Carbon Footprint Calculations for Oregon State University and Guadalupe, Cerro Punta, Panama

By Kimberly Melendez-Rivera

THESIS

submitted to

Oregon State University

College of Agricultural Sciences

In partial fulfillment of
the requirements for the
degrees of

Baccalaureate of Science in BioResource Research
Sustainable Ecosystems Option

Baccalaureate of Arts in International Degree

Presenting June 12, 2013
Commencement December 2013

APPROVED:

Frederick Colwell, Mentor, representing College of Earth, Ocean, and Atmospheric Science

---

Sally Duncan, Committee Member, representing School of Public Policy

---

Nick Fleury, Committee Member, representing International Degree Program

---

Katharine Field, Director, Department of BioResource Research

I understand my project will become part of the permanent collect of Oregon State University Scholars Archive collection for BioResource Research. My signature below authorizes release of my project to any reader upon request

---

Kimberly Melendez-Rivera, Author

Table of Contents

Abstract

Greenhouse gases effects are a leading contributor to climate change; reducing harmful effects of these gases is important for future generations. Worldwide, household consumption makes up seventy-two percent of greenhouse gas emissions, followed by government consumption at ten percent, and investments at eighteen percent (Hertwich, 2009). In order to understand the significance of greenhouse gases, their link to climate change, and the role carbon footprint has on future neutrality goals, this project used literature research and survey techniques to address two objectives: (1) Establish a framework for the adaptation of a carbon footprint calculator to help gauge progress of OSU to its goal of campus neutrality by 2025; (2) Analyze carbon footprint data collected from a small community in Panama as a point of comparison for carbon consumption at OSU.

First, I selected a calculator to adapt to OSU needs. Extensive reviews from various sources and a comparison between leading carbon footprint calculators demonstrated commonalities and differences between them. In addition, OSU carbon consumption was analyzed and utilized to create visuals that represented the severity of OSU's carbon consumption. In order to analyze the carbon footprint data collected from a small community in Panama a survey was used to collect information on key factors of carbon induced activities such as electricity consumption and transportation. Seventy-five people were surveyed, comprising five percent of local Guadalupe residents.

Through analysis of different carbon footprint calculators, Santa Clara University carbon footprint calculator was chosen as the framework of the calculator used for adaptation for OSU based on their methodology and open access. Carbon consumption data at OSU estimated that emission for fiscal year 2012 was 126,815 tons eCO_2 (CO_2 equivalents) with a population size of 29,129. At 1 atm, this volume of CO_2 is equivalent to a sphere 506 m in diameter or a cube that is 407.8 m on an edge with a volume of 67.8 million m^3 (Carbon Visuals, 2013). Comparing this to local Oregon State University landmarks the sphere is equivalent in height to 7 Reser Stadiums stacked on top of one another or 24 OSU Bell Towers, or even 28 MU Buildings. The per capita amount averages to be 4.35 tons of eCO_2 per OSU resident per year.

Analysis using Carbon Footprint Calculator, LTD for the Panama study case indicated that while Panama reached the worldwide objective rate to fight climate change of 2.0 metric tons eCO_2 per person per year; Guadalupe did not meet this goal. Results indicate that the average rate of metric tons of carbon emissions for local residents of Guadalupe was 3.71 metrics tons of eCO_2 per person per year. This was compared to Panamá's average rate of 1.74 metric tons of eCO_2 per person per year and the objective rate to combat climate change of 2 metric tons of eCO_2 per person per year. Furthermore, this is different from the worldwide average of 4 metric tons of eCO_2 per person per year and the average rate for residents of the United States of 20.4 metric tons of eCO_2 per person per year. Four percent of Guadalupe residents are in the average Panamanian range, five percent are between average consumption for Panamanian resident and

the worldwide objective to fight climate change, and fifty-eight percent surpassed the objective but are under the world average, while thirty-three percent are above the average worldwide but are under industrial nation averages. The study showed that although Guadalupe has an average consumption of below 4 metric tons, it does not meet the goal of 2 metric tons of eCO_2 per person per year to combat climate change. However, because Panama overall has reached 1.74 metric tons of eCO_2 per person per year it is on track to combat climate change. Furthermore, this means that for every U.S. resident that consumes eCO_2, they consume 5-fold more eCO_2 per year than a Guadalupe resident. OSU with an average of 4.35 metric tons of eCO_2 per person per year is above worldwide consumption average of 4 metric tons per person per year. This amount may be underestimated due to additional factors that were not included in the calculated amount of eCO_2 emitted by OSU provided by the Office of Sustainability. Factors such as extracurricular activities, population inconsistencies with students off campus, online, and those that participate within less than full time status may all affect the average estimated. Thusly, while OSU may seem only slightly above Guadalupe average consumption it may be far more than projected.

The goal of this study was to create a carbon footprint calculator framework for future use and application on line. This could also benefit the Corvallis population and with additional adjustments it may be beneficial for future researchers and universities for adaptation. This would benefit not only the OSU community, but the overall global population.

Acknowledgements

First and foremost, I'd like to express my deepest gratitude to my amazing mentor Dr. Frederick Colwell. His continual support, guidance, and insight gave me the tools needed to accomplish the tasks at hand, and his constructive feedback was crucial to the success of my thesis. Thank you. Secondly, I want to recognize my committee members Dr. Sally Duncan and Dr. Katharine Field, for their encouragement and assistance throughout this whole process, and Nick Fleury, for not only helping me find my way in my final years at OSU, but also while I studied abroad.

Furthermore, I am grateful to Santa Clara University, for providing me with all the feedback I needed in regard to their Carbon Footprint Calculator; special thanks to Christina Lesnick SCU senior and one of the creators of the carbon calculator. As well as the Oregon State University, Office of Sustainability for all the information they've provided me.

In Panama, I'd like to thank Ana Sanchez and Lusiz Sanchez from AMIPILA and FUNDICCEP non-profit organizations for all their help and information on local projects and for connecting me with the local community; the organic farmers of Guadalupe for their helpful contribution to my project; as well as the residents of Guadalupe for being so welcome to a new stranger that asked strange questions about their daily routine and household consumption. Ruben Gonzalez, my mentor while I was abroad, deserves big thanks for getting me through the final leg of my journey and preparing me for what was to come.

Finally, I'd like to thank my academic advisor, Wanda Crannell, for always helping me along my path even when there were a few detours along the way.

Chapter 1: General Introduction

Since 1750, due to increased human activities, atmospheric concentrations of greenhouse gases consisting of methane, nitrous oxide, carbon dioxide and water vapors have exceeded pre-industrial levels established using ice cores spanning many thousands of years (Solomon, 2007). Worldwide, household consumption makes up 72% of greenhouse gas emissions, followed by government consumption at 10%, and investments at 18% (Hertwich, 2009). Greenhouse gas emissions are directly linked to climate change and affect many aspects of our lives, including ecosystem disturbances (e.g., drought, flooding, and ocean acidification), crop productivity, and services provided by water resources (Pachauri, 2008).

The International Energy Agency (IEA) has stated that with no changes in policy or supply constraints, a 70% increase in oil demand and a rise of 130% in CO_2 emissions can be foreseen by 2050 (IEA, 2008). The Intergovernmental Panel on Climate Change (IPCC) states that a rise of this magnitude of CO_2 has the possibility of raising temperatures by 6°C or beyond (Bernstein, 2007). This could (or will) lead to irreversible changes to our natural environment that will in turn have significant impacts to all aspects of life. The IEA promotes integration of environmental and energy policies, and policies in global co-operative relations with other countries and organizations (Bernstein, 2007). They have an extensive knowledge of not only energy consumption, but future implications in the field of energy. Currently, IEA estimates that eighty percent of potential opportunities for energy efficiency, or "hidden" fuel, remain untouched (IEA, 2013). The IEA has presented 25 energy efficiency recommendations to tap into this untouched "hidden" fuel. If all 28 IEA members execute recommendations proposed by the IEA, as much as USD 1 trillion in annual energy costs could be saved as well as provide countless security benefits in terms of environmental protection and energy supply (IEA, 2013).

Climate Change Background and History

Greenhouse gas is composed mostly of carbon dioxide, nitrous oxide, water vapor, and ozone. It is mostly transparent to incoming solar radiation, but it can still absorb long wave radiation that radiates outward from Earth's surface. The temperatures of Earth have warmed about 0.7 degrees Celsius in the last hundred years and even small temperature changes can have drastic effects on the ecosystem, vegetation, wildlife and other aspects of ecology. Atmospheric measurements from 1970 have detected atmospheric abundances in greenhouse gases especially, methane (CH_4) and nitrous oxide (N_2O) (Bernstein, 2007). There are several synthetic hydrocarbons and hydrofluorocarbons, halons, sulphur hexafluoride which are greenhouse gases that have large global warming potentials. Many chemical industries have produced these gases that have leaked into the atmosphere since about 1930 (Bernstein, 2007).

Earth's atmosphere is a layer of gases that surrounds the planet and is retained by Earth's gravity (Welch, 2012). The atmosphere protects life on Earth through the absorption of solar ultraviolet radiation, as well as the absorption of heat through the effects of greenhouse gases. The ozone layer absorbs around 97-99% of ultraviolet light from the Sun that would otherwise damage life on Earth (Welch, 2012). If there are too many greenhouse gases, when sunlight heats the surface of Earth, it is then blocked by the gases in the atmosphere so that the infrared radiation from the Sun cannot re-radiate into space (UCSD, 2002). Earth's carbon cycle constrains the release of carbon into the atmosphere that occurs on some planets such as Venus, by maintaining an equilibrium that restricts the flow of carbon (Riebeek, 2011). It also moderates the accumulation of carbon so that it does not entirely accumulate in rocks (Riebeek, 2011). Carbon dioxide has increased in the atmosphere through large emissions. An increased release of carbon dioxide and other gases into the atmosphere has resulted in rising temperatures (Riebeek, 2011). This causes Earth to warm and can induce climate change.

The warming of Earth through the increase of greenhouse gases has been attributed to what is known as global warming, climate change through the heating of Earth. This change has caused deforestation, changes in sea level, decreases in glaciers, and the reduction in the diversity of ecosystems (World Resources Institute, n.d.). The impacts of climate change can have many adverse effects on the economy and society (World Resources Institute, n.d.). For example, the increase and intensity of severe weather events can result from climate change, which may lead to billions of dollars in damage annually (World Resources Institute, n.d.). Extreme weather events such as heat waves, floods, avalanches, hurricanes, and windstorms have increased and are expected to continue to increase and intensify due to climate change (World Resources Institute, n.d.). Other effects may include increasing sea levels; according to the "Arctic Climate Impact Assessment (ACIA, an intergovernmental forum composed of the eight arctic nations[1])" sea levels have risen by an average of 8 cm and a further increase of 10 to 90 cm are projected during this century (Hassol, 2004). This can lead to an increase in flooding properties, as well as changes in aquatic ecosystems and changes to wildlife as when glacier ecosystems are lost due to melting. Food sources may be affected by climate change, threatening food security. Water shortages may occur as glaciers recede and water sources are not replenished (World Resources Institute, n.d.). In addition, changes in salinity, ocean water temperatures, and CO_2 concentrations in ocean waters may compound other stresses placed on the world's fisheries and will impact the coral reefs of the world, which have already begun to diminish considerably (World Resources Institute, n.d.). The loss of habitat alters ecosystems

[1] The eight arctic nations are Canada, Denmark/Greenland/Faroe Islands, Finland, Iceland, Norway, Russia, Sweden, and the United States

and may change the local diversity of wildlife and can increase the extinction of many species of native and agricultural plants.

Much of climate change is due to natural cycles, but the Intergovernmental Panel on Climate Change (IPCC) supports the theory that minor temperature increases may in fact be chiefly produced by carbon dioxide (CO_2) emissions made by man (Bognar, 2008). Leading scientific organizations are virtually unanimous in their consensus that human-induced global warming is real and very likely due to human activities (Jenkins, 2013). A study in the 'International Journal of Public Opinion' by Oxford University Press surveyed scientists on scientific views related to climate change. Scientists' ranged from atmospheric and oceanic scientists to hydrologists on scientific views related to climate change. Of the 489 survey respondents, virtually half of those suitable according to the survey's exact criteria worked in academia, government or industry, and are members of prominent professional organizations (Wihbey, 2011). Ninety-seven percent of the 489 surveyed said that scientists agreed that global temperatures have increased in the last century, and more than eighty-four percent believed that "human induced greenhouse warming" is now happening (Wihbey, 2011). In addition, only five percent did not agree that human activity causes of global warming. Scientists in academia predict that consequences from a rise in global temperatures will be particularly severe as it is likely it will rise substantially in the future. Furthermore, scientists in academia were also more likely than those in government or business to believe that this may occur (Wihbey, 2011). Although there may be criticism and controversies in opinions on global warming and future effects of climate change, there is little disagreement on the existence of climate change and anthropogenic global warming (Wihbey, 2011).

In order to understand the significance of greenhouse gases its link to climate change and the role carbon footprint has on future neutrality goals one must first delve into the basic concept of sustainability. Sustainability is based on a simple principle stated by the EPA, that everything one needs for the continuation of our survival and well-being, depends either indirectly or directly on our natural environment. Through sustainable practices such as limiting our carbon footprint we can pave a path for future generations towards a brighter future.

Small Changes-Positive Effects

The smallest of changes in one's small piece of the world may have positive effects towards increasingly harmful levels of greenhouse gas emissions when enough people undertake such a change. Sustainability is an important concept to understand in a world that continues to use resources beyond the capacity that it can produce. The U.S. is one of the largest contributors to household consumption and one cannot ignore the present issues of climate change and its importance to our society when there are increasing population sizes, energy consumption demands, and environmental issues of depletion throughout the world. That is why many organizations have begun to implement action plans in order to mitigate or even adapt to the ever increasing challenges that climate change and increasing greenhouse gases may have in store for us in the future. These adaptations will not occur by themselves. Tracking the progress however minute can help us gain knowledge for our future. Understanding how energy can be acquired without excessive consumption of carbon is a goal that many hope to attain. Again, this goal cannot be achieved overnight, but by making small changes throughout our society one can hope that it may lead to decreasing carbon consumption rates and increasing sustainable practices.

Carbon Footprint

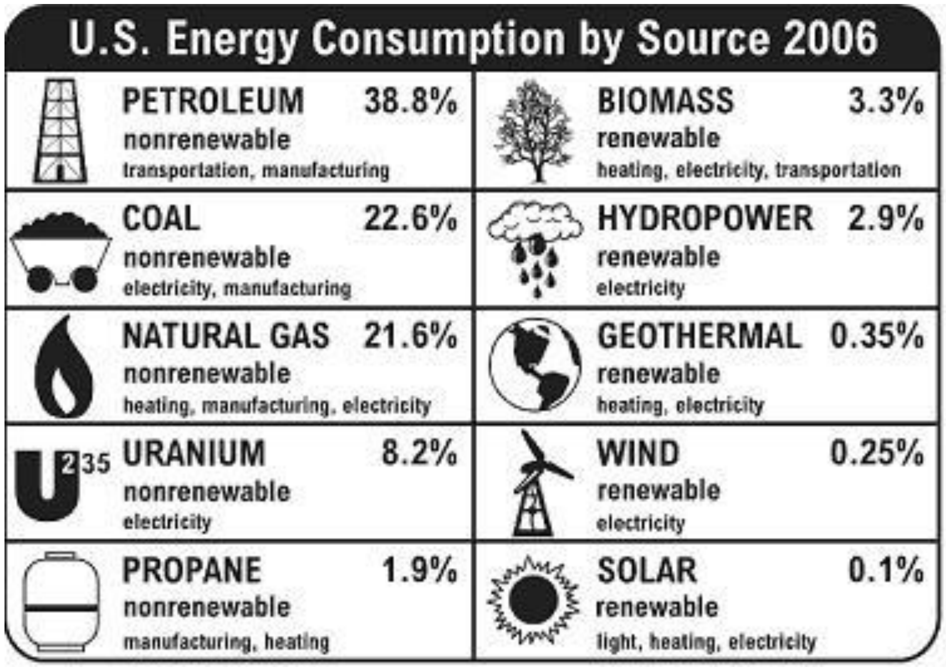
A carbon footprint is a measure of the total amount of carbon dioxide (or carbon dioxide equivalents) that are defined by a population, system, or activity (Wright et. al, 2011). It considers all relevant sources, sinks, and storage within the spatial and temporal boundary of the population, system or activity (Wright et. al, 2011). A carbon footprint is relevant to climate change and associates with human consumption activities and production (Wiedmann, 2007). A carbon footprint is usually expressed in several ways, including carbon emissions measured in tons or tons of CO_2 equivalents. There are several definitions of a carbon footprint, but the common denominator is that it is a form of measurement of gaseous emissions produced through the effects of greenhouse gases or emitted through daily activities. Although there is no consensus on how to measure or quantify a carbon footprint, leading organizations have developed their own tools to effectively quantify carbon footprints.

Renewable Energy & Non-renewable Energy

Renewable energy refers to energy that is renewed through natural resources, like rain, wind, tides, sunlight, or waves. Renewable sources of energy are easily regenerated and produce cleaner energy than those consisting of non-renewable energy (Renewable Green, 2013). Statistics indicate that renewable sources make up sixteen percent of the total global energy used and consumed daily (Renewable Green, 2013). The largest contributors to renewable sources of energy consist of solar energy, motor fuels through renewable bio-fuels, and hydro-power (Renewable Green, 2013). Unlike their counterpart non-renewable sources, renewable energy is plentiful and can be regenerated easily. The potential for solar energy is virtually unlimited and due to technical improvements and mass production, it is expected to compete with conventional sources within the next few years (Meisen et. al, 2006).

Renewable resources do, however, have limitations. For example, weather greatly affects many renewable sources of energy, therefore reducing consistency (Renewable Green, 2013). Wind turbines only rotate if there is wind of a given speed, while hydro generators need constant rainfall in order to overflow the dams needed for energy (Renewable Green, 2013). They are still considered "greener" than most non-renewable resources (Renewable Green, 2013).

Non-renewable resources (resources that are not easily renewable) continue to be the main source of energy throughout the world. Petroleum, coal, and natural gases are fossil fuels and main contributors to Earth's energy consumption. Petroleum products are currently the number one source of fuel (Table 1.1). Although we rely heavily on non-renewable resources, they are a finite commodity thus shifting away to a cleaner source seems like the logical choice, but a hard one to follow.



U.S. Energy Consumption by Source 2006

PETROLEUM	nonrenewable	transportation, manufacturing	38.8%	BIOMASS	renewable	heating, electricity, transportation	3.3%
COAL	nonrenewable	electricity, manufacturing	22.6%	HYDROPOWER	renewable	electricity	2.9%
NATURAL GAS	nonrenewable	heating, manufacturing, electricity	21.6%	GEOTHERMAL	renewable	heating, electricity	0.35%
URANIUM	nonrenewable	electricity	8.2%	WIND	renewable	electricity	0.25%
PROPANE	nonrenewable	manufacturing, heating	1.9%	SOLAR	renewable	light, heating, electricity	0.1%

Table 1.1 U.S. Energy consumption by source as determined in 2006 (source: Copus, 2009)

Bio-fuels are also increasing in popularity due to claims that there are a number of economic and environmental benefits (Balat, 2009). Many policy makers view bio-fuels as a key factor in reducing the dependence on foreign oil which can lower greenhouse gases (Koh, 2008). Unlike fossil fuels that are limited due to taking millions of years to form, bio-fuels represent energy that processes inorganic compounds to organic compounds in a short period of time that range from days to weeks or months. It is important to note that while bio-fuels are a cleaner alternative to fossil fuels the question still arises as to whether or not bio-fuels will contribute to climate change or global warming. Certainly, bio-fuels may have a hand in greenhouse gases since bio-fuels produce carbon dioxide, but it is also true that growing plants consumes carbon dioxide (Biofuel, 2010). Thus, it all depends on a balancing act: if plants we grow consume the sum of carbon dioxide that we create then we will have a zero net increase of carbon emissions, but this begs the question of whether this is a realistic view (Biofuel, 2010).

Current efforts have the U.S. in the forefront in transportation efficiency standards due to new fuel economy rules that could more than halve vehicle fuel consumption (IEA, 2013), while Japan plans to trim 10% of its electricity consumption by 2030 and China has committed to reducing the amount of energy for ‘each unit of gross domestic product’ by sixteen percent in the next two years (IEA, 2013). Table 1.1 represents how energy consumption is distributed between non-renewable energy and renewable energy in the U.S. in 2006. The U.S. is clearly more dependent on non-renewable energy rather than the cleaner alternative renewable energy. However, due to energy consumption needs and easily accessible natural gas available to the U.S., these statistics are not too surprising. Sustainable infrastructures have begun to play a bigger role in our economy and possibilities of renewable energy are being considered throughout the world. While many countries have begun to use some form of renewable energy, few countries have yet to establish or even started to implement a plan to shift away from their carbon based systems. Even with pledges to shift away from carbon, making a change does not occur overnight, and in our modern society carbon based energy and consumption is engrained throughout all aspects of our lives.

Carbon Offsets

Carbon offsets is a form of ‘making up for’ or replacing carbon emissions that have been emitted into the air and replaced with a carbon neutral solution. It allows land-use management practices, some industrial practices, and use of forestry to be substituted for reductions in emission of greenhouse gases (Macauley, 2013). It aims to neutralize the amount of greenhouse gas a person contributed by taking money from said person in order to fund projects that could reduce equal amounts of emissions somewhere else (Kirby, 2008). They are usually measured in tons of CO_2 equivalents and either bought or sold through charitable or profit making groups that broker offsets (Kirby, 2008). There are many types of activities that can generate carbon offsets, including renewable energy sources such as wind farms, solar, geothermal, hydro energy, and biomass energy (Kirby, 2008). Other ways to make up for carbon emissions include sustainability projects that contribute to a reduction in greenhouse gas emissions.

Oregon State University

Oregon State University is one of many universities and college campuses hoping to decrease the release of greenhouse gases. Several OSU entities including the Organic Growers Club and Student Sustainability Initiative may offer local solutions to offsetting one's carbon emissions. Through a campus wide initiative, OSU aims to be a carbon neutral campus by 2025. Thus far, twenty-nine percent of the school's energy comes from renewable resources and this can be considered as sustainable practice; however, the campus is not yet carbon neutral. Furthermore, OSU has been recognized in the past by organizations like the US EPA and Sustainable Endowments Institutes as a leader in campus sustainability, even ranking with the top 25 colleges and universities in the nation (Trelstad et. al, 2009). However, even with Oregon State's progress in sustainability efforts, OSU still has far to go in order to achieve its goals of neutrality. OSU has made strong contributions towards sustainability and carbon neutrality even ranking in the top 100 leading universities in the fight for neutrality in one poll (Sierra Club, 2013). Although this is impressive Oregon State still has far to go in order to achieve complete carbon neutrality.

Objectives

So, how can we contribute in the fight for campus neutrality? What can a small community do in order to help mitigate climate change? Helping students become acquainted with the concept of a carbon footprint is the first step. Several universities throughout the country have already implemented a carbon footprint calculator for their community. However, Oregon State University is not among them. In order to contribute in the fight for campus neutrality and understand the effects a small community may have on climate change, my project had two objectives:

1. Establish a framework for the adaptation of a carbon footprint calculator to help gauge progress of OSU to its goal of campus neutrality by 2025.
2. Analyze carbon footprint data collected from a small community in Panama as a point of comparison for carbon consumption at OSU.

The proposed framework for a carbon footprint calculator was adapted from Santa Clara University and was used to analyze the carbon footprint calculator methodology and calculations. The framework provides a planning structure needed to achieve a functioning online calculator (Figure 2.1), future goals and background information on local carbon neutral projects in the surrounding areas as possible carbon offsetting prospects. This initial project sheds light on the future neutrality goal and the importance of a carbon footprint calculator for the Oregon State University community. The second objective delves into the effects a small community may have towards their own goals of neutrality. The chosen focus was a small village called Guadalupe in the highlands of Cerro Punta, Panama. This small town does not have the vast technological advances possessed by the U.S., but residents are still working towards a sustainable and carbon neutral future within their own community. In an effort to understand the sustainable practices of Cerro Punta, a survey was created to ascertain the carbon footprint of the inhabitants and the traditional and organic farming roles in the local community.[2] [3] These two objectives allow interpretation of a carbon footprint at a local scale, adaptation of a working calculator that may increase community involvement, and benefit through lessons learned from a town that has a small carbon footprint.

[2]Traditional farming: the use of pesticides and other chemicals for farming
[3]Organic farming: the lack of use of pesticides and other chemicals for farming

Chapter 2: Selecting the Calculator

Understanding the background of what carbon footprint calculators entail was the first step in building a framework for a carbon footprint calculator at Oregon State University. The second step would be adapting the framework for future use. The carbon footprint calculator that I chose to focus on was created at Santa Clara University, which ranked in the top 30 for leading universities in sustainability (Sierra Club, 2013). SCU's carbon footprint calculator is open, easily accessible, and their online interface delves into campus life for both students and faculty and uniquely encompasses many aspects of campus life. They categorized their major sources of energy consumption as electricity, transportation, general consumption, water, gas, food, and waste. Within each category they included energy consumption by dorm, transportation by car, bus, and train, air travel, and an assortment of electronic devices energy outputs. The calculator also includes options like recreational activities such as TV, and even a few common but ingenious energy consuming categories, such as "gaming" and partying. It may seem improbable to harness a person's energy use through an online carbon footprint calculator. In reality, being able to harness the closest and most accurate account of how much a person consumes through the amount of CO_2 outputted is a major goal and seemingly common way to represent a person's carbon footprint. Santa Clara University has accomplished this goal while still giving a light-hearted flare to a very serious topic. Not only is Santa Clara trying to accurately represent a person's carbon footprint, but they wanted to make it social, interactive, easy to use, and informative to both student and faculty. This is one of the major reasons why I chose the Santa Clara University framework for my own carbon footprint calculator for Oregon State University. Figure 2.1 shows the steps that were used to complete a working and accurate carbon footprint calculator.

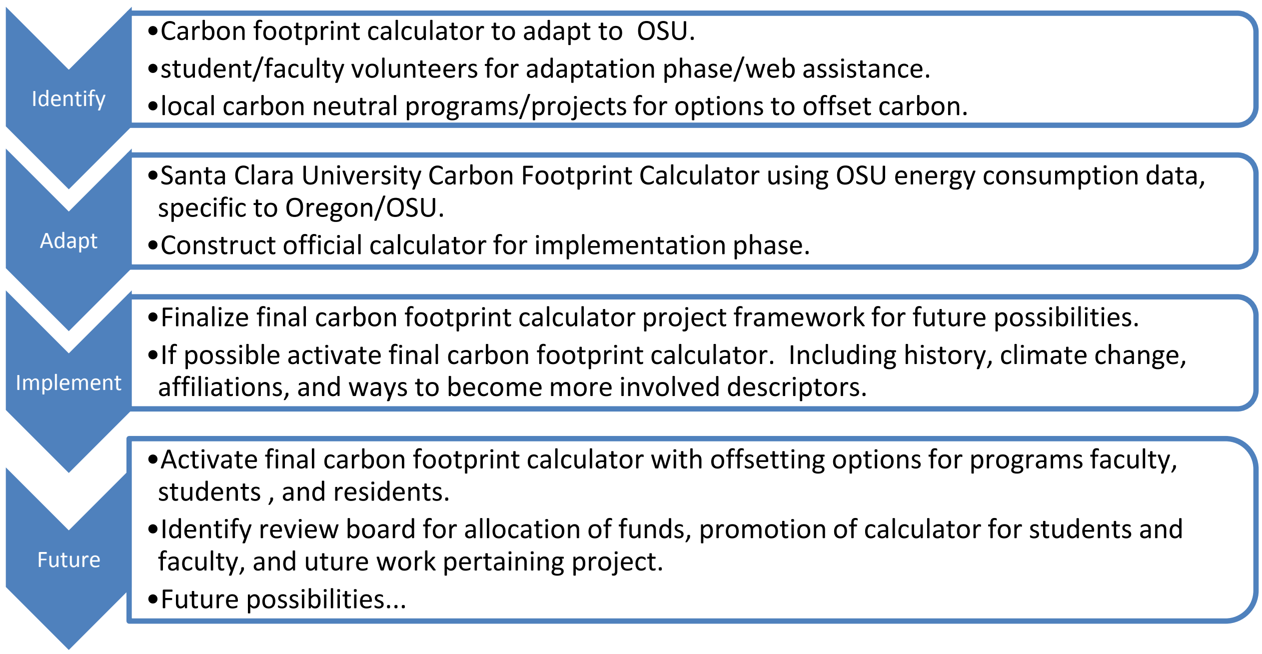


Figure 2.1. Carbon Footprint Offset Initiative planning structure.

Comparison between Different Carbon Footprint Calculators

In order to compare different calculators I used the example of one round-trip flight from Portland International Airport (PDX) to Ted Stevens Anchorage International Airport (ANC). The calculators were chosen from a list of online calculators at random. In order to compare calculators through CO_2 measurements, travel was selected as the common category measured among the calculators, but each was calculated differently depending on the carbon footprint calculator. The results of this comparison are shown in Table 2.1. Air travel was measured by mileage of air travel flown.

Carbon Calculator	PDX-ANC mileage	Metric tonnes CO_2/year	Recommended Offset costs
Nature Conservancy **(Nature Conservancy, n.d.)**	------------	2.2	$30
Terrapass **(Terrapass, 2013)**	3,076	0.54	$11.90
Carbon Fund **(Carbon Fund, 2013)**	3,096	0.52	$5.73
Conservation International **(Carbon calculator, 2013)**	2500-5000	3.1	$37.00
Carbon Calculator, Ltd. **(Carbon footprint, 2004)**	------------	0.49	Options to offset: $5.81- clean energy $7.35-Emission Reduct. $14.24- Reforestation $18.99- UK tree planting

Table 2.1 Comparison of results obtained using different carbon footprint calculators to assess the carbon released as a result of a PDX-ANC round trip flight.

This simple calculation demonstrated that each calculator has a different way to determine how much CO_2 is being emitted per year, as well as the funds needed to offset the emission. While calculators from Terrapass, Carbon Fund, and Carbon Calculator Ltd, generate relatively low CO_2 emissions for this trip, Nature Conservancy and Conservation International yield almost triple the amount emitted CO_2, with quite a substantial increase in the amount of offset they recommend for the trip. This may be due to the differing assumptions upon which organizations base their calculations. Conservation International, for example, assumes that travel is on a commercial aircraft, although additional options to change to jet or private aircrafts are available (Conservation International, 2013). They also assume:

- Short round-trip distance = 800 miles

- Long round-trip distance = 3,000 miles
- Emissions per commercial air passenger mile = 0.00041 tons of CO_2
- Emissions per private jet flight mile = 0.0099 tons of CO_2
- Emissions per person per hotel night = 0.0136 tons of CO_2

These assumptions are based on U.S. Department of Energy's Transportation Energy Data Handbook and then calculated as:

Your air travel emissions = average short round-trip emissions + average long round-trip emissions

- Short round-trip Emissions = number of yearly short round-trip flights x [emissions per commercial air passenger mile or emissions per private jet flight mile]
- Long round-trip emissions = number of yearly long round-trip flights x [emissions per commercial air passenger mile or emissions per private jet flight mile]

For a single flight:

Your commercial flight emissions = round-trip distance x emissions per commercial air passenger mile x number of passengers

Your private jet flight emissions = round-trip distance x emissions per private jet flight mile

This illustrates one organization's process to find an accurate carbon footprint representation for one round trip flight. The differences are likely to be compounded when one considers other aspects of a carbon footprint as well as different assumptions made by calculators.

In my quest for an adaptable carbon footprint calculator I found that trying to encompass a 'regular' life of the average person is the best way to represent a plausible carbon footprint analysis of an individual. Since one would like the closest representation of the amount of CO_2 an individual consumes the logical step would be to encompass as much of a person's daily life to better represent the amount of CO_2 emitted. They may calculate their usual daily life or just calculate one particular segment if needed, such as transportation for example. Terrapass allows Businesses & Institutions, Individuals & Families, Conferences & Meetings, Weddings & Parties as their main categories in which one can begin their calculations. This was similar to all other carbon footprint calculators from Nature Conservancy, Carbon Fund, Carbon Footprint Ltd., and Conservation International that allowed one to pick either individual or business.

Many organizations provide carbon offsets for those who wish to counterbalance their carbon use. Terrapass focuses on carbon offsetting projects throughout the world while Nature Conservancy encompasses all aspects of conservation from the 35 countries where they make positive impacts and throughout all states in the U.S. that have carbon offset possibilities (Nature Conservancy, 2013). They also include an interactive interface that allows the possibility to delve into habitats and regions they work in and urgent issues they are involved in. Carbon Fund directs their attention specifically to climate change and reducing the effects of climate change through offsetting possibilities. Each calculator categorizes consumption for air travel, driving, and home, separating each category to discern specific details in order to get an overall rounded carbon footprint calculation.

The only negative aspect I've found with each of the calculators are that many boast to have the most accurate interpretations of carbon footprint emissions, but each result differs from the other. This discrepancy makes it difficult to determine which the most accurate carbon footprint calculator is. The best way to determine accuracy would be to evaluate their methodology and calculation process. However, this is not available for many calculators.

Carbon footprint calculators lack consistency as well as information of their estimations and methods. This hinders the comparison of carbon footprint calculators (Padgett, 2008).

Carbon Footprint Calculators

My ultimate goal is to see implementation of a carbon footprint calculator that student and faculty of Oregon State University may depend upon in order to offset their carbon releases. There are a wide variety of non-profit organization and universities such as Duke University Green Devil Smackdown: Carbon footprint calculator (Deans GreenTeam, 2007) and Yale University Carbon Fund Carbon Footprint Calculator (Yale, 2013) that have carbon calculators that could be used for adaptation. However, I couldn't access the calculations that support each calculator. In contrast, Santa Clara University (SCU) had easily accessible calculations and methodology for its carbon footprint calculator. Santa Clara University is but one path that can be taken in the beginning steps of a carbon footprint calculator framework that is both reliable and easy to interpret.

Existing Carbon Consumption Data at OSU

The Oregon State University, Office of Sustainability uses an extensive program in calculating greenhouse gases emitted each year by the university. Through an excel program from the Cool Air Clean Planet Calculator they are able to determine energy consumption of CO_2, CH_4, N_2O in kilograms, and the eCO_2 in metric tons. Categories are separated into three scopes and then subcategorized to represent the whole of Oregon State University (Table 2.2). Scope 1 represents cogeneration of electricity and steam, direct transportation, refrigerants and chemicals, and agriculture. Scope 2 represents purchased electricity, while scope 3 represents consumption from direct air travel as well as student/faculty commuting. Energy consumption is calculated by CO_2, CH_4, and N_2O with a final number measured in equivalents of CO_2 (eCO_2). All scopes are combined and carbon offsets eCO_2 are then subtracted to get a final net emission of 126, 815 eCO_2 at standard temperature and pressure for OSU's fiscal year 2012.

MODULE	Comprehensive FY12 Summary						
WORKSHEET	Overview of Annual Emissions						
UNIVERSITY	Oregon State University						
Select Year -->	2012	Energy Consumption	CO_2	CH_4	N_2O	eCO_2	% change from FY11
		MMBtu	kg	kg	kg	Metric Tonnes	
Scope 1	Co-gen Electricity	2,217.8	117,662.1	11.7	0.2	118.0	-9.7%
	Co-gen Steam	904,403.0	47,981,267.4	4,778.2	96.2	48,129.4	7.4%
	Other On-Campus Stationary	72,964.0	2,972,019.9	18,021.9	17,728.1	3,957.8	3.3%
	Direct Transportation	30,607.3	2,055,899.1	2,316.8	2,049.8	2,247.2	6.5%
	Refrigerants & Chemicals	-	-	-	-	399.5	0.0%
	Agriculture	-	-	66,654.9	815.1	3,165.7	-1.9%
Scope 2	Purchased Electricity	576,937.4	37,135,655.6	71,221.2	70,728.2	41,466.9	-29.6%
Scope 3	Faculty / Staff Commuting	40,872.3	2,921,476.2	592.1	199.0	2,995.6	47.6%
	Student Commuting	85,838.2	6,149,674.2	1,184.3	400.7	6,298.7	-18.9%
	Directly Financed Air Travel	92,877.7	18,713,051.7	535.5	562.2	21,164.5	26.7%
	Other Directly Financed Travel	20,970.4	1,497,176.1	311.1	104.2	1,536.0	-9.1%
	Solid Waste	-	-	(3,145.1)	-	(78.6)	5.7%
	Scope 2 T&D Losses	57,059.7	3,672,757.1	7,043.9	6,995.1	4,101.1	-22.6%
Offsets	Additional					(1,732.1)	1208.2%
	Non-Additional					(6,890.5)	-90.5%
Totals	Scope 1	1,010,192.1	53,126,848.6	91,783.5	20,689.5	58,017.6	6.5%
	Scope 2	525,893.5	37,084,611.7	20,177.4	19,684.4	41,466.9	-22.6%
	Scope 3	309,906.7	32,966,423.7	18,810.1	20,549.5	36,017.2	7.8%
	All Scopes	1,806,722.0	123,138,613.6	91,500.7	21,653.0	135,501.7	-4.2%
	All Offsets					(8,686.3)	-88.1%
					Net Emissions:	**126,815.4**	85.1%

Table 2.2. Summary of annual carbon emissions at Oregon State University for 2012 (data courtesy of Sonja Mae and Brandon Trelstad of the OSU Office of Sustainability)

Using the amount of net emissions of 126,815 metric tons and dividing it by the total OSU population of 29,129 (population size established from OSU Office of Sustainability) received an average consumption of 4.35 metric tons of eCO_2 per OSU resident per year. While the Office of Sustainability has considered many factors related to the amount of eCO_2 emitted by OSU per year the data does not encompass all ways in which CO_2 is generated by OSU students and staff and these additional factors could likely change the actual amount of eCO_2 emitted per OSU resident per year. For example, the calculations do not include energy consumption for residents of OSU that live off campus or additional emissions such as extracurricular activities (e.g., going out to eat, shopping or even watching a movie) inside OSU and in the surrounding area. Population size for OSU is a combination of full and part time students FTE (full-time equivalent) combined, FTE faculty, and staff. If online students that go to OSU full time are accounted for, this would also affect OSU emission amount since online students use OSU facilities a lot less than students on campus. Furthermore, students who go to OSU below part time status may not even be accounted for since this survey only accounted for part-time and full time students. Accordingly, the estimate of 4.35 metric tons of eCO_2 per OSU resident per year may be an underestimate.

While the amount of emissions per OSU resident per year may vary, the Office of Sustainability has accounted for many of the required measurements needed to track eCO_2. Through this process the Office of Sustainability calculates OSU consumption as a whole, compares different fiscal years, and determines whether Oregon State University is on track to meet their 2025 Campus Neutrality Goal. While their main focus is to decrease greenhouse gas and measure energy consumption on a yearly basis, an overall campus goal to achieve neutrality is still present. In 2009, the Office of Sustainability released a university climate plan entitled: A Strategic Plan for Institutional Climate Neutrality. This plan consisted of a Climate Plan Organizational Framework, infrastructure that included categories required for the action, and emission category mitigation strategies that ranged from air travel, purchased electricity, ground transportation, and agriculture (Trelstad et. al, 2009). The plan also recommended support of educational experiences and enhancing campus and community engagement. This plan was one of the major reasons why a carbon footprint calculator for Oregon State University is so important to the cause of campus neutrality.

Visualizing Carbon Emissions

Net Emissions for Oregon State University during its 2012 fiscal year was 126,815 eCO_2. To visualize the amount of CO_2 OSU produces I have created a carbon patch through CarbonQuilt.org which allows greenhouse gases to be visible. A carbon patch is what one emits and contributes to the worlds carbon quilt.

“A carbon quilt is a layer of carbon dioxide made up of the whole world’s emissions (Carbon Visuals Ltd, 2013).” Figure 2.2 is a visual representation of what may be considered the ‘Carbon Quilt’. The company provides carbon visualizations services to NGOs, governments, and any other organizations that have a ‘carbon story’ to tell (Carbon Visuals Ltd, 2013; Figure 2.2).

Figure 2.2. “In 2006 we added 30 billion tons of carbon dioxide into the atmosphere. Instead of mixing with the air it forms a layer 3cm thick and each year we add another layer to the 'Carbon Quilt' (Carbon Visuals Ltd, 2013)."

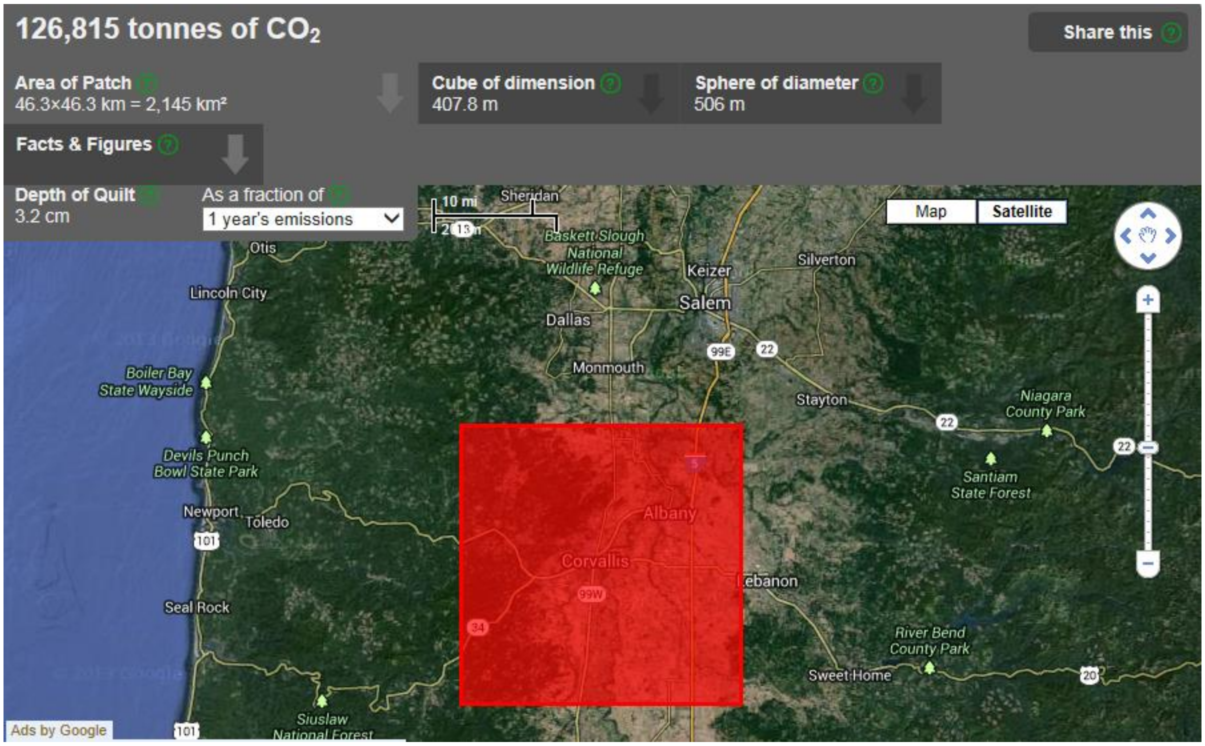


Figure 2.3. Carbon Quilt of total OSU net emissions of eCO_2 overlaid on top of city of Corvallis (Carbon Visuals Ltd, 2013).

In 2006, the world emitted enough carbon dioxide to form a layer – or a quilt - 31 mm deep (Carbon Visuals Ltd, 2013). A similar quilt is depicted for OSU emissions in 2012 as a red patch in Figure 2.3 with an area of 2,145 km^2. The quilt covers Corvallis and Albany and extends from Benton County Fair Grounds to Jefferson, and Sara Helmick State Park to the William L. Finley National Refuge. Shown in different ways this net emission is also equal to a sphere with a diameter of 506 m or a cube 407.8 m in dimension and a volume of 67.8 million m^3. (Carbon Visuals Ltd, 2013; Figure 2.4). The volume occupied by this much CO_2 is calculated from the density of the gas: 1.87 kg/m^3. This value is the density of carbon dioxide at standard atmospheric pressure (1.013 bar, 101,325 Pa) and the average temperature at sea-level (15 ˚C) (Carbon Visuals Ltd, 2013).

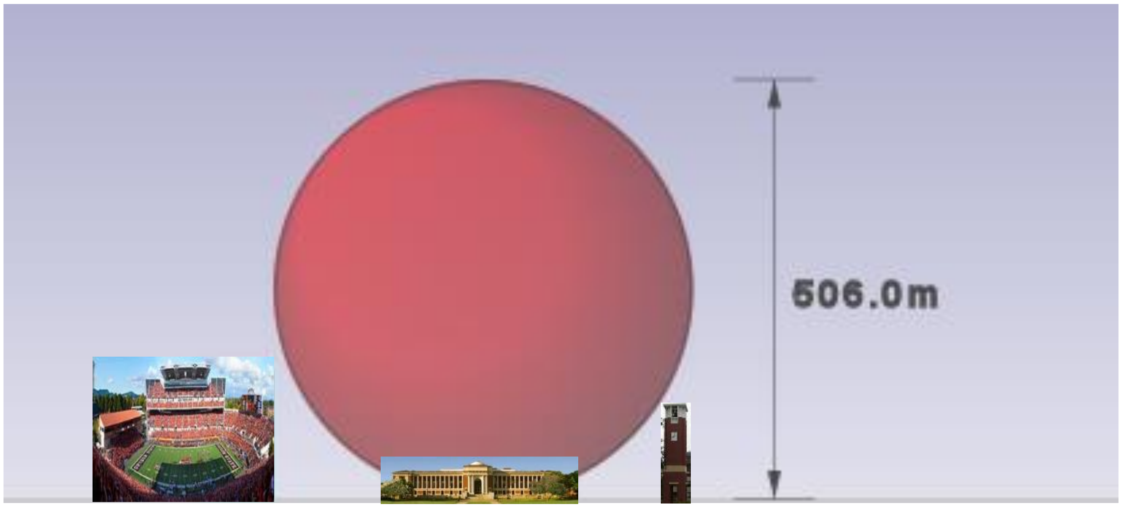


Figure 2. 4. OSU net emissions in eCO_2 (at standard temperature and pressure) during 2012 shown as a sphere equivalent to 506.0 m (Carbon Visuals, 2013). Reser Stadium: 73 m (Building Services, personal communication), MU Building: 18 m (MU help desk, personal communication), OSU Bell Tower: 21 m (Building Services, personal communication).

As a point of comparison, I've introduced OSU landmarks with Reser Stadium at 73 m in height, MU Building at 18 m in height, and OSU Bell Tower at 21 m in height (Building Services, personal communication) to Figure 2.4 along with the sphere of gas representing OSU's 2012 eCO_2 emissions. The sphere is approximately equivalent to 7 Reser Stadiums if stacked on top of each other, 24 OSU Bell towers, or even 28 MU Buildings. A reduction of OSU's net eCO_2 emissions by lowering emissions and compensating with carbon offsets may decrease the size of the sphere.

Plans for an OSU Carbon Calculator

The planned OSU calculator will include a format similar to that developed by Santa Clara University which will begin with an introduction about climate change and transition to a tier of easy response questions like

- On Campus
- Off Campus or Full-time Commuter Student

- Part time Commuter Student/Faculty and Staff

Subsections will include:

- OSU Neutrality goal in detail
- Introduction to the OSU carbon footprint calculator
    - Transportation
    - Energy usage: Items (e.g. fridge, microwave, laptop, etc.)
        - # of items, set wattage, usage: hrs in day plugged in
    - Waste
        - Amount of waste recycle: below average, average, above average
    - Consumption: Hard covered books/soft covered books, new articles of clothing per month, # nonrefillable plastic bottles, smart phone or mobile, ipad/kindle/eReader/ipod, length of time in years of current ipod/eReader.
    - Your results

Appendix A contains both conversion factors needed for the calculations portion of the online calculator and the sources associated with each subcategory. Below is an example of the 'Transportation' subsection of the carbon footprint calculator from Santa Clara University including calculations associated with the 'small' car option available under the section entitled: "Do you own a car?" Choices for this section will include small, average, SUV/truck. The user inputs approximately the number of miles driven in a given month.

Transportation

Question: Do you long-board, skateboard, or bike to class?
Radio buttons: option for yes and option for no

Question: Do you own a car?
Drop down menu with following options: small, average, SUV/truck, hybrid

Question: Approximately how many miles do you drive/month?

Input element: allow user to input
Help link that expands when rollover with mouse that gives the following info:

Automobile Distances:
Santa Clara University to: Santa Cruz—30.0 miles
Valley Fair Mall————————2.1 miles
Downtown San Jose——————3.6 miles
San Francisco————————46.1 miles
Tahoe——————————228.4 mile

SMALL:

- $\frac{x \text{ miles}}{\text{month}} \times \frac{0.32990 \text{ kg CO2e}}{\text{mile}} \times \frac{1 \text{ month}}{4 \text{ weeks}} \times \frac{33 \text{ weeks}}{1 \text{ school yr}} = \frac{\text{kg CO2e}}{\text{school yr}}$

- $\frac{x \text{ miles}}{\text{month}} \times \frac{0.32990 \text{ kg CO2e}}{\text{mile}} \times \frac{1 \text{ month}}{4 \text{ weeks}} \times \frac{1 \text{ week}}{7 \text{ days}} = \frac{\text{kg CO2e}}{\text{day}}$

In order to adapt the travel section to OSU, one might remove automobile distances since it reiterates how many miles were driven per month. This may be unnecessary information to include for the OSU calculator since millage is calculated by the required information needed in the vehicle section as well as the question that requests the amount of miles one drives per month. Adding automobile distances to known areas may be useful, but ultimately unnecessary. In place of 'Automobile distances' to known surrounding areas, the inclusion of the number of miles traveled per month on the Corvallis or Albany Transit and on Greyhound buses or on Amtrak buses would be useful. All options are common forms of transportation in Oregon and could present a better summary of an individual's transportation choices. The SCU calculator uses constants provided by TerraPass and these yield the estimates of eCO_2 based on data that an individual enters into the calculator.

Keeping a similar style as that used by SCU will provide consistency for the calculations behind each of the categories.

SCU's calculator has an easy interface and straight forward calculation methodology; however, there are some improvements or changes that I recommend for the OSU calculator. First, including calculations for each category will be added for easy access to the general public. Second, offering carbon offset options will be a new aspect to include in the finalized version of the carbon footprint calculator. This change should benefit not only local carbon offset projects within our community, but may even introduce community service opportunities. Local offsetting possibilities I envision will be linked to the calculator and will represent credible local sustainability projects such as Green Belt Land Trust or even local student organizations such as OSU Organic Growers Club. The site will include project descriptors that will be updated frequently and information on ways students and faculty can improve their calculated eCO_2 measurements.

The goal is to offset with carbon neutral projects which are projects that completely offset the amount of carbon emitted by a person's gaseous emissions. Sustainability projects differ from carbon neutral projects because unlike neutrality, sustainability can be defined by both preserving existing ecosystems and meeting economic needs of all humans in the present (Gatto, 1995). Neutrality however, means nullifying carbon altogether so if one was to produce carbon they would offset the carbon to make up for the emissions emitted, bringing the total amount of eCO_2 spent to zero (Macauley, 2013). Carbon neutrality projects come in many forms and could range from organic waste composting schemes, an agricultural methane capture project, or even something as simple as planting a specific amount of trees or re-vegetation projects, to soak up carbon you generate thus neutralizing the amount of greenhouse gases (Kirby, 2008). The diagram below shows a process to achieve carbon neutrality. Each of the projects presented are possibilities for carbon neutrality if they follow the steps in regards to an efficient offsetting plan and work towards achieving carbon neutrality goals.

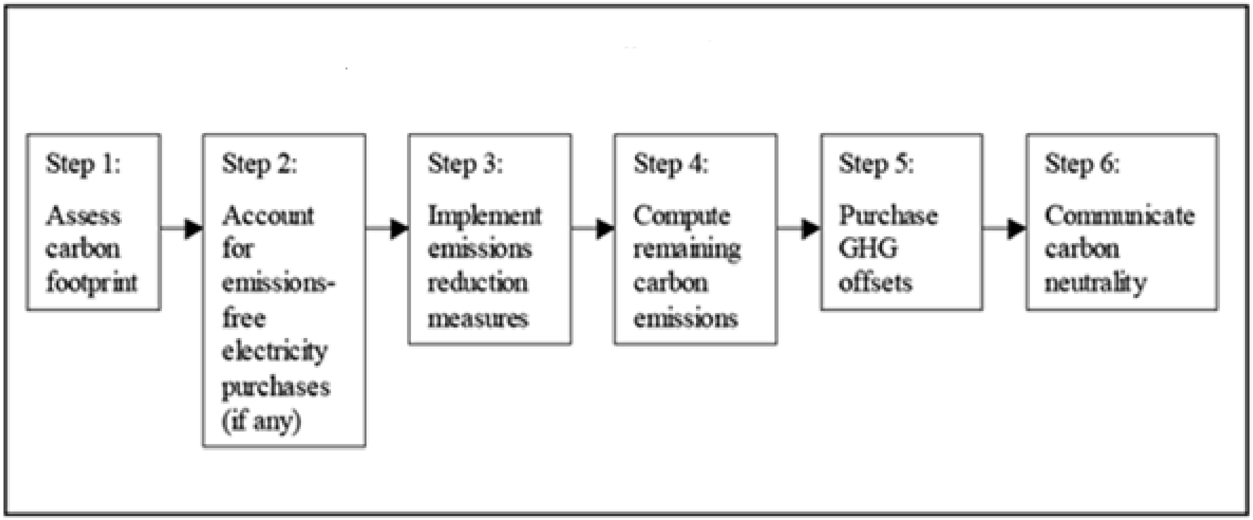


Figure 2.4. Achieving Carbon Neutrality (Planet, 2006).

Local Projects to Help Achieve Carbon Neutrality

A wide variety of neutrality projects in the OSU area may be used for the carbon footprint framework.[3] Some examples of programs or organizations that might be considered for future carbon neutrality offsets that are local to OSU are listed below. In all cases, assessing whether or not the projects are actually carbon neutral will be important once carbon offset options become available for the online carbon footprint calculator.

- The Greenbelt Land Trust: Benefits the people of Oregon's Mid-Willamette Valley by protecting open spaces in their communities (GBLT, 2011). The GBLT permanently safeguards over 1800 acres of riparian areas, meadowland, forest, and farmland (GBLT, 2011). A current project is the Bald Hill Farm-Land Acquisition, an urban farm that supports local food production, education, and ecological restoration (GBLT, 2011). Choosing this option may provide funds for restorative projects like the hundreds of Douglas spirea that were planted along Jackson and Frazier Creeks at Owen Farm (GBLT, 2011). Douglas spirea is a native plant to Oregon and works as a natural buffer in most riparian environments (Wissmar, 2004). Planting Douglas spirea and similar plant species in their natural habitat can encourage maintenance of riparian and fluvial functions and even reestablish neighboring habitats

[4] List provided by Sally Duncan, Background information provided by several different sources.

(Wissmar, 2004). Any program that involves planting has the potential to remove carbon dioxide from the atmosphere and help to achieve carbon neutrality.

- OSU Organic Growers Club: This option provides community members the chance to fund student run club projects and to interact with the community by heading out to the student farm located in Corvallis (Organic Growers Club, n.d). The club sponsors several carbon neutral projects such as planting dozens of varieties of vegetables and fruit crops (Organic Growers Club, n.d.).
- Willamette Valley Vineyards: Fifteen wineries have pledged, to work towards carbon neutrality (Willamette Valley Vineyards, 2012). Willamette Valley Vineyards have partnered with CorkReharvest.org to begin a nationwide cork recycling campaign (Willamette Valley Vineyards, 2012). Willamette Valley Vineyards signed the pledge to work towards carbon neutrality and are currently investigating solar energy, green energy, carbon offsets and other unique ways to address global warming (Willamette Valley Vineyards, 2012). Choosing this option will allow students and faculty the opportunity to explore unique projects through Willamette wineries.

Additional options may be discovered once the OSU Carbon Footprint Calculator is fully researched.

Chapter 3: Guadalupe, Cerro Punta Panama Case Study: Community and Organic Farming, Carbon Footprint Impacts on Climate Change

The focus for my second objective was to analyze carbon footprint data collected from Guadalupe, a small town in Panama, and observe how this town strives towards a more sustainable future. I wanted to observe farming practices and compare average consumption rates for residents of Guadalupe to the average consumption rates for citizens of other countries as well as to the average consumption rates of a U.S. citizen.

The majority of Cerro Punta is filled with many inhabitants of indigenous descent and although the city seems small compared to Panama City; it plays a pivotal role in subsistence. Combinations of heavy rainfall and dry seasons allow the country to grow many tropical vegetables. Cerro Punta maintains both traditional and organic farms and is known as having the country's most productive and fertile lands (McCarthy, 2013). Climate ranges throughout Panama’s highlands which include provinces of Bocas del Torro, Chiriquí, and Veraguas (McCarthy, 2013). Cerro Punta, located within the Chiriqui province, has four distinct villas, the Miranda, Guadalupe, Las Nubes, and Bajo Grande (McCarthy, 2013).

Figure 3. 1 Upper northwest region of Panama map. Source: (Propiedades En Panama, n.d.)

Guadalupe is unique from other cities in Panama because of their cultivation techniques on hillsides and extensive farmland and through their sustainable practices. Carbon footprint estimates through the collection of environmental data can establish a basis for carbon expenditure for countries, regions, institutions, businesses, and people. Measurements can be split up through primary consumers such as electricity, transportation, chemicals, manufactured products, and secondary consumers such as recreational activities, furniture, and other indirect sources. A breakdown on one's carbon footprint depends solely on the carbon footprint calculator that is used in order to gauge one's emissions. Once the average carbon consumption was ascertained from the town it was then compared to worldwide objective rates in hopes to see whether or not Guadalupe reached the goal to combat climate change, which is 2 metric tons per person per year (Carbon Footprint, 2004).

My experience in Guadalupe allowed me to delve into a new world unlike one I have faced before. I was able to unravel carbon footprint consumption in a town that was quite different from Corvallis. The impact of climate change and how a carbon foot print affected climate change was the major theme throughout my project; one of the major reasons I chose Guadalupe and household consumption was to learn whether or not Cerro Punta provided an example of a small rural town that does not have carbon intensive use of resources that we have adopted in the US, but thrived and moved forward in regards to neutrality.

Research question

How do the organic farms and household consumption practices of the residents of Guadalupe translate into a carbon footprint estimate?

Objectives of the project

- Identify conservation efforts in Cerro Punta.
- Observe organic farming practices (e.g., creation of organic fertilizer).
- Interview four professional organic farmers to determine their views on organic farming and their transformation from 'traditional' to organic farming.

- Survey and interview residents to determine the average carbon footprint of the inhabitants of Guadalupe.
- Determine whether the community has met the world wide objective to combat climate change of 2 metric tons of eCO_2 per person per year. (Carbon Footprint, 2004).

Methods

The site of Cerro Punta allowed examination of sustainable practices and organic farming which may have a hand in the mitigation of future climate change. It allows a natural contrast of traditional farm practices and the practices of organic farms and the possibility to transition from one to the other. I wanted to observe how the transition from traditional to organic may have affected residents environmentally, socially, and economically. In order to achieve my objectives, I conducted a survey to determine information about conservation projects, as well as first-hand knowledge about the practices of organic farms. The identities of participants from local organic farmers were concealed by using the OFCPI-01 code: Organic Farms Cerro Punta Interview-01. I interviewed four local organic farmers and studied the literature on the effects of climate change on the community. Answers were compared from the four organic farmers to see how they differed and how each farmer varied on subjects such as transition from traditional to organic farming, organic practices, and how they were affected socially, economically, and environmentally by the transition. I also determined household consumption rates to determine the carbon footprint of the average residents of Guadalupe by using a survey that touched many factors contributing to CO_2 emissions. Individuals' data was inputted through a carbon footprint calculator to show the average rate of consumption for the residents of Guadalupe.

The carbon footprint is separated into primary emissions of carbon including the use of electricity and automobiles, and the secondary emissions of carbon including food preferences, organic products, consumption of food in-season, imported food and goods, fashion (i.e., buy new clothes by need or buy the most recent popular T-shirt), packaging, furniture and appliances, recycling, recreation, and finance and services (Carbon

Footprint, 2004). These two categories were added to estimate the total carbon footprint for an individual or a household.

A carbon footprint total in eCO_2 was calculated for each of the residents that was interviewed. This allowed a comparison of the carbon footprint of Cerro Punta residents to that of an average resident of Panama as well as to the average values for citizens of other countries and global average. Base standards were provided by Carbon Footprint Ltd. Inhabitants of Guadalupe were asked the same questions used in the carbon footprint calculator of Carbon Footprint Ltd. but translated into Spanish. Sources of primary emissions calculations were based on conversion factors provided by the Department of Environment, Food and Rural Affairs (DEFRA) of the United Kingdom, World Resource Institute (WRI) Greenhouse Gas (GHG) Protocol, Vehicle Certification Agency (VCA)-United Kingdom, US Environmental Protection Agency (EPA)-USA, US Department of Energy (DOE)-USA, Green House Office - Australia, and Standards Association (CSA) GHG Registries-Canada (Carbon Footprint, 2004). Estimates for secondary emissions for the carbon footprint calculator were researched by Carbon Footprint Ltd. in order to represent the impact on the environment through every day activities (Carbon Footprint, 2004).

The materials used for the project included a Spanish carbon footprint survey, writing utensils, and mechanisms to record the progress of the survey (i.e. computer and camera), as well as a reliable carbon footprint calculator used to determine emissions in CO_2 equivalents.

The conservation efforts: AMIPILA - FUNDICCEP

"La Organización Amigos del Parque Internación la Amistad," better known as Amilipa is an organization "that was born with the interest of ecological damage and to stop the advance of the agricultural frontier that began in the decade of the nineties (AMIPILA, 2002)". AMIPILA and FUNDICEEP (Fundación para el Desarrollo Integral Comunitario y Conservación de los Ecosistemas en Panamá or Foundation for Comprehensive Community Development and Conservation of the Ecosystems in Panamá) are non-profit non-governmental organizations (NGOs). They aim to organize sustainable conservation efforts in order to improve biodiversity and the way of life for future generations. Both organizations are aware of climate change and its effects, as well as the danger of overexploitation of the land, the abundance of chemicals in agricultural practices, and the depletion of natural resources that have occurred in Cerro Punta. AMIPILA is prominent in the community and projects on conservation and sustainability include cleaning the community, cleaning of streams, and environmental education (AMIPILA, 2002). AMIPILA's vision is to promote the sustainable development and conservation of natural resources in La Amistad biosphere reserve and its buffer areas (AMIPILA, 2002).

One of the largest conservation projects for the citizens of Cerro Punta is the application of organic fertilizers, which play a large role in the community of Guadalupe. Beginning in 2000, this project was born due to concern of soil deterioration, increase use in agro-chemicals, and most importantly, the possible adverse effects of increased pesticide use to producers and their families. The project entitled: "Application of Organic Fertilizers: An Alternative for the Restoration of Soils and Ecosystems Maintenance" aspired to improve soil physicochemical structure. By encouraging the use of organic fertilizers and natural pesticides, it aims to reduce the use of agro-chemicals that pollute soils and waters (Amipila, 2002). Organic fertilizer differs from mineral fertilizer by being completely devoid of artificial or synthetic chemicals to enhance growth yields, instead using natural ingredients in order to reduce soil depletion (Isherwood, 2000). While mineral fertilization may increase yields it has been claimed that the use of mineral fertilizers has an adverse effect on soil structure (Isherwood, 2000). The diversification of crops and the application of organic production techniques can increase the sustainability of the town of Guadalupe. Although currently there are only 7 organic farms known to the locals and local organizations out of hundreds of farms in Cerro Punta there is a possibility that through community awareness these numbers may increase in the future.

Interviews organic farming / organic farm practices

The first interview called Organic Farms Cerro Punta Interview-01 (OFCPI-01) began with the conversion of a traditional farm to an organic farm. The subject i.e. the farmer that was currently being interviewed stated that, "many people can say that they are organic, but have no real basis behind the declaration. I have that basis." The process was to make a change from traditional to organic and began with a respite for the ground for a short time by taking away chemicals formerly used. The subject used ½ acres as the smallest farmed unit to start the process of change from traditional to organic farming that farmed plants of tomato, pears, chiote, peppers, lettuce, and a variety of other plants without chemical conditioning. The change was made because the subject wanted to learn how to make fertilizer and natural insect repellents without killing the natural barriers that separated crops and farms. Instead of chemicals the farmer used 'Aje' spice and garlic repellent as both fungus repellant and ant repellant. The participating farm families have an abundance of organic food and are well provided for. Moreover, the organic farms avoid high concentrations of chemical substances used on traditional farms that lead to physical ailments like lung problems, skin problems, and infections amongst workers. All four subjects, Organic Farms Cerro Punta Interview-01, OFCPI-02, OFCPI -03, and OFCPI-04, agreed that organic farming was better from an environmental perspective because it lacks the chemicals used so abundantly in traditional farming. All confirmed that organic farming takes time and diligence. Some took more than thirteen years to convert completely to an organic farm.

A resounding negative aspect that each of the subjects interviewed expressed during the interview process was the social stigma associated with converting their lands over from the local norm of traditional farming to organic. The organic approach to farming is still an 'out of the box' idea and traditional (non-organic) agriculture is usually observed by the local residents. All of survey participants claimed that with the change came criticism from close friends and unknown colleagues. They were all affected socially at first by their decisions, often due to the fact that people did not understand the change. Members of the community and other traditional farmers do not openly deny the ideas of organic farms, but considered that they were very strange for them.

The rewards of switching over appear to outweigh the possibility of failing. OFCPI-03, said that, "organic means completely without chemical, as natural as possible." Using compost, organic fumigation products, and spicy aje is a widely used approach in organic farming (OFCPI-01). Processing products organically helps them in all aspects, "to my family and to sell". None of the subjects saw or had any bad issues to state over having an organic farm. Nevertheless, they still face difficulties in production. OFCPI-04 stated, "sometimes with the weather one must invent things to be able to produce." That leaves me to conclude that erratic weather has affected farms in Guadalupe and some organic farms have begun to adapt with the changes for the future.

Carbon footprint data

Carbon footprint data were determined on a portion of the Guadalupe residents as a way of estimating their emissions of CO_2. Seventy-five people completed the survey, equivalent to five percent of the estimated population of fifteen hundred. A copy of the survey is included in the Appendix B. Electricity consumption in the survey was converted to kilowatt per hour. The survey results are reported as currency because I deduced that many people in town did not know or understand kilowatt hours but they did understand how much money was spent per month for various expenses. Using a local bill for electricity from my host family I calculated kWh with the following example of the calculation:

The ticket from the family in October said that the consumption was 135Kwh, and the cost was $17.55.

$17.55/135Kwh = 0.13$/Kwh

Using this number you can convert money to energy. For example, if someone spends $15 per month

$15/ (0.13$/Kwh) = 115.38 Kwh

This conversion is dependent upon the cost of electricity and so the interpretation of survey results is similarly dependent on the cost of electricity at the time that the survey was conducted. Electricity consumption was calculated per person and then converted to an estimate of carbon footprint.

Results

The carbon footprints of the residents of Guadalupe that I surveyed are reported in Figure 3.1. Of the Guadalupe residents that were interviewed, only four percent had a carbon footprint below the average Panamanian resident (1.78 metric tons of CO_2 equivalents per person per year; Carbon Footprint, 2004). Five percent of the inhabitants of Guadalupe passed the residential average of Panama but exceeded the global target of 2 metric tons of CO_2 equivalents per year per person that is required to combat climate change (Carbon Footprint, 2004). The majority of those interviewed (fifty-eight percent) passed the global goal to combat climate change but were less than the world average of 4.00 tons of CO_2 equivalents per person per year and thirty-three percent passed the world average but did not pass the value used for citizens of industrialized nations (11 metric tons of CO_2 equivalents per person per year).

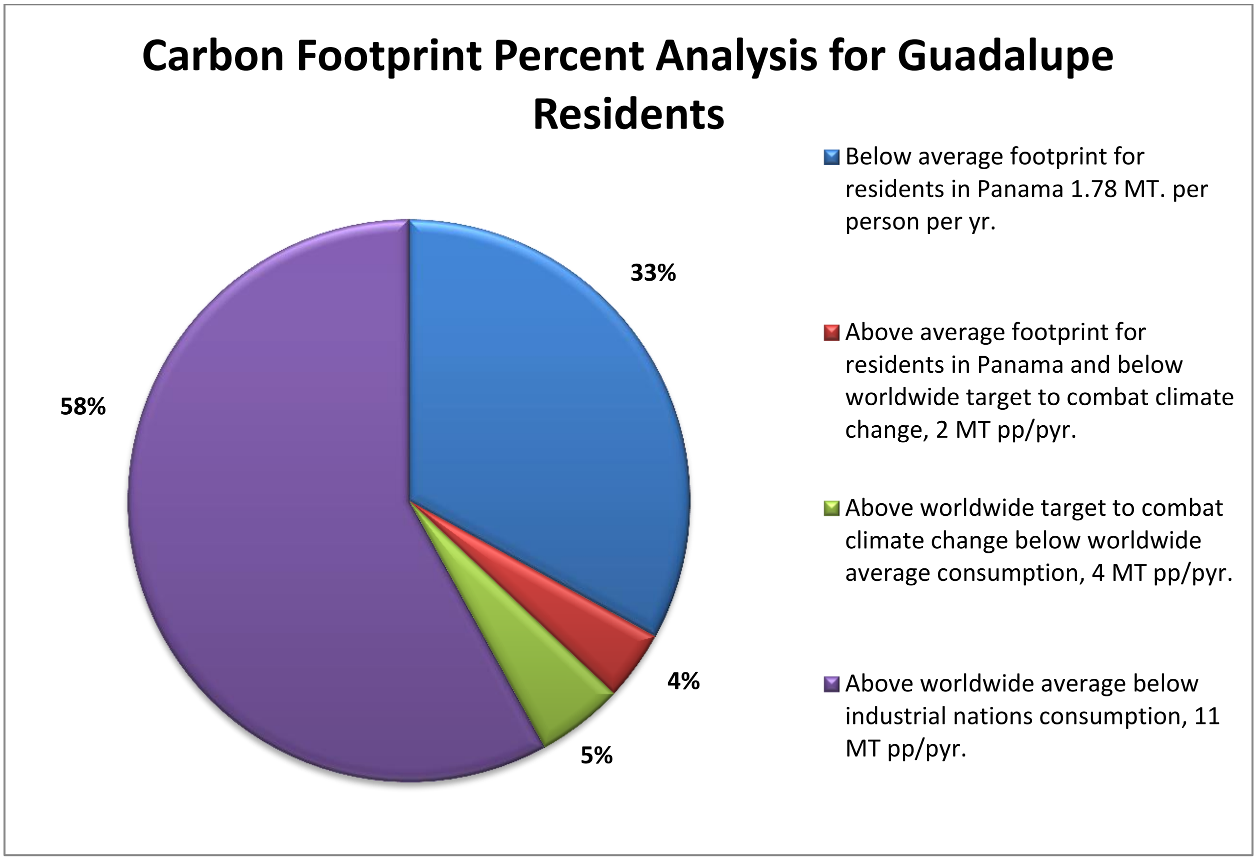


Figure 3.2. Relative proportions of residents of Guadalupe having carbon footprints that are below, meet, or exceed the worldwide per capita target of 2 metric tons per year of carbon dioxide equivalents produced.

For comparison, the per capita carbon emissions in metric tons for several important categories are presented in Figure 3.2. The United States has an average of 20.4 metric tons of CO_2 per person per year (Carbon Footprint, 2004). The average I calculated was for the residents of Guadalupe which had an average of 3.71 metric tons of CO_2 per person per year.

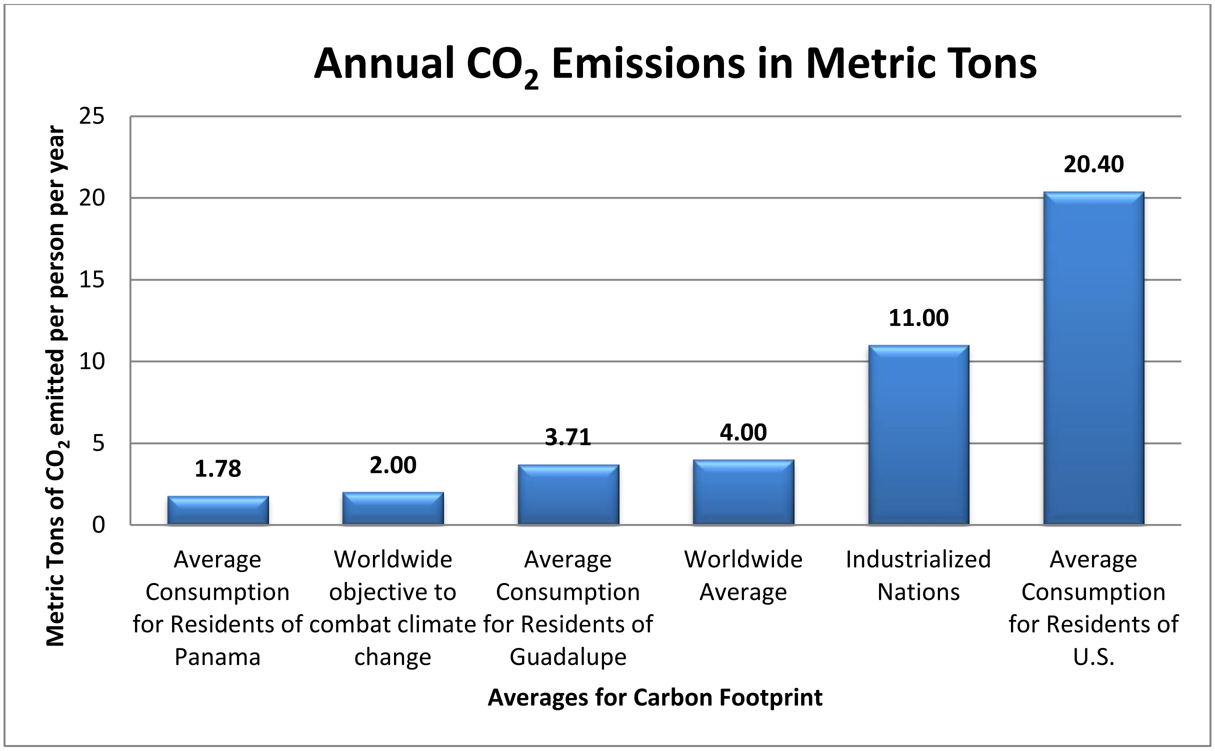


Figure 3.3. Carbon Footprint Emissions of CO_2 in metric tons per person per year for following categories: Average consumption for Panamanian residents, worldwide objective to combat climate change, average consumption for residents of Guadalupe, worldwide average, industrialized nation average, average consumption for residents of U.S.

Discussion

Conservation projects such as the development of organic farms and the use of organic fertilizer can influence parameters that play into how climate change occurs. From the interviews of organic farmers that I conducted, all confirmed that with diligence and patience the change from traditional to organic farming can be beneficial and can be undertaken gradually. Although there were people who did not fully understand the implications of changing to organic farming, they might acknowledge that the change was still beneficial for health and environmental reasons. By reducing the use of chemicals, the act of farming generates lower carbon emissions which helps the environment in the long run.

Through the projections of the carbon footprint I deduce that while four percent of the inhabitants of Guadalupe are below the average of inhabitants of Panama, 58% are passing the global goal to combat climate change, and 33% of the residents are passing worldwide consumption average. Guadalupe residents have an average of 3.71 metric tons of CO_2 equivalent per resident per year, which is close to the world wide average of

4 metric tons of CO_2 equivalent per person per year. However, neither of these values meet the goal needed to combat climate change. Even so, the average consumption for Panama is 1.78 CO_2 equivalents per person per year, meaning Panama, as a whole, is on track to combat climate change.

Initially, all of the farmers were socially affected by their decisions to switch from traditional farming to organic farming. Many times, this was due to the fact that people did not understand the change or did not care to understand. Members of the community don't deny that organic farming may be healthier overall, but they still consider the idea strange.

Conclusion

Based on the surveys that were carried out in Guadalupe and the responses of many of the inhabitants in the area I can conclude that many people believe that the idea of organic farming is alien to them. Much of the community is integrated and traditional and this includes their farming techniques. When asked about a carbon footprint many didn't understand or hadn't heard of the concept. While there are professionals who are involved with organic farming and conservation efforts, many residents are very set in their ways when it comes to agricultural practices in the highlands. Of the hundreds of farms in Cerro Punta, only seven were organic. The organic farms in Cerro Punta used zero chemicals and practiced recycling. Furthermore, there is evidence that organic farming is better for the environment. Organic agriculture that emphasizes closed nutrient cycles, effective soil management, and biodiversity seems to have the capacity to mitigate or even reverse effects of climate change (Meleca, 2008). Many field trials worldwide show that organic fertilization, compared to mineral fertilization increases soil organic carbon, thus sequestering large amounts of CO_2 from the atmosphere to the soil (Organic Agriculture, 2013). The heavy use of chemical fertilizers and pesticides destroys soil fauna that aerates the soil (Karkee, 2004). Organic farmers in Cerro Punta have stated that the chemicals used in traditional farming were one of the main points why they transferred away from traditional farming as it has been stated that chemicals used for traditional farming has caused sickness in local workers (OFCPI-1, OFCPI-2).

Data from the carbon footprint estimates from published values showed that residents of Panama are on track to combat climate change. Data derived from the household surveys that I conducted on the residents of Guadalupe indicate a higher rate of consumption (3.71 metric tons of CO_2 equivalent per person per year). That is a little below the worldwide average of 4 metric tons CO_2 equivalent per person per year and double the average for the rest of the inhabitants in Panama (Carbon Footprint, 2004) . While Guadalupe is just below the worldwide average for consumption, Guadalupe's average carbon footprint is much lower than that estimated for the average U.S. citizen. The U.S has an average consumption rate of 20.4 metric tons of CO_2 equivalent per person per year (Carbon Footprint, 2004), close to 5 times the amount of CO_2 equivalents produced by one resident of Guadalupe in a year.

While projects such as organic fertilizer and different efforts of conservation may have a positive effect towards the fight against climate change there is no statistical evidence in my findings that support this conclusion. Although this does not necessarily negate the ecological importance to mitigate and adapt to climate change further examination on possible outcomes of organic fertilizer and conservation projects in Guadalupe may be required for future research. In a large sense, minimizing carbon emissions is a goal of many countries and agencies. Achieving this goal can have large consequences for future climate change and may affect the smallest ecosystems to the very largest.

Chapter 4: Conclusions Panama to OSU

Human activities are contributing to climate change through the increased release of greenhouse gases into the atmosphere (Solomon, 2007). Decreasing greenhouse gases through renewable resources and carbon offset equivalents have positive effects to our environment because these steps reduce the net amount of greenhouse gases added to the atmosphere (Renewable Green, 2013). Small changes in one's local community can reduce eCO_2 and it can be as simple as riding a bike to work rather than driving a car or unplugging appliances when not in use. Guadalupe residents for example, usually either biked or walked to work or the store. These could have contributed to their decreased carbon footprint. Even bringing a shopping bag for groceries rather than asking for paper or plastic could have significant benefits in reducing a carbon footprint.

One step that can be taken for Oregon State University is the adaptation of a carbon footprint calculator. This would have many benefits for the local community. It may increase awareness towards carbon consumption and give ideas on how to reduce an individual's greenhouse gas impact. It may also get people involved in their community. A carbon footprint calculator for OSU with options to offset also provides the OSU populace with information. Carbon neutral projects that contribute to a reduction in greenhouse gas emissions include the Organic Growers Club, Student Sustainability Initiative, and local businesses that offer possibilities of restoration of natural habitats and carbon neutral initiatives that have positive effects towards our local community and ecosystems. In order to even begin offsetting, an accurate and complete carbon footprint calculator is needed in order to help individuals determine how they can reduce their carbon footprint. Choosing the correct calculator was my first task, and one of the most difficult steps.

There were several carbon footprint calculators available for adaptation; however, Santa Clara University provided easy access to its calculator. Each carbon footprint calculator I've encountered had their own process in calculating carbon emissions and while most were equally reliable alternatives, SCU's calculator offered some benefits. Calculations used for SCU's online calculator were readily available for public view. Many online calculators do not have their calculations available for public view, so there was no way to verify their thought process or calculation methodology. Secondly, the carbon calculator was a local project created and run by students and faculty indicating that such an idea could become a reality. Lastly, calculations behind SCU's calculator were straightforward and could easily be adapted for use at Oregon State University allowing students and faculty to calculate their individual carbon consumption.

Current review of carbon consumption data for OSU provided by the Office of Sustainability indicated that a net emission for fiscal year 2012 was an estimated 126,815 eCO_2 (Table 2.2). Using Carbon Visuals, I was able to show that 126,815 eCO_2 at standard temperature and pressure was equal to a patch 3.1 cm thick with an area of 2,145 km^2 which covers all of Corvallis and Albany and several surrounding state parks and a wildlife refuge. Shown differently, this volume equals a sphere 506 m in diameter or a cube with a volume of 67.8 million m^3 and a diameter of 407.8 m (Carbon Visuals, 2013). The sphere is equivalent in height to 7 Reser Stadiums stacked on top of another or 24 OSU Bell Towers, or 28 MU Buildings. Using a carbon footprint calculator may help individuals set personal goals to track their carbon footprint in the fight towards carbon neutrality.

Analyzing the carbon footprint data collected from a small community unlike Corvallis I've found that Guadalupe, Panama sets a good example with regards to household consumption. By surveying 75 residents of Guadalupe I discerned that the average resident produces more eCO_2 per person per year than that required to achieve the goal to combat climate change (2 metric tons eCO_2 per person per year). They were below the worldwide average to combat climate change of 4 metric tons eCO_2 per person per year with an average amount of 3.71 metric tons eCO_2 per person per year (Carbon Footprint, 2004). They are far ahead of the U.S. residential average of 20.4 metric tons eCO_2 per person per year (Carbon Footprint, 2004). This means that every U.S. resident that consumes 5-fold more eCO_2 per year than a Guadalupe resident. While the U.S. average might be high compared to Panama, it may also depend on where you reside. With an estimated 126,815 eCO_2 and a population size of 29,129 the average carbon consumption for OSU resident per year is 4.35 eCO_2. This amount is below the U.S. average, but is still above worldwide consumption average of 4 metric tons per person per year. However, they are not meeting the goal to combat climate change (2 metric tons per person per year). While the eCO_2 emissions estimated by the Office of Sustainability may be as close to accurate for OSU as possible, it may be lacking some key factors and these omissions could have a significant impact on the calculated amount of eCO_2 emitted per OSU resident per year. For example, calculations may not have included household energy consumption for students that live off campus, which is a key factor in the amount of metric tons of eCO_2 OSU residents emit. Furthermore, extracurricular activities that are carbon inducing i.e. secondary emissions which could include examples such as shopping, going to movies, using motorized bikes, whether or not they recycle, all of these may not have been considered in the overall calculation. Thus the OSU average of 4.35 eCO_2 may actually be quite underestimated. In fact, it seems likely that the average amount for OSU may be somewhat closer to the U.S. average of 20.4 eCO_2 per person per year. While OSU as a university may be working towards carbon neutrality OSU residents should take part in the initiative to reduce their own carbon footprint.

My experience from Panama has shown me that no matter where you are there are always possibilities to increase self-awareness regarding how much you consume. A carbon footprint calculator for Oregon State University may be able to provide this awareness. Although Guadalupe is quite different from Corvallis, I've found that both places have sustainability projects underway and although we strive to reduce the rise of carbon gas emissions, the only way we can do it is by taking an active step toward neutrality. In the future, the framework provided should act as a stepping stone towards the creation of an online carbon footprint calculator. I've identified why a carbon footprint calculator would be beneficial for OSU and provided a planning structure to guide future students or faculty in the creation of the online calculator.

This project still has far to go towards adapting calculations from SCU for OSU needs and towards constructing an official calculator for implementation (Figure 2.1). Once a draft of the online carbon footprint calculator is made, it may be sent to local OSU professors interested in the idea for student/faculty assessment. A trial period should reveal needs for improvement, what works, and what doesn't work. Once final assessments are given and changes have been made a finalized version of the carbon footprint calculator should become activated. Descriptors such as history of the carbon footprint calculator, climate change, affiliations, so on and so forth should be added. Research on current local carbon neutral projects in the area will be a future inclusion once the calculator has been implemented (Figure 2.1).

Offsetting options for the online carbon footprint calculator should be a definite goal after the calculator has been established. Further research on carbon neutral and sustainable projects in the area should occur, and a small committee may be needed in order to select the first possible offsetting potentials for the calculator. A faculty mentor is a must, in order to begin this process due to the fact that people who opt to offset their carbon will be donating to these specific projects. Thus, opening an account with OSU to hold funds for allocations of donations will be needed. An application process may need to be considered once the offsetting portion to the calculator has been implemented and becomes known to the general public. By this time, a panel including both student and faculty should be formed in order to take applications from local projects that may need funding and would like to be included as a possible donation option. It should be noted, that donation amounts may vary based on public selection. Some projects may be more popular than others. Thus, in the application process a money cap should be implemented in order to limit the amount a certain project may recieve if they are short term projects. Long term or continuing projects will be considered depending on the project and its effects towards neutrality. There are many possibilities for continuing this project. It would benefit the Corvallis population and OSU faculty and students. With additional adjustments it may be beneficial for future researchers and other universities for adaptation. This would benefit not only the OSU community, but the overall global population.

Bibliography

Amipila. (2002). *Aplicación de Abono Organico:Una Alternativa de Restauracion y Mantenimiento de Ecosistemas, Guadalupe*. Guadalupe: Panama. Print. N.p.

Balat, M. & Balat, H. (2009). Recent trends in global production and utilization of bio-ethanol fuel. *Applied Energy*, *86*(11), 2273-2282 pp.

Bernstein, L., Bosch, P., Canziani, O., et al. (2007). IPCC, 2007: climate change 2007: synthesis report. *Contribution of working groups I. II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva.*

Bogner, J., Pipatti, R., Hashimoto, S., et al. (2008). Mitigation of global greenhouse gas emissions from waste: conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation). *Waste Management & Research*, *26*(1), 11-32 pp.

Carbon Calculator- Conservation International. (2013). *Conservation International*. Retrieved May 4, 2013, from http://www.conservation.org/act/live_green/carboncalc/Pages/default.aspx

Carbon Footprint Calculator. (2004). *Carbon Footprint Ltd - Carbon Footprint Calculator*. Retrieved December 5, 2012, from http://calculator.carbonfootprint.com/calculator.aspx

Carbon Fund. (2013) *Reduce carbon footprint with carbon offsets*. Retrieved May 4, 2013, from http://carbonfund.org/business-calculator

Carbon Visuals Ltd. (2013). *Carbon Quilt*. Retrieved May 25, 2013, from http://www.carbonquilt.org/visualiser

Cerro Punta, Resident #1 Organic Producer, FOCPE-01: Fincas Orgánicos Cerro Punta Entrevista-01, Interviewed November 20, 2012

Cerro Punta, Resident #2 Organic Producer, FOCPE-02: Fincas Orgánicos Cerro Punta Entrivista-02, Interviewed November 20, 2012

Cerro Punta, Resident #3 Organic Producer, FOCPE-03: Fincas Orgánicos Cerro Punta Entrivista-03, Interviewed November 25, 2012

Cerro Punta, Resident #4 Organic Producer, FOCPE-03: Fincas Orgánicos Cerro Punta Entrivista-04, Interviewed November 25, 2012

Conservation International. (n.d.). *Home- Conservation International*. Retrieved May 6, 2013, from http://www.conservation.org/Pages/default.aspx

Copus. (2009). Explore Energy Resources - YOS Energy Resources 2. *Welcome to the Year of Science 2009!! - YOS Home*. Retrieved June 3, 2013, from http://www.yearofscience2009.org/themes_energy_resources/explore/

Deans' Green Team | Duke Carbon Calculator. (2007). *Sites@Duke.* Retrieved September 4, 2013, from http://sites.duke.edu/deansgreenteam/category/duke-carbon-calculator/

Organic Agriculture: Climate Change. (2013). *Food and Agriculture Organization of the United Nations*. Retrieved June 2, 2013, from http://www.fao.org/organicag/oa-specialfeatures/en/

Karkee, K. (2004). *Land degradation in Nepal: A menace to economy and ecosystems*. International Master's Programme in Environmental Science, Lund University. Lund, Sweden. 1-10 pp.

Kirby, A., Bogdanovic, J, Heberlein, C. et al. (2008). *CCCC Kick the Habit: A UN Guide to Climate Neutrality*. Nairobi, Kenya: United Nations Environment Programme. Print. 159-169 pp.

Koh, L. & Ghazoul, J. (2008). Biofuels, biodiversity, and people: understanding the conflicts and finding opportunities. *Biological conservation*, *141*(10), 2450-2460 pp.

Gatto, M. (1995). Sustainability: is it a well-defined concept? *Ecological Applications* Ecological Society of America., *5*(4), 1181-1183 pp.

GBLT. (2011). Greenbelt Land Trust: Who We Are. *Greenbelt Land Trust*. Retrieved April 5, 2013, from http://www.greenbeltlandtrust.org/about/index.html

Hassol, S. (2004). *Impacts of a warming Arctic: Arctic Climate Impact Assessment*. Cambridge, U.K.: Cambridge University Press. 13-42 pp.

Hertwich, E. G. & Peters, G. P. (2009). Carbon Footprint of Nations: A Global, Trade-Linked Analysis. *Environmental Science & Technology*, *43*(16), 6414-6420pp.

IEA. (2008). *Energy technology perspectives 2008: scenarios & strategies to 2050: in support of the G8 Plan of Action*. Paris: OECD/IEA.

IEA. (2013). The Journal of the International Energy Agency. *Visualizing the "Hidden" Fuel.* (4).

Isherwood, K.F. (2000). International Fertilizer Industry Association United Nations Environment Programme. *Mineral Fertilizer Use and the Environment.* 7-51 pp.

Jenkins, A. (2013). Climate Change: Consensus. *Climate Change: Vital Signs of the Planet*. Retrieved June 3, 2013, from http://climate.nasa.gov/scientific-consensus

Macauley, M. (2013). Carbon Offsets and Earth Observations - NASA Science.*NASA Science*. Retrieved June 5, 2013, from http://science.nasa.gov/earth-science/climate-policy-speaker-series/climate-policy-carbon-offsets-and-earth-observations/

McCarthy, C. (2013). *Lonely Planet-Panama*, Footscray, Victoria: Lonely Planet Publications. Print. *6*(1), 127 pp.

Meleca. (2008). Climate change. *Organic Guide*. Retrieved April 6, 2013, from http://www.organicguide.com/organic/climate-change/

Nature Conservancy. (n.d.). Free Carbon Footprint Calculator | The Nature Conservancy. *Nature Conservancy | Protecting Nature, Preserving Life*. Retrieved May 4, 2013, from http://www.nature.org/greenliving/carboncalculator/index.htm

Organic Growers | Club. Crop and Soil Science | Oregon State University. (n.d.). *Crop and Soil Science | Oregon State University | Oregon State University*. Retrieved June 1, 2013, from http://cropandsoil.oregonstate.edu/organic_grower

Pachauri, R.K. & Reisinger, A. (2008*). Climate Change 2007: Synthesis Report. Geneva: Intergovernmental Panel on Climate Change*. 104 pp.

Padgett, J., Steinemann, A., Clarke, J., et al., (2008). A Comparison of Carbon Calculators. *Environmental Impact Assessment Review*, *28*(2-3), 106-115 pp.

Planet, C. A. C. (2006). *A consumer's guide to retail carbon offset providers. Clean Air-Cool*. Trexler Climate and Energy Services. 26, 1 pp.

Propiedades En Panama. *Propiedades En Panamá: Terrenos, Casas Y Tierras En Panama: Ubicación*. Digital image. *Propiedades En Panamá: Terrenos, Casas Y Tierras En Panama: Ubicación*. N.p., n.d. Retrieved Dec. 9, 2013, from http://www.propiedadesenpanama.net/p/ubicacion.html

Renewable Green| Renewable vs. nonrenewable energy pros and cons. (2013). *Renewable Green Energy | renewablegreen.net*. Retrieved June 1, 2013, from http://renewablegreen.net/?p=124

Riebeek, H. (2011). The Carbon Cycle: Feature Articles. *NASA Earth Observatory: Home*. Retrieved March 15, 2012, from http://earthobservatory.nasa.gov/Features/CarbonCycle/?src=eoa-features

Sierra Club. (2013.). Cool Schools: Complete Rankings - September/October 2012 - Sierra Magazine - Sierra Club. *Sierra Club Home Page: Explore, Enjoy and Protect the Planet*. Retrieved May 25, 2013, from http://www.sierraclub.org/sierra/201209/coolschools/complete-rankings-cool-schools.aspx

Solomon, S. (2007). *Climate change 2007: the physical science basis: contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (Vol. 4). Cambridge: Cambridge University Press. 387 pp.

Terrapass. (2013). Personal carbon calculator. *TerraPass | Fight climate change, reduce your carbon footprint*. Retrieved May 4, 2013, from http://terrapass.com/carbon-footprint-calculator-2/

Trelstad, B. & Smith, G. (2009) *Oregon State University Climate Plan: A Strategic Plan for Institutional Climate Neutrality.* Oregon State University Climate Plan. Retrieved May 2013, from <http://oregonstate.edu/sustainability/sites/default/files/docs/osuclimateplan2009.pdf>.

UCSD | University of California, San Diego | The Greenhouse Effect. (2002) *The Greenhouse Effect*. Retrieved June 2013. <http://earthguide.ucsd.edu/virtualmuseum/climatechange1/02_1.shtml>.

Welch, C. (2012). The Ozone Layer. *The Ozone Hole*. Retrieved June 3, 2013, from http://www.theozonehole.com/ozonelayer.

Wihbey, J. (2011). Structure of Scientific Opinion on Climate Change - Journalist's Resource Journalist's Resource: Research for Reporting, from Harvard Shorenstein Center. *Home - Journalist's Resource Journalist's Resource: Research for Reporting, from Harvard Shorenstein Center*. Retrieved March 19, 2012, from http://journalistsresource.org/studies/environment/climate-change/structure-scientific-opinion-climate-change/

Wissmar, R. C. (2004). Riparian corridors of Eastern Oregon and Washington: functions and sustainability along lowland-arid to mountain gradients. *Aquatic sciences*, *66*(4), 373-387pp.

WRI. (n.d.). What are the effects of climate change? | World Resources Institute. *World Resources Institute | Global Warming, Climate Change, Ecosystems, Sustainable Markets, Good Governance & the Environment*. Retrieved February 19, 2012, from http://www.wri.org/publication/hot-climate-cool-commerce/what-are-effects-of-climate-change

Willamette Valley Vineyards - Sustainability. (2012). *Willamette Valley Vineyards | Oregon Pinot Noir | Oregon Wine Country*. Retrieved February 19, 2012, from http://www.wvv.com/about/sustainability/

Yale University. Calculator Methodology | Yale Sustainability. (2013). *Welcome | Yale Sustainability*. Retrieved June 2, 2013, from http://sustainability.yale.edu/research-education/community-carbon-fund/calculator-methodology

APPENDEX A: SCU Calculation Sources **(Tables courtesy of Christina Lesnick and Santa Clara University Office of Sustainability)**

	LOCATION	Methodology	Conversion	Sources	Questions	Still To Do	Other Useful Info
ELECTRICITY	**Dormitories** (Graham, McLaughlin, SanFilipo, Sobrato, Dunne, Casa Italiana, Campisi, Swig) **All Other Buildings on Campus**	Instead of basing energy on what dorm you live in, have user fill out energy audit -- what electronics are in room and how long use/day. Acquire energy baseline as being a member of university minus energy from dorms.		Silicon Valley Power and green managerhttp://www.energysavers.gov/your_home/energy_audits/index.cfm/mytopic=11170	Green-manager calculates electricity only -- YES. Since we're calculating energy baseline we no longer need to consider specifics of Malley, Library, and classrooms, right?? We would still have to add in the carbon from manufacturing the appliances, right?? How are we going to weigh student vs factulty?	Get conversion from Lindsey. Get numbers to calculate baseline and finalize methodology for baseline.	give hints as to what hours of usage are average

	TYPE	Methodology	Conversion	Sources	Questions	Still To Do	Other Useful Info
TRANSPORTATION	**Small**	Ask miles traveled in a given month. Multiply that by conversion factor		DEFRA		Figure out distance to santana row, santa cruz, san francisco, downtown san jose	tip: zip car
	Average	Ask miles traveled in a given month. Multiply that by conversion factor		DEFRA			
	SUV/truck	Ask miles traveled in a given month. Multiply that by conversion factor		DEFRA			
	Hybrid	Ask miles traveled in a given month. Multiply that by conversion factor		DEFRA			
	Air Travel	Need to know pkm (passenger kilometers). Find average pkm for flights to west coast, midwest, and east coast. Then multiply that by km uplift factor. Then multiply that by CO2 conversion factor		DEFRA		Figure out average pkm for different regions in U.S.	let user know about carbon offset for flight
	Bus	Multiply CO2 conversion factor with average bus trip. Ask how many bus trips/week.		DEFRA and VTA		Find average bus trip	buses: make sure that people are aware of how public transport is aiming to be more green
	Train (Bart/Cal Train)	Multiply CO2 conversion factor with average train ride. Ask how many train rides/week.		DEFRA		Find how many miles to SF using bart	

Figure A1. Transportation and electricity sources of Kg CO_2 for SCU calculator.

C	CATEGORY	Methodolgy	Conversion	Sources	Questions	Still To Do	Other Helpful Info
	Computer	Ask PC or Mac user. Calculate carbon dioxide that goes into manufacturing, also daily carbon output. Average how many hours a day college student uses computer (decided on 8 hours).	9.0 g CO2/hour of using 2010 Macbook. 350 kg CO2 for 4 year lifespan. 52% of that is production. Dell Latitude E6400 is also 350	http://www.apple.com/environment/#footprint. Mackbook environmental Report (pdf). Dell CF whitepaper (pdf). http://www.hp.com/large/psg/carbon-footprint-calc.html	Do we even have to ask Mac or PC if both have same lifetime CO2 output? HP computer has Carbon Footprint Calc around 400 kg CO2e	Take a second look atif they are similar. Hp? What most popular PC? Is apple more carbon friendly?	Dell: Plant a Tree Program to offset carbon.
	Ipod		23 kg CO2	http://offsetmyipod.com/	NEED TO RESEARCH		
	Cell phone	Ask if smart phone vs. mobile phone. Divide appropriately to capture CO2 in day	mobile: 112 kg CO2/yr 60 kg of which from prod. 88kg to charge/yr. Iphone 3GS: 55 kg CO2 for 4 yr life 50% of which is prod.	http://fatknowledge.blogspot.com/2008/10/carbon-footprint-of-macbook.html http://operationsbuzz.com/2010/04/5-carbon-footprints/			
	Textbooks	Ask user average number of textbooks and soft covers/quarter. Divide out to capture CO2/day. New or used?	avg bk: 7.5 kg CO2. avg txtbk: 10.2 kg CO2	http://www.re-nest.com/re-nest/simple-living/whats-more-environmentally-friendly-ereaders-vs-books-125720. Amazon Kindle Brief (pdf)	should we ask user to average per quarter. Should we think about readers and nontextbook books? NO READER. Carbon offset between new and used?	new vs. used	Chegg. You save money and plant a tree. Newspaper sector uses most carbon, than book production, than magazine production. Textbooks are a third of the books sold globally
	Gaming	Get carbon released from maufacturing xbox disk and average usage of system. 28 M sold.	13.76 kg of CO2/disk	http://gamerlimit.com/2009/04/the-environmental-sustainability-of-the-games-industry/	What is the average use of gaming system/day? If say yes then 2hours a day How much carbon used for one hour playing game? Get number from Tim. kWh at bottom xbox and convert.		
	TV	1.5 hours a day as average. Manufacturing for average flat screen TV.	.13 kg CO2/hr. for 10 yr life 2900 kWh	http://www.chinapost.com.tw/life/environment/2009/03/24/201499/Environmental-agency.htm Life cycle assessment (pdf)			Watching TV for an hour less per day could mean 0.13 kg less emissions per day
	Clothing	Ask user how often by new article of clothing in a given month. Multiply weight of clothing times CO2 conversion factor. Divide out to get CO2 output for day.	Average dress: .282 kg. cotton: 6.5 kg CO2/kg. Cotton/polyester blend: 5.3 kg CO2/kg	Analysis by Stormberg by CO2 Focus (pdf). http://www.gaia-movement.org/TextPage.asp?TxtID=136&SubMenuItemID=103&MenuItemID=47			every ton recycled will result in 1.5 tons less carbon emitted to the atmosphere.
	Partying	How many times a week party? Average carbon/party	2.756 kg CO2/keg of beer. .085 kg CO2/red cup	http://www.glproject.com/filebin/pdf/312_Keg_Footprint_Report.pdf http://www.eco-collectoor.fr/IMG/pdf/ECO_Comparative_Study.pdfhttp://ecofx.org/wiki/index.php?title=Beer http://www.stanford.edu/~sjdavis/NBB-FT.pdf	How are we average carbon for one party? 2 keg/party. 1 big bag/ party.	TALK TO TIM	
	eReader	Ask if have ireader. Ipad or Kindle? Use for school purposes? If so how many books a quarter? Divide out to get CO2 per day	ipad: 130 kg CO2 for 4 yr lifespan. Kindle: 168 kg CO2 for 4 yr lifespan	http://www.photojbartlett.com/2010/08/29/the-carbon-footprint-myth-the-un-green-ipad/. Amazon Kindle Brief (pdf). http://www.re-nest.com/re-nest/simple-living/whats-more-environmentally-friendly-ereaders-vs-books-125720			18 paper books with electronic ones to offset your iPad and 23 to offset a Kindle. When you consider other factors such as the water consumed during book publishing, the picture becomes more clear. It takes about seven gallons of water to produce the average printed book. Digital books, on the other hand, are electronically published on less than two cups of water

Figure A2. Consumption sources for Kg CO_2 for SCU calculator.

WATER	CATEGORY	Methodolgy	Conversion	Sources	Questions	Still To Do	Other Helpful Info
		Subtract out the average gal/shower and average gal/load of laundry average gal/flush and replace with the users inputted shower time/week and loads/week. Use weighted population to add on a baseline	352 kg CO2e / Ml of water treated	http://www.anglianwater.co.uk/_assets/media/Greenhouse_Gas_Emissions_Annual_Report_2010_(2).pdf www.maytagcommerciallaundry.com/.../MAH22PDAGW_Dimension%20Guide_EN.pdf http://environment.nationalgeographic.com/environment/freshwater/water-footprint-calculator/http://www.zerofootprintfoundation.org/images/uploads/Equivalencies_-_Justifications.pdf		Look at what other people ask about this usage.	egg timer for five minute shower
GAS	**CATEGORY**	**Methodolgy**	**Conversion**	**Sources**	**Questions**	**Still To Do**	**Other Helpful Info**
		Add this carbon to the energy tab based on weighted population				get conversion from lindsey	
FOOD	**CATEGORY**	**Methodolgy**	**Conversion**	**Sources**	**Questions**	**Still To Do**	**Other Helpful Info**
		Which meal plan. Take into consideration the amount of food. Meat vs. vegetarian. Meat at every meal vs. once a week.		Bon appetit co2 calculatorhttp://www.guardian.co.uk/environment/green-living-blog/2010/jun/17/carbon-footprint-of-tea-coffeehttp://www.eatlowcarbon.org/	local vs. nonlocal	Look at clean air cool planet. Consider coffee. Consider tofu. Calc carbon for certain meals at benson	ask leslie for cookbook
WASTE	**CATEGORY**	**Methodolgy**	**Conversion**	**Sources**	**Questions**	**Still To Do**	**Other Helpful Info**
		Baseline number based on entire campus. How often take out trash. Weigh how much trash accumulates/day	2.75 MT CO2e/ ton of recycling 1.34 MT CO2e /ton of trash	http://www.recycling-revolution.com/recycling-facts.html http://www.ie.unc.edu/content/education/courses/capstone/09/carbon_footprint.pdf http://www.epa.gov/cleanenergy/energy-resources/refs.html	coffee cups? Reusable container? Do you use ecotrays	get waste weight. Think about methodology. Consider water bottle vs. reusable	

Figure A3. Water, food, gas and waste sources in kg CO_2.

APPENDIX B. Carbon Footprint Calculator Survey (Spanish)

Entrevista sobre Huella de Carbon

Cuál es el consumo por mes de:

Electricidad________$
Propano___________ litros
Leña ______________toneladas métricas

<u>Comida:</u>
Las Preferencias alimentarias:
Yo soy vegetariano___
Yo como una mezcla de carne blanca y roja___
Yo como carne roja todos los días____

Los productos orgánicos:
Yo solo compro o cultiva comida orgánica____
Nunca compra o produce alimentos orgánicos_______
Sabe si lo que compra es orgánico o no_____

En condimentar los alimentos:
Produce o compra producto según la temporada_____
Trato de comprar o producir algo de comida de la temporada____
No trato de comprar o producir alimentos de temporada___

Los alimentos importados y bienes:
Cultivo mis propios alimentos, y no comprar cualquier producto____
Yo solo comprar alimentos producidos localmente y bienes____
Yo sobre todo comprar productos locales____
Yo prefiero comprar los bienes producidos más cerca de casa____
No me doy cuenta de donde provienen los productos____

Recreación:
De vez en cuando salir a lugares como el cine, bares, o restaurantes_____
Voy a menudo a lugares como el cine, bares, o restaurantes_____
Me gustan las actividades intensivas en carbono, por ejemplo four-wheel, paracaidismo, o vuelo_____

¿Cuántas personas hay en tu familia?_____

<u>Coche</u>
Cuantos kilometro recorre tu carro por mes:
___________ Kilometro
Es: Coche____ Moto____ Camioneta___

Qué tipo de coche:
Diesel____ Gasolina Coche____

Seleccione de modelo: (escoje uno para tu carro)
Coche diesel/gasolina medio___
Coche diesel o gasolina grande ___
Coche diesel/de gasolina mediano ___
Coche diesel/de gasolina pequeño ____

Tractores: ____________ Kilometro/mes
Autobús: _____________Kilometro/mes
Taxi: ________________Kilometro/mes

Moda:
Regularmente compras para tener lo último en moda____
Puedo comprar ropa nueva cuando los necesito_____
Solo compro ropa de segunda mano_____

Mobiliario y material eléctrico:
Me gusta tener la última tecnología y última moda para el hogar____

En general mantiene su tecnología (celular, tv, etc.) más de 5 anos _____
Solo compro equipo esencial y utilizarla hasta que se dañe____
Solo compro muebles de segunda mano y electrodomésticos ____

Finanzas y otros servicios:
Yo uso algún servicio financieros ___

Reciclaje:
Todo lo que se utiliza reciclados o compostados ____
La mayoría de mis residuos se recicla____
Algunos de mis residuos se recicla____
Yo no reciclo nada__