CARBON NEUTRALITY BY 2020:

THE EVERGREEN STATE COLLEGE'S

COMPREHENSIVE GREENHOUSE GAS INVENTORY

by

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ABSTRACT

Carbon Neutrality by 2020: The Evergreen State College's Comprehensive Greenhouse Gas Inventory

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This study provides the results of The Evergreen State College's comprehensive greenhouse gas inventory. In light of the latest scientific research on the issue of global warming and in response to recommendations made by the Sustainability Task Force, The Evergreen State College committed to carbon neutrality by 2020 as specified in the 2006 updated Strategic Plan. Furthermore, in January 2007, Evergreen President Les Purce joined the Leadership Circle of the Presidents Climate Commitment agreeing to achieve "climate neutrality as soon as possible." I conducted Evergreen's comprehensive greenhouse gas inventory as an essential step of these new climate policies in order to begin the process of tracking Evergreen's emissions over time. I followed the protocol established by the Clean Air-Cool Planet Campus Carbon Calculator. Evergreen's gross greenhouse gas emissions were 19,870, 21,671 and 22,112 metric tonnes for the years 2004, 2005, and 2006, respectively. In all three years, Evergreen's single largest source of emissions came from purchased electricity. Electricity use combined with space heating and commuter habits accounted for over 90% of total emissions for each of the three years. Partially offsetting emissions, Evergreen's forest ecosystem and composting facility sequesters less than 800 tonnes of carbon dioxide per year. Based on these results, achieving net-zero emissions (by reducing gross emissions and/or increasing rates of sequestration) is highly improbable in the foreseeable future without the purchase of offsets from the retail carbon market. Therefore, I recommend that The Evergreen State College achieve carbon neutrality sooner (by Fiscal Year 2009), rather than later (Fiscal Year 2020) through the purchase of high quality retail carbon offsets. Most importantly, Evergreen should commit to specific and incremental greenhouse gas reduction targets. I recommend the following goals: 1) reduce 2006 emissions 15% by 2012; 2) reduce 2006 emissions 40% by 2020; and 3) reduce 2006 emissions 80% by 2050.

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~ ACKNOWLEDGEMENTS ~

Covering a topic as large as global warming and completing a comprehensive greenhouse gas inventory with no previous training would have been an impossible feat without the help of many people in the Evergreen community. First and foremost, I want to thank Evergreen faculty member and my thesis reader Rob Cole. One afternoon, while having lunch, Rob convinced me of the importance and value of taking on this project. In the months that followed, Rob was instrumental in helping me get through the inevitable "roadblocks" that accompany a project such as this. I particularly enjoyed his directness, enthusiasm, and knowledge on the topic – this led to several engaging and insightful conversations.

If not for the assistance of Paul Smith (Director of Facilities) and Rich Davis (College Engineer), I would not have been able to acquire the enormous amount of data within the necessary timeframe. I am grateful for the time they spent with me and their willingness to add this project to their list of responsibilities.

Special thanks to Evergreen's Sustainability Task Force who recognized the importance of establishing an aggressive climate policy and maintained the perseverance to see it become reality. I am especially appreciative of Nancy Parkes and Steve Trotter who co-chair the Task Force. Over the past few years, Nancy taught me more about the concept and practice of sustainability than she will ever know. Steve reminded me that nothing can replace face-to-face communication; a lesson easily forgotten in today's world of email and cell phones. Moreover, Steve always made time to discuss the history and current state of Evergreen and his experience provided great insight into institutional planning. He has a gift for knowing how to get things done. Overall, working with Steve helped me develop great care and appreciation for the Evergreen community. I owe both Nancy and Steve a world of thanks.

I want to personally thank Evergreen President Les Purce who has taken a regional and national leadership role on the issue of climate change. Our discussions regarding sustainability and climate change helped me to better understand these issues from the perspective of executive planning.

Finally, many Evergreen community members provided me with important data for the inventory. Thanks to Karina Anderson (Facilities), Melissa Barker (Manager Organic Farm), Laura Coghlan (Institutional Research), Daniel Duncan (Parking Services Intern), Jennifer Dumpert (Travel Office), Dylan Fischer (Faculty Member in Forest Ecology), Clifford Frederickson (Accounting), Mark Kormondy (Facilities, Grounds), Jenni Minner (Institutional Research), Sherry Parsons (Facilities, Motor Pool), Ed Rivera (Facilities, Specialist), Susie Seip (Parking Services), Craig Ward (Food Services, Aramark), and last but not least to Lisa Bellevue, Evan Griffith, Alexandra Kazakova, Jake Kirby, Justin Kirsch, Guy McGuire, and Alexandra Stefancich who were students in this years Introduction to Environmental Studies program. Their excellent work and survey data contributed greatly to my thesis work.

PREFACE

Global warming has seen a hundred years of scientific investigation, decades of congressional hearings, and nearly 20 years of international scientific collaboration, however, no other time has changed the debate like this past year. In 12 short months global warming has come to dominate the national conversation and the vast majority of Americans are no longer wondering whether human activities are driving global warming. Instead, they are wondering how severe the impacts are going to be and what we are going to do about it. In response to this meteoric rise in public awareness, many companies, local governments, organizations, and institutions have enacted self-imposed climate policies. Most, like the U.S. Mayors Climate Protection Agreement, are commitments to reduce greenhouse gas emissions by a certain percentage by a certain date (i.e. 7% below 1990 levels by 2012). Others, like The Evergreen State College, are striving for carbon neutrality. For most Americans, the tide has shifted and business-as-usual is no longer acceptable policy.

In an attempt to capture this sudden shift in national sentiment and awareness, I have divided this thesis into two parts. Part I will examine how Americans have suddenly come to terms with the fact that the issue of global warming will not go away and must be dealt with. Chapter 1 will take a close look at the science behind global warming and investigate how scientists understand global warming to be an "unequivocal" fact, that it is "unprecedented" in at least the past 1300 years, and how anthropogenic greenhouse gas emissions are the main driving force behind our current warming trend. Chapter 2 will concentrate on both the global and regional impacts of climate change. Much of this chapter will be devoted to the current and projected impacts of global warming to Washington State. Chapter 3 will retrace a history of inaction around the issue of anthropogenic climate change and support my argument as to why any further delay to reduce greenhouse gas emissions is dangerous and irrational.

Part II will bring the global and national issue of climate change home by detailing the events that led to The Evergreen State College's commitment to reduce greenhouse gas emissions (Chapter 4) and the necessary decision to complete Evergreen's comprehensive greenhouse gas inventory. Chapter 5 will help the reader understand the basic concepts and calculations of any carbon inventory and my decision to use the protocol established by Clean Air-Cool Planet (a New Hampshire based organization that partners with college campuses all over North America to help reduce greenhouse gas emissions). Chapter 6 will detail the approach I took in gathering the necessary institutional data in order to complete the inventory. Chapter 7 details my step-by-step decision-making process and calculations behind Evergreen's greenhouse gas inventory. This chapter is essential reading for anyone interested in conducting Evergreen's next greenhouse gas inventory or for anyone interested in the results of the inventory for the years 2004-2006. Finally, Chapter 8 will peer into the future and ask, "where does Evergreen go from here now that the inventory results are in?" While Evergreen's effort to reduce greenhouse gas emissions must involve thoughtful community dialogue and well-reasoned decision-making, in Chapter 8 I will provide my personal recommendations on what I believe Evergreen's next steps ought to be.

PART I

COMING TO TERMS WITH GLOBAL WARMING

CHAPTER 1

Climate Change – An Anthropogenic Effect

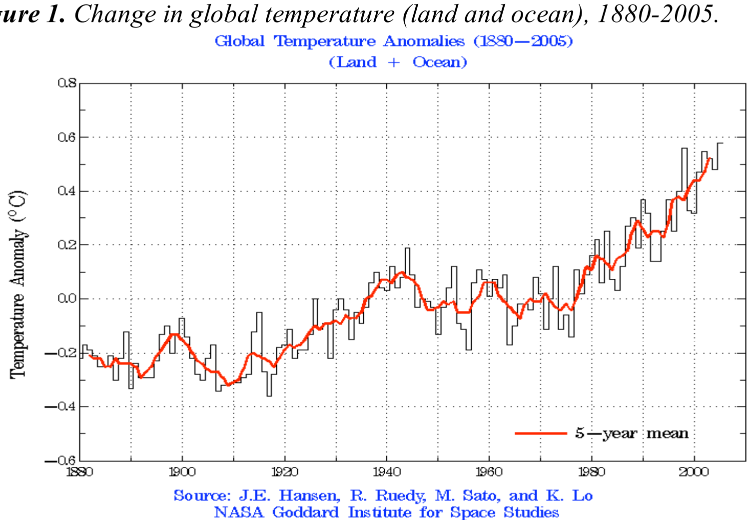
I. Global Warming: An Unequivocal Fact

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air temperature and ocean temperatures, widespread melting of snow and ice, and rising global mean sea-level."

IPCC, Fourth Assessment Report, Working Group I, 2007

According to the 2007 Fourth Assessment Report published by the Intergovernmental Panel on Climate Change (IPCC), it is an "unequivocal" fact that Earth's temperature is rising. Humans have been witness to this change and it is well documented. Since 1850, the average global temperature has risen 0.74 degrees Celsius (IPCC, 2007b). However, this warming trend has not been evenly distributed. The rise in temperature (for both the United States and the world) has been accelerating at a rate approximately three times faster over the past 30 years than it did during the rest of the 20th century (Figure 1) (NOAA, 2007b). More significantly, eleven of the past twelve years have been the warmest in recorded history (IPCC, 2007b). And, according to the National Oceanic and Atmospheric Administration (NOAA), 2006 was the warmest year ever recorded in the U.S. and our annual average temperature is now approximately 1.0 degrees Fahrenheit warmer than it was at the turn of the century (NOAA, 2007b). Because this warming trend has been gradual, up until the last few years, the scientific community and especially the general public have been slow to reach consensus that our planet is warming.

Figure 1. *Change in global temperature (land and ocean), 1880-2005.*



As late as 1985, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) – after their conference in Villach, Austria – concluded that global warming was a serious *possibility* (Houghton & Woodwell, 1989). One year later, the National Aeronautic and Space Administration (NASA) and the WMO issued a three-volume report with much stronger wording. They agreed that climate change was not only taking place but that it was happening at a relatively rapid rate (Porter, Brown, & Chasek, 2000). In 1995, the Intergovernmental Panel on Climate Change released their Second Assessment Report indicating that Earth's temperature had increased by 0.3 to 0.6% over the past 100 years.

Air temperature is not the only indicator that our planet is heating up. Our oceans absorb more than 80% of the heat added to the climate system (IPCC, 2007b). Consequently, oceans have not only been warming up on the surface, but the warming has increased to at least 3000 m in depth (IPCC, 2007b).

Taken altogether, there is no longer any doubt that the Earth is warming and that the rate of warming is increasing, but how significant is a 0.74 degree C rise in temperature in the span of a hundred years? Is it unprecedented or typical of a natural pattern? Answering this question is critical, because it can help reveal what may be causing this change, whether it is threatening to life as we know it, and what (if anything) can be done about it. In order to answer these questions and put the recent warming trend in perspective we need to have a historical understanding of global temperature change. That is, knowledge of global temperatures extending far beyond human records. Here lies a challenge: how can scientists know, with any kind of precision, what global temperatures were like hundreds, thousands, or hundreds of thousands of years ago? Incredibly, the answer lies (in part) in the very substance vulnerable to warming itself: glacial ice.

II. The Paleoclimatic Record: Glacial Ice Reveals an Unprecedented Warming Trend

"Recent record high hemispheric temperatures are probably unprecedented in at least 1200 years. Twentieth Century global warming is a reality and should be taken seriously."

Jonathon Overpeck, Director, NOAA National Climatic Data Center

Researchers have been drilling cores of ice out of Greenland and Antarctic ice sheets since the late 1960s (NASA, 2005). These cores of ice contain archived information on the chemical composition of Earth's atmosphere in the form of tiny air bubbles. These air bubbles are ancient and incredibly important because scientists have the ability to precisely age them. This deserves a brief explanation.

In the polar regions, there is a difference between summer and winter snow. In the summer, incessant sun causes changes in the texture and composition of the snow and this snow is distinct from the winter snow that falls under dark, cold skies (NASA, 2005). The difference in these seasonal snowfalls causes an annual layer in the ice. By drilling and removing ice cores, researchers can count the number of layers, and by counting back from the present, can estimate the year that each layer was formed.

By the early 1990's, scientists had pulled a nearly 2-mile-long core of ice out of both the Greenland Ice Sheet and the Vostok Ice Sheet in Antarctica (Lorius et al., 1990; NASA, 2005). The tiny air bubbles contained within each layer represented over 110,000 and 750,000 years of atmospheric information, respectively (NASA, 2005).

As one would expect, these air bubbles contain atmospheric oxygen. Oxygen comes in different isotopes including "light" oxygen (^{16}O) and "heavy" oxygen (^{18}O). As it turns out, determining the ratio of these oxygen isotopes ends up being a remarkably accurate predictor of air temperature from a long time ago (Gore, 2006). More specifically, cooler air causes water molecules with ^{18}O to condense and precipitate at a greater ratio than ^{16}O. This condensation and precipitation happens at lower latitudes and by the time air reaches the poles it has become depleted of ^{18}O (NASA, 2005). Therefore, oxygen from polar ice cores with a low ratio of ^{18}O reveals lower global air temperatures. This is just the type information needed to put Earth's current warming trend in perspective. The Vostok ice core in particular has been extremely valuable because its 750,000-year record transcends a complete glacial-interglacial cycle.

Data from these ice cores (along with a multitude of other proxy data[1]) have confirmed that there have been both warmer and cooler periods relative to today. For example, during the last interglacial period (about 125,000 years ago), polar temperatures were approximately 3 to 5 degrees C warmer than today (IPCC, 2007b). And only 18,000 years ago (at the height of the Last Glacial Maximum) temperatures were cooler

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[1] Proxy data include a suite of climatically sensitive indicators that reveal past changes in global climatic patterns. Examples, of proxy data include tree ring width, preserved pollen grains, oxygen isotopes, ice texture, fossils, marine sediments, etc.

than present (Lorius et al., 1990). Understanding what caused this estimated 5 degree C fluctuation in temperature is critical because it may shed light on what causes global climate change and why global warming is happening today.

Remarkably, these glacial and interglacial periods coincide fairly well with the astronomical theory of ice ages. The astronomical theory suggests that the beginning and ending of ice ages is ultimately the result of the interplay between the Earth's orbit and aspect in relation to the sun. There are three main factors: 1) the changing shape of the Earth's orbit around the sun (eccentricity) which is a 100,000 year cycle; 2) the changing tilt of the Earth's rotation axis (obliquity) which is a 44,000 year cycle; and 3) the changing "wobble" of the Earth's axis (precession) which is a 23,000 year cycle (Keller, 2003). The interrelationship between these patterns and their resulting radiative forcing[2] is commonly known as the Milankovitch Cycle (Schneider, 1997).

The question now before us is whether or not the Earth is at a period in the Milankovitch Cycle that is the root cause of our current warming trend. In other words, in terms of the Milankovitch Cycle should Earth be getting warmer or cooler? The answer is cooler. According to the Milankovitch Cycle, solar forcing began increasing around 20,000 years ago and peaked around 10,000 years ago (Pielou, 1991). Therefore, over the past 10,000 years, solar forcing should be decreasing (or negative) and the Earth should be experiencing an overall cooling trend. The paleoclimatic record agrees. We know that our latest glaciation (the Last Glacial Maximum) peaked around 18,000 years ago. At that time, our planet began to warm and Earth's huge continental ice sheets began to recede. In North America, for example, the Laurentide and Cordilleran ice sheets (which together covered most of Canada and the northern half of the U.S.) began melting away and eventually disappeared. We also know that we should be entering our next glacial period and that average global ice coverage should be increasing.

However, as with all things related to climate, nothing is this straightforward. In other words, the Milankovitch Cycle by itself cannot and never has completely explained Earth's prevailing climate pattern. Numerous "other" climate forcings such as volcanic eruptions, water vapor, CO_2 levels, cloud properties, the eleven-year sunspot cycle, etc. superimpose themselves over the general pattern of the Milankovitch Cycle. As a result, actual climatic patterns vary from what is predicted from the Milankovitch Cycle alone.

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[2] Forcing refers to any variable that may influence global temperatures. Examples include, carbon dioxide, solar radiation, aerosols, etc. A positive forcing tends to cause a warming affect while a negative forcing has a cooling affect.

The Medieval Warming Period (890 to 1170) and the Little Ice Age (1300 to 1850) offer two prime examples. And, the paleoclimatic record from the past several hundred thousand years also confirms this. At first, original reconstructions of Earth's past climate cycles from the Vostok ice core showed a "strong" correlation between the Milankovitch Cycle and global temperatures (Lorius et al., 1990). However, a more recent reevaluation of the data demonstrated that there was a "mismatch" in the one hundred thousand year cycle (Rind, 2002). More specifically, the warming trend ended before the astronomical forcing predicted it would. This "mismatch" is not limited to ice cores. Oxygen isotope data from sediment, corals, and more recently from Devils Hole Cave in Nevada suggest that the glacial termination event was virtually completed 135,000 years ago (Karner & Muller, 2000). This is approximately 10,000 years before solar forcing began according to the Milankovitch Cycle. Furthermore, it has also long been realized that the Milankovitch Cycle is inconsistent with more rapid and shorter-term climate events that have been well documented in ice cores (Lorius et al., 1990). In other words, interrelated climate forcings (other than solar radiation) have a powerful influence over global temperature.

None of this, of course, implies that the Milankovitch Cycle is wrong. On the contrary there is considerable evidence supporting the astronomical theory and the influence that solar forcing has over glacial periods (Rind, 2002). What paleoclimatologists are telling us, however, is that global temperatures are not solely influenced by anyone factor (including the Earth's rotation and tilt as it relates to the sun). The dominant theory of today suggests that solar forcing is the ultimate decider over the start and end of ice ages while other forms of climate forcings amplify or overshadow this affect at smaller temporal scales (Rind, 2002).

Ultimately, what this boils down to is that the Milankovitch Cycle deals with time scales too large and patterns too broad to provide much insight into what is causing Earth's recent and comparatively short-lived temperature surge. For this reason, scientists have been forced to narrow their focus to relatively modern time periods (within the past couple of thousand years) where data is more universal and more reliable. Within this timeframe, ice cores taken from thick mountainous glaciers throughout the world (including the Mendenhall Glacier in Alaska, Mt. Kilimanjaro in Tanzania, as well as glaciers in the Himalayas and Andes Mountains) become a source of extremely valuable data. After decades of intense ice core research, spanning all of these various geographic locations, paleoclimatologists have learned a great deal about climatic patterns within the past several thousand years.

At this temporal scale, it becomes obvious that Earth's current warming trend is highly unusual. The scientific community is in near consensus that the late 20^{th} century warming is "unprecedented" (Jones & Mann, 2004). In a study of the paleoclimatology of the Northern Hemisphere, Osborn and Briffa (2006) concluded that the warming event that has taken place within the past 50 years is more widespread and of greater significance than any other climatic event that has taken place within the past 1200 years (Osborne & Briffa, 2006). And, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) concluded that average Northern Hemisphere temperatures during the late 20^{th} century are likely higher than any other 50-year period in at least the past 1300 years. This means that our current warming trend is even more significant than the Medieval Warming Period. More significant, not only because average temperatures are greater today, but also because the MWP was mainly limited to Europe and the North Atlantic while our current warming is global in nature. Moreover, scientists have ruled out the simple explanation that our current warming pattern is a "recovery" from the Last Glacial Maximum or even the Little Ice Age (which ended in the mid-1800's) (U.S. National Assessment Synthesis Team, 2001).

In summary, it is now obvious and with a high degree of scientific certainty that Earth's current warming trend is taking place at a level and at a rate that is unnatural and unprecedented in recorded human history.

III. The Facts Are In: Anthropogenic Greenhouse Gas Emissions are Very Likely the Cause of Global Warming.

"The understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report (TAR), leading to very high confidence[3] that the globally averaged net effect of human activities since 1750 has been one of warming."

IPCC, Fourth Assessment Report, Working Group I, 2007

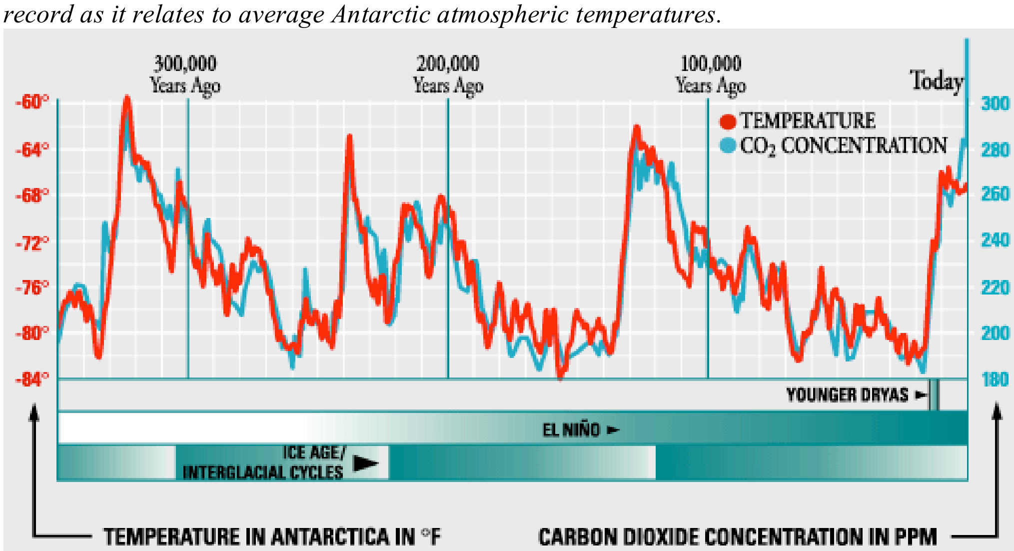
Now that we have established "unequivocally" that the Earth's temperature is rising and that this warming trend is likely "unprecedented" in at least the last 1300 years

[3] *Very high confidence* is defined by the IPCC as having at least of 90% chance of being correct.

it is critical to know why. Knowing why can help us better understand how long the warming may continue and how intense it could get.

Over the past several decades the number one public debate in the global warming controversy is whether or not human activities are causing today's warming trend. The circumstantial evidence that humans may be causing global warming has long been known and is irrefutable. Scientists have long understood the direct relationship between levels of atmospheric greenhouse gases (i.e. water vapor, carbon dioxide, ozone, methane, nitrous oxide, etc.) and global temperatures. Figure 2, for example, shows the direct relationship between atmospheric levels of carbon dioxide and Antarctic temperatures. Furthermore, because humans are adding concentrations of GHGs to Earth's atmosphere through the combustion of fossil fuels and certain land use activities, it is entirely plausible that humans are contributing to global warming. However, without scientific measurements we can never fully understand the degree to which we our affecting our planet's climate.

Figure 2. *Levels of atmospheric carbon dioxide as determined from the Antarctic ice core record as it relates to average Antarctic atmospheric temperatures.*



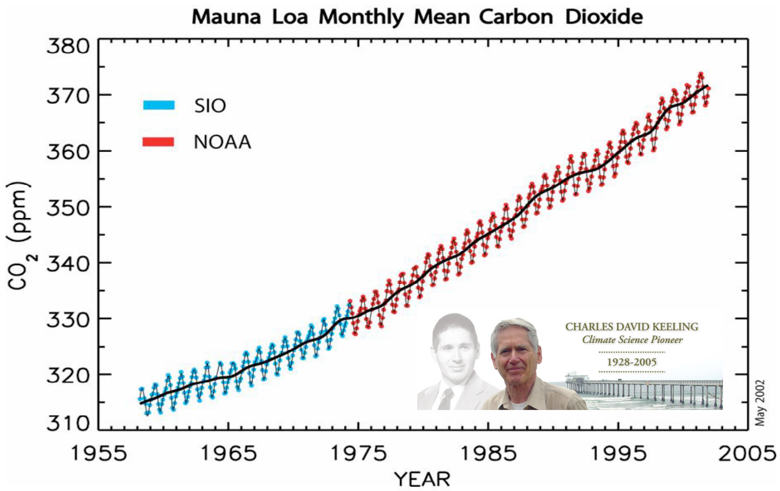
Source: Koshland Science Museum

From a scientific perspective, it is difficult to precisely measure how AGHG emissions are impacting global temperatures. There are two major reasons for this: 1) climate fluctuates regardless of human activities, therefore, scientists attempt to tease out the human effect in order to better understand potential impacts; and 2) atmospheric greenhouse gas composition also naturally fluctuates regardless of human activities. It is worth remembering that the greenhouse effect occurs naturally and is necessary to life as we know it. Greenhouse gases play an essential role in Earth's overall heat balance: they trap radiant heat that would otherwise pass through Earth's atmosphere back into space resulting in an overall warming effect. This natural greenhouse effect is relatively well understood. Water vapor is the most powerful of the GHGs contributing approximately 60% to the natural greenhouse effect. Carbon dioxide contributes another 25% while ozone, methane, nitrous oxide, and clouds make up the rest. Without these gases, climatologists estimate that the average global temperature would be negative 18 degrees C causing the surface of the Earth to be covered in snow and ice (U.S. National Assessment Synthesis Team, 2001). Paleoclimatologists have enlightened us to the fact that fluctuating levels of naturally occurring GHGs have had profound consequences on Earth's past climate regime.

Because Earth's climate naturally fluctuates and because composition of naturally occurring greenhouse gases also naturally fluctuates, it is challenging for climatologists to decipher the anthropogenic effect of our planet's current warming trend. In order to help simplify matters, climatologists have focused on one greenhouse gas in particular: carbon dioxide. Carbon dioxide is a natural choice not only because human activities directly add it to the atmosphere, but also because it has a larger overall greenhouse effect than the other major AGHGs (ozone, methane, and nitrous oxide) (Lorius et al., 1990). For these reasons, climatologists are more interested in CO_2 levels than on any other GHG.

As early as 1904, Swedish scientist Svante Arrhenius, was studying the effect that doubling atmospheric CO_2 would have on global climate(PBS:_Science_&_Health, 2005). And in the 1950's, famous climatologist Roger Revelle understood the potential implications of the world's dependence on fossil fuels as it relates to global warming. He worried that, "Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years…" (Revelle & Suess, 1957). More importantly, Revelle understood the necessity of measuring CO_2 levels in order to verify and quantify the possible anthropogenic effect. He hired Charles David Keeling to begin measuring CO_2 from the Mauna Loa research station on the big island of Hawaii. From Mauna Loa, atmospheric CO_2 has now been measured continuously since 1958. In 1958, the atmospheric concentration of CO_2 was just over 310 parts per million (ppm). Atmospheric CO_2 levels have steadily increased over this time and in 2005 they measured 381 ppm (Gore, 2006). The nearly 50 years of measurements from the top of Mauna Loa have produced the famous “Keeling Curve” the most widely recognized graph in all of climatology (Figure 3).

Figure 3. *The “Keeling Curve.” Atmospheric carbon dioxide levels as recorded from the Mauna Loa research station on the big island of Hawaii.*



Through this direct measurement we now know that there has been a rise in atmospheric CO_2. However, is a 70 ppm increase in 50 years significant? Once again, to put this increase in perspective, scientists look to the paleoclimatic record. The same tiny air bubbles from the same ice cores used to measure oxygen isotope ratios are also used to measure CO_2 levels and other GHGs. The results are alarming. These ice cores have revealed that for hundreds of thousands of years the composition of Earth’s atmosphere has been relatively consistent. Then, starting around the time of the Industrial Revolution (about 150 to 200 years ago), levels of carbon dioxide along with methane, nitrous oxide, and sulfur dioxide all increased (Schneider, 1997).

Methane levels, for example, have risen about 150% since the Industrial Revolution and this is most likely due to an increase in the spread of global agriculture and mining activities (Schneider, 1997). In 2005, the global atmospheric concentration of methane was 1774 parts per billion (ppb) (IPCC, 2007b). This remarkable increase from pre-industrial levels (about 715 ppb) is well above the natural range (320 to 790 ppb) of the last 650,000 years as determined from ice cores (IPCC, 2007b). The Intergovernmental Panel on Climate Change concludes with 90% certainty that the global rise in atmospheric levels of methane is a direct result of anthropogenic activities (IPCC, 2007b). Since methane is 23 times more powerful as a greenhouse gas than CO_2, its levels must also be closely watched (EPA, 2006b).

Nitrous oxide is another GHG whose levels have increased. According to the Intergovernmental Panel on Climate Change, global nitrous oxide levels have increased about 18% from a pre-industrial value of 270 parts per billion (ppb) to 319 ppb in 2005 (EPA, 2006b; IPCC, 2007b). The Intergovernmental Panel on Climate Change estimates that more than a third of all nitrous oxide emissions are anthropogenic in nature caused by a rapid increase in the global use of nitrogen fertilizers (IPCC, 2007b; Schneider, 1997).

However, for the reasons mentioned above, CO_2 levels are of the greatest interest and are also the most alarming. The rate at which humans have been adding CO_2 to the atmosphere is astonishing. In the United States alone, researchers estimate that deforestation, agricultural practices, and the combustion of fossil fuels have increased levels of atmospheric carbon by roughly 35% since 1750 (EPA, 2006b). This increase should not be surprising when one realizes that since 1750 the U.S. has taken over 400 gigatonnes of carbon (GtC) from the biosphere and added to the atmosphere (U.S. National Assessment Synthesis Team, 2001)). This pattern is not unique to the United States but is found throughout the world especially in the industrialized north. A global estimate by the U.S. Department of Energy places 305 billion tons of carbon into the atmosphere from the burning of fossil fuels since the start of the Industrial Revolution (Marland, Boden, & Andres, 2006). Not surprisingly, global levels of atmospheric carbon have skyrocketed. Pre-industrial levels of atmospheric CO_2 fluctuated around 280 ppm and at no point in the past 650,000 years did levels exceed 300 ppm (Gore, 2006). As illustrated in Figure 2, we can now see that levels have surged to approximately 381 ppm. This data is not controversial. Former vice president and presidential candidate Al Gore, who was a former student of Dr. Revelle, expresses this clearly and succinctly, "There is not a single part of this graph – no fact, date, or number – that is controversial in any way or in dispute by anybody" (Gore, 2006).

The fact that CO_2 concentrations are directly correlated to warmer global temperatures, that humans are emitting over 25 million tons annually of CO_2 into the atmosphere (EIA, 2006), and that current CO_2 levels have exceeded anything seen within hundreds of thousands of years is quite convincing that human activities are in some way responsible for today's global warming. In fact, modern state-of-the-science climate models conclude that natural forcings are not enough to explain today's warming trend

(Zwiers & Weaver, 2000). Only anthropogenic forcings can account for Earth's rising global temperatures. As a result, the 2007 Intergovernmental Panel on Climate Change Fourth Assessment Report profoundly changed the debate by concluding, with 90% certainty, that the rise in global temperatures since the mid-20th century is caused by anthropogenic emissions of GHGs (IPCC, 2007b).

IV. Chapter Summary

In summary, we have seen that it is an unequivocal fact that global warming is happening, that our current warming trend is unprecedented in at least the past 1300 years, and finally, that we can no longer reasonably question whether humans are responsible for today's global warming. The next logical step is to consider what the potential impacts of anthropogenic warming may be. This will be the focus of the next chapter.

CHAPTER 2

Impacts of Anthropogenic Warming

"Humanity's influence on the global climate will grow in the 21st century. Increasingly, there will be significant climate-related changes that will affect each one of us."

U.S. National Assessment Synthesis Team, 2001

As discussed in the previous chapter, we know that global warming is a reality and that only anthropogenic greenhouse gas (AGHG) emissions can explain the unprecedented rise in average global temperatures during the past 50 years. The next logical question to consider is what the impacts of global warming may be. This should be a main focus of policymakers, scientists, and the general public in the months and years ahead.

Society needs to understand the potential consequences of global warming for two predominate reasons: 1) to judiciously decide what priority global warming should be given on the list of threats and challenges facing modern-day civilization, and 2) understanding the severity of global warming impacts allows societies to weigh the risks associated with addressing the problem against the risks associated with global warming itself. In other words, decision-makers and citizens need to ask, "Are the consequences of global warming going to outweigh the risks associated with sufficiently reducing GHG emissions?"

So, what are the potential consequences of global warming? How widespread will they be? Will you be personally affected by global warming? When will these impacts occur and how severe will they be? The objective of this chapter is to answer these questions. I have organized it into two parts: 1) global and U.S. impacts of climate change and 2) impacts of global warming for the Northwest focusing on Washington State.

I. Global and U.S. Impacts of Climate Change

"At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones."

IPCC, Fourth Assessment Report, 2007

Unquestionably, climate change is a global issue. This is true for two specific reasons. First, anthropogenic greenhouse gas emissions do not remain in the place where they are emitted (impacting that place and nowhere else). In other words, CO_2 molecules emitted from a factory in Seattle can drift halfway around the world within weeks and remain in the atmosphere for over one hundred years contributing to climate change in every part of the world. Second, no one is isolated from the consequences of global warming. Today's unparalleled level of globalization virtually guarantees that any significant event happening in one part of the world will have ripple effects throughout. Whether it is a gradual collapse of a regional agricultural industry, the displacement of entire communities living along a flooded coast, or a powerful hurricane that slams into America's Gulf Coast, the effects can be felt nationwide and in some cases worldwide. Hurricane Katrina, for example, struck land several thousand miles away from Washington State yet drained millions of dollars from our local economy due to a surge in oil prices (Sightline Institute, 2006). The point is, the sustenance of cultures and economies are highly dependent on resources and labor that cross national and continental boundaries. Because no one is immune from the consequences of global warming, every nation and every individual must take it seriously. These are two of the reasons why climate change is a global issue.

As emphasized in the previous chapter, we know that global temperatures have risen 0.74 degrees C since the 1850's and that the rate of warming has significantly increased over the past 50 years. What have the impacts been? In other words, what discernable consequences have paralleled these warmer temperatures and what can we expect in the future?

~ Melting & Thawing ~

Melting Sea Ice. Let us start with a seemingly obvious expectation. One would expect that warmer temperatures would result in an average reduction of global ice cover. Has this happened? The answer is yes. According to the latest U.S. Climate Change Science Program report (2006), perennial Arctic sea ice has declined 9.8% per decade in area since 1978. And, since 2002, satellite images have revealed a 1.3 million km^2 reduction in area of Arctic Sea Ice (double the size of Texas) (U.S. Climate Change Science Program, 2006). The thickness of the sea ice is also affected. An estimated 40% reduction in volume has occurred since the 1950s (Diaz, 2006). This trend is expected to continue well into the future for both the Arctic and Antarctic regions. In fact, some projections predict that by the end of the 21^{st} century, Arctic late-summer sea ice will almost entirely disappear (IPCC, 2007b). This reduction in sea ice is threatening the arctic ecosystem (most notably the polar bear population) and the subsistence lifestyle of northern indigenous peoples.

Melting Polar Ice Sheets and Alpine Glaciers. Continental ice sheets are also affected. Greenland contains the Northern Hemisphere's largest ice sheet. It is about 1.7 million km^2 in area or nearly the size of Mexico (U.S. Climate Change Science Program, 2006). Over the past 15 years, approximately 105 million acres in area of this ice has melted (Arctic Climate Impact Assessment, 2004). But this only tells part of the story. The Greenland ice sheet is also 3 km thick in some areas and what it is losing in volume every year is even more revealing. The U.S. Climate Change Science Program estimates that approximately 162 km^3 (39 mi^3) of volume reduction has occurred in Greenland every year since 2002 (U.S. Climate Change Science Program, 2006). Earth's other pole is experiencing similar affects. The Antarctic Ice Sheet – the largest reservoir of fresh water on the planet – is losing an estimated 150 km^2 of ice every year (Velicogna & Wahr, 2006). And over 1,000 mi^2 of the Larsen Ice Shelf (on the Western Antarctic Peninsula) have melted (Diaz, 2006). Of course, melting ice is not limited to the poles. Most people are familiar with the disappearing glaciers at the summit of certain famous mountains such as Mt. Kilimanjaro. But the effect is pandemic. Today, an estimated 90% of the world's alpine glaciers are receding (Landler, 2006). This is striking, because as recently as 1980 approximately 75% of these same glaciers were advancing.

Rising Sea-Level. Should we be alarmed at this sudden change in course of the world's glaciers? Once again, the answer is yes. The rate and volume of landlocked ice melting into freshwater is substantial and this has consequences for the human race. One consequence is a rise in sea-level. The U.S. National Assessment Synthesis Team (2001) estimates that global sea-level has risen 4 to 8 inches throughout the 20^{th} century. And, the rate is increasing. Since 1993, the average rise in sea-level has been 3.1 mm per year compared to 1.8 mm per year from 1961 to 1993 (IPCC, 2007b). Thus far, the problems associated with this rise in sea-level have been local, but should this trend continue we could expect widespread problems in the form of human displacement and mass migrations. The reason being, a large percentage of the world's population lives along the coast. Nearly 70% of the worlds population lives within 100 miles of the ocean and approximately 50 million people currently live at risk of coastal flooding and storm surges (Diaz, 2006). In the U.S., the problem is no better – more than half of the population lives within 50 miles of the coast (NOAA, 2007a). The fact is, if even a portion of our planet's coast becomes inundated it would cause enormous social and economic disruption. Where will all of these people go and how is this going to impact the communities they settle into? Furthermore, coastal areas are hubs of commerce, home to corporate headquarters, and serve as essential ports of trade (NOAA, 2007a). Not to mention that some of humanities most affluent development exists along the waterfront.

The question now before us is will sea-level continue to rise and how far will it go? Once again, the past provides a key to the future. The last time arctic temperatures were comparable to today's temperatures for an extended period was 125,000 years ago. At that time, sea-level was 12 to 18 feet higher (IPCC, 2007b). In fact, sea-level will continue to rise. There are two very straightforward reasons why. First, CO_2 is long-lived with a residence time of over a century (Keller, 2003). This means that the CO_2 released into the atmosphere today will still be there in 2100. Because the rate of global CO_2 emissions continues to increase at a rate of about 1% per year (Karl & Trenberth, 2003), we know that atmospheric levels of CO_2 will continue to do the same and for many decades to come. Second, climate change from CO_2 emissions has a delayed reaction. In other words, even if global CO_2 emissions were stabilized today, we know that Earth's atmosphere will continue to warm as it reacts to the CO_2 already in the atmosphere (Karl & Trenberth, 2003). For these two reasons, even conservative estimates predict that by 2100 the Earth's temperature will be 2.4 degrees C (4 degrees F) warmer than today (U.S. National Assessment Synthesis Team, 2001). According to James Hansen (NASA's chief climate scientist at the Goddard Institute for Space Studies), the last time atmospheric temperatures were that warm sea-level was approximately 80 feet higher than today (Time Magazine, 2006).

Air temperature is not the only factor accounting for a rising sea-level. Warmer ocean temperatures cause an expansion of water molecules also resulting in sea-level rise. Therefore, even if the amount of freshwater running into the ocean somehow stabilized, sea-level would still rise due to thermal expansion alone. The 2007 Intergovernmental Panel on Climate Change report states that an expanding ocean will continue for many centuries to come due to the delayed time it takes to vertically transport heat from the surface into the deep ocean (IPCC, 2007b).

To be sure, glacial recession and the thermal expansion of the ocean will continue and so will a rise in sea-level. By some estimates, sea-level could rise three feet by the end of the century and continue to rise for centuries (Karl & Trenberth, 2003; U.S.

National Assessment Synthesis Team, 2001). Some coastal communities are already taking action. The residents of Shishmaref, Alaska, for example, have recently voted in favor of spending $100 million to pick-up and move their entire town inland to escape coastal erosion and flooding (Diaz, 2006).

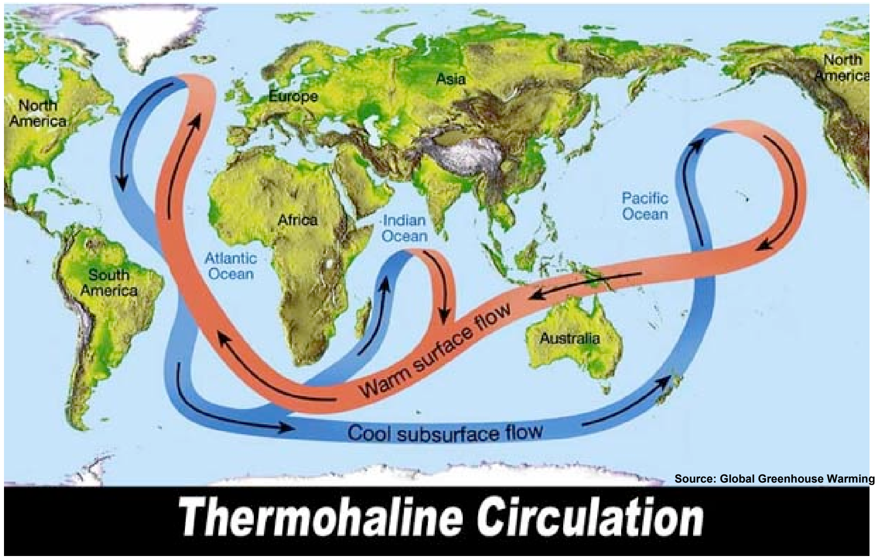
It is important to note that future estimates of sea-level rise are conservative. The Intergovernmental Panel on Climate Change, the U.S. National Assessment Synthesis Team, and the U.S. Climate Change Science Program do not account for the potential catastrophic collapse of huge ice shelves in either Greenland or Antarctica. If this were to happen, the affect would be sudden and severe. For example, if the Western Antarctic ice sheet were to suddenly collapse, global average sea-level would increase by approximately 18 feet (Diaz, 2006). This would submerge huge portions of Florida (including the Florida Keys), Bangladesh, the Marshall Islands, and many other islands and coastal areas (Diaz, 2006). James Hansen guarantees that these ice sheets will collapse if the world continues with a business-as-usual scenario. Hansen also believes that "sea-level rise is going to be the big issue soon, more even than warming itself (Hansen, 2006)."

Decline in Global Fisheries. Mass migrations and property damage are not the only problems associated with the melting of Earth's glaciers. The huge volume of freshwater rushing into mid and high latitude oceans have caused an overall decrease in ocean salinity (IPCC, 2007b). Additionally, there is a direct relationship between the amount of atmospheric CO2 and acidification of the world's oceans. Average ocean surface acidity has already increased since pre-industrial times and this trend is expected to rise at a greater rate during the 21st century (IPCC, 2007b).

As these trends continue we need to consider how this will affect the ocean's ecosystem. Warming ocean temperatures, a rapid change in ocean salinity, and increased acidification will further exacerbate the depletion of today's overexploited fish stocks. Putting economic losses aside, commercial fisheries provide 40% of the human population with its source of dietary protein (Diaz, 2006).

Disruption of Global Ocean Currents. One truly frightening scenario is the possible shut down or disruption of the Global Ocean Conveyor Belt (Figure 4).

Figure 4. *Diagram of the Global Ocean Conveyor Belt.*



This interconnected global circulation of ocean water is fundamental to our planet's overall climate and nutrient cycling. The Gulf Stream portion (in the North Atlantic) of the Global Ocean Conveyor Belt, for example, is responsible for the relatively warm temperatures in Western Europe. Officially, it is called the Atlantic Meridional Overturning Circulation. It is a classic thermohaline circulation: thermo for temperature and haline for salinity. It is the combination of temperature and salinity that makes this Global Ocean Conveyor Belt possible. However, the warming of the ocean's temperatures coupled with its changing salinity (from the invasion of freshwater from the melting Greenland Ice Sheet) threaten to shut down the Gulf Stream portion of the Conveyor Belt. This happened at the end of the last ice age (around 10,000 years ago), and when it did, Europe slipped back into its own ice age for approximately another 1,000 years (Gore, 2006; U.S. Climate Change Science Program, 2006). If this were to happen today, the consequences would be nothing short of a global catastrophe. The 2007 Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC, 2007b) concludes – with near certainty – that the Atlantic Meridional Overturning Circulation will slow down during the 21st century. Fortunately, the Intergovernmental Panel on Climate Change report also concludes that the possibility of a large abrupt shutdown of the Global Ocean Conveyor Belt during the next 100 years is remote (IPCC, 2007b). However, when faced with consequences as severe as the shutdown of the

Global Ocean Conveyor Belt, pre-emptive action should be taken seriously (no matter how remote the possibility).

Thawing Permafrost. Ice also exists in the form of permanently frozen ground known as permafrost. And, as expected, warmer global temperatures are reducing the total land area covered by permafrost. Since 1900, the area covered by permafrost in the Northern Hemisphere has decreased by 7% (IPCC, 2007b). Alaska provides a well-documented case study of the problems caused as permanently frozen land begins to thaw. Permafrost underlies 85% of Alaska and the discontinuous permafrost – found in the central and southern part of the state – has experienced significant thawing. As this permafrost thaws, the land subsides in some places and heaves in others causing infrastructure damage to roads, airports, homes, and other forms of development. Current damage to Alaska's infrastructure is costing the state approximately $35 million annually (U.S. National Assessment Synthesis Team, 2001). Similar to melting ice, the problem is going to get worse as global temperatures continue to rise. For example, in central and southern Alaska, the top 30 feet of permafrost is likely to thaw by 2100 (U.S. National Assessment Synthesis Team, 2001).

People may take comfort knowing that permafrost, found in the northern reaches of the Northern Hemisphere, exists where few people do. However, the consequences of thawing permafrost are far reaching. Alaska's North Slope, for example, provides America with nearly one-quarter of its domestic oil supply. This oil is delivered to the lower 48 by the 800-mile long Trans-Alaska pipeline. The pipeline was built to handle some ground instability, but future increased maintenance costs due to the thawing of the permafrost is likely. If the pipeline's support structures fail, it would cost roughly $2 million per mile to replace them (U.S. National Assessment Synthesis Team, 2001).

From an ecological standpoint, the disappearing permafrost also has global consequences. Permafrost regions support vast areas of wetlands: the frozen ground prevents infiltration of melting snow and ice. As a result, water becomes locked on the surface creating globally important wetlands during the spring and summer. These places create critical breeding habitat for migrating birds (especially waterfowl). If the subsurface thaws and these wetlands disappear, the consequences will be far reaching for ecosystems throughout the Northern Hemisphere.

Melting Snowpack. Of course, warmer global temperatures not only melt ice, but snow as well. Since the 1960s satellite data has revealed about a 10% decrease in global snow cover (Diaz, 2006). As more wintertime precipitation comes in the form of rain and ice rather than snow, the snowpack is dwindling. This is troubling because there is less springtime snowmelt to refill reservoirs for human consumption and use. Inevitably, if this trend continues it will exacerbate already contentious water rights issues.

~ Extreme Weather Events ~

Extreme weather events are also a source of significant concern. As tropical sea surface temperatures increase so does the intensity of tropical cyclone activity in the North Atlantic. According to the Intergovernmental Panel on Climate Change's latest assessment report, there is observational evidence to support that this has already happened since the 1970's and more severe hurricanes are likely to become more frequent in the future (IPCC, 2007b). Additionally, the El Nino Southern Oscillation (ENSO) events have been more severe, more frequent, and longer lasting in the past 30 years when compared to the previous 100 years (Berliner, 2003). To be sure, the effects of El Nino are global with varying regional impacts. One particularly problematic effect of El Nino occurs along the Pacific coast of the Americas. Here, the normally cold, nutrient-rich ocean currents fail causing a break down in the food chain. This has enormous impacts on the marine ecosystem and commercial fishing industries in this part of the world. Furthermore, heavy precipitation events go hand-in-hand with El Nino causing significant flooding, landslides, and infrastructure damage. In fact, heavy precipitation events have significantly increased over most land areas since 1900 while at the same time more intense and longer droughts have been observed throughout the tropics and subtropics since the 1970s (IPCC, 2007b). This is another example of extreme and highly variable weather patterns correlated with global warming. Of course, all of these trends are expected to not only continue but increase in frequency and severity as global warming continues.

~ Extinction & Loss of Biodiversity ~

Conservation biologists are reaching consensus that anthropogenic climate change is going to have severe ecological consequences. Understanding the problem is rational enough. Long-term warming temperatures, changing water regimes, longer droughts, disappearing sea and glacial ice, thawing permafrost, changing wind patterns, and more extreme weather patterns are profoundly changing the biosphere. Inevitably, this is and will continue to impact ecosystems around the world as living organisms try to keep pace with these changes. The specific question on the mind of most conservation biologists' is, "how are ecological communities going to adapt to a rapidly changing climate?" Vastly altered plant and animal communities, the spread of invasive species, increasing rates of extinction, and the widespread loss of ecosystem services are the main concern. I am going to cover each of these, briefly, below.

Let us start with altered plant and animal communities. There is a common misconception that as the Earth continues to warm, ecosystems will migrate northward, intact. Those adhering to this belief, envision today's ecological communities still existing in their integrity, but simply moving higher in latitude or higher in altitude. This over simplistic view will be the exception rather than the norm. It rarely happened during the warming period following the end of the last glaciation and it is even more unlikely to happen in today's world. Paleontologists, especially those who specialize in the study of fossil pollen (palynologists), learned from past records that species have different migratory histories (Pielou, 1991). That is, every species making up an ecological community is unique in its ability to adapt and disperse in response to changing climatic conditions. Some species spread at faster rates and at different times. Consequently, the plant and animal communities that established themselves after the last glaciation were quite different from the communities they originated from. What resulted were entirely new classes of species associations and ecosystems.

We do not have to rely on historic records for this evidence – it is happening all around us today. Researchers have documented recent widespread northward shifts in species of mammals, birds, and butterflies throughout North America and Europe (McCarty, 2001). In Great Britain, for example, 59 species of birds and 34 species of butterflies shifted their range northward within the past several decades (Parmesan et al., 1999; Thomas & Lennon, 1999). This shift in range occurred faster than the plant communities they were formerly associated with. As a result, ecosystems are changing.

Plant communities are also changing in response to increased temperature and varying precipitation patterns. In the southwestern United States, for example, arid grasslands are being replaced by desert shrubland in response to climate change (Brown, Valone, & Curtin, 1997). This change in habitat has led to the extirpation of several locally abundant species (Brown et al., 1997). Northern latitude ecosystems are also under threat. The plant and animal communities adapted to cold, dry climates are losing ground in the southern portion of their boundary to species better adapted to warmer, wetter climates (McCarty, 2001). Montane ecosystems are another high-risk ecosystem. As higher elevations warm, species from lower elevations advance upward pushing existing vegetative communities (i.e. alpine meadows, cloud forests, etc.) to the brink of extirpation (Grabherr, Gottfried, & Pauli, 1994; Still, Foster, & Schneider, 1999; U.S. National Assessment Synthesis Team, 2001).

Widespread changes in biotic communities have not been limited to terrestrial ecosystems. Ocean surface temperatures have warmed significantly off the coast of southern California over the past few decades. This has caused an 80% decrease in the amount of zooplankton which is likely responsible for species declines higher up the food chain (such as the collapse of the Sooty Shearwater population) (Roemmich & McGowan, 1995; Veit, McGowan, Ainley, Wahls, & Pyle, 1997).

Range and abundance are not the only ways species are affected by global warming. Phenology[4] is another. For example, a study of 65 species of breeding birds in the United Kingdom revealed that 78% of them were breeding, on average, nine days earlier in 1995 than in 1971 (Crick, Dudley, Glue, & Thomson, 1997). In New York, over half of the migratory birds studied (76 species) are now returning from their wintering grounds significantly earlier than they were at the beginning of the century (McCarty, 2001). Phenological changes are not limited to birds. Species of amphibians, insects (especially butterflies), trees, and spring wildflowers have all experienced significant changes in the timing of their life history traits (McCarty, 2001). Problems emerge when shifts in phenology result in a breakdown of symbiotic relationships and when basic species' requirements become mismatched with important ecological events. For example, bird species time their breeding cycle so that their chicks hatch at or around the peak abundance of insects. A variation of a few days can make a big difference. This has happened in the Netherlands with Great Tits. Their insect food source is now peaking nine days earlier and on the wane when Great Tit chicks hatch (McCarty, 2001). The result of less food is less reproductive success and a decline in the overall population. Darwinian theory suggests that individual Great Tits that breed earlier will increase their reproductive success and the species will adapt to this change in phenology. This may happen, however, climate change is happening so fast and impacting all ecological variables that it may prove to be impossible for the Great Tits to adjust their reproductive

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[4] Phenology, as used here, refers to long-term changes in the timing of species' natural history traits (i.e. the onset of courtship, nest-building, egg laying, flowering, hibernating, etc.) as a consequence of changing climatic conditions.

timing. Of course, this example of the Great Tit and its food source represents one specific (and simplified) case study. Shifts in species phenology are now pervasive and affecting the dynamic relationships between and within ecosystems in a manner that we are only beginning to understand.

Abundance, range, and phenology are just a few of the many ways species are likely to change in response to global warming. Physiology, behavior, and morphology will likely be others. The point is, change does not necessarily mean worse. So why are conservation biologists so concerned? A primary reason is the unprecedented rate and magnitude of our current warming trend. Once again, the main question is: "will ecosystems and their corresponding species be able to adapt quickly enough to keep pace with our rapidly changing climate?" For some biotic communities the answer is likely no. The U.S. National Assessment Synthesis Team (2001), predicts that some alpine meadows, mangroves, tropical mountain forests, and coral reef communities will disappear by 2100.

Another reason why conservation biologists are so concerned about the effects of climate change on biodiversity is that the landscape has been extremely modified since the end of the last glaciation. In this case, the past may not be key to the present. The present is not favorable to species dispersal and reestablishment (Schneider, 1997). Human activities have created significant barriers over the past couple hundred years. People have cleared natural areas, built freeways, constructed large cities (complete with urban sprawl), and developed huge agricultural zones, industrial parks, and military bases. Additionally, we have dug, cleared, or altered the landscape in order to extract natural resources (i.e. natural gas, oil, coal, water, forests, limestone, copper, etc.) and create massive landfills. How will these barriers affect plant and animal communities as they struggle to adapt to a vastly different climate? The outlook is worrisome since many of today's biotic communities are already fragmented, polluted, and otherwise weakened.

Conservation biologists are also concerned about the spread of invasive species. Unfortunately, aggressive and highly adaptive invasive species are poised for proliferation under our new climate regime. In other words, the natural history traits of weedy plants, agricultural pests, mosquitoes, ticks, rats and others are best prepared to deal with unstable but warmer future conditions. Their proliferation will likely come at the expense of native species.

Taken as a whole, the synergistic effects of a rapidly changing climate, with profoundly altered ecological communities, combined with the likely spread of invasive species could push many of the world's declining and most charismatic species to the edge of extinction. Already, a conservative estimate of 20,000-30,000 species become extinct every year (Meffe, Carroll, & Contributors, 1997). In the U.S., where we have already lost approximately 500 of our native species since European settlement, one has to wonder what the future has in store for our 1,264 federally protected species (USFWS, 2007). If the past is any indication, then American citizens should be deeply concerned about the potential of wide-ranging species extinction. At the end of the last glaciation, our continent experienced a mass extinction. Thirty-five to forty of our largest most charismatic species (i.e. mammoths, giant ground sloths, sabertooth tigers, camels, shruboxen, bison, giant beavers, etc.) disappeared between 12,000 and 9,000 years ago (Pielou, 1991). While some of the underlying causes remain controversial, we can be quite certain that a rapidly changing climate coupled with hunting pressure from indigenous peoples played a key role. It seems reasonable to assume that today's climate change coupled with pressures from contemporary human societies would have similar if not worse results for U.S. and globally threatened species.

It is important to remember that species are essential and defining components of healthy ecosystems. The loss of enough species can compromise the integrity of functioning ecosystems. Researchers have demonstrated that greater biodiversity leads to greater productivity and greater productivity leads to greater ecosystem stability (Tilman, 2000). How many species can we lose before entire ecosystems collapse? Paul Ehrlich's "popping-rivet" analogy helps explain the situation: "The Earth is like a plane flying in the sky and the rivets that hold the plane together are its inhabiting species. Losing one or two rivets from the plane is not critical. However, rivets are popping out of the plane at an unprecedented rate. The impending result is obvious… (Ehrlich & Ehrlich, 1981)." Ehrlich wrote than in 1981. Since then, the rate of global extinction has continued to increase, and if predictions are right, we can expect this trend to continue as another consequence of global warming.

~ Threats to Human Health ~

Needless to say, when ecological communities change, when invasive species proliferate, and when species become extinct humans are affected. The quality of human life is utterly dependant on healthy and functioning ecosystems. Ecosystems cleanse the air and water, recycle nutrients, and provide us with fertile soils (Speth, 2004). Nature provides us with food, fuel, fiber, and medicines (Tilman, 2000). And, for countless millions of people worldwide, nature provides aesthetic beauty, psycho-spiritual benefits, and recreational opportunities. Simply put, humans must protect the biodiversity and natural ecosystems that sustain our lives.

The potential loss of biodiversity and ecosystem services is not the only direct threats of a changing climate to human health. Other concerns include surging cases of heat stroke. The U.S., should especially take note: average U.S. temperatures are expected to increase 3-5 degrees C compared to 2.4 degrees C for the global average by 2100 (U.S. National Assessment Synthesis Team, 2001). There is scientific consensus that heat waves throughout this period will increase in both frequency and intensity putting segments of the human population (i.e. infants, elderly, poor, etc.) at a much greater risk of heat induced mortality. The 1995 Chicago heat wave and the 2003 heat wave that swept through Western Europe provides insight into what can be expected. In Chicago, temperatures reached 106 degrees F (41 degrees C) and resulted in the deaths of approximately 600 people (The University of Chicago, 2002). In Western Europe, over 30,000 people died in their heat wave (McMichael, Woodruff, & Hales, 2006). France was hit especially hard: temperatures exceeded 104 degrees F (40 degrees C) resulting in the death of an estimated 14,000 people (Diaz, 2006). Closer to home, the summer of 2006 saw record-breaking heat throughout Washington State. East of the Cascades, for example, temperatures exceeded 107 degrees F in places. Air-conditioning is the often the best option to prevent heat stroke. Unfortunately, air-conditioning is also energy intensive increasing the amount of CO_2 emissions and further exacerbating global warming.

Global warming is also likely to spread certain human diseases. The spread of seasonal asthma and other respiratory diseases is now under investigation. In the U.S., for example, rates of acute asthma increased from 19 to 35 per 10,000 children from 1979 to 2001 (Diaz, 2006). This trend is expected to increase as warmer, drier summers cause more forest fires resulting in greater levels of air pollutants. Malaria is also spreading to new altitudes and latitudes where it was absent just a few years ago (Diaz, 2006). The combination of global warming and increased precipitation is believed to be the cause. This is of great concern because malaria is already the number one insect-born killer of people worldwide. Besides malaria, shorter, milder winters will likely result in the spread of other insect-born infectious diseases such as West Nile Virus, St. Louis encephalitis, and Lyme disease in North America; dengue and yellow fever in Latin America; dengue and Japanese encephalitis throughout Asia; and Ross River fever in

Australia, just to name a few (Diaz, 2006). And, bacterial infections, such as salmonella and cholera, also proliferate under warmer conditions and are expected to thrive under future scenarios (McMichael et al., 2006).

II. Impacts of Climate Change in the Northwest (especially Washington State)

"Climate change poses a profound threat to Washington's and the world's environment. The potential adverse impacts are of a scale and magnitude that are beyond daunting"

Jay Manning, Director, WA Dept. of Ecology

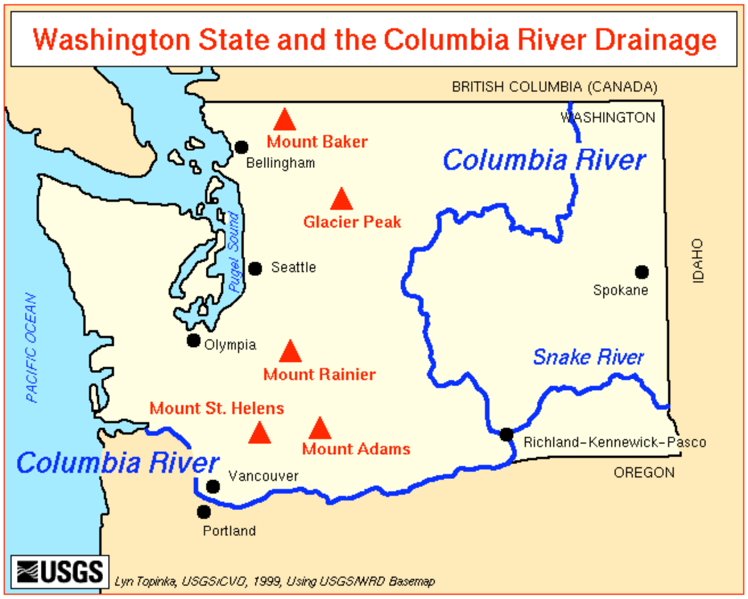
Despite the fact that climate change is a global issue, the local impacts will be vastly different. To develop a better sense of how global warming will affect you, it is important to consider how global warming will affect the people, place, and region where you live. This section will focus on climate change impacts specific to the Northwest (Washington State, Oregon, & Idaho) with particular attention on Washington State and the Puget Sound region.

To start, it is important to realize that no matter which region you live in, global warming will likely exacerbate many of the natural resource and sustainability issues that already exist. The Northwest is no exception. Our region is already faced with significant sustainability challenges and threats to our biodiversity. For example, only 10-20% of our regions old-growth forests remain, freshwater availability and quality are a constant source of tension including periodic severe shortages (i.e. 1987, 1992, and 1999), many wild salmon stocks are endangered with nearly half of the 58 wild stocks currently protected under the Endangered Species Act, and our orca population is considered the most contaminated marine mammal population on Earth and in 2005 was placed on the Endangered Species List (Sightline Institute, 2006; U.S. National Assessment Synthesis Team, 2001). This list, of course, is far from comprehensive. The question to consider is, "how will global warming impact these and other natural resource and sustainability challenges our region already faces?" It is time to consider the impacts of climate change to Washington State and our region.

~ Water Shortages ~

There is no better place to start than with freshwater issues. To be sure, of all the global warming impacts the Northwest is likely to experience, none will be more problematic than water shortages. This may come as a surprise to some since the Northwest is widely recognized as being wet and rainy. However, this is over exaggerated. Most of the precipitation our region receives occurs on the west side of the Cascades and even this area is fairly dry during the summer months. The truth is that the Northwest averages only about 20 inches of annual rainfall and water shortages are already a problem throughout the region (U.S. National Assessment Synthesis Team, 2001).

Figure 5. *The Columbia River Drainage Basin in Washington State.*



Problems along the Columbia River. No single source of freshwater better exemplifies the water problems of the Northwest than the Columbia River drainage basin. The Columbia River is the second largest river in the United States. It stretches for over 1200 miles as it cuts through Washington State and delineates the border between Washington State and Oregon (Figure 5). Without a doubt, it is the most heavily relied upon river in the region and its health and status are critical to the economy and quality of life for the millions of people who depend on it. This river sustains Native cultures and their traditions, supplies irrigation water for agricultural purposes, provides fishing opportunities, generates hydroelectric power, serves as habitat for endangered species, and allows for numerous recreational opportunities. Unfortunately, there is not enough water to support these multifarious needs and water shortages are a reoccurring problem.

Furthermore, this problem is going to get worse because the Northwest is experiencing a population boom. Since 1970, the regions population has nearly doubled with a growth rate almost twice that of the national average (U.S. National Assessment

Synthesis Team, 2001). In Washington State, population growth outpaced the national average 6.7% to 5.3%, respectively, from 2000-2005 (U.S. Census Bureau, 2007). For both the region and the state, this trend is expected to continue. Needless to say, more people will be demanding diminishing supplies of freshwater from the Columbia River basin further straining ecosystems, wildlife populations, agricultural productivity, and the economic and industrial sectors. And there is not much more that can be done. The Columbia River is already one of the most highly developed river systems in the world – it has been repeatedly dammed, drained, and altered. Yet, no one has figured out how to create more water. The result is an intense political battle (centered on value-sets) as to how available water should be allocated.

Battle-lines and value-sets are especially poignant and uncompromising in water issues. Water is highly valued for its aesthetic and recreational attributes (such as rafting, kayaking, fishing). It is valued as essential habitat for endangered species (i.e. such as salmon and/or riparian species such as migratory birds). Today, there is increasing recognition of the intrinsic value of in-stream flow. In other words, more people are demanding that more water be left in the river to support these recreational values and healthy ecosystems. At the same time, water is valued for economic growth and industrial purposes. And, most importantly, water is highly valued as a basic necessity to support human life (such as clean drinking water and crop irrigation). Supporting these values requires that water be pumped out of the river system. The point is, different values create different demands and as long as there is a water shortage there will continue to be troublesome value disagreements. Unfortunately, overcoming value disagreements require a cumbersome and long-term effort.

The Problem in Yakima Valley. The water situation in Eastern Washington is especially problematic. The Yakima Valley, which is the agricultural hub of Washington State, receives only seven inches of rain per year; making it one of the most arid places in the United States (U.S. National Assessment Synthesis Team, 2001). To be sure, the agricultural industry in the Yakima Valley is vital to the economy of Washington State. It is a $2.5 billion industry (U.S. National Assessment Synthesis Team, 2001). Unfortunately, it can only be supported through irrigation. Much of the water provided for summer irrigation is supplied by melting glaciers and winter snowpack. The rest comes from the pumping of groundwater from aquifers (particularly the Odessa Aquifer). The problem is that the farmers in this region are pumping the groundwater faster than it can be replenished. Inevitably, wells run dry and crops fail.

How did Yakima Valley farmers get in this situation? When agricultural interests first settled in Eastern Washington they were granted water rights on the supposition that dam storage would provide future water for their use. Until then, they were free to siphon water from the Odessa aquifer. The dams were never built and more farmers (along with industry and municipalities) kept requesting and receiving additional water rights. As a result, the Odessa aquifer is being sucked dry at the same time demand for its water has been steadily increasing. This situation has forced the Department of Ecology to place a moratorium on permitting new water rights. Therefore, the problem in Eastern Washington with the Columbia River watershed can be boiled down to one straightforward reality that captures the larger problem throughout the region: water has been over-allocated and today there is simply not enough water to satisfy everyone's needs.

Impacts of Global Warming on Existing Water Supplies. So, how will global warming impact the existing water problem of the Northwest (particularly Washington State)? The short answer: water problems will be amplified. The severity of future water problems will be directly correlated to increases in temperature (especially during the summer months). As we know, the rate of warming is expected to increase, therefore, so are water problems. More specifically, Northwest temperatures increased between 1-3 degrees F (0.6-1.7 degrees C) during the 20th century and are expected to increase another 2 degrees F before 2030 (U.S. National Assessment Synthesis Team, 2001; Climate Leadership Initiative, 2006). The reason being that warmer temperatures in the Northwest translate into warmer, wetter winters and longer, drier summers. As a result, mountain snowpack will decline because warmer winters mean less precipitation falling as snow and longer summers mean existing snow will melt at a greater rate than it can be replenished. Already, the snowpack in the North Cascades is disappearing: average snowpack has declined at nearly ¾ of the mountains studied thus far (Climate Leadership Initiative, 2006). Of course, warmer temperatures are also melting the region's glaciers. Glaciers in the North Cascades have lost nearly 1/3 of their volume since 1983 and by some estimates up to ¾ of them may disappear by 2100 (Climate Leadership Initiative, 2006).

For a region already stressed by water issues, warmer average temperatures are an unwanted reality. Warmer temperatures cause an earlier spring runoff (snowmelt). In Puget Sound, for example, spring snowmelt is now occurring 12 days earlier than it did just a few decades ago (Snover et al., 2005). And disappearing glaciers coupled with a diminishing snowpack means that less water is available to feed the region's rivers during the summer months. The combination of these factors means that these precious sources of freshwater are insufficient when they are needed most – in mid to late summer. The result is drought. Over the past 30 years, droughts have increased in both frequency and intensity. Streams have dried, crops have failed, fish have been killed, and revenue from hydroelectric power has been reduced (Climate Leadership Initiative, 2006). In the last few years, the Northwest has already experienced two severe droughts forcing gubernatorial intervention by declaring drought emergencies (Climate Leadership Initiative, 2006). In particular, the winter drought of 2004-05 was the worst in recent memory. By March the snowpack was only 26% of what it normally is (U.S. National Assessment Synthesis Team, 2001).

Pacific Salmon. Freshwater, as an available resource is not just threatening to humans, salmon populations are also at risk. All species of Pacific salmon (*Oncorhynchus spp.*) depend on freshwater for breeding purposes and to complete their lifecycle. When the Northwest Pacific salmon return to their natal grounds (between late summer and the end of fall) they depend on clean, cold, and oxygen rich water. Unfortunately, global warming is creating a situation where the flows are lower, the water is warmer, and the amount of dissolved oxygen is insufficient. And this all happens during the most stressful time in the lifecycle of the salmon – as they migrate upstream to their spawning grounds. It is exactly this combination of factors that weakens spawning salmon and causes the spread of pathogens. The result can be massive die-offs. For example, low flows and high temperatures appeared to be the ultimate cause of the massive Klamath River, California die-off of 2002 (where 20,000-30,000 fish died in the lower reaches of the river) (Quinn, 2005). And, on the Fraser River in 2004, there was a major die-off of sockeye salmon. Apparently the result of warm water temperatures (Climate Leadership Initiative, 2006).

The challenge for salmon populations does not end with the arrival to their spawning grounds. Low river flows can be problematic at anytime of the year for salmon. The drought of 2001 is a case in point. Juvenile salmon undertaking their annual migration from their natal grounds in the Columbia River to the ocean encountered extremely low-flowing sections of the riverbed and became stranded. Hundreds of thousands of salmon perished (Climate Leadership Initiative, 2006).

Another major problem salmon are encountering in the face of climate change is a disruption in the timing of their natural history events. Events, such as date of spawning, length of incubation, time spent in freshwater, when to commence their migration to the sea, etc., are all carefully coordinated (through natural selection) to maximize the populations likelihood of survival. The timing of these events is not only specific to each population but are perhaps the most important set of factors influencing each populations long-term survival. Global warming is changing the environmental in such a manner that the timing of these events is being critically altered. For example, each population of salmon has a range of dates in which to spawn that will maximize its chances of survival. Water temperature is an important environmental factor because it determines the rate of embryonic development (Quinn, 2005). More specifically, the warmer the temperature the faster the embryo's metabolism and development is. Because of this relationship, adult salmon have "selected" a spawning date that optimizes their offspring's chance of survival. However, warmer temperatures may result in faster embryonic development throwing their reproductive cycle out of whack. If this was the only factor influencing the timing of important natural history events then we could be more confident salmon would adapt. However, levels of dissolved oxygen, nutrient availability, spring runoff, predator abundance, inter and intra specific competition, and ocean temperature are just of few of the many factors that influence important timing events in each population's lifecycle. Throw in already existing stressors such as habitat degradation and pollution, hatchery fish, commercial fishing pressures, disease, dams, and predators and it may be more than wild salmon populations can handle. Already, Northwest salmon have disappeared from nearly 40% of their former range and many of the remaining populations are in decline or at risk of extinction (Climate Leadership Initiative, 2006). Despite their protection under the Endangered Species Act and the fact that millions of dollars are spent annually on salmon research and recovery, climate change is likely to hinder or completely overwhelm conservation efforts. In Washington State, for example, it is estimated that only 38% of the salmon populations are healthy (Quinn, 2005). The others are either in jeopardy (22%), already extinct (16%), or information is insufficient to know (24%) (Quinn, 2005). As global warming continues to intensify it will compound already existing pressures on salmon evolutionary capabilities. To say the least, this ought to make one feel uncomfortable about the fate of this all-important Northwest species.

Hydroelectricity. Global warming will also affect energy production throughout the Northwest. This region is highly dependent on hydropower. In Washington State, for example, dams generate 72% of the state's electricity (Climate Leadership Initiative, 2006). As mentioned above, global warming is causing earlier peak flows in the spring and reduced in-stream flows in the summer. Consequently, hydroelectric energy production is reduced at the very time when it is needed most – during the hot, dry summer months – to run air conditioners. Because the summertime supply will be reduced and the demand will be greater, residents can expect to pay higher rates for electricity and the hydroelectric industry can expect to lose substantial amounts of money because the dams will be unable to reach their potential production.

Groundwater. The regions other main source of freshwater – groundwater – is also at risk from climate change. Glacial runoff and snowmelt are both important factors for recharging aquifers. Also, longer, warmer summers will increase the amount of evaporation that will contribute to drier soils. Inevitably, wells are going to run dry. None of this translates very well for the agricultural community or aspiring water-rights holders.

In sum, climate change is exacerbating water shortage issues throughout the Northwest. For sure, water allocation will be a continuing challenge for Northwest decision makers in the years ahead.

~ *Rising Sea-Level* ~

Unfortunately, water availability is not the only threat to the Northwest from global warming. Rising sea-level is also a major concern. In Washington State, for example, a large portion of the population lives, works, and recreates near the states 2,300 miles of coastline (Climate Leadership Initiative, 2006). In some areas of the Northwest the problem is compounded by the fact that the land is also subsiding. South Puget Sound (between Tacoma and Olympia), for example, is subsiding more than 8 inches per century (or 2mm/yr) (Snover et al., 2005). The combination of sea-level rise with subsidence means that 1 to 5 inches of land per decade will be inundated by intruding salt water (Climate Leadership Initiative, 2006). A two-foot rise in sea-level, for example, would inundated approximately 56 square miles of land and displace over 44,000 Washingtonians (Climate Leadership Initiative, 2006).

Coastal Erosion and Infrastructure Damage. At the same time seawater is creeping closer to coastal communities, climate change is expected to produce more frequent heavy precipitation events and more powerful storms. This will not only increase the potential for landslides and erosion, but coastal infrastructure will be at an additional risk from storm surges and more intense wave action (Climate Leadership

Initiative, 2006). For example, above average winter rainfall contributed to the destructive 1999 landslide in the Carlyon Beach area of Thurston County. This landslide damaged 41 homes and millions of dollars worth the damage (Climate Leadership Initiative, 2006). Already, storm waves off the coast of Oregon and Washington have been measured eight feet higher today than only 25 years ago (Climate Leadership Initiative, 2006). By all accounts, the rate of property and road damage is expected to increase as a result of flooding and greater wave action.

Salinization of Aquifers. Rising sea-level is also a threat to coastal and low-lying freshwater aquifers. The fear is saltwater intrusion. As mentioned above, aquifers are already at risk from over-pumping and reduced recharge. The last thing coastal communities need is for their groundwater to become contaminated by saltwater. Unfortunately, this is likely to become reality as sea-level continues to rise.

Salt Marshes. Another impact of rising sea-level will be the likely loss of coastal salt marshes. From an ecological standpoint, these areas are incredibly important. They serve as nurseries for all kinds of aquatic organisms, are feeding grounds for shorebirds and wading birds, they purify the water, regulate levels of dissolved oxygen, and serve as buffer zones between the sea and shore (Snover et al., 2005). Regrettably, somewhere close to ¾ of the salt marshes that once existed in Puget Sound are now gone due to human activities. The character of the remaining salt marshes are highly affected by sea-level, salinity, temperature, and varying levels of freshwater inputs (Snover et al., 2005). Global warming will influence all of these factors. Whether or not salt marshes can overcome these near-term changes is a matter of speculation. What is certain is how important they are to the communities and biodiversity in the coastal Northwest.

~ Forest Ecosystems ~

The forest ecosystem is incredibly important to the people of the Northwest. The typical Northwest resident is hard-pressed to travel very far without encountering a stand of trees. Over half of Washington State (22 million acres out of 43 million acres) is forestland (Climate Leadership Initiative, 2006). These forests are essential for their ecosystem services, biodiversity, aesthetic value, and for the recreational opportunities they provide. In particular, half of the world's temperate rainforests are found in this region and are considered to be among the most biologically productive and beautiful places on the planet (U.S. National Assessment Synthesis Team, 2001). For many people these massive, dense, dark, and moist forests are some of the most awe-inspiring places on Earth. Taken together, the Northwest forest defines the character of its people. Washington's motto as "The Evergreen State" is only one indicator of this.

However, even these highly revered forests are not immune from the threats of modern day society. As mentioned above, approximately 80% of the old-growth forests have been harvested and no longer remain. By one account, this activity has resulted in the release of over 2 billion metric tons of carbon into the atmosphere (U.S. National Assessment Synthesis Team, 2001). Particular species, like the ponderosa pine (which formerly covered ¾ of the eastside of the Cascades), have been so selectively targeted that less than 10% of their stands remain (U.S. National Assessment Synthesis Team, 2001). Furthermore, a growing population coupled with urban sprawl, air pollution, clearing forests for agriculture, and invasive species will continue to threaten the composition and character of Northwest forests.

Forest Fires. Like all aspects of the biosphere, global warming is also impacting Northwest forests. Longer, drier summers are increasing the frequency, size, longevity, and intensity of large forest fires. The number of annual large forest fires (greater than 500 acres in area) are more than three times more frequent today than they were in the 1970's (Climate Leadership Initiative, 2006). Additionally, the number of acres projected to burn annually, will double by 2040 (Climate Leadership Initiative, 2006). This will not only cause air quality problems but will also threaten communities and precious forest resources when these fires burn out of control. Fires are also an effective means to rapidly release decades of stored carbon into the atmosphere in a very short period of time. Obviously, this positive feedback mechanism will further contribute to global warming.

Insect Outbreaks. Under the influence of a new climate regime, Northwest forests are ripe for massive insect infestations. Bark beetles, for example, have a lower rate of mortality during shorter, milder winters. These circumstances not only extend their breeding season, but more survive to reproduce. Additionally, much of the logged old-growth forests throughout the Northwest, have been replanted with dense, even aged stands of the same type of trees. Under these conditions the spread of bark beetles can be rampant. Huge tracts of standing dead trees, all in close proximity, only facilitate the likelihood of forest fires. This exact situation is currently happening in the Tongass National Forest in Alaska. Millions of acres of forest have been killed by bark beetles and every summer there are massive forest fires. Closer to home, in British Columbia, Canada, more than 21 million acres of forest have already been killed by the beetle and that number is likely to triple in the next few years (Climate Leadership Initiative, 2006).

As mentioned earlier, drought conditions are likely to increase under the new climate regime. Because droughts stress trees they make them less resistant to insect pests. Studies have shown a direct correlation between outbreaks of bark beetles, spruce budworms, and other defoliating insects with drought conditions (Swetnam & Lynch, 1993).

Forest Productivity. Not all of these impacts are potentially bad. Trees, of course, breathe in CO_2 and convert it to food (carbohydrates) through photosynthesis. Therefore, increasing the amount of atmospheric CO_2 may increase the growth rate and productivity of managed forests (U.S. National Assessment Synthesis Team, 2001). However, trees also need water in combination with CO_2 in order to grow. As it turns out, water (in the form of soil moisture) may be in short supply especially in the arid eastern part of the region. In sum, the combination of drought, reduced soil moisture, insect pest outbreaks, and more frequent and intense large forest fires will likely offset any long-term benefit increasing levels of CO_2 may have on Northwest forest ecosystems (U.S. National Assessment Synthesis Team, 2001).

~ Economic Consequences ~

Obviously, the costs of global warming are not only measured in frequency of forest fires, inches of sea-level rise, occurrence of water shortages, or any of the other impacts associated with global warming, they are also starting to be measured in economic terms. In fact, the Climate Leadership Institute out of the University of Oregon just completed the first ever state-level assessment of the economic costs of climate change to the state of Washington[5]. To be sure, there are significant information gaps in that report. Imagine the daunting task of determining (with a reasonable degree of certainty) the total cost of all possible economic impacts associated with global warming. There are many assumptions and uncertainties. As a result, no final all encompassing lump sum can be given at this time. Furthermore, the researchers took a conservative approach so what figures are available are likely underestimated. Nevertheless, this is a highly valuable

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[5] In this section, I relied heavily on the results of the Climate Leadership Initiative Report. The full report, and all of its details, can be accessed through the Washington State Department of Ecology website: http://www.ecy.wa.gov/climatechange/

assessment and a great place to begin our look into the fiscal costs of global warming to Washington State.

Water Shortages Associated with Longer, Drier Summers. The most easily quantifiable costs associated with global warming come from straightforward projections stemming from water shortages. For example, we know that global warming will likely result in longer, drier summers throughout most of Washington State. As a result, Seattle, Spokane, and Yakima-area communities are all likely to face water conservation costs of $8 million annually by 2020, while at the same time the state government will spend an additional $680,000 per million gallons per day in conservation efforts (Climate Leadership Initiative, 2006).

Another major concern with longer, drier summers is a lack of irrigation water needed to support Washington's multi-billion dollar agricultural industry. Eastern Washington, for example, provides our nation with 60% of its apples and a significant portion of other crops (i.e. wheat) and fruit (U.S. National Assessment Synthesis Team, 2001). The Climate Leadership Institute estimates that summer droughts could cost Yakima Valley alone $79 million per year by mid-century (Climate Leadership Initiative, 2006).

As mentioned earlier, global warming will also be a financial burden to the hydroelectric industry. This could present a significant economic impact for Washington State and its citizens because hydropower is produced relatively cheap and it comprises the overwhelming majority (72%) of all electricity produced in the state (Climate Leadership Initiative, 2006). Right now, Washington State residents pay some of the lowest energy rates in the nation (i.e. 9^{th} lowest in 2003) (Climate Leadership Initiative, 2006). Global warming is likely to change this desirable condition, because the supply of hydroelectricity will, at best, remain the same while summertime demand increases. Unfortunately, lower summer in-stream flows are less able to generate electricity at the time when more electricity is needed to run energy intensive air-conditioners and irrigation pumps. Furthermore, Washington's rapid population growth will add further demand to limited supplies. Inevitably, this increase in demand will increase the cost of electricity.

Fortunately, milder winters will reduce the energy needed to heat homes. Consequently, demand and cost will likely be lower during the winter season. However, these savings will be more than offset by a protracted and more intense summer season. Researchers at the University of Washington concluded, under a wide variety of scenarios, that up to $165 million could be lost annually in Washington's hydroelectric industry (Climate Leadership Initiative, 2006). Complicating the situation will be the unknown affects of warmer temperatures on juvenile salmon. If water temperature increases too much, it could result in massive die-offs of salmon. Dam managers will be forced to consider the release of precious water through dam spillways in order to save federally protected salmon populations (Climate Leadership Initiative, 2006).

Forest Resources. I mentioned above some of the ways Washington's forests will be affected by climate change. Obviously, economic impacts will be profound as these vast forests are a vital component to the regions economy. Over 43,000 Washingtonians have jobs associated with the timber industry (Climate Leadership Initiative, 2006). Coniferous trees, for example, are especially abundant and they provide our country with about 3.6 billion board feet annually or about ¼ of its softwood lumber and plywood (U.S. National Assessment Synthesis Team, 2001; Climate Leadership Initiative, 2006). Forest fires may prove to be the largest drain to Washington State's timber industry. Global warming is expected to be the cause of a doubling of the number of acres burned annually by 2040 (Climate Leadership Initiative, 2006). The Climate Leadership Initiative figures that the cost of fire prevention and response to Washington State could double from $26 million today to $52 million by 2040 and the direct costs of fighting wildfires could increase 50% by 2020 (exceeding $75 million annually) (Climate Leadership Initiative, 2006)[6]. These costs do not account for a loss in timber sales, health impacts due to air pollution, tourist revenue lost from park closures, or other costs associated with forest fires. The total cost of increased forest fires to Washington State could be 4-5 times the estimates stated by the Climate Leadership Initiative (2006).

Besides the obvious loss of product from forest fires, timber yield is likely to also decrease due to reduced soil moisture, spread of disease, and insect infestations associated with warmer summer temperatures. Though there are no current quantitative estimates as to how much this might cost, one study out of California predicted an 18% reduction in yield (Battles et al., 2006). Surveys have revealed that forest managers are not overly concern about how climate change will impact their productivity because they feel that increased CO_2 and warmer temperatures will actually increase yield in the short-term (U.S. National Assessment Synthesis Team, 2001). However, as this study indicates, forecasts for long-term yields are much less promising.

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[6] This does not include federal expenditures in Washington State that are also expected to double from $24 million to $48 million by 2040.

Public Health Costs. Washington State health costs are likely to increase as a result of global warming. We have already seen that the frequency and intensity of forest fires will increase and this will significantly reduce air quality. According to the Washington Department of Health, costs associated with asthma, for example, currently cost the state about $400 million per year (Washington Department of Health, 2007). Unfortunately, Washington State has one of the highest rates of asthma in the country and it is increasing faster than the national average (Center for Disease Control and Prevention, 2007).

In September 2006, Washington State saw its first case of West Nile Virus (Center for Disease Control and Prevention, 2007). Future climate scenarios (droughts punctuated by short periods of intense rain), favors the spread of West Nile Virus. By considering what West Nile Virus has cost other states, health officials can project what it might cost Washington State. That projection is between $20 and $25 million per year (Center for Disease Control and Prevention, 2007). This does not include the "value of a statistical life" estimate. If the number of deaths is estimated and a "statistical life" is factored in then the annual costs exceed $670 million (Climate Leadership Initiative, 2006).

Sea-Level Rise and Flooding Damage. Washington State's vulnerability to sea-level rise may turnout to be the most costly effect of global warming. There are no comprehensive estimates as to how much this may cost, but undoubtedly, if sea-level rise projections occur, the price tag will be in the billions of dollars. Specific projects help to shed light on the enormous potential costs. Seattle's Alaskan Way seawall, for example, if it is re-designed to factor in a 2-foot rise in sea-level, would cost an additional $25-$50 million (Climate Leadership Initiative, 2006).

The Climate Leadership Initiative is clear to express how a final, lump sum, cost of global warming to Washington State cannot be estimated. The dynamic relationships between different economic sectors and on the economy as a whole are too complex for comprehensive projections. Additionally, the fiscal impacts of global warming on Washington State tourism, recreation, agriculture, commercial fishing (declining salmon stocks especially), wine production, and dairy revenues are just a few of the many economic sectors where uncertainties are so prevalent that even rough estimates are difficult to make. One of the challenges, of course, is the fact that Washington's economy is very much influenced by the economic conditions outside of state and national borders. For example, how will the specific impacts of global warming to Alaska, California, or Japan influence Washington's economy? A difficult analysis, to say the least. For these reasons, economists are only beginning to examine the potential costs of global warming and the estimates that are available are crude. Despite this, one relationship is seemingly obvious: *the economic costs of climate change in Washington State (and elsewhere) will grow as temperatures increase* (Climate Leadership Initiative, 2006).

III. Chapter Summary

It is critical for policymakers and citizens in general to understand the ongoing and potential impacts of global warming. Only then can informed decisions be made on how and when to address global warming. In this chapter, we have seen that climate change is a global problem for two specific reasons. First, the greenhouse gas emissions of one nation or region will impact the climate of other nations and regions. Second, no nation will be impervious to steadily increasing global temperatures and the impacts associated with them. This is especially true in today's highly globalized world where cultures and economies are dependent on events happening elsewhere. With this being said, specific local and regional impacts of global warming will be quite different and it is important for individuals to understand these impacts. "How will global warming affect the people and the place where you live?" is a question everyone should ask.

Until recently researchers have focused primarily on the geophysical impacts of climate change. However, serious attention is now being given to its economic costs. These impacts will be substantial and are a critical component in helping us to understand the full spectrum of climate change impacts.

Finally, a key theme underlying this chapter is that global warming will further exacerbate many of the social and environmental problems we already face as a modern-day civilization. Taken as a whole, global warming is a pervasive and significant threat to needs to be addressed.

CHAPTER 3

A Time for Action:

The Imperative Need to Reduce Greenhouse Gas Emissions

"We have to stabilize emissions of carbon dioxide within a decade, or temperatures will warm by more than one degree. That will be warmer than it has been for half a million years, and many things could become unstoppable. It's hard to say what the world will be like if this happens. It would be another planet."

James Hansen, Director of the NASA Goddard Institute for Space Studies, 2006

I. A History of Business-As-Usual

The issue of anthropogenic global warming is not new. Scientists have been studying the issue for over 100 years. For example, as far back as 1904, Swedish scientist Svante Arrhenius was researching what possible effect the doubling of CO_2 would have on our planet's climate regime (PBS, 2005). And, in the 1950s, Roger Revelle and Hans Suess demonstrated that the widespread burning of fossil fuels were causing global atmospheric CO_2 levels to rise (PBS, 2005). Global warming, as a political issue, is not new either. In the 1980s, representative Al Gore (D-TN), co-sponsored the first congressional hearings on the subject; and in 1988, NASA climate scientist James Hansen, submitted a report to Congress with a warning that global warming will have major social and environmental impacts (PBS, 2005). Also in 1988, the international community began to organize on the issue. The United Nations Environment Programme and the World Meteorological Organization established the Intergovernmental Panel on Climate Change. Its purpose was to thoroughly investigate global warming from a scientific, socio-economic, and policy perspective. The Intergovernmental Panel on Climate Change has since published four comprehensive reports with contributions from over 1,000 of the world's leading climate scientists. The four reports evolved from a suggestion of human induced global warming (First Assessment Report, 1990) to a greater than 90% probability that human activities are contributing to the unequivocal warming our planet is experiencing today (Fourth Assessment Report, 2007). Personally, I remember lengthy and unsettling discussions on global warming in my high school Earth Science class in 1989.

Yet, through it all, most of the industrialized world has done very little (if anything) to address the problem. The U.S., in particular, is the world's leading laggard. America emits an overwhelming majority (22%) of the world's anthropogenic greenhouse gases and instead of making an effort to lower or even stabilize emissions they continue to rise (Porter et al., 2000). The EPA recently reported that from 1990 to 2004, total U.S. greenhouse gas emissions rose 15.8% with an increase of 1.7% from 2003 to 2004 (the latest year the EPA had complete data for) (EPA, 2006b). Moreover, a 2007 White House report to the United Nations projected that the U.S. would increase their 2000 level emissions 20% by 2020 (McKibben, 2007).

One has to wonder why. Why – after 100 years of scientific investigation, decades of congressional hearings, nearly 20 years of international scientific collaboration, and in light of all the potential consequences that global warming imposes – has the global community utterly failed to take decisive action? There are three overarching reasons:

1. **Scientific Uncertainty.** A lack of consensus among the scientific community is a primary reason why modern civilization has failed to properly address global warming. Despite many decades of scientific inquiry, the science has been somewhat inconclusive. How could anyone expect otherwise? The climate system routinely fluctuates and is very complex. As a result, the debate as to whether global warming was occurring and whether human activities were responsible for it persisted. In fact, as late as the 1960s, the majority of scientists thought it impossible that humans could actually affect our planet's climate (PBS, 2005). To be sure, understanding global climate patterns as it relates to the human effect is a daunting challenge and scientific debate and uncertainty should be expected.

   In the U.S., another disturbing trend has recently emerged. The integrity of science has been under attack. Junk science, partisan funding and research, filtering of objective science that is in disagreement with political motives, and crafty editing and neutralization of scientific reports have cast a large shadow of doubt over the level of confidence and trust the American people once placed in the scientific community. This neutering of science has reached unprecedented heights over the past few years and creates a genuine concern for citizens trying to understand what is going on with our climate and what we need to do about it. Nevertheless, the 2007 Intergovernmental Panel on Climate Change Fourth Assessment Report virtually closed the door on the issues of scientific uncertainty and integrity. The report concluded that it is an unequivocal fact that the planet is warming with a greater than 90% probability that human activities are contributing to it (see Chapter 1). Furthermore, because the report had input from over 113 nations and over 1,000 of the world's leading scientists, eases concern over whether the report was done with integrity. As a result, scientific uncertainty over whether warming is happening and whether humans are contributing to it can no longer be considered acceptable reasons for inaction.

2. **Perception that Global Warming is Benign.** For years, there was a pervasive view among the general public that global warming was not a significant threat. After all, CO_2 (the villain greenhouse gas) is not exactly a frightening pollutant. It does not excite people into action the way other pollutants might. On the contrary, CO_2 is a basic and necessary component of our atmosphere. It makes life as we know it possible. Recognizing this, Svante Arrhenius in 1904, was the first of many scientists to suggest that warming would make the climate more favorable to humans and that an increase in atmospheric CO_2 would favor plant growth and world food production (PBS, 2005). For decades, the fossil fuel industry also promoted the vision of a greener more comfortable planet that would accompany increased CO_2 emissions. Undoubtedly, the thought of longer, greener summers, and shorter, warmer winters sounds quite welcoming to millions of residents living in northern latitudes in January. This view quells the social will to take compromising action against global warming.

   Furthermore, even citizens who are concerned about global warming may not place it high on their list of things to act upon. To them, there may be more pressing social issues to be concerned about. War, disease, substantial poverty, social and environmental injustice, population growth, sustainable use of natural resources, etc. are all important issues of our time. In the United States, major political concerns currently include, threats of terrorism, the war in Iraq, immigration reform, economic growth and prosperity, health care, and social security. How important is the threat of global warming when compared to these other societal challenges? In short, very important. Working Group II of the Intergovernmental Panel on Climate Change (2007a) reported that climate could threaten the lives of hundreds of millions of people in this century. And, as we saw in Chapter 2, the consequences of global warming will exacerbate many other social and environmental issues that we already deem to be important.

   The point is, the looming consequences of global warming are a major cause for concern. Visions of a global warming utopia have been replaced by images of more intense hurricanes, flooding coastlines, calving glaciers, and apocalyptic views such as those depicted in the movie "The Day After Tomorrow." A Doomsday scenario aside, the fact is, our modern-day civilization (since the Industrial Revolution) has been built under a relatively stable and predictable climate. That climate helped establish the "ground rules" for development, for industry, and for establishing cultural identity. Climate helps determine where we live, how we build, how and where we grow our food, etc. A rapid modification of the "rules" changes the game and sets the stage for harsh consequences.

In the previous chapter, I predominately focused on the negative impacts of global warming. To be sure, global warming will also have a suite of benefits. For example, milder winter temperatures will result in fewer deaths per year associated with exposure, longer agricultural growing seasons are expected in northern latitudes, and perhaps some land managers will benefit from increased forest productivity (over the short-term) (IPCC, 2007a). In the United States, overall agricultural output is not expected to be significantly impacted by global warming (U.S. National Assessment Synthesis Team, 2001). And, some nationally important crops, like Washington State's $524 million wheat yield, may actually increase under a new climate regime (Thomson et al., 2002; Climate Leadership Initiative, 2006).

However, no reputable scientist, policymaker, or informed citizen can cogently argue that global warming will have a net benefit for humanity. In fact, the potential negative consequences are so likely and so severe that no one has attempted to make this argument. Global warming as a benign situation can no longer be used to rationalize inaction.

3. **Fighting Global Warming is Economically Irrational.** The combustion of fossil fuels is the number one source of greenhouse gas emissions. Globally, over 25,500 Tg[7] of CO_2 are added to the atmosphere every year from the burning of fossil fuels (EPA, 2006b). And, in the United States, meeting our energy needs contributes over 86% of our GHG emissions (EPA, 2006b). Any serious attempt to reduce emissions would require a complete overhaul of our industrial and economic systems because our entire infrastructure is designed for the extraction, transportation, and combustion of fossil fuels to provide our energy and

[7] Tg = teragram. One teragram = 1,000,000,000,000 grams or 1,000,000,000 kilograms

transportation needs. Certainly, a radical shift away from fossil fuels would come with its own set of risks. Economic prosperity, human health and well-being, and individual standard of living could all be compromised. Today's loudest voices against aggressive action to reduce greenhouse gas emissions are coming out of the economic community. Their argument is clear. Many economists claim that it is economically dangerous to substantially reduce greenhouse gas emissions and the consequences of global warming are just not worth the risk. Jonah Goldberg, contributing editor for the National Review Online, captured their sentiment when he wrote in a February 2007 article that global GDP rose about 1,800% in the 20th century. The cost? …about 0.7 degrees C of warming. The benefits? …longer lifespan, better healthcare, less poverty, and an overall better quality of life. Given the option of another 1,800% increase in global GDP during the 21st century for another 0.7 degrees C of warming, Mr. Goldberg wrote that he would "take the heat in a heartbeat (Goldberg, 2007)."

The fear of economic slowdown or even collapse cannot be taken lightly. In fact, it is a major reason why the international communities greatest attempt to combat global warming – the Kyoto Protocol – ultimately failed. The U.S., for example, would have been required to reduce greenhouse gas emissions 7% below 1990 levels. When our elected officials realized this would cost approximately $1,000 per household per year and result in the premature disposal of expensive "capital stock" they decided against ratification (Victor, 2001). To be sure, the fact that developing nations such as China and India were not held accountable under Kyoto is also an important reason for the protocol's demise. However, that reason is also economic. Developing nations would have an economic advantage because it is cheaper to continue with a business-as-usual scenario while the U.S. and other industrialized nations would be forced to make expensive investments in order to comply with aggressive emission standards.

II. U.S. Inaction is No Longer a Rational Option

Today, economic fears remain the number reason why global warming skeptics are against aggressive measures to reduce greenhouse gas emissions. However, economic fears are no longer a sensible reason for inaction either. Economists are in the early phase of determining what the true financial costs of global warming may be. The conclusions from these initial studies are staggering and support the hypothesis that inaction is irrational.

The remainder of this chapter will focus on the United States and layout the reasons why inaction can no longer be justified. While much of this discussion will revolve around economic consequences of inaction, there are three general topic areas to support aggressive action against global warming:

1. **Economic Opportunities.** Undeniably, there will be risks associated with an aggressive campaign to shift our energy economy away from fossil fuels to one that is cleaner and more sustainable. However, economists and policymakers often overlook the enormous potential for economic prosperity and the corresponding costs of inaction.

   At the state level, California offers one example where aggressive policies and investments have been economically beneficial. Over the past 30 years (while the U.S. government has failed to take decisive action on global warming), the state of California (whose populous and economy is larger than many nations) has invested in newer, cleaner, and more energy efficient technologies (Kammen, 2007). At the same time, California has shutdown many outdated and polluting coal-fired electric generating plants (Kammen, 2007). As a result, California's energy use per person has remained constant for over 30 years while they have grown jobs and their economy has surged. Moreover, as a state, California is going to beat the targets established by the Kyoto Protocol.

   On the other hand, the state of Michigan offers a stark contrast. In the 1970s Michigan decision makers bet against global warming and a surge in oil prices. They continued to ignore the opportunity to invest in energy efficiency and cleaner technologies. Detroit automakers in particular carried on with a business-as-usual scenario and today the state is mired in dept and staring at an uncertain future (Rabe, 2007). While Detroit's problems run deeper than their shunning of global warming (i.e. union demands, pension plans, foreign competition), it is certainly a major factor in their problems of today.

   At a national level, Denmark provides a good example of how countries can prosper with aggressive policies and actions to thwart global warming. Denmark embraced homegrown, renewable energy in the 1970s and today they are world leaders in wind energy technology. Over 20% of Denmark's electricity comes from wind energy (compared to only 0.7% in the U.S.) and the industry provides more than 20,000 jobs and the Danish company Vestas controls over 35% of the market in the manufacture and sales of wind turbines (Schulte, 2007). Denmark is also revered for their global stewardship and this cannot be overlooked as another important reason why reducing carbon emissions can be beneficial.

On a global level, the 2006 Stern Review, published by the United Kingdom's Treasury Department, concluded that inaction today could cause economic and social disruption equal to the World Wars and economic depression experienced in the early part of the 20th century. The Stern Review estimates that an investment of 1% of GDP per year over the next 10-20 years could avoid the most catastrophic consequences of global warming (Stern, 2007). On the other hand, if the global community continues with a business-as-usual scenario the cost of global warming could reach 20% of annual GDP "now and forever" by the latter part of the 21st century (Stern, 2007). Clearly, action today demonstrates moral integrity, judicious decision-making, and fiscal responsibility.

2. **The Oil Crisis.** In the U.S., oil consumption is the number one contributor to global warming – even more than burning coal for electric power generation (Klare, 2005). Roughly, 45% of our carbon dioxide emissions come from burning oil through the transportation sector (Klare, 2005). However, U.S. dependency on oil is not only a global warming problem, it is also a geopolitical problem. In fact, America's dependency on oil (especially on foreign oil) can be characterized as a crisis. Oil provides 40% of our total energy needs; however, we do not have enough of our own supply to meet a 20 million barrel per day (bpd) consumption rate (Roberts, 2004; The National Commission on Energy Policy, 2004). This is not a new situation: domestic demand exceeded supply in 1946 when for the first time the United States became a net oil importer (Roberts, 2004). Our reliance on foreign oil became more pointed in 1970 when domestic production peaked at 9.6 million bpd and has steadily declined since (EIA, 2003). As a result, America's reliance on foreign imports is growing annually: our demand continues to increase while our domestic supply decreases (Riley, 2004). Today, we are forced to import a staggering 12 million barrels of oil every day (Roberts, 2004). This problem of foreign oil dependency has become a crisis for several reasons:

i. Global competition for diminishing oil supplies is intensifying. Global demand is forecasted to increase by 50% by the year 2025 (The National Commission on Energy Policy, 2004). However, since 1995, the world has consumed 24 billion barrels of oil annually while discovering only 9 billion barrels of new oil annually (Roberts, 2004). The competition for remaining oil is exacerbated by the fast growing economies of China and India who are aggressively pursuing a seat at the oil bargaining table. To say the least, this places the United States in a vulnerable situation.

ii. It is a geologic fact, global oil production will peak and no longer be able to meet global demand. This is known as Hubbert's Peak and no one knows with a high degree of certainty when this "peak" will occur. Some geologists, industry analysts, and government officials believe that Hubbert's Peak will be reached soon, possibly even this year, while the majority predict sometime between 2010 – 2015 (Hirsch, 2005; Roberts, 2004). Whenever peak production is realized, it will cause oil prices to rise suddenly and dramatically; most forecasts predict oil prices will rise to over $100 per barrel and stay there permanently (Klare, 2005; Roberts, 2004). For our society and economy that is dependent on cheap oil, this price spike would slow manufacturing, transportation, and most commercial activity while causing the cost of goods and services to increase (Roberts, 2004). In the words of author Paul Roberts (2004), this would drive the "entire economy into an enduring depression that would make 1929 look like a dress rehearsal." According to Hirsch et al. (2005), this dreadful scenario can be mitigated but preparations must be initiated at least 10 years in advance of peak oil. Currently, the U.S. is not making significant preparations towards a post oil energy economy.

iii. Crude oil is now over $60 per barrel (compared to an average of $17 per barrel in 1999), meaning that every barrel of high priced oil that we import is adding to our record high trade deficit that is approaching $700 billion annually (Bureau of Economic Analysis, 2005).

iv. Buying foreign oil transfers enormous amounts of money from our national treasury to politically unstable oil-rich regimes that financially support some of the most brutal and anti-American networks in the world. Publicly, this has become a salient irony since the terrorist attacks of 2001.

v. Defending our foreign oil supplies is a risky proposition. While the role of oil in our recent military campaigns in the Middle East is debated, oil certainly has *something* to do with it. Protecting our foreign oil supply with military force is not clandestine. In the 1980 State of the Union address Jimmy Carter warned "let our position be absolutely clear: an attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America. And such an assault will be repelled by any means necessary, including military force" (Jimmy Carter Library, 2004). The Carter Doctrine (as it is now called) still guides American foreign policy. For Americans, war is perpetually on the horizon. Any doubters should compare the world's largest oil reserves with the location of our international military presence.

America's growing dependence on oil threatens our economy, national security, and our quality of life. These issues cannot be thought of separately from oil's contribution to global warming: they are one of the same because they all threaten our long-term sustainability as a prosperous nation. Overall, switching our energy economy away from oil to newer, cleaner, more sustainable technologies is all-around good policy.

3. **Surprises.** Future climate projections are based on complex global climate models. Unfortunately, climate modeling is an inexact science. In fact, it is an art-form replete with uncertainties and assumptions. When scientists are faced with uncertainties and forced to make assumptions, they will, by nature, err on the side of caution. In other words, scientists do not like to be wrong and they inherently reduce their probability of making a mistake. In the case of predicting Earth's future climate regime, scientists favor assumptions that reduce the severity and potential impacts of global warming (because they can be more confident that these predictions will actually happen). The result of this is that the impacts of global warming – discussed in Chapter 2 – are *conservative* predictions of what is likely to happen. In other words, 21st century reality could be much worse. In fact, the U.S. National Assessment Synthesis Team (2001) states that the chances of unanticipated negative impacts from climate change are

"very likely." These are often referred to as "surprises" and they may result in dramatic and irreversible consequences unforeseen in future climate predictions. Future "surprises" are likely to occur from three different sources:

a. ***Uncertainty.*** Climate models attempt to numerically represent the biological, geological, and chemical processes of Earth's environment as it relates to the sun and other influences (such as volcanic eruptions) (Berliner, 2003). This translation is imperfect and increases uncertainty in the models conclusions.

   But, this is not the only type of uncertainty. Climate scientists are faced with others. And when they are, they are forced to make assumptions. In the case of climate modeling, assumptions are made for several reasons. First, the global climate system is very complex and only partially understood. For example, important aspects of the complex flow of carbon between the Earth's soils, its plants, the oceans, and the atmosphere are still unknown (Schiermeier, 2007). Other critical uncertainties include the ocean's ability to uptake CO_2. A leading hypothesis suggests that as atmospheric CO_2 increases, it causes the ocean to acidify, reducing its ability to absorb more carbon (Schiermeier, 2007). Obviously, if this is true, it will cause an increase in the greenhouse effect. The point is, the ability of the ocean to uptake carbon under a warmer climate regime is largely unknown. Perhaps the single largest source of uncertainty involves cloud feedback. Clouds can both reflect incoming solar radiation (having a cooling effect) or they can block reflected radiation from escaping back into the atmosphere (having a warming effect). How clouds influence the climate depends on their density, height, form, and location (Karl & Trenberth, 2003). Again, this is a significant source of uncertainty for climate predictions.

   Second, climate modelers depend on climatic records from the past. Unfortunately, these data are often incomplete or inaccurate. The work of paleoclimatologists, for example, is like that of a detective. They often have to base their conclusions on limited and sometimes insufficient evidence. As a result, paleontologists are forced to make assumptions; and, these assumptions become part of the data used by climate modelers.

   Third, inevitable assumptions stem from the fact that what is happening to the Earth's climate today is unprecedented (see Chapter 1). No one knows how the Earth's climate system will react to anthropogenic warming – we are embarking in uncharted waters. Some people refer to global warming as humanity's experiment with Earth's climate system. However, by no means is anthropogenic climate change a controlled experiment; we know of no other planets similar to Earth to use as reference (Berliner, 2003). Therefore, computer modelers have to assume that the climate system will behave in a certain way without much verification. These are some of the reasons why climate projections based on global climate models are replete with uncertainties and assumptions.

b. ***Positive Feedback Loops.*** When climate modelers do not scientifically understand certain climatic events or interactions, they often exclude this "uncertainty" from their calculations. In other words, some important characteristics of the global climate system are not factored into climate models. Climate feedback effects are a case in point. Relatively little is known about them and how they might enhance (or weaken) the rate and overall effects of climate change (Schiermeier, 2007). So, how does the scientific community deal with this situation? They exclude some feedback effects from their calculations. For example, the Intergovernmental Panel on Climate Change explains how they decided to exclude information on the climate-carbon cycle feedback because there is too much uncertainty and the data that is available is unpublished (IPCC, 2007b).

Excluding positive feedback systems from climate calculations is especially worrisome for two main reasons: 1) they are likely to occur; and 2) when they do occur they will result in climate impacts that will likely exceed the impact projections mentioned in Chapter 2. In other words, positive feedback systems are likely to result in greater warming, higher sea-levels, faster rate of melting ice, more hurricanes, etc., than those predicted by the Intergovernmental Panel on Climate Change and other climate assessment teams. Examples of positive feedbacks include:

- <u>The water vapor feedback</u>. Water vapor is by far the most powerful contributor to the greenhouse effect. When atmospheric temperature increases, the amount of water vapor the atmosphere can hold also increases (Karl & Trenberth, 2003; Lorius et al., 1990). This positive reinforcing cycle will significantly amplify the global warming affect. However, because this affect is not fully understood it is not factored into future climate projections.

- Ice-albedo feedback. Another commonly known positive feedback loop occurs with the melting of snow and ice. Snow and ice (and other brightly lit surfaces reflect the sun's radiation having a cooling effect. When snow and ice melts (as a result of global warming) this bright surface is replaced with a darker surface that absorbs and further heats the planet (Karl & Trenberth, 2003). Of course, a warmer planet further increases the rate at which snow and ice melt. The result? A classic positive feedback loop.
- Atmospheric CO_2. As we have discussed, when atmospheric levels of CO_2 increase so will global temperature. When global temperature increases it reduces the ability of the land and ocean to absorb CO_2, thereby increasing the amount in the atmosphere, causing further warming. Another frightening example of a positive feedback loop that can increase the greenhouse effect beyond most 21^{st} century predictions.
- Forests fires. Longer, drier summers will continue to increase the rate and severity of forest fires. When trees burn carbon is released into the atmosphere, further contributing to longer, drier summers.

c. ***Thresholds***. The most complex and widely used global climate models all assume that climate change is linear. That is, climate trends will move in a steady and predictable direction. However, paleontologists and climatologists know that this is not true. The climate has thresholds and once they are breached abrupt and extreme climate events can occur. For example, scientists assume that the rate at which the Greenland Ice Sheet will melt, and the amount of freshwater flowing into the North Atlantic, will remain somewhat constant. As a result, they predict that the slowing of the global ocean conveyor belt will also occur in a predictable and corresponding manner. However, neither of these assumptions may be true. In particular, the North Atlantic Ocean current may have a temperature and freshwater threshold that once crossed could cause this section of the global ocean conveyor belt to shut down resulting in catastrophic climate change. However, the dynamics involved are so complex and there is so much

> scientific uncertainty that scientists use the most conservative and reliable data. This approach caused the Intergovernmental Panel on Climate Change to conservatively conclude in their Fourth Assessment Report (2007a) that an abrupt transition of the North Atlantic ocean current is "very unlikely" in the 21^{st} century but slowing of the ocean current is also "very likely." Another threshold involves the arctic tundra. Currently, the tundra acts as an important carbon sink, however, there is scientific evidence suggesting that there is a warming threshold that when breach may turn the tundra into a carbon source (Schiermeier, 2007).

Uncertainty, positive feedback loops, and thresholds have not been factored into future climate projections. Certainly, they will increase the consequences and therefore the economic costs of global warming.

III. Chapter Summary

Over the past 100 years, scientific uncertainty, the pervasive belief that global warming was relatively benign, and economic recession have all been major reasons why decisive action has yet to be taken to combat global warming. The 2007 Intergovernmental Panel on Climate Change report put to rest any reasonable doubt that human activities are contributing to global warming. The scientific community has also made it quite clear that the consequences of global warming will be severe unless greenhouse gas emissions are reduced. Today, economic fears remain the number one reason why global warming skeptics are against aggressive measures to reduce greenhouse gas emissions. However, the science is absolutely clear: the impacts of global warming will occur for decades and perhaps centuries, whether society prepares for it or not. Societies that do prepare, can achieve economic growth and sustainability. Those that do not will face increasing geopolitical and economic costs as the impacts of global warming increase their intensity.

Most importantly, no one knows how warm Earth can get and how severe the true consequences may be. But, one thing is certain; every day that passes without aggressive action to thwart greenhouse gas emissions increases the likelihood of climate "surprises." As the Intergovernmental Panel on Climate Change so clearly points out in their Fourth Assessment Report (2007a), impacts and economic costs will continue to increase with global average temperature. We already know that past anthropogenic greenhouse gas emissions will contribute to warming and sea-level rise for centuries into the future (IPCC, 2007a). Society can no longer wait to reduce emissions; the global community must take action today to slow the rate of climate change. For all of these reasons, avoiding decisive action to combat global warming is irrational at best, and a crime against humanity at worst.

PART II

EVERGREEN'S

GREENHOUSE GAS INVENTORY

CHAPTER 4

The Evergreen State College Commits to Reducing Greenhouse Gas Emissions:
The Goal of Carbon Neutrality by 2020

I. Higher Education's Obligation to Fight Global Warming

"Leading society to reverse human-induced global warming is a task that fits squarely into the educational, research, and public service missions of higher education. There is no other institution in society that has the influence, the critical mass and the diversity of skills needed to successfully make this transformation."

Presidents Climate Commitment, A Call for Climate Leadership, 2007

In many ways fighting climate change is one of the greatest and most perplexing challenges humanity has ever faced. The international community's most concentrated effort to reduce greenhouse gas emissions – the Kyoto Protocol – is in obvious need of amendment, as few nations will meet their target. Moreover, most scientists agree that global emissions need to be reduced 80% by 2050 in order to avoid the most serious impacts of climate change (Porter et al., 2000). This means that even if the Protocol succeeded it would be far too little. It would take an additional 30 to 80 Kyoto Protocols to stabilize global emissions (Goldberg, 2007; Kammen, 2007); humbling, since the international community cannot accomplish one. Furthermore, the U.S. continues to increase annual emissions, and China is planning on building one new coal-fired power plant per week for the next several years. Finally, even if emissions were somehow stabilized at 2000 levels, our planet will continue to warm and sea-level will continue to rise for decades (perhaps centuries). Clearly, the situation is problematic.

Faced with this reality, some economists and U.S. policymakers simply throw up their arms believing that mitigation is too costly and too late. They argue that adaptation is the better policy now. However, because there is no known upper limit on how severe the impacts of global warming may get and because we know that the fiscal costs of climate change will continue to increase with emissions, adaptation without mitigation is a dangerous public policy. Simply put, this way of thinking threatens societies' long-term viability.

What is needed is a new way of thinking. It is time for skeptics, laggards, and pessimists to step aside and make way for proactive leadership. Thinking about climate change in a new way must be pervasive and infiltrate all levels of society. Additionally, the effort to fight climate change must be sustained – there is no quick fix to this problem. It will take aggressive research, technological innovation, whole systems thinking, and a much higher degree of environmental and ecological literacy. Clearly, these criteria fall directly into the purview of higher education. Without higher education's dedicated effort to fight global warming, society will be less capable of slowing the rate of warming and less capable of dealing with its effects. Let us examine the reasons why.

First, higher education is a powerful economic force. Currently, over 4,100 U.S. colleges and universities employ over 1.2 million faculty and enroll over 17 million students (National Center for Education Statistics, 2005). Obviously, this creates huge economic leverage. In fact, the higher education sector is a $315 billion industry (National Center for Education Statistics, 2005) with billions being spent every year purchasing fuel and energy (The Apollo Alliance, 2005). Imagine if all U.S. institutions of higher education purchased 100% renewable energy – it would increase demand, increase production, lower the cost of manufacturing, and lower the overall purchasing cost. We have witnessed this trend in western Washington State. In 2005, The Evergreen State College and Western Washington University initiated a policy to offset 100% of their energy use by purchasing Green Tags[8]. The University of Washington (a much larger institution) followed suit by also agreeing to a 100% renewable energy policy. Suddenly, Puget Sound Energy had a huge customer-base interested in clean, renewable energy. Consequently, the cost of Green Tags and the cost of renewable energy have been substantially reduced. At the same time, the amount of investment targeted for new production of renewable sources or energy has grown exponentially which has increased production. This is a win-win-win situation for producers of renewable energy, Puget Sound Energy, and the region in general. This example demonstrates how the purchasing power of higher education can be used to reduce greenhouse gas emissions.

Second, our country's future political leaders, CEO's, engineers, architects, developers, scientists, lobbyists, business-owners, and educators are currently enrolled in college. Imagine if their educational experience included a robust practical and philosophical training in sustainability. If institutions of higher education incorporated a 100% renewable energy portfolio, they would become working models for every student

[8] Specific information about Green Tags can be found on their website: www.greentagsusa.org

that passed through their doors. If past graduates have led us down this unsustainable path – partly because they are energy and ecologically illiterate – then future graduates can be expected to help society change course towards a better, more sustainable energy economy (Cortese, 2003). No matter what economic sector they eventually find themselves in (or what level of employment) they would be prepared to contribute knowledge and ideological support towards sustainable planning.

Third, reversing global warming requires the advancement of renewable energy technologies such as solar, wind, geothermal, hydrogen fuel cells, biofuels, and others. Few institutions in the world are better situated for cutting-edge research than colleges and universities. Housed within academic institutions are some of the most innovative and brilliant minds in the world. They benefit from tax-free status, academic freedom, and are the recipients of billions of dollars annually in endowment funds (Cortese, 2003).

Fourth, solving the problems created by global warming and working to reduce emissions will take a motivated, interdisciplinary, and collaborative effort. Who else contains such a diverse level of brainpower and expertise in a central location? Moreover, the collegiate student body is highly motivated and creative. Already, tens of thousands of students in collaboration with faculty, staff, and community neighbors are forming new climate action groups, lobbying their administrators, fostering new community partnerships, and implementing innovative solutions to reverse global warming (Dautremont-Smith et al., 2006).

Fifth, many colleges and universities embrace a civic duty and moral responsibility to strengthen society and contribute to the public good. As former Vice President Al Gore so fervently reminds us, global warming is a moral issue (Gore, 2006). And, the latest Intergovernmental Panel on Climate Change Report (2007a) makes it clear that the most underprivileged people in the poorest nations are likely to be the most adversely affected by climate change.

Reducing greenhouse gas emissions 80% by 2050 is the greatest challenge of our time. Any chance of accomplishing this – and therefore overcoming the worst impacts of global warming – requires a new way of thinking, will take a fundamental transformation in the way society is organized, an overhaul of our economic system, landmark shifts in public policy, considerable investments in new infrastructure, considerable investments in research and development (in the hopes of inventing or advancing existing technologies), and extensive conservation efforts. And this must all be accomplished within one generation. Higher education has the influence, diversity of expertise, civic duty, motivation, and fiscal resources to be leaders in the fight against global warming. And, therefore, has a critical role to play. As Tony Cortese (2003) of Second Nature so provocatively asks, “If higher education does not lead this effort, who will?”

II. The Goal of Carbon Neutrality at The Evergreen State College

If higher education must play an important role in fighting climate change, then The Evergreen State College is welcoming the responsibility. To start, Evergreen began purchasing 100% green energy in 2005. Which, according to the EPA, made it the 8th largest purchaser of green energy in the country by January 2006 (EPA, 2006a). However, this is nothing new, Evergreen has long been dedicated to environmental education and social activism. Moreover, Evergreen is widely known as a premier liberal arts college focused on interdisciplinary, collaborative learning. Evergreen’s faculty members are highly principled, they focus on teaching, and they strongly encourage student participation. Indeed, students are active participants in the learning process (not passive recipients of information). Through individual learning contracts, students have the added opportunity for community-based learning where turning theory into practical application is routine. It is just this mix of institutional principles that fosters sustainable thinking. As a result, Evergreen’s faculty, staff, and students have established themselves as leaders in the field of sustainability and have taken a prominent role in the fight against global warming.

Evergreen is one of the first institutions in the country to establish the all-important goal of becoming carbon neutral by 2020. Evergreen’s story of carbon neutrality begins with the formation of the Sustainability Task Force. Evergreen’s President and Vice Presidents created the Task Force in 2005 following three summers of faculty-initiated sustainability institutes. Members of the Task Force include the director of institutional planning and budgeting, the director of purchasing, the director of residential and dining services, the college engineer, ten faculty members, and two students. The initial charge of the Task Force was to create a long-term plan intended to guide the Evergreen community to a sustainable future. This “plan” was to become the new sustainability section in the College’s five-year Strategic Plan. As far as institutional planning goes, the strategic plan is an ideal place for sustainability. The Strategic Plan identifies Evergreen’s core values, guides operations, and is closely linked to budget allocations. I became the first coordinator of the Task Force shortly after it was created. Therefore, in many ways, Evergreen’s story of carbon neutrality is a personal story. I have either been involved with or a firsthand witness to the major events that have led to this goal.

As a Task Force, we spent our first year organizing, collecting information, and writing Evergreen's long-term sustainability plan. We realized that in order for our plan to be both meaningful and enduring we had to engage a large cross-section of the Evergreen community. Accordingly, we developed a broad-based community outreach program asking what sustainability means to the people at Evergreen. We realized that it would be difficult to engage a diverse and busy population in our deliberations. So, we chose several different methods that would bring a large number of people into the conversation. These included one-on-one interviews with faculty members, interviews with students and student groups, well-designed student workshops that were facilitated within academic programs, initial visits to sector staff meetings culminating in a cross-campus staff institute, interviews with key administrators and decision-makers at the college, and an online web survey.

Thinking about all of these different forms of engagement with our many diverse community members, we needed to have some measure of consistency. This would be especially critical when it came time to analyze the feedback from our engagements. Therefore, we chose three central themes for our questioning. These were:

- What is your current perception of sustainability at Evergreen?
- What should a sustainable Evergreen look like in the future?
- How do we make the transition from your current perception to your future vision?

By the time Spring Quarter 2006 was over, we had face-to-face interactions with over 380 employees and students. This generated a tremendous amount of feedback and provided directive and great insight as we labored toward our final report.

Attempting to manage and make sense of all this data, the Task Force divided itself into working groups. Each focused on a different constituent of the Evergreen community (i.e. students, faculty, staff, and administration). Next, each working group prepared a synthesis report, and the Task Force convened for a day-long retreat to organize and discuss the results.

Based on the community feedback and insights of the Task Force members, several key strategies and goals emerged[9]. They included:

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[9] The Sustainability Task Force's complete report with its full complement of strategies and goals can be viewed online at: www.evergreen.edu/committee/sustainability/interimreport.htm

- Establish a curricular pathway in sustainability
- Increase opportunities for a practical education in sustainability
- Initiate a robust plan for the reduced and efficient use of resources
- Examine and implement best sustainable practices/purchases policies
- Increase communication and assemble the history behind Evergreen's sustainability goals, achievements, and indicators
- Manage Evergreen's land endowment for increased biodiversity and maximum educational opportunities related to sustainable practices
- Strengthen bonds and relationships among all Evergreen's programs
- Strengthen bonds and relationships with Evergreen's neighbors and greater community region
- Improve campus spirit and internal wellness and foster healthy relationships
- *Become a carbon neutral college by 2020*

In essence, the strategies and goals represented in the final Task Force report are a product of the entire Evergreen community. Of all the details in the report, the goal of carbon neutrality has spawned the most discussion and has generated the greatest level of excitement. The majority of the Evergreen community and Task Force members believe that if our institution cannot achieve carbon neutrality, then we have failed to achieve sustainability. In other words, carbon neutrality is a key indicator of Evergreen's progression towards a sustainable future. The reason is simple: Evergreen's greenhouse gas emissions contribute to global warming which threatens our economic viability, threatens the services that our ecosystem provides, and exposes social and environmental inequities. On the other hand, balancing Evergreen's carbon budget would indicate that college operations and community activities were no longer contributing to global warming.

By the end of 2006, the Sustainability Task Force's recommendation to become a carbon neutral college by 2020 had been approved by Evergreen's President, the Vice Presidents, and by the Board of Trustees; thereby, becoming official college policy.

In October 2006 (at the time when the Task Force's Sustainability Report was going through the approval process), seven members of the Task Force attended the largest campus sustainability conference in the history of North America. More than 650 faculty, staff, and students representing 44 states and 4 countries gathered at Arizona State University to attend the Association for the Advancement of Sustainability in

Higher Education (AASHE) meeting. The purpose of the conference was for academic institutions to come together to share information and demonstrate how higher education can lead the way to a sustainable future. A central theme of the conference was global warming.

One speaker's message was particularly affecting. Eban Goodstein (faculty member in economics at Lewis and Clark College) called all to action. He is using his sabbatical to organize a year-long nationwide discussion on global warming solutions that will culminate with a national teach-in on January 31, 2008. It is called *Focus the Nation* and it fits really well with Evergreen's intention to raise community and regional awareness on the issue of global warming. Therefore, the Sustainability Task Force embraced *Focus the Nation* and is helping the Evergreen community in planning for this event.

As 2006 came to a close, another initiative emerged also with a focus on global warming. A number of college and university presidents were organizing a campaign called the Presidents Climate Commitment[10]. Modeled after the U.S. Mayor's Climate Protection Agreement, the Presidents Climate Commitment is a call for college and university presidents to commit to a carbon neutral policy. The goal is to have a commitment from 200 college and university presidents by June 2007 and 1,000 by the end of 2009 (Dautremont-Smith et al., 2006).

Throughout 2006, members of the Sustainability Task Force became aware of two significant realities that relate to Evergreen's role as a national leader in sustainability.

First, the October AASHE conference clearly reconfirmed that Evergreen's institutional approach to the teaching and practice of sustainability places us at the forefront of advancing sustainability on campus. For example, very few colleges have sustainability as a key component of their institutional strategic plan, have a committee devoted towards advancing sustainability on campus, offset 100% of their energy purchases with renewable sources, have a LEED certified Gold building on campus, have the opportunity for students to put sustainability theory into practice through individual learning contracts, and have a built-in collaborative, interdisciplinary teaching philosophy that is essential to sustainable thinking. While these examples represent only a portion of Evergreen's overall dedication to sustainability, taken as a whole they certainly indicate a

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[10] Detailed information on the Presidents Climate Commitment can be found online at www.presidentsclimatecommitment.org

high level of dedication to sustainability and place Evergreen among the most progressive in the advancement of sustainability.

Second, it also became quite obvious that the Evergreen community was not effectively communicating our sustainability accomplishments within our community, region, and country. In other words, Evergreen was not living up to its capability as a community and national leader on the issue of climate change despite the fact that we were well-positioned to do so. An unfortunate result of this is that our consultation is not extensively sought within South Puget Sound and among the national collegiate community.

The combination of these factors prompted the Sustainability Task Force to devote significant energy to raising awareness and educating others on the issue of global warming. Task Force members also realized that, as an institution, we could not consider ourselves a regional and national leader without proactive leadership measures from our administration. Therefore, the Task Force initiated a meeting with Evergreen President Les Purce to ask for his support.

On January 17, 2007 we met with President Purce and requested two actions in relation to global warming:

1) **Support Evergreen's efforts in promoting and organizing for the "*Focus the Nation*" event.** The Sustainability Task Force envisions a large community event held in a prominent location that will bring our regional community together to raise awareness and discuss solutions regarding impending threats associated with global warming and climate destabilization. We asked President Purce for his commitment to help the Task Force promote and organize for this event. We explained how this would better demonstrate Evergreen's leadership in the region and be further recognized as an institution that can provide expertise on issues of sustainability.

Without hesitation President Purce asked the Task Force members to draft up a memo explaining how he would invite local colleges and universities to join Evergreen in making January 31, 2008 remarkable. Additionally, President Purce sent an all-campus email stating, "For my part, I will take a personal role in raising the regional and national visibility of global warming issues by reaching out to higher education institutions in our region and to leaders in the community, in an effort to generate broad-based momentum for *Focus the Nation*."

2) **Join the "Leadership Circle" of the American College & University Presidents Climate Commitment.** Because Evergreen already established the goal of

carbon neutrality and was therefore ahead of most other institutions in their thinking on the issue, we asked President Purce to become one of the founding members and key supporters of the Presidents Climate Commitment. This is known as the Leadership Circle and was intended to be made up of 15-25 presidents. Task Force members believed President Purce's membership on the Leadership Circle was important for a few different reasons:

a. **A national leader from the outset:** Undoubtedly, Leadership Circle presidents are going to receive nationwide recognition for their institutions and for their leadership on addressing global warming. This recognition will be a clear indicator that Evergreen is a leader in sustainability.
b. **A valued member of the Leadership Circle:** Evergreen's decentralized organization, distinctive philosophical approach to education, and rich history of sustainable thinking would add to the diversity of the Leadership Circle. Among other benefits, this would ensure another unique perspective in institutional planning for reductions in greenhouse gas emissions.
c. **Increased morale:** The Sustainability Task Force considers global warming to be the number one threat to a sustainable future. President Purce's membership on the Leadership Circle would signify to the Task Force (and our community as a whole) that our President also considers global warming to be an imposing threat to our society. To be sure, this would lead to an increased recognition of the problem throughout our community and result in an increased devotion to address the problem.
d. **Evergreen is well-positioned to achieve the Presidents Climate Commitment and be a leading institution of the pledge:** Signatories of the Presidents Climate Commitment will agree to: 1) plan for climate neutrality; 2) create an appropriate infrastructure to guide in the development and implementation of a climate neutral plan by late 2007; 3) complete a comprehensive carbon inventory by the middle of 2008; and 4) create an institutional action plan for becoming climate neutral by 2009. In light of the actions already taken at Evergreen these target dates and goals are "soft." In other words, Evergreen has already committed to carbon neutrality by 2020; the Sustainability Task Force already provides

> the necessary infrastructure to guide in the development of a carbon neutral plan; and a comprehensive carbon inventory is the subject of my thesis and will be completed by June 2007. It is obvious that Evergreen is already a leading institution in addressing global warming and the Presidents Climate Commitment is entirely achievable. However, achieving carbon neutrality in isolation will be of little educational value to our community and the academic world as a whole.

Once again, President Purce agreed with this rationale and within days had completed the Presidents Climate Commitment "Letter of Intent." President Purce is now a member of the Leadership Circle.

When Evergreen's President, Vice Presidents, and Board of Trustees accepted the Sustainability Task Force recommendation to become carbon neutral by 2020, when President Purce and the Sustainability Task Force took on a leadership role in planning and organizing for *Focus the Nation*, and when President Purce signed on the Leadership Circle of the Presidents Climate Commitment, Evergreen firmly committed itself to the goal of carbon neutrality and the fight against global warming.

III. The Rationale Behind Evergreen's Carbon Inventory

Can Evergreen achieve carbon neutrality by 2020? The answer is somewhat of a mystery. When the goal was established, Evergreen had never officially calculated its carbon emissions, and therefore, had no quantitative data as to where and at what levels our emissions were coming from. The truth is, Evergreen knows very little about its emissions and contribution to global warming. Without this information, attaching a timeframe to the goal is a bit presumptuous. Certainly, calculating Evergreen's carbon emissions would have been a reasonable first step. Then, Task Force members would have had more insight prior to determining a specific climate policy and timeframe. However, completing a carbon inventory is not exactly a strategic goal and by itself does not reduce emissions. In other words, a carbon inventory is not a final goal; rather it is a critical first step in the process. In terms of Evergreen's Strategic Plan, completing a carbon inventory would be an action step in route to achieve the ultimate goal of carbon neutrality. This is why the goal was established before the inventory.

Because the goal and the timeframe are somewhat arbitrary, one might also wonder why carbon neutrality was picked at all. After all, some other institutions that have passed a climate policy have decided on a reduction of greenhouse gas emissions over a specified period of time[11]. For example, Bowdoin College in Maine established a policy of 11% below 2002 emissions to be achieved by 2010. So, why did the Sustainability Task Force decide on a carbon neutral policy? Well, members of the Sustainability Task Force consider carbon neutrality to be a minimum goal. It means that once achieved the institution will have a net-zero impact on global warming. More specifically, carbon neutrality means that the institutions emissions through operations and daily activities are balanced by other activities that offset or remove greenhouse gases from the atmosphere. If every nation, institution, organization, and individual accomplished this, then the human contribution to global warming would be stopped. With that being said, we do not know at what level this could be achieved. For example, on a global basis, if carbon neutrality is ever reached this could happen at 500, 600, or 1,000 ppm. In other words, achieving carbon neutrality does not necessarily mean the problem of global warming has been solved; only that society is no longer contributing to further warming. This is one reason why it should be considered a minimum goal and became the goal specified by the Sustainability Task Force.

Another reason why carbon neutrality was the goal favored by Evergreen's Sustainability Task Force was because it is easier to conceptualize on an annual basis. Because carbon neutrality means balancing Evergreen's carbon emissions with its carbon sinks, the institution can evaluate its contribution to global warming on an annual basis. On the other hand, establishing a goal of say 10% below 2000 levels by 2010 without the concurrent goal of achieving carbon neutrality, may or may not look at sinks or offsets. Ultimately, carbon sinks and offsets will be a critical part of any climate policy and must also be measured. Additionally, comparing future emissions with an arbitrary baseline year may not account for institutional growth or major changes. Both can influence the level of emissions causing the undue failure *or* success of the policy. This has been a major roadblock in the Kyoto Protocol. For example, Russia and Ukraine's 1990 emissions were accounted for, but after their economies declined they had virtually no chance of failing to meet their specified reductions. On the contrary, the United States found it nearly impossible to meet their specified goal within the timeframe required because the U.S. economy continued to surge. Initially, the goal of balancing each nation's carbon budget may have been a better policy. Learning from this, the Task Force decided on a carbon neutral policy. Ultimately, the goal of carbon neutrality not

[11] A list of U.S. college and university commitments to climate change can be accessed from the AASHE website at http://www.aashe.org/resources/gw_commitments.php

only necessitates a reduction of emissions but also necessitates increasing carbon sinks and/or offsets.

V. Chapter Conclusion

Clearly, higher education has a fundamental role if global and especially U.S. greenhouse gas emissions are going to be brought under control. The Evergreen State College has taken responsibility for global warming by making an institutional commitment to reach carbon neutrality by 2020. This is one of the most aggressive climate policies of any college or university in the United States. An initial step in the process of achieving carbon neutrality is to complete a comprehensive greenhouse gas inventory.

CHAPTER 5

Understanding Evergreen's Carbon Inventory

Climate policies are pervasive. Nations, governments, cities, businesses, organizations, and of course, institutions of higher education have all established goals to reduce greenhouse gas emissions. As mentioned in the previous chapter, the first step in accomplishing any climate policy is to complete a carbon inventory. Understanding the basic concepts and calculations of the inventory is not only important for the individuals carrying out the methodology but is also important for anyone interested in what the inventory is telling us and how the results where derived. In this chapter I will discuss: 1) understanding the basic concepts and calculations behind the methods and 2) the decision to use the Clean Air-Cool Planet Campus Carbon Calculator.

I. Basic Concepts and Calculations of the Carbon Inventory

Evergreen's policy of carbon neutrality is actually a bold statement indicating that the college will no longer contribute to global warming by 2020. A critical step in achieving this goal is to quantify Evergreen's current contribution to global warming. This is accomplished by completing a carbon inventory. A carbon inventory will reveal an institutions net greenhouse gas emissions (total emissions minus the sum of its offsets). Offsets can be any process or activity that removes greenhouse gases from the atmosphere (i.e. forest productivity, composting, etc.) or any strategy that increases the amount of energy produced from clean, renewable sources (i.e. purchase of "Green Tags" or any other green electricity investments). A carbon inventory produces a greenhouse gas budget. Because The Evergreen State College initiated a policy of carbon neutrality the goal is to balance our greenhouse gas budget at zero. In other words, where total emissions equal total offsets. Once armed with a greenhouse gas budget, the Evergreen community can make informed decisions on how to reduce its emissions and increase its offsets in order to achieve net-zero emissions.

Evergreen's contribution to global warming will be measured in the internationally recognized units of metric tonnes of carbon dioxide equivalents (MTCDE). Therefore, it is important to understand what metric tonnes of carbon dioxide equivalents really mean and how it is derived. As a metric measure, a carbon dioxide equivalent is the amount of a greenhouse gas emitted multiplied by its radiative forcing or global warming potential (GWP). For Evergreen's inventory, I am interested in measuring each of the greenhouse gases specified by the Kyoto Protocol. These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulphur hexafluoride (SF_6) (UNFCCC, 2007). Therefore, it should be understood, without ambiguity, that Evergreen's goal is actually *climate* neutrality despite the stated goal of *carbon* neutrality.

Four important pieces of information are necessary in order to determine the metric tonnes of carbon dioxide equivalent for a particular energy source or activity that emits greenhouse gases:

1. The amount of activity or quantity of energy used over a specified period of time. Common units of measurement are: kWh (kilowatt-hours), MMBtu's (one million British thermal units), or any unit of weight, distance, or volume. For example, in 2006 Evergreen used 115,753.3 MMBtu's of natural gas, 16.5 million kWh of purchased electricity, and six thousand gallons of diesel fuel for transportation for the college fleet.
2. The greenhouse gases emitted from each activity or energy source. For example, Evergreen burns natural gas for the purpose of space heating and cooling. This process releases the greenhouse gases of carbon dioxide, methane, and nitrous oxide into the atmosphere.
3. The emissions factor for each greenhouse gas. The emissions factor is a measure of the average rate of emission of a particular greenhouse gas from a particular source. To clarify, it simply means that certain activities – whether it is converting coal into electricity, burning gasoline for transportation, or combusting oil for space heating and cooling – release different greenhouse gases into the atmosphere in different amounts. For the stationary internal combustion of natural gas, the emission factor (or rate of emission of greenhouse gas into the atmosphere) is 52.8 kg of CO_2, 0.00528 kg of CH_4, and 0.00011 kg of N_2O for every MMBtu of heat (EPA, 2006b). The U.S. EPA (2007) maintains a complete list of standard emission factors, which is available to the public and can be accessed from their website.

4. The global warming potential for each different greenhouse gas. The global warming potential is a measure of each gas's radiative forcing. The greater the radiative forcing the more potent the greenhouse gas. Carbon dioxide is used as the standard for which the other greenhouse gases are compared (hence the term carbon dioxide equivalent), and therefore, has a global warming potential of one. Methane has a global warming potential of 23 and nitrous oxide is more powerful yet with a global warming potential of 296. To explain in further detail, because methane has a global warming potential of 23, it means that one kilogram of methane has a radiative forcing that is 23 times greater than one kilogram of carbon dioxide over a 100 year period (EPA, 2006b). Table 1 lists the global warming potentials for additional greenhouse gases.

Table 1. *Global warming potentials for the greenhouse gases emitted through Evergreen's operations and daily activities.*

Greenhouse Gas	100 Year GWP
CO_2	1
CH_4	23
N_2O	296
HFC-134a	1,300

Once these four pieces of information are obtained, then metric tonnes of carbon dioxide equivalent can be calculated for any particular energy source or activity. For example, as stated above, Evergreen burned 115,753.3 MMBtu's of natural gas in 2006. Because natural gas emits carbon dioxide, methane, and nitrous oxide we need to multiply each gas's emissions factor by their global warming potential. Adding each of these three values together equals the emissions coefficient for the internal combustion of natural gas. Emission coefficients are fixed values and in the case of natural gas it is 0.053 metric tonnes of carbon dioxide equivalent. See Table 2 for the list of emissions coefficients used in Evergreen's greenhouse gas inventory. Multiplying the emission coefficient by the total amount of activity or energy used gives metric tonnes of carbon dioxide equivalent over the specified time period. In the case of natural gas Evergreen used 115,753 MMBtus in 2006. Multiplying 115,753 MMBtus by natural gas's emissions coefficient (0.053) equals 6,134.9 metric tonnes of carbon dioxide equivalent for 2006. This value was Evergreen's contribution to global warming in 2006 just from our on-campus stationary burning of natural gas. Adding each source of emissions (i.e. purchased electricity, air travel, commuter habits, etc.) in a similar manner will lead to Evergreen's total emissions of all greenhouse gases.

Table 2. *Emission coefficients (conversion factors) for the greenhouse gases emitted through Evergreen's operations and daily activities.*

Evergreen Activity		**Emission Coefficients**	
Electricity Consumption	Purchased Electricity	0.00054	MTCDE/kWh
Space Heating	Combustion of Natural Gas	0.05300	MTCDE/MMBtu
	Distillate Oil #2	0.01000	MTCDE/gallon
Forklift, Labs, Longhouse	Propane Use	0.00500	MTCDE/gallon
Transportation	Commuter Gasoline Use	0.00900	MTCDE/gallon
	Commuter Diesel Use	0.01000	MTCDE/gallon
	Air Travel	0.00078	MTCDE/mile
Agriculture	Swine (pigs)	0.35950	MTCDE/head
	Goats	0.14140	MTCDE/head
	Poultry	0.00483	MTCDE/head
Fertilizer	Organic	0.00380	MTCDE/lb
Solid Waste	Landfill	0.14670	MTCDE/short ton
Space Cooling	Refrigerant (HFC-134a)	0.59000	MTCDE/lb
Offsets	Purchased Green Tags	0.00054	MTCDE/kWh
	Composting	0.18000	MTCDE/short ton
	Forest Productivity	No Standard Rate	

II. Choosing The Clean Air-Cool Planet Campus Carbon Calculator v5.0

A "carbon calculator" is the most widespread and effective tool for analyzing an institutions greenhouse gas budget. While there are various organizations and government agencies that provide carbon calculators to the general public, my decision to use the Clean Air-Cool Planet Campus Carbon Calculator was an easy choice. There are several reasons why:

1. The Clean Air-Cool Planet Carbon Calculator (2006b) is presently used at over 200 schools throughout North America. Therefore, it has not only become a

reputable tool but is also the standard for calculating emissions. Furthermore, because the Clean Air-Cool Planet Carbon Calculator is so widely used it allows institutions to learn from one another as they complete their inventories.

2. The American College and University Presidents Climate Commitment specifically recommends the use of the Clean Air-Cool Planet Carbon Calculator. Obviously, it would be wise to use this tool since Evergreen President Les Purce is on the Leadership Circle of that commitment.
3. Incorporates reporting standards established jointly by the World Business Council for Sustainable Development and the World Resource Institute. This avoids "double counting" emissions and prioritizes the institutions accountability for the source of its emissions.
4. Because the Clean Air-Cool Planet Carbon Calculator has become so widely used institutions can be confident that this tool will not disappear anytime soon and will likely be updated and improved over time. At the time of my thesis, for example, Clean Air-Cool Planet had already released version 5.0. This is important for institutions like Evergreen with a long-term commitment to global warming where a carbon inventory should be completed on an annual or biannual basis.
5. As we learned in Chapter 1, CO_2 may be the most important of the greenhouse gases but it is not the only one. The Clean Air-Cool Planet Carbon Calculator (despite the specific reference to "carbon" in its title) includes the calculation of the other greenhouse gases (CH_4, N_2O, HFC, PFC, and SF_4) specified in the Kyoto Protocol (Clean-Air Cool-Planet, 2006b). This is important for Evergreen because we want to complete a full assessment of our contribution to global warming (not only our carbon emissions).
6. The Clean Air-Cool Planet Carbon Calculator is relatively easy to use. Calculating an institutions carbon budget involves complex formulas, conversion factors, global warming potentials, and subjective decision-making on what should or should not be included. Fortunately, the Clean Air-Cool Planet Carbon Calculator (which is a Microsoft Excel spreadsheet) has these formulas built-in and they follow Intergovernmental Panel on Climate Change protocol based on the latest science. Therefore, once the data is collected and entered, most of the calculations can be performed automatically.

7. The developers of the Clean Air-Cool Planet Carbon Calculator created a users guide to help facilitate data collection and analysis. The guide helps to standardize the methodology and permits different institutions to compare the work of other institutions. Moreover, a standardized protocol is important at the college and university level where a high rate of turnover means that different individual students or faculty members are likely to repeat the calculations. Ultimately, this eliminates some of the subjective decision-making regarding what should or should not be included in the inventory.
8. If there is unavailable emissions data, the Clean Air-Cool Planet Carbon Calculator allows the user to carry-on with the inventory and allows analyses with the information that is available.
9. The Clean Air-Cool Planet Carbon Calculator facilitates analyzing and summarizing the results by automatically producing charts and graphs once the data is entered.
10. The Clean Air-Cool Planet Carbon Calculator is designed to be used on an annual basis permitting institutions to track their emission trends over time.

Overall, the Clean Air-Cool Planet Carbon Calculator is the most reputable, comprehensive, and widely used campus carbon calculator in the country. For these reasons, I have decided to use it as the primary tool to complete Evergreen's emissions inventory. When possible I followed their protocol. With this being said, a significant challenge with completing Evergreen's carbon inventory is the numerous judgment calls and decisions that must be made. For example, whether or not to include certain activities in the inventory such as emissions from the application of lawn fertilizer, transportation miles from food distribution centers, or student out-of-state travel during vacations, just to name a few. Other decisions concerned what to do with partial data sets, lack of data, and choosing between various methods of estimation. Therefore, understanding the decision-making process and details behind the numbers are important and will be a major focus in the remainder of this chapter.

CHAPTER 6

The Data Acquisition Process

Prior to using the Clean Air-Cool Planet Campus Carbon Calculator I highly recommend reading the latest version of their *User's Guide*. The *User's Guide* can be downloaded from the Clean Air-Cool Planet website (www.cleanair-coolplanet.org). This document provides a general overview of the data acquisition process.

It is important to note that the most time consuming part in the entire process of completing Evergreen's carbon inventory was acquiring the necessary data. Therefore, allow at least one month for the data acquisition process. To provide a frame of reference, I began the process of collecting Evergreen's inventory data in early February 2007. By the second week of April, I still had not received some transportation and refrigerant data. However, because I was asking Evergreen staff for this data for the first time, it took longer than I expect it to in the future. I made a considerable effort to explain to the various departments and personnel what the purpose of the study was, why I was doing it, and informing them that this data will be asked for again on a regular basis in the future. Therefore, I expect that this will help speed the process for future inventories. Regardless, because of busy schedules and data that are not easily available, Evergreen staff members will need time to meet your request. Furthermore, you must anticipate that you may have to make multiple requests for the same data. Be courteous but persistent in explaining the importance of these data. Explain that you will be using the data they provide to help meet an important strategic goal of the college.

Officially, I began the data acquisition process on February 1, 2007. On that date, I met with Paul Smith (director of facilities), Rich Davis (college engineer), and Azeem Hoosein (assistant director for planning and construction). I provided an overview of Evergreen's climate policy of carbon neutrality and why it is an important strategic goal of the college. Then, I informed them that completing a carbon inventory was a critical step in the process and how it will provide Evergreen with important information necessary for future decision-making. Because Rich Davis is a member of the Sustainability Task Force, he is already familiar with this goal and the process that led to it. This, of course, helped facilitate the meeting. I then projected the Carbon Calculator (via digital projector) and walked them through the spreadsheet.

For reasons of consistency, I followed the protocol of the Clean Air-Cool Planet Campus Carbon Calculator. Their calculator is divided into the following broad data collection categories:

- Institutional Data
- Energy
- Transportation
- Agriculture
- Solid Waste
- Refrigeration and other chemicals (PFC's, HFC's, SF6)
- Offsets

For each of these categories, the Clean Air-Cool Planet calculator specifies what data are needed (i.e. purchased electricity, natural gas consumption, air travel, etc.) and in what units (i.e. kWh, MMBtu's, miles traveled per year, etc.). As we went through the spreadsheet the facilities team helped me identify who within each department is likely to have the data I needed.

Following our meeting Rich Davis sent an email to all the individuals we identified informing them that I will soon be contacting them for specific data related to the college's sustainability and strategic planning goals. At this point I created a "Data Acquisition Journal" using Microsoft Excel. This allowed me to fully document all communications and dates of data requests and deliveries. The Journal was an invaluable resource as it allowed me to keep track of whom I contacted, when, what method (i.e. email, phone, personal conversation, meeting, etc.), and what the outcome was. Furthermore, with Excel's data sorting capabilities, I was able to reorganize the information by date, person, data category, etc. This allowed me to manage the data and was a great asset for organizational purposes. I would highly recommend that whoever undertakes Evergreen's next greenhouse gas inventory to create a similar data acquisition journal listing who you contacted, what department they are in, and what method of communication was successful. This will likely save you time and effort.

Starting on February 5, I began emailing the individuals identified during my meeting with the facilities staff. I made three general requests:

1. I specified that I would like to have the data by February 19;
2. I requested data for Evergreen's main Olympia campus, Tacoma campus, and Gray's Harbor program (if appropriate);

3. I asked for information dating back to 1990 (if possible).

In most cases, I followed-up this initial data request with other emails, phone calls, office visits, and small group meetings. Expectedly, I received some responses stating that two weeks was not enough time to meet my request. In these cases I negotiated as to how much time was needed and we agreed on a future date. Additionally, I learned early on that I would need to focus on the Evergreen campus. I included data for the Tacoma and Gray's Harbor programs when possible, but at this time little of this data was available. Finally, I received relatively little data prior to 2004. Either records have not been kept or were not easily accessible. The main problem occurred because of Evergreen's recent transition to the Banner system. Because of this seemingly accessible data was difficult to acquire without significant effort. For example, detailed institutional budget data was not easily accessible prior to 2004. With this being said, I had a really strong and reliable data set between the years 2004-2006 for Evergreen's main Olympia campus.

CHAPTER 7

The Step-by-Step Process in Completing Evergreen's Carbon Inventory:

Inventory Data, Calculations and Results

In order to track The Evergreen State College's progression towards carbon neutrality, Evergreen's greenhouse gas inventory will need to be completed on a regular basis. Because this procedure requires numerous data acquisitions, calculations, and frequent judgment calls, it is important to provide the reader with the rationale and step-by-step process for how Evergreen's carbon inventory was calculated.

The Clean Air-Cool Planet Campus Carbon Calculator (2006b) follows the emissions reporting protocol established by the Intergovernmental Panel on Climate Change, the World Business Council for Sustainable Development, and the World Resources Institute. The result of this is accounting principles and formulas that require specific units of measure. These units must be entered into the Clean Air-Cool Planet Carbon Calculator. However, the data I acquired from Evergreen and the data required by the calculator were often different. There are a few reasons why. First, sometimes Evergreen recorded their data in different units of measurement. For example, pounds instead of gallons. This form of inconsistency was the easiest to rectify. Second, Evergreen had only partial or incomplete data, in some cases. For example, only the last six months of air travel data was available for Fiscal Year 2005. Third, some data required by the calculator forces judgment calls or estimates from Evergreen's available data because of incomplete knowledge. For example, determining the productivity and therefore the metric tonnes of CO_2 offset by Evergreen's forest. Fourth, some data required by the calculator is not measured at Evergreen. For example, the Carbon Calculator asks for student commuter miles per year. However, obtaining this data is very difficult forcing estimations by extrapolating existing institutional data. Fifth, in some cases I decided to include data and certain activities not specified by Clean Air-Cool Planet's Campus Carbon Calculator. For example, I decided to include Evergreen's application of lawn fertilizer on campus grounds and the greenhouse gas emissions released in delivering food from our vendor's distribution centers to campus.

For each of these reasons, the inventory (at one level or another) is subjective. I was forced to make estimates and utilize available data in a manner that required my best judgment. Because of this it is important to highlight the rationale I used in the methodology.   I will do this by breaking down each general category of the inventory independently.

~ *Institutional Data* ~

Tracking institutional data is useful because it establishes a frame of historical reference. Obviously, significant changes in budget allocations, population or physical size can have a great influence over college activities and energy consumption and therefore greenhouse gas emissions. Therefore, institutional data should be recorded every year that an inventory is completed. Table 3 provides an overview of Evergreen's institutional data for Fiscal Years 2004–06.

Table 3*. Evergreen's Institutional Data for Fiscal Years 2004-06.*

Fiscal Year	Budget (dollars)		Population				Physical Size (sq ft)
	Operating Budget	Energy Budget	Full-Time Students	Part-Time Students	Faculty	Staff	Total Building Space
2004	$95,619,333.16	$1,499,980.95	3,872	538	224	495	1,618,039
2005	$90,384,806.57	$2,220,036.43	3,954	516	221	505	1,618,039
2006	$101,672,907.22	$2,410,483.48	3,909	507	232	502	1,618,039

Budget

- Data Requested: Total operating budget, research dollars, and energy budget from 1990 to 2006.
- Data Received: Operating budget and energy budget data from 2004-06.
- Data Received by: Accounting manager (Clifford Frederickson, CPA) and Executive Director of Operational Planning and Budget (Steve Trotter).
- Comments: Budget data prior to 2004 was unavailable within the specified period of time because of Evergreen's transition to the Banner system. Research dollars is not applicable because Evergreen does very little sponsored research. Finally, Pell awards were subtracted from the operating budget because this money simply moves through the system. Evergreen does not have financial control of these dollars and they are not used to operate the college.

Population

- Data Requested: Total number of full-time students, part-time students, faculty, and staff.
- Data Received: 1992-2006 full-time and part-time student enrollment; Operating budget and energy budget data from 2004-06.
- Data Received by: Office of Institutional Research and Assessment. This data is available on the Evergreen website at: http://www.evergreen.edu/institutionalresearch/factpage.htm

Physical Size

- Data Requested: Total building space and total research building space in square feet for Evergreen's Olympia and Tacoma campuses.
- Data Received: Total building space for Olympia and Tacoma campuses in square feet.
- Data Received by: Facilities College Engineer (Rich Davis).
- Comments: Evergreen does have research space within the Lab buildings; however, this is included in the total building space. Furthermore, Evergreen does not have buildings designated solely for research. Therefore, it was not necessary to account for total research building space required by the Carbon Calculator. The total building space number includes the campus core, shops, student housing, organic farm, and Tacoma campus. Construction of the Seminar II building was completed by 2004 and is therefore included in the total building space for 2004.

~ Energy ~

Energy use is fundamental to any carbon inventory. Generally speaking, emissions from either purchased electricity or on-campus stationary sources of energy are responsible for the vast majority of a campus's overall emissions. Therefore, tracking Evergreen's energy use over time is critical.

Purchased Electricity

Table 4 reveals the amount of greenhouse gases emitted from Evergreen's use of purchased electricity from Puget Sound Energy and Tacoma Power and Light between Fiscal Years 2004 and 2006. For each year the total amount of energy used, and therefore greenhouse gases emitted, increased.

***Table 4**. Evergreen's Greenhouse Gas Emissions from Purchased Electricity, Fiscal Years 2004-06.*

Fiscal Year	Purchased Electricity (kWh)	Emission Coefficients	Evergreen's Emissions (MTCDE)
2004	15,299,000	0.00054 MTCDE/kWh	**8,298**
2005	16,066,000	0.00054 MTCDE/kWh	**8,740**
2006	16,459,000	0.00054 MTCDE/kWh	**8,954**

- Data Requested: Kilowatt-hours of purchased electricity from Puget Sound Energy for Evergreen's Olympia, Tacoma, and Gray's Harbor programs from 1990 to 2006.
- Data Received: Megawatt-hours of purchased electricity from 2002-06 for Evergreen's main campus.
- Data Received by: Facilities College Engineer (Rich Davis).
- Comments: Multiplying megawatt-hours by 1000 converts the data to kilowatt-hours. When purchasing data from a provider one has the option of entering the standard fuel mix for the region or one can get more specific and enter a custom fuel mix. I contacted Puget Sound Energy to receive their power supply profile and entered this data. In 2005, Puget Sound Energy's fuel mix was: hydroelectric (42.10%), coal (36.35%), natural gas (18.92%), nuclear (1.12%), wind[12] (0.15%), and

[12] Wind power was expected to increase to 5% of Puget Sound Energy's power supply by the end of 2006 but this was not confirmed at the time of this writing.

other (1.36%). The "other" category included petroleum, waste to energy, and biomass. Since I did not have specific values for each I simply divided 1.36% by three and entered 0.45% for each category. Finally, Evergreen does not purchase steam or chilled water so there was no data to enter for these categories.

On-Campus Stationary Sources of Energy

Evergreen purchases natural gas and distillate oil #2 from Puget Sound Energy to produce steam in order to provide heat to the buildings. When Puget Sound Energy experiences high demand for natural gas they inform Evergreen and we purchase distillate oil until regional demand decreases. This is a contractual agreement between Puget Sound Energy and Evergreen. Evergreen does not co-generate electricity and therefore has no data to enter in the calculator.

Evergreen burns propane fuel to power a forklift, lab equipment, and for the fireplace in the Longhouse. Evergreen's combined use of natural gas, distillate oil #2, and propane fuel comprises Evergreen's on-campus stationary sources of energy that emit greenhouse gases (Table 5).

Natural Gas:

- Data Requested: MMBtu's of natural gas for Evergreen's Olympia, Tacoma, and Gray's Harbor programs from 1990 to 2006.
- Data Received: I received natural gas in therms from 2002-06 for Evergreen's main campus.
- Data Received by: Facilities College Engineer (Rich Davis).
- Comments: I had to convert from therms to MMBtu's. 1 therm = 100,000 Btu's and 1,000,000 Btu's = 1 MMBtu's. Or, 10 therms = 1 MMBtu. Therefore, all I had to do was divide the total number of therms by 10 in order to convert Evergreen's data into MMBtu.

Table 5. *Evergreen's Greenhouse Gas Emissions from On-Campus Stationary Sources, FY 2004-06.*

Fiscal Year 2004		**Consumption**	**Emission Coefficients**	**Evergreen's Emissions (MTCDE)**
Space Heating & Hot Water	Natural Gas	109,605 MMBtu	0.05300 MTCDE/MMBtu	**5,809**
	Distillate Oil #2	3,542 Gallons	0.01000 MTCDE/gallon	**35**
Forklift, Labs, Longhouse	Propane Use	250 Gallons	0.00500 MTCDE/gallon	**1**
				Total Emissions = 5,845
Fiscal Year 2005		**Consumption**	**Emission Coefficients**	**Evergreen's Emissions (MTCDE)**
Space Heating & Hot Water	Natural Gas	107,237 MMBtu	0.05300 MTCDE/MMBtu	**5,683**
	Distillate Oil #2	3,542 Gallons	0.01000 MTCDE/gallon	**35**
Forklift, Labs, Longhouse	Propane Use	250 Gallons	0.00500 MTCDE/gallon	**1**
				Total Emissions = 5,719
Fiscal Year 2006		**Consumption**	**Emission Coefficients**	**Evergreen's Emissions (MTCDE)**
Space Heating & Hot Water	Natural Gas	115,753 MMBtu	0.05300 MTCDE/MMBtu	**6,135**
	Distillate Oil #2	3,542 Gallons	0.01000 MTCDE/gallon	**35**
Forklift, Labs, Longhouse	Propane Use	250 Gallons	0.00500 MTCDE/gallon	**1**
				Total Emissions = 6,171

Distillate Oil #2:

- Data Requested: Gallons of distillate oil #2 for Evergreen's Olympia, Tacoma, and Gray's Harbor programs from 1990 to 2006.
- Data Received: 3,542 gallons of distillate oil #2 for 2006.
- Data Received by: Facilities Utility Services Specialist (Ed Rivera); Facilities Maintenance Mechanic (Patty Van de Walker); Introduction to Environmental Studies Program (Student Project – *Why we should care, why we must act: TESC Carbon Budget, Preliminary Report*, March 2007), instructed by Rob Cole and Dylan Fischer.[13]
- Comments: After several requests by email and during two guided tours of Evergreen's Central Utility Plant I had not received gallons of distillate oil used per year. But, I was told on several occasions that Evergreen's use of distillate oil is low (averaging about two weeks per). When in use, Evergreen burns about 253 gallons per day of oil. This information was stated by the facilities staff and corroborated in the Introduction to Environmental Studies student report. Therefore, I estimated that Evergreen uses about 3,542 gallons of distillate oil #2 per year (14 days per year multiplied by 253 gallons per day).

Propane:

- Data Requested: Gallons of propane for Evergreen's Olympia, Tacoma, and Gray's Harbor programs from 1990 to 2006.
- Data Received: 250 gallons per year.
- Data Received by: Facilities Maintenance Services (Sherry Parsons).

[13] A copy of this report can be requested by contacting Evergreen faculty member Rob Cole.

- Comments: Evergreen uses propane for a forklift, laboratory work in the Lab buildings, and for a fireplace in the Longhouse. Sherry informed me that Evergreen had previously used a 250-gallon propane tank that was filled on average less than once per year. In the fall of 2006, facilities removed the tank and are now using three cylinders that they take into town to have refilled. Since no specific records are kept I gave a high estimate of 250-gallons of propane used per year.

~ Transportation ~

College Fleet

Evergreen, like most colleges and universities, owns and maintains a fleet of vehicles. The decisions Evergreen makes regarding the purchase and operation of this fleet has a direct impact on our institutions greenhouse gas emissions. Therefore, it is important to keep track of Evergreen's fleet fuel use, as it is a direct contribution to global warming. Evergreen does maintain an electric fleet used by facilities personnel. However, charging these vehicles is not recorded in the transportation sector because the electricity used to recharge them is recorded under purchased electricity from Puget Sound Energy. Table 6 shows Evergreen's greenhouse gas

***Table 6**. Evergreen's Greenhouse Gas Emissions from College Fleet Vehicles, FY 2004-06.*

Fiscal Year 2004			
Fuel	**Consumption**	**Emission Coefficients**	**Evergreen's Emissions (MTCDE)**
Gasoline	25,111 gallons	0.009 MTCDE/gallon	**226**
Diesel	5,504 gallons	0.010 MTCDE/gallon	**55**
			Total Emissions = 281
Fiscal Year 2005			
Fuel	**Consumption**	**Emission Coefficients**	**Evergreen's Emissions (MTCDE)**
Gasoline	23,782 gallons	0.009 MTCDE/gallon	**214**
Diesel	5,768 gallons	0.010 MTCDE/gallon	**58**
			Total Emissions = 272
Fiscal Year 2006			
Fuel	**Consumption**	**Emission Coefficients**	**Evergreen's Emissions (MTCDE)**
Gasoline	25,550 gallons	0.009 MTCDE/gallon	**230**
Diesel	6,240 gallons	0.010 MTCDE/gallon	**62**
			Total Emissions = 292

emissions from the college fleet for Fiscal Years 2004-06.

Gasoline Fleet:

- Data Requested: Total gallons of gasoline purchased for Evergreen's Olympia, Tacoma, and Gray's Harbor programs from 1990 to 2006.
- Data Received: Total gallons of gasoline purchased from 2004-06 for Evergreen's main campus fleet.
- Data Received by: Facilities Maintenance Services (Sherry Parsons).
- Comments: Facilities keeps records for fuel consumption at Evergreen's motor pool garage gas pump. However, this does not include information for vehicles fueled off campus. For this information, Sherry had receipts recording the total dollar amount. By knowing the total amount of money spent on gasoline for the off-campus vehicle fleet, Sherry estimated the total gallons used based on the average cost of fuel. However, data for off-campus gasoline use was unavailable for the year 2004. Because of this I averaged the 2005 and 2006 data in order to estimate 2004 off-campus fleet fuel consumption. Based on this estimation, Evergreen's 2004 total fleet gasoline consumption was 25,111 gallons. In 2005, it was 23,782 gallons. And, in 2006, it was 25,550 gallons.

Diesel Fleet:

- Data Requested: Total gallons of diesel fuel purchased for Evergreen's Olympia, Tacoma, and Gray's Harbor programs from 1990 to 2006.
- Data Received: Total gallons of diesel purchased from 2004-06 for Evergreen's main campus fleet.
- Data Received by: Facilities Maintenance Services (Sherry Parsons).
- Comments: Again, similar to the data for gasoline use, gallons of diesel use were available from the motor pool and from an estimation of receipts. Once again, data for off-campus diesel use was unavailable for the year 2004 so I averaged the 2005 and 2006 data. Based on this estimation, Evergreen's 2004 fleet diesel fuel consumption was 5,504 gallons. In 2005, it was 5,768 gallons. And, in 2006, it was 6,240 gallons.

Food Delivery

There are many factors that ultimately decide what food Evergreen purchases and from whom. One of these factors should be the amount of greenhouse gases emitted as a result of the distance that Evergreen's food needs to travel to get to campus. In Fiscal Year 2006, the total distance traveled to bring food to Evergreen's main Olympia campus from our supplier's food distribution centers was 151,410 miles which emitted 126 metric tonnes of carbon dioxide equivalent (Table 7). See Appendix A for the complete list of vendors and the distance and frequency they traveled to campus. This data was unavailable for Fiscal Years 2004 and 2005.

***Table** 7. Evergreen's Greenhouse Gas Emissions from Food Delivery for FY 2006.*

Total Roundtrip Distance	Estimated Average Fuel Economy	Diesel Fuel	Emissions Coefficient	Evergreen's Emissions (MTCDE)
151,410 miles	12 mpg	12,618 gallons	0.01 MTCDE/gallon	**126**

Details Behind the Data:

- Data Requested: Total gallons of diesel fuel used to deliver food to the Evergreen campus in 2006 from our suppliers distribution centers.
- Data Received: Total roundtrip miles traveled from Evergreen's food suppliers (distribution centers) to camps for 2006.
- Data Received by: Director of Food Services for Aramark (Craig Ward).
- Comments: Ultimately, I had to make a rough estimate as to the average fuel economy and type of fuel use because I did not have information on what type of vehicles are used for food deliveries. I decided on 12 miles per gallon of diesel fuel as an estimated average.

Air Travel

- Data Requested: Faculty, staff, and student air miles traveled per year. This includes air travel for conferences, educational programs, awards, business trips, athletics, etc. that the institutional pays for. It does not include any personal travel. For example, student travel to and from home during breaks.

- Data Received: I received information on the airport of origin and destination city for each trip paid for by Evergreen. I received 5 months of information for 2005 and the complete year for 2006.
- Data Received by: Air Travel Department (Jennifer Dumpert).
- Comments: I had to calculate the number of miles between airport of origin and destination. I used Google Earth ruler to measure the distance between cities and corroborated this with an online airport calculator that is available online at: http://www.world-airport-codes.com. Once I determined the number of miles between airports I summed up the total for the year. For 2005, I only had data for five months (February – June). So, I determined the average air miles traveled per month and extended this for the other seven months to get an estimation for the year. The number of annual air miles I entered for 2006 is a low estimate because the air travel department did not have data for the number of flights that were originally purchased by Evergreen community members then reimbursed by the college. Though the Air Travel Department stated that reimbursement for air travel was uncommon. Table 8 shows the number of air miles traveled and the greenhouse gas emissions associated with it.

***Table 8**. Evergreen's Greenhouse Gas Emissions from Air Travel for FY 2005-06.*

Fiscal Year	Total Distance	Emissions Coefficient	Evergreen's Emissions (MTCDE)
2005	1,819,099 miles	0.00078 MTCDE/mile	**1,419**
2006	1,380,178 miles	0.00078 MTCDE/mile	**1,077**

Commuters

Evergreen is located several miles from the nearest urban area (Olympia) and does not provide enough living accommodations for all of its community members. As a result, many faculty, staff, and students either choose or are forced to commute several miles to get to work or to attend classes at Evergreen. Transportation to and from campus can be a significant contribution to Evergreen's overall greenhouse emissions. Ultimately, the approximate number of gallons of gasoline and diesel fuel used per year is needed to determine overall emissions from commuter habits.

Unfortunately, this data is difficult to come by. Parking Services does a thorough job of conducting daily parking lot counts. This information tells how many cars are in the parking lot at any one time, but fails to account for how far they have driven to get to campus, whether the driver has come alone or part of a carpool, and what the turnover is. In other words, in all likelihood many community members commute to Evergreen and stay for part of the day and are replaced by other commuters. Parking lot counts do not track different vehicles coming and going into the parking area (only the number of open parking spaces).

Parking Services also conducts "random moment counts." One day per quarter, staff will count the number of vehicles and the number of passengers within each vehicle driving into Evergreen's main entrance (McCann Plaza). However, this method also has several limitations when determining the number of commuter miles per year. First, the counts where done on the same day each quarter (Thursday). This can be problematic because some days of the week are very busy while others are relatively quiet. Counting the same day every quarter may lead to results that are far above or far below the average. Second, the counts started at 8:30am which means that a fair number of commuters are likely missed from 7:00-8:30am. Third, commuters parking at the Dorm Loop or any of Evergreen's other entrances are not counted in the survey. Fourth, counts do not reveal whether the commuters are students coming to campus three times per week or staff arriving everyday. Fifth, random counts do not reveal how far the commuter has traveled. Additionally, I did not have random count data for 2006. For these reasons, I decided not to use the data from either the daily parking lot counts or the random moment counts.

So, how did I estimate the average number of gallons used per year? Four questions need to be answered:

1) How many commuters are there and how do they get to campus (i.e. drive personal vehicle alone, carpool, public transportation, etc.)?
2) How far do they travel?
3) How many times per week do they commute?
4) What is the fuel efficiency of the vehicle(s) they use to get to campus?

Fortunately, the answers for each of these questions can be estimated using existing institutional data.

Faculty/Staff Gasoline:

The first step is to estimate the number of gallons of gasoline used by faculty and staff on an annual basis to get back and forth to work. Estimating this was possible from data contained in Evergreen's 2005 Commute Trip Reduction Survey Report. This report is available through the Parking Supervisor (Susie Seip) in Parking Services. The easiest way to break this down is to look at each of the above questions in turn.

1) How many commuters are there and how do they get to campus (i.e. drive personal vehicle alone, carpool, public transportation, etc.)?
   According to the 2005 Commute Trip Reduction Survey, 71% of Evergreen employees drive alone to work and 24% carpool.
2) How far do they travel?
   The average home to work distance was 13.3 miles or 26.6 miles roundtrip.
3) How many times per week do they commute and how many weeks per year do they work?
   Employees who drive alone do so 4.1 times per week. Those who carpool do so three times per week. The average Evergreen employee works 48 weeks per year. Evergreen's payroll manager (Ladronna Herigstad) informed me that staff members have 10 days off per year for holidays and receive a minimum of four days of leave per year. So, the average staff member works 50 weeks per year with 2 weeks of vacation/holiday time. Additionally, I estimated that faculty members work on average 44 weeks per year (there are 4 quarters with 11 weeks per quarter). Because there is more than twice as many staff as faculty the weighted average comes out to be 48 weeks per year for the average Evergreen employee.
4) What is the fuel efficiency of the vehicle(s) they use to get to campus?
   Students working in the Parking Office who were also enrolled in the 2007 Introduction to Environmental Studies program estimated that vehicles registered through parking services average 24.3 miles per gallon.

With all of the necessary information in place, it is now possible to estimate the metric tonnes of carbon dioxide equivalent emitted annually by Evergreen employees commuting back and forth to work.

Calculations:

Employees who drive alone:

Step 1: Determine total annual miles traveled:

(Total # employees) x (% that drive alone) x (# of trips per week) x (roundtrip distance) x (# weeks per year) = total annual miles traveled.

Step 2: Determine total gallons of fuel used per year:

(Total annual miles traveled) / (average miles per gallon of Evergreen fleet) = gallons of gasoline used annually.

Step 3: Determine the metric tonnes of carbon dioxide equivalent:

(Gallons of gasoline used annually) x (gasoline's emissions factor) = total amount of metric tonnes of carbon dioxide equivalent emitted annually from Evergreen employees who drive alone to work.

Employees who carpool:

Step 1: Determine total annual miles traveled:

(Total # employees) x (% that carpool) x (# of trips per week) x (roundtrip distance) x (# weeks per year) = total annual miles traveled.

Step 2: Determine total gallons of fuel used per year:

(Total annual miles traveled) / (average miles per gallon of Evergreen fleet) = gallons of gasoline used annually.

Step 3: Determine the metric tonnes of carbon dioxide equivalent:

(Gallons of gasoline used annually) x (gasoline's emissions factor) = total amount of metric tonnes of carbon dioxide equivalent emitted annually from Evergreen employees who carpool to work.

See Table 9 for an overview of Evergreen employee commuter habits.

Student Gasoline:

Determining an estimate for the number of gallons of gasoline used by student commuters follows the same methodology for employees. However, since the Commute Trip Reduction Survey only questions employees, I had to find another source for the information. This came from the Evergreen Student Experience Survey 2006 conducted by the Office of Institutional Research and Assessment.

Table 9. *Employee Commuter Habits that Contribute to Evergreen's Overall Greenhouse Gas Emissions.*

Employees that Drive Alone: Single Occupancy Vehicle (SOV)

Year	Employees that Drive Alone	Trips Per Week	Roundtrip Miles	Weeks Per Year	Annual Miles Traveled	Average Miles Per Gallon	Gallons Per Year	Gasoline Emissions Coefficient	**Total MTCDE**
2004	510	4.1	26.6	48	2,672,354	24.3	109,973	0.009	**990**
2005	515	4.1	26.6	48	2,698,371	24.3	111,044	0.009	**999**
2006	521	4.1	26.6	48	2,728,105	24.3	112,268	0.009	**1,010**

Employees that Car Pool: Estimated Average is 2.5 Passengers Per Vehicle

Year	Employees that Carpool	Trips Per Week	Roundtrip Miles	Weeks Per Year	Annual Miles Traveled Per Commuter	Average Miles Per Gallon	Gallons Per Year Per Person	Gasoline Emissions Coefficient	**Total MTCDE**
2004	173	3	26.6	48	264,390	24.3	10,880	0.009	**245**
2005	174	3	26.6	48	266,964	24.3	10,986	0.009	**247**
2006	176	3	26.6	48	269,905	24.3	11,107	0.009	**250**

Let's once again answer each of the necessary questions:

1) How many commuters are there and how do they get to campus (i.e. drive personal vehicle alone, carpool, etc.)?

   According to the 2006 Student Experience Survey, 56.3% of Evergreen students drive alone to work and 17.7% carpool.

2) How far do they travel?

   The average home to campus distance was 13.3 miles or 26.6 miles roundtrip.

3) How many times per week do they commute and how many weeks per year do they work?

   Students who drive alone do so 2.9 times per week; those who carpool do so 2.1 times per week; and those who take the bus do so 3.1 times per week. The average Evergreen student commutes to campus 44 weeks per year. This, of course, is an estimate. I figured four quarters per year with 11 weeks per quarter.

4) What is the fuel efficiency of the vehicle(s) they use to get to campus?

   Once again, I obtained this information from the research done by the students working in the Parking Office (who were also enrolled in the 2007 Introduction to Environmental Studies program). They estimated that vehicles registered through parking services average 24.3 miles per gallon.

Once again, with all of the necessary information, it is now possible to estimate the metric tonnes of carbon dioxide equivalent emitted annually by Evergreen students commuting back and forth to classes.

Calculations:

Students who drive alone:

Step 1: Determine total annual miles traveled:

(Total # students) x (% that drive alone) x (# of trips per week) x (roundtrip distance) x (# weeks per year) = total annual miles traveled.

Step 2: Determine total gallons of fuel used per year:

(Total annual miles traveled) / (average miles per gallon of Evergreen fleet) = gallons of gasoline used annually.

Step 3: Determine the metric tonnes of carbon dioxide equivalent:

(Gallons of gasoline used annually) x (gasoline's emissions factor) = total amount of metric tonnes of carbon dioxide equivalent emitted annually from Evergreen students who drive alone to work.

Students who carpool:

Step 1: Determine total annual miles traveled:

(Total # students) x (% that carpool) x (# of trips per week) x (roundtrip distance) x (# weeks per year) = total annual miles traveled.

Step 2: Determine total gallons of fuel used per year:

(Total annual miles traveled) / (average miles per gallon of Evergreen fleet) = gallons of gasoline used annually.

Step 3: Determine the metric tonnes of carbon dioxide equivalent:

(Gallons of gasoline used annually) x (gasoline's emissions factor) = total amount of metric tonnes of carbon dioxide equivalent emitted annually from Evergreen students who carpool to campus.

See Table 10 for an overview of student commuter habits.

Table 10. *Student Commuter Habits that Contribute to Evergreen's Overall Greenhouse Gas Emissions.*

Students that Drive Alone: Single Occupancy Vehicle (SOV)

Year	Students that Drive Alone	Trips Per Week	Roundtrip Miles	Weeks Per Year	Annual Miles Traveled	Average Miles Per Gallon	Gallons Per Year	Gasoline Emissions Factor	**Total MTCDE**
2004	2,331	2.9	26.6	44	7,913,087	24.3	325,641	0.009	**2,931**
2005	2,371	2.9	26.6	44	8,048,762	24.3	331,225	0.009	**2,981**
2006	2,344	2.9	26.6	44	7,955,127	24.3	327,371	0.009	**2,946**

Students that Car Pool: Estimated Average is 2.5 Passengers Per Vehicle

Year	Students that Carpool	Trips Per Week	Roundtrip Miles	Weeks Per Year	Annual Miles Traveled Per Commuter	Average Miles Per Gallon	Gallons Per Year Per Person	Gasoline Emissions Factor	**Total MTCDE**
2004	733	2.1	26.6	44	720,596	24.3	29,654	0.009	**667**
2005	746	2.1	26.6	44	732,951	24.3	30,163	0.009	**679**
2006	737	2.1	26.6	44	724,425	24.3	29,812	0.009	**671**

Public Transportation – Intercity Transit (Bus):

Public transportation is also available to the Evergreen community. Intercity Transit provides two bus routes to the Evergreen campus: routes 41 and 48. These buses run regardless of how many community members take advantage of the transportation. Therefore, in order to determine total emissions, it is necessary to calculate the total metric tonnes of carbon dioxide equivalent emitted by the two buses that service Evergreen without factoring in the number of riders. With this being said, there is an obvious advantage to increasing ridership on the bus. For example, the bus will emit the same amount of metric tonnes of carbon dioxide equivalent whether one person takes the bus or forty.

Determining an estimate for the number of gallons of fuel used by the two buses servicing Evergreen one needs to ask:

1) What is the number of times per week each bus stops at Evergreen?
2) What is the distance from downtown to the campus?
3) What type of fuel is used and what are the average miles per gallon?

Again, I will answer each of these questions in turn:

1) What is the number of times per week each bus stops at Evergreen? Route 41 makes 216 trips to Evergreen per week and route 48 makes 135 trips

per week. This information came from the students working in Parking Services who also conducted Evergreen's carbon budget preliminary report.

2) What is the distance from downtown to the campus? Bus 41 makes a 13.4-mile loop from downtown to campus and bus 48 makes a 13-mile loop. This information also came from the students working in Parking Services who conducted Evergreen's carbon budget preliminary report.
3) What type of fuel is used and what are the average miles per gallon? The bus uses ultra low sulfur B20 diesel fuel and gets 4.7 miles per gallon. This information can be obtained from the Intercity Transit website at: http://www.intercitytransit.com/page.cfm?ID=0075. It is important to note that according to the EPA, B20 biodiesel emits the same level of greenhouse gases as regular diesel (EPA, 2002a). The advantage to biodiesel is of course that it is renewable.

Equipped with all of the necessary information, it is once again possible to estimate the metric tonnes of carbon dioxide equivalent emitted annually by the two bus routes that service the Evergreen campus.

Community members who use public transportation (bus):

Step 1: Determine total annual miles traveled:

(Total trips per week) x (miles per trip) x (# weeks per year) = total annual miles traveled.

Step 2: Determine total gallons of fuel used per year:

(Total annual miles traveled) / (average miles per gallon of buses 41 and 48) = gallons of gasoline used annually.

Step 3: Determine the metric tonnes of carbon dioxide equivalent:

(Gallons of gasoline used annually) x (biodiesel (20% biodiesel; 80% diesel mix) emissions factor) = total amount of metric tonnes of carbon dioxide equivalent emitted annually from the two buses that service the Evergreen Campus.

See Table 11 for an overview of Intercity Transit emissions in metric tonnes of carbon dioxide equivalent.

Table 11. *Public Transportation (Bus): Employee and Student Use.*

Intercity Transit: The Bus uses B20 Ultra Low Sulfur Diesel

Year	Total Trips Per Week	Total Miles Per Week	Weeks Per Year	Annual Miles Traveled	Average Miles Per Gallon	Gallons Per Year	Biodiesel Emissions Factor	**Total MTCDE**
2004	351	4,649	52	241,769	4.7	51,440	0.01	**514**
2005	351	4,649	52	241,769	4.7	51,440	0.01	**514**
2006	351	4,649	52	241,769	4.7	51,440	0.01	**514**

Year	% that Bus	Employees that take the Bus	% that Bus	Students that take the Bus	Evergreen Commuters that take the Bus	Total MTCDE	MTCDE Per Evergreen Commuter	**Pounds Per Person Per Year**
2004	6	43	29	1,180	1,223	514	0.42	**924**
2005	6	44	29	1,200	1,244	514	0.41	**902**
2006	6	44	29	1,186	1,230	514	0.42	**924**

Finally, by adding the sums together (the values of step 3 above from each section) we can get the grand total metric tonnes of carbon dioxide equivalent emissions from Evergreen's commuter habits for Fiscal Years 2004-06 (Table 12**)**.

Table 12. *Evergreen's Total Commuter Greenhouse Gas Emissions (MTCDE).*

	Single Occupancy Vehicles			Carpool			Intercity Transit	**TOTAL EMISSIONS (MTCDE)**
Year	Employees	Students	Total	Employees	Students	Total	Total	
2004	989.8	2930.8	3920.6	244.8	667.2	912.0	514.4	**5347.0**
2005	999.4	2981.0	3980.4	247.2	678.7	925.9	514.4	**5420.7**
2006	1010.4	2946.3	3956.7	249.9	670.8	920.7	514.4	**5391.8**

Table 13. *Comparison of Greenhouse Gases Emitted Per Person for Different Commuter Habits. Carpooling significantly reduces greenhouse gas emissions per commuter. Commuters who take the bus also have a much smaller greenhouse gas footprint than those who drive alone. As bus ridership continues to increase the emissions per person decreases.*

	Employees				**Students**				**Intercity Transit**	
	Drive Alone: SOV		Carpool		Drive Alone: SOV		Carpool		Bus	
Year	MTCDE Per Person Per Year	lbs Per Person Per Year	MTCDE Per Person Per Year	lbs Per Person Per Year	MTCDE Per Person Per Year	lbs Per Person Per Year	MTCDE Per Person Per Year	lbs Per Person Per Year	MTCDE Per Person Per Year	lbs Per Person Per Year
2004	1.94	4,265	0.57	1,248	1.26	2,766	0.36	801	0.42	924
2005	1.94	4,265	0.57	1,248	1.26	2,766	0.36	801	0.41	902
2006	1.94	4,265	0.57	1,248	1.26	2,766	0.36	801	0.42	924

However, it is also instructional to know the average emissions per person for each mode of commuting. For those who drive alone this is straightforward: take the total metric tonnes of carbon dioxide equivalent and divide it by the total number of commuters who drive alone to campus. For those who carpool, take the total metric tonnes of carbon dioxide equivalent, divide it by the total number of commuters who carpool, then divide it again by the average number of people in each carpool. I estimated 2.5 people per carpool for the Evergreen community. For those who take the bus to campus, take the total metric tonnes of carbon dioxide equivalent and divide it by the total number of commuters who take the bus. Obviously, the more community members that take the bus, the smaller the emissions are per person. Increasing bus ridership is, therefore, one possible way to reduce Evergreen's overall greenhouse gas footprint. Table 13 provides an overview of metric tonnes and pounds of carbon dioxide equivalent emitted per person for the different types of commuter habits. Carpooling and taking the bus significantly reduces the level of greenhouse gas emissions per commuter.

Figure 6. *Greenhouse gas emissions per person for different commuter habits for in 2006. Commuters who Carpool and take the bus significantly lower their greenhouse gas emissions.*

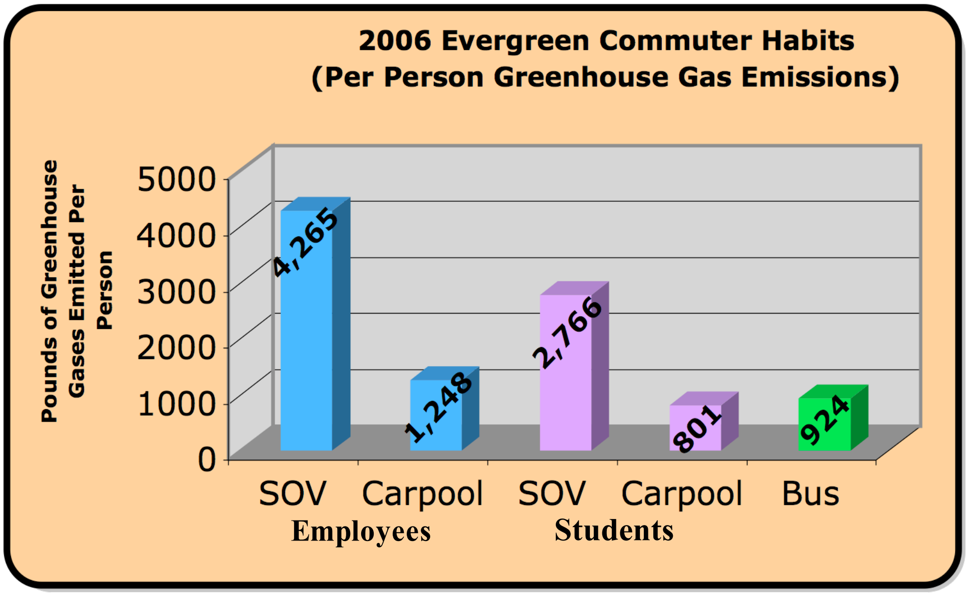


Figure 6 illustrates pounds of emissions per person for different commuter habits for Fiscal Year 2006. Both carpoolers and those who ride the bus to campus have a lower level of greenhouse gas emissions than commuters who drive alone.

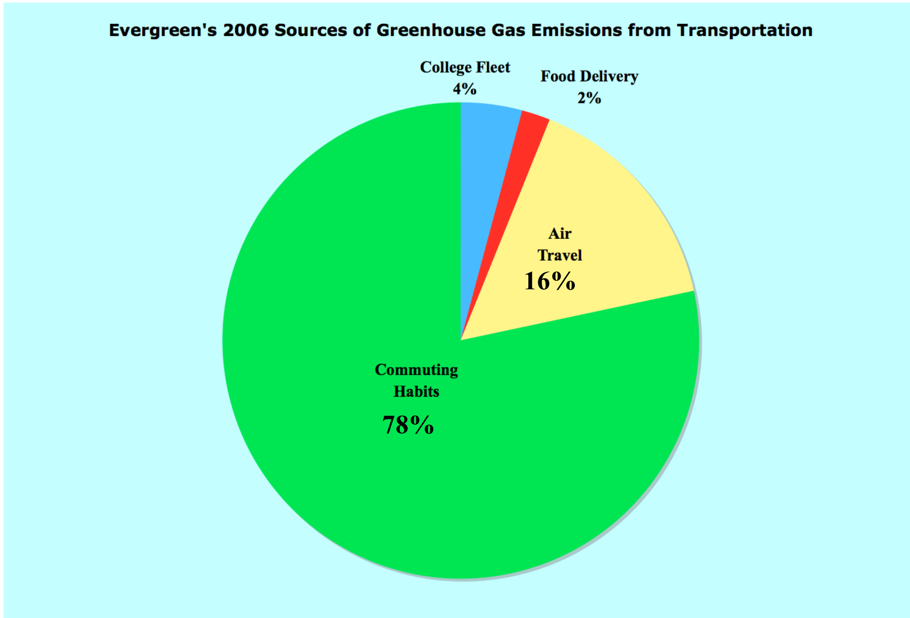
Table 14. *Evergreen's total greenhouse gas emissions in metric tonnes of carbon dioxide equivalent from the transportation sector for FY 2004-06. Commuting back and forth to campus is the greatest source of transportation emissions.*

Fiscal Year	College Fleet	Food Delivery	Air Travel	Commuting Habits	Evergreen's Total Transportation Emissions (MTCDE)
2004	281	NA	NA	5,347	**5,628.0**
2005	272	NA	1,419	5,421	**7,112.0**
2006	292	126	1,077	5,392	**6,887.0**

<u>Transportation Summary</u>

Commuting back and forth to campus is the main source of greenhouse gas emissions from the transportation sector (Table 14). However, air travel contributes another significant source of emissions contributing over 1,000 metric tonnes of carbon dioxide equivalents for Fiscal Years 2005 and 2006. Figure 7 illustrates the percentage of emissions coming from the different sources of transportation emissions for Fiscal

Figure 7. *Evergreen's 2006 Sources of Greenhouse Gas Emissions from Transportation. Commuting habits contribute the majority (78%) of Evergreen's transportation emissions.*



Year 2006. Commuting was responsible for over 78% of transportation emissions in 2006.

~ Fertilizer Application and Agricultural Practices ~

Any fertilizer used on campus that contains nitrogen will release nitrous oxides into the atmosphere and should be calculated in Evergreen's carbon inventory. Additionally, dairy animals from Evergreen's organic farm will also contribute methane to the atmosphere as they metabolize their food and as their waste decomposes (Clean-Air Cool-Planet, 2006b). Calculating emissions from fertilizer application and agricultural practices are a small percentage of Evergreen's overall emissions but they do contribute to global warming and are therefore worth tracking (Tables 15 and 16).

Fertilizer Application

- Data Requested: Pounds of synthetic and organic fertilizer used on campus per year and what percentage of nitrogen they contain.

Table 15. *Evergreen's Greenhouse Gas Emissions from Fertilizer Application on College Grounds including the Organic Farm for FY 2004-06.*

Fiscal Year	Organic Fertilizer	% Nitrogen	Emissions Coefficient	Evergreen's Emissions (MTCDE)
2004	8,200 pounds	22%	0.0038 MTCDE/lb	**6.9**
2005	8,140 pounds	22%	0.0038 MTCDE/lb	**6.8**
2006	8,125 pounds	22%	0.0038 MTCDE/lb	**6.8**

- Data Received: from 2004-2006 Evergreen applied 8,000 lbs of Wilbur Ellis organic based fertilizer containing 22% nitrogen (22-2-12) on campus grounds. On the organic farm it varied between years:
  - 2004: 200 pounds of Biogrow with 7% nitrogen (7-7-2);
  - 2005: 100 pounds of feathermeal and 40 pounds of BioGrow with 7% nitrogen (7-7-2);
  - 2006: 100 pounds of canola meal with 6% nitrogen (6-2.5-1) and 25 pounds of kelp meal with 14% nitrogen.
- Data Received by: Facilities Grounds and Motor Pool Manager (Mark Kormondy) and Organic Farm Manager (Melissa Barker).
- Comments: Annually, at least 97.6% of the fertilizer used on campus contains 22% nitrogen. Since the Carbon Calculator asks for only one percentage, I decided to sum the total weight of all the fertilizer used at Evergreen at 22% nitrogen. For example, for 2006, I entered 8,125 pounds of fertilizer containing 22% nitrogen. This amounts to an insignificant overestimate of the total amount of nitrogen applied as fertilizer. Annually, less than eight metric tonnes of carbon dioxide equivalent are emitted from Evergreen's campus-wide use of organic fertilizer (Table 15).

Table 16. *Evergreen's Greenhouse Gas Emissions from Animal Agriculture on the Organic Farm for FY 2004-06.*

Fiscal Year	# Swine (Pigs)	# Goats	# Poultry	Evergreen's Emissions (MTCDE)
2004	2	0	140	**1.4**
2005	0	0	145	**0.7**
2006	0	2	176	**1.1**

Animal Agriculture

- Data Requested: Average number of animals living on the Organic Farm from 2004-2006.

- Data Received:
    - 2004: 140 chickens and 2 pigs;
    - 2005: 130 chickens and 15 ducks;
    - 2006: 155 chickens, 12 ducks, 9 turkeys, and 2 goats.
- Data Received by: Organic Farm Manager (Melissa Barker).

~ Solid Waste ~

Solid waste includes mixed paper, co-mingle (glass and plastic), cardboard, aluminum, wood, ferrous metals, and garbage that ends up in a landfill. For the purposes of Evergreen's carbon inventory, I am only concerned about the amount of solid waste that ends up in a landfill (this does not include composted or recycled waste). Landfill waste will emit methane as it decomposes. However, different landfills have different techniques and methods for how it handles its solid waste and these different techniques result in different levels of greenhouse gas emissions. Therefore, it is important to know where Evergreen's waste ends up and how it is processed.

The facilities department trucks Evergreen's solid waste to the Hawk's Prairie Transfer Station in Lacey, WA. From Hawk's Prairie, it is trucked to Centralia, WA where it is loaded onto a train destined for Goldendale, WA. From Goldendale, Evergreen's landfill waste is trucked to the Roosevelt Landfill in Klickitat County, WA. The fuel used, and therefore greenhouse gas emissions, to transport Evergreen's solid waste from campus to the Hawk's Prairie Transfer Station is included in the College Fleet

Table 17*. Gallons of Diesel Fuel Per Year to Transport Landfilled Waste from Hawk's Prairie to Centralia, WA.*

Distance (Roundtrip): Hawk's Prairie – Centralia (miles)	64
Average Fuel Economy (mpg)	7
Diesel Fuel per Roundtrip (gallons)	9.1
Trucks Capacity (tons)	19.5
Annual Trips to Centralia	16
Gallons of Fuel per Year	**146**

data. However, the fuel used to bring Evergreen's waste from Hawk's Prairie to Centralia, WA is unaccounted for and ought to be included in the inventory. Approximately, 146 gallons of diesel fuel per year are used to transport Evergreen's landfilled waste to Centralia and this accounts for 1.5 metric tonnes of emissions (Tables 17 and 18).

I was unable to account for the amount of emissions to transport Evergreen's waste from Centralia to Goldendale via freight train on the Burlington Northern Santa Fe Railway (BNSF). To calculate this information one would need to know the fuel economy of the train, how many trips the train makes per year carrying Evergreen's solid waste, and what portion of the emissions Evergreen should be accountable for. Ultimately, this accounts for a very small percentage of Evergreen's overall emissions so I made a decision not to inquire about the train logistics for this inventory due to time constraints. Perhaps this is information could be included in future inventories.

What is important for carbon inventory purposes is that the Roosevelt Landfill practices methane recovery and generates electricity. The process of turning this methane gas into electricity ultimately reduces Evergreen's overall emissions footprint

***Table 18**. Evergreen's Greenhouse Gas Emissions from Landfilled Waste and from Transporting that Waste to the Roosevelt Landfill in Klickitat County, WA for FY 2004-06.*

Fiscal Year	Landfilled Waste (Short tons)	Emissions Coefficient	Evergreen's Emissions (MTCDE)	Diesel Fuel Per Year (Hawk's Prairie to Centralia)	Emissions Coefficient	Evergreen's Emissions (MTCDE)	Total Emissions from Landfilled Waste (MTCDE)
2004	311	0.1467 MTCDE/short ton	**45.6**	146	0.01 MTCDE/gallon	**1.5**	**47.1**
2005	318	0.1467 MTCDE/short ton	**46.7**	146	0.01 MTCDE/gallon	**1.5**	**48.2**
2006	319	0.1467 MTCDE/short ton	**46.8**	146	0.01 MTCDE/gallon	**1.5**	**48.3**

and therefore has a unique emissions coefficient (Table 18). It is important to record and track the amount of solid waste produced by the campus as it is an annual source of greenhouse gas emissions. Evergreen produces just over 300 short tons of landfilled waste per year that emits just under 50 metric tonnes of greenhouse gases annually (Table 18).

Landfill Waste

- Data Requested: Short tons of landfill waste per year.
- Data Received: pounds of solid waste from 2004-2006 Evergreen:
    - 2004: 622,990 pounds or 311 short tons;
    - 2005: 636,278 pounds or 318 short tons;
    - 2006: 637,200 pounds or 319 short tons.

- Data Received by: Facilities Motor Pool Coordinator (Sherry Parsons).
- Comments: I needed to convert pounds to short tons. The conversion is 1 short ton equals 2,000 pounds or 1 pound equals 0.0005 short tons.

Landfill Waste (Transported from Hawk's Prairie to Centralia):

- Data Requested: Total gallons of diesel fuel used in order to bring Evergreen's landfill waste from the Hawk's Prairie Transport Station to Centralia.
- Data Received: Average fuel economy (mpg), gallons of diesel fuel per roundtrip, annual trips to Centralia to bring Evergreen's landfill waste from Hawk's Prairie (Table 17).
- Data Received by: Introduction to Environmental Studies Program (Student Project – *Why we should care, why we must act: TESC Carbon Budget, Preliminary Report*, March 2007), instructed by Rob Cole and Dylan Fischer.[14]
- Comments: Because there was no separate category in the calculator for the amount of diesel used per year (146 gallons) to transport landfill waste, I entered this data under College Fleet (Diesel).

Table 19*. Evergreen's Annual Greenhouse Gas Emissions from HFC-134a Refrigerant Chemical Use in College Chiller, Refrigerators, and Water Coolers.*

Source	Estimated Rate of Loss Per Year	Emissions Coefficient	Evergreen's Emissions (MTCDE)
800-Ton Chiller	50 pounds	0.59 MTCDE/lb	**29.5**
Refrigerators	20 pounds	0.59 MTCDE/lb	**11.8**
Water Coolers (including drinking fountains)	5 pounds	0.59 MTCDE/lb	**3.0**

TOTAL EMISSIONS = 44.3

~ Refrigerant Chemicals ~

Evergreen has an 800-ton chiller, water fountains, and refrigerators across campus that use HFC-134a refrigerant. HFC-134a is a hydrocarbon that meets all the

[14] A copy of this report can be requested by contacting Evergreen faculty member Rob Cole.

required standards specified by the EPA in order to reduce the rate of ozone depletion. Unfortunately, hydrocarbons are powerful greenhouse gases. HFC-134a, for example, has a global warming potential of 1,300 (meaning that it is 1,300 times more potent as a greenhouse gas than carbon dioxide). Therefore, it is important to calculate the amount of HFC-134a refrigerant Evergreen uses on an annual basis. Currently, HFC-134a accounts for over 40 metric tonnes of greenhouse gas emissions annually (Table 19).

HFC-134a for 800-Ton Chiller

- Data Requested: Pounds of HFC-134a used on an annual basis.
- Data Received: Seventy-five pounds of HFC-134a refrigerant used per year. This was an estimate of refrigerant lost annually from Evergreen's 800-ton chiller, water fountains, and on-campus refrigerators.
- Data Received by: Facilities College Engineer (Rich Davis).
- Comments: York is the company that manufactures centrifugal water chillers and is responsible for checking and filling Evergreen's chiller. In order to get the amount of HFC-134a refrigerant that Evergreen uses, facilities had to contact them for this information. Unfortunately, they never returned facilities calls and Rich had to estimate the amount of refrigerant used on campus. This will be the last carbon inventory before Evergreen installs a new 1,000-ton chiller (also using HFC-134a). Therefore, Evergreen's emissions will increase from refrigerant chemical use in future inventories.

Table 20. *Evergreen's Gross Greenhouse Gas Emissions, FY 2004-06.*

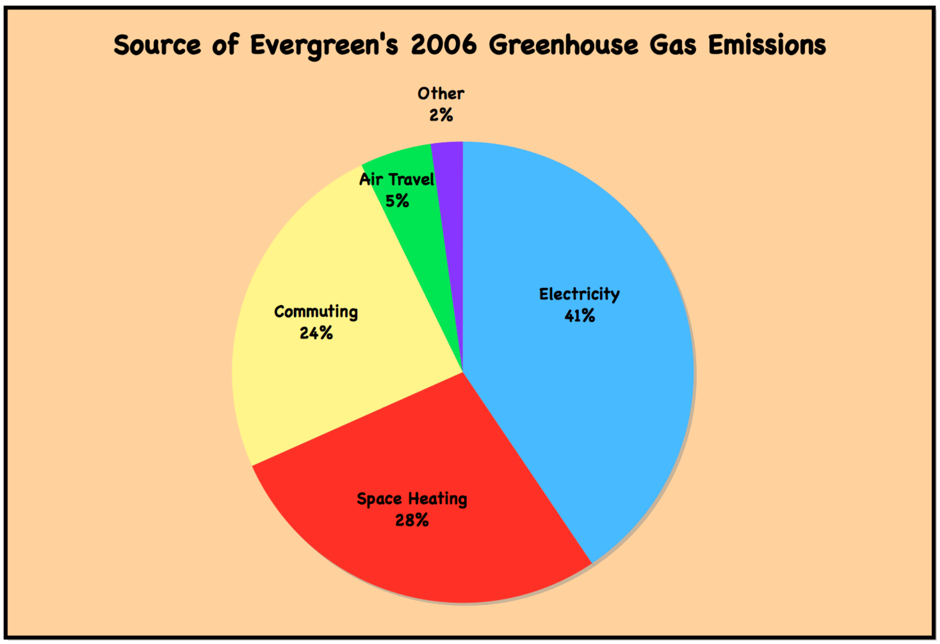
Source of Emissions	2004 Emissions (MTCDE)	2005 Emissions (MTCDE)	2006 Emissions (MTCDE)
Electricity	8,298	8,740	8,954
Space Heating/Hot Water	5,845	5,719	6,171
Commuting	5,347	5,421	5,392
Air Travel	NA	1,419	1,077
College Fleet	281	272	292
Food Delivery	NA	NA	126
Fertilizer/Animal Agriculture	8	8	8
Solid Waste	47	48	48
Refrigerant Chemicals (Space Cooling)	44	44	44
Total Greenhouse Gas Emissions:	**19,870**	**21,671**	**22,112**

~ *Evergreen's Gross Greenhouse Gas Emissions* ~

With only three years of reliable data it is difficult to make general statements about trends. However, one trend was clear. Evergreen's electricity use increased annually and comprises the single largest source of greenhouse gas emissions (Table 20). In fact, in 2006, Evergreen's electricity consumption *and* combustion of natural gas (for space heating) both increased from 2004 and 2005 levels. As a result, Evergreen emitted more metric tonnes of greenhouse gases in 2006 than in either 2004 or 2005. It should be noted however, that the 2006 inventory took into account more sources of emissions than the other two years. Specifically, Fiscal Year 2004 did not include air travel nor food delivery emissions, while Fiscal Year 2005 lacked food delivery data. Obviously, if these data were available gross emissions for the three years would be closer in value. Unfortunately, even when considering the absence of air travel and food delivery data in previous years, Evergreen's annual emission increased in 2006 taking us farther away from our goal of carbon neutrality.

Annually, purchased electricity, space heating, and commuting back and forth to campus account for over 90% of Evergreen's greenhouse gas emissions. In 2006, for example, these three sources of emissions accounted for 93% of Evergreen's 22,112

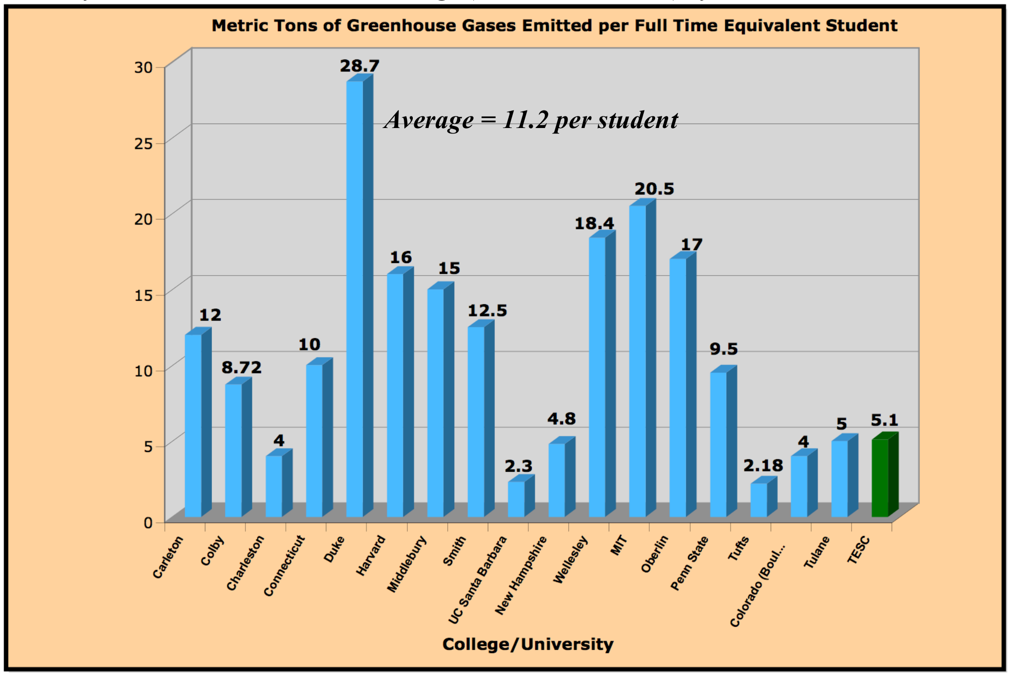
Figure 8. *Source of Evergreen's 2006 greenhouse gas emissions. Electricity consumption, combustion of natural gas for space and water heating, and commuting habits were responsible for 93% of Evergreen's gross emissions. The category "other" equals college fleet, food delivery, fertilizer and animal agriculture, solid waste, and refrigerants.*



metric tonnes of emissions (Figure 8). To put 22,112 metric tonnes in some kind of perspective, one pound of CO_2 could fill 120 party balloons. Therefore, on average, every student, faculty and staff member at Evergreen emits 1.1 million balloons worth of greenhouse gases.

How does this compare to other institutions? In short, quite well. The average of 17 other campuses (who have completed their carbon inventories) is 11.2 metric tonnes per full-time equivalent student (Figure 9). Evergreen averages less than half as much emissions (5.1 metric tonnes) per full-time equivalent student.

Figure 9. *Average greenhouse gas emissions per full-time equivalent student for 17 campuses across the U.S. Evergreen averages 5.1 metric tonnes per full-time equivalent student or less than half as much as the combined average (11.2 metric tonnes) of other schools.*



~ *Offsets* ~

Thus far we have examined Evergreen's activities that contribute to global warming by placing greenhouse gases into the atmosphere. However, Evergreen has also undertaken certain activities (composting and forest preservation) and initiated certain policies (Clean Energy Initiative) that partially offset our emissions. Generally, speaking, offsets are any activity that 1) removes greenhouse gases from the atmosphere (i.e. carbon sinks), 2) avoids adding greenhouse gases into the atmosphere (i.e. methane capture and destruction), or 3) increases the amount of energy produced from clean, renewable sources (i.e. investing in windfarm projects). The quantity of Evergreen's offsets are summed up in Table 21 and will be considered in turn below.

Table 21. *Evergreen's Annual Greenhouse Gas Offsets, FY 2004-06.*

Offsets	**2004 Offsets (MTCDE)**	**2005 Offsets (MTCDE)**	**2006 Offsets (MTCDE)**
Green Tags	0	0	6,584
Composting	18	28	4
Forest Productivity	757	757	757
Total Greenhouse Gas Offsets:	**775**	**785**	**7,345**

Evergreen Forest

The purest way for Evergreen to achieve carbon neutrality would be if the amount of greenhouse gases removed or absorbed from the atmosphere by Evergreen's forest and through composting equaled its total emissions. Evergreen contains 1,033 acres of forest on its Olympia campus. The trees within this forest, like all plants, store carbon. The United States Forest Service estimates that the average northwest forest contains 93 metric tonnes of stored carbon per acre (Birdsey, 1992). Using this value we can estimate the total amount of stored carbon in Evergreen's forest to be around 96,069 metric tonnes of carbon.

More importantly, as the trees on Evergreen's campus continue to grow they continue to remove carbon from the atmosphere through photosynthesis. More specifically, trees take in CO_2, water and sunlight and convert it into glucose ($C_6H_{12}O_6$). Glucose serves as food for further growth. Therefore, Evergreen's trees should not only be viewed as a carbon storage center but also as an annual carbon sink that may be calculated in the inventory. Does Evergreen's forest absorb enough carbon to render our college carbon neutral?

In order to determine the amount of carbon absorbed by Evergreen's trees, one needs to study the productivity or annual growth rate of the trees. Researchers at Evergreen are in the process of doing this now and preliminary results may be available later in 2007. I say preliminary because an accurate data set requires a multi-year study that mitigates a potential year where growth conditions were high above or below the norm. Either way, even these initial results were not available at the time of this inventory.

Even so, Evergreen's trees are only one component of Evergreen's forest ecosystem. In order to determine the role the forest plays in Evergreen's carbon inventory one needs to take a more holistic approach and measure total forest carbon. Measuring total forest carbon must consider each of the four forest components:

1) Trees – rate of growth and level of decomposition;

2) Understory Vegetation – saplings, shrubs, bushes, etc.;

3) Forest Floor – dead organic matter, litter humus, woody debris, etc.;

4) Soil – it is estimated that the vast majority of organic carbon in any forest ecosystem is locked up in the soil. Therefore, measuring the organic matter in the soil should be considered necessary when evaluating the role Evergreen's forest ecosystem plays in the carbon inventory.

The point is, Evergreen's forest is actually a separate carbon budget complete with its own sources and sinks. Trees not only absorb carbon (acting as a sink), but also "breathe" it out through respiration (acting as a source). The difference between a tree's rate of absorption and respiration of carbon is called its net primary productivity (NPP). Even determining NPP will not give a final answer to a forest's overall carbon budget. After all, leaves and trees themselves decompose and release carbon after death. Determining rates of decomposition, soil types, species of trees present, their age class, other kinds of plant species, animal species, and natural disturbances (such as fires, wind storms, insect outbreaks, etc.) all interact affecting the forest's overall rate of carbon budget. Complex indeed. Once again the United States Forest Service researchers have estimated that the average northwest forest absorbs 0.568 metric tonnes of carbon per acre per year (Birdsey, 1992). Using this figure reveals that Evergreen's total forest carbon sequestration is approximately 586.7 metric tonnes per year.

Unfortunately, the forest ecosystem contained on Evergreen's campus may be profoundly different in character and composition than a forest found in south central Alaska or interior Idaho. Therefore, any estimation over this vast region may not leave us feeling very confident in these numbers. On the spot field study would help remove some of the uncertainty in the numbers. Fortunately, Evergreen has a team of researchers along with committed academic programs that have already initiated a long-term in-depth study of Evergreen's forest. Over the years, their research will contribute data to the rate of sequestration of Evergreen's forest. Their work is titled The Evergreen Ecological Observation Network (EEON) and information is available from their website at http://academic.evergreen.edu/projects/EEON/. Also, I suggest that whoever completes Evergreen's next carbon inventory checks directly with Evergreen faculty members

Dylan Fischer, Carri LeRoy, and Paul Przybylowicz. They oversee the EEON project and can be an invaluable source of information on forest carbon sinks.

For this inventory, I used the research from the 2007 Introduction to Environmental Studies program (co-taught by Dylan Fischer and Rob Cole). The students here combined data specific to Evergreen's forest structure along with peer-reviewed research on rates of forest sequestration to make an initial estimation for Evergreen's forest. They concluded that Evergreen's forest sequesters approximately 757 metric tonnes of carbon dioxide equivalent every year.

Composting

According to the EPA (2002b), composting can lead to carbon sequestration for a few different reasons. First, adding compost to depleted soils raises the overall carbon level of the soil by adding organic matter. Second, nitrogen (contained in compost) stimulates increased plant growth that serves as a carbon sink. Third, composting stabilizes carbon compounds, such as humic substances, that can be stored in the soil for long periods of time (over 50 years). For these reasons, it is worth recording how much composting Evergreen does and the estimated amount of annual carbon sequestration (Table 22).

***Table 22**. Evergreen's Rate of Greenhouse Gas Sequestration from Composting at the Organic Farm for FY 2004-06.*

Fiscal Year	Composting	Sequestration Coefficient	Evergreen's Rate of Sequestration (MTCDE)
2004	100 short tons	0.18 MTCDE/short ton	**18.0**
2005	150 short tons	0.18 MTCDE/short ton	**27.0**
2006	23 short tons	0.18 MTCDE/short ton	**4.1**

- Data Requested: The amount of compost per year in short tons.
- Data Received: short tons of compost per year from 2004-2006:
  - 2004: 100 short tons;
  - 2005: 150 short tons;
  - 2006: 23 short tons.
- Data Received by: Organic Farm Manager (Melissa Barker).
- Comments: In 2006, the Organic Farm experienced problems with their composting facility and was forced to significantly reduce the amount of food scraps they were able to accommodate.

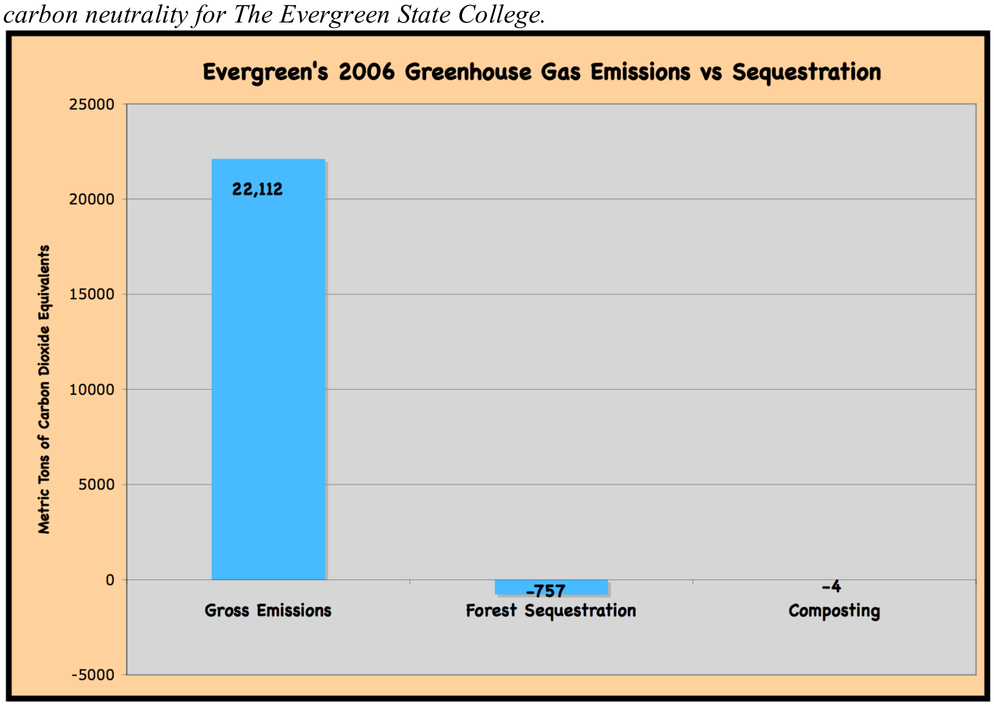
Annually, forest sequestration combined with carbon intake from composting accounted for a small percent of Evergreen's annual rate of greenhouse gas emissions (Table 23). In other words, Evergreen's carbon budget is out of balance and strongly

Table 23. *Carbon Inventory: Evergreen's Net Greenhouse Gas Emissions, FY 2004-2006.*

Fiscal Year	Gross Emissions (MTCDE)	Sinks (MTCDE)		Net Emissions
		Forest Preservation	Composting	
2004	19,870	757	18	19,095
2005	21,671	757	28	20,886
2006	22,112	757	4	21,351

skewed towards the emissions side of the equation. In 2006, for example, Evergreen emitted 21,351 metric tonnes more greenhouse gases than it absorbed (Figure 10). This is problematic because Evergreen's forest may be at or near its maximum rate of carbon

Figure 10. *Evergreen's 2006 gross greenhouse emissions compared to the estimated rate of carbon sequestration from the forest ecosystem and composting. Any strategy focusing solely on increasing the rate of carbon sequestration from these two sources will not achieve carbon neutrality for The Evergreen State College.*



absorption. As forests continue to mature the annual rate of absorption is thought to decrease. And, composting alone cannot make up the difference. Evergreen would have to compost approximately 120,000 tons of food scrap annually to offset Evergreen's current emissions. This is 5,000 times greater than our current level of composting of 23 tons. Evergreen does not have the capacity or produce enough food scraps to make this a reality. Therefore, achieving carbon neutrality has to come from a combination of reducing overall emissions and purchasing carbon offsets from retail providers.

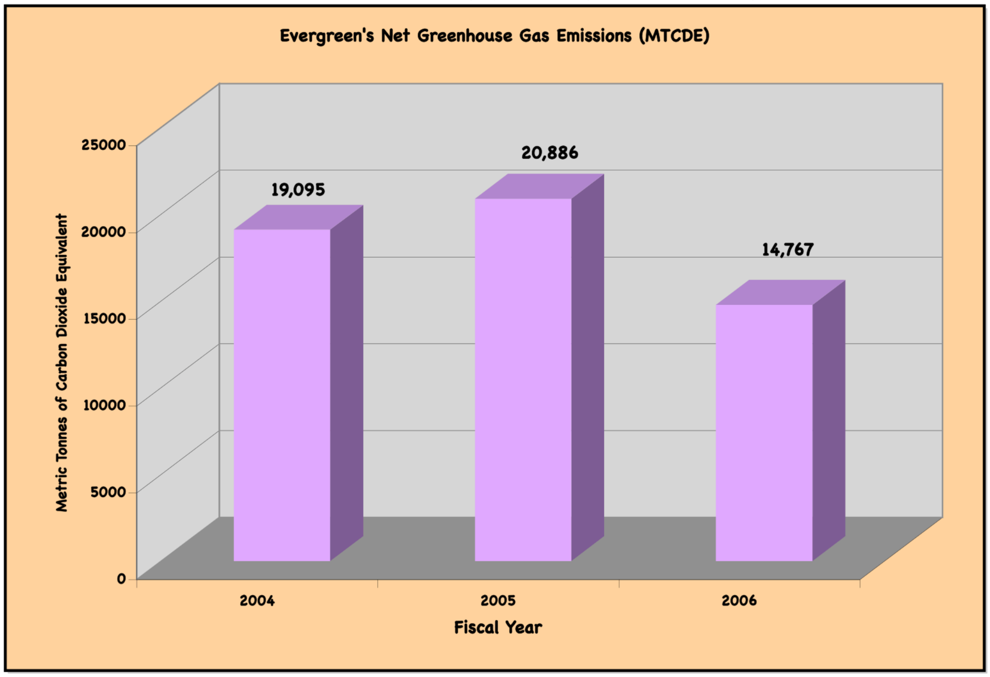
Renewable Energy Credits or Green Tags

In the winter of 2005, Evergreen students voted in favor (91% of those who voted, voted yes) of a self-imposed clean energy fee. As a result, every student currently pays $1.00 per credit, every quarter, in order to purchase Renewable Energy Credits or Green Tags from Evergreen's energy providers (Puget Sound Energy and Tacoma Public Utilities). Because of this student vote, Evergreen now offsets 100% of our electricity purchases with third party qualified renewable sources (wind, solar, biomass, etc.).

So, what exactly does this mean for Evergreen's carbon inventory? Simply put, it has the potential to balance Evergreen's emissions from electricity to zero. Why? Because for every megawatt-hour of electricity Evergreen uses, we pay for another megawatt-hour of electricity to be produced by a new clean energy facility. All in all, it means that Evergreen is investing in clean, renewable energy. Most importantly the money Evergreen spends to purchase Green Tags is invested in *new* green energy projects that might not otherwise be feasible. Puget Sound Energy purchases the Green Tags from the Bonneville Environmental Foundation that is Green-e certified. Green-e is a third party regulator who pre-certifies every Green Tag to assure that the money is spent on qualified renewable sources and that they are not double-counted. Because Evergreen buys Green Tags, and therefore pays for new clean, renewable energy production, Green Tags are frequently considered legitimate offsets for any institution's carbon budget. Regardless, purchasing Green Tags does not alleviate Evergreen's responsibility to reduce electricity consumption (as long as it contributes greenhouse gas emissions).

Evergreen began purchasing Green Tags in October of 2005. That was 3½ months into Fiscal Year 2006. As a result, Evergreen did not purchase enough Green Tags to offset the entire year. More specifically, Evergreen purchased 12.1 million kWh worth of Green Tags but used 16.5 million kWh of purchased electricity. Starting in Fiscal Year 2007, Evergreen will achieve its stated objective of offsetting 100% of its electricity purchases.

Figure 11. *Evergreen's annual net greenhouse emissions including purchase of Green Tags. In 2006, Evergreen's gross emissions were greater than in 2004 and 2005, however, Evergreen's net emissions in 2006 were lower because Evergreen offset 6,584 metric tonnes of emissions from the purchase of Green Tags from Puget Sound Energy.*



~ Balancing Evergreen's Carbon Budget ~

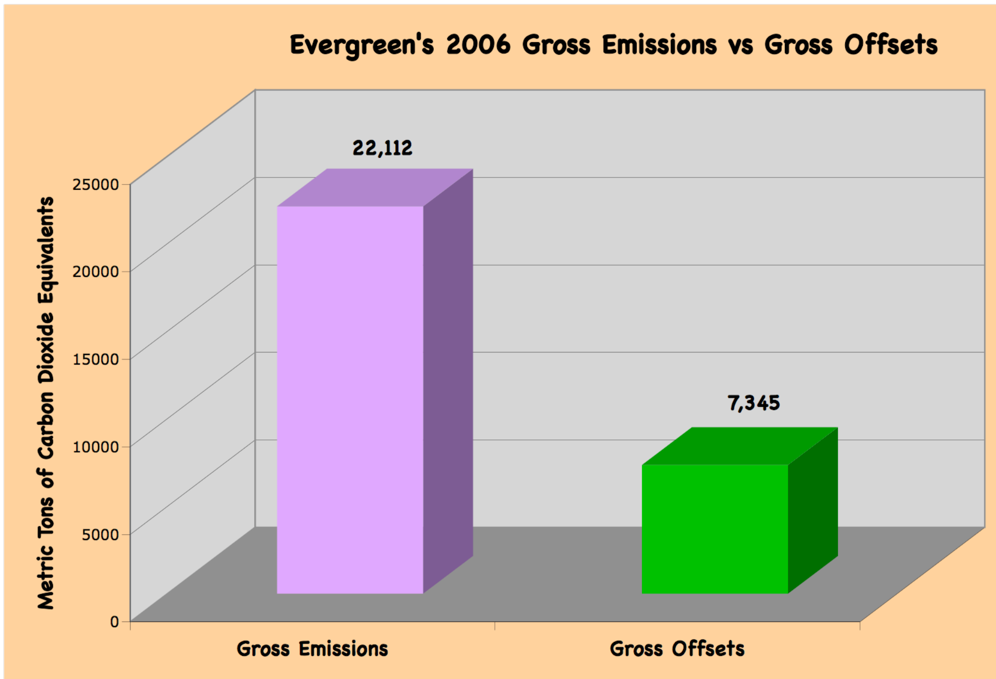
Once Evergreen's data is collected and converted into metric tonnes of carbon dioxide equivalent it is time to perform the calculation that will result in Evergreen's annual carbon budget. I had reliable data from 2004-2006. Therefore, I calculated a budget for those three years. For each year, I totaled the levels of emissions from the energy, transportation, agriculture, solid waste, and refrigerant chemicals sectors. The result is Evergreen's gross emissions. From this sum, I then subtracted the total offsets (Green Tags, composting, & forest productivity). The result is Evergreen's net emissions (Figure 11). In 2006, Evergreen's net greenhouse gas emissions were 14,767 metric tonnes of carbon dioxide equivalent (Figures 11 and 12). The Evergreen State College would need to reduce greenhouse gas emissions by over 1,000 metric tonnes per year to meet the specified goal of carbon neutrality by 2020.

~ Summary of Inventory Results: Key Discoveries ~

The process of completing The Evergreen State College's comprehensive greenhouse gas inventory and the results of that inventory has revealed several key discoveries. In summary, these discoveries are:

- ***Data acquisition is time consuming.*** By far the most time consuming aspect of completing Evergreen's greenhouse gas inventory was gathering the necessary data. I spent the better part of 10 weeks emailing, calling, and meeting with numerous community members in order to gather the necessary data. Whoever completes Evergreen's next inventory should allow for ample time to request and gather the necessary data.
- ***Purchased electricity, combustion of natural gas for space heating, and commuter habits account for over 90% of Evergreen's greenhouse gas emissions.***
- ***Evergreen's gross greenhouse gas emissions per full-time equivalent student (5.1 metric tonnes of carbon dioxide equivalent) are comparatively low.*** Again, the average of 17 different colleges equaled 11.2 metric tonnes per full-time equivalent student. Furthermore, Evergreen's value does not take into account any offsets. If one chooses to include net greenhouse gases per full-time equivalent student the value is much lower.
- ***Evergreen's commuter emissions are comparatively high.*** Evergreen's rural location means that many students and nearly all staff and faculty need to travel further distances to get to campus than most other institutions. As a result, 24% of all of Evergreen's greenhouse gases are emitted by commuters. This is a significantly higher proportion than most other institutions that I looked at.
- ***Evergreen will need to average a 1,000 metric tonne reduction of greenhouse gas emissions per year in order to achieve carbon neutrality by 2020.***
- ***Ultimately, Evergreen will need to purchase offsets from the retail market in order to accomplish carbon neutrality.*** That is, unless Evergreen somehow produces on-campus energy from clean, renewable sources *and* figures out a way to eliminate greenhouse gas emissions from commuting while at the same time increasing the rate of carbon uptake from our forest and compost.

Figure 12. *Evergreen's 2006 gross greenhouse emissions compared to Evergreen's gross offsets (the combined rate of carbon sequestration from the forest ecosystem, composting, and purchase of Green Tags from Puget Sound Energy). In 2006, Evergreen's net emissions were 14,767 metric tonnes of carbon dioxide equivalent. The Evergreen State College would need to reduce emissions by over 1,000 metric tonnes per year to meet the stated goal of carbon neutrality by 2020.*



CHAPTER 8

Where does Evergreen go from here?

Next Steps/Recommendations

- ***Establish Greenhouse Gas Data Collection as an Institutional Priority.*** Significantly reducing greenhouse gas emissions will not be easy. It will take a dedicated community who not only comprehends the issue but also is capable of making significant operational and behavioral changes. This sort of commitment requires strong administrative leadership. Evergreen's administration has already demonstrated that our college is dedicated to the issue of global warming. Now, they will need to communicate this to the rest of the Evergreen community. When change happens and difficult decisions are made (in order to reduce greenhouse gas emissions), the Evergreen community will need to understand, clearly, why these changes are important. The Evergreen community will need to understand the threats of global warming to our region as well as the opportunities available as a reward for decisive action.

  One immediate step the administration can take is to communicate the importance of Evergreen's carbon inventory. Because we already know that Evergreen's carbon inventory will need to be completed on a regular basis[15] and because we already know what data is needed, Evergreen's staff should collect the data in real-time and have it readily available upon request. The best way to make this happen is if it is clearly expressed and made a requirement by Evergreen's administration. In other words, staff members should be notified that they are expected to provide relevant greenhouse gas emissions data in a timely manner. To help facilitate this, I created a summary page (Appendix B) that lists what information is needed and what departments are expected to provide it.

  Obviously, one of my greatest concerns for whoever carries out the next inventory is that they will have to go through the process of explaining what the inventory is, why it is important, and what data they need all over again.

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[15] The Presidents Climate Commitment recommends that member institutions update their carbon inventory every two years and report this information to the Association for the Advancement of Sustainability in Higher Education (AASHE).

Repeating this process is so time consuming that I doubt whether any student, student group, or academic program could gather the data, perform the calculations, and summarize the results within a 10-week timeframe. Furthermore, I am concerned that the quality of the data will fail to improve or even degrade. These possibilities could jeopardize the completion of future inventories and threaten Evergreen's progress to reduce greenhouse gas emissions. On the other hand, if Evergreen's emissions data is routinely collected and readily available upon request, the quality and process of repeating Evergreen's carbon inventory will improve. Then, more energy can be spent on evaluating the results and communicating them to the Evergreen community.

Commuting habits are one specific problem. In order to evaluate the amount of annual fuel used by Evergreen commuters I had to rely on data extrapolated from Evergreen's 2005 Commute Trip Reduction Survey for staff and faculty. This data set sufficed for this inventory but it should be noted that a small percentage (27.4%) of Evergreen employees completed the survey and it is not random. Community members complete the survey on a volunteer basis – that could skew the results. For example, it is a possibility that staff and faculty members who use alternative modes of travel (i.e. walk, bus, carpool, etc.) are more likely to complete the survey because they are proud of their behavior. Furthermore, the Commute Trip Reduction Survey does not include information on student commuting behavior. For that information I relied upon the 2006 Student Experience Survey available through Institutional Research. Unfortunately, there is no guarantee that this survey will be repeated in the future. If not, the quality of the data would be degraded for a significant component of Evergreen's overall emissions. As previously mentioned, Parking Services currently conducts parking lot counts three times daily. As far as I know, this data is not being used by anyone and does not provide useful information for the carbon inventory. Perhaps these efforts can be changed to better capture appropriate data for all of Evergreen's commuters (i.e. ratio of drivers who commute alone, number of carpoolers, distance of commute, trips per week, weeks per year, etc.).

Air travel presents another potential problem. Unless the air travel department is notified that they are expected to provide annual air travel miles staff members will be forced to rifle through receipts again when it is time complete the next inventory. This is not only frustrating work but time consuming also. Furthermore, someone then has to calculate the distance traveled for each and every flight. Determining the distance between airports for hundreds of flights took two complete workdays. Because this is now important institutional data it should be captured at the time the flight is issued and maintained in a database that sums the total distance traveled of all flights. If the next inventory is completed in 2009, then it should not come as a surprise to anyone when air travel miles are requested once again.

- ***Rethink Goal of Carbon Neutrality by 2020. Change to Carbon Neutral by 2009?*** I strongly recommend that the Evergreen community achieve carbon neutrality by FY 2009. How? By purchasing greenhouse gas offsets from the retail market. Currently, Evergreen has the opportunity to invest in new renewable energy projects, reforestation projects, energy efficiency projects, methane capture and destruction projects, and others by purchasing offsets from any of 35 retail carbon offset providers.

  The average offset sells at $10/metric ton (Clean-Air Cool-Planet, 2006a). Therefore, Evergreen could become carbon neutral (at current levels of emissions) at an estimated cost of $147,670 annually (or 0.15% of Evergreen's 2006 operating budget). To be sure, there is widespread pushback coming from environmental groups and higher education institutions that it is improper to "purchase" one's way to carbon neutrality without making a substantial effort to reduce emissions. In Evergreen's case, this does not make much sense. There are several reasons why:

  1. I believe that "neutralizing" Evergreen's carbon footprint cannot wait until 2020 or any date too far into the future. Due to the severity of the problem and the need to reduce emissions as soon as possible, I think postponing investment in quality offset projects is immoral.
  2. It seems to be assumed that once a company or institution purchases offsets they will abandon their responsibility to further reduce emissions. In Evergreen's case this is highly unlikely. This community is far too principled to avoid responsibility on the global warming issue. It seems more than reasonable, that the best

policy would be a combination of establishing short-term reduction strategies and targets coupled with the purchase of high quality offsets.

3. Evergreen already has comparatively low per student emissions. In fact, as mentioned earlier, Evergreen's emissions per full-time equivalent student is less than half the average of other institutions. When has a "substantial effort" to further reduce emissions been reached? In Evergreen's case, it seems reasonable to conclude that this threshold has been achieved.
4. Everyday that goes by where Evergreen does not hold itself financially accountable for contributing to global warming is at best a statement that global warming is not a priority and at worse an affront to future generations. In essence, avoiding the purchase of carbon offsets is a statement that Evergreen does not believe it should internalize the cost of global warming and we are passing this burden on to future generations.
5. For nearly 2 years now Evergreen students have been digging into their pockets to purchase Green Tags from Puget Sound Energy. Student money has helped finance local wind projects and helped to increase clean, renewable energy coming into our regional electric grid. It is time for the rest of the Evergreen community to follow suit and equally contribute. This would be a wonderful message to Evergreen's student body and the rest of the Olympia community.
6. Evergreen could leverage its purchasing power to improve the retail offset market. Perhaps this is the most far-reaching and influential reason why Evergreen ought to purchase retail carbon offsets. Currently, there are no standards and no clear assurance that purchasing offsets meets the intended purpose. Through careful research and by demanding project transparency and evidence of additionality, Evergreen has the power to help improve the quality of offsets being provided to the average consumer. The fact is, the only way Evergreen and countless other institutions are going to achieve their carbon neutrality goals are through the

purchase of retail offsets. Evergreen can play an important role in helping to improve that market. And that brings me to my seventh and final point.

7. Eventually, Evergreen is going to have to purchase more offsets to meet the goal of carbon neutrality. So, why wait?

- ***Establish Short-term Emissions Reduction Targets.*** Regardless of when Evergreen achieves carbon neutrality (whether it is in 2020 as specified in the college's updated Strategic Plan or in 2009 as suggested above), our college needs to establish specific greenhouse gas reduction targets. Again, the ultimate goal is to reduce greenhouse gas emissions. This is even more important than achieving carbon neutrality. Therefore, I suggest the following challenging but feasible goals of reducing greenhouse gas emissions:
    - *15% below 2006 levels by 2012.* If this goal is established and achieved it would be a reduction of 3,317 metric tonnes of greenhouse gases by 2012.
    - *40% reduction of 2006 levels by 2020.* This would eliminate 8,845 metric tonnes of greenhouse gas emissions.
    - *80% reduction by 2050* (the target agreed upon by the Intergovernmental Panel on Climate Change to avoid the worst impacts of global warming). This would eliminate 17,690 metric tonnes of emissions leaving Evergreen with a gross emissions value of 4,422 metric tonnes.

  See Appendix C for a list of climate commitments and emissions reduction targets established by other institutions of higher education.
- ***Establish and Implement Greenhouse Gas Reduction Strategies.*** This involves research and a discussion worthy of another thesis. Nevertheless, it is an important next step if Evergreen is going to achieve significant emissions reductions. I would suggest that any strategy look at each of the three main contributors to Evergreen's gross emissions (purchased electricity, combustion of natural gas, and commuter behaviors) and determine short-term and long-term strategies to reduce emissions, piecemeal.

- ***The Sustainability Task Force Formally Establishes Global Warming as a Major Sustainability Issue and Dedicates itself to Advancing Evergreen's Global Warming Initiatives.*** As a result, the timely completion of future greenhouse gas inventories fall under the purview of the Sustainability Task Force.

CONCLUSION

Global Warming: A Year to Remember

How will this past year be remembered? Will it be remembered for today's horrific war in Iraq? How about the global war on terrorism? Will Americans long remember today's debate over immigration reform or the so-called domestic spy program? Hardly. Global warming, on the other hand, will be familiar to everyone, everywhere for a long time to come. Polar icecaps will continue to melt away while sea-level and global air temperature will continue to rise well into the next century. A hundred years from now, the consequences associated with those trends will influence everyday life. Lag times in the climate system, the long persistence time of atmospheric greenhouse gases, and the fact that global emissions continue to rise ensure that global warming will still be an issue for 22nd century citizens. Future generations will understand, clearly, that it was our 25 billion tons of annual greenhouse gas emissions that is the root cause of their climate problems. Historical records will also remind them how we basically ignored over 20 years of international scientific consensus that global warming was not only happening but that our activities were the driving force. So, how will future generations remember us? I am going to guess, unfavorably. However, it doesn't have to be this way. It is never too late to redefine our legacy. And, that is exactly what we are doing.

Changing The National and Global Conversation

Few could have imagined only one year ago how the issue of global warming would come to dominate the national conversation. Al Gore introduced Americans to an "Inconvenient Truth," Thomas Friedman encouraged Americans that "Green" is "The new Red, White and Blue," and Tom Brokaw emerged from retirement just to tell you "What You Need to Know" about global warming. And, if you don't watch much TV, then reading the headlines on any given day would have likely taught you something new about global warming. This past year also saw the U.S. Supreme Court rule that greenhouse gases are pollutants and that the EPA is responsible for regulating them. Just what kind of impact this decision will have is yet to be determined, but some are calling it the most important environmental decision the Supreme Court has made in decades.

Internationally, Britain's chief economist, Sir Nicholas Stern, published the most extensive report thus far detailing the economic impacts of global warming. The so-called Stern Review concluded that global efforts to reduce greenhouse gas emissions could cost the world about 1% of its annual GDP. While the impacts of global warming, under a "do nothing" scenario, could cost the world upwards of 20% of its annual GDP. And, of course, the most widely anticipated international report on global warming was also published this past year. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change ended any doubt as to whether global warming is happening and ended any reasonable doubt as to whether human activities are a main contributing factor.

From Talk to Action?

So, has all this talk led to any action? Yes. Many companies, organizations, institutions, and local governments have established climate policies. Most, like the U.S. Mayors Climate Protection Agreement, are commitments to reduce greenhouse gas emissions by a certain percentage by a certain date (i.e. 7% below 1990 levels by 2012). Others are striving for carbon neutrality. In fact, "carbon neutral" has become so pervasive that the New Oxford American Dictionary selected it as its 2006 "Word of the Year."

What does carbon neutral mean? As we have learned in this thesis, carbon neutrality is achieved when greenhouse gas emissions – through operations and daily activities – are balanced by other activities that offset or remove greenhouse gases from the atmosphere. If every nation, institution, organization, and individual accomplished this, then the human contribution to global warming would effectively end.

What About Evergreen?

As expected, Evergreen has been anything but passive. In November of 2006, Evergreen's Board of Trustees approved the updated Strategic Plan with the stated goal of "achieving carbon neutrality by 2020." Then, on January 18, 2007, President Les Purce joined the Leadership Circle of the Presidents Climate Commitment. An agreement to "achieve climate neutrality as soon as possible." And just recently, Evergreen's administration officially formed a Focus the Nation Steering Committee. The Committee – comprised of faculty, staff, and students – will be organizing a regional event dedicated to global warming solutions.

From Action to Action…

Indeed, for those long concerned about global warming this has been a year to remember. The level of national dialogue and policy implementation crossed a threshold. Global warming is officially mainstream. These are reasons to feel good, but not too good. Avoiding the most serious impacts of global warming will, according to most scientists, require an 80% reduction of greenhouse gas emissions by 2050.

Unfortunately, global emissions continue to rise (not decline as they ought to be). The U.S., which contributes around 22% of global emissions, is the world's leading laggard. A 2007 White House report to the United Nations was discouraging. It projected that the U.S. would increase 2000 level emissions 20% by 2020. China is another major concern. The Wall Street Journal recently reported that last year China built the equivalent of one large coal-fired power plant per week and (perhaps as early as November 2007) they will overtake the U.S. in gross emissions. Not even the Evergreen community can point fingers. According to our recently completed greenhouse gas inventory, our gross emissions have increased every year for the past three years.

Our Legacy

How will this past year be remembered? That depends on our ability to reduce emissions. All the talk and all the policies in the world won't make a difference until emissions begin to decline. The coming generation will not say, "Hey, at least they talked about it" and give us a "good try" pat on the back. They will hold us accountable. Can we succeed? Well, if you believe – like John F. Kennedy believed – that humans are capable of solving all human-made problems, then we better get to work. And, if the global picture is too daunting, then I encourage Evergreen community members to focus closer to home. Small changes can have large effects. Ask, "What will Evergreen's greenhouse gas emissions be next year?" Then, do your part to ensure that they do not increase for the fourth year in a row.

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~ APPENDIX A ~

Estimated food delivery miles traveled per year from vendor distribution center/store to Olympia campus.

Vendor	Vendor Round Trip Distance (Miles)	Deliveries Per Week	Miles Traveled Per Week
Bagel Brothers	6.8	6.0	40.8
Be Bop Biscotti	271.3	0.1	35.3
Black Hills Distribution	10.8	0.3	2.7
Brinks Incorporated	69.8	5.0	349.0
Charlie's Produce	127.6	6.0	765.6
Coca Cola Bottling	62.4	1.0	62.4
Danny's Delivery	11.6	2.0	23.2
Dreyers Grand Ice Cream	108.4	1.0	108.4
EK Beverage	107.2	0.5	53.6
Franz Family Bakery	26.6	5.0	133.0
Frito Lay	21.6	1.0	21.6
Fuji Restaurant	10.0	2.0	20.0
Harbor Wholesale	16.0	1.0	16.0
Healthy Baking	743.5	0.3	185.9
L&E Bottling Company	7.4	1.0	7.4
Mountain People's	92.4	1.0	92.4
Naked Juice	121.2	1.0	121.2
R&K Foods	128.6	2.0	257.2
Revi Incorporated	112.2	0.1	14.6
Service Linen Supply	114.2	2.0	228.4
Sysco Food Service	121.4	2.0	242.8
Tri City Meats	23.2	3.0	69.6
Tully's Coffee	121.4	0.5	60.7

TOTAL MILES TRAVELED PER WEEK 2,911.70

x 52 weeks/yr

TOTAL MILES TRAVELED PER YEAR 151,410

~ APPENDIX B ~

Source and type of information needed for future greenhouse gas inventories at The Evergreen State College

DEPARTMENT	INFORMATION SOUGHT	COMMENTS
The Evergreen Ecological Observation Network	**Total Forest Carbon (MTCDE)**	**Does Evergreen's forest serve as a carbon sink or source? What is the quantity in metric tons? Ideally, estimates should include tree productivity/decomposition, soil carbon content/emissions, understory data, and forest floor sources and sinks of carbon**
Budget & Planning	**Operating Budget and Energy Budget**	
Institutional Research	**Number of full-time, part-time, summer students/faculty/staff**	
Facilities	**Total Building Space (square feet) including Tacoma Campus**	
Facilities	**Electricity purchased in kWh/year and number of green tags purchased per year in kWh**	
Facilities	**On-Campus Stationary Energy Use: Natural Gas (MMBtu), Distillate Oil #2 (Gallons), Propane (Gallons)**	
Facilities	**College Fleet: Gallons of Gasoline and Diesel Fuel Used**	
Facilities	**Fertilizer used for lawn and grounds maintenance (pounds)**	
Facilities	**Landfilled Solid Waste (short tons)**	
Facilities	**Refrigeration Chemicals Used (pounds)**	**Amount of HFC-134a (and other refrigerants) used in Chillers, Water Coolers, Refrigerators, etc.**
Travel Office	**Air Miles Traveled: Student Programs and Faculty/Staff Business**	
Parking	**Student Commuting: Gallons of Gasoline and Diesel Fuel Used Commuting to Campus in Personal Vehicles and by Intercity Transit**	**Need % that drive alone, % that carpool, trips per week, weeks per year, roundtrip miles, average fuel efficiency**
Parking	**Faculty Commuting: Gallons of Gasoline and Diesel Fuel Used Commuting to Campus in Personal Vehicles and by Intercity Transit**	**Need % that drive alone, % that carpool, trips per week, weeks per year, roundtrip miles, average fuel efficiency**
Parking	**Staff Commuting: Gallons of Gasoline and Diesel Fuel Used Commuting to Campus in Personal Vehicles and by Intercity Transit**	**Need % that drive alone, % that carpool, trips per week, weeks per year, roundtrip miles, average fuel efficiency**
Organic Farm	**Number of Farm animals (poultry, pigs, goats, cows, horses, sheep, etc.)**	
Organic Farm	**Fertilizer Use**	**Amount of Fertilizer used (pounds), type of Fertilizer (organic/synthetic), and % Nitrogen**
Organic Farm	**Total Compost (short tons)**	
Aramark	**Gallons of Gasoline and Diesel Fuel Used to Delivery Food to Campus from Vendor Store or Distribution Center**	**Need list of vendors, distance to campus, trips per week, weeks per year, fuel economy, type of fuel used.**

~ APPENDIX C ~

Campus Global Warming Commitments (as of June 2007)

Institution	Commitment	Date of Commitment
College of the Atlantic	Climate Neutrality (Immediately)	October 2006
Cornell University	7% Below 1990 Levels by 2008	April 2001
Middlebury College	8% Below 1990 Levels by 2012 on a Per Student Basis	May 2004
Tufts University	7% Below 1990 Levels by 2012	April 1999
Yale University	10% Below 1990 Levels by 2020	October 2005
Williams College	10% Below 1990 Levels by 2020	January 2007
University of British Columbia	25% Below 2000 Levels by 2010 (only for emissions from buildings)	2006
Bowdoin College	11% Below 2002 Levels by 2010	January 2006
University of Oklahoma	4% Below 1998-2001 Baseline by 2006	January 2004
University of Iowa	4% Below 1998-2001 Baseline by 2007	May 2004
University of Minnesota	4% Below 1998-2001 Baseline by 2008	December 2004
Michigan State University	6% Below 1998-2001 Baseline by 2010	November 2006
University of California System	80% Below 1990 Levels by 2050	January 2006
UNC at Chapel Hill	60% Below 2005 Levels by 2050	June 2006
Oberlin College	Carbon Neutrality (No Timetable)	April 2004
Carleton College	Carbon Neutrality (No Timetable)	May 2006
University of Florida	Carbon Neutrality (No Timetable)	October 2006