section of the population (see Appendix, Table 5d and Figure 5d).

“Most of the increased losses from natural disasters can be attributed to increased population and value concentration in coastal cities” (ECA 2009, 21). The trend to develop in coastal areas is continuing. “Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution” (IPCC 2007a, 52). An additional 25 million people will move to U.S. coastal areas in the next 25 years further reducing natural resilience (IPCC 2007b, 630), with for example more than 50% of original salt marsh in the U.S. already lost” (623). One study by the OECD (Nicholls et al. 2008, 3) ranks the following cities as the top ten in terms of most population presently exposed to flooding (U.S. cities in bold): Mumbai, Guangzhou, Shanghai, **Miami**, Ho Chi Minh City, Kolkata, **Greater New York**, Osaka-Kobe, Alexandria and **New Orleans**. The cities ranked in order of exposed assets are:

Miami, Greater New York, New Orleans, Osaka-Kobe, Tokyo, Amsterdam, Rotterdam, Nagoya, Tampa-St. Petersburg and Virginia Beach.

Miami-Dade County alone has an estimated \$3.5 trillion in assets exposed (Seijas et al. 2010). Despite the risk, exposure and affluence, New York is only protected to a 1 in 100 year flood standard, far less than London, Tokyo, Amsterdam and Shanghai. The OECD suggests that flood protection levels are strongly influenced by culture, history and politics (Nicholls et al. 2008, 9). It is yet to be determined how much has been learned from Katrina, despite the potential for a severe storm to “trigger permanent city decline” as could be the case with New Orleans (37). Nationwide 8,651,000 people live in areas subject to a 100-year coastal flood hazard (Coulton et al. 2011). Significant measures will be required to protect such a large number of people.

5.1d Water

The changing demand and supply of freshwater due to climate change will be of considerable concern to society and will be a growing strategic problem for many businesses. Although it will not be possible to cover water in the depth it deserves here, we will broadly examine regional variations in the availability of fresh water as an important indicator of an area’s resiliency. While total U.S. precipitation has increased, there have been important regional differences with projections suggesting that the North will become wetter, and the South and particularly the West, will become drier (USGCRP 2009, 30). The reduction will be most pronounced in the winter “as the subtropical dry belt expands” and will “have serious ramifications for water resources” in the Southwest (30). Periods of drought will become increasingly frequent in the Southwest (33). The trend

for an earlier melting of the snowpack in the West will exacerbate already limited water supplies as spring run-off becomes less reliable (33). Warming will lead to a “decreased snowpack, more winter flooding and reduced summer flows,” further straining fresh water supplies (IPCC 2007a, 52). It is estimated that 41% of southern California’s water supply will be vulnerable by the 2020s (633). (See Appendix, Figure 5e for illustration of expected changes in North American Precipitation).

In many coastal areas, SLR will encroach upon fresh water aquifers. Southeast Florida is at particular risk of saltwater intrusion, with Miami sitting on top of porous limestone, containing the sole source aquifer for the city (Seijas et al. 2010). Many other urban areas, particularly in the South and West, are already at the limits of their supply of fresh water, a problem that will be exacerbated by climate change. (See Appendix, Figure 5f for illustration).

5.1e Energy Supply

According to the U.S. Climate Change Science Program [USCCSP] there are four ways climate change could affect energy production and supply (2007, 1):

- Extreme weather events become more intense
- Water supply for hydropower and/or power plant cooling faces reductions
- Temperature increases decrease overall power generation efficiencies and
- Changed conditions affect facility siting decisions

The greatest of these threats will be increases in the intensity of extreme weather events and reductions in regional water supply (USCCSP 2007, 2).

“Severe weather events and associated flooding can cause direct disruptions in energy services. With more intense events, increased disruptions might be expected” (45). Florida is at particular risk of disruption (USCCSP 2007, 36).

(See Appendix, Figure 5g for illustration).

High water temperature and lack of flow due to drought can lead to power plants being shut down. The NRDC (2008, 11) “estimate that more than 320 plants, or at least 85% of electrical generation in Alabama, Georgia, Tennessee, North Carolina, and South Carolina, are critically dependent on river, lake, and reservoir water” for cooling. The 2007 drought highlighted the problems for water management, as officials struggled to allocate water from the Chattahoochee River, Atlanta’s main drinking water source, but also the cooling source for 6% of the region’s power generation (11).

More obvious problems due to reduced river flow will be related to hydroelectric power. Annual production of hydropower in the U.S. is already highly variable, with for example, a difference in generation of 59 billion kWh from a low output year in 2001, to a high in 2003 (USCCSP 2007, 40). The USCCSP (1) points out that in some regions the effect will be negative and in others positive. For instance, the Colorado River, Great Lakes and Southern Québec are likely to see a decrease in capacity, whereas Northern Québec and James Bay are projected to increase (IPCC 2007b, 634). Areas will also see seasonal changes, for example the Columbia River and British Columbia will very likely see an increase in winter capacity (634). For other renewables the picture is even less clear. North America’s wind and solar resources have an equal chance of increasing or decreasing according to the IPCC (634), although siting problems will affect both due to the possibility of changing wind patterns and the availability of water for solar power (USCCSP 2007, 43). Regional differences and future changes in energy demand will be covered in depth in Chapter 7.

5.2 Which locations are most resilient to climate change?

More studies are available of areas at risk of climate change than those that are resilient. Looking at the four major impacts: SLR, hurricane damage, temperature and water supply/drought, we see that the least impacted areas are in the North. Although some coastal cities will face significant challenges, they are less than those faced by their counterparts in the South. The most resilient areas will not just be less at risk, but also taking steps to develop sustainably and have access to the resources needed to thrive in a changing world. Along with studies of resilient cities it is useful to look at studies exploring sustainable cities as they share many commonalities.

The World Bank (2009, 32) defines a resilient city as being “able to sustain itself through its systems by dealing with issues and events that threaten, damage, or try to destroy it.” The World Bank (32) goes on to outline three characteristics of resilience:

“(a) the amount of disturbance a society can absorb and still remain within the state of the domain of attraction; (b) the degree to which the society is capable of self-organization or adjustment; and (c) the degree to which the society can build and increase the capacity for learning and adaptation.”

There have been some fairly subjective attempts to list or rank the most climate resilient or climate ready cities in the U.S. Such rankings are an interesting guide to the cities which are early adaptors and mitigators despite missing elements. For example, Cohen’s (2011) list of Climate Ready cities (1.San Francisco, 2.Seattle, 3.Portland, 4.Washington DC, 5.Denver, 6.San Diego, 7.New York, 8.Philadelphia, 9.San Jose, 10.Chicago) does not account for risk in any way, particularly the fact that risk will vary not just by a cities’ preparedness, but

also by geographical location.

Another informal study by the Nature Conservancy (Opperman 2011) ranks the 50 largest metropolitan areas, based upon three important risks (to water supply, of heat stress and of natural disaster), but takes no account preparedness. Opperman uses water supply and risk of natural disaster rankings from Sustainlane's (2008) earlier study. Opperman homes in on climate risk rather than broader sustainability as in the Sustainlane study, which causes many of the usual suspects (Portland, San Francisco, Seattle) to slide down the rankings and Cleveland, Milwaukee and Detroit to occupy the top spots. Closing the gaps in these studies will be an important area of future research. It will be important to accurately quantify risk and risk mitigated from resilience development. (See Appendix, Table 5e for results of the two studies). Although these studies are valuable and showcase good work by cities, there are, as mentioned, gaps to close. Larger urban areas tend to be surveyed, when smaller municipalities may prove to be the most sustainable in the long term.

The NRDC's (2010b) Smarter Cities program (Table 5c) awards Smarter City status to cities meeting a broad range of sustainability criteria, in different city size categories. Unfortunately little account is made of climate risk.

Large Cities	Medium Cities	Small Cities
Seattle, Portland, Oakland, San Francisco, Long Beach CA, Dallas, Austin, Chicago, Columbus, Boston, New York	Fort Collins, Reno, Berkeley, Santa Clarita, Huntington Beach, Springfield IL, Jersey City	Bremerton WA, Beaverton WA, Santa Cruz CA, Davis CA, Denton TX, Lincoln NE, Dubuque IA, Urbana IL

Table 5c - Cities Achieving Smarter City Status from The NRDC (NRDC 2010b)

5.3 Which locations offer the greatest potential for renewable energy?

There is no obvious candidate for nation's best place for renewable energy, although, on a regional scale, the West and Southwest have great potential in solar, geothermal and wind. The Southeast has sparse potential by comparison, with only photovoltaic offering good possibilities. In the long term a smart grid, or at least regional smart grids will allow renewable energy to travel considerable distances with greater efficiency, negating the need to locate close to the power source. Figures 5h – 5m (See Appendix) show renewable energy potential in the U.S.

5.4 Which areas could absorb new businesses and population?

In considering a host location, businesses will choose a location that is best for their needs. It is unlikely a business will consider the impacts on the host community in much depth, unless compelled to do so. Federal government is obliged under the National Environmental Policy Act to consider the effects on the host location if it is choosing policy to affect such moves. Therefore, we need to know not only which locations offer less risk from climate change and the opportunity to use less energy, but also which are able to absorb a growing population. Looking at the lists of climate resilient cities it becomes apparent that several of the highly ranked cities are those that have suffered population decline in recent decades, as demonstrated by Figure 5n.

Migration to these shrinking cities, far from straining their resources could actually improve the standard of living for existing residents, by expanding the

tax base and supporting infrastructure previously in decline. Paradoxically population growth has been greatest, and is projected to continue, in areas that are low in resilience to climate change (see Appendix, Figures 5p, 5q and 5r). Many of these cities have faced the problems typical of areas experiencing rapid growth including urban sprawl, loss of open space, pressure on infrastructure and social services and outgrowing ecological limits.

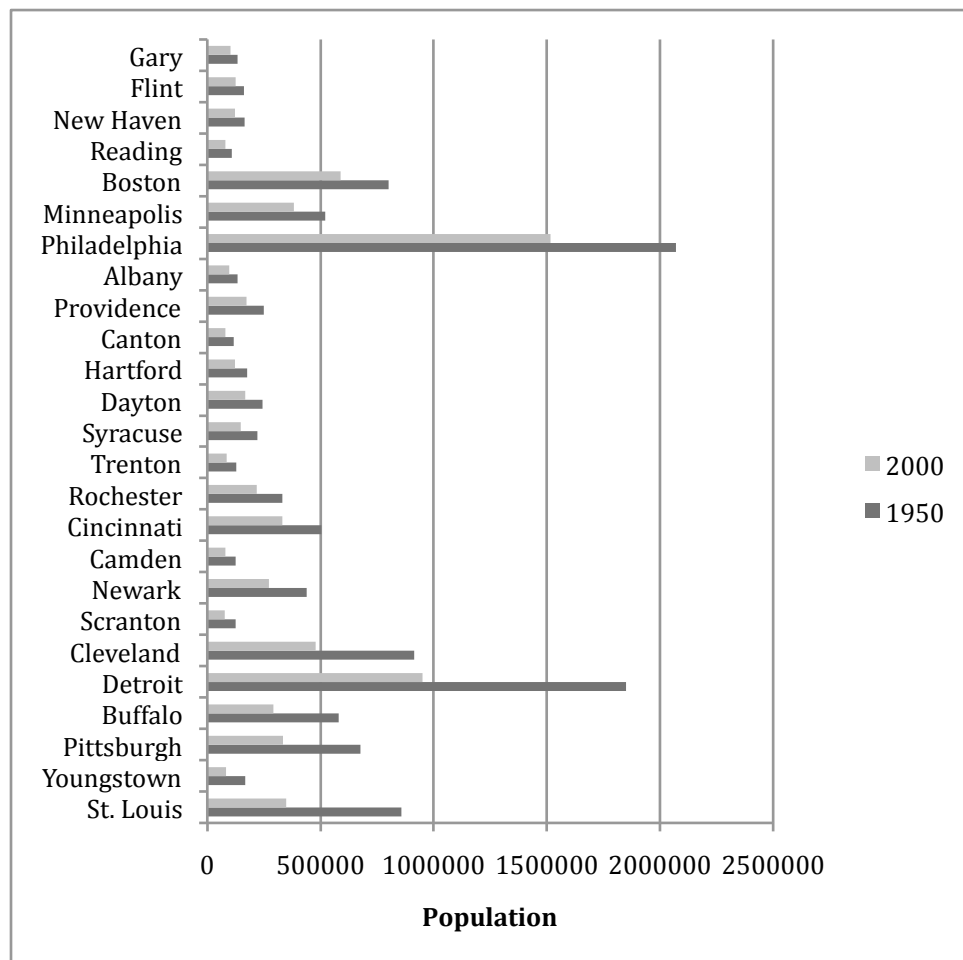


Figure 5n - Top 25 Most Declining Cities in the Northeast and Midwest
(Data from Hollander 2011)

5.5 Conclusions – Best locations

A poorly adapted urban area can serve as a multiplier of climate risk and also that many firms prefer to relocate outside of urban areas. Consequently, is it feasible to look at urban areas for a relocation? Increased urban density is the only way we can hope to manage given increasing populations and income in a low carbon world. It is not in the best interests of society to encourage sprawl, with sprawl being a contributing factor to climate change. For this reason the focus for relocation will be on urban areas. Climate change offers an opportunity to address distorted development patterns and encourage development in more sustainable urban places.

Some urban areas are adapting to threats and others will follow. Adaptation measures that can reduce risk include improved construction codes and restoration of wetlands, but uncertainty remains as to their economic benefits (Entergy 2010, 2). It is possible that some areas will wait too long to act, and others, already at the limits of their supporting systems, will struggle to develop or maintain resiliency. We have explored cities at the high end of their range in terms of ability to adapt to temperature and SLR. Areas of the Gulf Coast and Florida could also find that an increasing frequency of hurricanes pushes them beyond their ability to rebuild infrastructure to pre-storm levels. Data from Swiss Re suggests hurricane damage is already responsible for \$17 billion in annual losses, or 8% of GDP in Broward, Miami-Dade and Palm Counties Florida (ECA 2009, 107). It is estimated that 40% of future losses in Florida will not be covered through cost beneficial adaptation (ECA 2009, 108).

Some urban areas risk suffering from three or four of the main impacts of

climate change, causing compounding problems for their ability to cope. Two large cities that stand out as being at extreme risk due to exposure to SLR, high temperatures, hurricanes and unsustainable water resources are Miami and New Orleans. Given the current problems and uncertain future faced by New Orleans, we will use Miami, Florida as our example in Chapter 7 as a place to move development away from. For a receiving location we will look to the rust belt and in particular the area around the Great Lakes. Although areas around the shores of The Lakes could be subject to a rising water level, the area is not subject to increasing damage from major storms and accompanying storm surges as on the ocean coasts. Water sustainability in the region is good and there is access to renewable wind energy on the Great Plains and Lakes. Many cities around The Lakes that have sustained population losses would benefit from population growth and have the infrastructure to facilitate it. The region is close to rich resources including raw materials and prime agricultural land. It is a transportation hub, with access to the oceans through the Saint Lawrence Seaway and the entire country through its central location, basically all the reasons the area grew originally. Several cities could fit the role, but for the purposes of illustration we will use Cleveland, Ohio in Chapter 7.

6. Companies Most Likely to Consider Location Change as a Synergistic Response to Climate Change.

Studies tend to focus on companies moving to evade environmental regulations, rather than moving to evade the environment. One exception is the report mentioned in Chapter 4 by Linnenluecke, Stathakis and Griffiths (2011, 125), exploring the dimensions of firm relocation as an adaptive response to climate change. There is little in the literature about companies moving to lower their GHG emissions. To explore which companies are most likely to move for synergistic purposes, we will examine which businesses face the most physical risk. We must also look at companies with high energy costs and particularly those that have space heating, ventilation and cooling, or HVAC, as a large proportion of their energy costs. Companies most likely to face pressure to mitigate emissions will be high energy users and particularly high emitters of GHGs, which will also be explored below. We will also look at companies most likely to be early adapters and mitigators seeking crossover between categories.

6.1 Sectors at Risk

Large consulting firms are at the forefront of efforts to examine climate change risks to business. KPMG suggests four types of risk for businesses from climate change: regulatory, reputational, physical and litigation risks, with the level of risk varying by industry (2008, 7). All sectors are exposed to at least one type of risk but there is “considerable discrepancy between sectors” when preparedness is included in the calculation of risk (KPMG 2008, 8). Sectors were placed into the self-explanatory bands (see Table 6a) based on this combination of risk and preparedness.

Danger Zone	Middle of the Road	Safe Haven
Oil & Gas Aviation Healthcare Finance Tourism Transport	Automotive Construction & Materials Insurance (including reinsurance) Building & Real Estate Manufacturing Mining & Metals Pharmaceuticals Retail Utilities	Telecommunications Chemicals Food & Beverage

Table 6a – Sectors at Risk from Climate Change (KPMG 2008, 8)

Clearly, many sectors in the highest risk category are those facing risks from climate change to their core competencies. Perhaps this is why U.S. firms are still more concerned with regulatory risk than physical risk (KPMG 2008, 31).

Implications of physical risks are not always obvious, with the most apparent including damage to property, increased insurance premiums and asset losses and the less obvious including workforce impact, relocation and increases in commodity prices (19). Some companies will reduce risk by adaptation whereas “others will have to reassess their entire business model” (19).

Linnenluecke, Stathakis and Griffiths (2011, 125) suggest energy generation and distribution, automotive and transportation are exposed to the physical risks of climate change due to being “dependent on large-scale, geographically embedded and dispersed infrastructure in exposed areas.” Also mentioned are agriculture, fisheries, forestry and tourism due to their reliance on seasonal conditions and temperature, along with the insurance, financial and infrastructure management sectors (125). Their mention of agriculture contradicts the KPMG assessment, stating that food and beverage are at low risk. Linnenluecke, Stathakis and Griffiths (2011, 125) feel that agriculture, herding and fishing will reach the limits of adaptation, although writing from Australia

their perspective may be somewhat different, with much of Australia's produce already at its ecological limits. The Congressional Budget Office [CBO] (2009, 11) suggests that, "in contrast to the difficulties for unmanaged ecosystems, risks to agriculture in the United States are comparatively modest." Some agricultural regions will be adversely affected by climate change, mainly due to changes in rainfall for Western states and increases in temperature for Southern states (12). Crops already near the warm end of their range will face considerable pressure (IPCC 2007a, 52).

Sussman and Freed (2008, 19) suggest that the physical impacts of climate change are most likely to affect sectors "currently affected by weather events, those that make long-term investments, and those that are global in nature." (See Appendix, Table 6b for projections of physical risks from climate change).

6.1a Insurance

Several reports outline not only the risks posed to insurance by climate change but also the important role insurance can play in catalyzing adaptation. Insurance will also play a primary role in distributing the uneven costs of climate change (USGCRP 2009,104). Unfortunately, there is agreement that most insurers are not prepared (Ceres 2011, 5). Only the largest companies, particularly reinsurance and property, have the capacity to develop their own risk models, with the majority relying on models from third-parties (6).

There are other problems insurers will have to face if they are to help their clients and themselves manage climate risk. Marsh (2006, 20) outlines the need to cover climate change damage by bringing it under the umbrella of pollution and by clarifying the issues around the attribution of blame for climate change.

Ceres (2011, 5) suggests that the sector needs to broaden their assessment of the risks to include areas such as “non-coastal extreme weather and climate liability.” Chapter 8 will look at how the policy of insurance companies could be used to impact the location of homes and businesses.

6.1b Sectoral Clustering in at Risk Areas

Certain sectors are clustered in areas at higher risk, particularly on the coast. KPMG (2008, 52) highlights the chemical industry as being particularly exposed to physical risks, with 45% of facilities located on the coast. There is a well-known cluster of oil, gas and petrochemical facilities on the Gulf Coast along with tourism clusters on both the Gulf and Atlantic Coast of Florida. A common feature of these sectors is that they tend to be highly geographically embedded.

6.2 Business Sectors and Energy Consumption

Only the biggest users of energy, for example primary metal producers, have been found to locate specifically for lower energy costs (Kahn and Mansur 2011). Climate change will challenge corporate energy policy in a number of ways including supply interruptions, increased cooling costs and increased costs for energy, due to carbon pricing and shortages (WRI 2008, 5). Increasing energy costs pose challenges and risks to businesses including a possible reduction in output (5). The WRI (2008, 5) suggests that four variables determine the extent of a production decline associated with increased energy costs: energy intensity of production, potential for efficiency improvement, ability to switch to low-carbon energy sources and product demand elasticity. Relocation offers the opportunity to affect the first three factors.

6.2a Sectors or Businesses with High Energy Use

According to IEA figures (see Appendix, Figure 6a for world energy use by sector) manufacturing and industry account for around a third of world energy use and a slightly higher share of CO₂ emissions. Raw materials production (chemical and petrochemicals, iron and steel, non-metallic minerals, paper and pulp, and non-ferrous metals) accounts for most industrial energy use worldwide (IEA 2007, 39). In the U.S., energy use is proportionally similar except the commercial sector uses a larger share of total final energy. (See Appendix, Figure 6b). Figures 6c and 6d illustrate total energy consumption across commercial and industrial sub-sectors. Data used was from different years due to the most recent 2006 commercial sector data being unavailable.

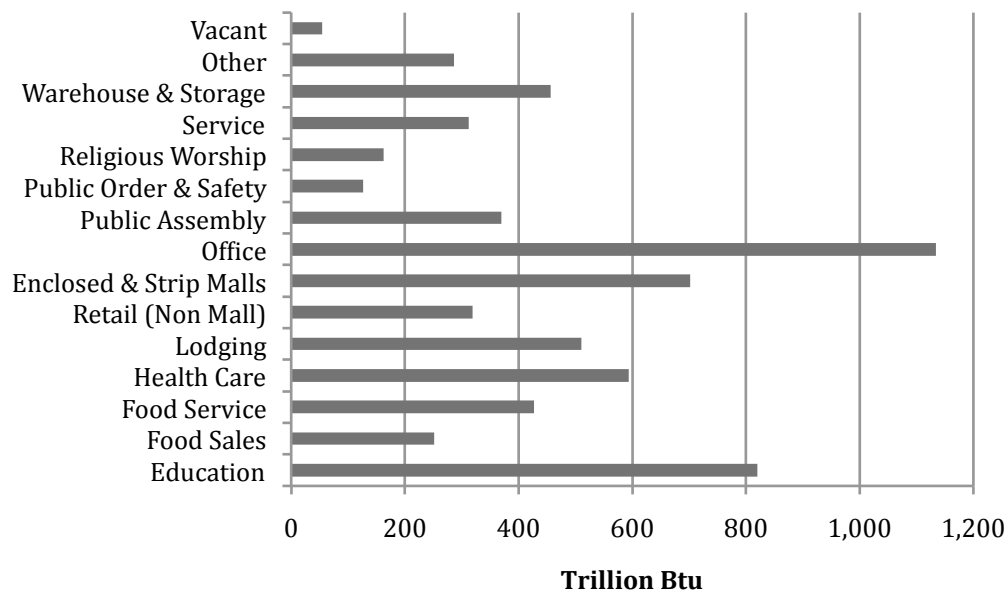


Figure 6c – Commercial Energy Consumption for All Purposes 2003, Trillion Btu
(Data from EIA 2003)

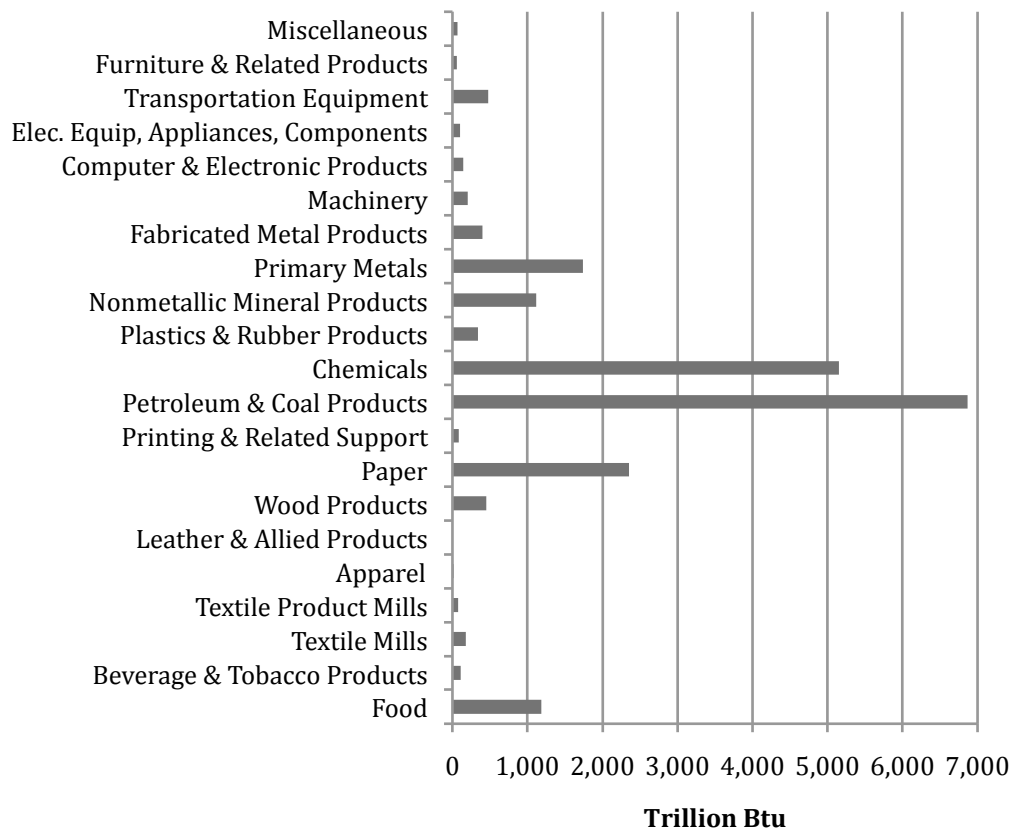


Figure 6d – U.S. Industrial Energy Consumption for All Purposes 2006
(Data from EIA 2006)

6.2b Sectors and Businesses with High HVAC Costs

Although certain industrial sub-sectors are the most energy intensive, not all of their energy use is variable with climate. To see which sub-sectors have the highest motivation to move to a climate with less cooling and heating costs, we need to examine those with the highest HVAC costs as a percentage of their total energy costs. These statistics are not easy to find. The IEA estimates 20% of total industry energy demand is for non-process uses such as lighting and transport (IEA 2007, 41). Figure 6e uses data from two different years to approximate the differences in HVAC energy use between industrial and commercial uses in the

U.S. Clearly, the commercial sector uses considerably more energy for HVAC, both in real and relative terms.

Figures 6f and 6g demonstrate the large difference in HVAC costs at the sub-sectoral level. Commercial buildings used for public assembly, education and religious worship all have high proportional HVAC costs, at over 60% of total energy costs. All three are also highly embedded in their location, geographically and socially. For the Industrial sector, producers of raw materials tend to have lower HVAC costs as a proportion of total energy costs than secondary producers such as apparel, machinery and electronic manufacturers.

The data examined suggests that it is more likely that a commercial business would move for potential HVAC energy savings than an industrial business. This corresponds with findings from the literature in Chapter 4, which suggest commercial businesses are more likely to move for all reasons.

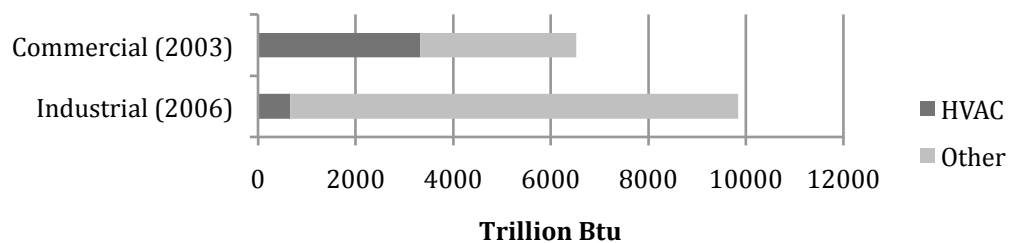


Figure 6e Energy Use and HVAC for Commercial (2003) and Industrial (2006) Sectors, Trillion Btu (Data from EIA 2003 and EIA 2006b)

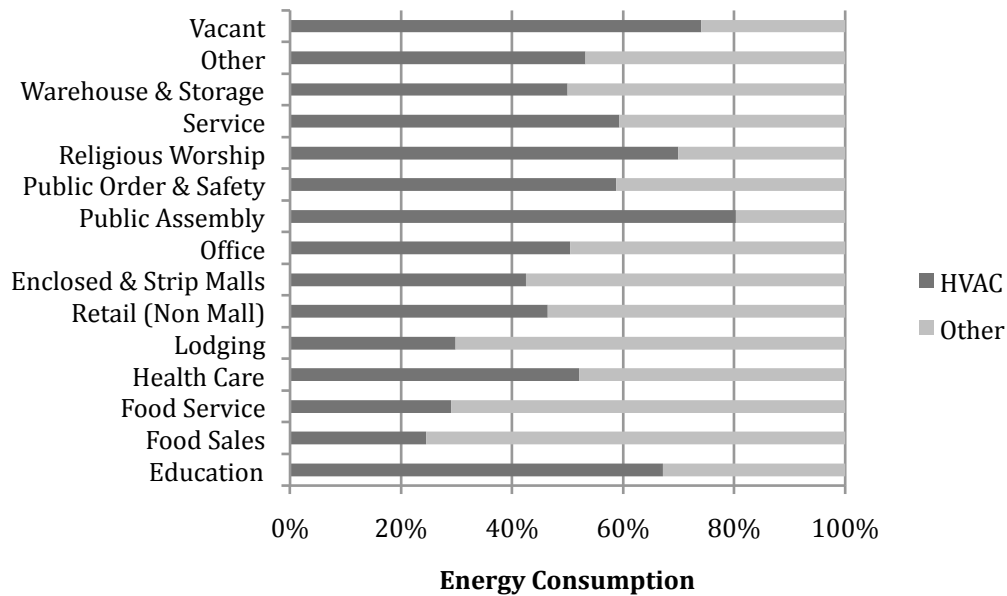


Figure 6f – Percent of Energy Used for HVAC by Commercial Sub-Sector 2003
(Data from EIA 2003)

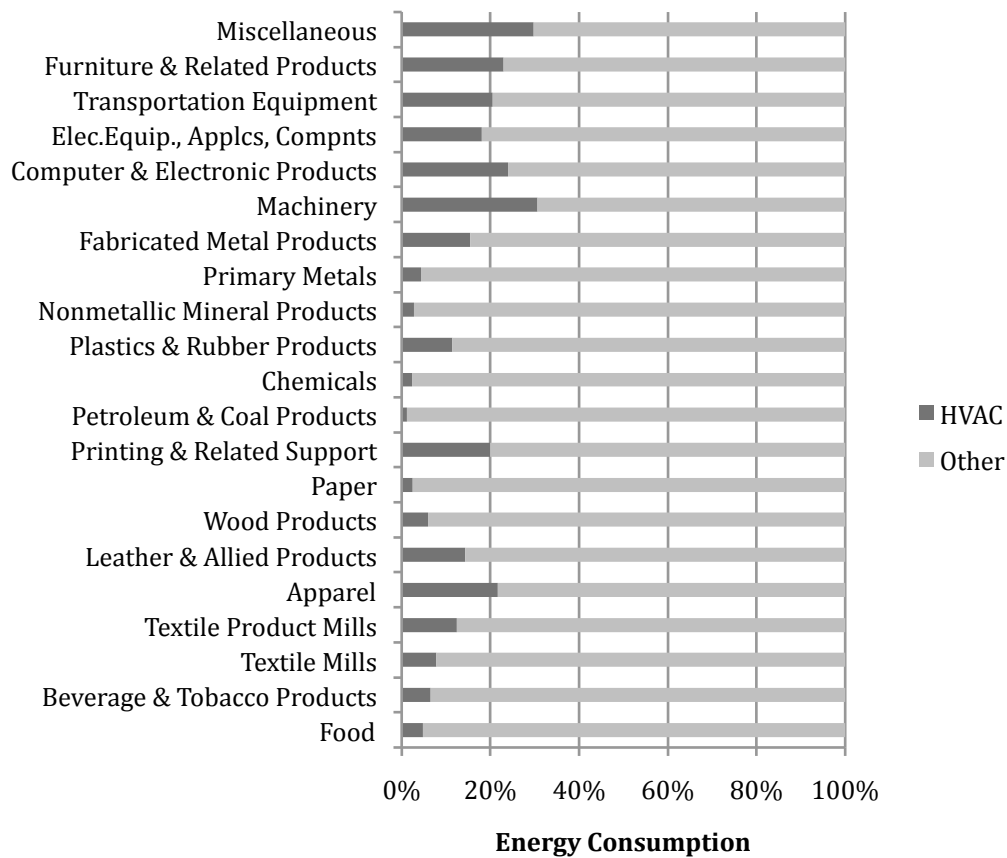


Figure 6g – Percent of Energy Used for HVAC by Industrial Sub-Sector 1998
(Data from EIA 1998)

6.2c Sectors or Businesses with High GHG Emissions?

Industry does not have as strong of a correlation between energy use and CO₂ emissions as other sectors do. “Process CO₂ emissions unrelated to energy use are large in some sectors, especially in cement production” (IEA 2007, 43). CO₂ emissions also differ by fuel, which varies across sub-sectors. World industry CO₂ emissions were 36% of total global emissions in 2004, however, “three sub-sectors were responsible for 70% of the direct industrial CO₂ emissions: iron and steel, non-metallic minerals, and chemicals and petrochemicals” (IEA 2007, 43). Further complicating the link between energy and emissions is the fact that the fuel of choice for energy intensive U.S. industries is natural gas, whereas other sectors users rely more heavily on higher carbon fuels such as heating oil and electricity (which can be GHG intensive, depending on the utility). Figure 6h contrasts World emissions with those of the U.S. by sector.

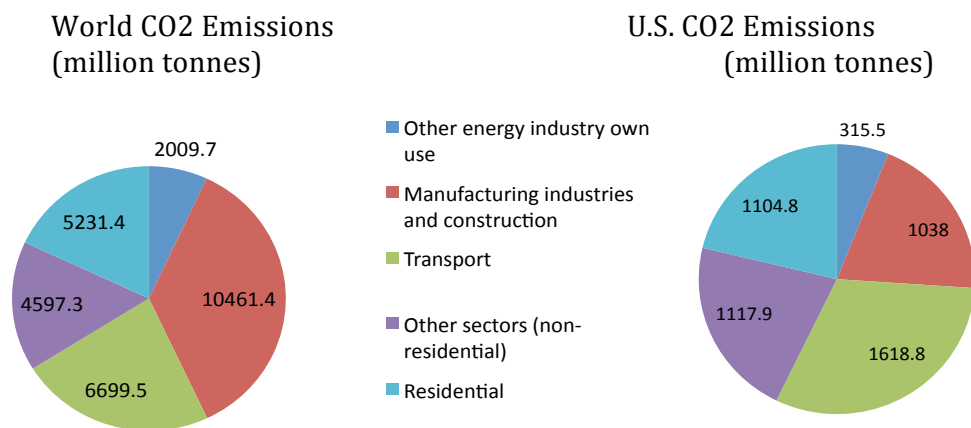


Figure 6h - World and United States CO₂ Emissions 2009 (million tonnes CO₂)
Electricity and heat are allocated to consuming sectors (Data from IEA 2011, 70)

Detailed sub-sectoral GHG emissions are not available for the commercial sector and are only partially available for industry through the EPA's (2011)

Inventory Report, covering only primary producers of raw materials. At this point, we will focus on businesses within the commercial sector as the most likely to move to save on future HVAC costs. For these businesses it is fair to say that there is a strong correlation between energy use and GHG emissions.

6.3 Businesses Most Likely to Move

6.3a Which sectors or companies are influenced most by energy price?

Energy price is important to the big users such as metal production and chemicals. Aluminum smelters originally located near hydro dams to take advantage of the cheap and consistent electricity and one of the contributing elements in the industrial move to the sunbelt was low energy prices, so business is no stranger to shopping for energy deals. As outlined in this Chapter, commercial energy users are more likely to move for synergistic purposes, but which commercial users would be most likely to move?

6.3b Which companies are most influenced by energy source?

In the commercial sector, office buildings have the highest total energy use and therefore represent a large proportion of the sector's GHG emissions. Narrowing this down to types of business that are high emitters is problematic, due to a lack of data. Large emitters with a high public profile are most likely to face pressure to seek reductions. Large emitters are the most likely to be at risk from carbon legislation. Public companies are also generally easier to hold accountable than private companies.

6.3c Which companies are most able to move for synergistic purposes?

We know that firm competencies will be a decisive factor in their response to climate risks. Resistance or acceptance of change will depend “on how they perceive the impact on the value of their complementary assets and capabilities” (Pinkse and Kolk 2010, 263). Companies operating in “industries with a high level of technological dynamism,” will take greater risks and receive greater benefit (265). Another significant factor in a firm’s ability to move is their “embeddedness . . . within existing networks of industry and competition as well as economic, political, social and technological structures” (Linnenluecke, Stathakis and Griffiths 2011, 125). Due to the advantages of clusters, we have noted that firms sometimes known as flagship companies find it easiest to move. We have also found that the decision to move is most often made for firm internal reasons such as growth or for better exposure and image. Technology companies may offer a good fit for the criteria outlined so far, and data centers have been at the forefront of the location choice/sustainability nexus.

6.3d Lessons Learned from Data Centers

Among the most footloose of businesses are data centers. Data centers are huge consumers of energy, with the largest now rivaling aluminum smelters. One Microsoft facility near Chicago requires 198 megawatts of capacity (Economist 2008). Data centers are estimated to use around 1.3% of global electricity, an amount that is growing rapidly (Google 2011). A large proportion of data center operating costs are facility HVAC leading to a heavy industry focus on facility location, aiming to find cheap, reliable and increasingly clean power (Economist 2008). High profile firms such as Facebook and Google have faced

campaigns, such as Greenpeace's Unfriend Coal, to disclose GHG emissions and clean up their power sources. These factors have led to the clustering of data centers in places like Oregon, Washington (Economist 2008) and Iceland (Guardian 2011), where the world's first carbon neutral data center is being built, in order to take advantage of local renewable energy supplies and cool ambient temperatures. Facebook's new data center is being built near the Arctic Circle in northern Sweden (Guardian 2011b) and Google is seeking to patent floating data centers, which would be located at sea (U.S. Patent & Trademark Office 2008). Harnessing excess heat by co-location with sites requiring heat could be another tactic for data centers to employ.

Most new data centers are due to expansion rather than relocation, however because of the exponential growth of the industry, there is growing information on the location decision. Locating in old rust belt cities has been a strong theme, due to cheap land and cheap available power. Concerns have been raised regarding the lack of long-term jobs (beyond construction) for local people, the amount of energy drawn from the regional grid and the ability of companies to negotiate long-term local tax exemptions (Data Center Dynamics 2011).

Even with a business as mobile as a data center there is a risk of being geographically embedded. The Economist (2008) suggests that data centers for services relying on speed, such as automated financial transactions, will have to remain close to financial centers such as New York and London. Others will be deterred from moving by the uncertainties of climate change itself. A British Government report (Foresight 2011) suggests significant threats to remote data centers from climate change, recommending diversifying location. Data centers

offer an interesting test case for many aspects of this thesis. However, due to the lack of jobs they provide (200 for the largest), they do not offer the opportunity to draw significant population away from risk prone areas.

6.4 Conclusion - Which businesses should be encouraged to move?

When thinking about which businesses should be moved, vital industries such as power generation, agriculture, transport, communications and water seem obvious. Equally apparent is that these are amongst the most geographically embedded. As discussed, technology companies meet many of the criteria we have explored including being commercial sector, high energy users, often high profile, image conscious, fast growing and innovative. They are also mobile when not attached to a cluster. Although technology companies are not particularly at risk as a sector, certain companies will face location specific hazards. Another important factor is the issue of scale. In order to draw population, large employers or entire clusters must be encouraged to move. Many technology companies do not like to be lone wolves. Although other businesses could probably be found to fit many of the criteria, technology firms have a significant advantage in that many of them are already considering the synergistic benefits location can provide through their experience with data centers. For simplicity, in Chapter 7 we will use a typical commercial building for analysis of the locational differences in HVAC energy use.

7. Climate Impacts on Energy Use for Commercial HVAC: Miami, Florida vs. Cleveland, Ohio

Chapter 7 will compare present energy use and GHG emissions for HVAC between a typical commercial building in Miami and one in Cleveland. We will also project these figures into the future and compare the impact that a high and low emissions scenario could have on these figures. Calculating GHG emissions for an individual, household or business is complex and involves substantial assumptions. There are many regional variables, including differences in energy generation and transmission, building and insulation efficiency, transportation infrastructure, agriculture and industry. We will presume that our business is moving between two identical locations, except that one location has the climate of Miami and the other has the climate of Cleveland. The variable, as far as energy use is concerned, is the HVAC needs of the firm.

The amount of heating and cooling required in a given location can be quantified through the use of degree days (DD), often split into heating degree days (HDD) and cooling degree days (CDD). “A degree day is a measure of the average temperature’s departure from a human comfort level of 18 °C (65 °F)” (Baumert and Selman 2003). For example, with a baseline of 65 °F, a day with an average temperature of 60 °F would count as 5 HDD, because heating would have to be used for the day to raise the temperature by 5 °F. If a given day had an average temperature of 70 °F, air conditioning would have to be employed to lower the temperature by 5 °F over the span of the day, adding up to 5 CDD. An inherent flaw with using DD is that the real life comfort range where no heating or air conditioning is employed is larger than one degree. Taken over a period of

time, HDD and CDD figures can help determine energy demand in a given location. Once we have a figure for HDD and CDD we can ascertain the energy required and thus GHG emissions. Predicting equivalent 2050 emissions we will hold the same spatial variables constant and presume that all variables will remain unchanged over time, except for climate. For example, we will have to presume that fuels, building efficiency and building size will stay the same. In a real forecast of emissions these factors would have to be accounted for.

7.1 Background

Climate change will have a discernable impact on energy consumption. Put simply “average warming can be expected to increase energy requirements for cooling and reduce energy requirements for warming” of buildings (USCCSP 2007, 1). Net demand for energy could remain constant, with the extent of the shift in energy depending upon the uptake of air-conditioning and level of temperature increases in the North (IPCC 2007b, 634; USCCSP 2007, 10-12).

A basic problem with predicting future DD and energy use lies with the inherent uncertainty of climate models. Furthermore, the best models are at a scale that makes city level predictions difficult. For example, Ruosteenoja et al. (2003) which was part of the 4th IPCC Assessment, splits the U.S. between just three zones: East, West and Central. Such grouping draws no contrast between Miami and Cleveland. USCCSP (2007, 10) estimates that for “regions with more than about 4000 heating degree-days Fahrenheit” (see Figure 7a), or “roughly the dividing line between “north” and “south” in most national studies”, that “climate warming tends to reduce consumption of heating fuel more than it

increases the consumption of electricity,” while the reverse is true in the South.

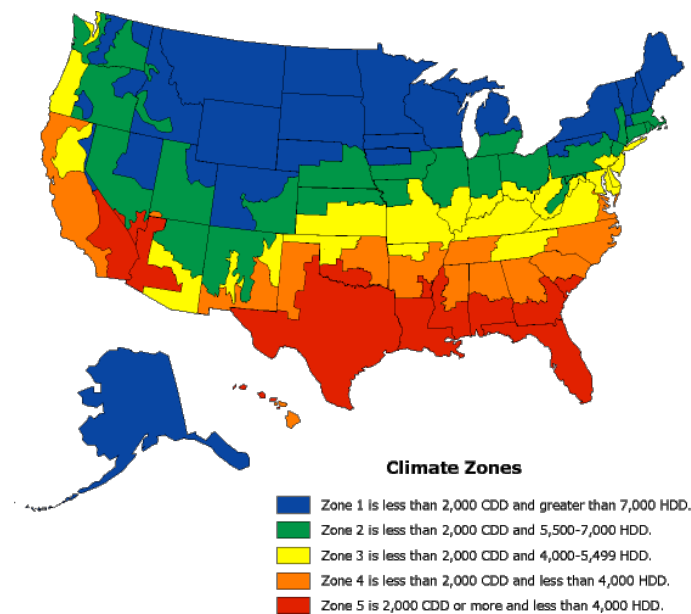


Figure 7a – United States Climate Zones (EIA 2003b)

Changes in seasonal energy use, from heating to cooling, will have an impact on GHG emissions due to the different fuels used for each, with important regional variations. For example, GHG reductions could be significant in the Northeast which relies mainly on oil for heating, compared to lower reductions in other regions where gas is the main fuel for heating (USCCSP 2007, 12). In some regions, a switch in energy use to electricity for summer cooling could increase CO₂ emissions, due to the reliance on coal for electricity generation and the amount of energy lost in the transmission of electricity (12).

Changes in overall national energy demand will be determined by more variables than just future temperatures and the adoption of air conditioning. Also, we must consider the level of investment in building energy efficiency and national migration patterns, presently predicted to continue toward net cooling

load regions (USCCSP 2007, 60). There are many unpredictable variables, for example “lower winter energy demands in Canada could add to available electricity supplies for a few U.S. regions” (60).

7.2 Estimated Temperature Changes from 2010 to 2050

Based on USGCRP (2009, 29) predictions, from 2010 to 2050 the Cleveland area will experience a 2°F increase in average annual temperature under a low emissions scenario and 3°F under a high emissions scenario. For Miami, the increase will be 1°F under a low emissions scenario and 2°F under a high emissions scenario. Using data from NOAA’s National Climate Data Center [NCDC] (2011) of daily average temperatures between November 2008 and November 2011, a three-year daily average was derived for both Cleveland and Miami. These three-year average temperatures were then used as the 2010 temperature. Predicted increases by 2050 were applied to the three-year daily averages for each location, giving us estimated average daily temperatures for high and low emissions scenarios. The results are shown in Figure 7b. The problem with this method is that warming is not expected to be constant throughout the year, with most warming in winter in the North and in summer in the South (USGCRP 2009, 111). In reality, all 2050 curves will move up the y-axis, the Cleveland 2050 curves will likely flatten and the Miami 2050 curves will likely take on a more pronounced “s” shape, meaning that our results are skewed in favor of Miami. More detailed seasonal temperature predictions on a regional basis would help with predictions.

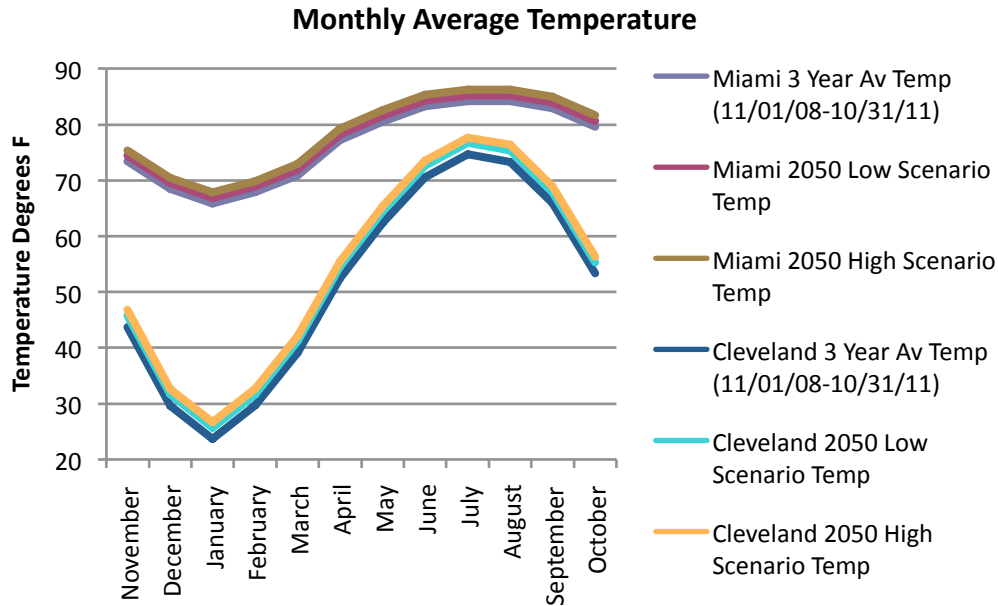


Figure 7b – Monthly Average Temperatures, All Scenarios

7.2a Changes to Degree Days from 2010 to 2050

Historical DD data is available for many U.S. locations. No detailed DD estimates are available for future climate change scenarios for our locations. In order to source data consistently, it was decided that both 2010 and 2050 DD data would be derived from the daily temperature data. The daily deviation of the temperatures shown in Figure 7b from the base temperature of 65°F was calculated and is illustrated in figures 7c to 7j.

The calculations show an overall decrease in DD for Cleveland from 6577 to 6347 (Low Emissions) or 6248 (High Emissions) and an overall increase for Miami from 4307 to 4636 (Low Emissions) or 4981 (High Emissions). These were not as significant as expected. Because the DD estimates are taken from the daily average temperature, they do not account for daily swings in temperature. For example, Miami was shown to average 37 HDD over the last three years,

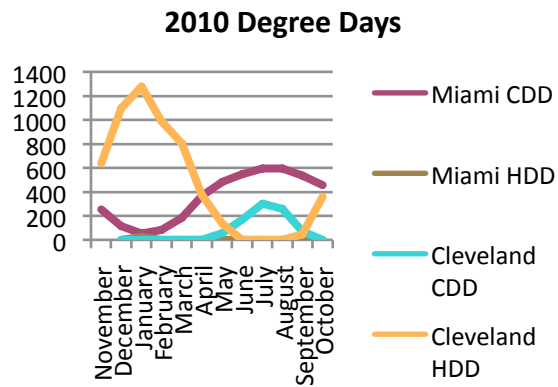


Figure 7c

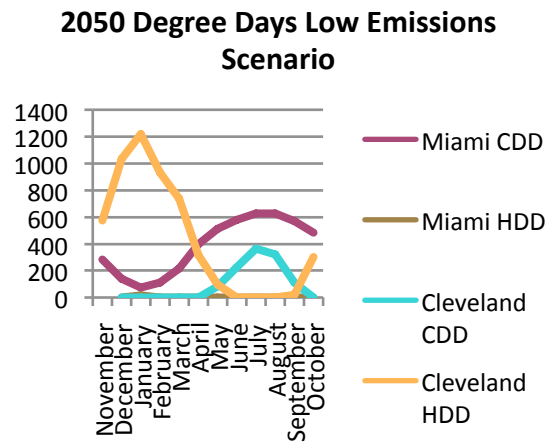


Figure 7d

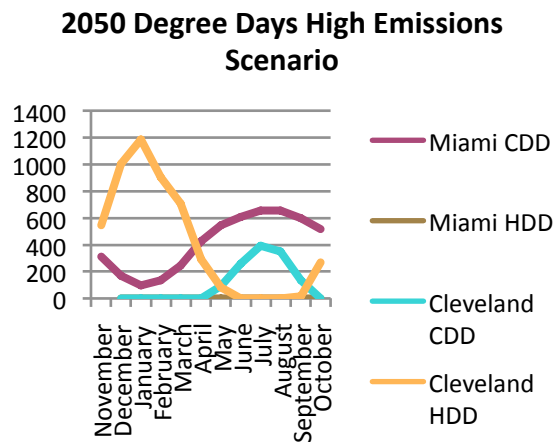


Figure 7e

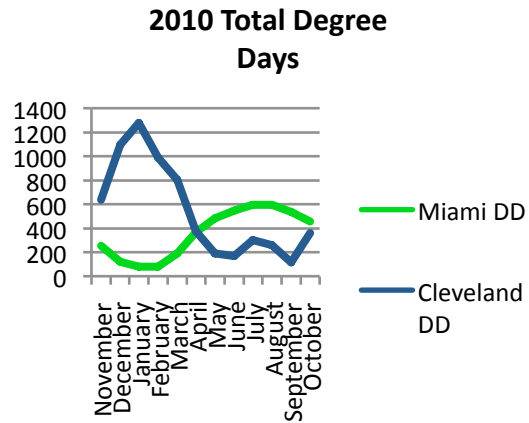


Figure 7f

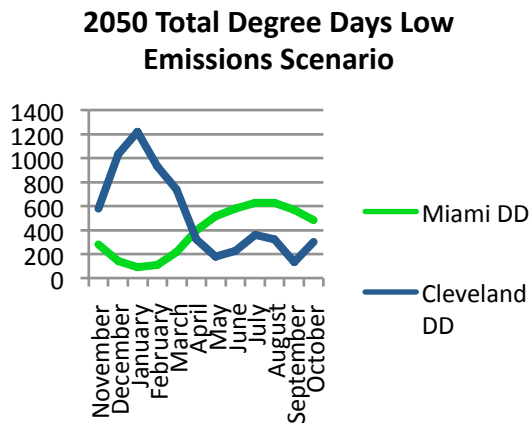


Figure 7g

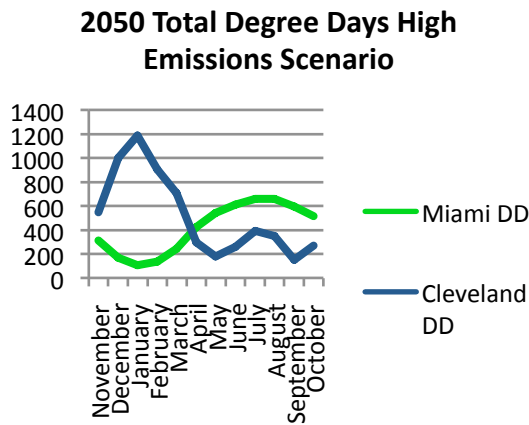


Figure 7h

whereas degreedays.net (2011) calculate the figure as 291. Commercial DD data providers such as degreeday.net calculate using half hour temperature readings, providing much richer data. It is beyond the scope of this paper to predict annual temperatures in half hour increments for 2050. For this reason DD were calculated for all dates and scenarios using daily averages.

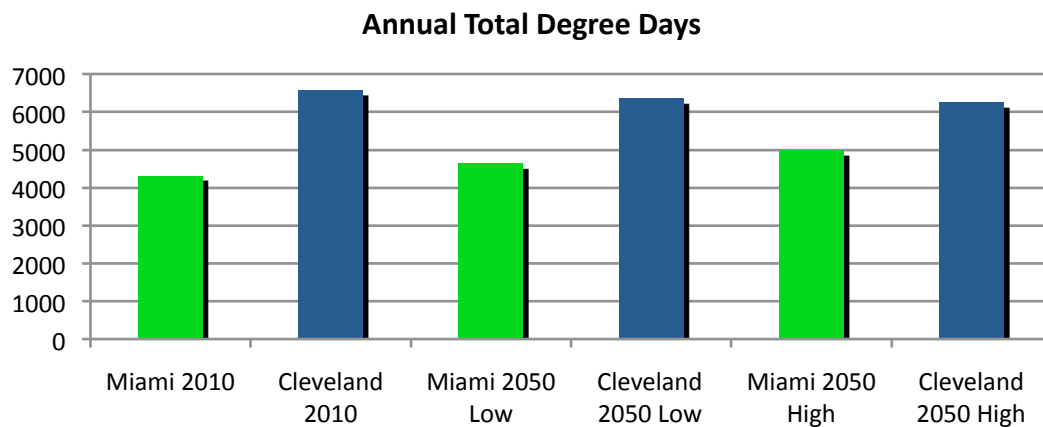


Figure 7i – Annual Total Degree Days, All Scenarios

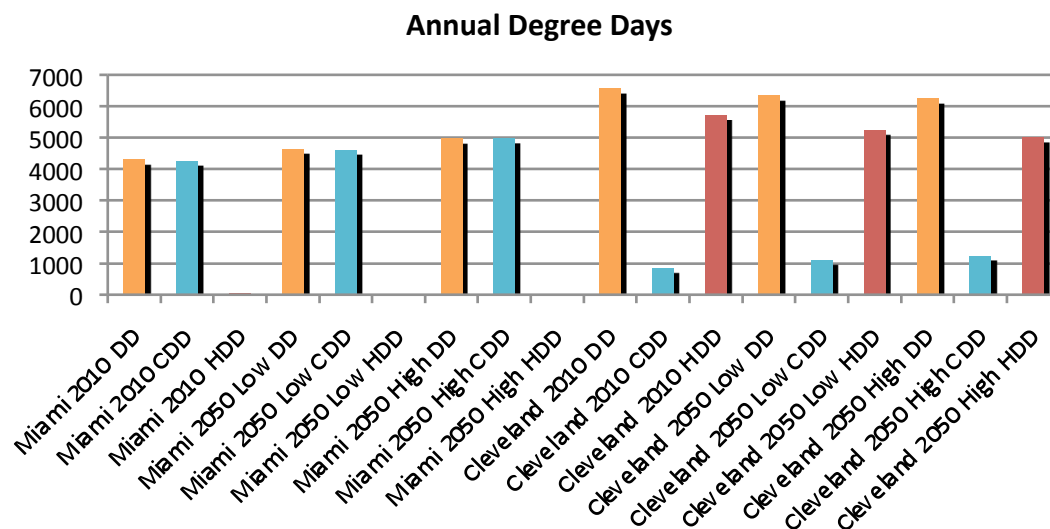


Figure 7j – Annual Degree Days, by HDD and CDD, All Scenarios

7.3 HVAC Energy Use for a Typical Commercial Building

The total annual energy required to heat or cool a building per year is measured in British Thermal Units (Btu) and depends upon DD (see Table 7a for summary), area heated, insulation, building use and heating system efficiency. To approximate annual consumption, the building use, insulation and system efficiency will be held constant as we compare Cleveland and Miami. We will also hold the area of the building constant at 14,700 SqFt, the average for a commercial building (EIA 2003a).

	Miami CDD	Miami HDD	Cleveland CDD	Cleveland HDD
2010	4270	37	854	5722
2050 Low	4617	18	1105	5243
2050 High	4972	9	1238	5010

Table 7a - Summary of HDD and CDD

Knowing the degree days and square footage, we also need to know how much energy is required to heat or cool per square foot per degree day. The best available estimate of a commercial building average is from a study performed by the Lawrence Berkeley National Laboratory, using Data from The EIA's Commercial Building Energy Consumption Survey. The study suggested U.S. averages of 11.9 Btu/SqFt/HDD and 11.8 Btu/SqFt/CDD (Blum and Sathaye 2010, 12-14). The approximate Btu consumption for each location and scenario, shown in Table 7b, was obtained by multiplying the average Btu/SqFt/HDD or CDD by the square footage and by the annual HDD or CDD. Given the similarity between energy consumption per square foot for heating and cooling, results reflect the locational and temporal differences in DD.

	Miami Cooling	Miami Heating	Cleveland Cooling	Cleveland Heating
2010	740,738	6,414	148,216	1,000,996
2050 Low	800,888	3,225	191,627	917,076
2050 High	862,524	1,534	214,686	876,481

Table 7b - Total Energy Use, Thousand Btu

7.4 GHG Emissions from HVAC for a Typical Commercial Building

Detailed fuel use, by end use, is not available at this scale. Nationally, the main source of energy for heating is natural gas, whereas cooling is mostly from electricity. We will hold these presumptions in order to compare CO₂ emissions from HVAC between our two locations and into the future. To convert Btus of natural gas used for heating to CO₂, we used the conversion of 53.06 kg CO₂/MMBtu (EIA 2011). To estimate emissions from electricity for cooling, it was necessary to first convert energy use from Btus to KWh (see Table 7c) using an equivalent of 3412 Btu/KWh (EIA 1998a). CO₂ emissions were then calculated using the national average emissions for the end use of electricity of 1.3lbs CO₂ per KWh (EIA 2011a, 2), which was then converted to Kg for comparison. Results are shown in Table 7d.

	Miami Cooling	Cleveland Cooling
2010 Three Year Average	217098	43440
2050 Low	234727	56163
2050 High	252791	62921

Table 7c - Energy Use for Cooling, KWh

	Miami Cooling	Miami Heating	Miami Total	Cleveland Cooling	Cleveland Heating	Cleveland Total
2010	128,016	340	128,356	25,615	53,113	78,728
2050 Low	138,411	171	138,582	33,117	48,660	81,778
2050 High	149,063	81	149,145	37,102	46,506	83,609

Table 7d - CO₂ Emissions for Miami and Cleveland, All Scenarios, Kg

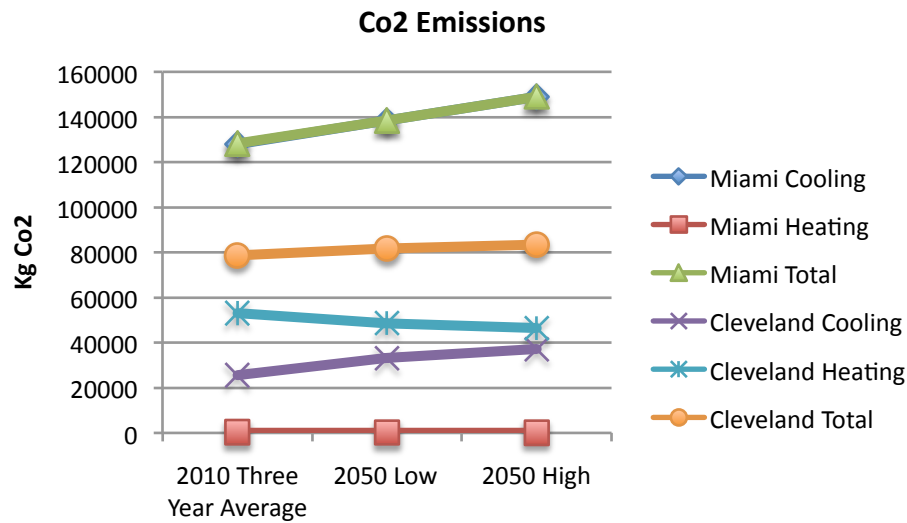


Figure 7k - CO₂ Emissions for Miami and Cleveland, All Scenarios, Kg

Once we calculate CO₂ emissions for each location and scenario, a different picture emerges, as illustrated in Figure 7k. Emissions in Miami are much greater than Cleveland. Total emissions are set to increase in both locations, however increases will be greatest in Miami as demand for electricity for space cooling increases.

There are several issues with these conclusions, stemming from assumptions that we have yet to outline. First, we assume that more energy will be used for space cooling, instead of finding other ways to mitigate warmer temperatures. Second, we assume that the energy portfolio will remain unchanged and we do not account for state level differences in the present portfolio, an area extremely malleable to policy. Florida has an electricity generation portfolio, which emits slightly less GHG than the national average, whereas Ohio is slightly higher than average (EIA 2011a, 2). Accounting for this difference, 2010 GHG emissions would be closer in figure 7k. Future GHG emissions, if present energy

portfolios were maintained would also be closer if we accounted for the regional differences. Given the many unknowns, it seems fair to use national averages to approximate in this circumstance. Lastly, we do not account for emissions from electricity lost in transmission, which is estimated at 6.156% nationally (EIA 2011a, 10).

7.5 Conclusions

Hopefully, we will never see the level of warming necessary for HVAC energy use in Miami to be greater than in Cleveland. The difference in emissions between locations, both now and in the future will become important when carbon emissions begin to be priced, either through cap and trade or taxes. Considerable GHG emissions reductions are already possible from switching location and could become more pronounced if warming increases the use of electricity produced from the present portfolio. There are many uncertainties and substantial assumptions in each layer of predictions, from the temperature change, to the change in DD, the calculation of energy use and finally the calculation of GHG emissions. Obviously, such uncertainty makes the results of this chapter unusable for decision-making. Figure 7r provides a summary of the method, assumptions and possible impact of those assumptions.

The exercise was never meant as a scientific assessment, but rather an illustration of the possibilities and kinds of calculations firms will have to deal with when making complex decisions relating to climate change. Our process, rather than the results, has also demonstrated some of the gaps in the research and data, particularly localized temperature and DD predictions.

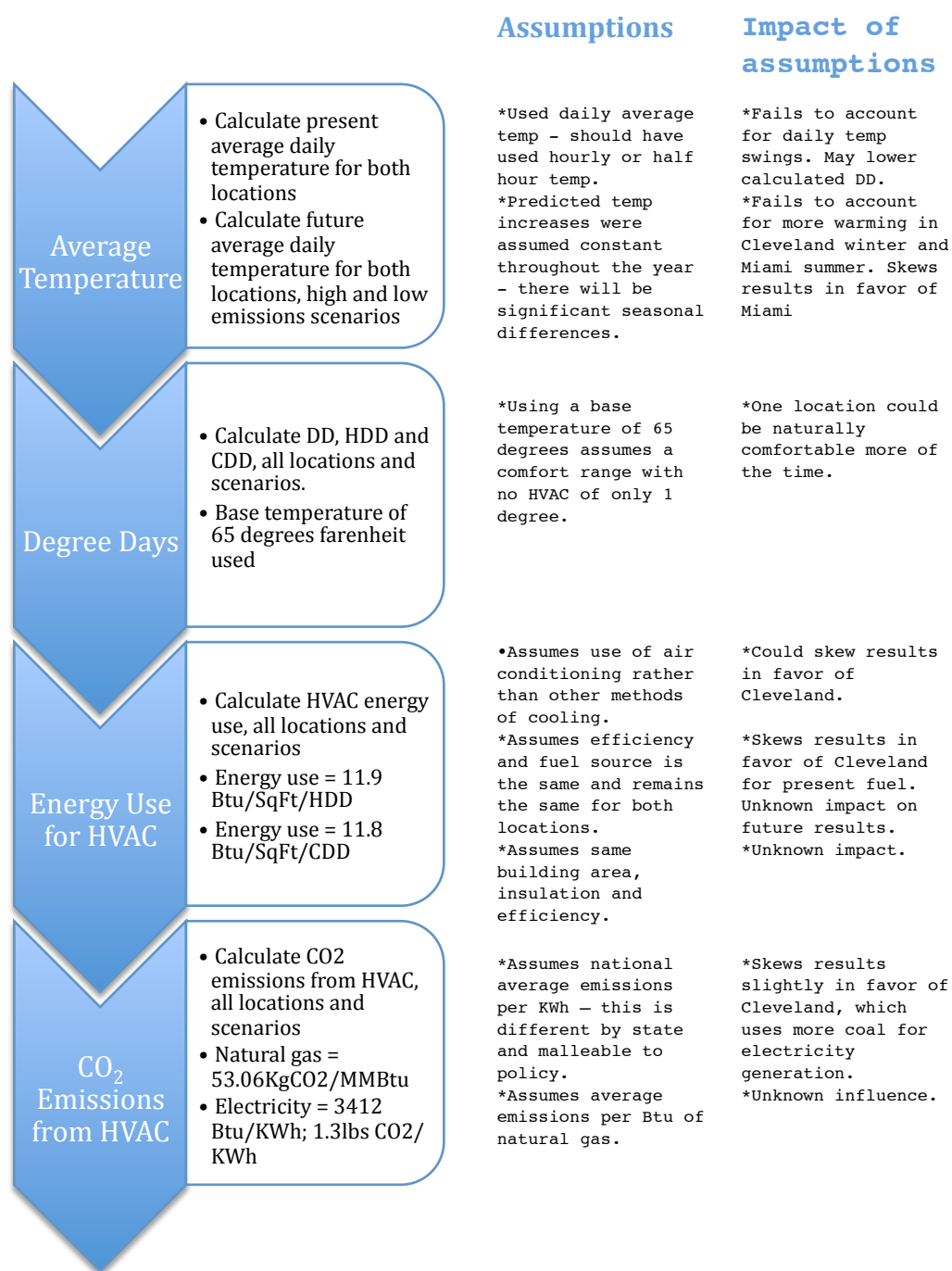


Figure 7m – Summary of Method, Assumptions and Possible Influence on Results

8. Policy for Business Relocation

Many documents and reports (see ECA 2009 and United Nations Development Program 2011) outline strategies for implementing adaptation policies, which we will not repeat here. Rather, we will examine the policy tools available to move businesses to more sustainable areas and whether such policies are desirable or feasible.

8.1 Policy Options

8.1a Push Vs. Pull

As we found in Chapter 4, relocations tend to be a complex mixture of push and pull factors. Although the primary reason for moving may be climate change benefits, there are likely to be a host of factors involved in determining when, why, where and how a relocation occurs. To facilitate movement in a desired way, these factors will have to be accounted for, necessitating the development of new ways of modeling and influencing relocation behavior.

8.1b Local, State or National

States and municipalities have varied greatly in their implementation of adaptation and mitigation policies. Due to their reliance on growth to fund tax revenue, local municipalities can be expected to fight policies seeking to reverse their growth, whether they come from federal or state government. Cities that lose population also lose revenue from state and federal aid, much of which is dependent upon certain thresholds (Hollander 2011, 4). Even movement within a state would be complex and controversial. State government can be expected to offer similar resistance due to their power, from Electoral College votes to

Congressional seats, being tied to population.

Local government policymakers and planners can do little to change their population and employment levels as “national forces often overshadow local efforts to direct growth and change” (Hollander 2011, 11). Realistically, policies on the scale required can only be coordinated by the federal government. As with most U.S. businesses, the national climate change discourse has been based around mitigation legislation. The discourse of national legislation has been set for failure, with the result that it is now conveniently pushed down the priority list during our present economic crisis. Presidential Executive Order 13514 (2009) titled Federal Leadership in Environmental, Energy, and Economic Performance, bypasses congress and leverages the considerable influence of federal agencies. Among other things it mandates federal agencies to:

- Establish and report a comprehensive inventory of GHG emissions
- Participate in the interagency Climate Change Adaptation Task Force and integrate that strategy into agency operations
- Review policy and practice associated with site selection for facilities
- Provide recommendations to the Council on Environmental Quality regarding sustainable location strategies, prioritizing central business districts/town centers, transit access, proximity to affordable housing, adaptive reuse or renovation of buildings and avoiding the development of sensitive resources

The wording in Executive Order 13514 could provide the catalyst for location to be used much more as an adaptive and mitigative tool. The federal government could also seek to leverage the influence of its own agencies through the federal building codes for commercial buildings. This could be done through the introduction of stronger performance standards for withstanding spatially variable weather and climate risks. The federal government could also influence national building codes but would have limited power over their adoption. This

point brings us to the crux of the local, state or federal question. In order for a climate smart national policy to be implemented, the distribution of power between the different levels of government must be addressed.

8.1c Insurance

As we noted in Chapter 6, insurance will play a key role in helping society adapt to climate change. Insurance will allow the transfer of risk associated with low frequency, high-impact events which cannot be affordably adapted to (ECA 2009, 44). For risk that is not insurable, Marsh (2006, 24) suggests increasing the availability of weather related derivatives to help absorb the financial impact of unexpected weather. First, many insurance companies will need help in developing new risk models. Ceres (2011) and Marsh (2006) provide a good overview of some of the steps insurance companies are already taking to adapt to climate risks. Some risks will simply prove uninsurable.

Stern (2006a, 21) suggests that risk-based insurance provides strong signals about the size of climate risks and encourages good risk management.

Unfortunately, when insurance has been withdrawn from markets such as Florida and Louisiana, government provided insurance coverage, removing the market signal. Such measures are not necessarily in the national interest, but preventing them would be unpopular. A related problem is that disaster relief is heavily subsidized by federal agencies. The World Bank (2009, 74) recognizes a similar market failure on the international stage, with many countries relying on funding from donors and development banks for disaster recovery, removing the economic incentive for risk management. Perhaps FEMA could be funded directly by the states, with contributions based upon risk, acting almost as an

insurance scheme for states. Actions that increase risk, for example propping up the property insurance market, could be accounted for under such a system.

Research suggests that insurance is not facilitating long term resilient behavior. Ceres (2011,47) finds that few companies have specialized products designed to encourage low carbon behavior and Marsh (2006, 19) recommends a greater need for insurance companies to lobby to change policies such as building codes. Changes to land use planning are also in the interests of insurance companies. Seemingly, the problem boils down to the lack of incentives for insurance companies to act in the long term. Government could provide incentives through tax breaks for climate friendly products or alternatively through legislation which encouraged or required longer-term relationships between insured and insurer. There is huge potential to create climate resiliency through the channel of insurance. Perhaps what is needed first is a coalition of government, insurance, industry associations and reinsurance to examine shared interests and missing knowledge and incentives.

8.1d What do corporations want?

Most businesses hope for a predictable platform on which to base decisions. Many major US companies have even called for climate legislation in order to provide U.S. firms with a competitive advantage as early adopters in the long to medium term (WRI 2008, 11). As we found in Chapter 3, business will not adopt a broad strategy on climate change without legislation. In terms of business relocation “business executives contend that public officials frequently do not understand business operations and what motivates location and re-location decisions” (Cohen 2000, 2). In order to create the right pull factors, policy

makers will have to close this knowledge gap.

Most businesses are out of their depth when assessing their exposure to climate change. First, a change of outlook is required so that adaptation is considered a core business issue. Most will need help to develop competencies in key areas such as monitoring, interpretation and resilience. In order to help them make location decisions, businesses will need information based on superior, more localized climate models.

Businesses are also looking for incentives to make sustainable long-term decisions including relocation. Such incentives could include tax breaks or reduced taxes, grants and low interest loans and also subsidization of the components of agglomeration, such as transportation, utilities, research and culture.

8.1e Tax and Incentives

The use of tax breaks, subsidies and other incentives to attract industry, is both hugely popular and increasingly controversial. Incentives, subsidies and tax benefits for location, often focus on short-term fixes rather than removing long-term disadvantages (Schwartz, Pelzman and Keren 2008, 167-168).

Furthermore, although “it is generally accepted that location incentives have some success in inducing investment in preferred locations,” many studies “show that their effect is not dominant in the location decisions of the firms and that primary location factors play a more important role” (168). They often offer poor value for money as Hollander (2011, 5) points out, Orlando tried to counter the foreclosure crisis by providing an economic incentive package worth \$367.2 million for the Burnham Institute for Medical Research to relocate with 303 jobs.

The problem with most incentives is that they are part of a pull strategy leading to competition between locations, whereas a push and pull strategy could be much more beneficial. Properly pricing carbon would cause factors such as HVAC and transportation to become significant in location decisions. However, pricing carbon would only be the beginning of what should be a suite of environmental taxes, necessary to direct development towards sustainable locations. Water needs to be properly priced to account for supply. As already mentioned, the risks of locating in disaster prone areas should also be properly apportioned, either through risk based insurance or weighted land use taxes. Property tax reform could correct for biases towards unsustainable behaviour (Kamal-Chaoui and Robert 2009, 15). Property taxes could be a powerful tool in directing development to sustainable locations (Kamal-Chaoui and Robert 2009, 118), however the federal government would find it difficult to affect the structure of these taxes to reflect nationally sustainable and unsustainable places. Corporate tax credits with a locational bias could be one of the few ways in which the federal government could hope to influence this area.

8.1f Planning

Planning is beginning to respond to the challenges of climate change. For example, rolling easements are used in some areas of the U.S., granting public right of way to coastal land, which migrates with erosion or SLR, therefore discouraging coastal development (Kamal-Chaoui and Robert 2009, 82). Good local planning will surely play a role, but national level planning is the only scale that can realistically make the kind of changes discussed in this thesis. Planning regimes vary nationwide, with some locations having effective local and regional

spatial planning and other areas having very little. Therefore, the concept of spatial planning at the national level can seem a little far-fetched. However the lack of a long-range national plan is somewhat of an historical anomaly. Yaro (2009, 13) gives several examples of national scale planning which have fundamentally shaped the modern U.S. including building of the transcontinental railroads, the Homesteads Act, the New Deal, the Federal-Aid Highway Act and the GI Bill of Rights. The federal government's current approach to underperforming regions is that people will move to the where the jobs are and compared to Europe, Japan, Korea and China there is massive underinvestment in new infrastructure (13). The lack of national strategy has resulted in a huge disparity in economic fortunes (Ronderos 24, 2009).

Eleven megaregions [Northeast, Great Lakes, Piedmont Atlantic, Florida, Gulf Coast, Texas Triangle, Arizona Sun Corridor, Southern California, Northern California and Cascadia (Yaro 2011, 244)] have emerged in the last century. These comprise networks of metropolitan areas 300-500 miles across, which will absorb 70% of America's anticipated population and economic growth by 2050 (Ronderos 24, 2009). While most regions will experience rapid growth, the Gulf Coast and Great Lakes will likely continue to experience slow or stagnant population and economic growth (Ronderos 24, 2009). A strategy to "re-magnetize" underperforming places, would not only benefit them but also ease the pressure on the more successful regions (Yaro 2009, 18).

Planning for these megaregions by providing better transportation and communication both within the cities and to outlying areas is seen by regional planners as the core of a new national strategy, in particular by building High

Speed Rail (HSR) lines. HSR provides the opportunity to reshape development patterns nationwide (Yaro 2011, 243). Yaro (2009 and 2011) and Ronderos (2009) view HSR as a way to share economic growth more evenly, but it is the contention of this paper that it could be used more strategically. Given the propensity for such projects to spur growth and development, the question has to be asked, can certain megaregions cope with such growth and do we want to see it occur in risky, unsustainable places? The development of HSR could instead be prioritized in the most sustainable locations, for water resources, renewable energy potential, HVAC intensity, climate and weather risk.

Figure 8a summarizes the push and pull factors which could be used to impact population and business growth in desired locations.

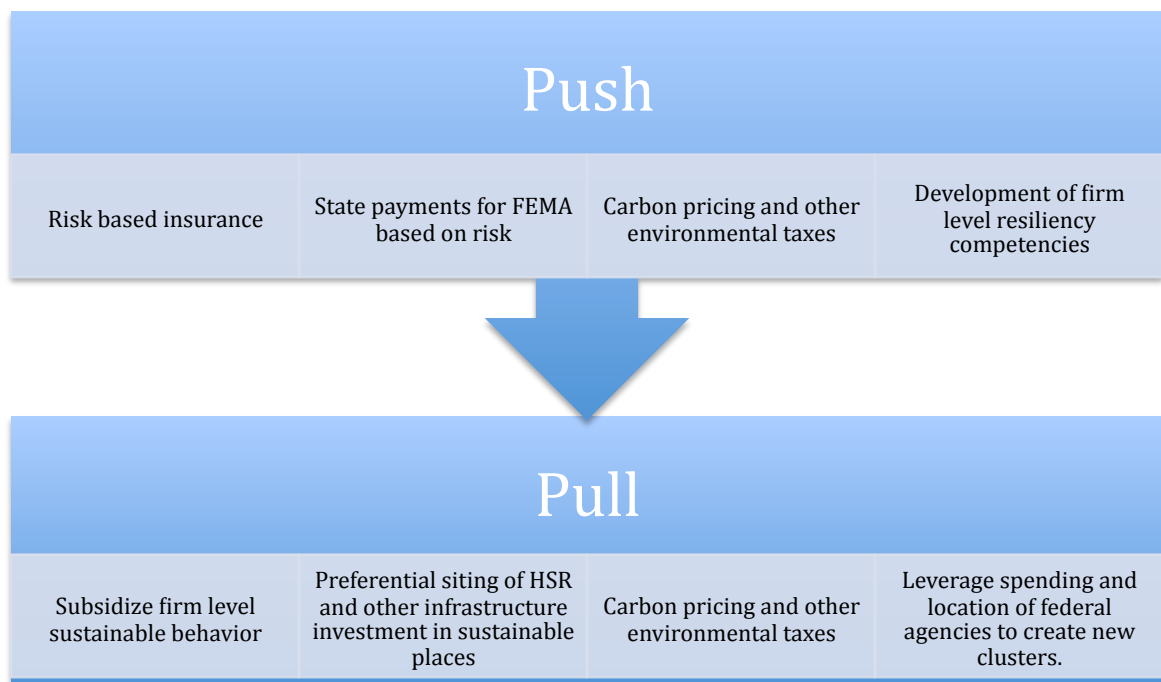


Figure 8a – Summary of Push and Pull Policies for Business Relocation

8.2 Should policy be directed to help business move?

Climate change is likely to cause people and businesses to move whether planned or not. At the firm level, Linnenluecke, Stathakis and Griffiths (2011, 123) propose a decision framework (see Appendix, Figure 8b) whereby high locational risk assessment leads to feasibility study and cost benefit analysis of relocation. Low and medium locational risk usually result in other adaptive behaviors (127). Decisions will be made at the firm level, however national policy has a tremendous potential to influence.

Location has already been addressed by some low-lying Pacific-Island states (Linnenluecke, Stathakis and Griffiths 2011, 127), with the Maldives diverting a share of annual tourist income to a fund in order to buy a new homeland should the Maldives become uninhabitable (131). The ECA (2009,7) suggests that the “modification of national policies might significantly enlarge the solution space for climate-resilient development.” Difficulties lie in deciding policy because decision-makers must address both current and future climate risk under “considerable uncertainty about the source, probability, and extent of that risk” (ECA 2009, 27). Below we briefly explore the benefits, risks and barriers of government relocation policy.

8.2a Benefits

As we found in Chapter 2 policy decisions made now will determine whether movement is an adaptive choice rather than a matter of survival. Unplanned, responsive migration such as in the aftermath of Hurricane Katrina, can have severe humanitarian consequences. The IPCC (2007b, 635) found “strikingly

poorer health of storm evacuees, many of whom lost jobs, health insurance, and stable relationships with medical professionals.” If planned, relocation can empower the most vulnerable populations to move to less risky and more sustainable locations, with greater opportunities. Relocation also has the potential to provide benefits to the receiving location, through reversing population decline or the provision of new infrastructure (and jobs to create it) to draw people and businesses to the area. For business, clear federal government policy would reduce the uncertainty they currently face over climate change decisions and prevent them from locking expensive infrastructure into risky areas.

8.2b Risks

Another finding of Chapter 2 was that top-down adaptation to environmental change carries the risk of mal-adaptation. The main risk with a large relocation policy would probably be the impact on receiving areas. Without significant planning, resources and infrastructure could be stretched and the cultural impact could be detrimental causing friction with established communities. There could also be problems if newcomers struggle to establish themselves, find work and good housing, leading to social and environmental justice issues.

The risk of environmental injustice is also significant for relocating firms. Already with high energy users such as data centers, we have seen problems when firms relocate chasing low costs, but bring little work in return for draining cheap power from the grid. For the firm itself, climate change impacts at the current location and the benefits of moving will be difficult to quantify (Linnenluecke, Stathakis and Griffiths 2011, 128). Uncertainties will include “the

new socioeconomic situation, new stakeholders, a new institutional and regulatory environment, a new customer base, and so on” (128).

8.2c Barriers

Spatial planning on a national scale would face many barriers and vested interests. As mentioned, states would resist an erosion of their political power and would fight to benefit from any infrastructure project such as HSR (at least in most cases). Brewer (2005, 1) suggests that US climate change policy is significantly impacted by “regional variations in the location of carbon intensive industries. For example, coal, a tiny fraction of the national economy, is significant politically due to its presence in the battleground states of Pennsylvania, Ohio and West Virginia (2-4). Similar vested interests will be encountered with the oilfields of the Gulf Coast and at the city scale, with the beneficiaries of the “Urban Growth Machine,” (see Logan and Molotch 1987) such as developers.

For any relocation policy to gain traction, we will have to move beyond the growth paradigm. In particular, the false dichotomy that growth is good and decline causes suffering will have to be countered with smart decline (Hollander 2011, 8-9) or “planning for less – fewer people, fewer buildings, fewer land uses” (4-5). Coincidentally, many Sunbelt cities are now facing the prospect of having to manage decline after the subprime housing collapse (4-5). For a region defined by growth, decline presents a vexing problem for local, state and federal officials (18).

Chapter 9: Conclusion

Unfortunately, we are at a stage where all policy options should be on the table. National spatial planning would help to relieve some of the worst impacts of climate change and has the potential to reduce GHG emissions. Perhaps the most promising option is leveraging HSR to produce growth in desirable areas. Government seems to have had mixed and limited success in using incentives to influence location. Furthermore, targeting specific business is difficult as they have different needs. Infrastructure projects have been historically proven to draw population and business. If HSR development were combined with the right environmental taxes and risk based insurance, a powerful suite of push and pull factors would be created. Renewable energy infrastructure is another project which could be used as a pull to desirable areas. The Green New Deal, which many organizations are calling for contains such elements. The important difference and main suggestion of this paper is that place is important. Why should billions be spent on embedded infrastructure in high-risk locations, actually encouraging further development?

The serious question of where to discourage development and where to encourage it requires much further study. Water will be an important factor, as will access to renewable energy, safety from weather risks, comfortable ambient temperature and the potential for low energy use. Rust belt towns offer fascinating potential, as many already have the infrastructure and resources to deal with a much larger population. Small cities should not be overlooked either. The development and marketing of climate resiliency, offers significant potential for these struggling cities to draw businesses to them. The Gulf Coast stands out

in the literature as not only being at extreme risk, but also having a large vulnerable population. Many organizations including the Council on Environmental Quality (2010,7) recognize that “adaptation measures should focus on helping the most vulnerable people and places reduce their exposure and sensitivity to climate change and improve their capacity to predict, prepare for, and avoid adverse impacts.”

This paper highlights several areas for further study and the improvement of existing knowledge including: bringing climate models to the local scale, incorporating climate change in business location models, exploring impacts on future energy demand and the impacts of HSR and national spatial planning.

The most important step in moving forward with the ideas outlined in this thesis is improving the quantification and understanding of climate risk, to both the firm and the city. Specifically, which companies are at risk and what kind of risks are they exposed to. Insurance organizations will play a fundamental role in this process, but government will have to lead. Government must enable more businesses to develop climate change competencies, such as the detection and interpretation of climate signals, and the development and codification of responses. Legislation mandating certain workplace policies and systems will be required for this to happen, with the OSH (Occupational Safety and Health) Act possibly serving as an interesting template.

Based on the heroic extrapolations in Chapters 6 and 7, it is impossible to conclude that we should downsize Miami and develop Cleveland. Hence, quantifying location risk more precisely would enable proper planning of expensive infrastructure such as HSR. The crux of better location risk

assessments lies with developing better climate models. Once we have a clearer image of what the future holds for different locations, decision makers can begin to make the tough decisions. In the absence of detailed climate models, precautionary and no-regret approaches must be applied, such as directing future growth to more sustainable areas. Ultimately, many of the policies discussed in the last two chapters, require a fundamental reassessment of the distribution of planning and economic development power between local, state and federal authorities.

Appendix

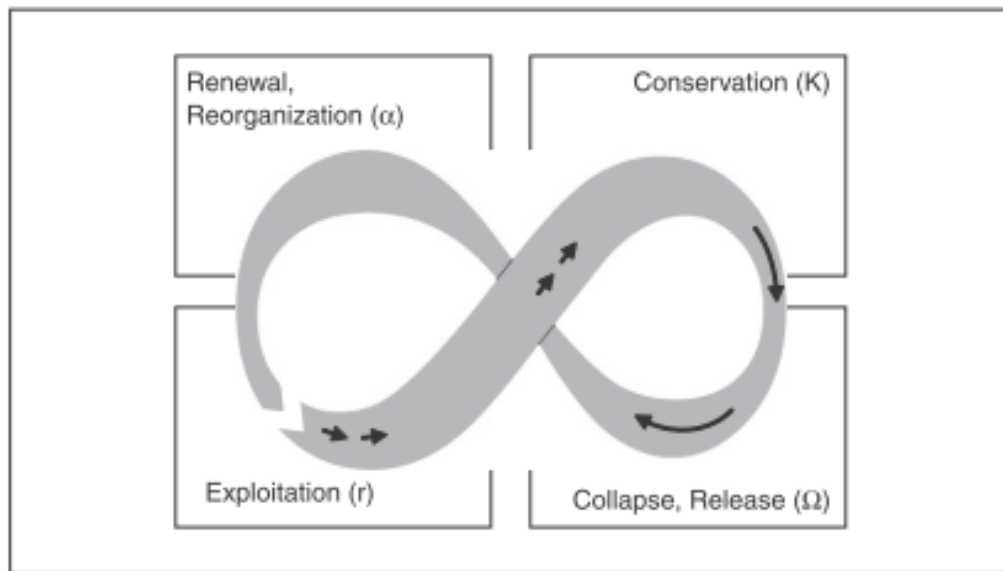


Figure 3a - The Adaptive Cycle Framework
(Linnenluecke and Griffiths 2010, 491).

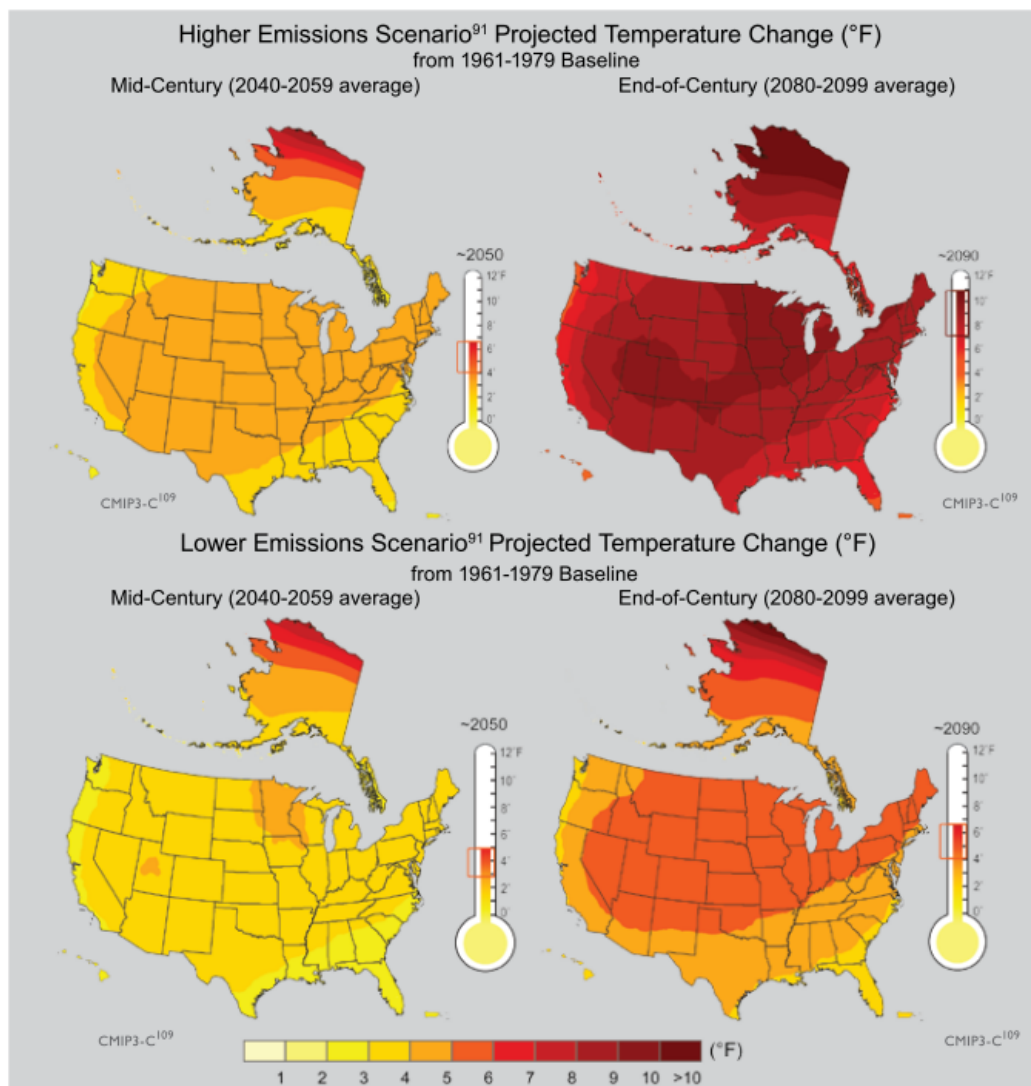


Figure 5a - United States Projected Temperature Changes (USGCRP 2009, 29)

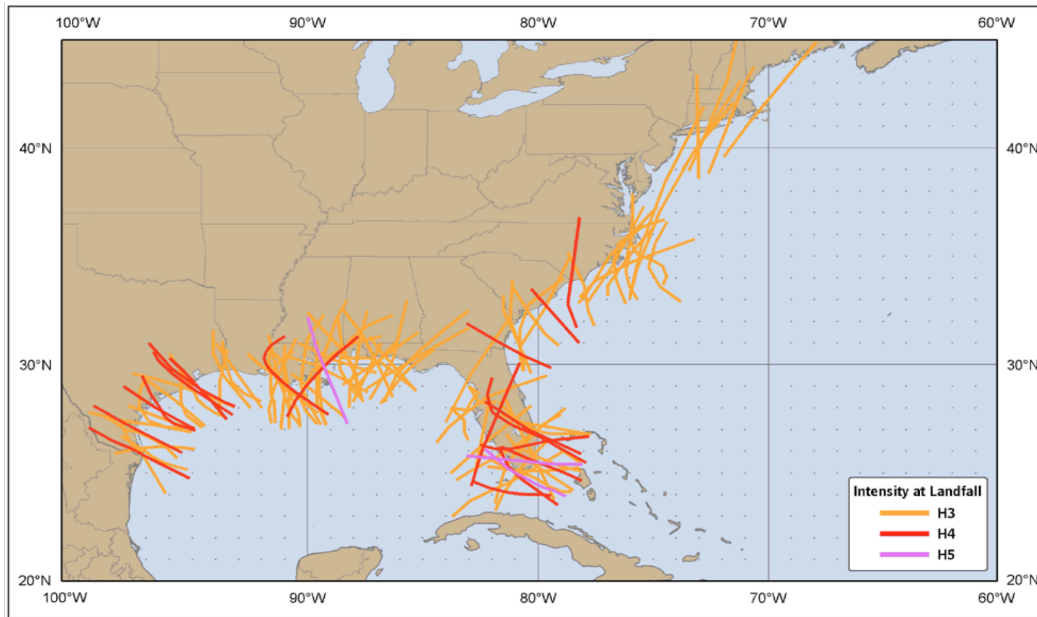


Figure 5b - United States Major Hurricane Strikes (category 3 or higher), 1851- 2010 (National Hurricane Center 2011, 41)

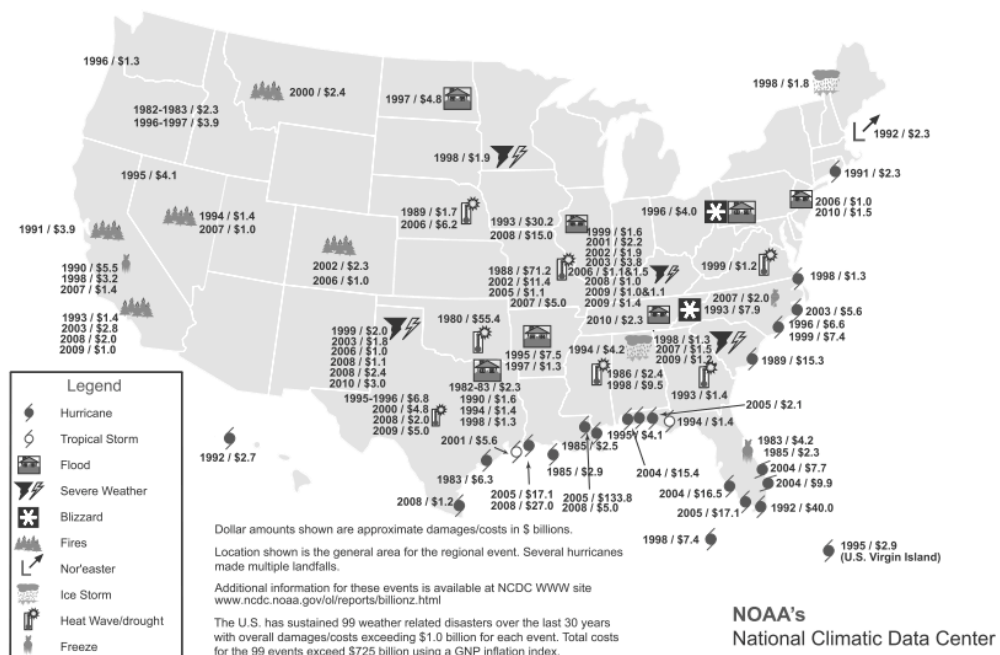


Figure 5c - Billion Dollar Natural Disasters (Ceres 2011, 9)

Region	<100K(%)	100-500K(%)	500K-1M(%)	1-5M(%)	5M+(%)
Africa	9	23	39	50	40
Asia	12	24	37	45	70
Europe	17	22	37	41	58
Latin America	11	25	43	38	50
Australia & New Zealand	44	77	100	100	N/A
North America	9	19	29	25	80
Small island states	51	61	67	100	N/A
World	13	24	38	44	65

Table 5d - Share of Urban Settlements Whose Land intersects the Low Elevation Coastal Zone (LECZ), by urban settlement size, 2000
(Kamal-Chaoui and Robert 2009, 53)

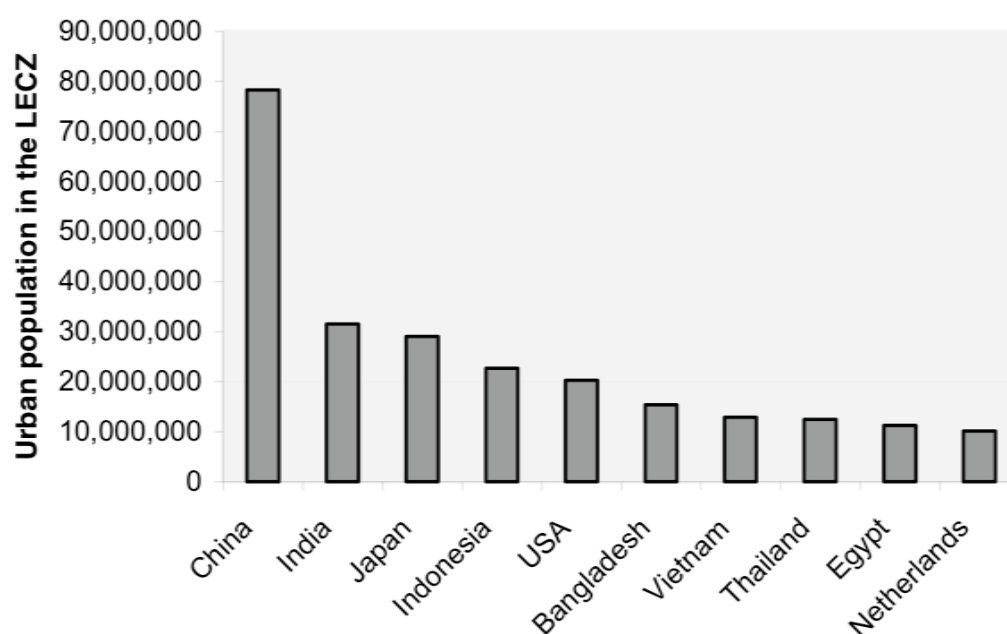


Figure 5d – Countries with Highest Urban Population in LECZ
(Satterthwaite et al. 2007, 22)

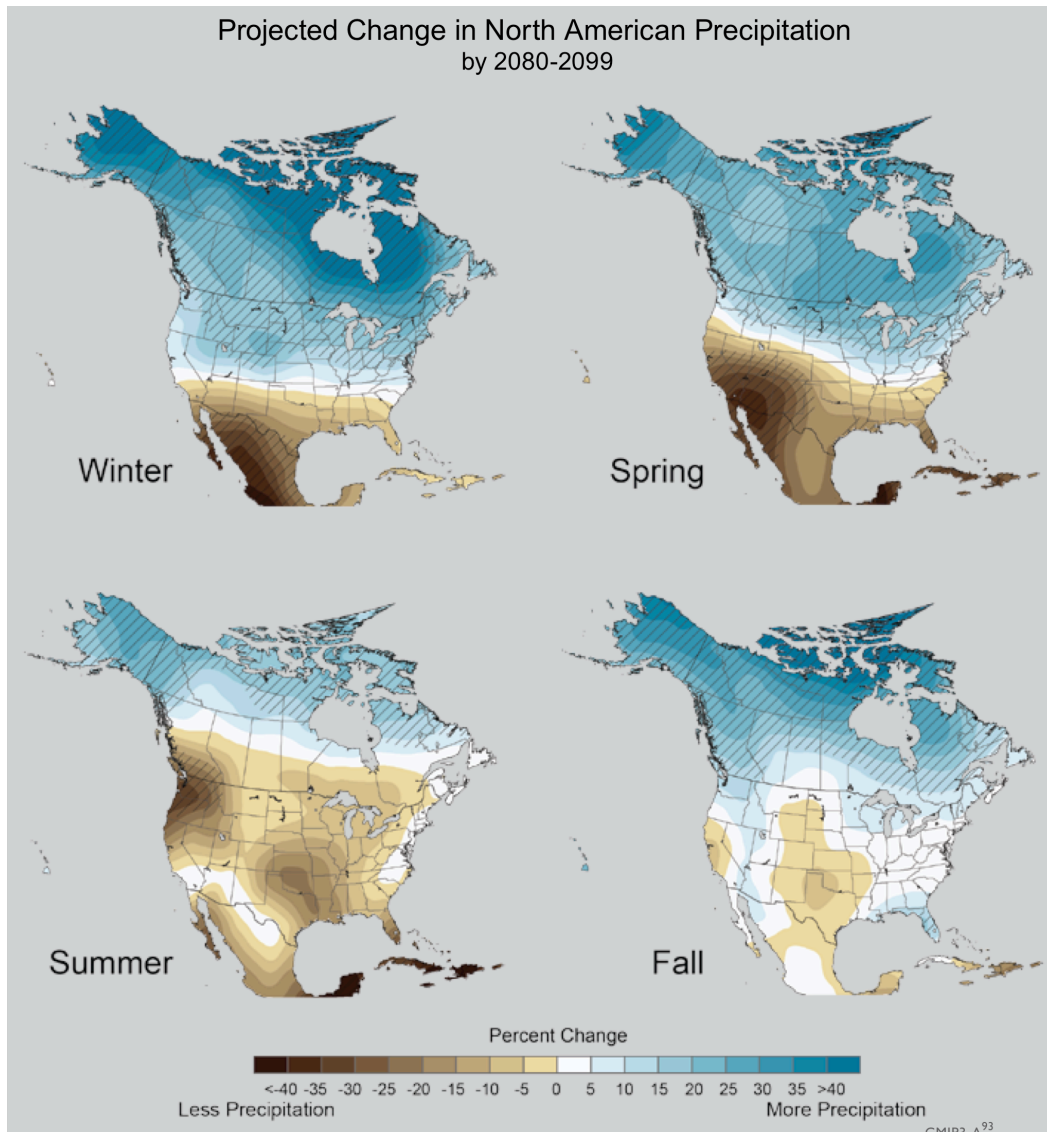


Figure 5e - United States Projected Precipitation Changes (USGCRP 2009, 31)

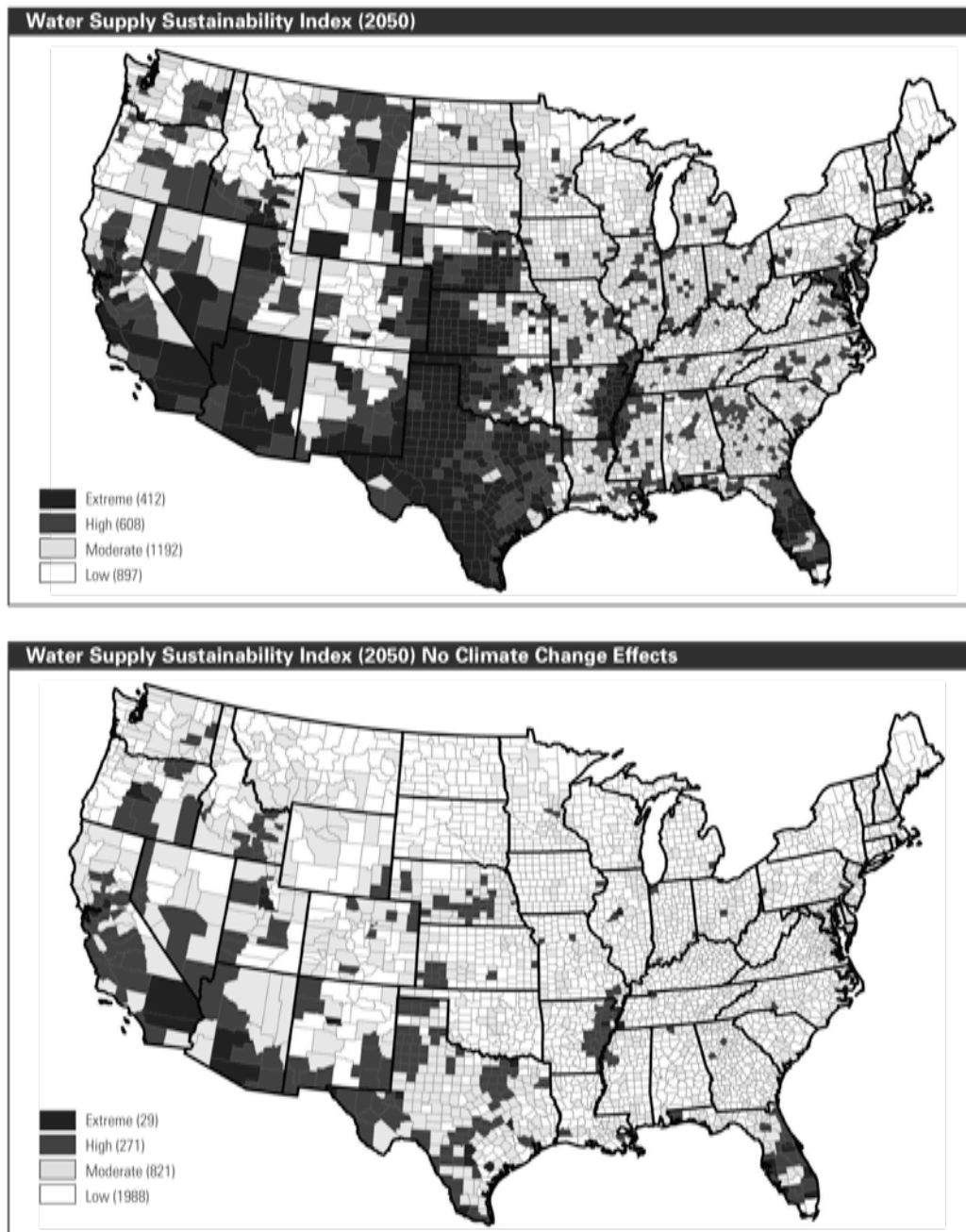


Figure 5f - United States Water Sustainability (NRDC 2010, 3)

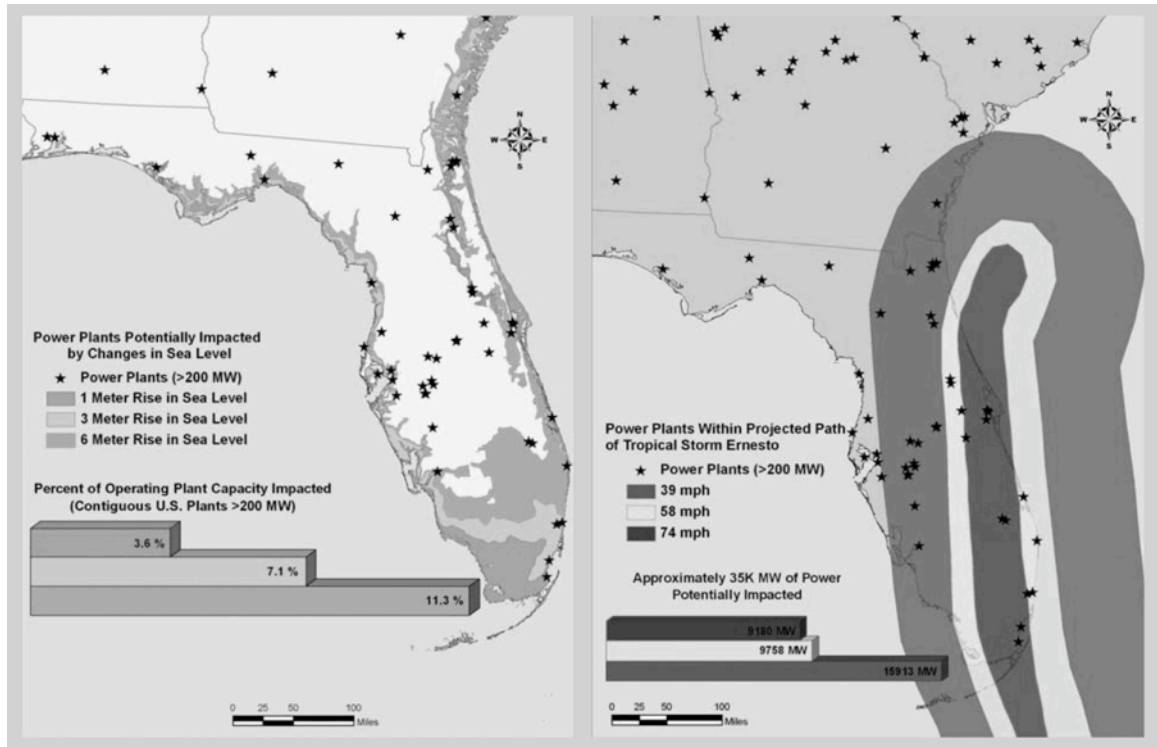


Figure 5g - Power Generation Risk in Florida (USCCSP 2007, 36)

NRDC (Opperman 2011)	Sustainlane (2008)
1 Cleveland	1. Portland, OR
2 Milwaukee	2. San Francisco, CA
3 Detroit	3. Seattle, WA
4 Chicago	4. Chicago, IL
5 Minneapolis	5. New York, NY
6 Indianapolis	6. Boston, MA
7 Atlanta	7. Minneapolis, MN
8 Seattle	8. Philadelphia, PA
9 Nashville	9. Oakland, CA
10 Jacksonville	10. Baltimore, MD
11 Kansas City	11. Denver, CO
12 Omaha	12. Milwaukee, WI
13 Columbus	13. Austin, TX
14 Colorado Springs	14. Sacramento, CA
15 Philadelphia	15. Washington, DC
16 San Francisco	16. Cleveland, OH
16 Oakland	17. Honolulu, HI
18 Portland	18. Albuquerque, NM
19 Long Beach	19. Atlanta, GA
20 New Orleans	20. Kansas City, MO
20 Baltimore	21. San Jose, CA
20 Memphis	22. Tucson, AZ
23 Boston	23. Jacksonville, FL
24 San Antonio	24. Dallas, TX
25 San Diego	25. Omaha, NE
25 Los Angeles	26. San Diego, CA
27 San Jose	27. New Orleans, LA
28 Washington	28. Los Angeles, CA
28 Louisville	29. Louisville, KY
30 New York	30. Columbus, OH
31 El Paso	31. Detroit, MI
32 Charlotte	32. Phoenix, AZ
32 Tulsa	33. San Antonio, TX
34 Honolulu	34. Miami, FL
35 Dallas	35. Charlotte, NC
35 Denver	36. Houston, TX
35 Oklahoma City	37. Fresno, CA
38 Austin	38. El Paso, TX
39 Arlington	39. Fort Worth, TX
40 Virginia Beach	40. Nashville, TN
41 Fresno	41. Arlington, TX
42 Fort Worth	42. Long Beach, CA
43 Tucson	43. Colorado Springs, CO
44 Albuquerque	44. Indianapolis, IN
45 Mesa	45. Virginia Beach, VA
46 Phoenix	46. Memphis, TN
47 Houston	47. Las Vegas, NV
47 Sacramento	48. Tulsa, OK
49 Las Vegas	49. Oklahoma City, OK
50 Miami	50. Mesa, AZ

Table 5e – Climate Resilience and Sustainability Rankings

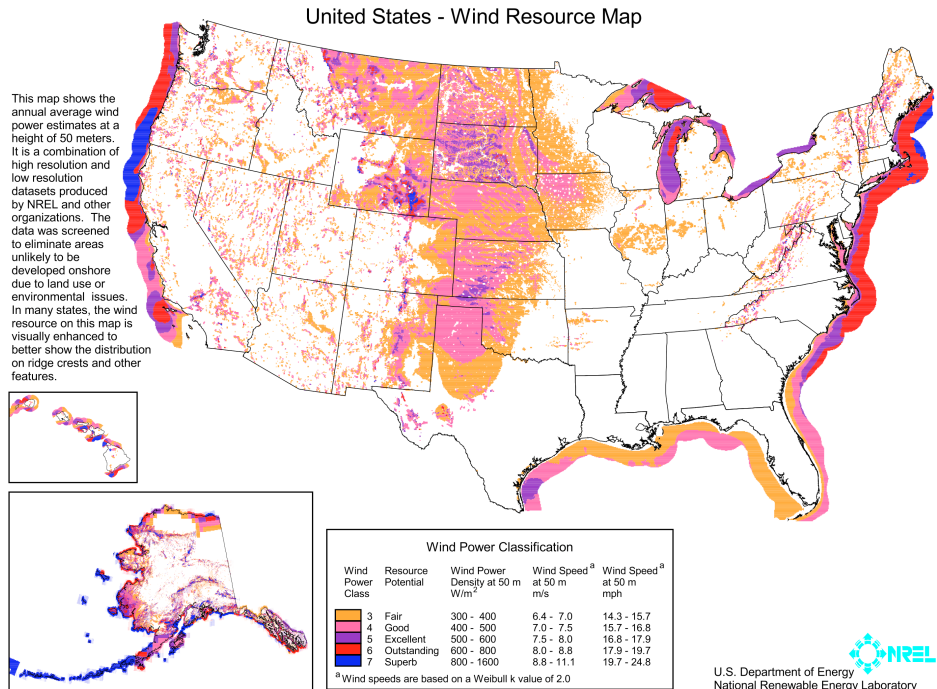


Figure 5h – United States Wind Resource Map
(National Renewable Energy Laboratory 2011a)

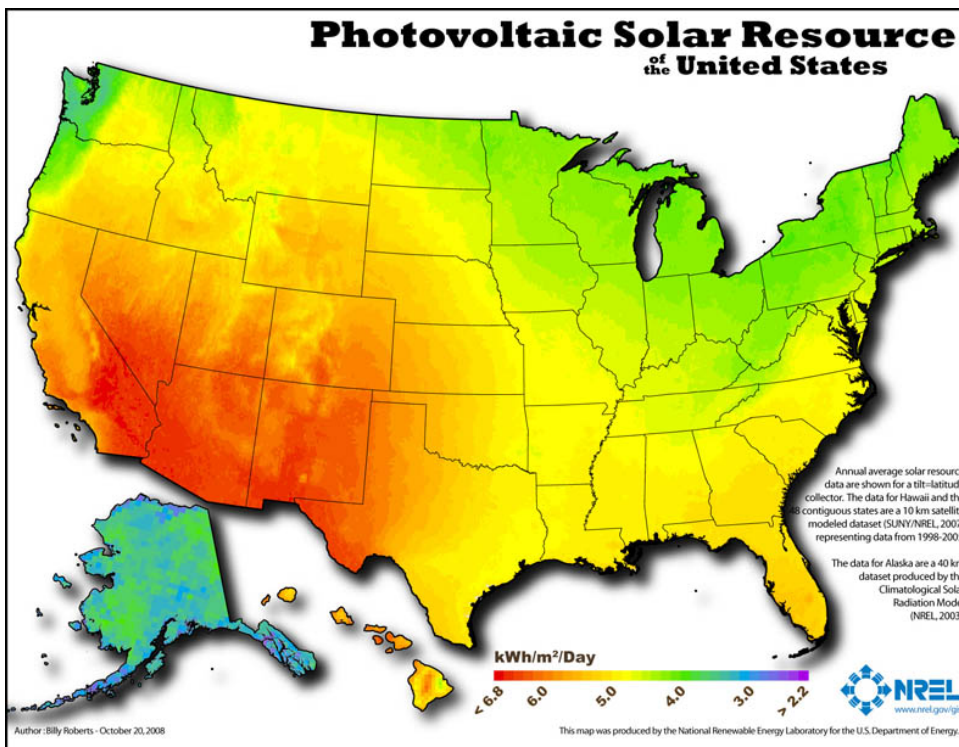


Figure 5i – Photovoltaic Solar Resource of the United States
(National Renewable Energy Laboratory 2011b)

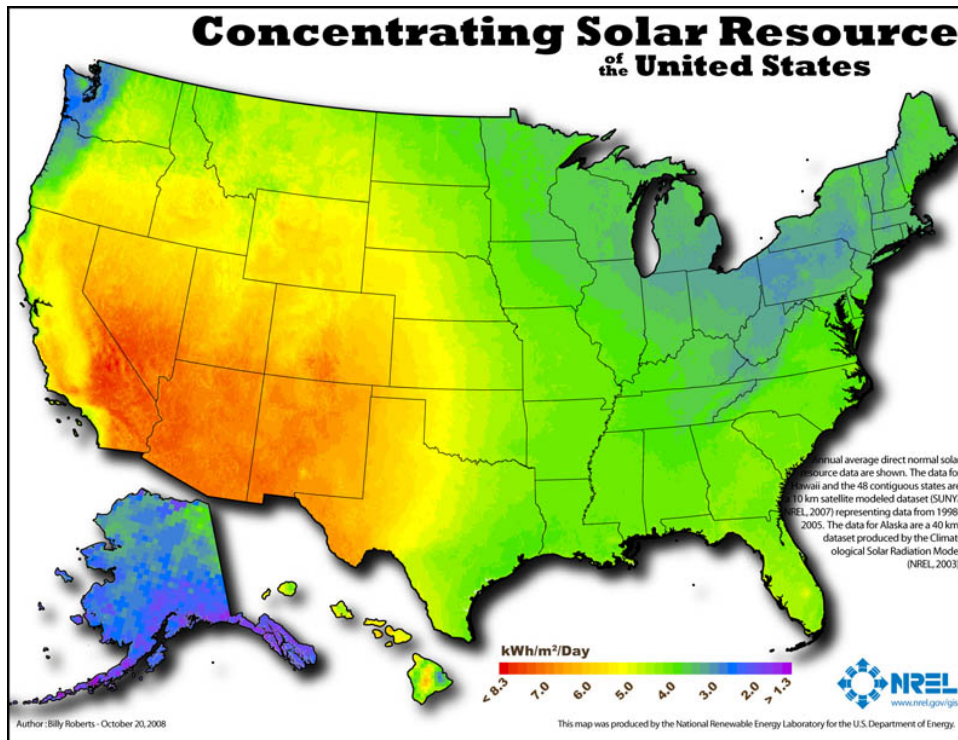


Figure 5j - Concentrating Solar Resource of the United States (National Renewable Energy Laboratory 2011c)

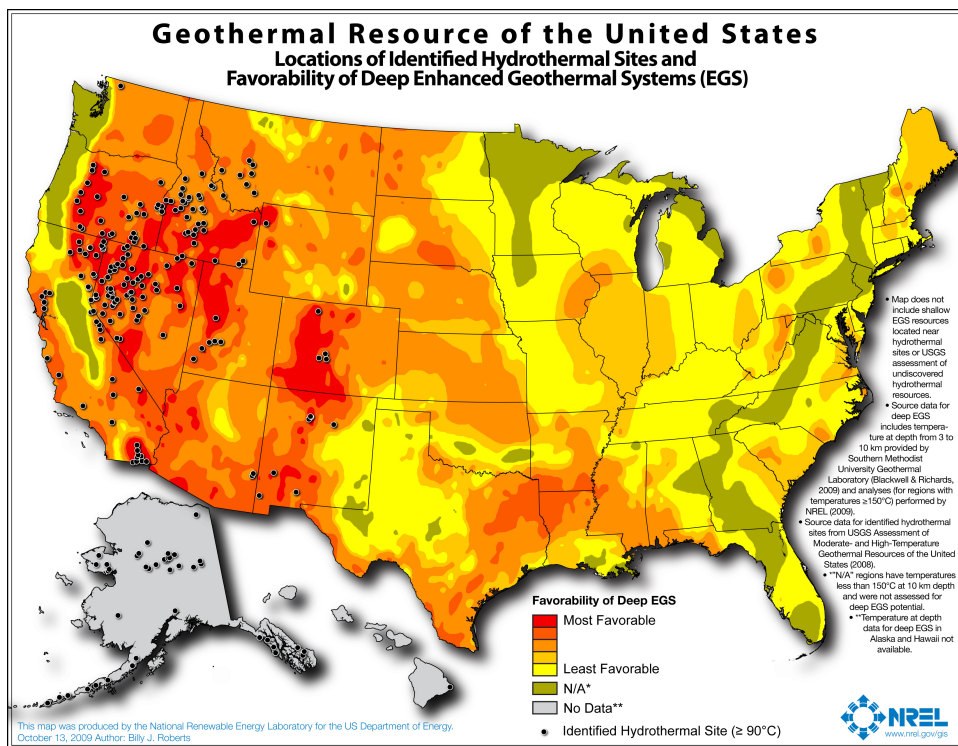


Figure 5k - Geothermal Resource of the United States (National Renewable Energy Laboratory 2011c)

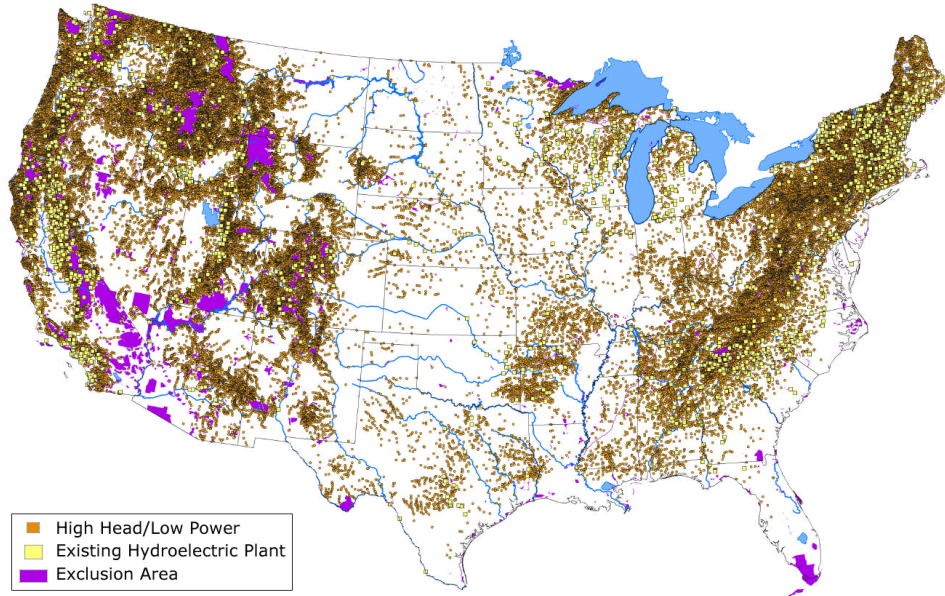


Figure 5m - Water Energy Resources of the United States (National Atlas 2011)

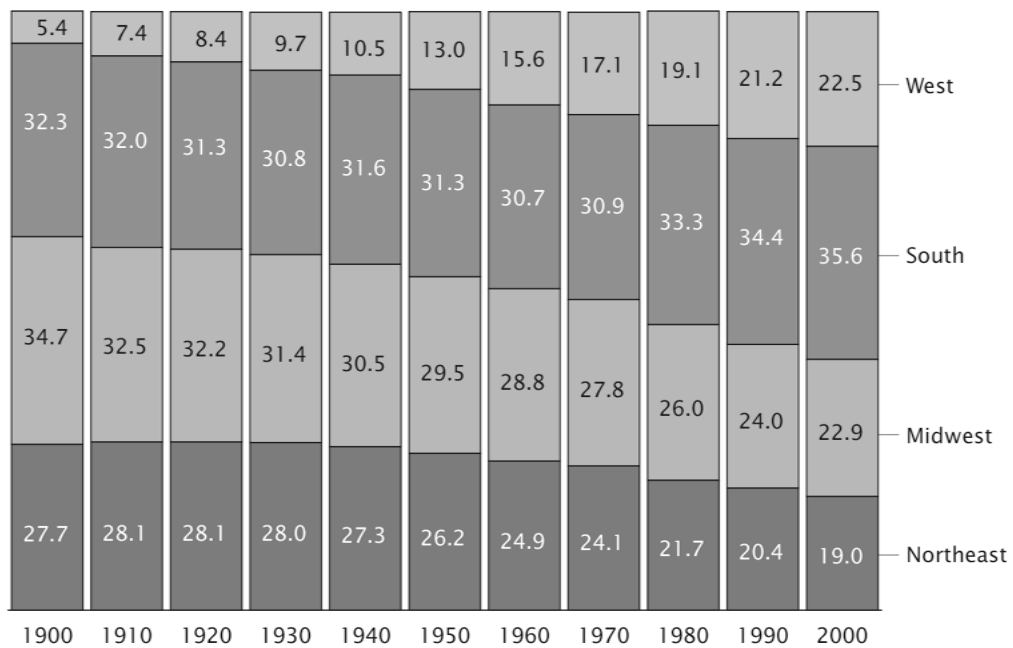


Figure 5p - Percent Population Distribution by Region: 1900 to 2000 (Hobbs and Stoops 2002, 24)

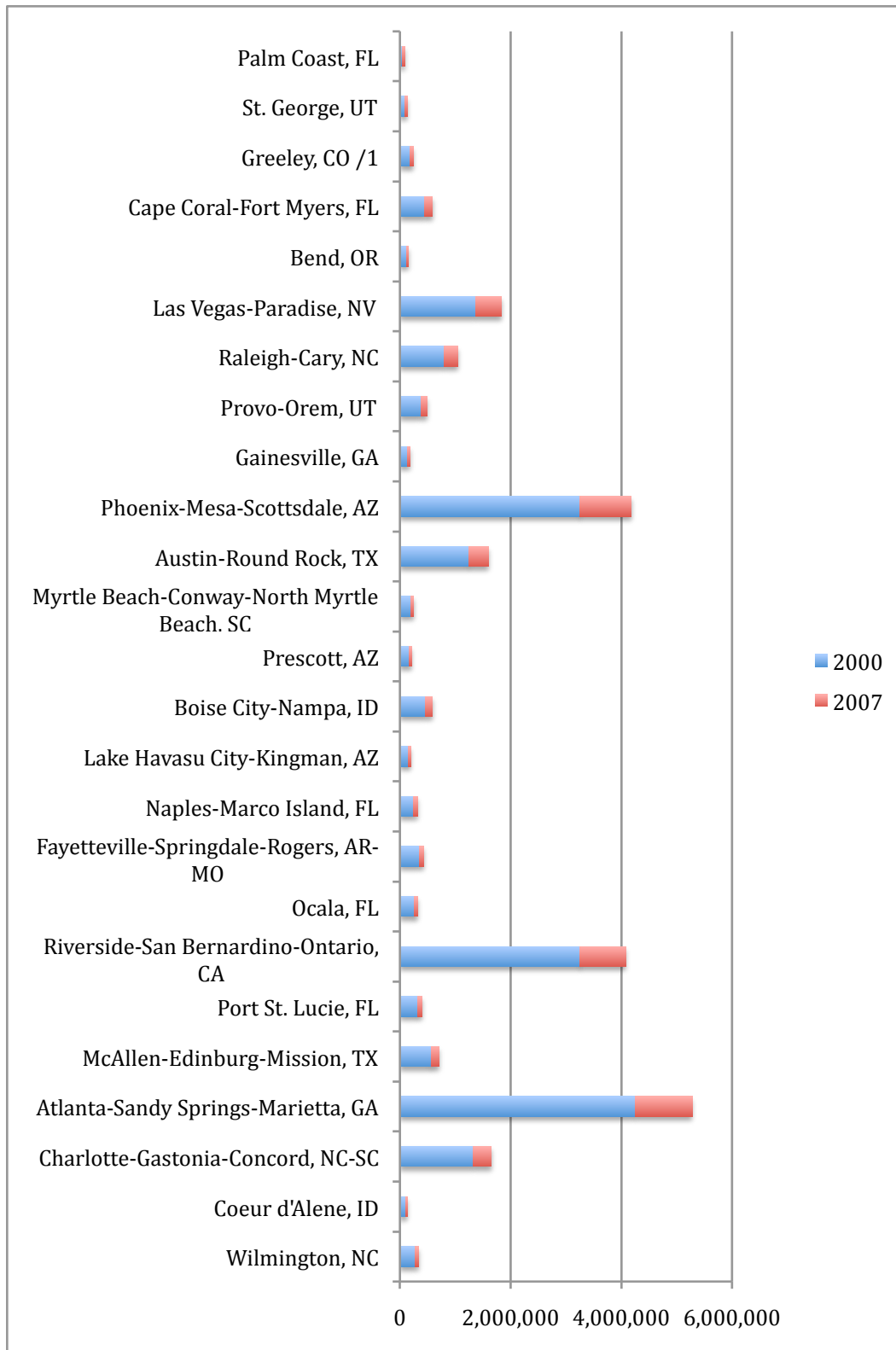


Figure 5q - Top 25 Fastest Growing Cities 2000-2007
(Data from U.S. Census Bureau 2007)

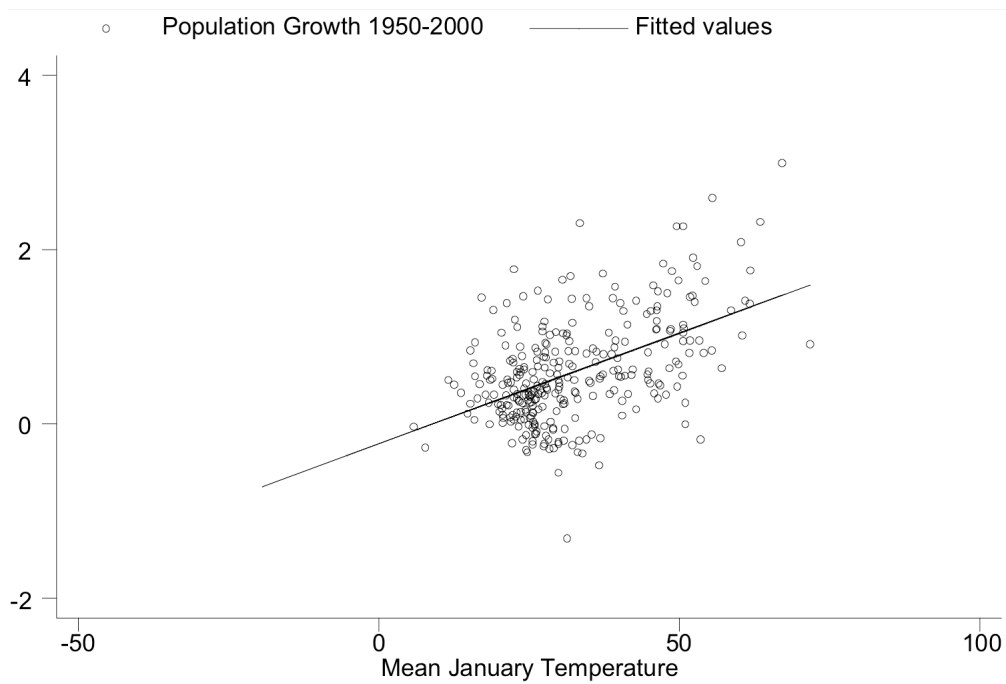
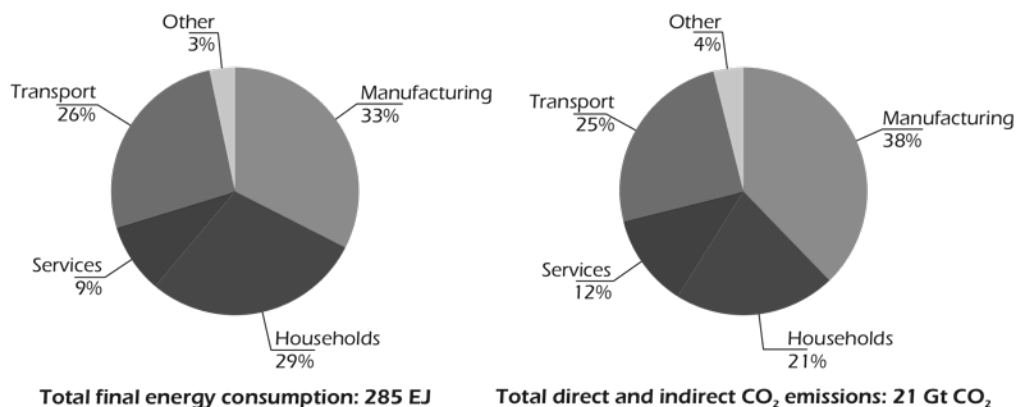


Figure 5r - Population Growth 1950-2000 and January Temperature (Glaeser and Tobio 2007, 40)

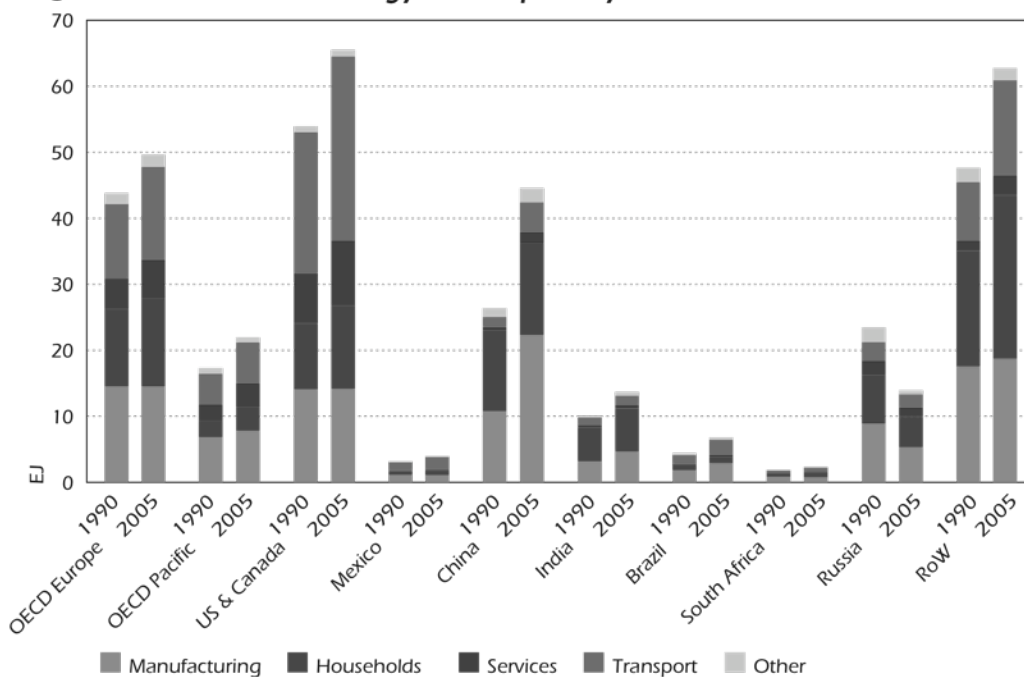
	Billions of 2006 dollars				Percentage of GDP			
	2025	2050	2075	2100	2025	2050	2075	2100
Hurricane Damage	\$10	\$43	\$142	\$422	0.05%	0.12%	0.24%	0.41%
Real Estate Losses	\$34	\$80	\$173	\$360	0.17%	0.23%	0.29%	0.35%
Energy Sector Costs	\$28	\$47	\$82	\$141	0.14%	0.14%	0.14%	0.14%
Water Costs	\$200	\$336	\$565	\$950	1.00%	0.98%	0.95%	0.93%
Total of Four Categories	\$271	\$506	\$961	\$1,873	1.36%	1.47%	1.62%	1.84%

Table 6b - Summary of U.S. damages for Four Impact Areas Under “Business-as-Usual” Scenario (NRDC 2008, 2)



Sources: IEA, 2007c; IEA, 2007d; IEA, 2007e.
Note: Other includes construction and agriculture/fishing.

Figure 2.2 ► **Total Final Energy Consumption by Sector**



Sources: IEA, 2007c; IEA, 2007d; IEA estimates.
Note: Other includes construction and agriculture/fishing.

Figure 6a - Shares of Global Final Energy Consumption and CO₂ Emissions by Sector, 2005 (IEA 2008, 17)

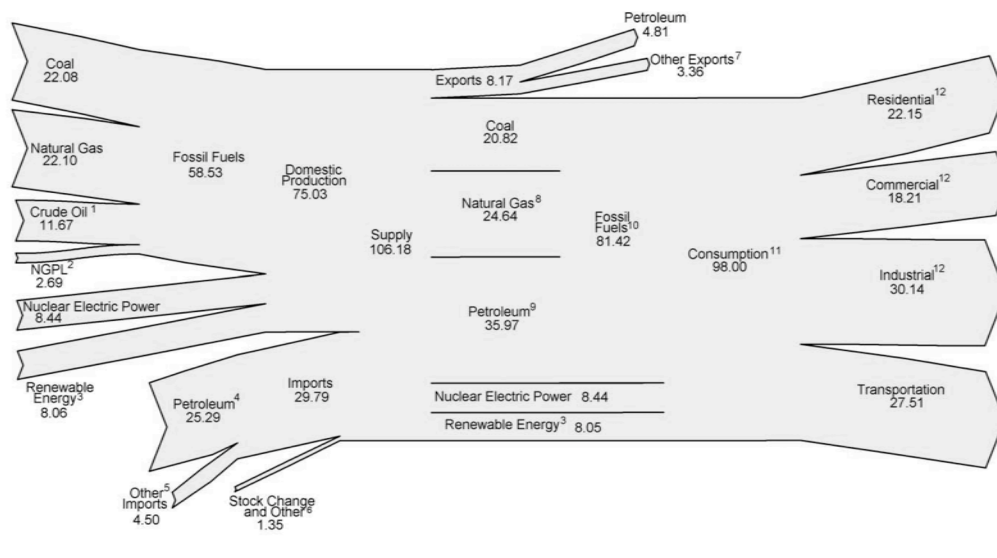


Figure 6b – Total U.S. Energy Flow 2010, Quadrillion Btu (EIA 2010)

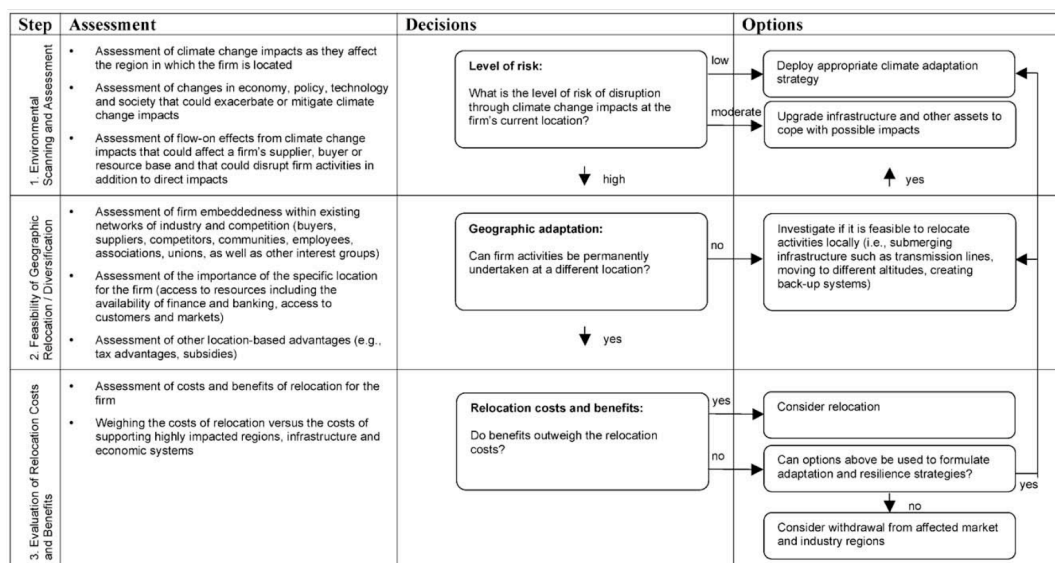


Fig. 1. Decision-making framework for assessing firm relocation due to climate change impacts.

Figure 8b – Decision-making Framework for Assessing Firm Relocation (Linnenluecke, Stathakis and Griffiths 2011, 127)

References

- AECOM. 2010. "An Estimate of the U.S. Population Living in Coastal Flood Hazard Areas," *Carbon Disclosure Project Report 2008, FTSE 350*. Accessed September 20, 2011. http://www.norfma.org/conference/2010/090810_conf/090810/estimate_us_cooling.pdf.
- Akooorie, Michele E.M. 2000. "Organizational Clusters in a Resource Based Industry: Empirical Evidence from New Zealand." In *Industrial Networks and Proximity*, edited by Milford B. Green and Rod B. McNaughton, 133-164. Burlington, VT: Ashgate.
- Aydogan, Neslihan and Yiu Por Chen. 2008. *Social Capital and Business Development in High-Technology Clusters*. New York: Springer.
- Bartik, Timothy J. 1985. "Business Location Decisions in the United States: Estimates of the Effects of Unionization, Taxes, and Other Characteristics of States." *Journal of Business & Economic Statistics* 3:14-22. Accessed May 3, 2011. <http://www.jstor.org/stable/1391685>.
- Baumert, Kevin and Mindy Selman. 2003. "Data Note: Heating and Cooling Degree Days." World Resources Institute. Accessed May 1, 2011. <http://cait.wri.org/downloads/DN-HCDD.pdf>.
- Berkhout, Frans, Julia Hertin and David M. Gann. "Learning to Adapt: Organisational Adaptation to Climate Change Impacts." *Climatic Change* 78-1 (2006): 135-156. Accessed December 8, 2010, doi:10.1007/s10584-006-9089-3.
- Black, Grant. 2004. *The Geography of Small Firm Innovation*. Boston: Kluwer Academic Publishers.
- Blum, Helcio and Jayant Sathaye, 2010. "Quantitative Analysis of the Principal-Agent Problem in Commercial Buildings in the U.S.: Focus on Central Space Heating and Cooling." International Energy Studies Group, Lawrence Berkeley National Laboratory Berkeley, California. Accessed October 31, 2011. http://ees.ead.lbl.gov/bibliography/quantitative_analysis_of_the_principal_agent_problem_in_commercial_buildings_in_the_u_s_focus_on_central_space_heat
- Brewer, Thomas L. 2005. *Industry Location and Climate Change Policy-Making in the United States*. Centre for European Policy Studies, Policy Brief 87. Accessed May 10, 2011. www.ceps.eu/ceps/download/1128.
- Bronowski, Jacob. 1973. *The Ascent of Man*. Boston: Little, Brown and Company.
- Brouwer, Aleid E., Ilaria Mariotti and Jos N. van Ommeren. 2004. "The firm relocation decision: An empirical investigation." *The Annals of Regional Science* 38: 2, June 2004: 335-347. Accessed October 10, 2011. <http://dx.doi.org/10.1007/s00168-004-0198-5>.
- Brown, Lester R. 2006. "Plan B Updates-Global Warming Forcing U.S. Coastal Population to Move Inland: An Estimated 250,000 Katrina Evacuees are Now Climate Refugees." Earth Policy Institute. Accessed May 1, 2011. http://www.earth-policy.org/index.php?plan_b_updates/2006/update57.
- Brown, Oli. 2008. "Migration and Climate Change." *International Organization for Migration* No.31.

Brunnermeier, Smita B. and Arik Levinson. 2004. "Examining the Evidence on Environmental Regulations and Industry Location." *The Journal of Environment & Development* March 2004 13: 6-41. Accessed October 31, 2011. doi:10.1177/1070496503256500.

Buss, Terry F. 2001. "The Effect of State Tax Incentives on Economic Growth and Firm Location Decisions: An Overview of the Literature." *Economic Development Quarterly*, February 2001, 15: 90-105. Accessed October 31, 2011. doi:10.1177/089124240101500108.

Carbon Disclosure Project. 2008. "Building business resilience to inevitable climate change," *Carbon Disclosure Project Report 2008, FTSE 350*. Accessed May 20, 2011. https://www.cdproject.net/CDPResults/65_329_211_Acclimatise_CDP6_FTSE_350_Building_Business_Resilience_HR%20%282%29.pdf.

Cavallo, James. 2008. "Comparing your house to others." Kouba-Cavallo. Accessed May 1, 2011. <http://www.kouba-cavallo.com/bnchmrk.htm>.

[CBO] Congressional Budget Office. 2009. "Potential Impacts of Climate Change in the United States." *Congressional Budget Office*. Accessed June 15, 2011. http://www.cbo.gov/ftpdocs/101xx/doc10107/05-04-ClimateChange_forWeb.pdf

CCSP. 2009. "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*. Accessed September 20, 2011. <http://www.climatechange.gov/Library/sap/sap4-5/final-report/default.htm>.

Cecil, Ben P. and Milford B. Green 2000. "In the Flagships' Wake: Relations, Motivations and Observations of Strategic Alliance Activity Among IT Sector Flagship Firms and Their Partners." In *Industrial Networks and Proximity*, edited by Milford B. Green and Rod B. McNaughton, 165-187. Burlington, VT: Ashgate.

Ceres. 2011. "Climate Risk Disclosure by Insurers: Evaluating Insurer Responses to the NAIC Climate Disclosure Survey." *Ceres*. Accessed September 20, 2011. <http://www.ceres.org/resources/reports/naic-climate-disclosure/view>.

Cohen, Boyd. 2011. "Top 10 Climate Ready Cities." Triplepundit. Accessed October 1, <http://www.triplepundit.com/2011/06/top-10-climate-ready-cities/>. Website

Cohen, Natalie. 2000. *Business Location Decision-Making and the Cities: Bringing the Companies Back*. The Brookings Institution, Center on Urban and Metropolitan Policy. Accessed May 10, 2011. http://www.brookings.edu/~media/Files/rc/reports/2000/05metropolitanpolicy_cohen/cohen.pdf.

Council on Environmental Quality. 2010. *Progress report of the Interagency Climate Change Adaptation Task Force*. [Washington, D.C.]: Interagency Climate Change Adaptation Task Force. <http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>.

Data Center Dynamics. 2011. "Verizon Granted Low Cost Hydroelectric Power for Somerset Data Center." Accessed October 1, <http://www.datacenterdynamics.com/focus/archive/2010/10/verizon-granted-low-cost-hydroelectric-power-for-somerset-data-center>

Degreedays.net. 2010. "Kilowatt meters versus degree days." BizEE. Accessed May 1, 2011. <http://www.degreedays.net/kill-a-watt-meter>.

[ECA] Economics of Climate Adaptation. 2009. "Shaping Climate-Resilient Development: a framework for decision-making." *ClimateWorks Foundation, Global Environment Facility, European Commission, McKinsey & Company, The Rockefeller Foundation, Standard Chartered Bank and Swiss Re*. Accessed September 20, 2011. <http://mckinseysociety.com/shaping-climate-resilient-development/>.

The Economist. 2008. "Down on the Server Farm: The Real-World Implications of the Rise of Internet Computing." *The Economist Magazine*. Accessed September 20, 2011. <http://www.economist.com/node/11413148>.

EIA. 1998. "Manufacturing Industry with Total Consumption of Electricity (trillion Btu)." Accessed September 20, 2011. <http://www.eia.gov/emeu/mecs/mecs98/datatables/contents.html#enduse>.

EIA. 1998a. "Evaluation of Electricity Consumption in the Manufacturing Division" Accessed November 14. <http://www.eia.gov/emeu/mecs/mecs94/ei/elec.html>.

EIA. 2003. "Major Fuel Consumption (Btu) by End Use for All Buildings." Accessed September 20, 2011. http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html#enduse03.

EIA. 2003a. "2003 Commercial Buildings Energy Consumption Survey—Overview of Commercial Buildings Characteristics." Accessed November 14. <http://www.eia.gov/emeu/cbecs/cbecs2003/introduction.html>.

EIA. 2003b. "U. S. Climate Zones for 2003 CBECS." Accessed November 14. http://www.eia.gov/emeu/cbecs/climate_zones.html.

EIA. 2006. "Manufacturing Energy Consumption for All Purposes, 2006." Accessed September 20, 2011. <http://www.eia.gov/totalenergy/data/annual/index.cfm#consumption>.

EIA. 2006a. "Manufacturing Energy Consumption for Heat, Power, and Electricity Generation by End Use, 2006." Accessed September 20, 2011. <http://www.eia.gov/totalenergy/data/annual/index.cfm#consumption>.

EIA. 2010. "Total Energy Flow 2010." Accessed September 20, 2011. <http://www.eia.gov/totalenergy/data/annual/diagram1.cfm>.

EIA. 2011. "Voluntary Reporting of Greenhouse Gases Program Fuel Emission Coefficients." Accessed November 14. <http://www.eia.gov/oiaf/1605/coefficients.html>.

EIA. 2011a. "eGRID2010 Version 1.1 Year 2007 Summary Tables." Accessed November 14. http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_1_year07_SummaryTables.pdf.

Encyclopedia Britannica. 2011a. "Johann Heinrich von Thunen." Accessed September 1, 2011. <http://www.britannica.com.ezproxy.library.tufts.edu/EBchecked/topic/594381/Johann-Heinrich-von-Thunen>.

- Encyclopedia Britannica. 2011b. "Location Theory." Accessed September 1, 2011.
<http://www.britannica.com.ezproxy.library.tufts.edu/EBchecked/topic/345682/location-theory>
- Energylens.com. 2010. "Degree Days; Handle with care." BizEE. Accessed May 1, 2011.
<http://www.energylens.com/articles/degree-days>.
- Entergy. 2010. "Building a Resilient Energy Gulf Coast: Executive Report." *Entergy*. Accessed September 20, 2011.
http://entergy.com/content/our_community/environment/GulfCoastAdaptation/Building_a_Resilient_Gulf_Coast.pdf
- EPA. 2011. "2011 U.S. Greenhouse Gas Inventory Report." *United States Environmental Protection Agency*. Accessed September 20, 2011.
<http://epa.gov/climatechange/emissions/usinventoryreport.html>.
- European Environment Agency. 2010. "EU-15 CO2 emissions from households compared with the number of permanently occupied dwellings, heating degree days and share of households in total GHG emissions," European Environment Agency. Accessed May 1, 2011.
<http://www.eea.europa.eu/data-and-maps/figures/eu-15-co2-emissions-from-households-compared-with-the-number-of-permanently-occupied-dwellings-heating-degree-days-and-share-of-households-in-total-ghg-emissions>.
- Foresight. 2011. "International Dimensions of Climate Change." *The Government Office for Science, London*. Accessed September 20, 2011.
<http://www.bis.gov.uk/foresight/our-work/projects/published-projects/international-dimensions-of-climate-change/reports-and-publications>.
- Forfas. 2010. "Adaptation to Climate Change: Issues for Business," Forfas August 2010. Accessed May 10, 2011.
<http://www.forfas.ie/media/Adaptation%20to%20Climate%20Change%20Summary%20Report%20ONLINE%20FINAL.pdf>.
- Gabe, T. M. and K. P. Bell. 2004. "Tradeoffs between Local Taxes and Government Spending as Determinants of Business Location." *Journal of Regional Science* 44: 21–41. Accessed May 10, 2011. doi: 10.1111/j.1085-9489.2004.00326.x.
- Galbreath, Jeremy. 2010. Corporate governance practices that address climate change: an exploratory study. *Business Strategy and the Environment* 19, no. 5, (July 1): 335-350. Accessed January 26, 2011. doi: 10.1002/bse.648.
- Glaeser, Edward L. and Kristina Tobio. 2007. "The Rise of the Sunbelt." Harvard Institute of Economic Research, Discussion Paper Number 2135, April 2007. Accessed October 31, 2011
<http://www.economics.harvard.edu/journals/hier2007>.
- Google. 2011. "Data Centers." Accessed September 20, 2011.
<http://www.google.com/green/the-big-picture.html#/datacenters/infographics>
- The Guardian. 2011. "World's First Zero-Carbon Data Centre to be Built in Iceland." September 26, 2011.
<http://www.guardian.co.uk/business/2011/sep/26/worlds-first-zero-carbon-data-centre>.
- The Guardian. 2011b. "Facebook builds 'green' datacentre in Sweden." 27 October 27, 2011.
<http://www.guardian.co.uk/environment/2011/oct/27/facebook-green-datacentre-sweden-renewables?newsfeed=true>.

- Guimarães, P., O. Figueiredo and D. Woodward. 2004. "Industrial Location Modeling: Extending the Random Utility Framework." *Journal of Regional Science* 44:1–20. Accessed May 10, 2011. doi: 10.1111/j.1085-9489.2004.00325.x.
- Haas, Peter. 2010. "Transit oriented development and the potential for VMT-related greenhouse gas emissions growth reduction." Accessed May 1. Center for Transit Oriented Development. <http://www.cnt.org/repository/TOD-Potential-GHG-Emissions-Growth.FINAL.pdf>.
- Hobbs, Frank, and Nicole Stoops. 2002. *Demographic trends in the 20th century*. Washington, D.C.: U.S. Census Bureau. Accessed October 31, 2011. www.census.gov/prod/2002pubs/censr-4.pdf.
- Hollander, Justin B. 2011. *Sunburnt Cities : the great recession, depopulation, and urban planning in the American Sunbelt* Routledge New York
- Hugo, Graeme. 2008. "Migration, Development and Environment." *International Organization for Migration* No.35.
- IEA. 2007. "Tracking Industrial Energy Efficiency and CO2 Emissions." Accessed September 20, 2011. http://www.iea.org/textbase/nppdf/free/2007/tracking_emissions.pdf.
- IEA. 2008. "Worldwide Trends in Energy Use and Efficiency: Key Insights from IEA Indicator Analysis." Accessed September 20, 2011. www.iea.org/papers/2008/indicators_2008.pdf
- IEA. 2011. "CO2 from Fuel Combustion Highlights." Accessed October 20, 2011. www.iea.org/co2highlights/co2highlights.pdf.
- IPCC. 2007a. "Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change." Accessed May 1. http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html.
- IPCC. 2007b. "Assessing key vulnerabilities and the risk from climate change. Climate Change 2007: Impacts, Adaptation and Vulnerability." Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 779-810.
- Johnson, Jerry D. and Raymond Rasker. 1995. "The role of economic and quality of life values in rural business location." *Journal of Rural Studies* 11(4):405-416. Accessed May 10, 2011. doi: 10.1016/0743-0167(95)00029-1.
- Kahn Matthew E. and Erin T. Mansur. 2011. "Do Local Energy Prices and Regulation Affect the Geographic Concentration of Employment? A Border Pairs Approach." NBER Working Paper 16538 and Energy Institute at Haas Working Paper-209. Accessed November 14. http://www.dartmouth.edu/~mansur/papers/kahn_mansur_manufacturing.pdf.
- Kalkman, Jaap, Laurent Nordin and Ahmed Yahia. 2007. *Moving Energy Intensive Industries to the Gulf*. McKinsey & Company, The McKinsey Quarterly. Accessed May 10, 2011. https://www.mckinseyquarterly.com/Moving_energy-intensive_industries_to_the_Gulf_1921.

- Kamal-Chaoui, Lami0a and Alexis Robert. 2009. "Competitive Cities and Climate Change." *OECD Regional Development Working Papers N° 2, 2009*, OECD publishing. Accessed August 10, 2011. www.oecd.org/dataoecd/30/36/44232251.pdf.
- Karakaya, Fahri and Cem Canel. 1998. Underlying dimensions of business location decisions. *Industrial Management + Data Systems* 98, (7): 321-329, <http://search.proquest.com/docview/234920824?accountid=14434> (accessed May 30, 2011).
- Klein, R.J.T., et al. 2007. "Inter-relationships between adaptation and mitigation. Climate Change 2007: Impacts, Adaptation and Vulnerability." *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC Secretariat.
- Kniveton, Dominic. 2008. "Climate Change and Migration: Improving Methodologies to Estimate Flows," *International Organization for Migration* No.33.
- Kolk, Ans and Jonatan Pinske. 2010. "Challenges and Trade-Offs in Corporate Innovation for Climate Change." *Business Strategy and the Environment* 19:261-272.
- Kolko, Jed and David Neumark. 2007. *Patterns and Trends in the Location Decisions of California Businesses*. Public Policy Institute of California, Research Brief 118. Accessed May 10, 2011. http://www.ppic.org/content/pubs/rb/RB_1107JKRB.pdf.
- Kolmannskog, Vikram Odedra. 2008. "Future Floods of Refugees; A comment on climate change, conflict and forced migration," *Norwegian Refugee Council*.
- KPMG. 2008. "Climate Changes Your Business." Accessed August 10, 2011. <http://www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/Climate-changes-your-business.pdf>
- Lee, Boyoung, Lin Liu and Howard A. Stafford. 2000. "Industrial Districts: Measuring Local Linkages." In *Industrial Networks and Proximity*, edited by Milford B. Green and Rod B. McNaughton, 87-104. Burlington, VT: Ashgate.
- Linnenluecke, Martina. and Andrew Griffiths. 2010. "Beyond Adaptation: Resilience for Business in Light of Climate Change and Weather Extremes." *Business and Society* 49, no. 3, (September 1): 477-511. Accessed February 9, 2011. doi: 10.1177/0007650310368814.
- Linnenluecke, Martina K. and Alexander Stathakis. "Firm Relocation as Adaptive Response to Climate Change and Weather Extremes." *Global Environmental Change* 21, Issue 1, February 2011: 123-133, ISSN 0959-3780, 10.1016/j.gloenvcha.2010.09.010. (<http://www.sciencedirect.com/science/article/pii/S0959378010000944>)
- Logan, John R., and Harvey Lusk Molotch. 1987. *Urban fortunes: the political economy of place*. Berkeley, CA: University of California Press.
- Longino Jr., Charles F. et al. 2008. "Predictors of Non-Local Moves Among Older Adults: A Prospective Study." *Journal of Gerontology* 63b. No. 1: S7-S14.
- Lovelock, James. *The Vanishing Face of Gaia*. 2009. New York: Basic Books.
- Maplecroft. 2011. "Climate Change Vulnerability Index 2012." Accessed October 28, 2011. <http://maplecroft.com/themes/cc/>.

- Marsh. 2006. "Climate Change: Business Risks and Solutions." Climate Change Volume V, Issue 2, April 2006. Accessed October 28, 2011. [.solutions.marsh.com/climate/documents/climateChange200604.pdf](http://solutions.marsh.com/climate/documents/climateChange200604.pdf).
- McHugh, Kevin E. and Robert C. Mings. 1996. "The Circle of Migration: Attachment to Place in Aging," *Annals of the Association of American Geographers* 86, No. 3: 530-550.
- McKinsey. 2007. "How companies think about climate change: A McKinsey Global Survey." The McKinsey Quarterly, December. Accessed May 1, 2011. <https://www.mckinseyquarterly.com/PDFDownload.aspx?ar=2099>.
- McNaughton, Rod B. 2000. "Industrial Districts and Social Capital." In *Industrial Networks and Proximity*, edited by Milford B. Green and Rod B. McNaughton, 69-85. Burlington, VT: Ashgate.
- The Met Office. 2010. *Evidence: The state of the climate*. Edited by Vicky Pope, Lizzie Kendon, Jason Lowe, Fiona Carroll, Sarah Tempest. Accessed May 1, 2011. <http://www.metoffice.gov.uk/climate-change/policy-relevant/evidence>.
- National Atlas. 2011. Water Energy Resources of the United States. Accessed October 28, 2011. http://nationalatlas.gov/articles/people/a_energy.html.
- National Renewable Energy Laboratory. 2011a. United States Wind Resource Map. Accessed October 28, 2011. <http://www.nrel.gov/gis/wind.html>.
- National Renewable Energy Laboratory. 2011b. Photovoltaic Solar Resources of the United States. Accessed October 28, 2011. <http://www.nrel.gov/gis/solar.html>.
- National Renewable Energy Laboratory. 2011c. Concentrating Solar Resources of the United States. Accessed October 28, 2011. <http://www.nrel.gov/gis/solar.html>.
- National Renewable Energy Laboratory. 2011d. Geothermal Resources of the United States. Accessed October 28, 2011. <http://www.nrel.gov/gis/geothermal.html>.
- National Research Council. 1999. *Human Dimensions of Global Environmental Change-Research Pathways for the Next Decade*. Washington D.C.: National Academy Press.
- NCDC, 2011 National Climate Data Center U.S. Department of Commerce. "Three Year Average Daily Temperatures for Miami, FL GSOD ID 72202012839 and Cleveland, OH GSOD ID 72524014820." Accessed November 11, 2011. <http://www7.ncdc.noaa.gov/CDO/cdo>.
- New Energy Watch. "Pre-Calculated Energy Savings." New Energy Watch. Accessed May 1, 2011. http://www.newenergywatch.com/precaculated_energy_savings.html.
- NHC. 2011. "The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2010 (and other frequently requested hurricane facts." *NCDC Asheville, National Weather Service and National Hurricane Center*. Accessed October 20, 2011. <http://www.nhc.noaa.gov/pdf/nws-nhc-6.pdf>.
- Nicholls, R. J. et al. 2008. "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates." *OECD Environment Working Papers, No. 1*, OECD Publishing. Accessed September 20, 2011. <http://dx.doi.org/10.1787/011766488208>.
- [NOAA] National Oceanic and Atmospheric Administration. 2011. "Trends in Atmospheric Carbon Dioxide – Recent Global Monthly Mean CO₂." Accessed May 15. <http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html>.

- [NRDC] Natural Resources Defense Council. 2008. "The Cost of Climate Change." Natural Resources Defense Council. Accessed September 1, 2011. <http://www.nrdc.org/globalwarming/cost/cost.pdf>.
- NRDC. 2010. "Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable." NRDC. Accessed September 1, 2011. <http://www.nrdc.org/globalwarming/watersustainability/index.asp>.
- NRDC. 2010b. "Smarter Cities." Accessed September 1, 2011. <http://smartercities.nrdc.org/maps-2010/large>
- Okereke, Chukwumerije and Duncan Russel. 2010. "Regulatory Pressure and Competitive Dynamics: Carbon Management Strategies of UK Energy Intensive Companies." *California Management Review* 52, NO. 4, Summer 2010.
- Opperman, Jeff. 2011. "Climate Change Resilient Cities." *The Nature Conservancy*. Accessed September 1, 2011. <http://blog.nature.org/2011/06/cities-climate-change-resilient-jeff-opperman-vulnerable/>.
- Pellenbarg, Piet H., Leo J.G. van Wissen and Jouke van Dijk. 2002. "Firm Migration." In *Industrial Location Economics*, edited by Philip McCann, 110-148. Northampton, MA: Edward Elgar Publishing.
- Pinkse, Jonatan and Kolk, Ans. 2010. "Challenges and Trade-Offs in Corporate Innovation for Climate Change." *Business Strategy and the Environment* 19:261-272.
- Presidential Executive Order 13514. 2009. "Federal Leadership in Environmental, Energy, and Economic Performance." Accessed November 14. http://www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf.
- Redefining Progress. 2010. "Calculating Fossil Fuel Footprints." Redefining Progress. Accessed May 1, 2011. http://www.rprogress.org/energyfootprint/energy_footprint/?id=1b.
- Ronderos, L. Nicolas. 2009. "Spatial Strategies for U.S. Economic Development." Discussion paper for America 2050 - New Strategies for Regional Economic Development Research Seminar, Healdsburg, California – March 29-31, 2009.
- Ruostenoja, Kimmo, Timothy R. Carter, Kirsti Jylhä and Heikki Tuomenvirta, 2003. "Future Climate in World Regions: An Intercomparison of Model-Based Projections for the New IPCC Emissions Scenarios." Finnish Environment Institute, Helsinki. Accessed November 1. www.ipcc-data.org/sres/scatter_plots/scatter_plot_report.pdf.
- Santer, B.D. and Wigley, T.M.L. 2010. "Progress in Detection and Attribution Research." In *Climate Change Science and Policy*, edited by Schneider, Stephen Henry, Armin Rosencranz, Michael D. Mastrandrea, and Kristin Kuntz-Duriseti, 28-43. Washington DC: Island Press.
- Satterthwaite, David, Saleemul Huq, Mark Pelling, Hannah Reid and Patricia Romero Lankao. 2007. "Adapting to Climate Change in Urban Areas: The possibilities and constraints in low- and middle-income nations." *International Institute for Development and Environment*. Accessed September 1, 2011. <http://pubs.iied.org/pdfs/10549IIED.pdf>

Schwartz, Dafna, Joseph Pelzman and Michael Keren. 2008. "The Ineffectiveness of Location Incentive Programs: Evidence From Puerto Rico and Israel." *Economic Development Quarterly* 22, 2:167-179 10.1177/0891242408314100.

Seijas, Natacha, Susanne M. Torriente, Nichole L. Hefty, and Melissa Stults K. Otto-Zimmermann. 2010. "Preparing for Climate Change While Advancing Local Sustainability: A Closer Look at Miami-Dade County, Florida, USA." *Resilient Cities: Cities and Adaptation to Climate Change Proceedings of the Global Forum 2010*, Local Sustainability 1, Chapter 50. Accessed October 1, 2011. DOI 10.1007/978-94-007-0785-6_50.

Shadbegian, Ronald and Ann Wolverton. 2010. "Location Decisions of U.S. Polluting Plants: Theory, Empirical Evidence, and Consequences", *International Review of Environmental and Resource Economics*: Vol. 4:No 1, pp 1-49. <http://dx.doi.org/10.1561/101.000000029>

Shim, Jae K., and Joel G. Siegel. 1999. *Operations management*. Hauppauge, NY: Barron's Educational Series.

Smith, Stanley K. and Mark House. 2006. "Snowbirds, Sunbirds, and Stayers: Seasonal Migration of Elderly Adults in Florida." *Journal of Gerontology* 61b, No. 5: S232-S239.

Steiner, Michael. 2002. "Clusters and networks: institutional settings and strategic perspectives." In *Industrial Location Economics*, edited by Philip McCann, 207-221. Northampton, MA: Edward Elgar Publishing.

Stern, Nicholas. 2006a. *The Economics of Climate Change: Executive Summary*. New York: Cambridge University Press. http://webarchive.nationalarchives.gov.uk/+http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

Stern, Nicholas. 2006b. *The Economics of Climate Change*. New York: Cambridge University Press.

Sussman, Frances G. and J. Randall Freed. 2008. "Adapting to Climate Change: A Business Approach," *Pew Center on Global Climate Change*. Accessed February 28, 2011. <http://www.pewclimate.org/docUploads/Business-Adaptation.pdf>.

Sustainlane. 2008. "2008 U.S. City Rankings." Accessed October 1, 2011. <http://www.sustainlane.com/us-city-rankings/>.

Terra Pass. 2011. "Carbon Footprint Calculator." Terra Pass. Accessed May 1, 2011. <http://www.terrapass.com/carbon-footprint-calculator/#air>.

Ugo, Joseph R. 1995. *Willa Cather and the Myth of American Migration*. Chicago: University of Illinois Press.

U.S. Census Bureau. 2007. "Cumulative Estimates of Population Change for Metropolitan Statistical Areas and Rankings: April 1, 2000 to July 1, 2007." Accessed October 20, 2011. <http://www.census.gov/popest/metro/CBSA-est2007-pop-chg.html>.

UK Environment Agency. 2005. "The Climate is Changing; Time to Get Ready." Accessed October 1, 2011. www.direct.gov.uk/prod_consum_dg/groups/.../dg_073021.pdf.

United Nations Development Program. 2011. "Preparing Low-Emission Climate-Resilient Development Strategies." A UNDP Guidebook — Version 1 EXECUTIVE SUMMARY. Accessed October 20.

<http://www.beta.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/environmental-finance/low-emission-climate-resilient-development/in-focus/preparing-lecrds---executive-summary/UNDP-Guidebook-v16-web.pdf>.

[USGCRP] United States Global Change Research Program. 2009. "Global Climate Change Impacts in the United States." *United States Global Change Research Program*. Accessed May 1, 2011.

<http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>.

US Patent and Trademark Office. 2008. "Water-Based Data Center." Accessed October 1, 2011. <http://appft1.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PG01&p=1&u=%2Fnethtml%2FPTO%2Fsrchnum.html&r=1&f=G&l=50&s1=%2220080209234%22.PG.NR.&OS=DN/20080209234&RS=DN/20080209234>.

Van Arnum, Patricia. 2004. Business cost structures: Location-sensitive factors. *ICIS Chemical Business Americas* 265, (10) (Mar 08): 17-18, <http://search.proquest.com/docview/194744511?accountid=14434> (accessed May 30, 2011).

Warner, Koko et al. 2008. "Human Security, Climate Change and Environmentally Induced Migration," *United Nations University – Institute for Environment and Human Security*.

Warner, Koko et al. 2009. "In Search of Shelter; Mapping the Effects of Climate Change on Human Migration and Displacement." *UNHCR*.

Weinhofer, Georg and Hoffmann, Volker H. 2010. "Mitigating Climate Change – How Do Corporate Strategies Differ." *Business Strategy and the Environment* 19:77–89. doi: 10.1002/bse.618.

Webber, Michael John. 1984. *Industrial location*. Beverly Hills: Sage Publications.

Weber, Alfred, and Carl J. Friedrich. 1929. *Theory of the location of industries*. Chicago, Ill: The University of Chicago Press.

Weiss, Daniel J. and Charlie Guenther. 2008. "The Clean and Clear Winners." *Center for American Progress*. Accessed May 1, 2011.

http://www.americanprogress.org/issues/2008/10/emissions_interactive.html.

Werz, Michael, and Kari Manlove. 2009. "Climate Change on the Move; Climate Migration Will Affect the World's Security," *Center for American Progress*. Accessed May 1, 2011.

<http://www.americanprogress.org/issues/2009/12/pdf/climatechangeonthemove.pdf>

The World Bank. 2009. "Climate Resilient Cities: A Primer on Reducing Vulnerabilities to Disasters." Accessed October 1, 2011. DOI: 10.1596/978-0-8213-7766-6.

http://siteresources.worldbank.org/INTEAPREGTOPURBDEV/Resources/Primer_e_book.pdf.

WRI. 2008. "Leveling the Carbon Playing Field: International Competition and US Climate Policy Design." Accessed October 1, 2011. <http://www.wri.org/publication/leveling-the-carbon-playing-field>.

Yaro, Robert D. 2009. "Toward A National Reinvestment Strategy for Underperforming Regions." Discussion paper for America 2050 - New Strategies for Regional Economic Development Research Seminar, Healdsburg, California – March 29-31, 2009.

Yaro, Robert D. 2010. "Moving Forward: The Promise of Megaregions and High-Speed Rail." In *Regional planning in America: practice and prospect*, edited by Ethan Seltzer and Armando Carbonell, Chapter 9. Cambridge, Mass: Lincoln Institute of Land Policy.