Macalester College Greenhouse Gas Emissions Inventory: 1990-2006

Environmental Studies Senior Seminar 2008

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2008 Environmental Studies Senior Seminar

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Title of Contents

Preface

Calculator Data

Data Outside of Scope of Calculator

List of Figures

Executive Summary

The Macalester College Greenhouse Gas Emissions Audit, conducted by the 2008 Environmental Studies Senior Seminar class, compiled Macalester's carbon-equivalent emissions dating from 1990-2006. This audit satisfies the American College and University Presidents Climate Commitment mandate signed on to by Macalester College President Brian Rosenberg as part of the ACU Presidents Climate Commitment. The data collected will be used to supplement further research in abating Macalester's greenhouse gas (GHG) emissions and serve as a baseline for future carbon audit calculations.

The Clean Air-Cool Planet Carbon Calculator tool was used to complete the audit. The calculator was divided into 6 sections: energy, transportation, solid waste, agriculture, refrigerants and offsets. The energy sector includes both electricity use and heating in all 63 buildings that Macalester owns and represents the greatest amount of emissions on campus (annually 70-80%). Transportation, the next largest emissions sector, included the commuting habits of students, faculty and staff, college-funded travel, both ground and air. Additionally, food, recycling and sewage were examined to provide the most complete view of Macalester's impact.

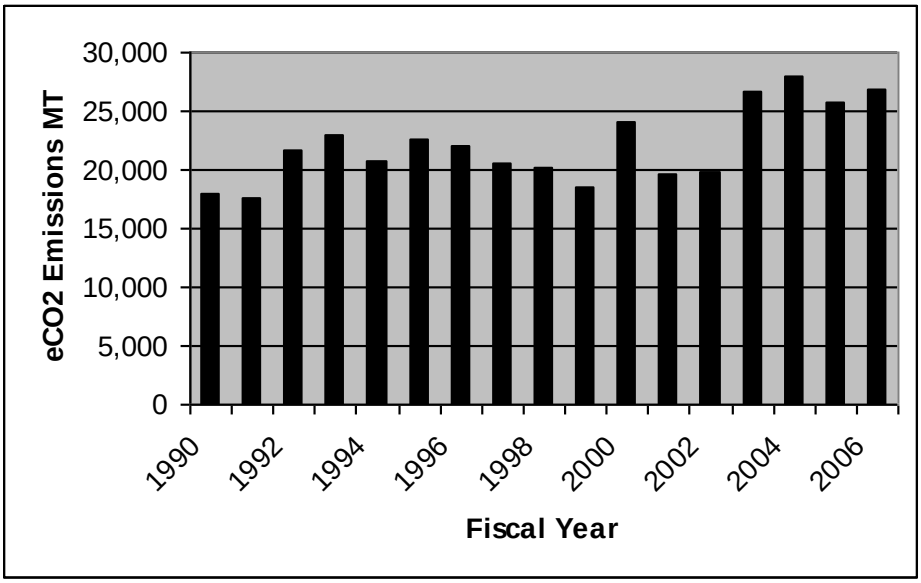

Figure X.1: Annual eCO_2 Emissions 1990-2006. Data included carbon dioxide emission equivalents from electricity, heating, transportation, and waste management.

Results:

In 1990 Macalester College emitted 17,930 tons of carbon dioxide equivalents (eCO_2). In 2006, the most recent year for which the data has been compiled, the College emitted 26,824 metric tons ofeCO_2 as shown in Figure X.1. Carbon dioxide equivalent is a number that converts all GHGs into a standard unit of heat trapping capacity. Over the last sixteen years Macalester emissions have risen 9,248 tons, an increase of 51%.

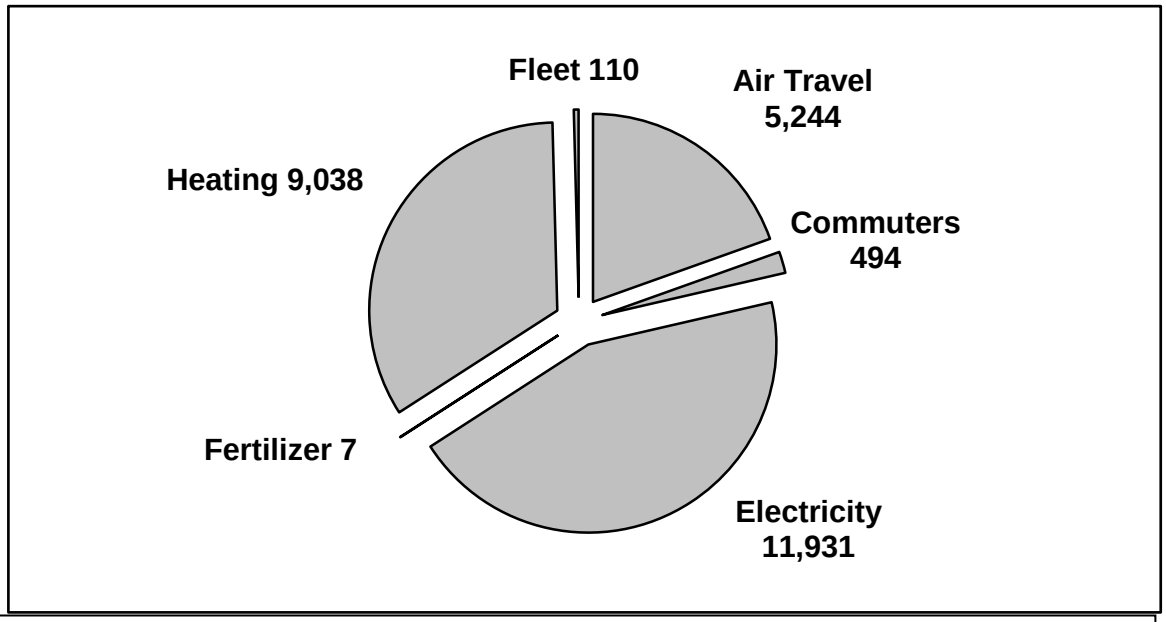

Figure X.2: 2006 eCO_2 Emissions Percentages. In fiscal year 2006, Electrical consumption represented 44% of Macalester College's eCO_2 emissions while Heating accounted for 34%.

Electricity: 11,931 MT eCO_2 (44% of overall emissions)

In 2006, electricity was the most substantial source of eCO_2 emissions at Macalester College. This total is comprised of kilowatt hours (kWh) consumed by all 63 Macalester-owned properties. Macalester's current electricity provider is Xcel Energy, the chief utility supplier for the Twin Cities. Macalester also owns a small, on-campus wind turbine generator; however, this offset source is proportionally insignificant.

On-Campus Stationary: 9,038 MT eCO_2 (34% of overall emissions)

"On-campus stationary" refers to the natural gas and fuel oil burned to produce steam to

heat the campus buildings. This category is the second largest source of Macalester's emissions in 2006. The Macalester heating plant operates on three kinds of energy: fuel oil #2 (used quite rarely), fuel oil #6 and natural gas.

Airline Travel:5,244 MT eCO_2 (20% of overall emissions)

Macalester's airline travel ranks third in emissions and includes all student, faculty and staff travel paid for by the College.

Commuter Transportation: 964 MT eCO_2 (2% of overall emissions)

Macalester's commuter transportation category is comprised of off-campus student, faculty and staff transportation to campus. This sector was divided into two pieces; the first used GIS mapping software to calculate actual distances off-campus students, faculty and staff lived from campus. The second group used two online surveys to analyze commuting frequency, modes of transportation, automotive fuel efficiencies, and a handful of other personal commuting habits.

Fleet: 110 MT eCO_2 (<1% of overall emissions)

The 2006 fleet category consists of all Macalester's campus-owned vehicles, referring to all rental vans and Facilities Services maintenance vehicles.

Solid Waste: 24 MT eCO_2 (<1% of overall emissions)

Macalester's waste category is comprised of solid waste values from all 63 Macalester-owned properties. In 2006, Macalester disposed of 413 tons of solid waste with most of it transported to a local incinerator.

Agriculture (Fertilizer): 7 MT eCO_2 (<1% of overall emissions)

The fertilizer applied on campus contains nitrous oxide (NO_x), a potent GHG. It was calculated that 7,444 lbs of fertilizer was applied in 2006, with a nitrogen content of 25.28%, contributing 7 MT eCO_2.

Additional Categories

Macalester also researched emissions from sewage, food and recycling. Although not included in the CA-CP calculator, it is believed that these are important sources of emissions and should be tracked as well. In 2006, sewage eCO_2 emissions were estimated at 43.5 MT eCO_2, more than waste and fertilizer combined. Recycling was calculated as an offset of 15 MT eCO_2.

Recommendations:

In addition to a quantitative analysis of Macalester College's GHG emissions, this report also explores the deficiencies in record keeping needed for a GHG inventory at Macalester College. The results found in the 2008 CACP Carbon Audit were carefully calculated yet remain vulnerable to discrepancies due to poor records and/or a lack of information.

Data Recommendations:

The annual energy report should be modified to include all gas and electrical consumption by Macalester and High Winds properties and should automatically calculate the inputs for the CA-CP Calculator.

The accounting system should be changed to track international and domestic flights seperately, as well as record miles traveled for reimbursements and rentals.

Commuting habits to and from campus should be surveyed each year to track changes – both coming from Macalester efforts to reduce personal car use in communting and due to the projected impacts of rises in energy costs across the economy.

Solid Waste, Refrigerants and Food either lack or have poor quality data and should be addressed so that these can be accurately calculated. The food system in particular is a very large source of emissions nationwide and – although beyond the technical capcity of this report – its omission needs to be addressed.

GHG Emissions Reductions Recommendations:

Heating/Cooling and Electricity is the largest sector of emissions and presents the greatest opportunities for reductions. The College should perform a campus-wide energy audit and commit to investing in all proejcts with a 10 year or less payback on investment. This will not only achieve significant emissions reductions but will help to insulate the College from the current rapid rises in energy costs.

There should be a campus-wide building code that addresses minimum levels of energy efficiency and insulation for all new construction and remodeling. A clear example would be to require all new projects to be 30% above MN building code requirements.

Of total transportation emissions, 88% comes from air travel. Macalester should create easily accessible telecommunication facilities on campus and encourage these to be used in place of travel – this will have a significant financial impact as well as reduce emissions. The College could also allocate a certain amount of money for each college funded flight - $25 for example- to invest in energy efficiency on campus. While not technically an offset, this will create a funding stream to reduce emissions and create energy cost savings. The Clean Energy Revolving Fund provides the perfect mechanims to operate these investments through.

List of Abbreviations

ACUPCC:……..….. American College and University Presidents Climate Commitment

BTU:……..…… British Thermal Units

CA-CP:…… Clean Air-Cool Planet Carbon Calculator

CCF:……... Hundred Thousand Cubic Feet

CH_4:…… Methane

CO_2:…… Carbon Dioxide

eCO_2:……... Carbon Dioxide Equivalent

GHG:……... Green House Gas

HDD:……... Heating Degree Days

kWh:…… Kilowatt Hours

MCF:……... Thousand Cubic Feet

MMBTU:…… Million British Thermal Unit

MT:……..Metric Ton

NO_x:……Nitrous Oxide

SQFT:…….. Square Footage

1. Introduction

Global climate change refers to the predicted climatic shifts caused by changes in atmospheric composition. Increases in concentrations of greenhouse gases (GHG) reduce the amount of infrared radiation (heat) that reflects back into space. This greenhouse effect can disrupt the earth's climate in a variety of ways, but it most prominently raises average global temperatures. Over the past century, global average temperatures have risen 0.7 degrees Celsius. Alarmingly, a 0.2 degree increase per decade is predicted if greenhouse gas concentrations continue to rise at their current rates.

The most significant greenhouse gases are carbon dioxide (CO_2), water vapor, ozone, and methane (CH_4). CO_2 is responsible for 60% of the increased greenhouse effect, and it is one of the GHGs directly linked to anthropogenic sources. CO_2 emissions, which began increasing in the early 19th century, have spiked dramatically in the last hundred years. This increase is likely the result of anthropogenic CO_2, the most significant of which is the burning of fossil fuels such as coal, oil, and natural gas for transportation, electricity and heating.

The acceptance that anthropogenic sources are increasing GHG emissions has resulted in multiple efforts by many actors to halt the growth of emissions. On the international stage, actions include the adoption of the UN Framework Convention on Climate Change and the 1997 Kyoto Protocol, a global commitment to reducing GHG emissions. The Kyoto Protocol established 1990 emission levels as a baseline for the highest acceptable CO_2 levels. Though the protocol entered into force in 2005 following ratification by Russia, it has not been adopted by the United States. Instead, the impetus for reducing emissions in the US has come from local agreements, including the American College and University Presidents Climate Commitment (ACUPCC).

The ACUPCC was designed to organize institutions of higher education to respond to

climate change by neutralizing greenhouse gas emissions. The ACUPCC developed from the recognition that climate change requires immediate response from all areas of society and, that colleges and universities are in a unique position to take action and educate about climate change. The ACUPCC requires an institution to take inventory of its GHG emissions, to create a concrete plan for achieving a set deadline for climate neutrality, and to take immediate action to reduce emissions. Sustainability must become an integral part of a college's wider curricula, and it must make all of its sustainability-related information and plans available to the public.

Macalester College's President Brian Rosenberg signed the ACUPCC in February of 2007 and acts as a member of the ACUPCC Leadership Circle. In the past year, Macalester has hired a sustainability manager, instituted a subsidized bus pass program and required energy star appliances to be purchased in order to fulfill the requirements of the program. Additionally, the building for the new Institute for Global Citizenship is being engineered to meet the requirements of the Platinum Level of the US Green Building Council Leadership in Energy and Environmental Design (LEED) program. Constructing buildings to LEED standards requires a dramatic shift in the way that campus buildings are conceived, created, and operated with an emphasis on efficiency and long-term durability. The operating costs for this building will be substantially less than a typical building of similar size and location.

Macalester students, staff, and faculty have been making significant efforts to reduce Macalester's carbon emissions in addition to the efforts made to fulfill the ACUPCC. The past endeavors of the institution and student organizations on campus have created the necessary foundation for many of the current programs at Macalester to be very strong.

Students have been very active on environmental and sustainability issues through student organizations such as the Macalester Conservation and Renewable Energy Society (MacCARES), Minnesota Public Interest Research Group (MPIRG), MacBike, and

Macalester Urban Land and Community Health (MULCH). MacCARES, in particular, has initiated a wide range of environmentally-focused projects. It is currently the largest environmental group on campus, with more than 30 students regularly attending meetings and more than 20 projects going at any given time. MacCARES has been instrumental in creating the Clean Energy Revolving Fund (CERF), a system whereby savings from current energy efficiency projects are reinvested into future efficiency projects. Students in MacCARES have also installed two green roofs on campus and encouraged the Macalester community to act on topics ranging from water privatization and energy waste to local economic development.

The following GHG emissions assessment was compiled by the Spring 2008 Environmental Studies Senior Seminar students using the Clean Air-Cool Planet Campus Carbon Calculator. The first requirement of the ACUPCC is that participating colleges and universities conduct a GHG emissions assessment. This carbon audit is the initial step Macalester as an institution is taking to develop a for climate neutrality. In order to reduce GHG emissions, the College needs to understand where emissions come from and what quantities are being produced. The report discusses and presents data on significant sources of GHG emissions at Macalester from 1990-.emissions. The report is divided into two sections: data requested by the carbon calculator, and sources of GHG emissions that are not required by the CA-CP calculator but that are pertinent for a carbon audit. The areas that pertain to the calculator include transportation, energy use, waste management, agriculture (fertilizer) and offsets. The transportation section evaluates all transportation funded by the college, as well as students' and employees' daily commutes to and from Macalester. The information that is not included in the calculator, but is included in this report, is emissions data from sewage, recycling, and food. When put together, the two sections represent Macalester's total carbon emissions since 1990.

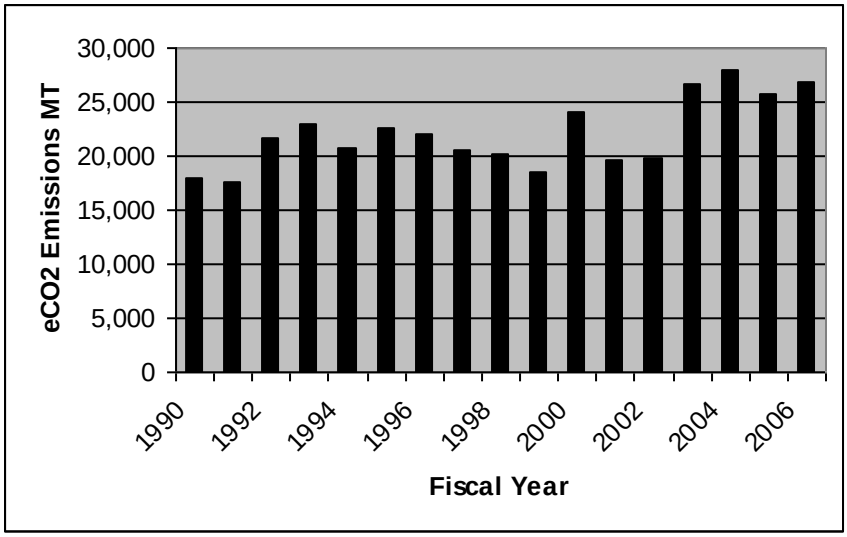

Figure 1.1: Annual eCO_2 Emissions 1990-2006. Data included concerns carbon dioxide emission equivalents from electricity, heating, transportation, and waste management.

As shown in figure 1.1, emission levels for Macalester College have increased since 1990. For every year, transportation, electricity and heating represent nearly all of the carbon dioxide emissions. There is a period of decrease in emissions after 1997 until about 1999. This decrease is due in part to Macalester College using a greater proportion of natural gas instead of highly polluting fuel oils in the campus heating plant.

In addition to the quantitative assessment of the campus's climate contributions, this report includes a summary of other actions on campus around sustainability and climate change. These parts together will provide a more complete understanding of the College's contribution to climate change. This report is meant to serve as a baseline for Macalester's future carbon footprint assessments, as well as a model for other university audits.

This report will explain how and why the various data sets were collected. It will provide the College with a framework to set a goal for emissions reductions as well as provide recommendations to re-structure record keeping systems to facilitate monitoring in the future. The report also recommends ways that the College can efficiently and effectively reduce GHG emissions.

2. Heating/ Cooling and Electricity

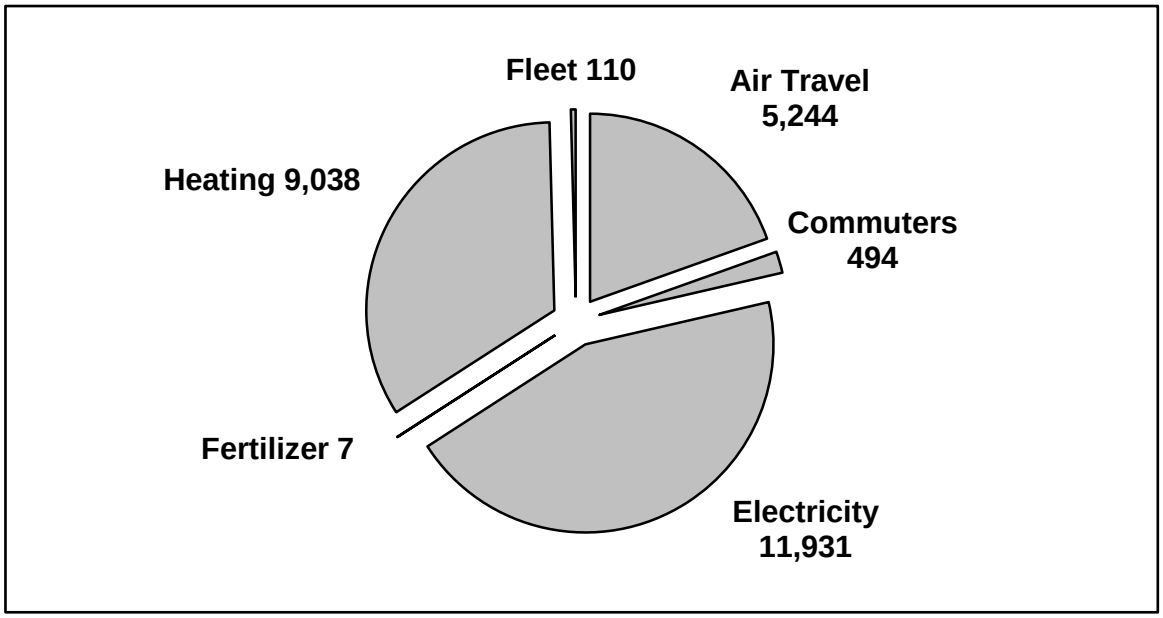

Figure 2.1: 2006 eCO_2 Emissions Percentages. In fiscal year 2006, Electrical consumption represented 44% of Macalester College's eCO_2 emissions while Heating accounted for 34%.

Introduction

Heating/Cooling and Electricity represent the largest source of eCO_2 emissions and includes all energy used directly by the 63 on campus buildings, as well as numerous rental properties that the College owns in the surrounding community. The College used over 13,000,000 kWh in 2006-07, accounting for 44% of emissions. Roughly 365,000 gallons of fuel oil and 43,000 MCF Natural Gas were used on campus, while contributed 34% of total emissions. Macalester College heats its buildings with steam produced by three boilers and purchases electricity from Xcel Energy, the local utility provider. Electricity is used to power all mechanical equipment, lights, electronics and some heating on campus. It is also used to cool the campus during the summer months. This is the energy source that members of Macalester's community have the most direct ability to influence, as it is highly susceptible to behavioral changes.

Macalester uses a mix of natural gas and fuel oils #2 and #6 to heat campus. Natural gas is a fairly clean energy source with relatively low eCO_2 emissions, but is usually more expensive than other options. Fuel oils #2 and #6 are often cheaper than natural gas, but highly polluting and very eCO_2 intensive. Macalester's steam plant has three boilers in a central plant that are used to produce steam to heat the main campus buildings, and smaller natural gas furnaces in several of the auxiliary campus buildings. The campus heating load does not vary independently of weather; this makes it difficult for individual student, faculty and staff behavioral changes to reduce the amount of energy needed for heating. A long-term reduction in the amount of heat required will necessitate a large investment in campus buildings to improve insulation and efficiency.

Heating, cooling and electricity are responsible for 70% to 80% of Macalester emissions. Electricity is a slightly larger percentage than heating but each contributes one third to one half total emissions. Due to the College's fuel purchasing policy, GHG emissions from the steam plant vary greatly depending on which fuels are cheapest in a given year. Electricity emissions have risen only slightly over the last 17 years as Facilities Services has increased campus efficiency, which has been partially offset by an increase in demand due to the rise of personal electronics and appliances.

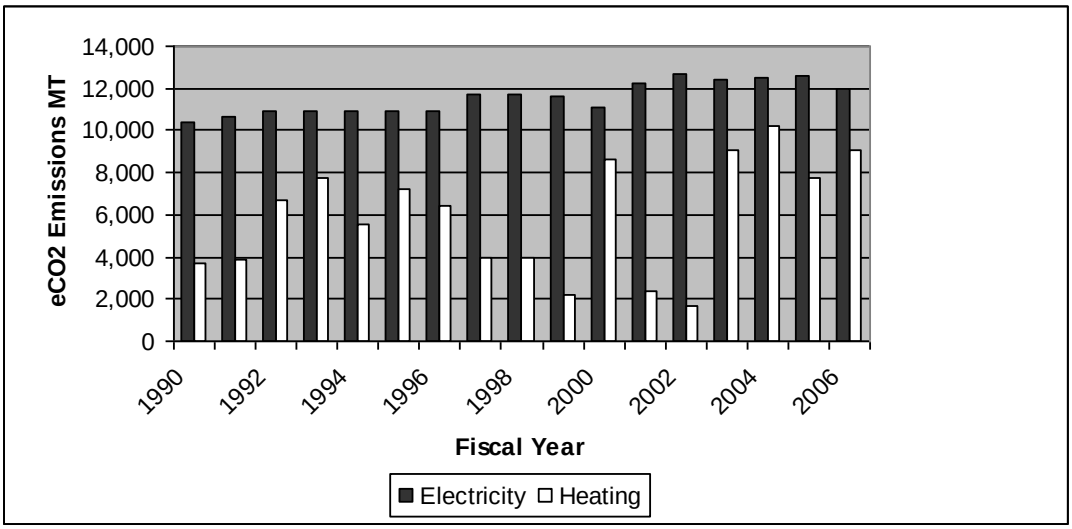

Figure 2.2: Electricity and Heating Emissions 1990-2006. Electricity is consistently responsible for greater amounts of eCO_2 emissions than heating but the difference varies greatly as a result of different proportions of fuel types used each year in the steam plant.

Methods

The first category is electricity. Macalester recorded electrical purchases from Xcel Energy, the local power utility. In addition to kilowatt hours (kWh) purchased, the calculator also requires information about the generation sources for this electricity, such as coal, nuclear, hydroelectric and wind, etc. The calculator provides regional averages used to estimate the GHG intensity of electricity production for Macalester College. The calculator uses the kWh purchased and the generation technique to calculate the GHG production.

The next significant part of Macalester's energy consumption is heating. Macalester College purchases natural gas each year from Xcel Energy to fuel the steam plant, heat water on campus, and heat individual properties, such as the High Winds buildings and faculty housing,. The amount of natural gas purchased each year varies for many reasons, the most obvious being the variability of the weather, which is standardized into heating degree days (HDD) for clear comparison year to year. In addition, Facilities Services also purchases fuel for the steam plant based on cost, so when natural gas is cheaper, the amount used rises. The

heating plant also uses fuel oil #6 and, on rare occasions, fuel oil #2. The calculator differentiates between distillate oil (#1-#4) and residual oil (#5-#6). Residual oil (#6) is generally cheaper than distillate oil (#2) but much dirtier in terms of green house gas emissions. It is important to remember that either type of fuel oil is considerably less desirable than natural gas, but both are normally cheaper. The fuel amounts are recorded as million British thermal units (MMBtu) of natural gas and gallons of fuel oil.

The calculator also records renewable energy sources. Macalester's only source of on-campus renewable energy is a small wind turbine on campus, which provides a limited amount of kWh to the campus. The turbine produces about 1300 kWh annually, less than 1% of total campus consumption.

Facilities Services is responsible for the energy consumption of the college and for running the steam and chilling plants. Their annual energy report includes the total amount of natural gas and fuel oils used to run the steam plant as well as the main meter electrical readings that include electrical use for the twenty major buildings on campus. Macalester owns and is responsible for 80 different buildings (63 heated and conditioned buildings and 17 unheated garages), so Xcel Energy was contacted to get all of the data not covered in Macalester College's Annual Energy Reports. Electrical and natural gas consumption used by buildings outside of Facility Services' annual report was missing, but Xcel Energy was able to provide detailed energy and natural gas bills for all of the college's buildings dating back to 1999. The sets of data from Facilities Services and Xcel Energy were then combined to find the total amount of kWh of electricity and MMBtus of natural gas used. Xcel Energy also provided the carbon intensity data for the electricity production, which provided more accurate numbers from the calculator. Heating degree day data were obtained from the Minnesota Chamber of Commerce.

Results

Although the report contains heating/cooling and electrical usage from 1990 to 2006, only the years 1999-2006 are the actual usage numbers from bills. The years 1990-1998 were estimated based on those bills and so are less accurate. The extrapolation process is detailed below in the section *Data Accuracy.*

Campus electrical consumption has remained relatively steady over the last eight and a half years. Macalester does have a history of focusing on energy efficiency, but there has been a marked increase in attention paid to it over the last few years.

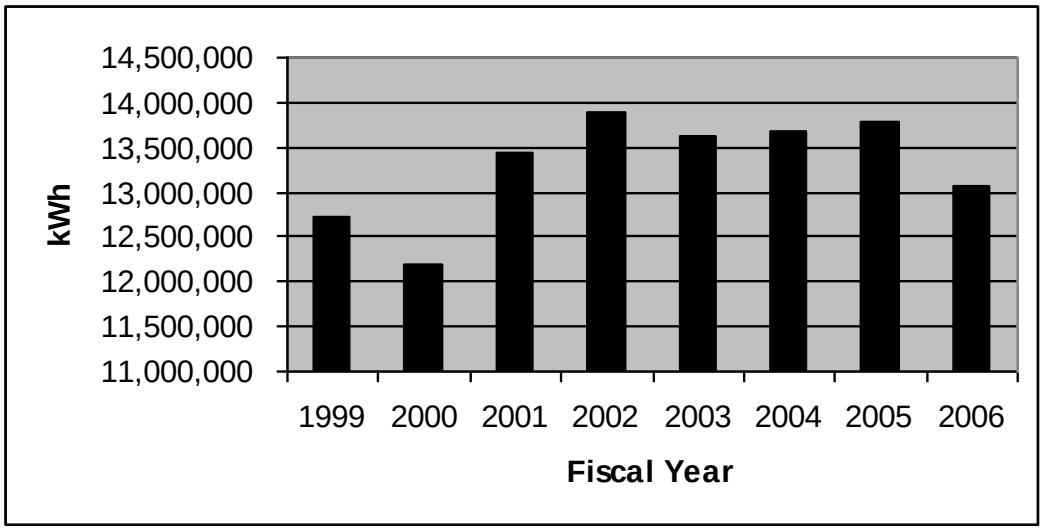

Figure 2.3: Electrical Consumption (kWh) 1990-2006. This graph includes all kWh purchased for Macalester owned buildings including on-campus, Highwinds properties, rental properties and residences.

Natural gas and fuel oil consumption are harder to evaluate due that levels of consumption are strongly influenced by price and weather, which can spike consumption regardless of conservation efforts. The aftermath of Hurricane Katrina dramatically increased the price of fuel oils resulting in an increased use of natural gas in the following years. Other than the recent shift, natural gas's consumption levels have remained fairly constant. Fuel oil usage on the other hand is more variable year to year as prices have fluctuated.

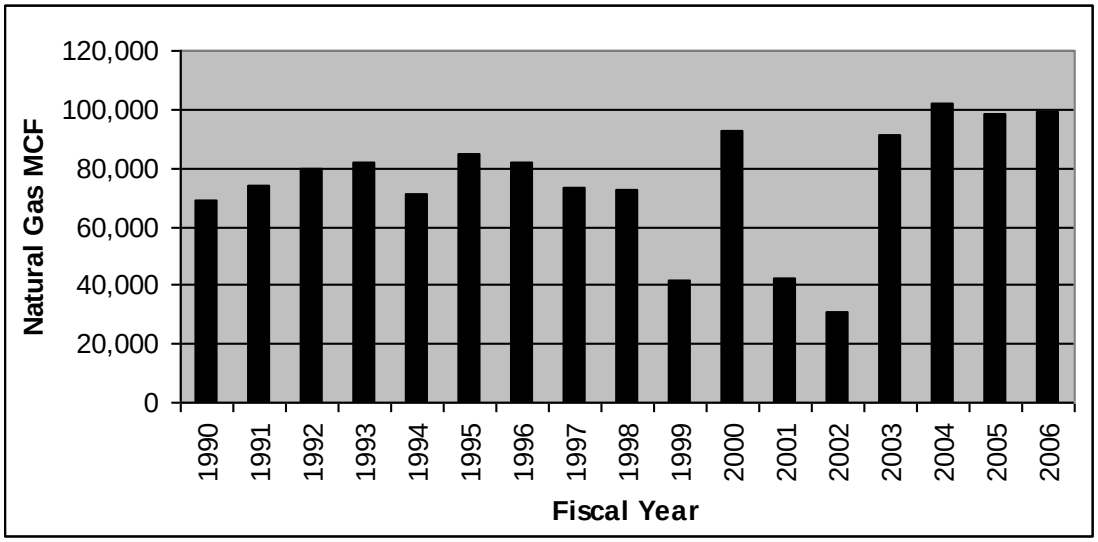

Figure 2.4: Natural Gas Consumption (MCF) 1990-2006. This graph includes all natural gas purchased for Macalester owned buildings including on-campus, Highwinds properties, rental properties and residences.

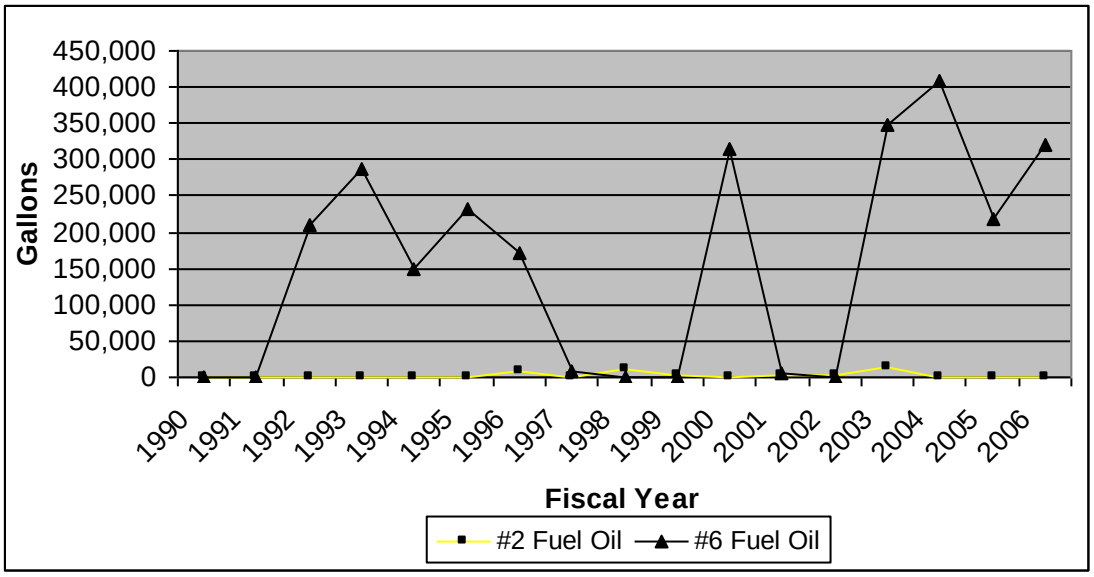

Figure 2.5: Fuel Oil Consumption 1990-2006. This graph represents the amount of fuel oil numbers 2 and 6 used by Macalester College in the steam plant to heat on-campus buildings.

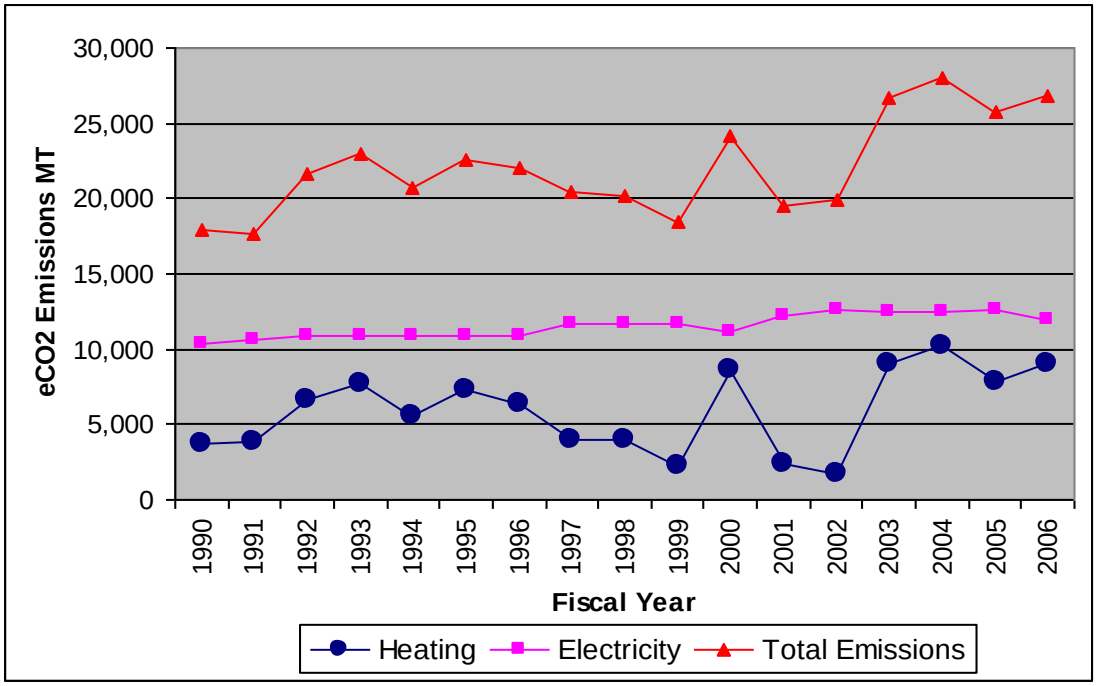

Figure 2.6: Total Energy eCO_2 Emissions 1990-2006. This graph shows the eCO_2 created by heating and electricity consumption of all Macalester owned buildings.

Discussion

Trends

It is important to note that in recent years, as the use of personal electronics and appliances has rapidly increased, Macalester College's electricity consumption remained relatively steady and has begun to show a small decline over the last 4 years. Such a pattern has not been the norm for the country over the past two decades. A continuation and expansion of this focus on energy efficiency is essential to addressing GHG emissions.

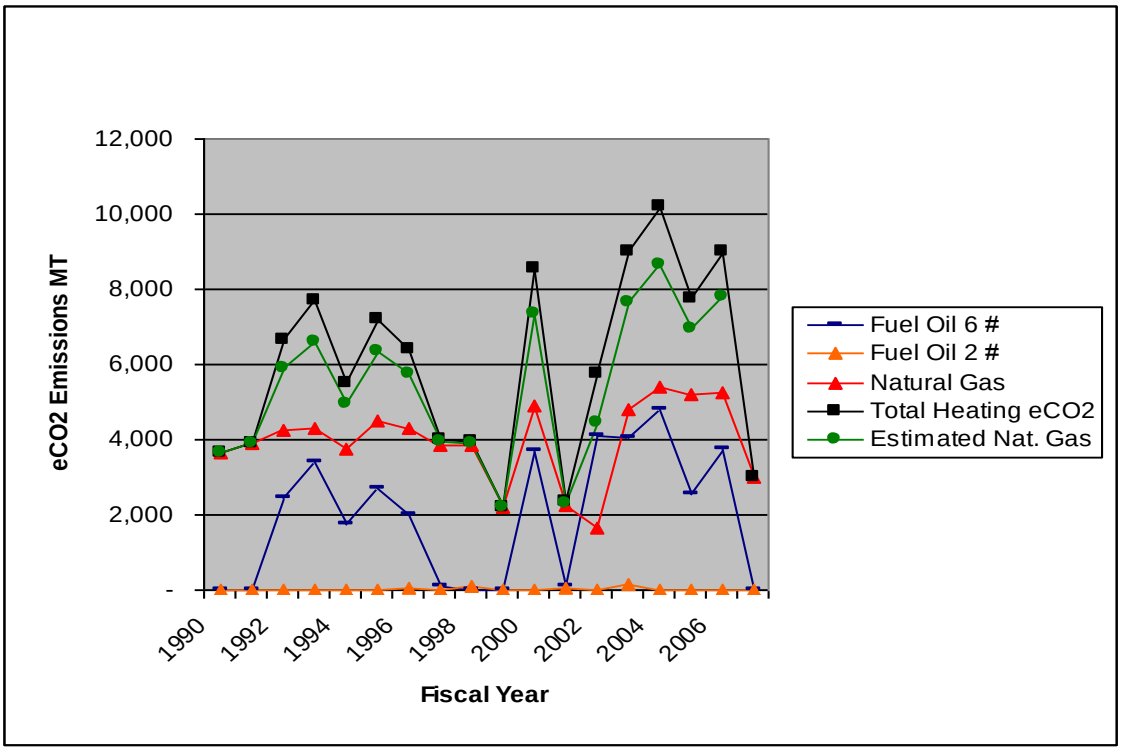

Figure 2.7: Heating eCO_2 Emissions by Fuel Source 1990-2006. The years that exhibit the highest levels of emissions are those in which more Fuel Oil #6 was consumed. The purple line represents predicted emissions if Macalester College were to move away from using Fuel Oils and instead purchase only natural gas for heating.

Residual Oil #6, the most commonly used type of fuel oil on campus, produces 1.47 times as much eCO_2 per MMBtu as natural gas. The quickest and largest step that the College could take to reduce emissions, although not necessarily the most cost-effective, would be to officially move away from fuel oil and initiate a policy of only burning natural gas. In 2006, if Macalester had only used natural gas and no fuel oil, total campus emissions would have been reduced by approximately 1,953 metric tons eCO_2 - an immediate 8% reduction in campus emissions for the year. Natural gas can be substantially more expensive per MMBtu than fuel oil, which must be accounted for in any fuel policy decisions, however it is the quickest large reduction that the College could make. There are no necessary mechanical changes or equipment upgrades to move to burning only natural gas; Macalester could switch immediately if the additional cost could be budgeted for.

Data Accuracy

The energy data for Macalester was difficult to accurately track. In theory, the energy data should be the easiest, since it is tracked monthly and billed, and it is relatively straightforward to convert between the various fossil fuels and their energy content and carbon intensity. Macalester College has prepared an annual energy report for the last several years; however the report only tracks the buildings on the central heating plant and is insufficient for the purposes of the GHG inventory. Copies of the Macalester utility bills were obtained from Xcel Energy back to 1999 - as far back as the utility keeps records, and then extrapolated backwards to estimate the amounts of fuel used from 1990-1998.

In order to extrapolate, all the heating fuels were converted to million cubic feet (MCF) natural gas equivalents and then the annual MCF/heating degree day (HDD)/square footage (SQFT) was calculated for the entire campus. This helps to account for changes both in weather and the overall size of campus during the years 1990-1998. The MCF/HDD/SQFT was then averaged for the 6 years of Xcel bills. This ratio was then multiplied by the SQFT of campus and HHD for each year 1990-1998 to calculate an estimated MCF natural gas for each year.

In order to estimate the total number of kWh used during the 1990-1998 period where there was no billing records the kWh/SQFT of campus was determined, and then used to calculate total campus electrical usage based on the changes in SQFT. This extrapolation also does not account for changes in kWh/SQFT usage, but it is difficult to accurately predict whether it should be assumed that overall campus usage relative to campus size would increase or decrease over time. The efficiency of electrical equipment improved substantially during the 1990s and would have pushed campus electric usage down over time; however, the rise in personal electronics could have increased electrical consumption. In the end, it was determined that it was best not to try to accommodate these changes, as they were too

unpredictable.

Data Recommendations

In the future, the energy portion of carbon emissions should be the easiest to track, as it is simply a matter of recording the monthly bills. Facilities Services has begun to examine how to redo the energy report format in order to make it more effective and user-friendly in the future. Provided here is an outline of how future reports should be processed:

1. Track every Macalester property including High Winds individually, which would in turn create a record of each building's energy usage that can be used for calculating energy efficiency projects in the future.
2. Rework the format of the energy report to make it easier to use and verify.
3. Setup an auditing system to check the Macalester report against the utility energy bills each year to verify their accuracy.
4. Make the energy report available on the Facilities Services and Sustainability websites so that it is easily accessible to the wider community. At the moment most of campus is not aware of the annual report.

Macalester College should consider an incentive system to encourage staff to actively pursue energy efficiency opportunities to save money. At the moment, if staff use work time to investigate possible savings, they are likely to fall behind on normal work, creating an economic disincentive for staff to try to save the college money. If someone is able to discover and carry out a project that generates real savings then they should get a portion of the savings for personal gain or as an addition to their department budgets. This creates an incentive for members of the Macalester community to identify and follow up on opportunities, and could save a substantial amount of money in the future, especially as energy costs continue to rise.

3. Transportation

Transportation is central to our lives and to the study of Macalester's greenhouse gas emissions. In 2003, emissions from transportation made up 27% of greenhouse gas (GHG) emissions in the United States, increasing from 25% in 1990. In a 2006 report, the Environmental Protection Agency (EPA) found that greenhouse gas emissions from transportation grew by the largest amount of any economic sector during this period. According to the US Department of Energy (US DOE), energy use for transportation is expected to increase by 48% between 2003 and 2025, and emissions of carbon and other GHGs can be expected to rise accordingly unless low GHG fuels are developed and used on a wide scale during this period[1].

It has been said that the United States is a 'car country,'[2] and transportation influences the way cities are built, food is grown, and the economy is structured. The world's dominant modes of transportation emit large amounts of GHGs, especially carbon dioxide (CO_2). Humans use cars, trucks, buses, aircraft, boats, trains and pipelines to move ourselves and our goods across neighborhoods and around the world. In the United States, 62% of transportation emissions come from personal light duty vehicles.

At Macalester, transportation constituted 22% of total GHG emissions in 2006. Commuting, campus fleet and air travel are the largest emitters of GHGs within the transportation sector, and thus the report will focus on these three.

Air travel makes up the largest part of GHG emissions with 20 percent of the college's emissions and between 3,000 and 5,200 MT eCO_2 emitted each year. Of total

[1] U.S. Environmental Protection Agency, Office of Transportation and Air Quality. *Greenhouse Gas Emissions from the U.S. Transportation Sector: 1990-2003*. March 2006. Pp. 7.
[2] Wells, Chris. *Car Country: Automobiles, Roads and the Shaping of the Modern American Landscape, 1890-1929.*

transportation emissions, 88 percent comes from air travel. Commuting, in contrast, makes up a relatively small portion of the college's total annual emissions with only 2 percent of total emissions coming from faculty, staff, and off-campus student commutes. The campus fleet, which consists of all Macalester owned vehicles, is an even smaller portion of the college's total GHG emissions making up less than one percent of the college's total emissions and just two percent of transportation emissions.

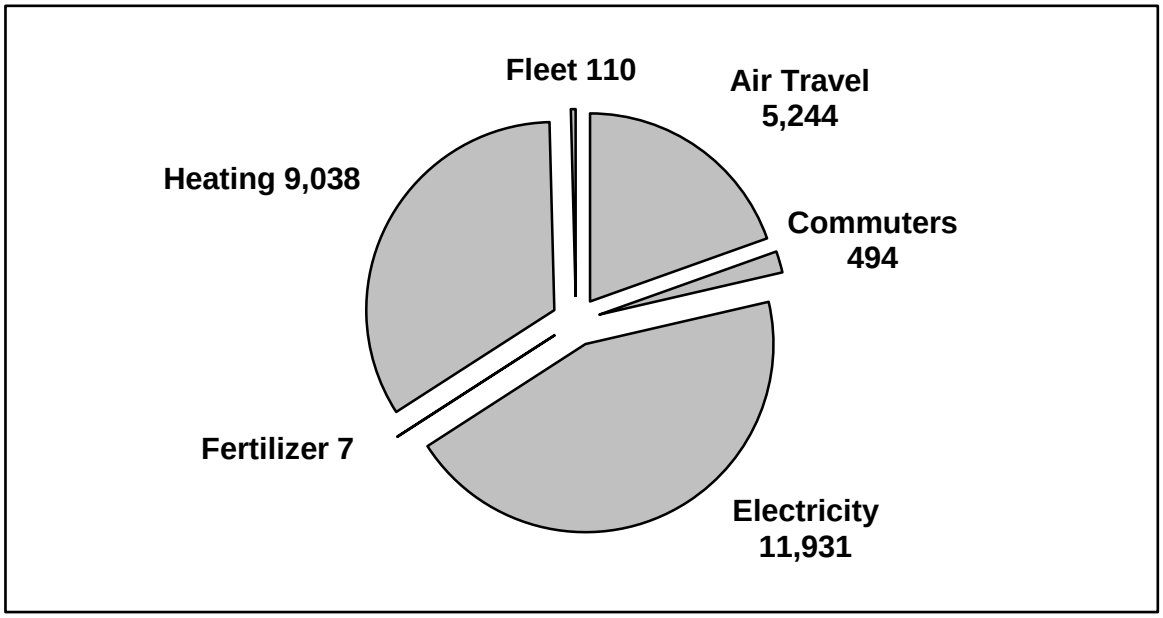

Figure 3.1 2006 Transportation Emissions by Sector

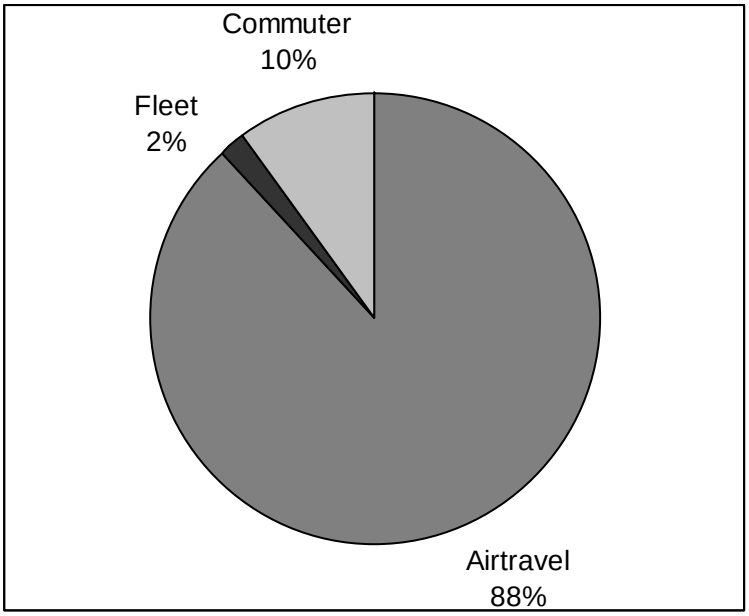

Figure 3.2: Emissions percentage breakdown for 2006. Transportation represents 22% of overall emissions. Of the total transportation emissions, 88% come from air travel, 10% from commuting and the final 2% from Macalester's fleet.

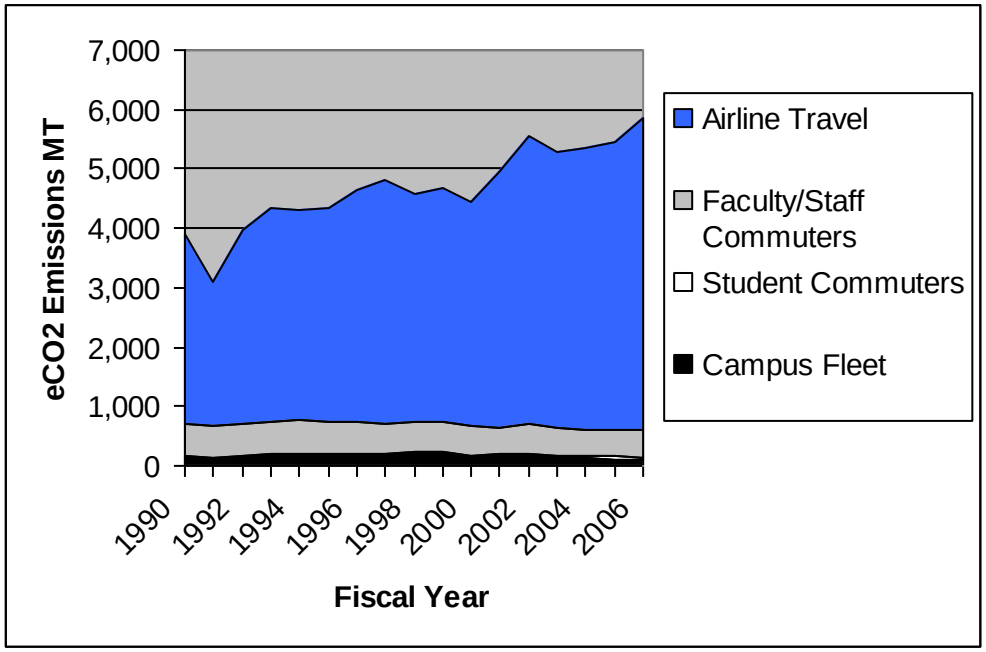

Figure 3.3: Annual eCO_2 emissions from the transportation sector. Airline travel makes up the largest sector of emissions, and is also the most variable. Emissions from commuting and from purchased gasoline have stayed relatively constant, with a slight decrease over time.

Transportation is divided into two subsections. The first focuses on faculty, staff and off-campus student commuting patterns; the second has data for all transportation paid for by the College – including gasoline for campus owned vehicles and reimbursed flights.

Commuting

Introduction:

Faculty, staff, and student commuting patterns make up a relatively small percentage of GHG emissions each year, emitting less than 750 metric tons of MT eCO_2 per year – two percent of total emissions.

According to American Community Survey (ACS) data released by the U.S. Census Bureau, Americans spend more than 100 hours commuting to work each year. For the nation as a whole in 2003, the average daily commute to work lasted about 24.3 minutes. This is higher than the average commute time for Minnesotans, which was reported by the ACS in 2003 as 21.7 minutes. The Twin Cities have a still lower commute time, with Saint Paul coming in at 21.0 minutes, and Minneapolis at only 20.2 minutes.

Fossil fuel based transportation has a significant effect on one's carbon footprint. In the United States a large part of an individual's carbon foot print comes from commuting to and from work because most parts of the country lack an efficient and extensive public transportation system. Faculty, staff and a small portion of the student body make up the Macalester commuting community.

The calculator requires commuting data to be split into faculty, staff, and student inputs, and calculates each separately depending on mode of transportation (i.e. personal vehicle, bus, walk, rail etc.). The calculator requires five inputs for each mode of transportation to calculate carbon emissions. These requirements are: "percent commuting

alone," "percent carpooling," "passenger trips/day," "passenger days per year," and "passenger miles/trip." To collect this data, a survey of faculty and staff commuting habits was conducted, and the commuter miles per trip were calculated with a Geographic Information Systems (GIS) program using faculty, staff, and student addresses from archived records.

Methods:

Survey

The data for three of the five categories necessary for the commuting patterns portion of carbon calculator were collected using two surveys. A 2006 Environmental Studies senior seminar conducted a survey of off-campus student commuting patterns. Out of 263 students who lived off campus, 113 responses were collected. This survey was augmented by another survey conducted by the 2008 Environmental Studies Senior Seminar that collected information about transportation habits and gasoline consumption patterns of Macalester's faculty and staff[3].This survey was sent by email to all 728 faculty and staff working at the college, and 290 responses were received: 93 from faculty and 197 from staff members.

The questions in the 2008 survey were based on the survey conducted by the 2006 Environmental Science class; however, they were tailored to fit the information needed for the calculator. The 2006 student survey was originally created to collect information about Macalester's general carbon footprint and therefore contained questions with answer choices that were not specific enough for the purposes of the GHG inventory. Therefore, questions were edited and answer choices made more precise for the 2008 staff/faculty survey.

The surveys provided percentages for faculty, staff, and students traveling alone and

[3] Survey Appendix

carpooling. Because this data was unavailable for previous years, student travel was extrapolated based on the 2006 survey, and faculty and staff based on the 2008 survey. In both, respondents were asked multiple choice questions with answers given in ranges. For example, respondents were asked how many round-trips per week they made to campus and given choices like 2-3 or 4-5 trips per week. To calculate the inputs for the calculator, the mean of the range was used, assuming that an equal number of people came to campus 2 or 3 times. This number was doubled to calculate one way trips per week, and was then divided by five working days. The final result was a number representing 'one-way trips/day,' the number called for by the calculator.

The survey directly yielded results for the 'percent commuting alone', 'percent carpooling', and the 'one-way trips/day' categories. To calculate 'days/year', the number of days in the school year was used for faculty and students. For staff, 240 days a year was used for all years, which represents 48 five-day work weeks allowing an average 4 weeks of vacation. GIS software calculated the final 'miles/trip' category.

Staff and faculty also frequently leave the college for errands; therefore, the survey asked faculty and staff how far and how many round-trips they make away from campus per day, besides their daily commute from home. This category was not originally called for by the calculator, but because of the ease with which it could be adapted to commuting patterns and the additional carbon emissions created by trips made for errands, it was deemed a necessary addition. For each question about errands, the median of the range was again used. These answers were multiplied by two to obtain the number of 'one-way trips/day'. The average distance was also calculated from the survey responses, and added into the calculator in the 'miles/trip' column. Trips made for errands were computed separately from commuting patterns because the average trip made was much shorter than the average

commuting trip. Thus, for faculty and staff, the additional carbon emissions generated from errands was added to the emissions for commuting to calculate total transportation emissions.

Geographical Information Systems

Calculating faculty, staff, and student commuting distances required three steps: data collection, data organization in GIS, and computation of final distance numbers. All Macalester address records were kept in the same database, which could be accessed through one IT technician. However, access to each of the records required permission from different departments. The Provost was able to grant access to faculty records, Human Resources access to staff records, and the Registrar access to student records. Each year's data was kept in separate spreadsheets, categorized by faculty, staff, and students. This data listed the last known address of each person in each of these categories. All addresses for faculty and staff back to 1990 were accessible, and all student addresses back through 1998. A sample of student addresses from 1991-1993 was also available.

A Geographic Information Systems software that manages spatial data, performs spatial analyses, and creates maps, ArcGIS 9.2was used to calculate the distance from faculty, staff, and student homes to campus. A standard Nad83 projection was used in ArcMap as well as tiger line files from the U.S. Census to import a roads layer that would be used to compute driving distances. The tiger line files are shapefiles that can be imported into the GIS software from an online database as a layer of information in the map. Maps were then created by geocoding the addresses for each year and for each category of person (i.e. faculty, staff, or student). In some instances, the software was unable to find an address, and in these cases, the nearest address on the map was used, or the address was discarded if no close address could be found. Fewer than 2% of all Minnesota addresses were discarded for each map. In all, 18 maps for faculty, 18 maps for staff, and 13 maps for students were

created.

An origin-destination cost matrix was then created using the Network Analyst extension of ArcMap. This matrix can calculate distances from multiple origins to destinations by following the least cost path distance along a road network. The geocoded address layer was used for origins, and a point layer for Macalester, geocoded at its 1600 Grand Avenue address, was used as the destination. Matrices were run for each map and ArcMap calculated the distances from each origin to Macalester. These distances were represented in the map by a "lines" shapefile with a column representing distance in meters for each address to the college. These line tables were then exported into a spreadsheet.

In the spreadsheet, meters were converted to miles for each of the distances, and then both the mean and the median distances for each year were found. The mean is significantly higher than the median for each year, which signifies that more people are commuting shorter distances than longer distances, but that a few people are traveling very far. This is consistent with the maps, which show a majority of people commuting from within the Twin Cities Metro Area, with a heavier proportion commuting from neighborhoods surrounding the college, and three to five outliers coming from far away areas such as Duluth and Northfield. (*Appendix A*).

Because the mean for each year heavily weighted those few commuters who lived farther away, and the median did not fully account for them, an average of the mean and median was taken for each year. This average of the mean and median commuting distances was plugged into the calculator's 'miles/trip' column.

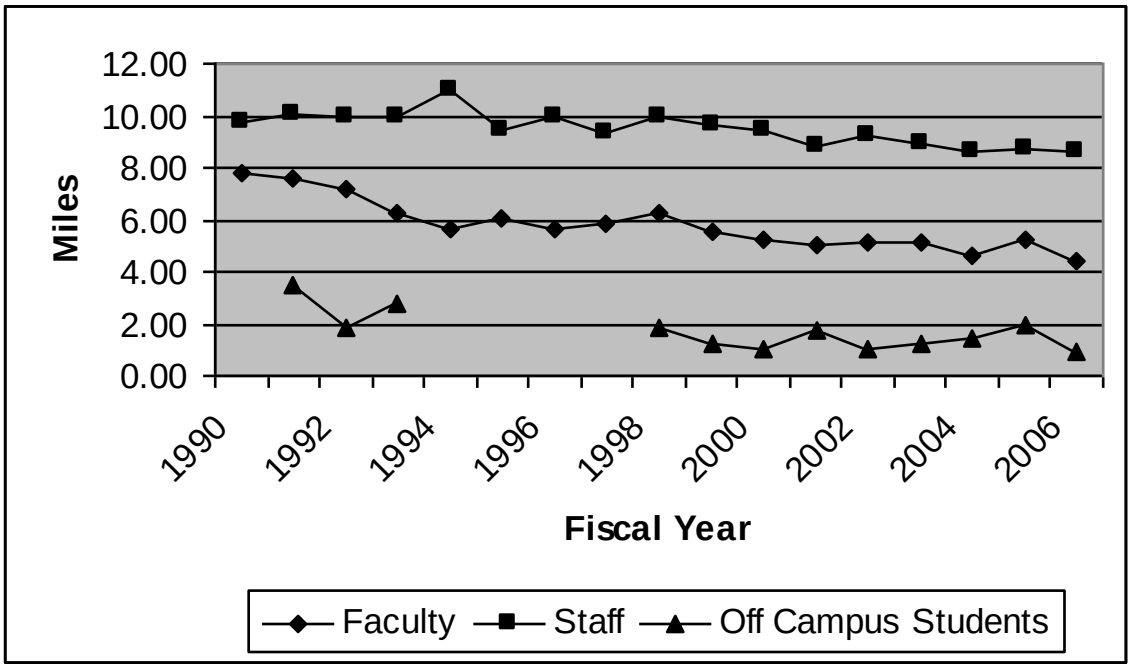

Figure 3.4. Average Commutes (Miles) 1990-2006. Y-axis represents miles commuted. Staff have a much longer average commute than faculty. The average student commute has consistently been below 2 miles.

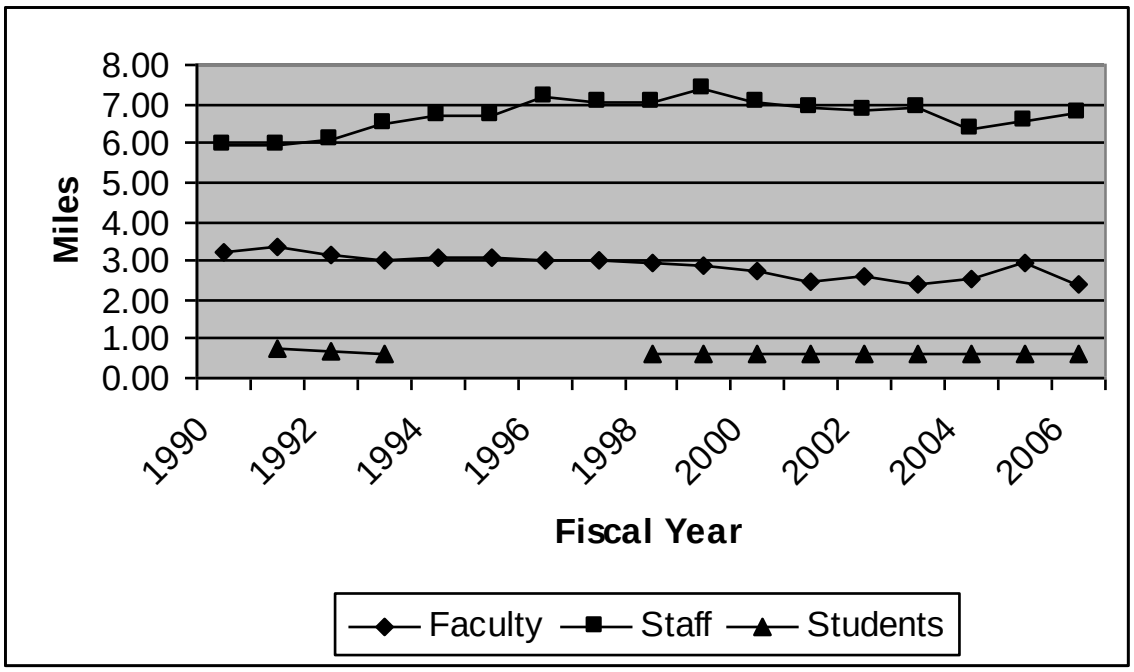

Figure 3.5: Median Commutes (Miles) 1990-2006. The medians are more constant than the mean, and are consistently lower than the mean. These trends show that the majority of faculty, staff, and students live close to campus, but a few outliers, who live as far away as Duluth, are raising the mean.

Results:

To obtain eCO_2 emissions calculations, results from the surveys and the commuter distances were inputted into the CA-CP calculator. Emissions were highly dependent on the total number of faculty, staff and students commuting each year, the number of school days per year, and to a lesser extent, the average distance traveled.

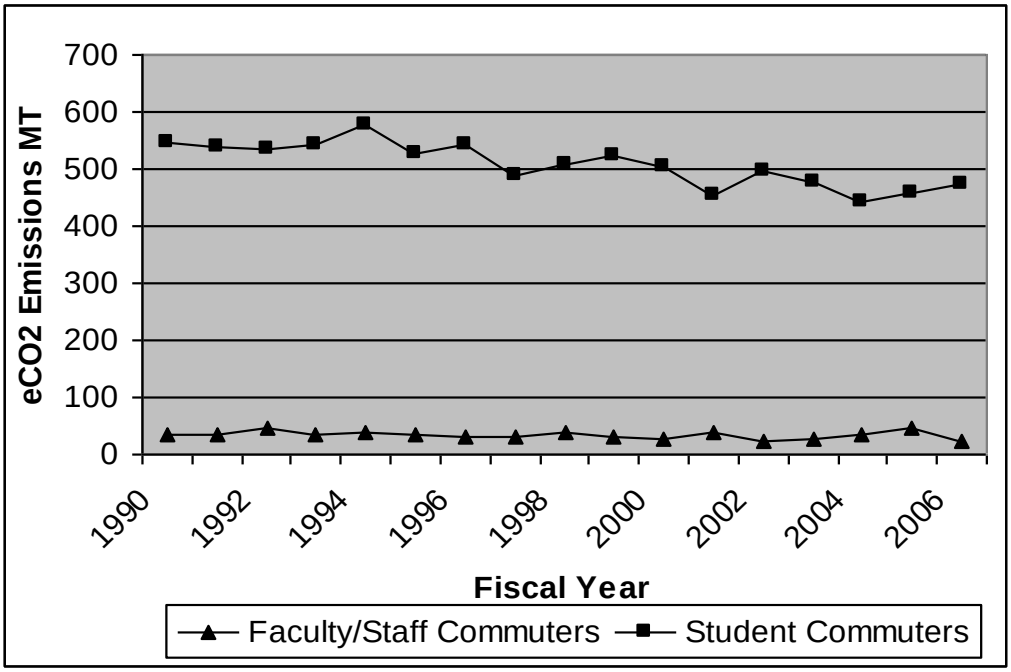

Figure 3.6: Total eCO_2 Emissions from Commuters 1990-2006. Macalester is not a commuter campus for students thus emissions from commuting are produced mostly by faculty and staff. Staff makes up a larger proportion because there is more staff than faculty and they tend to have longer commutes and work more days per year.

Discussion:

Trends

Total carbon emissions are relatively static over the 18 year period, fluctuating in relation to the changes in populations for faculty, staff, and off-campus students. Also, the number of days per year that faculty and students travel to campus influences the total carbon emissions. In years where Macalester had a J-term (1990-1994), more GHGs were released.

On average, faculty travel fewer miles per commute than staff. Over the past 18 years faculty commute distance has gradually decreased. Staff distances increased during the early 1990s, but subsequently decreased, and have been lower in the past few years than in the early 1990s. Student commuting distances fluctuate annually – the median distance hovers around 0.6 miles. This shows that the majority of students live within walking distance of Macalester. The slightly higher mean average commuting distance shows that a few students have longer commuting distances each year. However, even this average has remained under two miles for the 18 year period. Unfortunately, the total student body data was unavailable for the years 1994-1997, thus the extrapolation may have skewed the results.

Data Accuracy:

Survey

Since it was impossible to collect data from respondents other than those currently working or studying at Macalester, the data entered into the carbon calculator had to be extrapolated in order to fulfill the requirements of entering data back to 1990. This along with other issues, such as the survey being voluntary and the fact that answers to some of the survey questions are based on human memory, and the possibility of social pressures to appear greener, creates problems with the survey itself and that data that it produced. These problems will create some inaccuracy in the final data produced by the carbon calculator. More accurate record keeping could yield precise total numbers in the future. Using a new student survey would have also yielded more accurate results, but because of a lack of time and doubt that as many or more responses would be obtained than in the 2006 survey, a second best option was chosen.

Geographic Information Systems

There are a number of problems to consider in this data's accuracy – in regards to data collection as well as analysis. First, the addresses used are only those last known for faculty and staff, thus the addresses represented may not be reflective of the actual addresses for where they lived while working at Macalester. Because of this, out of state addresses were erased that were obviously not the real commuting addresses for faculty and staff. Another thing to consider in the calculation of the addresses is that Network Analyst calculates route distance based on shortest road distances from one point to another, and this may not be representative of the actual route that faculty, staff, and students take to the college. Lastly, student addresses were unavailable before 1998, except for a small sample between 1992 and 1994. Therefore the only truly accurate years for students are the years since 1998.

Macalester-Funded Air Transport and Fleet

In the last year, Macalester spent $1,609,012 on transportation and by doing so released a significant amount of GHGs into the environment. The College funds transportation in a variety of ways, which includes gasoline reimbursements for staff/faculty travel, gasoline and diesel fuel used by the campus owned and leased fleet of vehicles, provided for student use, and air travel for college related trips. The College funds flights to bring in speakers, to send faculty or students to conferences or to bring prospective students to campus. While transportation does support the institutional mission, these miles flown and gallons of fuel burned are 19% of Macalester's GHG output and should be reduced whenever possible.

Methods

In order to quantify eCO_2 emissions produced yearly by Macalester funded transportation, the calculator required the number of airline miles traveled by students and faculty each year, and the number of gallons of gasoline used by the campus fleet each year. Records of spending on travel over the past eighteen years were requested from the Budget office. The data for the last year and a half was readily available, and came in units of dollars spent per year in four categories, gasoline, airline travel, ground transport, and mileage/tolls/fees. Travel data for the preceding 16 years, however, were grouped into categories that included not only airline or gasoline prices, but also hotels, meals, and other fees. However, numbers from the budget office were the most accurate data available. Each college department and office is required to report all expenses to the budget office, so the budget records include multiple transportation sources grouped together consistently from year to year.

To find what percentage of the travel budget was spent on airfare, the amount spent on air-travel dollars spent on airfare for the last year and a half was divided by the combined total of all travel categories. This percentage was then applied to the total yearly amounts spent on travel from 1990 to 2006, yielding an estimate of the College's annual airfare expenses.

The category for gasoline included figures on gasoline spending that are outside the scope of the calculator, such as reimbursements for faculty and staff gasoline use for trips in their personal vehicle. Facilities Services had a record of gasoline purchases in 2006 for campus owned vehicles. This was then divided by the total college 2006 budget to calculate what percentage of the budget is spent on gasoline. This percentage was then applied to the annual budgets from 1990-2005 to estimate gasoline purchases for the rest of the years.

Calculations for annual airfare and gasoline spending yielded a dollar amount which was then converted into miles traveled and gallons burned respectively. To do this a cents/mile conversion factor for airline travel from 1990-2006 was obtained from the Air Transport Association of America, and a cents/gallon conversion factor for Midwest gasoline prices from 1992 to the present was found on the US Energy Information Administration (EIA) website.

There were separate airline cent/mile conversion factors for domestic and international flights. These were combined into weighted average that assumed 12% of flights were international and 88% domestic. This breakdown was recommended by Sustainability Manager Suzanne Hansen based on her previous experience calculating airline emissions for the University of MN. The 2006 conversion factor was used for 2007, which the EIA did not estimate.

Similarly, the 1992 gasoline conversion factor was used for 1990 and 1991. Once a conversion factor was established for each year in each category, dollar values for airline travel and gasoline were converted to cents (by multiplying by 100) and the conversion factor was applied to the calculated yearly values for airline travel and gasoline. This yielded annual values in miles traveled and gallons purchased for airline travel and gasoline, which was then entered into the calculator.

There was no way to separate faculty travel from student travel as required by the calculator. These categories are both included in the airline travel number, so the single value was entered into faculty and staff business with the assumption that all necessary data would be represented.

Results

The carbon calculator took miles traveled by airplane and gallons of gasoline consumed and calculated the net eCO_2 MT. Gasoline consumption shows an increasing trend from 1990-1998 at which point it begins to decrease until 2006. The total airplane miles have steadily increased since 1990. This is important because the number of miles traveled by airplane has a significantly higher contribution to the total GHG emissions than does gallons of gasoline consumed.

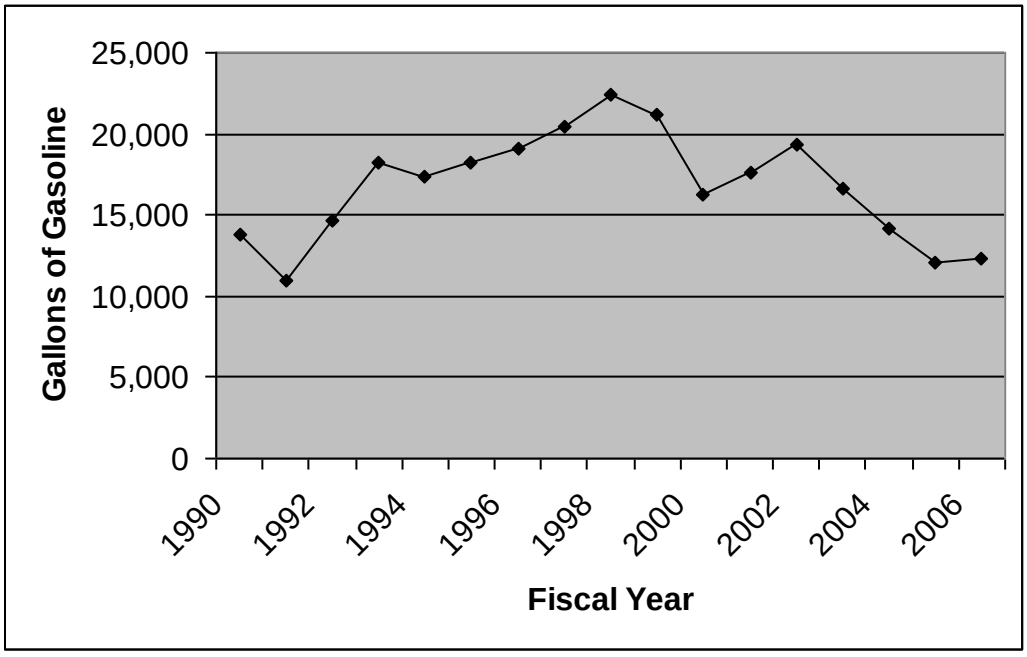

Figure 3.7: Macalester Fleet Gasoline Consumption(Gal) 1990-2006. Annual gallons consumed are based on the percentage of the budget spent on gasoline in 2006. The figure illustrates an increase in gasoline consumption until 1998 followed by a subsequent decrease in.

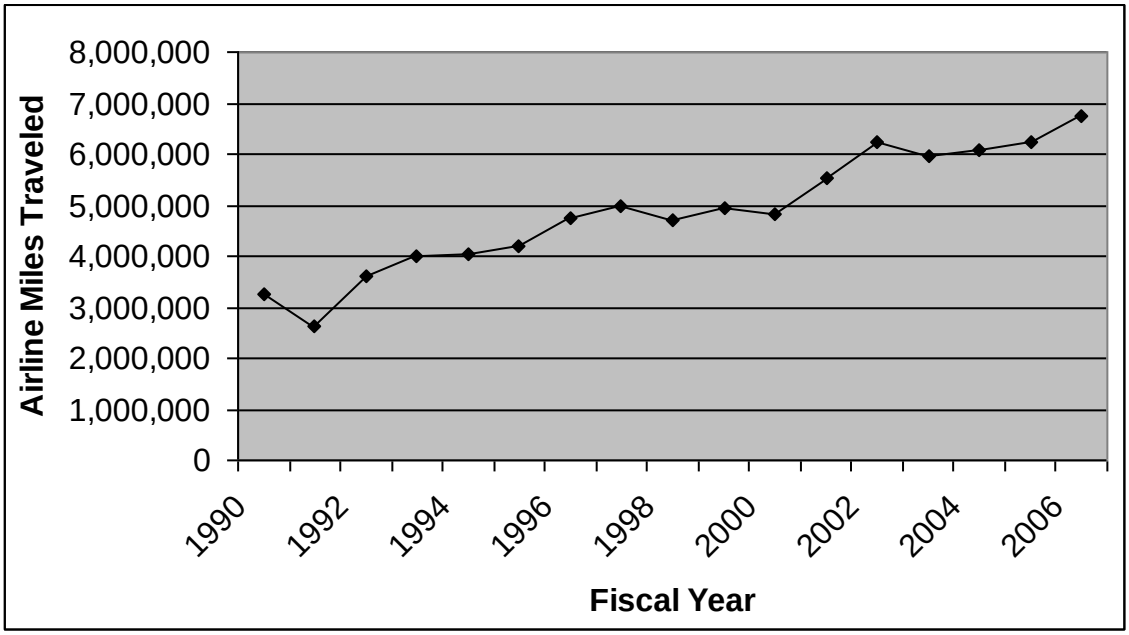

Figure 3.8: Airline Miles Traveled 1990-2006. Miles traveled was calculated from dollars spent on airfare. The figure illustrates an overall increase in airplane miles traveled since 1990.

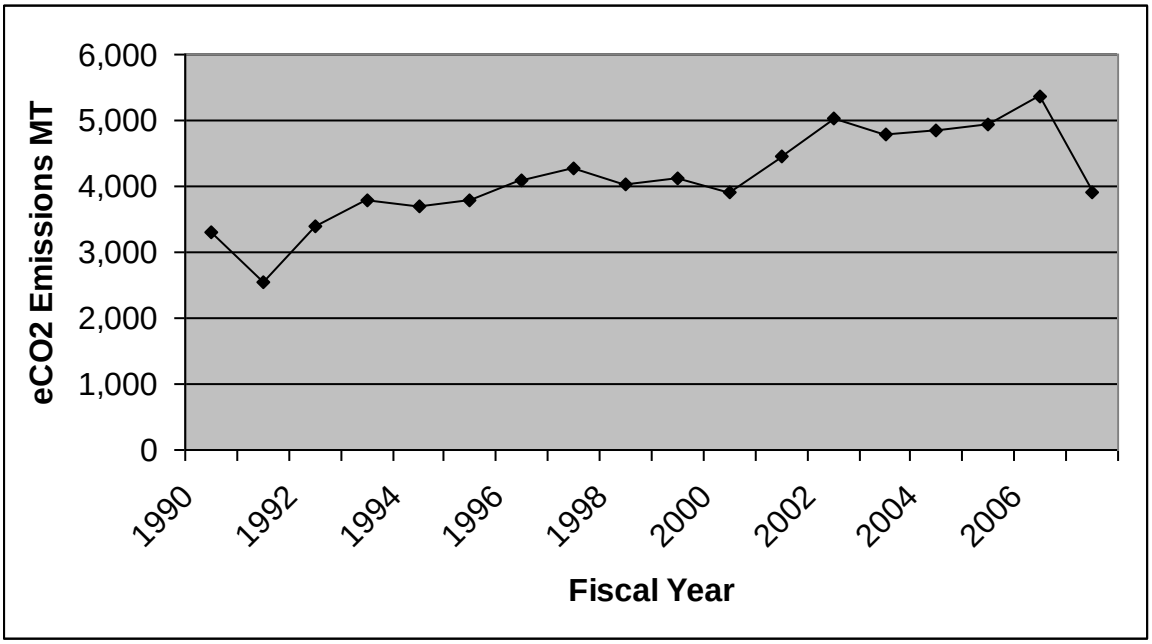

Figure 3.9: Macalester Funded Travel eCO_2 Emissions 1990-2006. This is a combination of the Macalester Fleet and school-sponsored air travel.

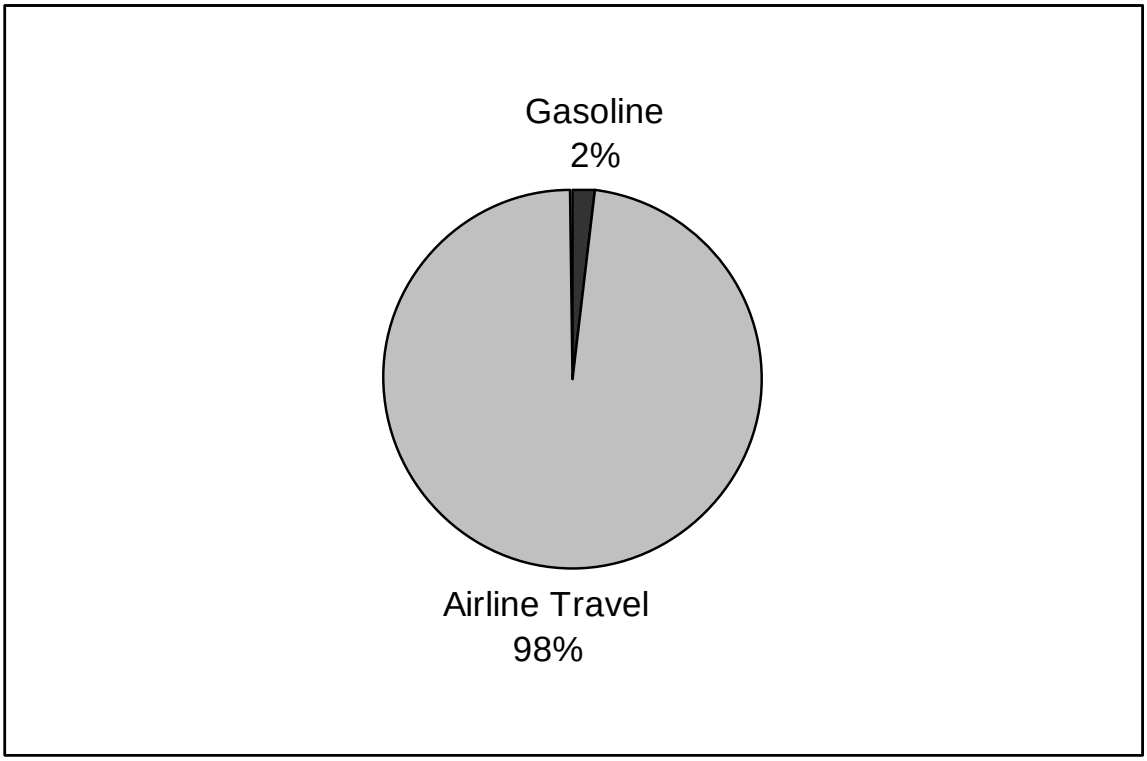

Figure 3.10: Relative % eCO_2 Emissions Gasoline and Airline Travel 2006. This data represents the amount that airplane travel and gasoline consumption by Macalester College contributes to the net MT eCO_2 of air travel and gasoline. The data was calculated by taking the sum of the yearly MT of CO_2 emitted by gasoline consumption and the sum of yearly MT of CO_2 emitted from airplane miles traveled. The figure shows that airplane miles traveled contributes more significantly to the amount of CO_2 emitted than gallons of gasoline consumed.

Discussion

Trends

The net MT eCO_2 calculated reveals that miles traveled by airplane have a larger proportional effect on the amount of eCO_2 emitted than gasoline consumed from ground travel by campus owned vehicles. Travel by airplane is known to be a large source of CO_2 emissions. Macalester funds flights abroad for faculty research, admission recruiting, and to fly in international perspective students coming to visit the college. Fostering internationalism is a fundamental value of Macalester, which means that air travel will continue to be a large source of the colleges overall GHG emissions.

The trends in gasoline consumption show a sharp decrease after 1998 and again in 2002. This decrease followed by a period of increased consumption until 2002 is unexplainable. The decrease in consumption after 2002 can be explained because from 2000-2006 Facilities Services added five electric vehicles to the campus fleet.

Data Accuracy

The data used for the calculator is relatively simple, which prevents a deeper analysis of the reasons behind the trends. Part of the expenditure of gasoline by Macalester comes from college owned vans that are used by various classes, clubs and athletic teams. The calculator does not take into account what types of vans Macalester owned 20 years ago. This data could reveal if the trend of decreasing gasoline consumption after 1998 is because of a switch to more fuel efficient vehicles.

The cents/miles conversion factor for air travel is different for international and domestic flights. The data keeping system did not distinguish between expenditures for international versus domestic flights. However, it was assumed that 12% of airfare spending is for international flights so a weighted average was used to calculate the cents/mile conversion factor for domestic and international flights. How much money Macalester spends on international flights is unclear. The decision to use a weighted average was made by the sustainability manager who had experience deducing international airfare proportions from previous carbon audits[4].

It was decided to use the data from Facilities Services and not from the college budget concerning the amount of money spent on gasoline. This is because the Budget Office included data such as faculty gasoline reimbursements that are outside the scope of the

[4] Suzanne Savanick, Macalester College's sustainability manager, Larry Baker and Jim Perry did a carbon audit for the University of Minnesota in 2007.

calculator. The 2006-2007 data from Facilities Services contained only the amount spent on gasoline for campus owned vehicles.

The data collected for "miles traveled by airplane" and "gallons gasoline used" did not allow for the change in percentage spent on airfare and gasoline to be assessed over time. The budget data from 2006-2008 included the category air travel, which the previous year's lacked, from which spending ratios were calculated and applied to the previous 15 years. The ratio between spending on gasoline and airfare was thus assumed to be the same for the last seventeen years, meaning it would not be known if Macalester had started spending more on airfare and less on gasoline or vice-versa. This is a significant potential source of error in the transportation calculations; however, there did not appear to be a more accurate method feasible.

Data Recommendations

The data keeping system for transportation expenses is inadequate for the needs of the GHG inventory. To track student, faculty, and staff address on an annual basis, the Registrar's Office could require students and faculty to fill out a short commuting survey when they validate or turn in their class schedules. This data would be sent to the Provost or the Sustainability Manager. Staff could submit this data to Human Resources as a requirement to receive their W2 form. This would ensure full participation, as well as an efficient record keeping system, which could be done in a spreadsheet.

In terms of air travel and campus fleet categories in the calculator, the largest source of error is the airfare figures. This is a result of not knowing the amount spent separately on international and domestic flights. A list or file of flight destinations should be kept for a more accurate account of mileage. It will be important in the future to observe trends in the

changes in airfare and gasoline spending in order to more accurately assess if fluctuations in GHG emissions are from gasoline consumption or air travel. This data keeping system would be beneficial to Macalester College because it would help track emissions and give a more accurate picture of college spending. Gasoline spending should be divided into separate categories for gas consumed from college owned vehicles and faculty/staff reimbursements because these data asked for separately in the calculator.

4. Agriculture

Introduction

Synthetic fertilizers are included in the carbon audit because one of the main byproducts, nitrogen oxide (NO_x), has 296 times the heat trapping capacity of CO_2 (Energy Information Administration 2003). In addition, the production process for fertilizer is extremely fossil fuel intensive. To make one 50 lb bag of the common 10-10-10[5] fertilizer (10% nitrogen, 10% phosphorus, and 10% potassium) a gallon and a half of fuel oil is used[6]. While fertilizer is only responsible for a small part of the greenhouse gases that Macalester produces, it still is important to monitor.

Methods

While fertilizer use has not been recorded over time, it is possible to estimate how much fertilizer is applied annually[7].While Macalester uses three different types of fertilizers, the calculator only requires the nitrogen percentage of the fertilizer, so a weighted average was used for calculations *(See Appendix C).* Next it was determined that Macalester annually applies 7444 pounds of fertilizer with an average nitrogen content of 25%. Since 1990 Macalester has applied 4,000 pounds of 10-10-10, 36,000 pounds of 46-0-0 (Urea), and 94,000 pounds of 18-0-18.

Results

Fertilizer use at Macalester is responsible for seven metric tons of CO_2 equivalent (eCO2) greenhouse gases a year. This is equivalent to less than 1% of Macalester's total

[5] When used to describe fertilizer, the first number stands for its nitrogen content, the second for its phosphorus content, and the third for its potassium content.
[6] Proescholdt, Kevin, Minnesota *Environmental Briefing Book.* St. Paul: Minnesota. Environmental Partnership, 2008. http://www.mepartnership.org/documents/Brief2008.pdf
[7] Nelson, Jerry. *Email Interview*, February 15, 2008.

carbon footprint, and is one of the smallest emitters of greenhouse gases at Macalester College. Even though a relatively small amount of fertilizer is used each year, the emissions from fertilizer still have an important effect since nitrogen oxides are such a powerful greenhouse gas.

Discussion

Trends

The figures that were used to calculate the annual application of fertilizer at Macalester are only an estimate. While there is no way to know for sure what the trend is over time, it is likely that fertilizer fluctuates annually and has a general declining trend. Over time there has been an increase in campus square footage and a decrease in open, green space. In addition, the football field has a newly installed artificial turf that does not need fertilizer.

Data Accuracy

There was no data for the annual use of fertilizer at Macalester so an estimate had to be made based on the total amount of fertilizer that had been used since 1990, which has been tracked. This was divided by eighteen (to account for the 18 years being assessed in the carbon audit) to get the calculator input. For this reason, Macalester's annual fertilizer use is less accurate than desired.

Data Recommendations

In the future a chart should be kept that records the type and amount of fertilizer used. This number should be compiled annually and recorded so Macalester's use of fertilizer over time can be accurately documented.

5. Solid Waste

Introduction:

At Macalester College waste currently contributes 34 metric tons of eCO_2 a year which amounts to less than 1% of the total greenhouse gas emissions emitted by Macalester. The GHG emissions have increased over time as more waste has been sent to a landfill that captures methane, and less waste has been sent to refuse derived fuel (RDF) incinerator.

Solid wastes in the United States are disposed of in two primary ways: incineration and land filling. If waste is incinerated, it can either be done in a mass burn incinerator or a RDF incinerator. If it goes to a mass burn incinerator, unrefined solid wastes are burned together in a single combustion chamber. In contrast, if it goes to a RDF incinerator, the waste stream will first be sorted and then similar types of wastes will be burned together and used to generate energy[8].

If waste is put in a landfill instead of an incinerator, it releases methane during the anaerobic process of decomposition[9], which is a powerful GHG twenty-three times more potent than CO_2. This methane can be handled in three different ways: it can be released into the atmosphere, captured and burned, or used to generate electricity.

Landfill waste from facilities that do not capture methane emits more GHGs than all other disposal options. According to the CA-CP calculator, 99 metric tons of eCO_2 are emitted for every 100 tons of waste put into the landfill. In contrast, incineration emits the least GHGs, with 11 metric tons avoided through incineration.

For every 100 tons of waste that is disposed, four tons will be avoided if incinerated

[8] U.S. Congress, Office of Technology Assessment. *Facing America's Trash: What Next for Municipal Solid Waste"* Washington DC: U.S. Government Printing Office, 1989. 217-295.
[9] Assuming the waste stream contains organic materials.

in an RDF facility. If disposed of in a landfill that burns methane, 26 metric tons eCO_2 will be produced, and 15 metric tons eCO_2 will be created if it is disposed of in a landfill that uses the methane to generate electricity[10].

Methods

The calculator requires number of short tons solid waste created both on campus and by properties off campus owned by Macalester. College operations also produce hazardous waste, biomedical waste, and construction waste. However, for the purposes of this, study it was determined that these should not go in the calculator *(See Appendix D for details on other types of waste that Macalester produces).*

Campus Buildings

Facilities Services handles and tracks waste removal on campus. After much investigation, two contradictory documents were recovered. The first recorded each dumpster from June 2006 to May 2007. The second had waste weights for the entire college from May 2006 to December 2007. From June of 2006 to May of 2007, dumpster by dumpster records stated that 295 tons of waste had been disposed of, while the sheet documented 374 tons. Macalester's current waste handler Veolia was contacted to resolve the discrepancy. After compiling their figures, Veolia was able to report that Macalester generated 234 tons of waste in 2006, and 274 tons in 2007[11].

Since Veolia has only been servicing Macalester waste since May 2006, they were unable to provide data for the other 16 years. For these estimates, Macalester's previous waste hauler

[10] These figures are based on the assumptions given by the CA-CP, and are not necessarily the case for individual waste facilities. The assumptions that the CA-Cap has used to determine these calculations demand further investigation.
[11] Walter, Lisa. *Phone Interview.* April 8, 2008.

Allied Wastes was contacted[12]. While Allied Wastes was missing much of the data, they were able to provide rough estimates of the amount of waste produced during the time school was and was not in session. This amounted to roughly 291 and half tons a year *(See Appendix D for a summary of estimates on trash from Allied Wastes)*[13].

When Allied Wastes and BFI had waste contracts with Macalester, roughly 95% went to a RDF incinerator in Newport, Minnesota and 5% went to the Pine Bend Landfill[14]. For the last few years Veolia has been taking approximately 25% of Macalester's waste to Resource Recovery Technologies, a RDF incinerator in Newport, Minnesota, and 75% to Seven Mile Creek landfill, which generates electricity from captured methane[15].

Off Campus Buildings

There were several obstacles to overcome before an estimated amount of waste from off-campus buildings could be determined. While it was known that Macalester currently owns 29 residential homes and several retail buildings on Grand Avenue, it was unknown how this figure had changed over time[16]. In addition there were no records kept for the rental homes, so a baseline assessment could not be determined *(See Appendix D for the current list of properties that Macalester owns).*

The estimate for the rental homes was based on a study by Allied that determined each home in Ramsey County produces about thirty-five pounds of waste a week[17]. However, as the quantity of waste coming from businesses varies widely, no estimates from

[12] Macalester's previous trash companies are Allied Wastes and BFI. However, Allied Wastes bought out BFI in 1999, so ever since they have been regarded as the same entity. As BFI's records are completely lost, the assumption was made that they would be the same as Allied Wastes.
[13] Link, Doug. *Personal Interview.* 14 April, 2008.
[14] Allied Wastes. *Phone Interview.* February 25, 2008.
[15] Veolia. *Phone Interview.* February 25, 2008.
[16] Cledwyn, Sarah. *Personal Interview.* March 10, 2008.
[17] Allied Wastes. *Phone Interview.* February 25, 2008.

Allied Wastes were available. For this reason, it was decided that a more precise method would be needed to have businesses self report on how much waste they generate weekly.

Patagonia, Cat-Man-Do, and Pad Thai, (properties owned by Macalester) were contacted to estimate the amount of waste created annually. Patagonia estimated that they produced roughly eight lbs a week and Cat-Man-Do estimated no more than forty pounds a week[18]. Pad Thai did not know how much waste they produce in a week; as they have roughly twice as many seats as Cat-Man-Do it was estimated that would produce twice as much waste as Cat-Man-Do[19]. While a rough estimate this was the best available method.

The two properties not included were Grand Cambridge Apartments and Breadsmith bakery. Since Grand Cambridge Apartments is composed of students, it was assumed that students would generate roughly the same amount of waste as produced on a per capita basis on campus[20]. For Breadsmith, a few months had been recorded, which was then extrapolated for a whole year.

Results

While Allied Wastes and BFI picked up Macalester's waste, the calculator estimated approximately ten metric tons of eCO_2 offsets each year because of the disposal methods. In 2006, with service split between Allied Wastes and Veolia, approximately twenty-four metric tons of eCO_2 were released. Finally in 2007 when Veolia services all Macalester properties waste accounted for thirty-four metric tons of eCO_2 *(See Appendix D for calculations).*

The difference in the amount of GHGs has very little to do with the actual amount of

[18] Grady, Ellen. *Personal Interview.* March 28, 2008. Adhikari, Ujjwal. *Personal Interview.* April 1, 2008.
[19] Pad Thai. *Personal Interview.* April 8, 2008.
[20] This value was calculated by taking the mean of the tons of waste from the years 2007, 2006, and 2005, converting them into lbs of waste created and then dividing by a rough estimate of the amount of full time equivalent students, faculty and staff at Macalester based on Institutional Research Documents. While enrollment has fluctuated over the years, there are approximately 1800 students, 300 full time equivalent staff, and 150 faculty members

waste generated. For instance, in 2006, approximately 413 tons of waste was created, but only twenty-four tons of eCO_2 were released, while in 2007, 336 tons of waste was created, but thirty-four tons of eCO_2 was released. The difference in emissions can be mostly attributed to the disposal method since disposal by incineration releases far fewer GHGs than does land filling. Changing the disposal method from incineration to primarily land filling resulted in more eCO_2 emissions. RDF incinerators release negative emissions in terms of eCO_2, while landfills create eCO_2 emissions.

However, this trend does not fully portray the environmental consequences of RDF incinerators. Incinerators, unlike landfills, produce powerfully carcinogenic dioxins, thus switching the disposal method caused Macalester's waste disposal system to be responsible for releasing fewer carcinogens into the atmosphere. In addition, incinerator flue gas contains other highly toxic chemicals such as carbon monoxide, nitrogen oxides, particulate matter, chlorinated hydrocarbons, volatile organic compounds, and trace metals. In contrast, while landfills can release some pollutants if not closely monitored, they are generally considered a lower health risk than incineration byproducts[21].The level of pollution controls on the disposal facilities that Macalester waste is sent is unknown, so it is impossible to calculate pollution levels from these facilities.

Discussion

Trends:

Concrete data on waste quantities only exist for 2007 so trends over time are too inaccurate to estimate.

Data Accuracy:

[21] U.S. Congress, Office of Technology Assessment. *Facing America's Trash: What Next for Municipal Solid Waste?* Washington DC. U.S. Government Printing Office, 1989. 217-295.

While the data discussed in this report was the best that could be found, it is far from perfect. Waste was not monitored or recorded in a consistent and reliable form and it was difficult to find data that had been collected prior to 2006. Macalester was charged a flat fee for their contract with Allied Wastes and BFI[22]so there was no incentive for Macalester or Allied Wastes/BFI to keep records[23].Most of the records that Allied Wastes/BFI had kept were deleted when Macalester terminated their waste contract.

The quantity and destination of waste from off-campus properties Macalester owns are not accurate. The number of properties and types of businesses has changed over the years, which has changed the amount of waste created - for the purpose of the inventory the amount and type was assumed to be static over time because reliable data was unavailable. While this study made the assumption that all Macalester properties were picked up by Veolia since May 2006 and Allied Wastes/BFI prior to that, this is likely not the case for many of the properties.[24]The waste generated off campus would likely have been sent to a landfill or an incinerator in different proportions, and consequently the emissions levels would change.

Grand Cambridge Apartments is another case where the estimated trash quantity is not very accurate. Thirty students live in the Grand Cambridge apartments and are estimated to produce the same amount of waste as the average student at Macalester[25]. However this is not a precise assumption for several reasons. First, the average student, faculty and staff member all are responsible for different amounts of waste roughly correlated to how much time they spend on campus. Also, many students in Grand Cambridge Apartments are not on

[22] Not including bulk item like yard waste and demolition waste which are charged separately.
[23] Link Doug. *Personal Interview*. 14 April, 2008.
[24] Pad Thai, a business that rents Macalester-owned property, for instance is picked up by Waste Management, who likely sends their waste to different places then Veolia does.
[25] This value was calculated by taking the mean of the tons of waste from the years 2007, 2006, and 2005, converting them into lbs of waste created and then dividing by a rough estimate of the amount of full time equivalent students, faculty and staff at Macalester based on Institutional Research Documents. While enrollment has fluctuated over the years, there are approximately 1800 students, 300 full time equivalent staff, and 150 faculty members.

the meal plan and prepare their own meals; it is unclear how this affects their waste generation. These students are juniors and seniors and are more likely to own cars, making it easier to acquire disposable goods that later end up in the waste stream. For these reasons, the estimate given for Grand Cambridge Apartment is not as accurate as it could be.

Data recommendations:

There are several methods that Macalester should pursue to improve waste monitoring. A file should be set aside specifically for waste bills, and should be recorded annually. This data should be recorded monthly for each individual dumspter. Once a year Veolia or the current waste handler should be contacted to double check that they are still sending 75% of their trash to the Resource Recoveries fuel incinerator and 25% to the Seven Mile Creek Landfill.

To keep track of how much waste comes from off campus properties, more research should be conducted on which companies pick up waste from the various properties that Macalester owns. It should be determined whether it is possible to have those companies send Macalester annual reports on weights picked up from each property as part of their lease agreement. If this is not possible, Macalester should conduct annual surveys of the properties to understand how the quantity and destination of off campus wastes is changing over time.

6. Refrigerants

Introduction

There are six refrigerants in use at Macalester College since 1990.[26] The hydro fluorocarbons (HCFCs), R-22 and R-123, have global warming potentials (GWPs) for a period of 20 years – R-22 with 5,160 times the potential of carbon dioxide, and R-123 with 273 times that of carbon dioxide. The chlorofluorocarbons (CFCs), R-11 and R-12, have GWPs (also over 20 years) of 6,730 and 10,990 times that of carbon dioxide. R-134a, a hydro fluorocarbon has a GWP for the same time period of 3,830 times that of carbon dioxide.[27] Data regarding R-404a was not available.

In refrigeration systems, a substance is passed through chambers of varying pressures. At a low pressure, the liquid substance boils removing heat from the surrounding environment. This process is used for air conditioning and food refrigeration. The vapor is then pumped to a higher-pressure chamber where it is condensed and can be used again and again in the refrigeration system. When leaks occur, the refrigerant that is released into the atmosphere can be very harmful to the environment. Chlorofluorocarbons were targeted in the Montreal Protocol for their ozone-depleting potential, but they are also potent greenhouse gases.[28] CFCs and HCFCs are often used as refrigerants because they have extremely low boiling points at atmospheric pressure. However, they are regulated by the Montreal Protocol and accounted for in the calculator because of their environmental impact.

[26] Personal interview. Curt Stainbrook, Facilities Management. March 31, 2008.
[27] http://www.esrl.noaa.gov/csd/assessments/2006/report.html. *World Meteorological Organization Global Ozone Research and Monitoring Project- Report Number 50*. National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, United Nations Environment Programme, World Meteorological Organization, European Commission. 2006.
[28] http://www.epa.gov/Ozone/title6/phaseout/22phaseout.html. United States Environmental Protection Agency. "What You Should Know about Refrigerants When Purchasing or Repairing a Residential A/C System or Heat Pump." 2008.

Since a typical Macalester school year has only a few months where air conditioning is needed, the school uses a relatively small quantity of refrigerants. Most buildings on campus are not air conditioned over the summer; those that are include the Ruth Striker Dayton Campus Center, the Dewitt WallaceLibrary, the Weyerhaeuser Memorial Chapel, Weyerhaeuser Hall, Old Main, Olin Rice Science Center, Humanities, Carnegie Hall, Kagin Hall, Winton Health Services, the athletics building, 30 Macalester Residence Hall and George Draper Dayton Hall.[29] Although heating buildings at Macalester has a greater impact on the college's carbon footprint, it is important to include refrigerants due to their extreme potency as greenhouse gases. Data regarding refrigerants is not kept on campus, and was unavailable for inclusion in this report. Data will be added as it becomes available.

Discussion

Since data regarding refrigerant emissions is not kept at the college, it was difficult to find this information. To improve the accuracy of the calculator's results and make the carbon footprint calculation easier in the future, a copy of data records for refrigerants should be sent to the college as soon as they are available from the refrigerant company. Although they represent a fairly small portion of Macalester's carbon footprint, it is still important to be aware of the refrigerant output of the college.

[29] Personal interview. Curt Stainbrook, Facilities Management. April 2, 2008.

7. Offsets

Introduction

The two offset methods employed at Macalester are forest and prairie preservation and composting. Preservation is counted as offsetting green house gas emissions because plants sequester carbon. During the process of photosynthesis, plants use light from the sun to fix CO_2 into carbohydrates. The carbon gained during this process is then allocated to the development of different plant tissues, such as roots, stems, and leaves.[30] Composting is considered an offset because it prevents organic material from decomposing in landfills. When organic materials decomposes in a landfill the lack of oxygen causes methane to be created instead of CO_2 – methane is twenty times more powerful a GHG.

Macalester owns the Katherine Ordway Natural History Study Area (Ordway), located in Inver Grove Heights, Minnesota. Macalester acquired Ordway in 1967. The area was set aside for preservation by the financial contributions of Katharine Ordway and is "dedicated to biodiversity preservation, education, research, extension and advancement of interdisciplinary practices in Environmental Studies."[31] According to the Natural Resource Management Plan prepared for Ordway by Friends of the Mississippi River, Ordway includes ten plant communities with an overall area of about 152 acres.[32] For the purposes of the inventory it was assumed that the plant communities at Ordway are not sequestering net new carbon. However, to perform a comprehensive inventory of the greenhouse gas emissions of

[30] Thomas M. Smith and Robert L. Smith, *Elements of Ecology* 6th ed. (San Francisco: Pearson, 2006), 105-106, 111-112, 634.
[31] Katharine Ordway Natural History Study Area, "Vision Statement," http://www.macalester.edu/biology/ordway/vision_statement.html.
[32] Katharine Ordway Natural History Study Area Natural Resource Management Plan.

the College and to begin to study carbon sequestration, an estimate of carbon sequestered by the plant communities at Ordway was conducted.

In the CA-CP Calculator, the category of offsets includes forest preservation projects.[33] The calculator requires input values of net new carbon stored each year, not the total amount of carbon stored in the community. Ordway is not designated as a forest preservation project, but for the purpose of this audit and report, it is included in this category.

Methods

To estimate the amount of carbon sequestered by the Katherine Ordway Natural History Study Area, values for the areas of different plant communities at Ordway were obtained from the Natural Resource Management Plan.[34] Values for carbon sequestration per unit of area were taken from the article "Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass" and from a greenhouse gas inventory conducted at Duke University. The article describes experiments in which plots of grassland species sequestered CO_2 in soil and roots at a rate of 4.4 metric tons/hectare/year.[35] The greenhouse gas inventory conducted at Duke University estimated that the Duke Forest absorbs 1 metric ton CO_2/acre/year.[36] The product of area values of plant communities at Ordway and values for carbon sequestration per unit of area is an estimate of the annual carbon sequestration in each of the plant communities. (*See Appendix E)*

Results

[33] Clean Air Cool Planet Campus Carbon Calculator User's Guide, 13.
[34] Katharine Ordway Natural History Study Area Natural Resource Management Plan.
[35] David Tilman, Jason Hill, and Clarence Lehman, "Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass," *Science* 8, no. 5805 (2006), http://www.sciencemag.org/cgi/reprint/314/5805/1598.pdf.
[36] Duke University, "Greenhouse Gas Inventory 1990-2003," http://www.duke.edu/sustainability/documents/Duke%20University%20Greenhouse%20Gas%20Report.pdf

The estimated total amount of carbon sequestered by the forest and prairie plant communities at Ordway is 150 metric tons CO_2 year. According to Allied Waste, approximately 2 tons of yard waste is created every month from May to October.[37]This waste is brought to a NRG transfer facility in South Minneapolis, and then brought to a composting site in Empire Township known as NRG Processing Solutions. Annually, 12 tons are composted, which negates approximately 2 tons of eCO_2 a year[38].

Discussion

The Duke forest and the experimental prairie plots that serve as the basis for estimating carbon sequestration at Ordway differ from the forest and prairie plant communities at Ordway. The CO_2 estimate excludes six of the ten plant communities at Ordway because they were considered incomparable. However, the plant communities included in this estimate represent about 141 acres of the total 152 acres of plant communities (93 percent of the total area).

As a result of these limitations, the estimate of carbon sequestration at Ordway is a rough illustration. To know precisely how much carbon is sequestered by the plant communities additional studies at Ordway are necessary. This exceeds the limits of the Environmental Studies Senior Seminar; however future studies could be conducted by other academic departments at Macalester.

Carbon sequestration by the plant communities at Ordway should be studied and recorded annually to make future estimates more accurate and precise. Such studies can be incorporated into coursework, perhaps in the departments of Biology or Environmental

[37] Up until the end of March in Minnesota the ground is covered in snow, and in April there is not very much grass on the ground to generate many grass clippings. In the months May to October the assumption is made that there will be enough yard waste through mainly grass clippings or leaves to generate two tons a month.
[38] The assumption is also made that Veolia composts Macalester's trash waste as well, but it is not known whether this is the case.

Studies. Involving students in studies at Ordway is consistent with the Natural Resource Management Plan for Ordway[39] and the implementation of the Presidents Climate Commitment.[40]

These estimates illustrate the scale of offset projects that would be necessary to offset Macalester GHG emissions. The 152 tons eCO_2 offset by plant growth at Ordway and composting is only .56% of Macalester's 2006 emissions. If Macalester were to offset its emissions through forest preservation, it would be necessary to preserve 25,211 acres. While offsets will eventually be necessary to offset some emissions such as international airline travel that cannot be avoided at this point in time, offsets will not be able to feasibly balance out all of the college's emissions.

[39] Katharine Ordway Natural History Study Area Natural Resource Management Plan, 4-5.
[40] ACUPCC Implementation Guide, 6.

8. Food

Introduction

The Food and Agricultural Organization (FAO) of the United Nations states that the food and agriculture sector is responsible for generating more than one third of GHG emissions.[41] This significant component stems from chemical and petroleum intensive practices in transportation, agriculture and refrigeration, large-scale livestock production, and intensive deforestation that is common practices of the industrial food system.

Unfortunately, most GHG calculators do not include food analyses in their calculations. This significant source of GHGs is omitted due to the largely invisible nature of the industrial food system. Studies have shown that the average American meal travels an around 1,500 miles before reaching consumers[42]. This distance is accounted for as most food items travel between several destinations to be processed, packaged, distributed and sold. This long chain makes tracking the source of particular food items nearly impossible, and is further complicated by the historical lack of incentive for food distributors to keep accurate records of food sources. As a result, the data needed to complete an accurate carbon audit of a particular institution's food system is currently unavailable. However, despite the absence of data and of a standard method for quantification, there are steps that can be taken to decrease food's impact on global warming.

Bon Appétit, Café Mac

Macalester College works with Bon Appétit Management Company to provide food to its students and staff. Bon Appétit operates nationwide and is a leader in incorporating sustainability into the food service industry. Bon Appétit manages Macalester's cafeteria,

[41] Food and Agricultural Organization of the United Nations. 2008.

[42] Church, Norman. 2005. Why Our Food is So Dependent on Oil. Powerswitch.

Café Mac; the Café Mac Grille; the Atrium Market; and also provides catering services for events at Macalester. Bon Appétit claims to be the first food service provider that has publicly recognized the connection between food and global climate change and has undertaken efforts to reduce their carbon footprint while maintaining a premium quality food service.[43]

Bon Appétit has instituted several programs to reduce the GHGs generated by Café Mac. The "Farm to Fork" Program was initiated in 1999 to source a minimum of 10% of Café Mac's products within a 150-mile radius of the school. Currently, Macalester obtains all of its milk, cheese, and butter from Hastings Cooperative Creamery in Hastings, MN; its beef from 1000 Hills Cattle Produce (a grass-fed beef cattle processor located in Cannon Falls, MN); and purchases in-season produce from local farmers, including from students running the on-campus community garden. Café Mac holds an "Eat Local Challenge" each fall where they serve a meal using as many local ingredients as possible to focus student, faculty and staff awareness. The 'Circle of Responsibility Program' was implemented in 2003; Café Mac serves only cage-free eggs and antibiotic-free chicken. In the fall of 2006, Café Mac held its first 100% "Zero Waste" compostable picnic which has been held once a semester since. The picnics are sponsored in partnership with Eureka Recycling, a Minneapolis-based organization working to initiate a large-scale composting program.

Café Mac has begun to reduce the total quantities of certain food items with particularly high carbon footprints. According to the Climate Action Program, the meat and dairy industries cause an estimated 50% of food-related climate change impacts largely due to the high quantities of methane associated with cattle production (Sample, 2007.) In response, Bon Appétit has reduced the total quantity of both beef and cheese served at Café Mac by 10% since February 2007. It is possible to make a general estimation of CO_2 averted

[43] Personal Communication. Lori Hartzell, April 1, 2008

by these reductions based on calculations for the beef and dairy industries at large. For example, in February 2008 Café Mac purchased approximately 250 lbs less than the total of 2,530 lbs of beef they purchased in February of 2007. Applying a conservative estimate that one pound of beef correlates to 18 pounds of carbon dioxide, this reduction alone results in a 4,500 lb net decrease in carbon dioxide in just one month.[44]

It is essential that Macalester and Café Mac begin to keep more accurate records of food purchases so that they may further reduce the impact food. In the approaching months Bon Appétit Management Company plans to issue a statement requiring vendors to provide the records of their product sources. Macalester should set up a framework to track this data on-campus in order to gauge, as accurately as possible, how their food purchasing decisions are contributing to the production of greenhouse gases.

[44] Fanellis, Daniele. "Meat is Murder on the Environment." The New Scientist Environment.com 18 July 2007. http://environment.newscientist.com/article/mg19526134.500-meat-is-murder-on-the-environment.html

9. Sewage

Introduction

The calculator does not have a section for calculating the GHG emissions released from wastewater sewage systems, although it was decided that Macalester does want to track this source. The College's water usage was used to estimate the amount of sewage produced annually. This number was converted into GHGs by an equation provided by a local waste treatment expert. The amount of eCO_2 in pounds released at the sewage treatment facility from Macalester's waste each year from 1990 through 2007 is detailed below. In total, over the past 18 years Macalester's sewage has emitted an estimated 1,576,055 pounds or 788 tons of carbon dioxide.

All of the water and waste that runs down the drain inside Macalester's buildings is sent into the city sewage system. Macalester's sewage flows to the Metropolitan Wastewater Treatment Plant (Metro), the facility that treats all of the sewage in the seven-county area. Once the sewage gets to Metro, a first set of tanks settles the sewage and removes 50-60% of the solids. A second set of tanks grows organisms that consume the suspended and dissolved solids. The remainder of the solids from both the first and second set of tanks is then burned in an incinerator. In addition to the CO_2 released from the organisms in the second set of tanks, the burning process also contributes a significant amount of CO_2. Since 2004 new incinerators have been removing some of the CO_2 before exhausting into the atmosphere. There is a small amount of nitrous oxide (N_2O) and methane emitted at the Metro Plant. Some methane is emitted in the sewer system between Macalester and the Metro Plant, but it is hard to calculate. The following report details how much CO_2 is released from Macalester's sewage because it composes a large majority of the GHGs emitted from waste processing. The other GHGs are not included because they are either immeasurable or

inconsequential. Sewage provides a great example of the relationship between energy, waste and water use. Reducing carbon emissions from sewage is possible through the twin practices of efficient water use by consumers and efficient energy use by the water treatment facility.

Methods

Emissions produced by Macalester sewage was calculated by 1) determining how much sewage Macalester has created since 1990, 2) contacting an expert from the waste water treatment plant who provided emission estimates and 3) performing basic calculations to determine annual CO_2 releases.

The sewage is not measured directly but can be estimated by water consumption. The City of Saint Paul Water Utility bills each customer for sewer services based on their water flow meter and thus has the water bills from every building on Macalester's campus since 1997. These bills provided the total amount of water used per year on Macalester's campus. The data uses units which are the equivalent of 100 cubic feet, so the totals from each year were converted into gallons by multiplying each billing unit by 748 (1 cubic foot = 7.48 gallons). Data for years prior to 1997 was extrapolated by multiplying the average amount of water used per student from 1997 till 2007 by the population data for the years 1990-1996. Determining the total amount of water that flows into the sewage system annually provides the best estimate of the quantity of sewage that flows to the treatment facility.

The second step entailed figuring out how many lbs eCO_2 are released for every gallon of water treated at the facility. A retired environmental and electrical engineer who worked for 30 years at the Metro Plant helped to determine this conversion. This expert provided information on both the process sewage undergoes after it leaves Macalester and a

carbon emission estimate. At Metro, for every one million gallons of sewage that is discharged into the system about 3,000 pounds of CO_2 are emitted to the atmosphere. This does not include the amount of CO_2 created while producing the energy required for operating the treatment processes.

The final step was calculating the carbon emissions from Macalester's sewage for every year since 1990. This was done by multiplying the estimated sewage per year in millions of gallons with the 3000 pound estimate.

Results

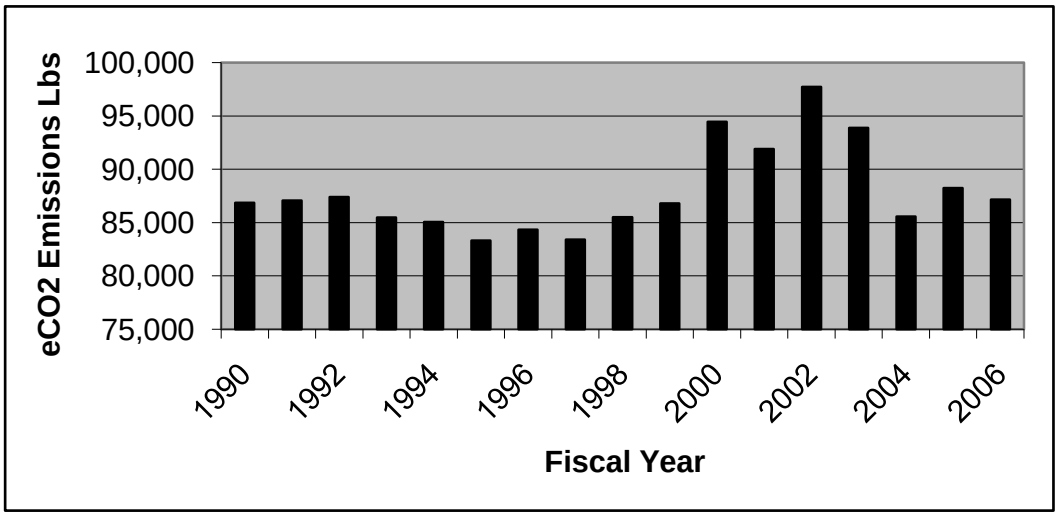

Figure 9.1 Sewage eCO_2 Emissions 1990-2006.

Discussion

Trends

There is one explainable trend in the sewage data which is the low estimate in 2007. The meter which monitors the pool and gym was shut off on March 9th 2007 due to the construction of the new athletic facility. The old gymnasium was closed for the rest of 2007 which directly impacted Macalester's water usage.

Data Accuracy

There are five weak points in the sewage emission calculations. First, it is assumed that the amount of sewage discharged from Macalester is equal to the amount of water consumed. This does not take into account either the amount of solid waste which was added to the sewage system or the amount of water which did not enter the sewage system (i.e. water used for landscaping).

Second, the exact locations and measurement areas of several water meters on the documented bills are unknown. The data that the city provides on the water bills does not detail building names; they only have the street address and the billing account number. Several key buildings are missing from the raw data, and some bills are not associated with an address or a building name on campus. This can be partially be attributed to the fact that several of the campus buildings share a water meter, but it also represents the fact that Macalester and the utility record water use differently. Regardless, these unknowns do not effect calculations because only the aggregate of the bills is needed.

Third, all of the data except Macalester's student population was extrapolated for years prior to 1997. These estimates are relatively sound because they reflect the average amount of water used per student, which has remained relatively constant.

Fourth, the numbers used to translate the amount of water Macalester uses into the carbon emissions is an estimate. Granted that the 3,000 pound per million gallons estimate was provided by a person knowledgeable in the field who works directly with the sewage treatment company, it was still his "best guess." The fact that new incinerators have been sequestering carbon since 2004 was not taken into consideration because the relevant information was not accessible.

Finally, the water bills for High Winds buildings (properties owned by Macalester) are not included because they only showed the price paid which cannot be translated into gallons. Several of the Highwinds buildings water bills are paid for by Facilities Services, such as Pad Thai and Grand Cambridge Apts. In order to simplify this, the water bills for Highwinds buildings which are not paid by Facilities Services are not included.

Data Recommendations

There are several ways in which the data can be collected more efficiently for the calculator. Facilities Services keeps a copy of each water meter's bill, but they only keep this information for three years. The water bills for all of the High Winds buildings are in a separate location and formatted differently than for the rest of the school. High Winds and Facilities should total up all of the water bills per year and enter them into a single spreadsheet. Alternatively, a relationship should be established with Saint Paul Regional Water Services in which they send Macalester the total amount of water used from all the water meters on campus each year. An increased amount of attention is being placed on water consumption and this focus will only intensify; keeping a simple and centralized archive of Macalester's water usage would be very helpful in the future.

10. Recycling

Introduction

Recycling can significantly reduce the amount of energy used to create products, preventing emissions from power plants and transportation. For example, it takes 95% less energy to recycle an aluminum can than it does to make a new one.[45] With the emphasis on innovation and new technology, many people ignore recycling, feeling that it is something old that is already being done. To the contrary, there are many ways to improve recycling programs.

Although there has been a recycling program at Macalester for thirty-eight years, only recently has it been embraced as a significant part of the College's sustainability plan. In 2007 the College implemented a Zero Waste Initiative, headlined by a partnership with Eureka Recycling of Minneapolis and a renewed commitment to recycling, reuse and waste reduction on campus. The goal of the initiative is to quickly come as close to generating zero waste as possible.

Methods

Before partnering with Eureka, Macalester's recycling was dealt with by various haulers and taken to different places depending on the hauler and the material being picked up. The college was charged for this service by weight. Yearly records of these transactions dating back to 1991 were obtained from Facilities Services. The data was in yearly spreadsheets with each monthly pickup detailed by material weight and price. Data for 2006-2008 came from Eureka Recycling. This data was all on one table, broken down by material (such as glass, metal, plastic, etc), and included trash weights and the recycling rate as a percentage.

[45] http://www.bir.org/aboutrecycling/index.asp

Results

The records were simplified on a spreadsheet with a graph tracking the total poundage of each material for each year. Figure 10.1 shows the total poundage as well as the percentage of each material recycled, unadjusted for missing data. Adjustment was not deemed necessary because recycling is not included in the calculator. Figure 10.2 is simplified to show only the total weight of recycled materials per year. It also includes 2002-03 adjusted to be an average of 2001-02 and 2003-04. 2004-05 and 2005-06 were removed because they were not accurate. This should not pose a problem because these numbers do not affect the calculator. The Eureka records were also included. The data from 2002-03 and 2004-06 is incomplete for unknown reasons.

The amount of carbon that would have been released had there been no recycling program was calculated by putting the recycling weights in the waste input columns. To reflect waste disposal methods, 95% of the weight was put in the column for Refuse Derived Fuel (RDF) incineration and 5% in the column Landfill with Electricity Generation for the years 1990-2005. From 2006 on, 75% of the weight was put in the Landfill with Elec. Gen. category and 25% of it was put in the RDF category (See Solid Waste Section). By recycling, Macalester avoids on average 15 Metric Tons of eCO_2 per year. Figure 10.3 shows yearly emissions averted, again with the year 2002-03 adjusted for accuracy and the years 2004-05 and 2005-06 removed.

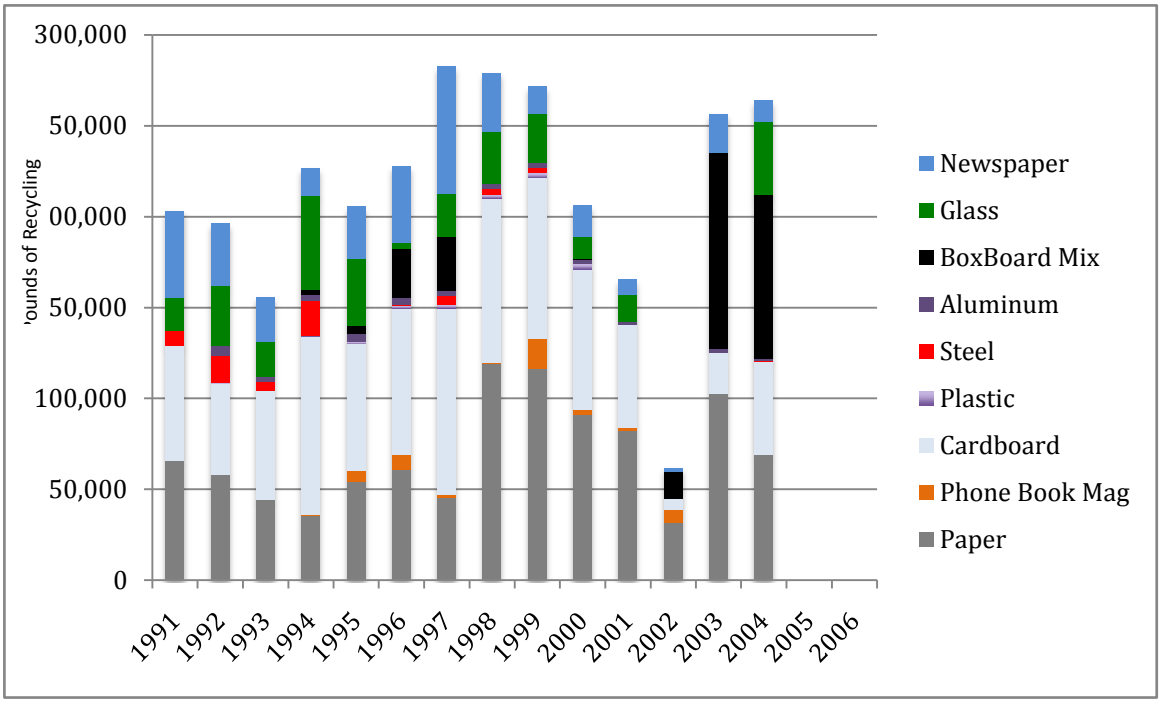

Figure 10.1: Recycling Weights by Material 1991-2006. Each annual weight is separated into percentages by material. The figure shows an increase in recycling until 1998, followed by a decrease and a recent upswing. Note: the data for year 2002-03 is incomplete.

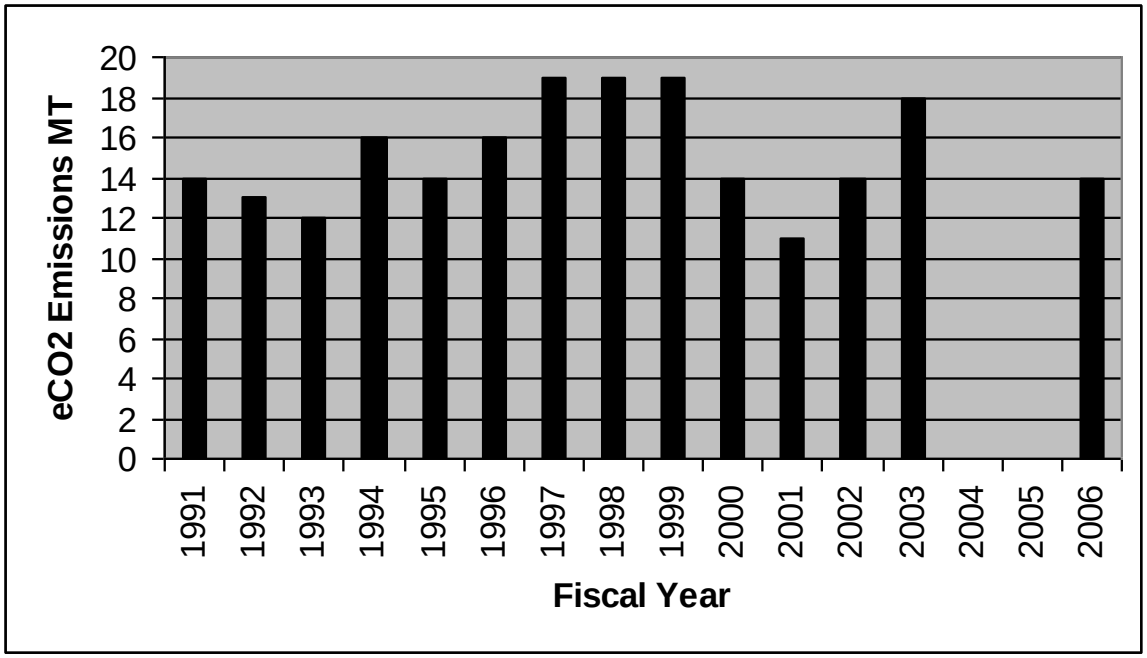

Figure 10.2: eCO_2Emissions Avoided by Recycling 1991-2006.

Discussion

Trends:

There was a peak in Macalester's total recycling in the late 1990's, with a slight dip and then rise again towards the present. The last two columns represent more than a year's time and are very different. The data for 2004-06 were the last data received from Facilities and was very incomplete. Because it was so inaccurate and there was no easy way to average it out, those data were removed. As the graphs show, emissions averted generally correlate to recycling weight. This means that recycling is one area that Macalester can develop in order to move toward a smaller carbon footprint.

Many efforts have been made to make recycling easier and more visible on campus. Eureka received Macalester's contract in May 2006, but many of the on-campus efforts did not go into effect until that fall, which is reflected in the data. The following graphs show the results of the baseline study that Eureka did of Macalester's waste stream in 2006, as well as the recycling rates for 2006 and 2007.

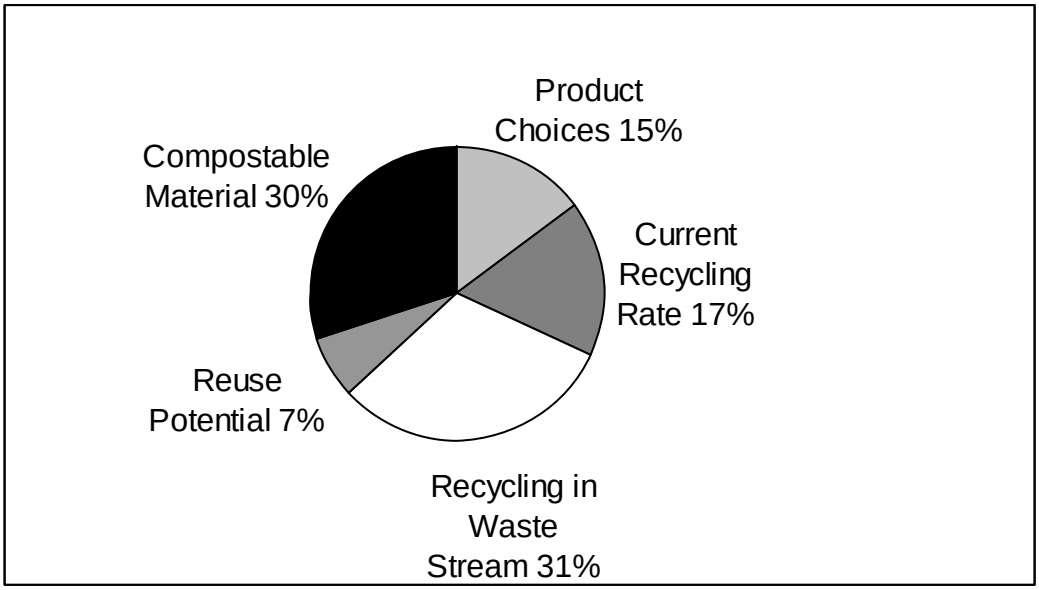

Figure 10.3: Eureka Recycling 2006 Baseline Study Macalester Waste Stream

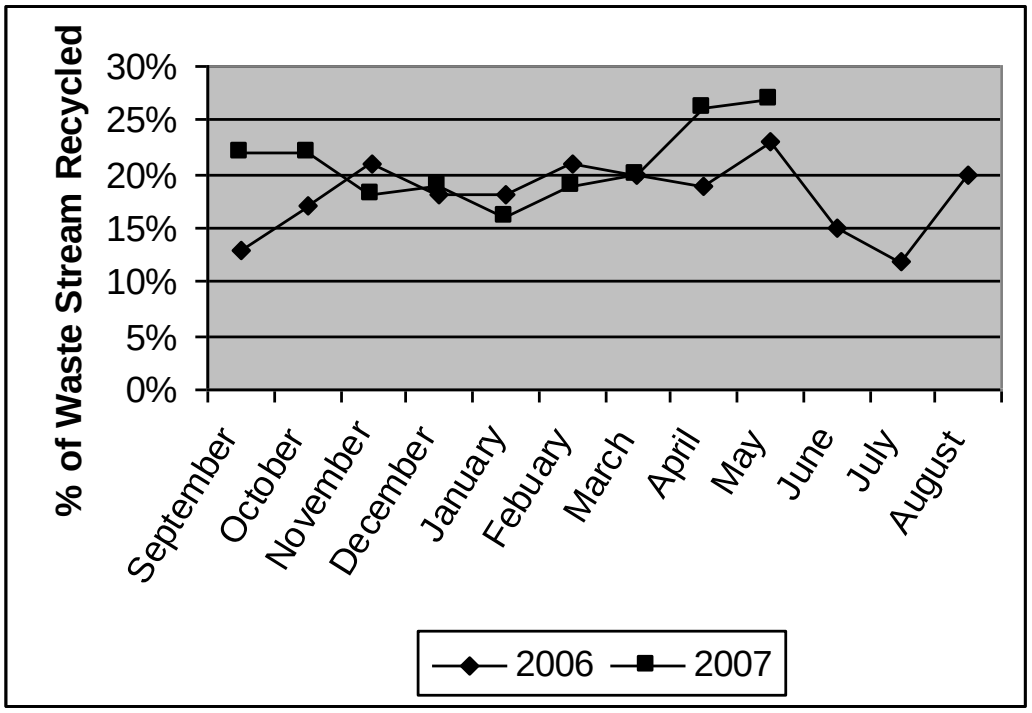

Figure 10.4: Recycling Rates 2005 & 2006. While Eureka obtained the Macalester contract in May 2006, many of the improvements to the program did not go into effect until fall. This data was tracked and assembled by Eureka Recycling working in partnership with Macalester College through a resource management contract. Eureka Recycling's mission is to reduce waste today through innovation and resource management and to reach a waste free tomorrow by demonstrating that waste is preventable, not inevitable.

There has been some success with the new program, which the data reflects. Future projects include major publicity in 2008 about the new program, new student recycle boxes in the dorms, a "reusables" room, more zero waste events, new plans for move-out day, outside recycling bins, and composting in Café Mac through a pilot project of Eureka's.[46]

The Macalester recycling program over these particular years has stayed roughly the same through 2007. In 1990 and 1991, Macalester purchased two cardboard balers and a can baler and greatly increased the efficiency and potential capacity of the program. Since 2006, Facilities Services has been working to redesign the recycling program at the College, to make recycling and the collection process more efficient. The act of recycling by the average student, faculty and staff has become much easier over the last year, through the application of new labels and new recycling lids with can- or paper-shaped cutouts to avoid confusion. The collection process will be improved by a completely overhauled student worker schedule being implemented in fall 2008.

Data Recommendations:

While both sets of records were well-organized, easy to read and analyze, it is important that Facilities work with Eureka to come to a consensus about how, where, and in what format the recycling records will be kept. Also, copies of the records should be kept in the Sustainability office, and on the Facilities Services department website.

[46] Interview, Custodial Shift Supervisor

11. Conclusion

It is important to understand the particular sources that contribute to Macalester College's GHG emissions so that strategies can be developed to achieve carbon neutrality. Several overriding trends have strongly influenced GHG emissions on campus. Heating/Cooling, Electricity and Transportation are by far the most significant sources of GHGs tracked in this report and will have to be critically addressed in the future. These three also provide the greatest options for reductions; heating/cooling and electricity in particular can offer attractive cost savings from emissions reductions, and should be viewed as financial opportunities. This report concludes with recommendations based on the individual GHG sources identified in the report, including energy usage, transportation, waste generation and disposal, refrigeration practices, fertilizer usage, and food choices.

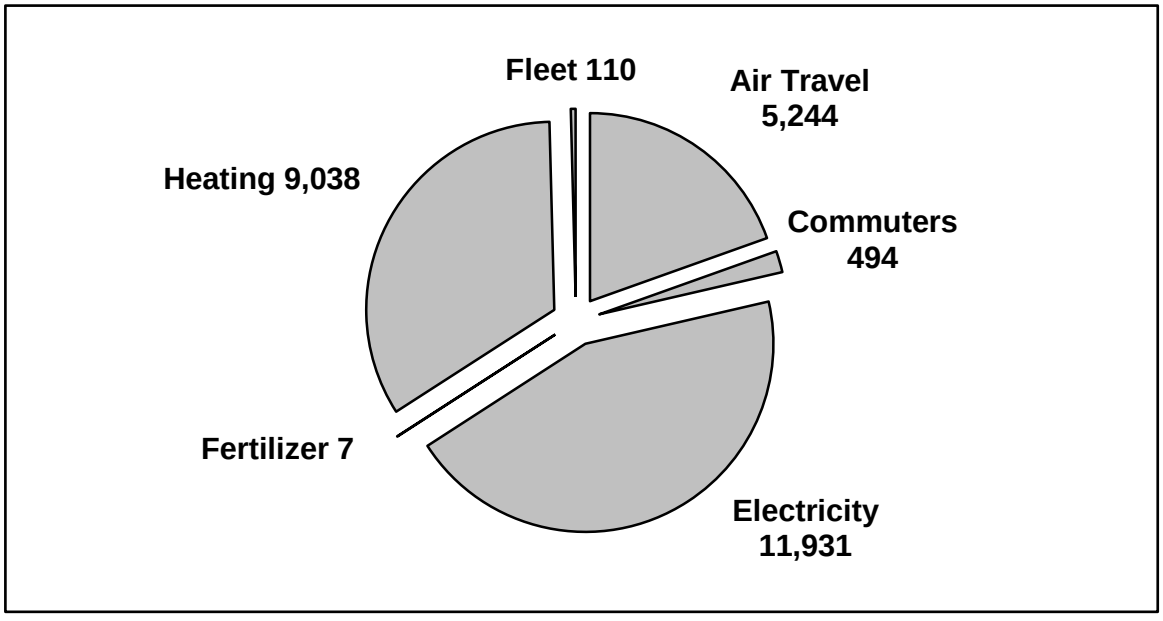

Figure 11.1: 2006 eCO_2 Emissions by Percentage. Energy consumption in the form of electricity and heating comprises the majority of Macalester College's emissions but transportation, especially college funded air travel, also represents a significant source of emissions.

In 2006, electricity was responsible for the majority of the carbon emissions produced at Macalester College (approximately 44 percent). Heating represented the next largest source of emissions (approximately 34 percent). The final 22 percent was almost entirely produced by the transportation section, with air travel accounting for 20 percent. Even as the proportions of emissions represented by energy and transportation shift they constitute nearly all Macalester College emissions. Electricity and transportation have been more consistent than heating emissions for a number of reasons such as the variance of heating degree days each year. Most notable, however, are the disparities observed in annual emissions as a result of fuel source purchasing policies. In the years that Macalester has purchased large amounts of fuel oil, especially fuel oil #6, heating has been responsible for a greater percentage of overall GHG emissions.

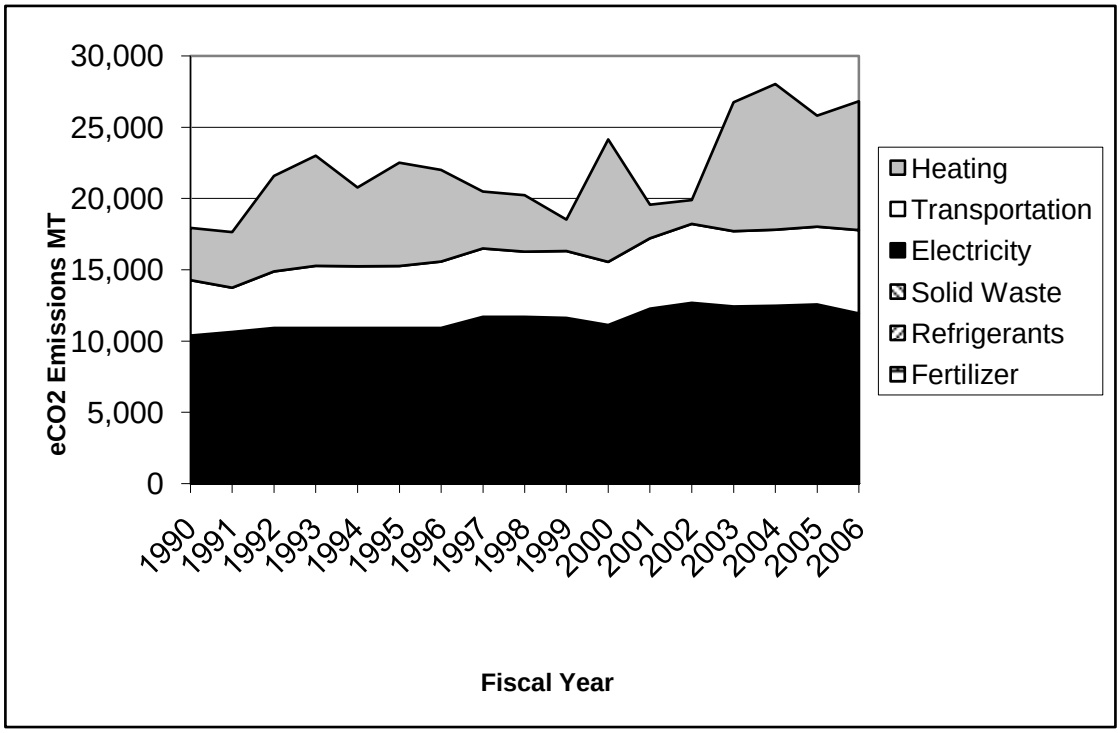

Figure 11.2: Emissions by Sector 1990-2006. Each year electricity, heating and transportation account for virtually all of Macalester College's GHG emissions. Of the three emissions, heating is most susceptible to change since different proportions of fuel oil versus natural gas can be used to heat campus.

Since 1990 the levels of CO_2 emissions have risen steadily as heating, electricity and transportation demands have increased. The rise of personal electronics and appliances has increased electricity demand but this increase has been tempered by Macalester College's efforts to increase energy efficiency. Heating demands have risen as more square footage is added to campus but again efforts to increase efficiency have helped to slow the growth of associated emissions. As Macalester continues to focus on internationalism, air flights will be a significant percentage of the college's GHG emissions and perhaps the hardest one to reduce.

The recommendations for each source offer varying levels of GHG reduction, require a range of degrees of investment, and may have additional benefits or costs. The amount of greenhouse gas emissions avoided as well as the ease of implementation need to be considered when implementing these recommendations. Certain recommendations are offered as intermediary steps while others are posited as long-term solutions. Some may be more easily implemented than others and several are currently being undertaken. Macalester has many areas to pursue in reducing its carbon footprint, and the college should further investigate the plausibility and implications of the following recommendations.

Energy Recommendations

Macalester can more easily influence the carbon footprint of the heating/cooling systems than other parts of the carbon footprint. For instance, Macalester can directly improve the efficiency of the heating system, whereas it can only try to influence changes in student, staff, and faculty commuting habits. There are two key strategies that could reduce the amount of energy used and emissions released: reduce overall campus usage and change the sources of campus energy.

Reduce Energy Demand:

Macalester can do little to influence how the area utilities generate electricity (wind, nuclear, hydroelectricity) because it depends on energy utilities in the Saint Paul area that offer little renewable electricity. Macalester can potentially provide some of its electricity by installing solar panels on buildings or investing in off-campus electrical production sources such as wind farms. However, this may not currently be the most cost-effective option.

One of the best things to do is to increase energy efficiency. The College can reduce its overall energy usage through various efficiency projects, such as electrical recommissioning in the Olin Rice Science Hall, improving insulation in campus housing, and upgrading lighting systems in campus buildings. The Clean Energy Revolving Fund (CERF) is a powerful tool to help finance efficiency projects. Energy efficiency generally has a high payback in terms of energy cost savings, and should be heavily invested in by Macalester over the next several years. Performing a comprehensive energy-efficiency audit of all campus and off-campus properties would be an important first step to determine where the greatest and most cost-effective changes could be made.

Replacing Campus Energy Sources:

To reach carbon neutrality, Macalester must transition away from using natural gas and fuel oils to heat the campus. Due to Minnesota's variable and extreme climate, energy efficiency strategies alone cannot adequately reduce the carbon footprint in Macalester's heating and cooling systems.

There are three options for replacing the heating plant on campus. One is to install a biomass heating system that would be carbon neutral. This could be difficult due to the College's location in the middle of a large city with no direct access to biomass sources. A

second option is to contract out heating and cooling to a citywide district system. However, there is no system in place that Macalester could connect to, and so is not a viable option in the near future. A third option is to install a large ground source heating and cooling system to replace the central plant. This could be best in the long run as it would reduce dependence on variable fuel prices and would make for easier budget control. A large-scale ground source system of the size necessary for the college may be prohibitively expensive, though a large investment in campus building efficiency could reduce the heating load enough to make the cost-benefit analysis of a new system more attractive.

Transportation Recommendations

Macalester should continue to foster programs to reduce carbon emissions caused by commuting by promoting walking, biking, etc., especially since many students, faculty and staff live within walking distance. There is a new subsidized bus pass program for the Macalester community that offers pre-paid bus passes at 50% the normal price. There is also a Walk to Work program for faculty and staff who live within one mile of campus. The program will pay up to $3,000 in matching funds for faculty and staff who want to make efficiency improvements to their homes if they live within walking distance. The goal is to encourage as many faculty and staff to live close to campus and become a part of the community as possible.

In order to accommodate staff and faculty in the nearby school districts, Macalester could create a day care program and promote a carpooling program to transport children to and from their schools. This would eliminate the necessity for many faculty and staff to leave campus by vehicle during the day. For faculty and staff who live farther away, Macalester should encourage carpooling and busing with similar incentives.

The College should also continue to invest in better infrastructure for bikes and bikers, including more bike racks, showers, and lockers. For example, bikers could be given locker priority in the new Macalester Athletic and Recreation Center. MacBike is a great resource to student bikers, and we suggest that Macalester support them with a permanent space to house their organization. This will allow MacBike to become more effective in sharing knowledge about bikes and bike repair with the campus.

As fostering internationalism and geographical domestic diversity is a priority for the College, not much can be done to significantly reduce air travel. However, eCO_2 emissions from air travel can be reduced. The buses and trains should be emphasized for domestic travel as opposed to flying. If traveling by plane is the only option, direct flights should be purchased, since 25% of eCO_2 emitted during a flight is from take-off and landing. For domestic flights, business trips can be consolidated so more work is done at a destination rather than making multiple trips to the same area. Promoting teleconferences would result in completely avoiding some airplane trips, hence creating a significant impact on transportation-related carbon emissions.

Macalester currently owns two pickup trucks, nine club cars (five of which are electric) and three Cushman cars (1 is electric) all for use by Facilities Management in their daily operations. Incorporating more electric vehicles into the campus-owned fleet would decrease gasoline consumption. Macalester also uses gasoline in its 15-passenger rental vans, which means choosing rental vans that have higher fuel efficiency will be important for reducing gasoline consumption. Wellesley College noted in their carbon audit that they switched to minivans and cars instead of 15-passenger vans and CO_2 emissions decreased as

a result.[47] Like Wellesley, Macalester has 15-passenger vans that are not insuredto carry 15 people due to the expense. The College should look into renting fuel-efficient minivans or cars instead of the 15-passenger vans to reduce gasoline consumption.

Another option is to support, expand, and fund access to the Hour Car car-sharing program near campus. This would involve lowering the age limitation so students could rent the car, and possibly offering an institutional membership for faculty, staff, and students who bike, walk, carpool, or ride the bus. The Hour Car could also be used by departments on campus to run work-errands as an alternative to a 15-passenger van.

Refrigerant Recommendations

Due to the current structure of Macalester's refrigeration system, opportunities for reducing emissions are limited. A simple way to reduce emissions would be raising the temperatures slightly in all air-conditioned buildings. Ensuring that refrigeration is used only when and where it is needed and using natural cooling methods when possible will further reduce emissions. The Institute for Global Citizenship, currently under construction, will not use any traditional refrigerants as the building's LEED Platinum certification prohibits use of chlorofluorocarbons and hydro chlorofluorocarbons. If the new cooling system is effective and reliable it could be an option for cooling other campus buildings.

Waste, Recycling, and Fertilizer Recommendations

The best way to reduce GHG emissions of waste is to not create any. Macalester is currently working to reduce waste production on campus through increased recycling efforts and requiring demolition projects to recycle and reuse as much of old buildings as possible as a part of the college's Zero Waste initiative. When the old athletic center was recently

[47] Members of ES 300, "Audit of Wellesley's Green House Gas Emissions," http://cs.wellesley.edu/~weed/papers/GHG-Assessment-spring-2003.pdf.

demolished over 95% of the building was reused or recycled – an enormous increase over efforts in the past.

Recycling has been offered at Macalester for several years now and is currently being expanded with new bins, signs and an educational campaign. As previously noted, Macalester has teamed up with Eureka Recycling, which holds the philosophy that all waste is preventable.[48] As a first step Eureka has been working to increase recycling rates at Macalester through techniques such as placing bins in more appropriate locations. However, Eureka is also excited about expanding beyond recycling to dramatically reduce Macalester's waste in the future. There is great potential for this as currently only 19% of Macalester's waste stream by weight is actually unusable. Of the 81% that could be diverted from the waste stream and put to other use, 36% is composed of organic substances that can be composted, 8% is potentially reusable, and 37% is recyclable.[49]

Compared to waste reduction on campus, it will be much more difficult to control waste created off-campus. Macalester should fund and run community education programs about waste reduction and support the initiatives of groups like Eureka Recycling to lower the amount of waste that is created. Information about waste reduction should be made available to students living off-campus when they register their off-campus addresses with the College.

Macalester should also look at where its waste is being sent. A student or staff member could research the various waste disposal options and determine an institutional preference – such as land filling or incineration. The College could then persuade Allied Waste to increase pollution controls or handle waste in a different treatment facility.

[48] Pers. Comm. Susan Hubbard, April 4, 2008.
[49] Eureka Recycling. Macalester College Baseline Study and Zero Waste Recommendations. October 2006.

Another opportunity for reducing trash is to compost Macalester's food waste and use it as fertilizer on campus. This could simultaneously address several issues: less fertilizer use releasing less nitrogen into the air, decreased waste in general, and less fuel for waste transportation. This composted waste would only contain about 4% nitrogen, which is far less than the synthetic fertilizers.[50] If higher nitrogen content is desired organic additives like coffee grounds, brewery waste, or animal waste could be added. The area around Macalester has several coffee shops and breweries; finding businesses willing to give or sell their waste to Macalester should not be a problem. Organic fertilizers are far preferable to synthetic fertilizers because synthetics add new net GHGs to the air.

Food Recommendations

Bon Appétit is currently in the process of establishing their most rigorous campaign for addressing climate change, the Low Carbon Diet (LCD) program. This program was initiated nationwide on Earth Day, April 22, 2008 and aims to develop operational strategies to minimize Bon Appétit's carbon impact while simultaneously running an educational campaign to increase their guests' and clients' awareness about environmental issues. Macalester has taken a significant interest in the LCD program, as Café Mac has signed onto the leadership level. By volunteering to take this position, Café Mac is required to make a number of specific changes in their operation by target dates. Such changes include reducing the percentage of high carbon foods and products such as meat, tropical fruits and vegetables, seafood, highly processed foods, and non-compostable packaging; reduce food waste 25% percent by April 2009; and reduce energy/water consumption at least 20% by April 2010. Although Bon Appétit has set specific standards for Café Mac, these targets are only

[50] Clean Air Cool Planet Campus Carbon Calculator's User's Guide: Creating a greenhouse gas emissions inventory on your campus, 2006.

temporary and by no means a final solution. These should be considered 'first steps' which serve as experiments to aid Macalester in developing methods to reach carbon neutrality.

A food waste study completed in 2007 by the Environmental Science Department at the University of Redlands found that only 20 percent of their food waste was generated during preparation while the remaining 80 percent was generated following consumption.[51] This implies that the majority of food waste is being thrown away by students. Macalester should undertake a similar study to determine how the cafeteria can manage their food waste most efficiently. Café Mac's directors should encourage servers to hand out smaller portions. Serving food on smaller plates without the use of trays would reduce the amount of food that is taken by students and then left uneaten.

The University of Redlands study also found that 97 percent of their total food waste is considered 'compostable'. This figure is consistent with other studies completed at institutions throughout the country and it serves to highlight the potential of college composting programs. At the present time, Eureka Recycling is planning to initiate a pilot composting program in the spring of 2009 that Macalester is scheduled to participate in. Bon Appétit already has experience composting on college campuses. St. Olaf College in Northfield, MN has been operating an in-vessel composting unit since 1999 in which they compost approximately 3.5 tons of food waste each week. St. Olaf has been able to use all of the compost on campus, most notably in their student-run organic garden, which provides produce for the Bon Appétit cafeteria.

It is essential that Macalester work with Café Mac to keep accurate records of food purchases. Fortunately, as a component of the Low Carbon Diet program, Bon Appétit will

[51] Sherman, Peter. 2007. Project Proposal: University of Redlands Composting Initiative: A Vision of Sustainable Waste Management.

require requiring all of vendors to provide records of product sources. Macalester should set up a framework to retain such data on-campus in order to understand how their purchases are contributing to the production of GHGs.

Offset Recommendations

The ACUPCC Committee considers offsets to be a lesser measure as they allow emissions on-campus to continue while carbon reductions are pursued elsewhere. Local offset projects the College could invest in are preferred to projects located in remote locations and administered by third parties. Research into local offset opportunities should determine whether viable projects exist in the surrounding community.

The estimate of carbon sequestration at the Katherine Ordway Natural History Study Area indicates that a land preservation project capable of offsetting a significant portion of college emissions will have to be significantly larger than what Macalester currently owns. In order to offset approximately50% of 2007 emissions, a preservation project must be roughly 25,000 acres - 100 times the size of Ordway.

Summary

Macalester has many areas to pursue GHG reductions and should further investigate the above recommendations. When doing so, Macalester should mind the proportional contribution of each sector. In particular, heating and electricity account for nearly three-quarters of all emissions; no serious reductions can be achieved without focusing on these two areas.

The mission of Macalester calls to mind "internationalism, multiculturalism, and service to society." As Macalester approaches carbon neutrality, the college has an opportunity to once again realize this commitment, act as a leader among colleges and

universities in America, and catalyze the response to climate change in the United States. Climate change poses a global challenge. Education in a multicultural and international context prepares students to cooperate multilaterally as they face such challenges. By preparing students in this way, Macalester embodies the unique role of colleges and universities to lead society to innovative ideas and actions.

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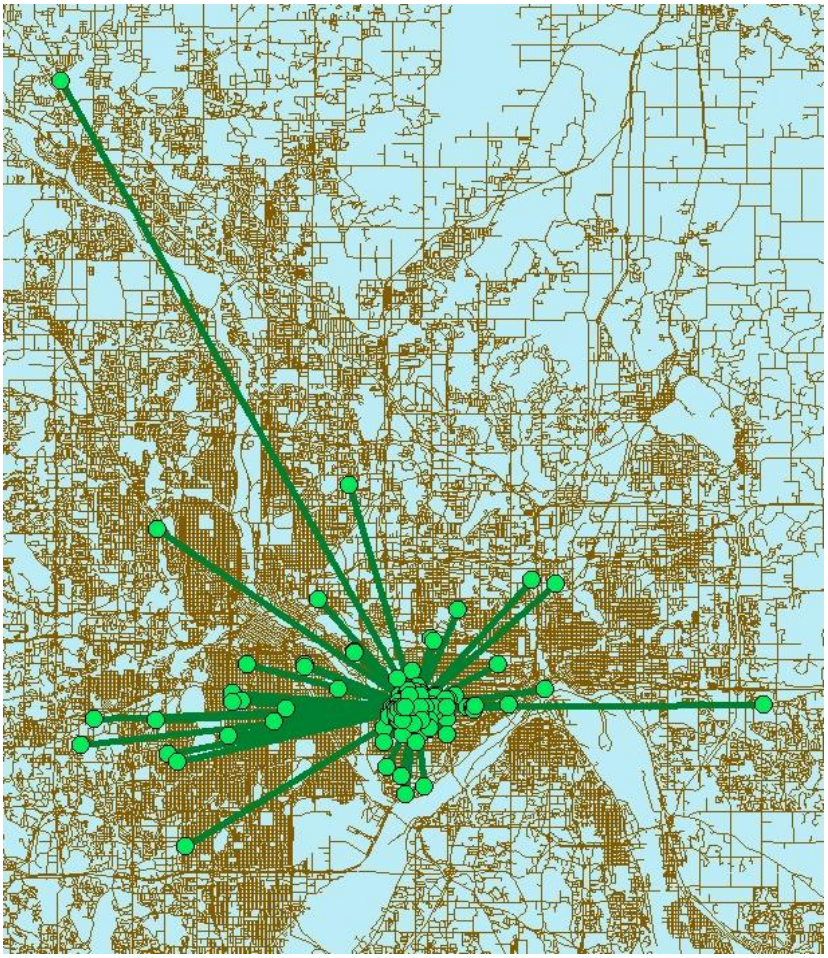
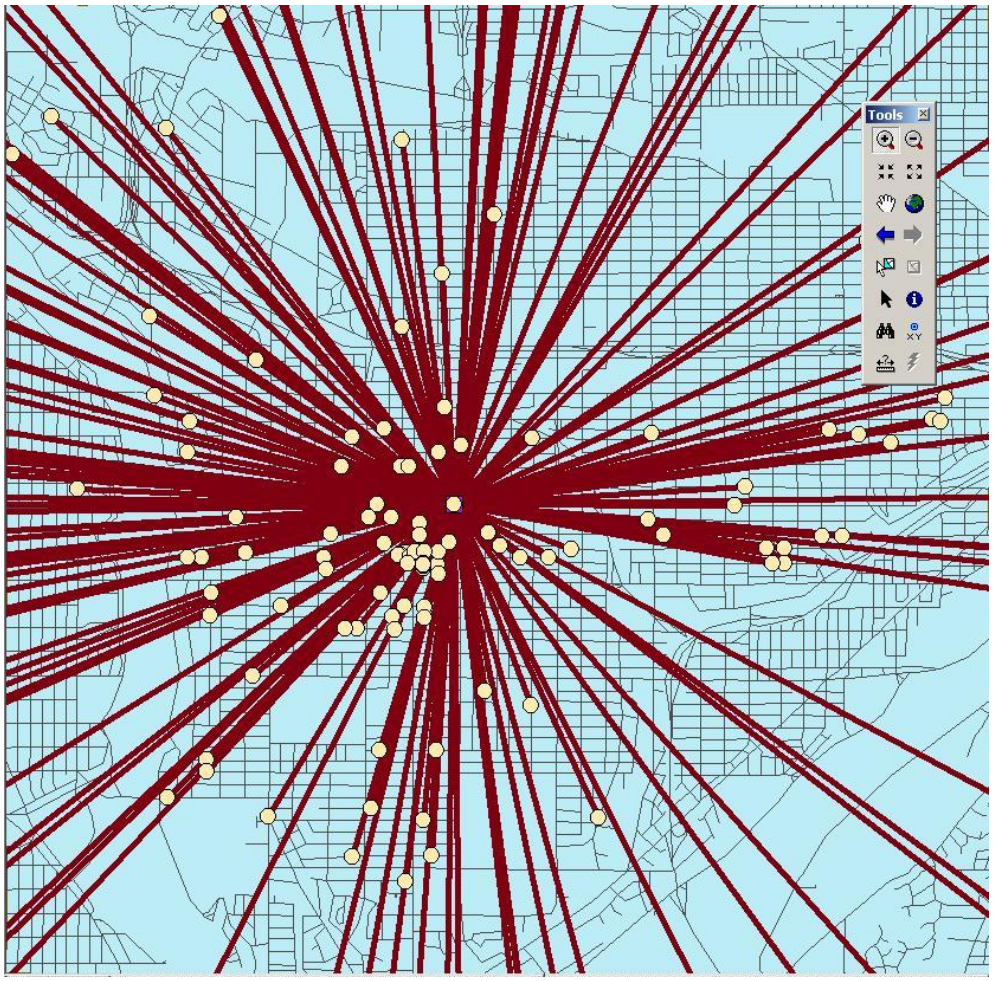
Appendix A Transportation

Sample GIS Maps

2007 Student Addresses



1995 Faculty Addresses



Appendix C Fertilizer

Calculation for finding the weighted average nitrogen content between the three commonly used fertilizers on campus:

The calculator requires the nitrogen content, and only has one input space so it is necessary to calculate the weighted average nitrogen content.

18 tons(2,000)=36,000 lbs 47 tons (2,000)=94,000 lbs 2 tons (2,000)= 4,000 lbs

36,000 lbs(46%)= 16,560 lbs

94,000 lbs (18%)=16,920 lbs

4,000 lbs (10%)= 400 lbs

16,560+16,920+400=33,880 lbs nitrogen

36,000+94,000=4,000= 134,000 lbs fertilizer

33,880 lbs /134,000 lbs =25.28 % nitrogen content

Appendix D Solid Waste

Waste and Recycling 1990-April 2006

"In session" and "not in session" will be used during these calculations to clarify which months are during the academic year when students are on campus, and which are during the non-academic year when few students are on campus and waste production is consequently far less.

(Estimates created by Allied Waste representative Doug Link based on one year of information)

- Tons of Waste per month during time class is in session-
  - 34.5 tons
- Tons of Waste per month during time class is not in session-
  - 10 tons
- Tons of Demolition waste generated per month*
  - 2.5 tons
- Tons of Yard waste generated monthly during growing season**
  - 2 tons
- Tons of Cans, Glass, and Plastic recycling when class is in session
  - 2.5 tons

BFI/Allied did not handle paper and cardboard recycling for Macalester

The primary site for solid waste disposal was the Newport, MN Refuse Derived Fuel Plant (95%). The secondary site was at the Pine Bend Landfill in Inver Grove Heights, MN (5%)

*This number represents the smaller demolition waste projects that are picked up by Allied Wastes in roll off containers and went to demolition landfills. The larger ones are dealt with separately by demolition Contractors.

**"In season" was not defined, for the carbon calculator I estimated that approximately 6 months of the year yard waste would be generated. This yard waste goes to the NRG transfer site in South Minneapolis and then is composted at the Empire Township composting site.

On Campus Waste Calculations

2007

Veolia #= 25% (273.8 tons) to RDF =68.4 tons per year from on campus waste. 75% (274 tons) landfill=205 tons from on-campus waste

2006

First 4 months, Allied Waste handled waste: 95% (3 in season + one off season month) = refuse derived fuel incinerator 95% (3(34.5 tons) + 10) = 107 tons refused derived fuel

5% (3(34.5 tons) +10) = 5.7 tons to landfill

For the next 8 months Veolia handled waste (75% (237 tons)) = 178 tons to landfill, (25% (237 tons)) =59 tons to RDF.

Total to landfill from on campus waste= 5.7+178= 183.7 tons

Total to RDF from on campus waste= 108+59 = 167 tons

1990- 2005

(Allied Waste estimate (34.5 tons a month (school in session X 7) + (10 tons a month school not in session X 5) = about 2912 tons a year from on campus waste

(292)(95%) = 277 tons a year to RDF from on campus waste (292(5%) =14.6 tons a year to landfill from on campus waste

Off Campus Waste Calculations

35 lbs residential waste/wk X 27 houses X 52 weeks=49,140 lbs

8 lbs Patagonia trash/wk X 52 wks= 416 lbs

40 lbs Cat-Man-Do waste X 52 weeks= 2080 lbs

80 lbs Pad Thai waste X 52 weeks= 4160 lbs

(2560+5800+6500+5610)/4X12= 61,410 lbs annual Breadsmith waste

272 lbs annual per capita waste* X 30 students living in Grand Cambridge Apts =8137 lbs

49140+416+2080+4160+ 61410+ 8137=125343/2000=63 tons off campus waste generated a year

* This value was calculated by taking the mean of the tons of waste from the years 2007, 2006, and 2005, converting them into pounds of waste created and then dividing by a rough estimate of the amount of full time equivalent students, staff, and faculty at Macalester based on Institutional Research Documents. While enrollment has fluctuated over the years, there are approximately 1800 students, 300 full time equivalent staff, and 150 faculty members.

Calculation: 305 tons x 2000 lbs= 610,286 lbs/2250 Macalester community members=272 lbs per capita

Off Campus Waste

2007

62.7 x 25% = 15.7 tons (waste used as RDF in 2007)

62.7 x 75% = 47 tons (waste land filled in 2007)

2006

(62.7/3) x 95% = 19.9 tons (amount that went in the first 4 months of the year to RDF from off campus waste)

(62.7/3) x 5% = 1 ton= (amount that went in the first 4 months of the year to the landfill from off campus waste)

42 x 25% = 10.4 tons (amount that went to RDF in second 8 months)

42 x 75% =31.3 tons (amount that went to landfill in second 8 months)

19.9 + 10.4 = 30.3 tons (total amount that went to RDF from off campus waste in 2006)

1 + 31.3 = 32.3 tons (total amount that went to landfill from off campus waste in 2006)

1990-2005

62.7 x 95% = 59.5 tons (estimated total amount that went to RDF per year from off campus waste from 1990-2005)

62.7 x 5% = 3.1 tons (estimated total amount that went to landfill per year from off campus waste from 1990-2005)

Total amounts to RDF in 2007: 68.4 + 15.7 = 84 tons

Total amounts to Landfill in 2007: 205.3 + 47 = 252 tons

Total amounts to RDF in 2006: 167 + 30.9 = 197 tons

Total amounts to Landfill in 2006: 183 + 32.4 = 215.4 tons

Total amounts to RDF 1990-2005: 277 + 59.5 = 336.5 tons

Total amounts to Landfill 1990-2005: 14.8 + 3.2 = 18 tons

Types of Waste

Chemical and Hazardous Wastes

There are many different kinds of solid and liquid hazardous wastes that Macalester produces including corrosive materials, "dangerous when wet" materials, and combustible liquids. The Director of Environmental Health/Safety & Security is responsible for safely disposing of hazardous wastes. Currently hazardous wastes are disposed of in a number of ways including land filling, incineration, fuel blend, recycling, fuel burning, treating and then land filling, and treating and then sewering (Gorman 2008).

Biomedical

Biomedical wastes include needles, syringes, gauze pads, or anything that has remnants of bodily wastes, and are handled by a company called Stericycle (Johnson 2008). The areas at Macalester that produce biomedical wastes include Winton Health Services, The Animal Facility, which the Biology and Psychology departments use, and the Athletic Department. Waste that is picked up is autoclaved in a facility in St. Paul, Minnesota. In this process, the biomedical wastes are put into high-pressure chambers. Once inside, 325 degree Fahrenheit steam is applied to the wastes for 30 minutes, ensuring that the waste is completely sterilized, and that all disease organisms are killed. Once the wastes have been autoclaved, they are put in "environmentally approved containers," and then brought to the KSB Rosemont Landfill, which is a landfill that does not capture methane. The amounts of biological wastes that are created from Macalester are nominal. In 2007 only 171 pounds of biological wastes were created (Stericycle).

Construction Waste

Since 1990, the construction company Kraus-Anderson has handled the vast majority of on campus construction projects (Dickenson 2008). Kraus-Anderson subcontracts their waste out to various demolition contractors. During the time Kraus-Anderson handled Macalester construction projects, Kamish, Bolander & Sons, or VEIT, dealt with most waste that was created (Boerboon 2008). Many construction projects have occurred on the Macalester campus since 1990, and with the exception of the new athletic facility, there have been no consistent records of how much trash has been created from each one. It is the same with demolition contractors. They have not been required to keep consistent records, and so have no idea how much waste would have been created for each construction project (Mackey

2008). The only information that was found on construction waste was for the recently demolished athletic facility where 93% of the waste from the building was recycled or reused. Construction materials from the old athletic facility are finding their way into places as diverse as horse stables, churches, and electrical motor stores. The 1,020 tons that were not reused or recycled were brought to a landfill that does not capture methane in Becker, MN (Carlson 2007).

Appendix E Forest Preservation Offsets

Table 7.1. Area of Forest and Prairie Communities at Ordway

Plant Community	Area (acres)
Dry Oak Forest and Oak Savanna	74
Floodplain forest	54

Carbon sequestration in the forest communities equals

1 metric ton CO_2/acre/year * (74 acres + 54 acres)

= 128 metric tons CO_2 year

Carbon sequestration in the prairie communities equals

4.4 metric tons hectare/year * 0.4 hectares/acre * (10.5 acres + 2 acres)

= 22 metric tons CO_2 year