U.S. Higher Education and Global Climate Change: An Exploration of Institutional Factors That Affect Greenhouse Gas Emissions

A thesis submitted by

Luba Zhaurova

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Advisor: Julian Agyeman, Ph.D.

Reader: Ann Rappaport, Ph.D.

ABSTRACT

In this study, I explored the differences between greenhouse gas emissions of different colleges and universities in the U.S.A. and analyzed some of the factors that might explain these differences. I collected and analyzed a non-representative sample of 96 greenhouse gas emission reports, gross square footage, institutional wealth, and other characteristics of public and private not-for-profit colleges and universities. 84% of these institutions were American College and University Presidents Climate Commitment (ACUPCC) signatories.

First, I found that both *research activity* and *institutional control* of colleges and universities in my sample were strong predictors of the institutional greenhouse gas emissions (Scopes 1 and 2) and were interacting with each other in a complex fashion. Secondly, I found strong positive correlations between total revenues (*institutional wealth* proxy), *gross square footage*, and greenhouse gas emissions.

A major limitation of this study was greenhouse gas emissions data accuracy as methodology used to collect and calculate emissions by colleges and universities is not yet standardized.

Higher education institutions have a unique role as learning laboratories and potential climate leaders. Further research could be used to identify and develop case studies from which other institutions (both academic and non-academic) could learn about successful strategies used to move toward the carbon neutrality goal.

Keywords: Global climate change; greenhouse gas emissions; higher education; colleges and universities; institutional wealth; gross square footage; climate neutrality.

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ABBREVIATIONS

ACUPCC	*American College and University Presidents Climate Commitment*
FTE	*Full-time equivalent student*
GCC	*Global Climate Change*
GHG	*Greenhouse Gas*
IHE	*Institutions of Higher Education*
IPEDS	*The Integrated Postsecondary Education Data System.* (U.S. Department of Education, National Center for Education Statistics. nces.ed.gov/ipeds)
MTCO2-e	*Metric Tonnes of Carbon Dioxide Equivalent*

Chapter 1. Introduction

Global Climate Change Crisis and Greenhouse Gas Emitters

Global climate change (GCC) is an approaching environmental and humanitarian crisis and as such is one of the most critical issues facing our planet today. There is a strong international consensus both on the basic science behind climate change (i.e. its cause and mechanism) and on a broad range of future climate projections coming from the modeling efforts (Schneider et al 2002).

The main cause of global climate change is heat-trapping gases, also called greenhouse gases (GHG), which in large part are caused by human activity as a result of fossil fuel burning activity on which much of the world is currently relying for its energy needs. Other emissions come from land use changes (such as deforestation), agricultural activities, industrial processes, and waste management. Carbon dioxide comprises the majority of GHG emissions, at about 77% of the worldwide total. The remainder comes mostly from methane (CH_4) and nitrous oxide (N_2O), with small shares coming from fluorinated gases (SF_6, PFCs, and HFCs) (Baumert et al 2005).

Global climate change has the potential to alter the earth's average temperature, raise sea levels, and shift entire ecosystem zones to an extent not seen since periods of glacial transformation, which in turn undoubtedly will severely affect people's well-being and cause massive species extinctions.

Presently, a relatively small number of countries, United States being one of them, produce a large majority of global GHG emissions. In 2000, the U.S. was the highest total GHG emitter (contributing 20.6% of world's total emissions at

6,928 million metric tonnes of carbon dioxide equivalent), followed by China (14.7%), EU-25 (14.7%), and others.[1] The same year, the U.S. was also the 6th largest per capita GHG emitter (Baumert et al 2005).[2] Still, U.S. emissions are continuing to grow. In 2005, its total emissions were 7,260 million tonnes of carbon dioxide equivalent, a 16% increase since 1990 (U.S. EPA 2007).

Mostly industrialized countries are responsible for the majority of the GHG emissions that happened in the past two centuries and as such bear a large burden of responsibility for mitigating the emissions and helping others to adapt to the effects of GCC.

Global Climate Change and the Role of the Higher Education Institutions

Given the critical nature of global climate change, many organizations, municipalities, countries, and individuals around the globe have acted to reduce their GHG emissions and have appealed to others to do the same. In the U.S. in particular, federal inaction have created a "policy gap" that is being increasingly filled by local governments, businesses, non-governmental organizations, and colleges and universities.

The role of institutions of higher education (IHE) in this challenge is unique. First, and perhaps most importantly, colleges and universities have educational missions that impress upon them a moral obligation to address GCC (Knuth et al 2007) and make them well suited to take on the climate change leadership challenge (Rappaport and Creighton 2007).

Secondly, the contribution to the GCC by these institutions is considerable as the sheer number of postsecondary institutions and enrolled students in the U.S. is impressive: over 7 thousand and 25 million respectively.[3] The vast majority of these colleges and universities operate buildings[4] that require electricity, heating and cooling fuels, as well as transportation of students, employees, goods and services, all of which contribute to GCC. In addition, starting in the 1990s there have been two complementary trends further contributing to the problem: campus growth and increasing usage of electricity as students began acquiring high numbers of electronic devices (Rappaport 2008). As a result of all these factors, it is no surprise that many large universities produce GHG emissions profiles similar to those of small cities (Knuth et al 2007).

In addition to large total GHG emissions, the financial power of colleges and universities is also substantial. For example, in a study done by the U.S. National Center for Education Statistics (2007, *Digest of Education Statistics, 2006*), in the 2005 fiscal year, the market value of the endowment funds with the largest amounts of the selected sample of only 120 colleges and universities was $235 billion, a 13% increase from 2004, and almost 2% of the country's Gross Domestic Product. To put it in perspective, it is close to the total gross domestic product of Chile or Portugal in 2007.[5]

Levine (2008) summarizes the leadership role of higher education well: "(F)ew institutions in modern society are better equipped to catalyze the necessary transition to a sustainable world than universities. They have access to the leaders of tomorrow, they have buying and investment power today, and they are widely respected. What they do matters to the wider public. Lessons learned from universities could provide a significant contribution to efforts to address the global warming problem."

Colleges and Universities' Sustainability Efforts and Greenhouse Gas Emission Inventories

Following the emerging knowledge about the severity and dangers of global climate change and other environmental problems, many colleges and universities have responded with such sustainability initiatives as green purchasing, green building, energy efficiency measures, food composting, increasing recycling rates, creating new positions on campus for staff dealing with sustainability efforts, among others. Institutions of higher education vary widely in terms of which aspects of sustainability they decide to pursue due to such factors as available resources, internal and external drivers, and more.

Many sustainability efforts can benefit if IHE use global climate change as an overarching principle around which many sustainability issues can be organized (Rappaport and Creighton 2003). Thus, such often seemingly disparate sustainability actions can be seen as tightly connected because all of them decrease overall GHG emissions of an institution.

There is evidence of increasing commitment by higher education institutions in the U.S. to be seen as leaders in addressing global climate change. As of April 2008, more than 500 of the U.S. colleges and universities (or 11% of all postsecondary degree-granting institutions in the country) have signed an American College & University Presidents Climate Commitment (ACUPCC), which is only approximately two years old. The pledge commits signatories to achieving climate neutrality. This goal is defined by ACUPCC as having no net GHG emissions achieved by minimizing GHG emissions as much as possible and using carbon offsets or other measures to mitigate the remaining emissions (ACUPCC 2008).

The most common first step used to directly address GCC on campus involves conducting a greenhouse gas emissions inventory. There are multiple benefits of conducting such an inventory. First, this step helps with assisting an institution in the systematic identification and recording of sources of GHG emissions and gaining knowledge of the structure and operation of the college or university. Additionally, a GHG emissions inventory serves as a starting point for identification of the actions that need to be taken to mitigate the emissions. If the inventory is conducted periodically, it also helps to measure progress toward the goals of reducing GHG emissions and to understanding the effectiveness of the programs. This step is also essential in justifying the commitment of university resources to reduce emissions. Lastly, it is a great education and communication tool for the university community as it promotes awareness and action of many stakeholders (Tufts Institute of the Environment, Tufts Climate Initiative 2002).

Despite the benefits of conducting a GHG inventory, some IHE take steps to reduce their GHG emissions (through such actions as energy efficiency retrofits or acquiring more energy-efficient boiler) without first conducting such inventory. On the one hand, given how pressing and time-sensitive GCC is, these types of actions are commendable as they take prompt steps in reducing emissions. On the other hand, when total emissions are not accounted for, an institution might not know if it really makes progress in the cases when total growth in the GHG emissions offsets achieved reductions. Therefore, it is generally advisable to complete a GHG emissions inventory as the first step in the process of planning for effective reductions strategies of the *total* emissions.

Previous Studies

To my knowledge, there have been only two preliminary studies that analyzed colleges and universities' GHG emissions and compared to them to other IHE characteristics. In their book *Degrees That Matter: Climate Change and the University* (2007), Rappaport and Creighton plotted GHG emissions and endowments of 13 U.S. colleges and universities (normalized by student). The results have suggested a likely positive association between these two variables (***Figure 1-1)***.

Figure 1-1. A study of 13 U.S. colleges and universities illustrates positive association between GHG emissions and the endowments normalized by student. *Source*: Rappaport and Creighton 2007, Figure 2.2.

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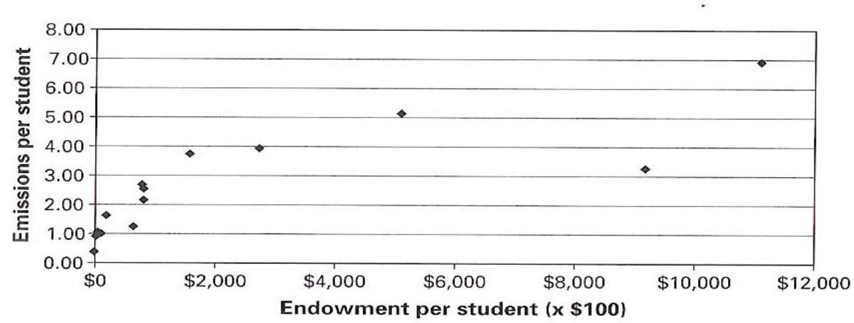
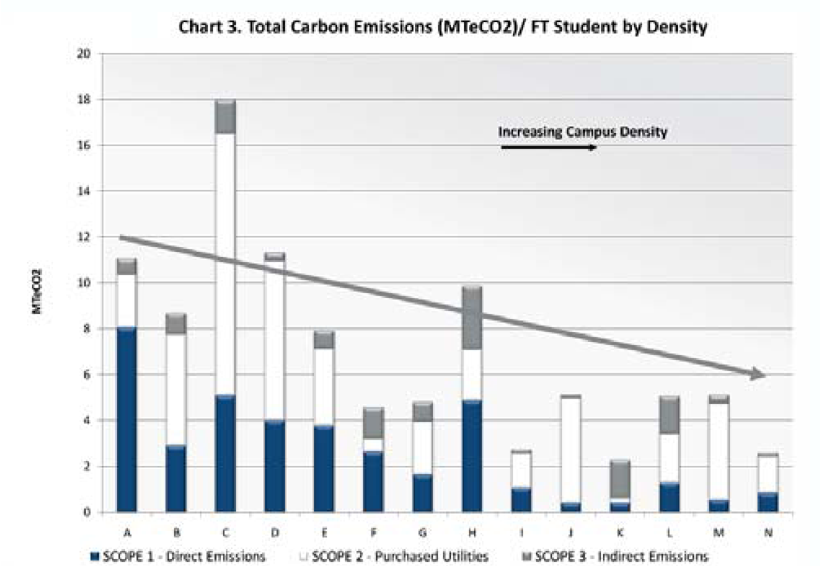


Figure 2.2
Plot of college and university endowment and emission data

The authors offered a possible explanation for this relationship. Wealthier institutions often have more facilities for instruction and research than their less wealthy peers. Consequently, more square feet of buildings generally mean more GHG emissions.

The link between facilities' square footage and GHG emissions was further reinforced by a Sightlines' GreenLine study of 14 public and private colleges and universities in the U.S. (***Figure 1-2)***. One of the results of the study had shown a likely negative association between the IHE emissions (normalized by student) and campus density (students per square foot).

Figure 1-2. Sightlines' GreenLine study of 14 colleges and universities shows a negative association between GHG emission and campus density.



Tufts University Greenhouse Gas Inventory (Tufts Climate Initiative. 2006 Update) provides another piece of evidence for a link between GHG emissions and the facilities' square footage. The report, analyzing a period between 1998 and 2005, had shown a positive association between increase in

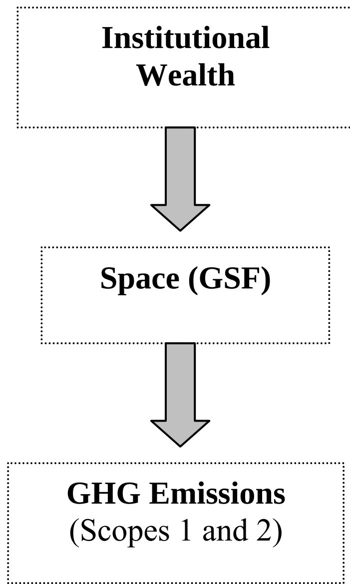
GHG emissions and increase in the total square footage at Tufts. In addition, the inventory identified a positive association between GHG emissions and the energy intensity of buildings, such as research laboratories.

There are two chief reasons for high GHG emissions of colleges and universities doing laboratory research. First of all, these IHE have higher gross square footage than their non-research counterparts because of the space required to conduct research. Secondly, these laboratories are typically much more energy intensive than nearly any other building on campus due to ventilation requirements, other health and safety concerns, refrigeration and more. This results in the far higher usage of energy per square foot than the typical office building ultimately resulting in higher GHG emissions.

GHG Emissions, Institutional Wealth and Square Footage

The above-mentioned studies suggested that there is an association between GHG emissions, wealth, and square footage of colleges and universities. ***Figure 1-3*** below shows the schematic directional relationships between these three variables that I derived from the literature. The figure suggests that institutional wealth affects the scale of operations, and thus the size of gross square footage. Increase in institutional facilities space, in turn, increases the usage of energy required for heating, cooling, and electricity needs, among others, which translates into higher GHG emissions.

Figure 1-3. Suggested Schematic Directional Relationships between GHG Emissions and Possible Factors Affecting Them (based on the 3 studies).



Research Question

The three studies mentioned above have suggested intriguing associations between the IHE GHG emissions and the variables that might affect them. Because they had small sample sizes and used non-statistical methods, in this work I intend to verify the suggested associations and to remedy the previous studies' shortcomings by increasing my sample and by using statistical analyses.

The main question that I intend to address in this study is the following: What are the differences between greenhouse gas emissions of different colleges and universities in the U.S.A. and what factors might explain these differences? I intend to answer this main question via two smaller sub-questions:

1) To what extent are GHG emissions explained by educational institutions' wealth?

2) To what extent are GHG emissions explained by educational institutions' facilities' total area?

My hypothesis, based on the ***Figure 1-3***, is that both factors correlate with the GHG emissions and with each other.

To test my questions, I will first analyze the differences of GHG emissions, institutional wealth, and gross square footage between institutions of higher education broken into sub-samples according to their research activities and institutional control (i.e. public or private). I will then follow with correlation test to analyze the associations between the three variables.

I believe that this study is ripe for analysis for two main reasons. First, the number of GHG emissions inventories conducted by colleges and universities has increased dramatically in the last 2-3 years, thus providing necessary data for the analysis. Secondly, this research is important as it has the potential to provide insights into the underlying causes of the differences in GHG emissions by different institutions thus possibly guiding emissions reduction efforts in the right direction.

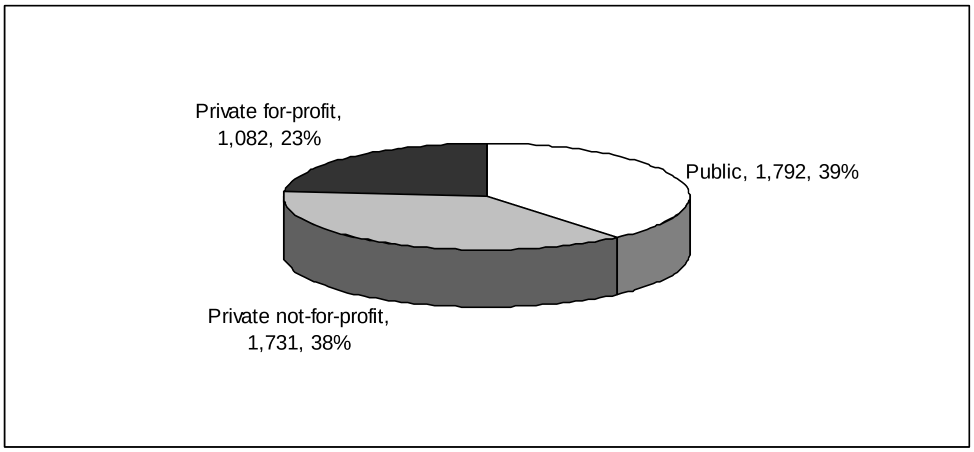
Chapter 2. Methodology

Because of the quantitative nature of this study, the methods section is fairly extensive. Additionally, the data quality and inconsistency issues resulted in several limitations that are discussed in the second part of the chapter.

Sample Universe

In 2007, there were 7,052 postsecondary institutions in the U.S.A. according to the IPEDS (accessed April 06, 2008). 65% of these, or 4,605, were degree-granting institutions. 6%, or 281 institutions, were research colleges and universities according to 2005 Basic Carnegie Classification. They are broken into roughly thirds by control – public, private not-for-profit, and private for-profit IHE (***Figure 2-1)***.

Figure 2-1. Breakdown of All Postsecondary Degree-Granting Education Institutions in the U.S. by Control (out of total 4,605).
Source: IPEDS (accessed April 06, 2008).



Public educational institutions are defined as those whose programs and activities are operated by publicly elected or appointed school officials and which are supported primarily by public funds. *Private* educational institutions are controlled by a private individual(s) or by a nongovernmental agency, usually supported primarily by funds other than public funds, and operated by other than publicly elected or appointed officials. *Private not-for-profit* educational institutions are those in which the individual(s) or agency in control receives no compensation, other than wages, rent, or other expenses for the assumption of risk (NCES IPEDS 2008).

Due to the non-representative nature of my study sample, as will be explained below, my sample does not contain private for-profit IHE. Therefore, my universe consists of 3,523 U.S. degree-granting public and private not-for-profit colleges and universities.[6]

Sample Selection Process

Initially, I planned to have a representative sample of ACUPCC[7] signatories by randomly selecting IHE from the population of around 500 institutions that had signed the pledge. However, I discovered that most Presidents' Climate Commitment members had joined less than a year ago, which did not give them sufficient time to complete a greenhouse gas inventory.

Consequently, I used a non-random sampling strategy by conducting an extensive search of available greenhouse gas emission inventories, reports, or other sources that would lead me to colleges and universities which completed such an inventory.

My sample search lasted two months, from mid-February to mid-April, 2008. I was able to collect 96 GHG emissions inventories that ranged in length and type from Excel spreadsheets to 160 page reports. The scope of these projects, rationale for doing them, as well as the information presented varied considerably from institution to institution.

I used the following sources and organizations to find the necessary information:

- General internet search during the months of February and March of 2008.

- Two-Month Reporting System of the American College and University Presidents Climate Commitment website (www.aashe.org/pcc/reports) which had contact information of the point person in charge of the initiative. In February, I e-mailed approximately 200 implementation liaisons. I was hoping that those institutions that had reported their 2-month progress are also more likely to have completed their inventories. (Contact information of the rest 300 or so signatories would be too time-consuming to obtain individually given my timeframe).
- Bibliographies of the inventories I have obtained.
- AASHE's Campus Sustainability Profiles.[8]

Appendix A lists three other potential sources of information on the IHE GHG emissions inventories which I was not able to use, but could potentially be tapped in the future.

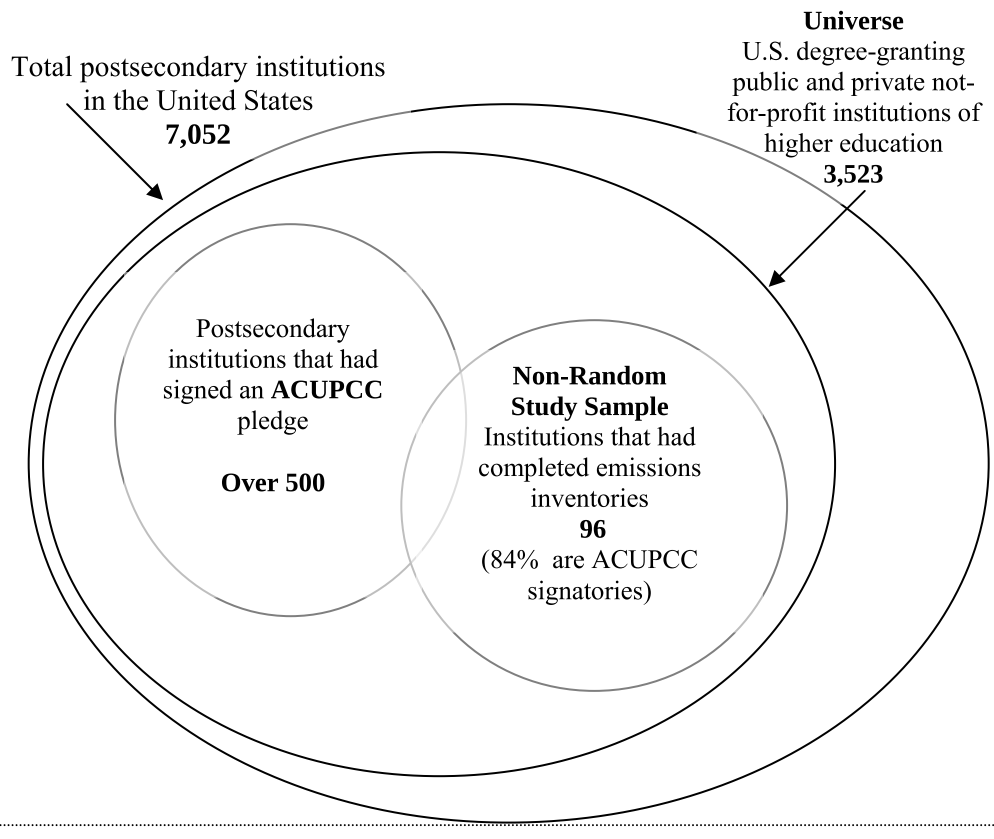
Sample Description

Figure 2-2 is a representation of the sample's position within its universe. My study sample consists of 96 U.S. public and private not-for-profit higher education institutions. ***Appendix B*** contains the names and other characteristics of the IHE in my study. Notably, 84%, 81 of 96, of the inventories that I could access belonged to the IHE that had signed the ACUPCC pledge (as of April 12, 2008), which suggests a connection between the climate change commitment and carrying out an inventory.

Another interesting fact about the composition of my sample is that some of the largest and most prestigious schools in my sample have not signed

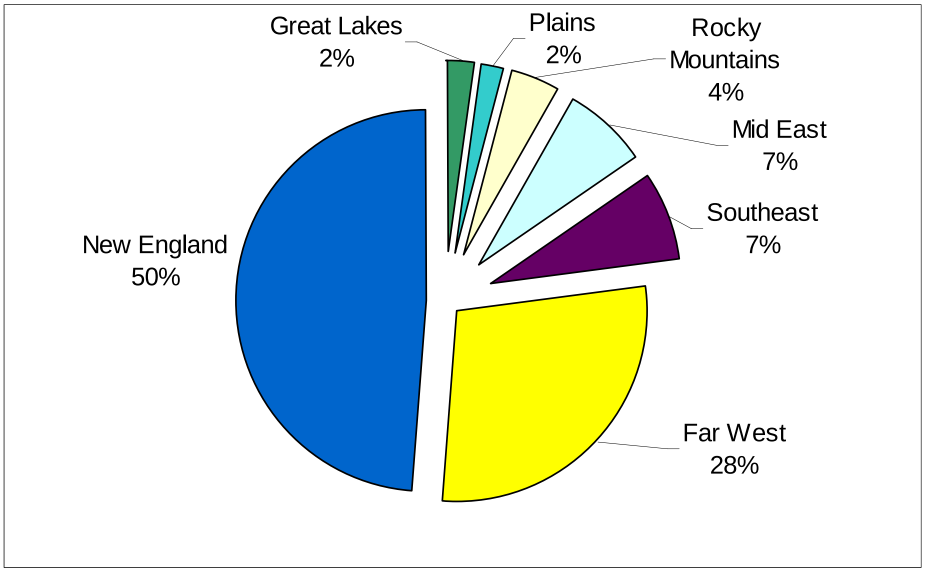
ACUPCC pledge as of yet, such as Tufts University, Brown University, Harvard University, Massachusetts Institute of Technology, Stanford University, and Yale University, among others. Additionally, out of the seven Ivy League schools, four are present in my sample, and currently only one out of these four is an ACUPCC signatory. I will speculate about to the reasons for this pattern in the conclusion chapter.

Figure 2-2. Representation of the Universe and the Study Sample.
Source: ACUPCC and IPEDS (accessed March-April, 2008).



I obtained GHG emissions inventories from the IHE in 22 states. New England and Far West geographic regions (as defined by IPEDS) are heavily represented in my sample (***Figure 2-3)***. The highest number of the institutions in my sample was from Massachusetts (36), in large part because I was provided with emission inventories for 29 public MA IHE by the Massachusetts Executive Office of Energy and Environmental Affairs.[9]

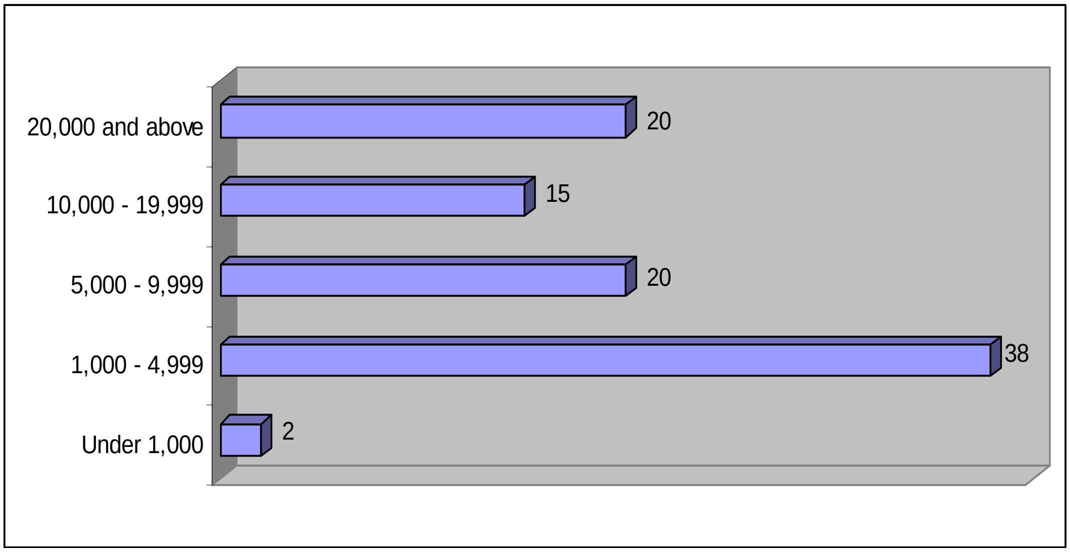
Figure 2-3. Study Sample's Distribution by Geographic Regions using IPEDS Categories



Institutional Size Category

Institutional category is derived by IPEDS based on the institution's total students enrolled for credit. The majority of institutions in my sample, 38 of the 96, are in the 1,000-4,999 institutional category, but the range varies from under 1,000 students to over 20,000 (***Figure 2-4***).

Figure 2-4. Study Sample's Institutional Size Categories.



Sub-Sample –Research Activity and Institutional Control

Analyzing the sample separately based on its Carnegie Classification is very important for my analysis. Literature, anecdotal evidence, and e-mail communication with university collegues have suggested that research institutions often have laboratory facilities that are several-fold more energy intensive than classrooms, offices, or dormitories. Therefore, research schools are very likely to have much higher total and per student GHG emissions than their non-research counterparts.

33 (or 34%) of 96 IHE in my sample are research institutions (classified as doctoral/research universities, research universities (high research activity), and research universities (very high research activity)) .[10] Ten of the research institutions have a hospital and are categorized as research universities with very high research activity according to the 2005 Basic Carnegie Classification.

Figures 2-5 and ***2-6*** show the break down of institutions in the universe and my sample by both research activity and institutional control. The proportion of public non-research IHE in my sample is very similar to that of the universe. Non-research private not-for-profit IHE are underrepresented in my sample as compared to the universe. Research institutions, private and public, are overrepresented in my sample as compared to the universe.

Figure 2-5. Study Sample's Universe Sorted by Research Activity and Institutional Control.

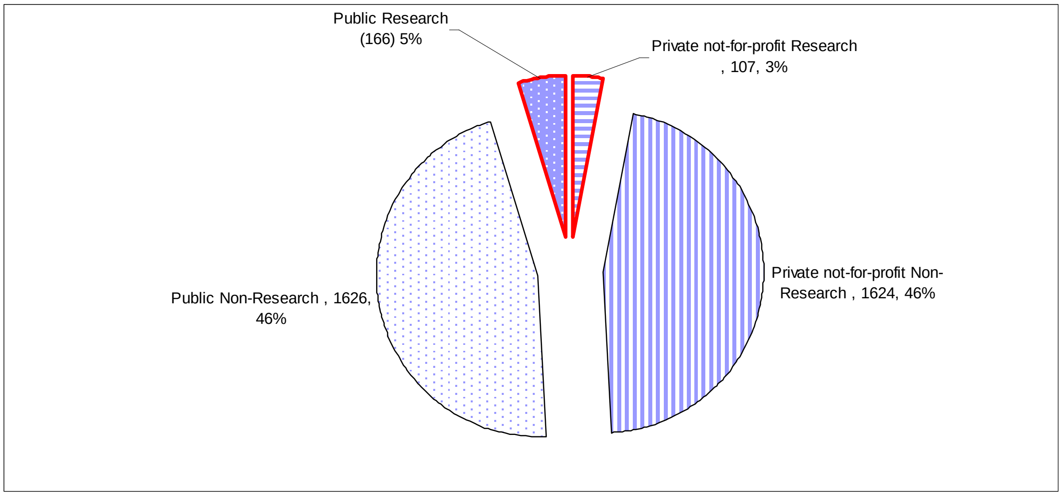
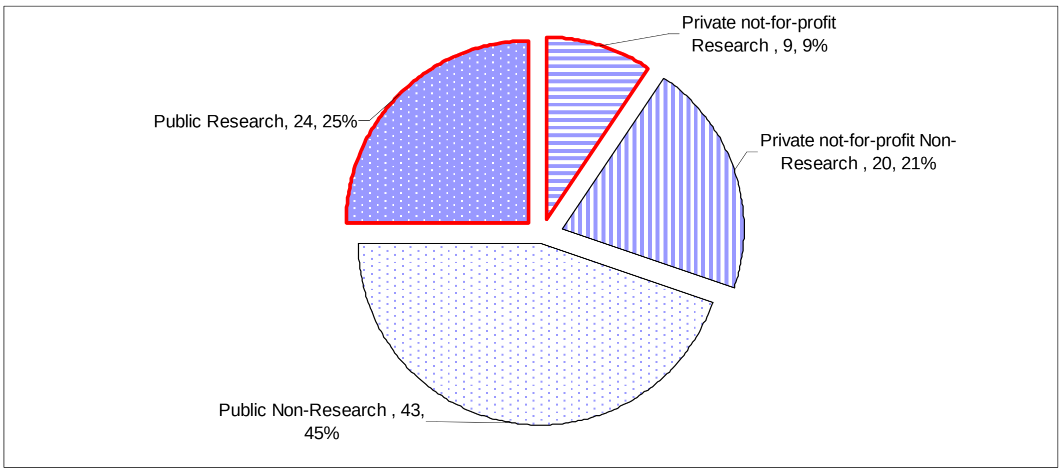


Figure 2-6. Study Sample Sorted by Research Activity and Institutional Control.



Data Gathering – Collection Strategies, Decisions Made, Categories, Units

My study's dependent variable was GHG emissions. The four independent variables I analyzed included institution research activity (a derivative of Carnegie Classification), institutional control (public or private not-for-profit), a wealth proxy (or total revenues), and total building space (measured as gross square footage). Additionally, I used student enrollment (or full-time equivalent students) to normalize the variables during the analysis.

Dependent Variable - Greenhouse Gas Emissions

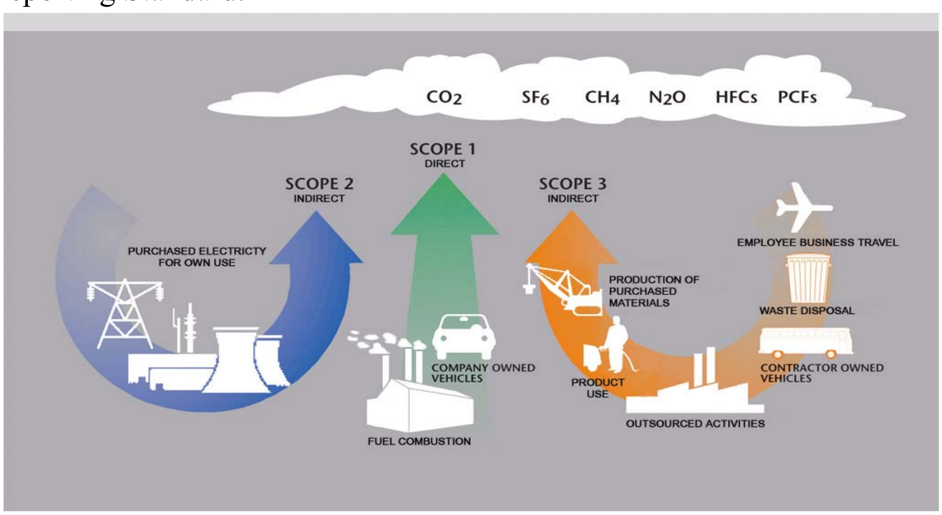
The source of the information on the greenhouse gas emissions came from the institutions themselves. While some inventories are available on-line, I obtained most through contacting individual colleges and universities. The limitations regarding data quality will be addressed later in the chapter.

I excluded inventories done for the years previous to 2000. I also excluded Scope 3 from the analysis. The description and differences between Scopes 1, 2, and 3 that help to consistently group greenhouse gas emissions are shown in the ***Table 2-1*** and ***Figure 2-7.***

Table 2-1. Greenhouse Gas Emissions Groupings – Scopes 1, 2 and 3 .*Source*: The Greenhouse Gas Protocol's Corporate Accounting and Reporting Standard.

Scopes	Emissions Included (Sectors)
Scope 1 – Direct Emissions (emissions from sources owned and operated by the IHE)	• On Campus Stationary Sources for Heating and Cooling • College Fleet • Refrigerant/Fugitive Emissions
Scope 2 – Imported Emissions (emissions from imported sources of energy)	• Purchased Electricity • Purchased Steam / Chilled Water
Scope 3 – Other Indirect Emissions (emissions resulted from the activities of the institution but from sources owned or controlled by another company)	• Outsourced Travel (e.g. deliveries to campus) • Commuting – staff, faculty, students • Solid Waste • Waste Water • Agriculture (fertilizer use, animal waste)

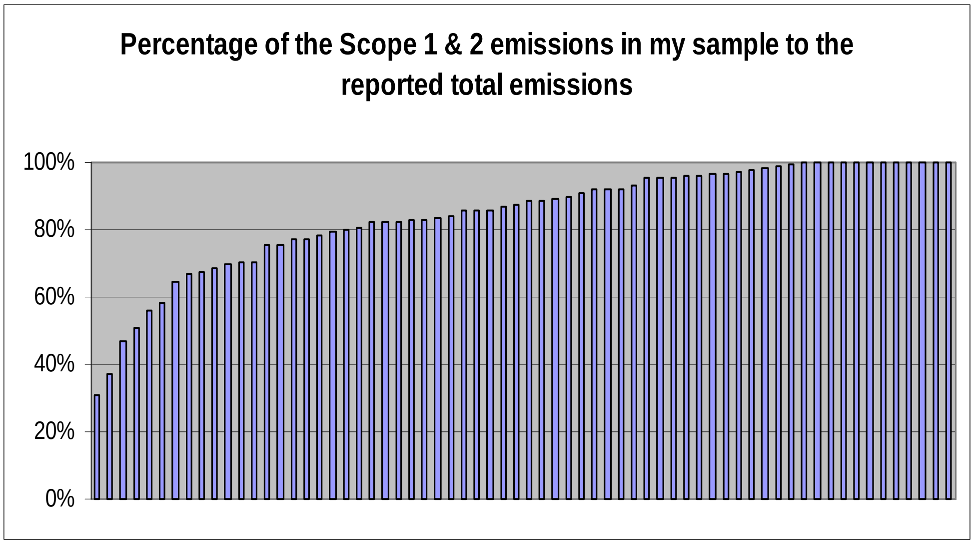
Figure 2-7. Greenhouse Gas Emissions Groupings – Scopes 1, 2 and 3 *Source*: The Greenhouse Gas Protocol's Corporate Accounting and Reporting Standard.



There are large differences between the ease of data collection for the Scopes 1 and 2 as compared to the Scope 3. For the first two scopes, the data can be mainly collected from university documents, such as utility bills, gasoline purchasing for institutional vehicle fleets, facilities reports, and more. Scope 3, however, are frequently considered out-of-boundary by many IHE for many reasons, such as insignificant amounts of emissions values, double counting, low return in time and resource investment, or highly uncertain data.

I decided to exclude Scope 3 from my analysis for three main reasons. The first reason was for the sake of data uniformity because the inconsistency in drawing Scope 3 audit boundaries by the IHE in my sample was very high. Secondly, according to the Clean Air – Cool Planet's Campus Carbon Calculator (2006), Scopes 1 and 2 (i.e. energy sector) in most cases contribute over 90% of the university's emissions. Thus, I believe that the exclusion of Scope 3 would not significantly change my results. Lastly, the actual *reported* Scope 3 emissions[11] in my sample make up only a small percentage of the total emissions. As can be seen in ***Figure 2-8***, the reported Scope 3 emissions in most cases make up less than 20% of total emissions. (The IHE to the farther right of the graph did not report any Scope 3 emissions, thus Scope 1 and 2 make up 100% of total reported emissions).

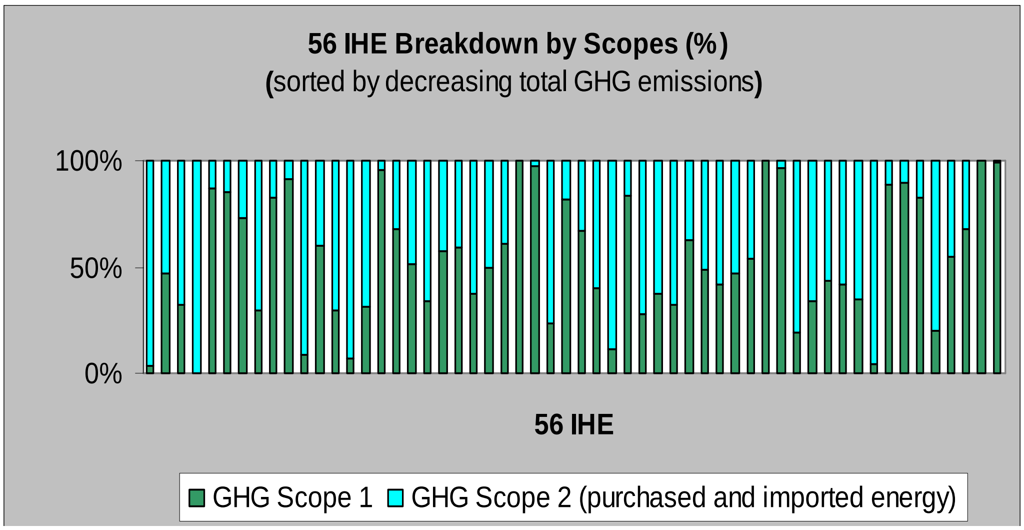
Figure 2-8. Scopes 1 and 2 GHG emissions in my sample in majority of cases make up the bulk of the total reported emissions.



Currently, the most commonly accepted GHG emission measure is metric tonne(s) of carbon dioxide equivalent[12] (MTCDE or MTCO2-e). While most IHE reported their emissions using this measure, there were three exceptions. Some IHE reported their emissions either in English pounds or in English (also called short) tons. In that case, I simply converted these quantities into the metric tonnes. Additionally, a few IHE have reported their emissions as carbon equivalent, as opposed to carbon dioxide equivalent. I used a factor of 44/12 to convert these metrics into $MTCO_2$-e. Lastly, and more importantly, some IHE only reported carbon dioxide emissions, and not other greenhouse gasses. In that case, I still included the data in my analysis, because non-carbon dioxide GHG emissions are minimal for Scopes 1 and 2. I will discuss this limitation further in the chapter.

Another interesting observation is that there does not seem to be a pattern as to how IHE allocate their energy needs. As shown on ***Figure 2-9***, GHG emissions of the 56 colleges and universities in my sample are listed in the order of decreasing total reported GHG emissions but do not show a trend in terms of Scopes distribution.

Figure 2-9.



Independent Variable - Wealth Proxy

Because selecting and justifying the right wealth proxy was an important part of this study, the following chapter explains in depth challenges associated with defining institutional wealth, variety of methods used to measure it, followed by my justification of choosing total revenues as institutional wealth proxy for this study. The data was accessed from the IPEDS on April 13, 2008 for the collection year 2006.

Independent Variable – Gross Square Footage

Total gross square footage (GSF) of buildings on campus is the standard benchmarking metric used by campus facilities and physical plant managers.[13]

This number is derived by multiplying the footprint of a building (outside width multiplied by length) by the number of building floors.

The only database of IHE' gross square footage that I am aware of is maintained by the Association of Physical Plant Administrators (www.appa.org). However, I could not access needed information because the report was prohibitively expensive. Additionally, not all colleges and universities in my sample were members of the APPA.

While some GHG emissions inventories contained gross square footage information, for the remainder I needed to contact the IHE directly. First, I researched the web pages of IHE' facilities, physical plants, Offices of Institutional Research[14], and/or capital planning departments. If information was not available on-line, I then e-mailed and/or called personnel working in these departments.

While it is largely true that obtaining GHG emissions inventories is harder than finding GSF data, it was not the case for two higher education institutions. While I was able to obtain inventories for the Tulane University of Louisiana (uptown campus) and Warren Wilson College, I could not get reliable gross square footage from these institutions, and consequently did not use them for the study.

Independent Variables from IPEDS

One of the data sources that I used extensively in this research is the U.S. Department of Education's National Center for Education Statistics, The Integrated Postsecondary Education Data Systems (IPEDS), available on-line at http://nces.ed.gov/IPEDS. This database contains an extensive amount of data on all postsecondary education institutions in the U.S., including information on institutional characteristics, enrollment and graduation rates, human resources, finances, student financial rates, and more.

Using IPEDS, I obtained the data for three more variables for my study: institution control, research activity (a derivative of Carnegie Classification), and student enrollment (*full time equivalent (FTE) student*[15]).

The decision to focus on FTE student as opposed to total enrollment or total community members as a measure was two-fold.[16] First, it is one of the best ways to report consistently on total enrollment so that it will allow for comparisons between schools. It also is labeled as a common institutional characteristic under IPEDS and is a generally more widely used metric based on my literature review and inventory reports I have read for this study. Secondly, part-time students spent less time on campus and thus, arguably, cause fewer Scopes 1 and 2 GHG emissions than full-time students. As such, the FTE metric is useful, as it assigns a smaller corresponding value to part-time students as compared to full-time students.

Statistical Analysis

My study is the explanatory type of research as it seeks to understand the relationships between different variables. Since my sample is non-random, I can not draw inferences from my study's results and generalize them to the entire IHE population. However, the test results will explore the emerging patterns and relationships that can be tested in the future with a larger representative sample and over longer periods of time.

Hypothesis

My hypothesis is directional as it predicts the relationship between the concepts. I expect to find a positive correlation between institutional GHG emissions and wealth, as well as emissions and total built space. I also expect to find associations between institutional characteristics, such as institution control, research activity, and GHG emissions.

Research Design

My sample consists of 96 higher education institutions. I conducted the analyses of the total sample as well as the sub-samples broken down by institution control and research activities.

Data Analysis

I used an Excel program for the descriptive analysis and SPSS program for the statistical analysis. For the correlation analysis, I chose *bivariate Pearson correlation test* (whose coefficient (r) ranges in value from +1 to -1) which describes the strength of the association between variables measured at the interval level.

I did not utilize regression analysis for two main reasons. First, a regression is recommended for random samples, which is not the case for this study. Secondly, and more importantly, when I ran a trial regression test, I found that the independent variables I selected for this study interacted strongly with one another. As a result, the independent contribution of each variable was inconclusive.

Data Limitations

In this study, I was working with inherently rough data. The only consistent data I used was sourced from the IPEDS. Greenhouse gas emissions and gross building space, on the other hand, presented several data limitations worth discussing at some length.

Major limitations were data inconsistency, data accuracy, lack of standard emission calculators and emission factors, and other factors that might have influenced the correlations but that I could not have accounted or corrected for in this study. In large part, there was little I could do to standardize the data, as I was highly dependent on the highly varied information provided in the inventory reports. However, I believe that by excluding Scope 3 I minimized a lot of inconsistencies.

It has been noted that as inventory methodology becomes more sophisticated and an institution gains more experience conducting GHG inventories, calculated total GHG emissions tend to increase. Therefore, given that most institutions in my sample have performed their inventories for the first time, I believe that the reported GHG emissions are conservative estimates.

Different Methodologies and Emission Factors

Because the process of inventorying greenhouse gas emissions is relatively recent, it is not standardized. The Greenhouse Gas Protocol,[17] developed by the World Resource Institute and the World Business Council for

Sustainable Development, gives broad guidance for the definition, scope, organization and verification of GHG inventories. Yet, under this general umbrella of rules there exist numerous technical methodologies.

The Greenhouse Gas Protocol is used internationally by many corporate entities. Municipalities in the United States tend to use the ICLEI (International Council for Local Environmental Initiatives) methodology. A common calculator for colleges and universities is Clean Air – Cool Planet Campus Carbon Calculator, specifically developed for IHE and used by 30% of my study sample. Other methodologies include The Climate Registry[18], Climate Action Registry Reporting Online Tool by the California Climate Action Registry, and numerous other individually-derived methodologies, which a majority of my study sample used.

Crucially, there is neither a standard methodology to compute GHG emissions nor a standard way to report them. While most IHE in my sample used the GHG Protocol as the guide to plan out their inventories, actual methodologies varied and included individually-derived methodologies (57% of my sample), Clean Air – Cool Planet Campus Carbon Calculator (30% of the sample), California Climate Action Registry's CARROT (California Action Registry Reporting Online Tool), Chicago Climate Exchange reporting system, and other. While CARROT and CCX report their emissions using a consistent and comparable format, the majority of my sample used a variety of data presentation mediums ranging from the actual CA-CP calculator spreadsheets to 160 page reports. In most cases, I needed to read thoroughly through these inventories to extract the information needed for my study.

The significance of using different methodologies is that they might set different operational boundaries as well as different GHG emission factors that are used in the formula: *GHG emissions = activity data x GHG emission coefficients.*

An example of this is purchased electricity. For a majority of the IHE in my sample, this type of emission is a significant contributor to total emissions. Therefore, the emission factors used to calculate emissions might affect the results considerably. For example, emission factors for electricity *by state* can be sourced from the U.S. Department of Energy's EIA. These factors are used by the Clean Air – Cool Planet calculator. Different *regional* electricity factors can be obtained from ISO New England, a regional transmission organization serving six New England states. For example, these factors are used by the 29 Massachusetts state IHE whose emissions are calculated by the EOEEA (Executive Office of Energy and Environmental Affairs). The best quality data can be obtained by directly contacting a *utility provider*, and asking for the fuel mix used to create electricity and the emission conversion factors. Because different factors often give different results, there exists a strong temptation for institutions to use those emission factors that show the least total emissions, thus potentially underestimating their actual contribution.

In addition to different emission factors, there are also uncertainties inherent with facilities tracking databases, as well as uncertainties associated with different year-to-year fuel mixes.

In terms of GHG emissions metrics, while most schools in my sample have reported their emissions as carbon dioxide equivalent, 3 IHE and 29 MA state colleges and universities reported their emissions as carbon dioxide only. However, I decided to use this data because Scope 1 and Scope 2 emissions in my study, unlike Scope 3, do not include significant amounts of other GHG than carbon dioxide (Cool Air – Cool Planet Campus Carbon Calculator's emissions factors). Therefore, I believe this limitation is not a considerable source of error.

Inventory Boundaries

When an institution decides to perform a GHG emissions inventory, it makes decisions about *organizational, audit, and temporal boundaries* of the project. In terms of *organizational boundaries*, an institution might choose to include or exclude auxiliary properties such as hotel, golf course, ski resort, overseas property, and more. Also, there is no standard method as to whether or not to include into the inventory properties used but not owned by an institution. Thus, there is a chance that reported total emissions, gross square footage, and total revenues cover different organizations scopes.

Two inventories that especially stood out in terms of drawing their organizational boundaries were University of North Carolina – Asheville and Yale University (**Appendix C)**. The former drew its boundary much further than CA-CP, WRI, or most individually-derived methodologies that I have come across. In addition to all three scopes, this institution included the life-cycle impacts of several of its consumption activities. The lifecycle of each sector was divided into upstream, operations, and downstream emissions. In comparison, most methodologies only include operations activities of the institution.

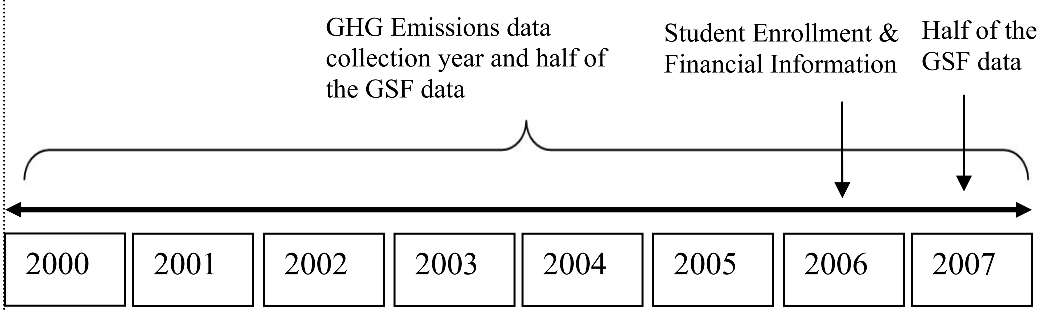
While Yale University's methodology is also individually-derived, its audit boundary is significantly smaller than that of UNC-Asheville, as is typical for most schools I looked at. However, unlike any other emissions report I have read, Yale acknowledged the inherent uncertainty associated with calculating emissions and included in the report three ranges of uncertainty – best estimate, high estimate, and low estimate.

Audit boundaries, or institutional activities included for an analysis, have variations as well. While in most cases, Scopes 1 and 2 are almost always included in the inventory, Scope 3 reporting is highly inconsistent, which is the reason why I did not include it in my study.

There are three important limitations in my study relating to time – *temporal boundaries set by institutions, inconsistency of data collection time frames, and lack of longitudinal data.* There are three major temporal boundaries used by the institutions in my sample: an academic year (9-month two-semester period where summer is not accounted for), a calendar year (January – December), and the fiscal year (July – June).

In terms of inconsistency of data collection time frames, because of lack of data for the timeframe I needed, I accepted emissions and gross square footage for the year in which they were available, as can be seen on ***Figure 2-10***. The result was that while all IPEDS data were for the year 2006 (the latest consistent year for which I could obtain information for all the IHE in my sample), both greenhouse gas emissions and gross square footage data ranged from 2000 to 2007, which could be a potential source of an error.

Figure 2-10. Temporal Limitation – Different Years of Data Collection for the Variables in the Study.



Another downside of reporting at different years is that the country-wide trend toward higher electricity consumption over the years would be higher for universities that have completed their inventories in the later years. However, some of these effects might be offset by another trend, namely institutional investments into energy and electricity-efficiency measures.

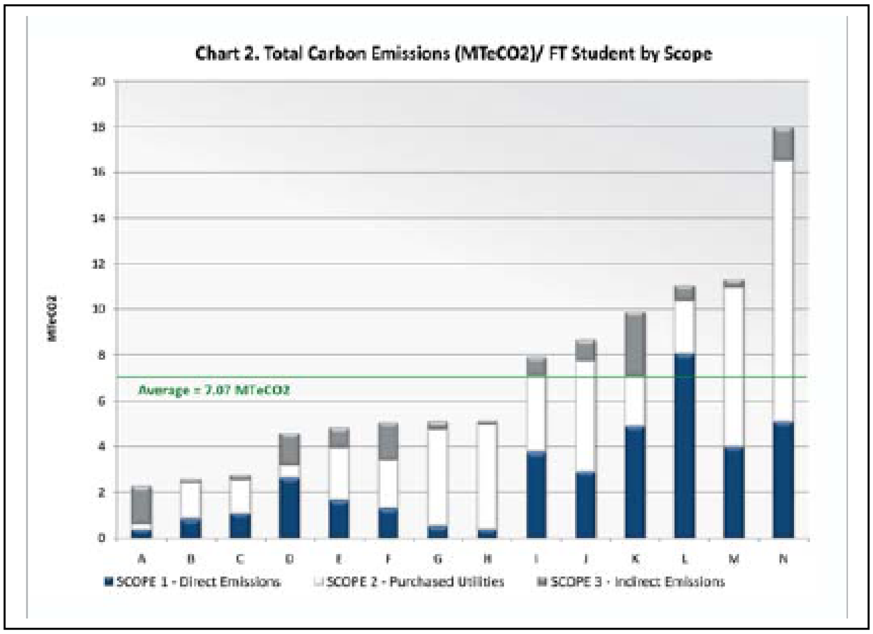
Lastly, I want to mention the lack of longitudinal data in my study. The GHG emissions inventory reports in my sample ranged in terms of the year when they started collecting the data, the year to which they extrapolated data going back in time, and the type of information collected in each year. Some reports were the very first ones that the institutions wrote (as a result of signing the ACUPCC pledge or for other reasons) and thus were reporting the data for only one year. Others have been collecting the data for several years, and have been improving on the data quality and detail with each year. Consequently, it has been noted that as inventory methods improve and become more refined, they usually result in higher reported emissions.

Scopes v. Sectors

In a majority of cases, greenhouse gas emissions can be reported by scopes (1, 2 or 3) or by sectors, such as electricity, heating, transportation, agriculture, etc.[19] During the data collection process I decided to use the scope data. As such, I often had to convert the data reported in sectors into scopes, which was not difficult most of the time. A few times it was difficult to do. This was when transportation-related emissions were reported as one number, thus I could not allocate the emissions to Scopes 1 and 3. Sometimes, it was not specified whether emissions from electricity and heating and cooling were Scope 1 or Scope 2. However, this specific limitation did not present a problem for this study because I am analyzing the sum of the two.

In the future, if one would like to analyze the distribution of emissions among the Scopes, they would need to get a more descriptive data. A study could look at the percentage break down by scopes in order to draw further conclusions, something that Sightlines did, as shown in the ***Figure 2-11***. Sightlines concluded that not only is total tonnage of e-CO2 important, but also the distribution of the emissions among the Scopes, which in turn provides an insight into high opportunities for emission reductions.

Figure 2-11. A chart from the study by Sightlines of 14 IHE showing the breakdown of the emissions by scopes.



Data Collection Practices

Data collection for calculating GHG emissions is often a time-consuming and complicated process. As the data needs to go through more hands, the chance of human error increases. This is especially true in the institutional context, where various departments and the bureaucracy associated with them often make consistent and accurate data collection difficult for this type of inventory.

The quality of data differs significantly as well. While some data comes from direct metering, assumptions need to be made for most other cases. For example, it is a common practice to purchase fuel for the year ahead, and thus it is not clear from records how much has been actually used. Several reports I looked at had suggested that a central data system is necessary for the future data collection efforts.

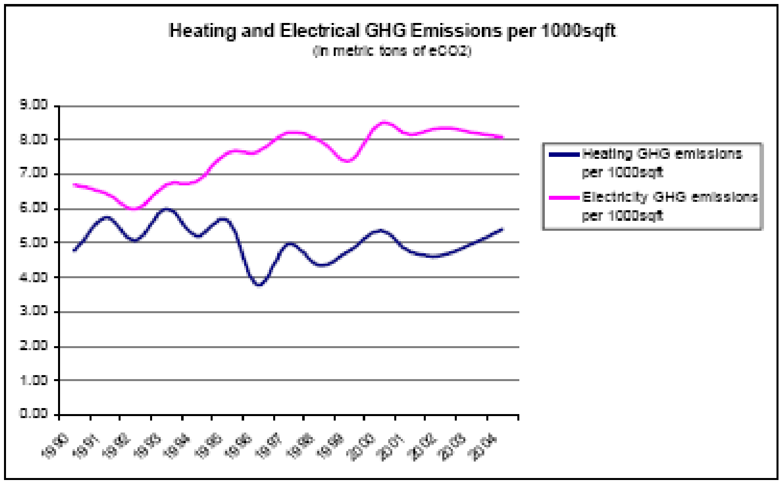
Weather Factor

One of downsides of not using consistent year and not analyzing data over time is the weather variations that might affect significantly *year-to-year* emissions. As was already mentioned, Scopes 1 and 2 in a majority of cases make up the majority of emissions. Therefore, on unusually warm years for example, the heating emissions might be down for the IHE residing in the northern parts of the USA. Similarly, unusually hot summers will yield higher than average emissions due to the cooling loads.

Weather is also an important factor in potentially explaining *regional differences* in GHG emissions due to heating and cooling of schools. Usually measured as "heating degree days" or "cooling degree days" a year, it is a factor I have not considered in this preliminary study, but is an important one to take into account in the future. In addition to regional differences, country-wide weather also has an affect on the energy use of IHE. An example of how weather affects GHG emissions due to weather is a graph from Carleton College's inventory (***Figure 2-12)***. The graph shows heating line's seasonal variation as well as weather variations for a period of 1990-2004. In addition, the gradual rise of the curve might also be explained by an increase in energy use due to other factors, such as the addition of energy-intensive labs or students using more personal electric devices.

Figure 2-12. Carleton College's GHG emissions variations due to weather and increased consumption

Graph 5:



Wealth

The following chapter will discuss at length the advantages and limitations of the chosen wealth proxy. While the data used was uniform as it was obtained from IPEDS for the same year (2006), I did not normalize the wealth relative to the cost of living, which might be a potential source of error.

Other Limitations

There are several other potential data limitations that are worth mentioning.[20] These factors are especially difficult to correct for if the goal of an analysis is to compare IHE to their peers.

- Many older wealthier colleges have bigger and less efficient buildings. These buildings might also be of historical value and thus harder and/or more expensive to renovate.

- Number and average age of the buildings and their design (which for example can preclude solar installations) might affect how much energy an institution consumes.
- Availability of clean (purchased) power in their region will affect emission factors for Scopes 1 and 2.
- Depending on when an institution began to undertake energy conservation measures and large onsite power generation investments, it will have an advantage or disadvantage when being compared to its peers.
- The mix of classroom vs. laboratories is an important factor to consider as well.

Conclusion

Due to inherently raw nature of the data in my study, it is unwise to use fine analytical tools for the analysis, and thus I will only look for emerging patterns.

Undoubtedly, in the future a lot more higher education institutions will be conducting greenhouse gas inventories. For example, in less than a year, 500 of the ACUPCC signatories will have completed their inventories and made it available publicly on the AASHE website. Yet, despite this wealth of upcoming information, the problem of different reporting methodologies and styles might hinder benchmarking, comparison and analysis of the schools to each other.

Additionally, there exists an argument that regardless of methodology, in these times of urgent need of quick action to address global climate change, it is of more importance that institutions use a *consistent* methodology year to year to monitor their *own* progress in reducing GHG emissions.

However, while this is a valid point, the advantages of consistent methodology can not be underestimated. More uniform standards might be developed by first looking at the existing inventories, as they are excellent depositories of knowledge of similarities and differences between the institutions and because they contain the necessary metrics needed to be included in the standards.

Chapter 3. Institutional Wealth: Measures and Proxies

Colleges and universities' wealth is a tool that allows them to maintain adequate operations and to guarantee the perpetuation and continued success of their academic and social goals. Furthermore, additional institutional capital allows schools to advance their status as an academic institution among peer groups through the recruitment of better students, more respected faculty, and the obtainment of more extensive institutional resources (Nagowski 2003).

Colleges and universities are economic hybrids. In part they are like a commercial firm selling a product to customers who are paying for it. At the same time, they resemble a charity organization by producing and giving things away in order to serve broadly held social values such as equality of opportunity, the democratic role of an educated citizenry, the contribution of education to economic growth, and more (Winston 2000).

Another example of the unusual nature of higher education institutions is that most of the public and private not-for-profit IHE charge less for their services (tuition and fees) than their costs of running the operations. Given these unique characteristics, defining, measuring, and comparing IHE wealth is not an easy task.

This chapter will first give an overview of different definitions of wealth as well as wealth disparities that exist among the IHE in United States. Then, I will discuss a variety of wealth metrics that are being used in the field. I will conclude with an explanation and the discussion of the institutional wealth measure chosen for this study.

It is worth noting that since private for-profit IHE are not included in my study sample and because they operate very differently from the public and private not-for-profit institutions, they are not part of this chapter's discussion.

Definitions of Institutional Wealth

Defining and measuring wealth is considerably harder than recognizing its merits (Bradburd and Mann 1993). Wealth is usually understood as the total amount of resources available to the institution to run its operations. While the concept of wealth and wealthy institutions is intuitively understood by many, one might disagree on the definition of the word. Merriam-Webster dictionary defines wealth in terms of material ownership: "abundance of valuable material possessions or resources" and "the stock of useful goods having economic value in existence at any one time."[21]

Bradburd and Mann (1993) define institutional wealth as the resources that allow institutions to set its level of tuition and fees (i.e. price of services) below the operating cost of educating a student (i.e. cost of services). Thus, educational institutions that can spend more than they receive from their students are considered wealthy. However, this definition's drawback is that it would allow most public and private not-for profit higher education institutions in the U.S. to be considered wealthy, as tuition and fees rarely cover institutional expenses. Thus, it might be argued that wealth is not an absolute, but a comparative measure.

Forms of Wealth

The difficulty in defining institutional wealth is in part because it can take many forms. One of the most common measures of it is ***endowment***. Endowment funds are defined by the IPEDS as monies whose principal is nonexpendable and that are intended to be invested to provide earnings for institutional use. Endowments have two primary functions. First, they serve as a smoothing device to financial resource management year to year. Additionally, they generate annual income that is most often used to support operations and capital expenditures of an institution.

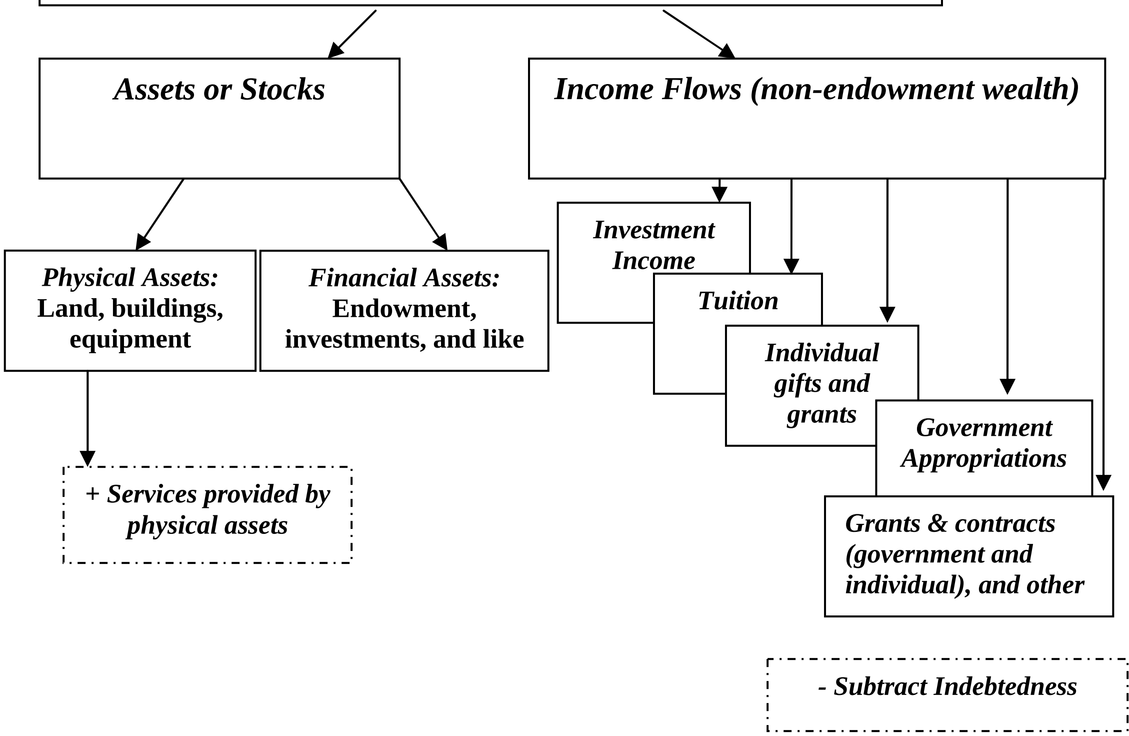
Endowment wealth constitutes a significant amount of total institutional wealth in the country. For example, in the 2007 annual endowment report by the National Association of College and University Business Officers (NACUBO), 785 participating colleges and universities totaled $411 billion in endowment assets.

Yet, this financial asset is not the only resource available to colleges and universities. Bradburd and Mann in their 1993 study "Wealth in Higher Education Institutions" highlighted the drawbacks of using endowment as the only measure of wealth and suggested several ways of accounting for other sources of resources available to the higher education institutions. The authors argued that regular income flows from ***non-endowment sources*** that are "wealth-like" in their effect are an important source of funding for the majority of IHE, public or private not-for-profit alike. Examples include individual gifts and grants, government appropriations, government grants and contracts, and more.

Lastly, the third considerable form of wealth is ***physical, or capital, assets***[22] of an IHE. It is one of the hardest forms of wealth to account for accurately because according to the current accounting rules physical assets (such as land, buildings, and equipment) do not appreciate. Especially the in case of land, this is a highly inaccurate representation of IHE wealth since the historic value recorded in the financial statement in most cases is only a fraction of its replacement cost.

Additionally, measuring physical assets' contribution to the wealth of an institution is complicated by the fact that the value of the *services* provided by assets (such as buildings, equipment, art collections, etc.) are frequently unrelated to the value of these assets on an institution's balance sheet (Bradburd and Mann 1993).

Figure 3-1: Diagram of Overall IHE Resources (or Total Wealth).



Adopted from: Bradburd and Mann 1993; Nagowski 2003; and IPEDS Glossary.

It is important to include both stock and flow sources in the comprehensive definition of institutional wealth. ***Figure 3-1*** graphically summarizes different sources of wealth available to the IHE. It shows institutional wealth captured in stocks or assets, such as physical assets (land, buildings, and equipment etc.) and financial assets (namely, endowment). The income flow wealth comes from the following sources:

1) Income (interests, dividends, and capital gains) from invested endowment principal and other investments;

2) Income from non-endowment sources such as annual alumni and other individuals’ donations, gifts and grants;

3) Income from non-endowment sources such as government (local, state, and federal) appropriations;

4) Government and individual grants and contracts;

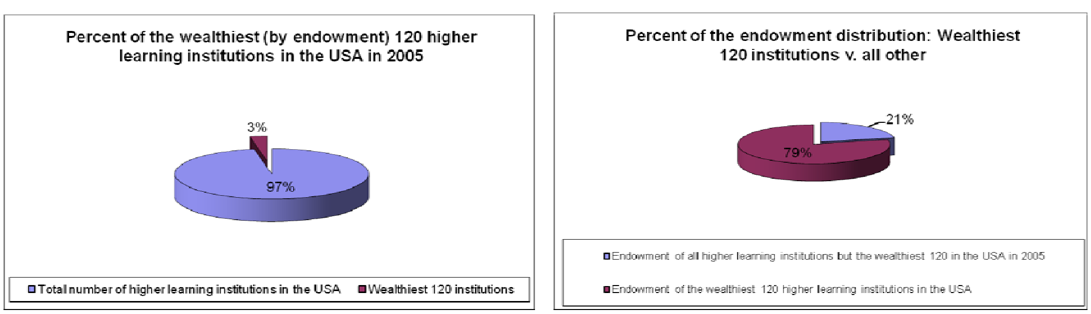
5) Tuition and fees.

Institutional Wealth Disparities

There is undoubtedly a huge wealth gap between different higher education institutions. While endowment is not a perfect measure of institutional wealth, it is worthwhile to start with endowment-based comparisons when analyzing these disparities.

In 2007, U.S. IHE endowment wealth ranged from $0 to astonishing $35 billion (NACUBO 2007). The proportion of institutions owning this kind of wealth further reveals deep inequalities. According to IPEDS, in 2007 out of 4,114 degree-granting public and private not-for-profit[23] IHE in the U.S., 61% possessed an endowment asset. However, the wealthiest 120 IHE, or only 3% of IHE that report their endowment information, held 79% of all the endowment wealth (***Figure 3-2)***.

Figure 3-2. Wealth Disparity among Higher Learning Institutions by Endowment. *Data Source*: IPEDS (accessed March 22, 2008).



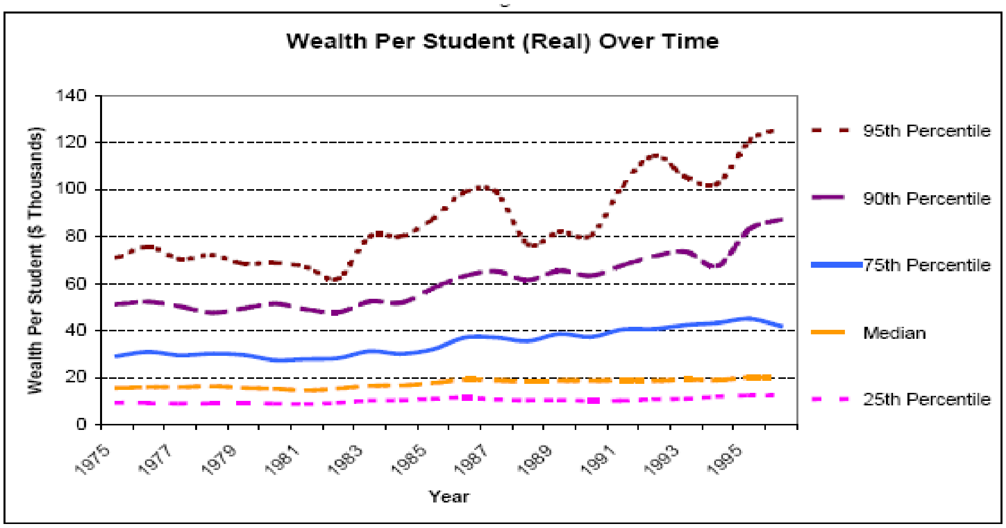
During the 1990s, the endowment wealth divide deepened further as the endowments of already wealthy institutions have grown even bigger with the advent of new financial instruments and a more technically sophisticated generation of trustees. During those years, many of the wealthier IHE invested substantial portions of their endowments in non-traditional assets, including foreign equities and bonds, hedge funds, private equity, private and public real estate, and a broad category of investments categorized as "absolute return" strategies (Kaufman and Woglom 2003).

The most commonly analyzed wealth disparity is that between private and public institutions. For example, of the sample of 120 largest endowments in 2007 (see above), the majority (75%) are private not-for-profit IHE. The difference becomes even starker when one compares top endowment per student capita, a common method of standardizing for discrepancies in institutional size. In that case, 97% of the 120 wealthiest (by endowment) institutions are private not-for-profit higher education institutions.

The endowment wealth disparity is not new. In their 1993 study, Bradburd and Mann (1993) discovered similar patterns. For example, they found that endowment per student for the richest 10% of schools is more than 4 orders of magnitude greater than that of the poorest 40% of schools.

However, the disparity in wealth and its growing nature is not unique to public versus private comparisons, as it is high among private institutions as well. In 2003, Nagowski (2003) analyzed how private institutions of higher education allocate their wealth between physical and financial assets. During the analysis of almost 3,000 schools for the duration of the period of 21 years (1975-1996) he had found a widening gap in wealth[24] among those private institutions (***Figure 3-3***). As the wealth per student in the 95th and 90th percentile of private IHE was going up at a high rate over the course of the 21 years, the rate of increase for the rest of the institutions was going at a much smaller rate or not increasing at all. Thus, only the truly well off academic institutions experienced a substantial rise in their wealth per student.

Figure 3-3. Growing Disparity in Wealth among Private Institutions.
Source: Nagowski 2003.



One explanation for this widening gap could be, as mentioned above, the rapid growth in the financial market and subsequent investments by some institutions doing riskier but higher-yielding investments (Kaufman and Woglom 2003). In this case, institutions with higher endowments to begin with yielded much higher returns than less wealthy institutions.

This study suggests that institutional control might not play as an important role in defining wealth disparity as was originally thought.

Alternative Wealth Measure and Its Affect on Wealth Disparities

While public perception of the relative wealth of public and private institutions is clearly affected by the great endowment wealth of a few elite private universities, most of the public tends to underestimate the magnitude of direct public subsidies to public colleges and universities. For example, Bradburd and Mann (1993) show the dramatic difference in institutional wealth when measured by endowment only between schools of two difference controls (***Figure 3-4***). The figure shows that public schools dominate the lower five deciles, while private ones are in the upper half of the scale. However, when 'total wealth' measure is used,[25] the distribution of institutions by control (***Figure 3-5)*** looked very different - private schools are shown less wealthy and public schools are relatively wealthy. The authors argue that when one considers all possible quantifiable income sources of the institutions, the wealth differential between public and private higher education institutions does not seem to be as wide.

Following the same logic, I compared all IHE (IPEDS, accessed April 13, 2008) based on their total revenues, which is another wealth proxy for the resources available to the institutions. My results confirmed the conclusion of Bradburd and Mann. The distribution of the public and private institution was more balanced than when I used endowment as a wealth proxy earlier. I found that public institutions make up 65% of the 120 wealthiest IHE (measured by total revenue), and 52% of the wealthiest IHE if the measure is normalized by full-time equivalent student.

Figure 3-4. Endowment Decile Densities (Distributed by Institutional Control).
Source: Bradburd and Mann 1993.

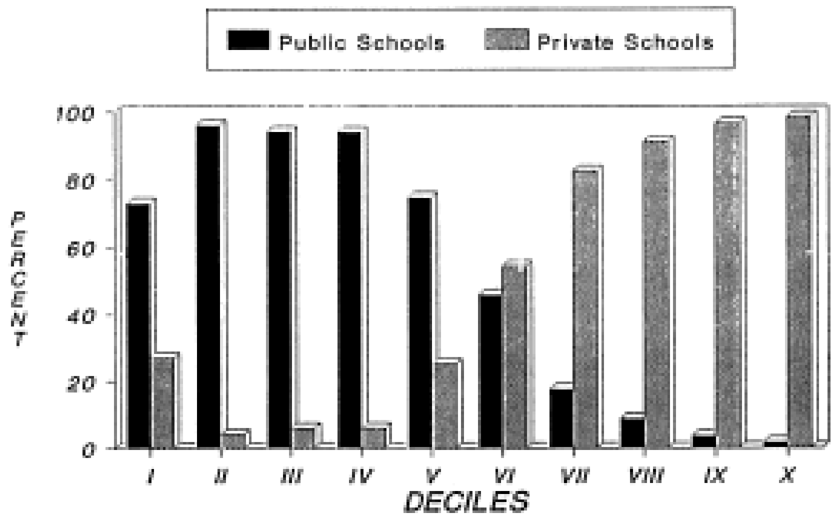


FIG. 1. Endowment Decile Densities (Distribution by Control)

Figure 3-4. Total Wealth Decile Densities (Distributed by Institutional Control).
Source: Bradburd and Mann 1993.

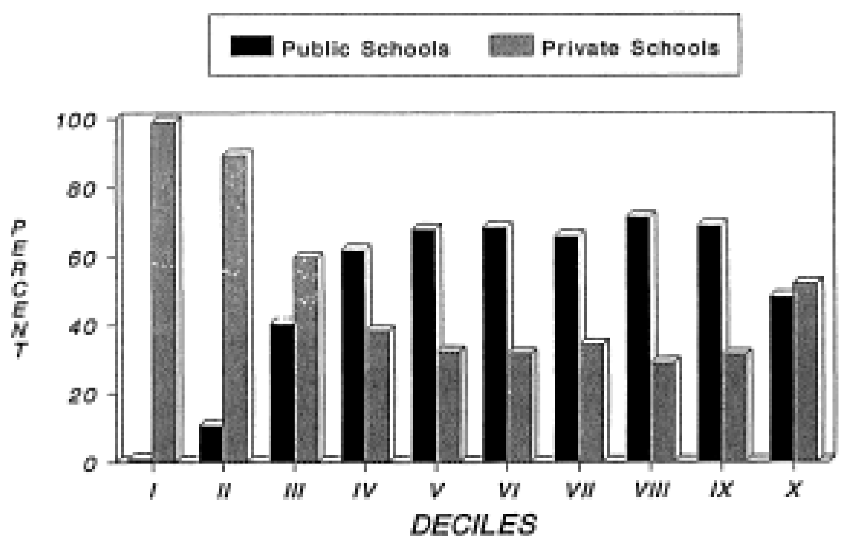


FIG. 2. Wealth Decile Densities (Distribution by Control)

Measuring Wealth – Different Methods

One of the more important and challenging decisions I had to make in this study was selecting an accurate measure of institutional wealth. The difficulty arose from the fact that wealth is not an easily defined entity. There is also no one consistent way to measure IHE' wealth in the literature. For example, Rappaport and Creighton (2007) used endowment, which is a common and easily accessible wealth proxy. However, endowment is not a very good overall measure for all IHE for two main reasons. First, most of IHE endowment wealth is concentrated in the hands of very few, mostly private, educational institutions. This might suggest that endowment is a good measure of wealth for large private institutions, but not so much for public and less wealthy private colleges and universities. Secondly, endowment is an inaccurate measure of wealth because it underestimates the amount of resources available to institution as it does not account for the non-endowment income flows.

Nagowski (2003) defined total wealth of his sample of private higher education institutions as a sum of endowment and a current replacement value of their physical assets.[26] While he accounted to a degree for the wealth captured in the physical stocks of wealth, he still only used the assets part of the total institutional resources (***Figure 3-1***).

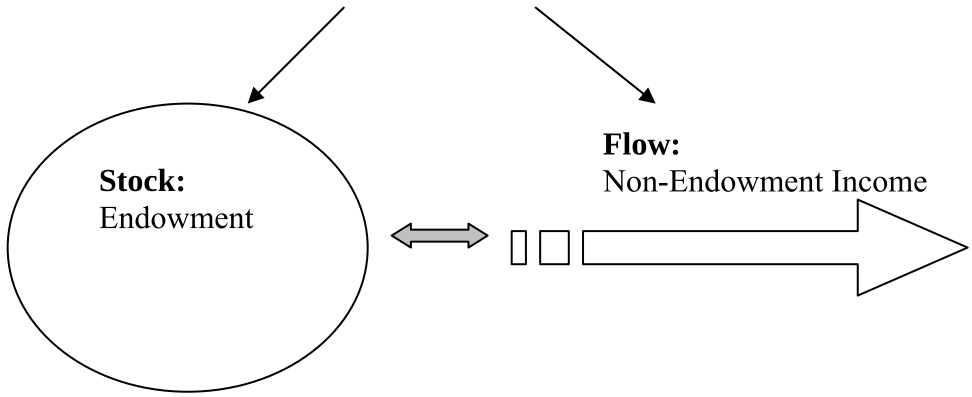
IHE have substantial cash flows (e.g., tuition, grants and gifts, and government appropriations) from sources other than the endowment. For example, the net present value[27] of many public IHE' annual government appropriations is comparable in size to the private endowments.

Bradburd and Mann (1993) defined wealth more comprehensively by adding a value of current endowments to a net present value of public appropriations, gift and grant income, assuming that the value will remain the same in years to come and applying to it a discount rate of 8%. This wealth proxy is superior to many others as it includes endowment and non-endowment forms of institutional wealth. However, it is still a proxy, not a comprehensive wealth measure. The latter would also have to include the true value of institutional physical assets.

This Study's Measure of Institutional Wealth and Resources [28]

A comprehensive wealth measure is intended to account for all the resources available to the institutions. There are two ways of measuring wealth – a stock measure (or 'present value' at one point in time) or a flow measure, such as amounts spent over some period of time (***Figure 3-5***). In order to consider both types of wealth at the same time when developing a comprehensive wealth measure, stock should be converted into flow, or vice versa, using a standard interest or payout rate.

Figure 3-5. Diagram of the Two Types of Resources Available to the Institutions of Higher Education



In this study, I initially planned to use two different institutional resource measures. Both measures would allow for realistic comparisons of wealth across IHE of two different controls as they included both stock and flow forms of wealth.

I first constructed a wealth proxy which measured a ‘present value’ of the institutional wealth by adding together the endowment stock and the capitalized value of the non-endowment income using a 5% discount rate:[29]

Wealth stock measure (*or annual gifts, grants & appropriations- adjusted endowment****) = Endowment + Non-Endowment Income Flows/0.05.***[30]

One limitation of using this measure is that one important wealth holder, namely physical assets such as land, buildings, and equipment, can not be included in the wealth measure, due to the reasons already mentioned. Secondly, IHE routinely make decisions on which asset to focus their resources – physical or financial. Thus, a smaller endowment might mean a decision of the institution to invest more into their physical assets (Nagowski 2003). At the same time, during periods of increased stock market growth relative to the real estate market, the opportunity costs of not investing assets into financial resources are greater, and subsequently, IHE consciously choose to allocate more resources into fiscal, rather than physical, forms of capital (Nagowski 2003). Yet, Bradburd and Mann (1993) argue that the above-mentioned limitation is not that significant because institutional physical wealth and financial wealth are likely to be highly correlated and the omission of physical asset wealth should not change the qualitative results of the analysis.

My second wealth proxy was ***total revenues***. Revenues reflect the non-endowment wealth of the institutions, or cash flows. They include government appropriations, government grants, private gifts, and endowment income. I decided to use total revenues as opposed to total *expenditures* (i.e. the actual monies spent by the IHE in a given year), because of the differences in accounting reporting between public and private institutions[31] (as will be discussed below). The differences between the two systems seemed to be smaller for total revenues than total expenditures. I chose to use *total* revenues (as opposed, for example, to research and non-research revenues) for the consistency, because I collected information on the total values of the other two variables in this study - greenhouse gas emissions and gross square footage of the university.

When I obtained and calculated all the financial data needed for my sample, I found that the correlation between the two wealth proxies is extremely high. The Pearson correlation coefficient was 0.94 for the entire sample, and 0.95 for the sub-samples of just public or just private not-for-profit institutions. Since there were no significant differences between the two wealth proxies I initially selected, I decided to use just one of them for the study's analyses. I chose total revenues over adjusted endowment proxy because it is more convenient to obtain through the IPEDS.

Appendix D shows the two wealth proxies I investigated, IPEDS variables I used to calculate the proxies, and the results of correlation analysis that tested association between the two proxies.

Data Limitations

All the financial data for the analysis was accessed from the IPEDS. The major difficulty that I faced was finding the common ground between two different accounting reporting systems. Public institutions follow the Governmental Accounting Standards Board (GASB) standards, and independent institutions follow the Financial Accounting Standards Board (FASB) standards. The coexistence of two standards boards, each with its own distinct mission, results in disparity in recognition, measurement, display, and disclosure that challenges comparable financial reporting transparency (Goldstein and Menditto 2005).

The differences between the two accounting systems are explained by the different missions of the IHE of different controls. While FASB's mission is to help investors and creditors make decisions, GASB's mission revolves around accountability, as so much of the income comes from the government (Goldstein and Menditto 2005).

The main problem I encountered was the inability to separate permanent income flows from non-permanent ones when calculating the first wealth proxy. Thus, in some instances, government appropriations, grants, and gifts (considered permanent income flows) were reported together with contracts[32] (not permanent income flows) and I could not separate the two. Thus, the adjusted endowment wealth proxy was overstated to a degree.

Chapter 4. Results & Discussion

Following the goals of this study, first I will analyze and record descriptive statistics of the variables (GHG emissions, wealth, and facilities' gross square footage) in the total sample. Secondly, I will study the differences in GHG emissions when IHE in my sample are sorted by their research activity and by institutional control. Then, I will test the extent to which institutional wealth and gross square footage are associated with the GHG emissions in order to suggest their potential effect on the emissions. I will conclude the chapter with a suggested framework of the associations between the variables in my study.

Descriptive Statistics of the Total Sample: GHG Emissions, Wealth, and GSF

Table 4-1 below shows descriptive statistics of the GHG emissions and other variables in my study. The variables are shown as total values as well as values normalized by student and by square foot.

Table 4-1. Descriptive Statistics of the GHG Emissions, Institutional Wealth and Space of the Total Sample of 96.				
Total Values	**Total Emissions in a Reported Year** ($MTCO_2$-e)	**Total Annual Revenues/1000**	**GSF/1000**	**FTE**
Average	59,936	$688,517	4,144	9,996
Range	673 - 431,651	$7,814 - 7,488,944	135 - 22,300	547 - 63,501
Total	5,753,853	$66,097,643	397,837	959,579
Values Normalized by Student	**Emissions per Student** ($MTCO_2$-e per FTE)	**Revenues/Student** ($/FTE)	**Campus Density** (GSF/FTE Student)	
Average	6	$66,141	451	
Range	0.44 - 96	$9,637 - 752,614	63 - 2,754	
Values Normalized by GSF	**Emissions per GSF** (MTCO2-e per GSF)	**Revenues/GSF** ($/GSF)		
Average	12,079	$119		
Range	1,299 - 34,784	$38 - 430		

The most notable results are summarized below.

◊ **Total GHG Emissions.** The average GHG emissions for the institutions in my sample were *59,936 $MTCO_2$-e a year*.[33] For easier visualization, 1 metric ton of CO_2 would approximately fill the volume of a common American home – a 2,000 sq ft house with 9ft ceilings (Lord 2005).

GHG emissions for a year for all 96 IHE in my sample totaled *5,753,853* $MTCO_2$-e. While it represents less than 1% of U.S. total emissions,[34] it is still a considerable amount that is similar in value to the total GHG emissions of such countries as Iceland or Belgium in 2005.[35]

◊ **Total Revenues**. In 2006, total revenues in the sample totaled *$66 billion* (for comparison, almost the size of GDP in Guatemala in 2007[36]) with an average of *$689 million* per institution.

◊ **Total GSF.** IHE facilities' built space averaged *4 million GSF* per institution and totaled almost *400 million* gross square feet, which, for comparison, is slightly more than the land area of Delaware.

◊ **Total Enrollment.** Lastly, there were almost one million full time equivalent students (*959,579*) enrolled in the 2006 by colleges and universities in my sample, with an average of *9,996* FTE per institution.

Studying total GHG emissions and corresponding independent variables has great value as it allows one to measure overall contribution of an institution to global climate change. However, the tendency to compare institutional contributions to the GCC as well as measuring the progress toward reducing emissions requires other useful and common measures as well. The summary of variables normalized by student and by square foot is listed below.

◊ **Normalized GHG Emissions.** The average annual GHG emissions per full time equivalent student in my sample were *6* $MTCO_2$*-e*[37], ranging 0.44 - 96 $MTCO_2$-e/FTE. Average GHG emissions per gross square foot were *12,079* $MTCO_2$*-e*, ranging 1,299 - 34,784 $MTCO_2$-e/GSF.

◊ **Normalized Revenues.** In 2006, average revenues per student and per gross square foot were *$66,141* (ranging $9,637 - 752,614) and *$119* (ranging $38 – 430), respectively.

◊ **Normalized GSF.** The average campus density equaled 451 *GSF per FTE student*, ranging 63 - 2,754 GSF per student per institution.

As can be seen, the ranges of the values are large indicating high diversity of the sample and possibly presence of other factors affecting these differences.

Research Activity and Institutional Control as Predictors of the GHG Emissions

As was mentioned earlier, research activity of the IHE undoubtedly affects their GHG emissions primarily for two reasons. First, they typically have more built space needed for research laboratories. Additionally, this space is much more energy intensive than most other buildings on campus thus producing higher GHG emissions.

In order to test whether or not research activity explains all or most of the variation in the GHG emissions, I compared the emissions of the sub-samples controlled for institutional research activity and split by institutional control, one of the principal institutional characteristics. ***Figure 4-1*** and ***Table 4-2*** illustrate the results.

Figure 4-1. GHG Emissions for the Sample Sorted by Institutional Research Activity.

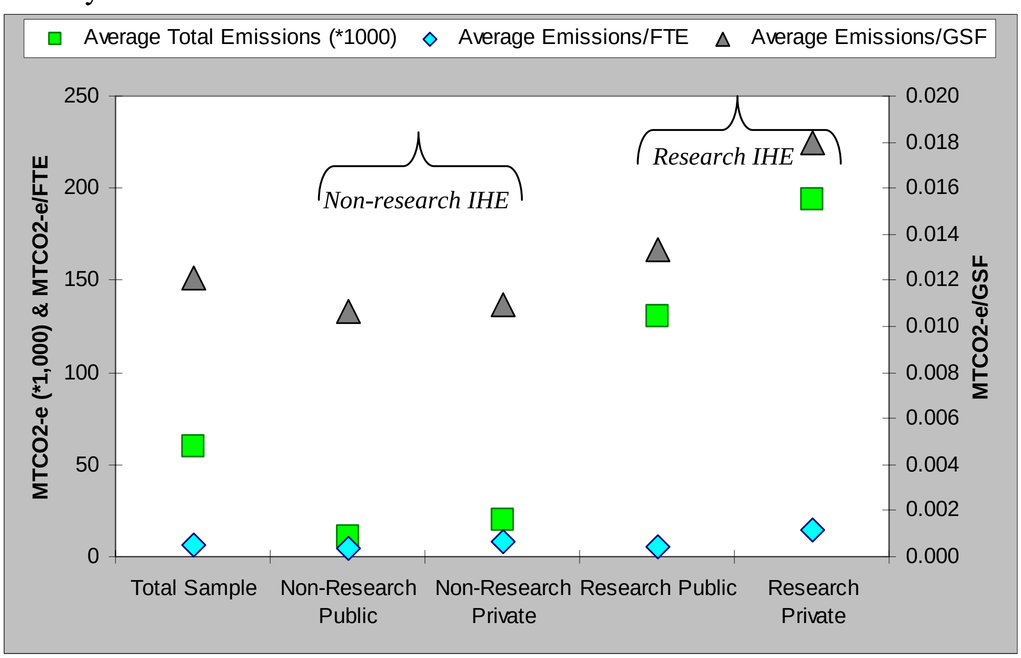


Table 4-2. Descriptive Statistics for the Total Sample Sorted by Research Activity and Institutional Control.							
Average Values	**Non-Research** (63 IHE)	**Research** (33 IHE)	**Factor** (research/ non-research)		**Public** (67 IHE)	**Private** (29 IHE)	**Factor** (private/ public)
Total Emissions	13,994	147,643	10.6		53,818	74,071	1.4
Emissions/FTE	6	8	1.3		5	10	2.0
Emissions/GSF	10,767	14,583	1.4		11,632	13,113	1.1

Several important observations are evident from the graph and the table above. First, as was suggested in previous studies and literature, *research activity* of an institution is an important predictor of its GHG emissions. The average total and normalized emissions are higher for research IHE as compared to the non-research IHE.

The second important observation is that *institutional control* plays an important role as well in determining institutional GHG emissions. As can be seen from the graph, differences between colleges and universities of different controls exist even when the sample is controlled by research activity. Invariably, GHG emissions are higher for private not-for-profit IHE as compared to the public ones.

In the non-research cohort, average total GHG emissions of private IHE are 1.8 higher than that of their public counterparts (20,236 v. 11,091 MTCO2-e, respectively). Average GHG emissions per full time equivalent student for private IHE are almost twice that of the public IHE (8.3 v. 4.4 MTCO2-e/FTE, respectively). Interestingly, the difference between GHG emissions per gross square foot for institutions of the two controls does not seem to be significant (10,687 as compared to 10,940 MTCO2-e/GSF).

The pattern is very similar in the cohort of the research IHE. Average total GHG emissions of the private IHE are 1.5 higher than that of their public counterparts (193,703 v. 130,371 MTCO2-e, respectively). The difference in average GHG emissions per FTE student is even bigger, almost three times as high for the private IHE as for the public IHE (14.8 v. 5.1 MTCO2-e/FTE, respectively). Unlike in the non-research cohort, there is a 1.3 factor difference between GHG emissions per gross square foot for research private not-for-profit as compared to the public IHE (17,942 v. 13,323 MTCO2-e/GSF, respectively).

Largest and smallest average GHG emitters provide another piece of evidence on how both research activity and institutional control interact. The largest emitters release 18 times more GHG emissions on average than the smallest emitters in my sample. The former are research private not-for-profit IHE (averaging 193,703 MTCO2-e a year), the latter are non-research public IHE (averaging 11,091 MTCO2-e a year).

Lastly, another interesting observation concerns the analysis of GHG emissions normalized by student and square foot. The data suggest that when GHG emissions are normalized by square foot, the differences between higher education institutions in my sample can be best explained by their research activity, where non-research IHE have lower emissions than research IHE. However, when GHG emissions are normalized by FTE student, it appears that the differences between the institutions can be best explained by institutional control, where private IHE release higher GHG emissions than their public counterparts.

In summary, while research activity of colleges and universities is a very important factor influencing GHG emissions, it is not the only one. Even when controlled for the research activity, the differences in the GHG emissions remained for colleges and universities divided by institutional control. Thus, these two factors, *institutional control and research activities, seem to be interacting* with each other and affecting GHG emissions of my sample's IHE in a complex fashion.

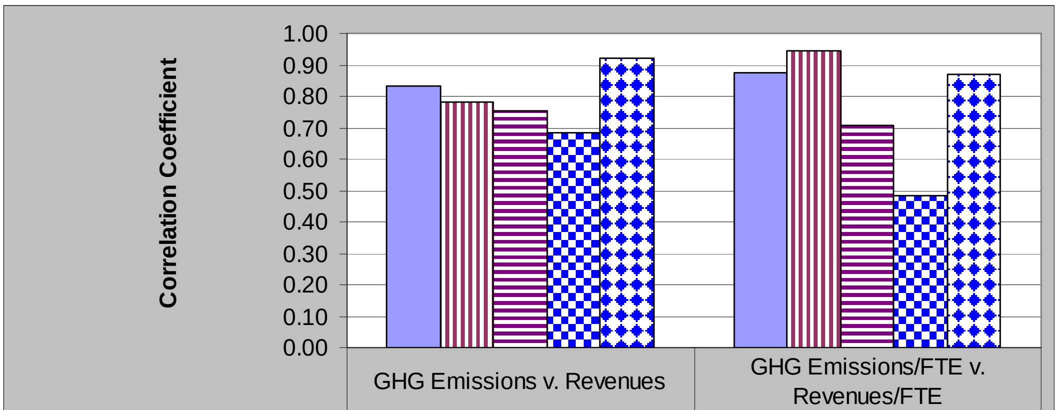
Institutional Wealth and Square Footage as Predictors of the GHG Emissions

In the previous sections, I have established an association between the GHG emissions and two institutional characteristics - research activity and institution control. I have shown that the differences in GHG emissions between colleges and universities exist even when they are controlled for research activity, institutional control, or both. In order to explain some of these differences, in the following section I will test the extent to which institutional wealth and gross square footage are associated with the GHG emissions.

Because all three variables are of the ratio type, I was able to use a Pearson correlation test to analyze statistical associations between them. ***Figures 4-2, 4-3, and 4-4*** below show the correlations between GHG emissions and institutional wealth, GHG emissions and square footage, and institutional wealth and square footage, respectively. I will discuss these results in very general terms, because due to the imperfect nature of the data, in-depth analysis of the differences and similarities between the correlation values is not warranted.

__Figure 4-2__ illustrates correlations values between institutional GHG emissions and the revenues (my study's chosen wealth proxy). As can be seen, all values are high and very high[38], ranging from 0.49 to 0.95, and all but one[39] are significant at the 0.01 level. This result indicates that the association between the GHG emissions and institutional wealth is strong, regardless of the IHE sub-sample and of whether or not the variables are normalized.

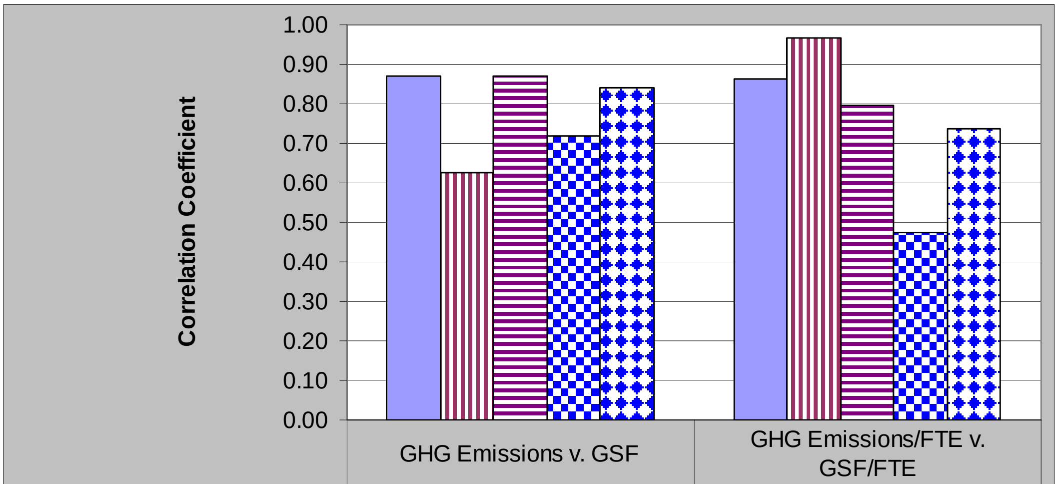
Figure 4-2. Correlations between GHG Emissions and Institutional Wealth.



	GHG Emissions v. Revenues	GHG Emissions/FTE v. Revenues/FTE
Total Sample (96 IHE)	0.83	0.87
Non-Research Public (43 IHE)	0.78	0.95
Non-Research Private not-for-profit (20 IHE)	0.75	0.71
Research Public (24 IHE)	0.68	0.49
Research Private not-for-profit (9 IHE)	0.92	0.87

__Figure 4-3__ illustrates correlation values between institutional GHG emissions and the gross square footage. All values are moderately high to very high, ranging from 0.47 to 0.97, and all but two values[40] are significant at the 0.01 level. This result indicates that the association between the GHG emissions and the GSF is very strong, regardless of the IHE sub-sample and of whether or not the variables are normalized.

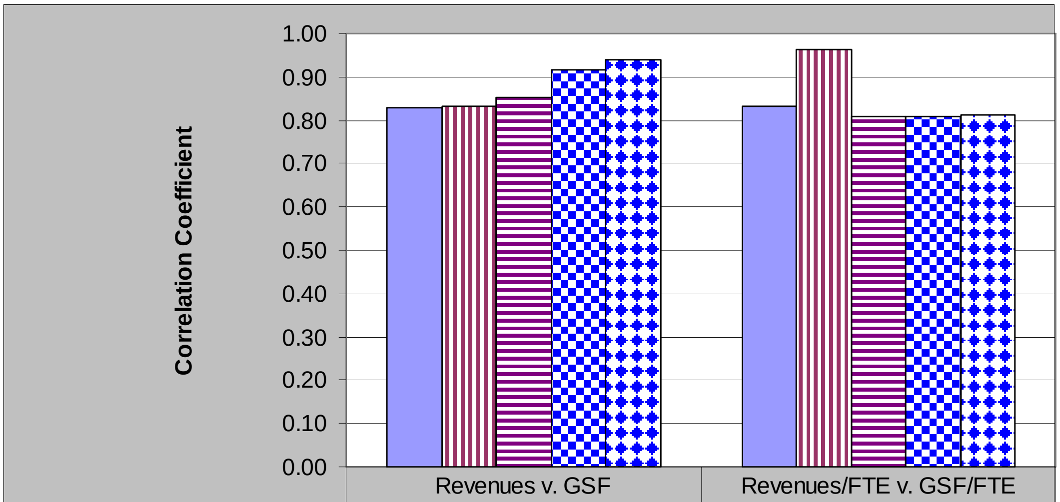
Figure 4-3. Correlations between GHG Emissions and Square Footage.



	GHG Emissions v. GSF	GHG Emissions/FTE v. GSF/FTE
Total Sample (96 IHE)	0.87	0.86
Non-Research Public (43 IHE)	0.63	0.97
Non-Research Private not-for-profit (20 IHE)	0.87	0.80
Research Public (24 IHE)	0.72	0.47
Research Private not-for-profit (9 IHE)	0.84	0.74

Lastly, ***Figure 4-4*** illustrates correlations values between institutional wealth and the gross square footage. Overall, these correlation values are the strongest of the three graphs. The values are very high, ranging from 0.81 to 0.96, and all are significant at the 0.01 level. Thus, the associations between these two institutional variables are very strong, regardless of the IHE sub-sample and of whether or not the variables are normalized.

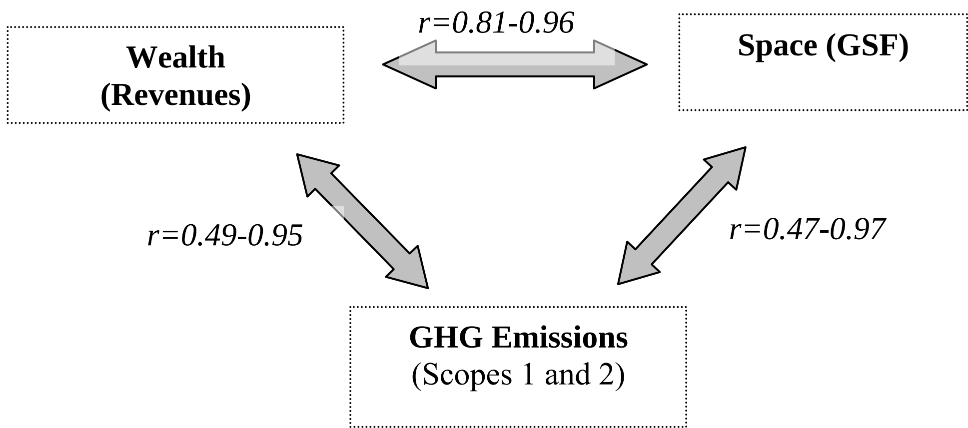
Figure 4-4. Correlations between Institutional Wealth and Square Footage.



	Revenues v. GSF	Revenues/FTE v. GSF/FTE
Total Sample (96 IHE)	0.83	0.83
Non-Research Public (43 IHE)	0.83	0.96
Non-Research Private not-for-profit (20 IHE)	0.85	0.81
Research Public (24 IHE)	0.92	0.81
Research Private not-for-profit (9 IHE)	0.94	0.81

In sum, correlations between GHG emissions, institutional wealth, and gross square footage range from moderately high to very high. The strongest association seems to be between institutional wealth and space. ***Figure 4-5*** shows schematically the results of these correlation tests.

Figure 4-5. Summary of Correlations between Total and Normalized Values of the GHG Emissions, Institutional Wealth, and Square Footage (for the total sample and sub-samples).
(r = Correlation Coefficient)



Discussion

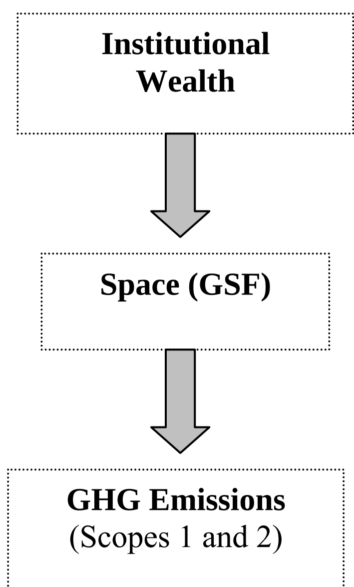
To my knowledge, this study is one of the first analytical studies of the U.S. higher education contribution to global climate change and possible factors explaining the differences in the greenhouse gas emissions.

The results of my study had revealed several interesting patterns. First, I have found a large difference in GHG emissions among colleges and universities in my sample. Some differences seemed to be explained by whether or not an institution is conducting laboratory research. Additionally, some differences in emissions seemed to be explained by institutional control.

The interactions between research activity and institutional control in terms of their influence on the GHG emissions seem to be fairly complex. For example, in my sample, the largest emitters were private research institutions and the smallest emitters were non-research public IHE. Also, when GHG emissions were normalized by GSF, the difference in emissions seemed to be better explained by institutional research activity. However, when GHG emissions were normalized by student, the difference in emissions seemed to be better explained by institutional control. Another example of this complex interaction is that the GHG emissions/GSF differences were negligible for non-research private v. public IHE, but significant for research private v. public IHE.

Another result of this study was finding moderate to very strong associations between GHG emissions, institutional wealth proxy, and gross square footage. However, because correlations do not explain causality, I can not explain the manner in which these variables affect GHG emissions. ***Figure 4-6*** shows the most likely relationship between these three variables, based on the literature review: institutional wealth affects the scale of operations which translates into larger gross square footages which ultimately increases the GHG emissions.

Figure 4-6. Suggested Schematic Directional Relationships between GHG Emissions, Institutional Wealth and Gross Square Footage.



The above results begged the question regarding the relationship between institutional wealth and GSF, and the two institutional characteristics – research activity and institutional control. ***Appendix E*** summarizes the results in tabular form. It shows that in my sample, research IHE are wealthier and have more GSF than their non-research counterparts. Likewise, private IHE are wealthier and have more GSF than their public counterparts. The results suggest that research and/or private IHE are bigger emitters because they are wealthier and have larger GSF.

However, one needs to keep in mind that I had a non-representative sample (Figures 2-5 and 2-6). Thus, the research IHE were over-represented in my sample (making 34% of the sample as compared to the 8% among U.S. colleges and universities), and private IHE were under-represented (making 30% as compared to the 49% among U.S. colleges and universities). Thus, it is not warranted to make inferences to the larger population based on my results.

While the relationships between institutional *research activities*, wealth, GSF, and, consequently, GHG emissions make intuitive sense, it is not the case for *institutional control*. In this study I have shown that my sample's private IHE are wealthier than public, have more GSF, and emit more GHG emissions. Yet, my sample was not representative of the U.S. IHE population and also included one of the wealthiest private institutions of higher education in this country. In addition, I had already shown in Chapter 3 that there is evidence suggesting the opposite result - that overall, private IHE might actually be less wealthy than their public counterparts. Consequently, I can not draw inferences regarding institutional control, wealth and GHG emissions to the larger population. Thus, the relationship between GHG emissions, wealth and institutional control for the entire IHE population is inconclusive.

Because my study's sample is non-representative, it prevents me from making generalizations about the universe of degree-granting public and private not-for-profit IHE in the U.S. My hope is that future studies will minimize the limitations of my study, will verify or modify my findings, and will be used to guide action in addressing the global climate change crisis.

Suggestions for Further Research Based on Improved Methodology

In order to advance this particular study, the researchers will need to concentrate on the two areas: improving the methodology and verifying the relationships between study variables.

In terms of methodology, first, a representative sample will need to be used once more GHG emission inventories become available. Secondly, the study should be done over a period of years in order to control for sporadic annual events. The third, and perhaps most important and difficult methodological improvement, would be establishing a standardized methodology used for collecting and computing GHG emissions by higher education institutions. If uniform approaches to data collection and reporting were adopted by colleges and universities, comparisons would be more meaningful in the future than they are today. While this factor is highly important to the data quality of the research, at the same time it is not dependent as much on a researcher. It is my hope that this issue will be addressed soon by such organizations as the Association for the

Advancement of Sustainability in Higher Education, American College and University Presidents Climate Commitment, Clean Air – Cool Planet, among others.

Besides methodological improvements, future studies should focus on investigating further, verifying and clarifying the relationships among GHG emissions, institutional wealth, gross square footage, research activity, and institutional control. Also, identification and analysis of *other* factors that might potentially influence IHE GHG emissions could be of great value as well.

Chapter 5. Conclusions & Recommendations

This study was focused on identifying factors that might affect GHG emissions of colleges and universities in the U.S. I have found that all four factors I chose for this study (institutional control, research activity, wealth, and gross square footage) affect in some way GHG emissions of these higher education institutions. The natural question stemming from these results is whether this knowledge could be used to help both academic and non-academic institutions to move closer toward the ultimate goal of climate neutrality.

In terms of policy, while institutional wealth is not a malleable policy variable that can be regulated, gross square footage seems to have more malleability. Thus, for example, policy incentives could be used to encourage institutions to explore ways to decrease or stop the growth of their campuses, to make existing built space more energy efficient, and to encourage building upward, instead of outward.

Yet, feasibility of actually achieving climate neutrality by these institutions given current conditions is doubtful. So far, only one higher education school in the U.S. has achieved climate neutrality. Maine's College of the Atlantic, a small school with a student body of 300 and an ACUPCC signatory, have achieved zero-emissions by investing in its buildings' energy efficiency, promoting alternative commuting methods, and choosing a Climate Trust project to offset the rest of the emissions (College of the Atlantic 2008).

It is much harder to achieve climate neutrality for larger schools, whose GSF and emissions per students tend to be larger than their smaller peers. Indeed, larger schools have not been as forthcoming with pledging to achieve climate neutrality as smaller ones. For example, in my sample of 96 schools, some of the wealthiest and largest (in terms of gross square footage) institutions have not signed the ACUPCC pledge at the time I conducted my study. As can be seen in the ***Table 5-1*** below, on average, total revenues, gross square footage, and total and normalized emissions are higher for non-ACUPCC signatories as compared to the ACUPCC signatories.[41]

Table 5-1. Comparison of GHG Emissions, Revenues, and GSF of ACUPCC v. Non-ACUPCC Signatories.

	Average of Annual Revenues	Average of GSF	Average of Total Emissions	Average of Emissions/ FTE	Average of Emissions/ GSF
ACUPCC Signatories (as of 04/12/08)	500,312,001	3,661,001	48,127	5.5	0.011
Non-ACUPCC Signatories (as of 04/12/08)	1,704,821,001	6,748,000	123,706	10.6	0.015

There might be several ways to explain this fact. One explanation might be that larger schools are more bureaucratic, which often slows down readiness to commitments and change. Also, as my results have shown, larger schools not only tend to have more *total* square footage, but also more square footage *per student*, thus making it more difficult to reduce their GHG emissions. Additionally, it might be argued that paying for offsets before investing in emission reduction activities on campus is not wise, while doing both is too expensive. Thus, another explanation could be that larger school might view climate neutrality as an unrealistic goal in the current political and financial climate.

Institutional Wealth and Greenhouse Gas Emissions

I have found in my sample that wealthier schools tend to have higher total, per student, and per GSF greenhouse gas emissions than their less wealthy counterparts. Perhaps this is not surprising as wealthier schools have more resources available to provide more facilities per student. I believe that the conclusions stemming from this result can be applied not only to colleges and universities, but other institutions as well. If wealthier institutions indeed are higher contributors of GHG emissions, they carry greater responsibility to address global climate change, and they have more financial resources to do it.

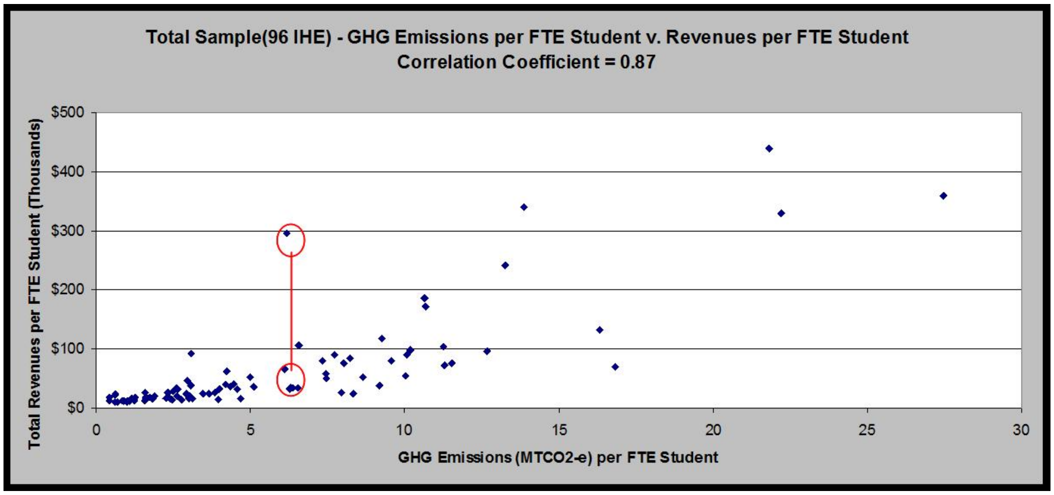
Future Research: Peer Cohorts v. Case Studies

Addressing global climate change is one of the best bellwethers of institutional sustainability. Because colleges and universities that signed ACUPCC pledge share the ultimate goal of reaching climate neutrality, they are naturally looking to their peers for progress comparisons and examples. Except for the presence or absence of research activities, in my sample of 96 U.S. colleges and universities I have found it difficult to break them further into meaningful cohorts due to such differences as diversity of carbon footprint sizes, the age of school and number of historic buildings on campus, the availability of cleaner forms of energy in the region, regional difference in terms of number of heating and cooling days, the period of time during which schools have already been actively addressing their impact on GCC, the timeline for reaching climate neutrality goals, institutional drivers and much more. Therefore, I would argue that case studies demonstrating best practices and strategies might be more useful and robust than comparisons based on peer cohorts.

Future research could focus on the analysis of colleges and universities' progress toward the carbon-neutrality by studying and comparing institutional goals, strategies, advancement made, and challenges faced. One could identify and analyze successful transferable lessons for institutions of higher education.

One analysis tool that could be helpful in identifying case studies for research is a scatter plot. For example, ***Figure 5-1*** demonstrates an association between GHG emissions and revenues normalized by FTE student (for the total sample in my study). The data points circled in red are an example of the IHE with similar GHG emissions but very different revenues per student. Thus, while These two institutions offer an opportunity for further research into the reasons behind these differences.

Figure 5-1: Example of How Scatter Plots' Outliers Help Identify Case Studies for Further Research.



Thus, for example, while all three colleges and universities' approximate GHG emissions per student is 6 MTCO2-2, University of California Merced's approximate revenues per student are $295,562, Occidental College's is $65,899, and Oregon State University's is $34,870.

Policy Implications

Currently, GHG emission reductions in most sectors of the U.S. are purely voluntary. However, given the size of the global climate change problem, the possibility of swift and radical policy changes in the near future is high, consequently prompting or even forcing colleges and universities toward faster action on addressing this impeding crisis.

Many colleges and universities, such as more than 500 that signed the ACUPCC pledge, understand the global climate change imperative and are taking steps to measure and reduce their GHG emissions. However, there are two important factors, short-term and long-term, that are making it difficult to achieve the ultimate goal of carbon neutrality. The short-term challenge is a continuing trend toward campus expansions, both in terms of total enrollment and infrastructure development. Thus, while absolute reduction of GHG might be increasing, so are institutional total emissions, thus undermining or even cancelling out the efforts aimed to reduce contributions to global climate change.

The long-term, and ultimately the greatest challenge, is that when the simplest and most cost-effective steps will have been taken,[42] the remaining emission reductions will require higher costs and will need deep cultural shifts to reorient institutional policies and practices (University of New Hampshire 2006).

Rappaport (2008) provides an innovative policy solution to the short-term challenge of achieving climate neutrality. She argues that most colleges and universities will not be able to fulfill their near-term neutrality pledges unless they purchase GHG emissions offsets. She proposes that those IHE that need to purchase offsets could make investments to capital-strapped universities to lower their GHG emissions through a revolving fund approach. This building of the financial capital will ensure that climate action promotes mutual advancement and helps close the gap between institutions that have wealth and those that do not.

The solutions to the long-term challenge mentioned above are not easy as well. I believe that colleges and universities need to invest in research that explores solutions to the zero-carbon way of life.

The role of federal policies both in the short-term and long-term challenges is crucial. In terms of the short-term challenge, national policies can enforce GHG emissions reduction policies while helping financially the institutions to achieve set goals. For example, they can promote drastic measures to improve energy efficiency, provide support for demonstration projects and information dissemination, and much more (Rappaport 2008).

Even more importantly, national policies can help with the long-term challenge of achieving institutional carbon-neutrality by providing funds for research and development of GHG emissions reduction technologies. The magnitude of the problem, its urgency, needed advancements in the science and technology, as well as financial resources needed are similar in a way to the challenge that United States faced more than 40 years ago when it set the goal to put first man on the moon and do it before any other country could. In a way, similar amounts of federal commitment and funds are needed urgently now to address a much more serious problem – global climate change. Because institutions of higher education are committed to the advancement of society and many conduct research, a strong working relationship between them and the federal government in solving this crisis is not only greatly needed but is also natural.

Institutional Systemic Transformation

While some colleges and universities have taken steps to calculate and reduce their emissions, there is still a long way to go for higher education institutions to achieve carbon neutrality. Ultimately, the carbon neutrality goal requires that colleges and universities undergo a systemic transformation, as opposed to just taking on specific projects to ‘green’ the campus (Sharp 2002).

Paradigm shift is needed on many levels in order to enable schools and universities to achieve climate neutrality. There is a critical need for strong leadership, voluntary and mandatory policies on all government levels, tough market incentives, and awareness building in order to launch the country on the path of sustainability. While as a whole colleges and universities are not large GHG contributors country-wide, as educational institutions and learning laboratories they have the capacity to teach others and lead the way to this transformation.

[1] According to the 2007 study by the Netherlands Environmental Assessment Agency (MNP), in 2006, China's carbon dioxide emissions surpassed those of the USA by an estimated 8% (Netherlands Environmental Assessment Agency. 2007. *Chinese CO2 Emissions in Perspective*. Press Release. www.mnp.nl/en/service/pressreleases/2007/20070622ChineseCO2emissionsinperspective.html (accessed June 18, 2008)).

[2] The top six per capita GHG emitters in 2000, in descending order, were Qatar, United Arab Emirates, Kuwait, Australia, Bahrain, and the United States (Baumert et al 2005).

[3] NCES IPEDS Dataset Cutting Tool. Accessed April 17, 2008.

[4] In the United States alone, buildings account for:

- 65% of electricity consumption,
- 36% of energy use,
- 30% of greenhouse gas emissions,
- 30% of raw materials use,
- 30% of waste output (136 million tons annually),
- 12% of potable water consumption.

Source: U.S. Green Building Council. Green Building Research. http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1718 (accessed April 6, 2008).

[5] The GDP of Chile in 2007 was $ 234.4 billion. The GDP of Portugal in 2007 was $ 232 billion. *Source*: Central Intelligence Agency. The World Factbook. Guide to Rank Order Pages. Economy. GDP (purchasing power parity). www.cia.gov/library/publications/the-world-factbook/index.html (accessed April 6, 2008).

[6] There is no formal distinction between colleges and universities according to IPEDS. It defines postsecondary education as a formal program designed primarily for students beyond the 'compulsory' high school age. It includes all institutions open to the public, education provided in combination with the hospitals, and excludes institutions providing noncredit continuing education programs.

[7] American College and University Presidents Climate Commitment, www.presidentsclimatecommitment.org.

[8] Association for the Advancement of Sustainability in Higher Education. Campus Sustainability Profiles. www.aashe.org/resources/profiles/profiles.php (accessed March 14, 2008).

[9] Eric Friedman, Director of Leading by Example Programs at the Executive Office of Energy and Environmental Affairs, has provided me with the data and a lot of helpful feedback. (E-mail communications in March and April, 2008).

[10] *Source*: Department of Education. National Center for Education Statistics IPEDS system. *Glossary*. http://nces.ed.gov/ipeds/glossary (accessed April 3, 2008).

Carnegie Classification is an institutional classification coding structure developed by the Andrew W. Carnegie Foundation for the Advancement of Teaching. The categories include:

- Associate's--Public
- Baccalaureate Colleges
- Doctoral/Research Universities
- Master's Colleges and Universities
- Research Universities (high research activity)
- Research Universities (very high research activity)
- Special Focus Institutions

[11] I can only say that these are reported, not actual, Scope 3 emissions, as I am bounded by the data provided by colleges and universities.

[12] The "equivalent" means that any non-CO_2 gases included in the total were weighted by their global warming potential values.

[13] Ronald Esposito, Facilities, Tufts University (e-mail conversation in March, 2008).

[14] Many IHE have an Office of Institutional Research which publish institutional FactBooks and "Common Data Set" (typically sent to the National Center for Education Statistics IPEDS system). While "Common Data Sets" typically do not report total square footage, the OIR sometimes additionally adds this information somewhere on its website or in the additional documents.

[15] Full-time equivalent enrollment variable is derived from the enrollment by race/ethnicity section of the fall enrollment survey. The full-time equivalent of part-time enrollment is estimated by multiplying the part-time enrollment by factors that vary by control and level of institution and level of student. This formula has been used to produce the full-time equivalent enrollment that is published annually in the Digest of Education Statistics (Source: IPEDS).
[16] Another metric that I came across was total number of IHE community members (i.e. a sum of students and employees). Since it was not a commonly used measure, I decided to use FTE instead. However, the correlation between total students and total community members is high, as can be seen in the GHG emission inventory reports of Bucknell University (Figure 13) and California State Polytechnic University-Pomona (pages 4 and 16 of the report).
[17] The GHG Protocol Initiative is a decade-long partnership between the World Resources Institute and the World Business Council for Sustainable Development. It is a most widely used international accounting tool for government and businesses to understand, quantify, and manage greenhouse gas emissions, www.ghgprotocol.org.
[18] The Climate Registry is collaboration between U.S.A. states, Canadian provinces and tribes aimed at developing and managing a common greenhouse gas emissions reporting system.
[19] I came across one notable exception during this study. Yale University develop an alternative system of six GHG emissions *tiers*:
● Tier 1 – Emissions from Yale power plants, including emissions from electricity, steam, and chilled water production;
● Tier 2 – Yale emissions from activities for which Yale has decision-making power, either through the procurement process or an equivalent, which includes purchased electricity and energy consumption by buildings;
● Tier 3 – Yale emissions from Yale activities that are decided on and transacted by other individuals, for example, work-related travel and commuting;
● Tier 4 –Yale's emissions from its outsourced activities where decisions are made through contract provisions, including waste generation in landfills and wastewater;
● Tier 5 – Yale's incidental emissions, for example, emissions from tourists visiting Yale's museums; and
● Tier 6 –Yale's emissions from embodied energy and resulting emissions – for instance, cement or steel used in the construction of university buildings or embodied in equipment like PCs owned by the university.
[20] Based on the conversations with Scott Lupin, Associate Director, Office of Sustainability & Department of Environmental Safety, University of Maryland (e-mail conversation, February, 2008) AND Mick Womersley, PhD, Associate Professor of Human Ecology, Director of Sustainability, Unity College (e-mail conversation, March, 2008).
[21] Merriam-Webster Online Dictionary. www.merriam-webster.com (accessed March 30, 2008).
[22] Capital assets are tangible or intangible assets that are capitalized under an institution's capitalization policy; some of these assets are subject to *depreciation* and some are not. These assets consist of land and land improvements, buildings, building improvements, machinery, equipment, infrastructure, and all other assets that are used in operations and that have initial useful lives extending beyond one year. Source: NCES IPEDS. Glossary. (Accessed March 6, 2008).
[23] I could not analyze private for-profit IHE endowments because they do not report this information under IPEDS.
[24] Nagowski defined wealth as a sum of the endowment assets and the replacement value of the physical assets.
[25] Bradburd and Mann defined the total wealth measure for the purposes of their study as a sum of endowment and capitalized value of annual non-endowment income flows.
[26] "Current replacement value - The estimated current cost to replace all buildings owned by the institution. It represents recent appraisal value or what is currently carried as insurance replacement value, but does not include the replacement values of those buildings which are a part of endowment or other capital fund investments in real estate. This figure is not a book value figure." Source: IPEDS Glossary.

[27] Present value is the value today of an amount of money in the future. Present value calculations are widely used in business and economics to provide a means to compare cash flows at different times on a meaningful basis. To calculate the present value of a money flow, one needs to divide the money flow by the current interest rate of r, r=.05. Thus, to combine an endowment value (a comparatively constant value over time of a stock wealth) and an annual cash flow, assuming it is constant in the future, one needs to use present value calculations at a certain discount rate, chosen here to be 5%, as it is a common percentage spent out of endowments by IHE.

[28] This section of the chapter is largely based on the helpful feedback provided to me by two economists - Ralph M. Bradburd (Chair of Economics and David A. Wells Professor of Political Economy at Williams College, e-mail conversations in March and April, 2008) AND David Garman (Associate Professor of Economics at Tufts University, e-mail conversation in April, 2008).

[29] According to Bradburd, 5% is a standard rate for IHE to use.

[30] An alternative to this is to have a measure of non-tuition and fees income available for operating expenses: 0.05*Endowment + Non-Endowment Income Flows (gifts & grants and government appropriations). The results of this formula will not equal but related to the above formula by the 1/20th factor. (Due to the differences in the accounting reporting, operating revenues and expenses are only reported under GASB, and not FASB (see the next footnote). That is the reason why the above-mentioned formula would need to be used.)

[31] Financial Accounting Standards Board (FASB) does not consider operation and maintenance of plant as a separate function, but rather allocates these expenses to the other functions such as instruction, research, public service, and academic support. This difference causes an otherwise comparable FASB institution to have higher expenses in functions such as instruction than a Governmental Accounting Standards Board (GASB) reporter.

[32] From economic standpoint, government grants and contracts typically pay for sponsored research and are best viewed as direct payment for these services, not as a source of wealth (Bradburd and Mann 1993).

[33] The reported years differed and therefore this number is an estimate only.

[34] 5,753,853 is 0.09% of U.S. total GHG emissions in 2005 (6,431,935,000 MTCO2-e). *Source*: United Nations Framework Convention on Climate Change. Time series - Annex I. Data for greenhouse gas (GHG) total. GHG total with LULUCF: Total CO2 Equivalent Emissions without Land Use, Land-Use Change and Forestry. Full table in Excel. http://unfccc.int/ghg_data/ghg_data_unfccc/time_series_annex_i/items/3814.php (accessed April 27, 2008).

[35] Both Belgium's and Iceland's GHG emissions in 2005 were 5,460,000 MTCO2-e.
Source: Ibid.

[36] The GDP of Guatemala in 2007 was $67.5 billion. Source: Central Intelligence Agency. The World Factbook. Guide to Rank Order Pages. Economy. GDP (purchasing power parity). www.cia.gov/library/publications/the-world-factbook/index.html (accessed April 30, 2008).

[37] The only other comparison I have found was from a study by The Evergreen College in WA. A much smaller sample of 17 campuses in the U.S. yielded a higher average of 11.2 GHG emissions per student (Figure 9, pg. 105). However, because the sample is very small and non-representative and because the author did not eliminate Scope 3 from the calculations, I believe that my estimate might be more accurate.

[38] Correlation coefficients:
0.00 - 0.24 = low correlation
0.25 - 0.49 = moderate degree of correlation
0.50 - 0.74 = high degree of correlation
0.75 - 1.00 = very high degree of correlation.

[39] 0.49 value is significant at the 0.05 level (GHG emissions v. Revenues, normalized by FTE student, for research public IHE).

[40] Correlation values for GHG emissions v. Revenues, normalized by FTE student, for research IHE are significant at the 0.05 level.

[41] Research activity is not a factor here, as research and non-research institutions are sufficiently represented in both groups.

[42] According to Michael Womersley, Associate Professor of Human Ecology and Director of Sustainability at Unity College, it is surprising how easily achievable are some of the GHG emission reduction strategies are. He thinks that IHE can save about 10% of their annual emissions just by better use of heating and cooling controls, such as $30 computerized thermostats sold in many hardware stores.

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4. Bunker Hill Community College
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9. Holyoke Community College
10. Massachusetts Bay Community College
11. Massachusetts College of Art
12. Massachusetts College of Liberal Arts
13. Massachusetts Maritime Academy
14. Massasoit Community College
15. Middlesex Community College
16. Mount Wachusett Community College
17. North Shore Community College
18. Northern Essex Community College
19. Quinsigamond Community College
20. Roxbury Community College
21. Salem State College
22. Springfield Tech. Community College
23. University of Massachusetts Amherst
24. University of Massachusetts Boston
25. University of Massachusetts Dartmouth
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Facilities Gross Square Footage:
Ibid.

Occidental College

GHG Emissions Inventories:
Occidental College. Preliminary Inventory of Occidental College's Greenhouse Gas Emissions. departments.oxy.edu/uepi/ecooxy/oxy_emissions.pdf (accessed 03/16/08).
Facilities Gross Square Footage:
Occidental College. Facilities Management. Facilities Statistics Last Revision: April 19, 2000. http://departments.oxy.edu/facilities/stats.htm (accessed April 17, 2008).

Oregon University System – seven campuses:

1) Eastern Oregon University
2) Oregon Institute of Technology
3) Oregon State University
4) Portland State University
5) Southern Oregon University
6) University of Oregon
7) Western Oregon University

GHG Emissions Inventories:
Oregon University System. 2007. *Greenhouse Gas Inventory. GHG Emissions for the 2004 Calendar Year: Report and Analysis.* A draft. www.ous.edu/dept/capcon/files/OUS_GHG_Inventory-July2007.pdf (accessed March 17, 2008).
Facilities Gross Square Footage:
Oregon University System 2006 Fact Book. Oregon University System Facilities. Oregon University System www.ous.edu/dept/ir/reports/fb2006/S9_Budget_and_Facilities.pdf#P9 (accessed March 17, 2008).

Pennsylvania State University - University Park Campus

GHG Emissions Inventories:
Steuer, Christopher. 2004. *A Greenhouse Gas Emissions Inventory and Projection for the University Park Campus of the Pennsylvania State University. Executive Summary.* Pennsylvania State University Center for Integrated Regional Assessment. www.cira.psu.edu/Chris%20Steuer/ExecutiveSummary.pdf (accessed March 16, 2008).
Facilities Gross Square Footage:
Office of Physical Plant. Fast Facts on the Pennsylvania State University. Pennsylvania State University. www.opp.psu.edu/about/fastfacts.cfm (accessed March 16, 2008).

Pomona College

GHG Emissions Inventories:

Pomona College. Pomona Campus Climate Challenge. 2007. *A First Step Toward A Climate Neutral Pomona College: Greenhouse Gas Emissions Inventory and Recommendations for Mitigating Emissions.* www.pomonacampusclimatechallenge.org/ghg-inventory (accessed 03/17/08).

Facilities Gross Square Footage:

Ibid.

Smith College

GHG Emissions Inventories:

Thomas, Elizabeth. 2005. *Greenhouse Gas Emissions at Smith College: A Comprehensive Inventory from 1990-2004 and Suggestions for Future Emissions Reductions*. www.smith.edu/green/ghgreport.pdf (accessed 03/16/08).

Facilities Gross Square Footage:

Physical Plant Department. Smith College. www.smith.edu/physplant (accessed March 16, 2008).

St. Lawrence University

GHG Emissions Inventories:

St. Lawrence University. 2007. Clean Air – Cool Planet Campus Carbon Calculator. (Mail to author by Louise Gava, Sustainability Coordinator, St. Kawrence University, April 7, 2008).

Facilities Gross Square Footage:

Ibid.

Stanford University

GHG Emissions Inventories:

California Climate Action Registry. Climate Action Registry Reporting Online Tool (CARROT). 2006. *Stanford University Annual Emissions Report.* http://www.climateregistry.org/CARROT/public/reports.aspx (accessed February 20, 2008).

Facilities Gross Square Footage:

Stanford University. Stanford Facts 2007. www.stanford.edu/home/stanford/facts/lands.html (accessed March 26, 2008).

State University of New York at Buffalo

GHG Emissions Inventories:

Simon, Jim. 2007. "UB Green Climate Action Report. An Opportunity for National Leadership and Environmental Excellence." A Project of the UB Green Office. The State University of New York. University at Buffalo. ublib.buffalo.edu/libraries/asl/guides/environment/UBGreenReport.pdf (accessed 03/18/08).

Facilities Gross Square Footage:

Ibid.

The Evergreen State College

GHG Emissions Inventories:

Pumilio, John F. 2007. Carbon Neutrality by 2020: The Evergreen State College's Comprehensive Greenhouse Gas Inventory. Master's thesis, The Evergreen State

College. www.evergreen.edu/sustainability/docs/Thesis%20-%20Evergreen%20GHG%20Inventory.pdf (accessed March 17, 2008).
Facilities Gross Square Footage:
Ibid.

The University of Tennessee System

GHG Emissions Inventories:
Chinery, Leslie E. Unknown date. *Preliminary Greenhouse Gas Emissions Inventory of the University of Tennessee, Knoxville.* University of Tennessee. www.cce.utk.edu/energyplan/chinery.pdf (accessed March 18, 2008).
Facilities Gross Square Footage:
Office of the Vice President for Administration and Finance. FY 2006-2007 Facts & Figures. The University of Tennessee System. https://my.tennessee.edu/portal/page?_pageid=34,52528&_dad=portal&_schema=PORTAL (accessed March 19, 2008).

Tufts University

GHG Emissions Inventories:
Tufts University. Tufts Climate Initiative. Tufts University Greenhouse Gas Inventory 2006 Update. www.tufts.edu/tie/tci/Inventory.htm (accessed 03/17/08). AWAITING APPROVAL TO USE.
Facilities Gross Square Footage:
Office of Institutional Research. Fact Book 2006-2007. Tufts University. http://institutionalresearch.tufts.edu/downloads/FactBook0607Abridged.pdf (accessed March 6, 2008).

Unity College

GHG Emissions Inventories:
Unity College. Excel. Campus Climate Impact. Data in pounds Co2e. Basic Run 2006-2007. http://www.aashe.org/resources/ghg_inventories.php (accessed March 18, 2008).
Facilities Gross Square Footage:
(Michael Womersley, PhD, Director of Sustainability, Unity College, March 19, 2008, e-mail message to author.)

University of California, Berkeley

GHG Emissions Inventories:
Ahmed, Fahmida. 2007. F*easibility Study 2006 - 2007 Final Report.* University of California Berkeley. Climate Action Partnership. sustainability.berkeley.edu/calcap/docs.html (accessed March 17, 2008).
Facilities Gross Square Footage:
(Kenyon Potter, Design & Construction Policy, Facilities Administration, University of California Office of the President, March 21, 2008, e-mail message to author.)

University of California, Los Angeles

GHG Emissions Inventories:
California Climate Action Registry. Climate Action Registry Reporting Online Tool (CARROT). 2006. *University of California, Los Angeles Annual Emissions Report.* http://www.climateregistry.org/CARROT/public/reports.aspx (accessed February 20, 2008).

Facilities Gross Square Footage:
(Kenyon Potter, Design & Construction Policy, Facilities Administration, University of California Office of the President, March 21, 2008, e-mail message to author.)

University of California, Merced

GHG Emissions Inventories:
California Climate Action Registry. Climate Action Registry Reporting Online Tool (CARROT). 2006. *University of California, Merced Annual Emissions Report.* http://www.climateregistry.org/CARROT/public/reports.aspx (accessed March 5, 2008).

Facilities Gross Square Footage:
(Kenyon Potter, Design & Construction Policy, Facilities Administration, University of California Office of the President, March 21, 2008, e-mail message to author.)

University of California, Riverside

GHG Emissions Inventories:
California Climate Action Registry. Climate Action Registry Reporting Online Tool (CARROT). 2006. *University of California, Riverside Annual Emissions Report.* http://www.climateregistry.org/CARROT/public/reports.aspx (accessed February 20, 2008).

Facilities Gross Square Footage:
(Kenyon Potter, Design & Construction Policy, Facilities Administration, University of California Office of the President, March 21, 2008, e-mail message to author.)

University of California, San Diego

GHG Emissions Inventories:
California Climate Action Registry. Climate Action Registry Reporting Online Tool (CARROT). 2006. *University of California, San Diego Annual Emissions Report.* http://www.climateregistry.org/CARROT/public/reports.aspx (accessed February 20, 2008).

Facilities Gross Square Footage:
(Kenyon Potter, Design & Construction Policy, Facilities Administration, University of California Office of the President, March 21, 2008, e-mail message to author.)

University of California, Santa Barbara

GHG Emissions Inventories:
California Climate Action Registry. Climate Action Registry Reporting Online Tool (CARROT). 2006. *University of California, Santa Barbara Annual Emissions Report.* http://www.climateregistry.org/CARROT/public/reports.aspx (accessed February 20, 2008).

Facilities Gross Square Footage:
(Kenyon Potter, Design & Construction Policy, Facilities Administration, University of California Office of the President, March 21, 2008, e-mail message to author.)

University of California, Santa Cruz

GHG Emissions Inventories:

California Climate Action Registry. Climate Action Registry Reporting Online Tool (CARROT). 2006. *University of California, Santa Cruz Annual Emissions Report.* http://www.climateregistry.org/CARROT/public/reports.aspx (accessed March 14, 2008).

Facilities Gross Square Footage:

(Diane Behling, Educational Facilities Planner, Capital Planning & Space Management, University of California, Santa Cruz, March 25, 2008, e-mail message to author.)

University of Central Florida

GHG Emissions Inventories:

University of Central Florida. Sustainability and Energy Management. GHG Report (unnamed).

Facilities Gross Square Footage:

Ibid.

University of Connecticut

GHG Emissions Inventories:

University of Connecticut. Office of Environmental Policy. "UConn Emissions Inventory. Results utilizing CA-CP Emissions Calculator. 2006/2007 Updates and Comparative Summary." www.ecohusky.uconn.edu/emissionresults.htm (accessed March 17, 2008).

Facilities Gross Square Footage:

(Dan Britton, Sustainability Coordinator, UConn Office of Environmental Policy, March 24, 2008, e-mail message to author.)

University of Florida

GHG Emissions Inventories:

University of Florida. Office of Sustainability. 2004. *Carbon Neutral Assessment Project.* International Carbon Bank and Exchange, Inc. and Greening University of Florida. E-mailed to me by Dedee DeLongpre-Johnston, Director of Office of Sustainability (accessed February 25, 2008).

Facilities Gross Square Footage:

Ibid.

University of Illinois at Chicago

GHG Emissions Inventories:

Klein-Banai, Cynthia. 2007. Greenhouse Gas Inventory for the University of Illinois at Chicago. UIC's Greenhouse Gas Profile (FY 2005-2006). www.aashe.org/resources/documents/UniversityofIllinoisatChicago.pdf (accessed March 18, 2008).

Facilities Gross Square Footage:

Office of Facility Information Management. Building List. University of Illinois at Chicago. https://fimweb.fim.uic.edu/Buildings/Buildinglist_prelog.asp (accessed March 31, 2008).

University of New Hampshire

GHG Emissions Inventories:

University of New Hampshire. Office of Sustainability. 2006. *Greenhouse Gas Emissions Inventory. 2004-2005 Update.* A Collaborative Project by UNH Office

of Sustainability, UNH Climate Education Initiative, and Clean Air - Cool Planet. www.aashe.org/resources/ghg_inventories.php (accessed March 18, 2008).
Facilities Gross Square Footage:
Ibid.

University of North Carolina at Asheville

GHG Emissions Inventories:
The University of North Carolina at Asheville. Department of Environmental Studies. Larson, Clark and Matthew Raker. "A Methodology to Advance National College Climate Response." Paper presented at the National Conference on Undergraduate Research by UNC Asheville students. www.unca.edu/craftcampus/Climatefootprint.htm (accessed March 17, 2008).
Facilities Gross Square Footage:
Ibid.

University of Pennsylvania

GHG Emissions Inventories:
University of Pennsylvania. 2007. University of Pennsylvania Carbon Footprint. www.aashe.org/resources/ghg_inventories.php (accessed March 18, 2008).
Facilities Gross Square Footage:
Ibid.

University of Redlands

GHG Emissions Inventories:
David Kadamus, President. 2007. *Benchmarking Campus Carbon Footprints: Fact vs. Fiction.* Sightlines. Power Point Presentation. E-mailed to me by Phil Doolittle, Exec VP - Operations/Planning (accessed February 27, 2008).
Facilities Gross Square Footage:
(Facilities Management, University of Redlands, March 19, 2008, telephone conversation with author.)

University of Vermont

GHG Emissions Inventories:
University of Vermont. *Greenhouse Gas Inventory Calculation, Summary, and Analysis Workbook.* 2003-2006. A Draft. Clean Air Cool Planet Campus Carbon Calculator v5.0. E-mailed by Gioia Thompson, Office of Sustainability Director (accessed February 20, 2008).
Facilities Gross Square Footage:
Ibid.

University of Washington – Seattle, Tacoma, Bothell.

GHG Emissions Inventories:
Hammerschlag, Roel. 2007. *2005 Inventory of Greenhouse Gas Emissions Ascribable to the University of Washington.* Daniel J. Evans School of Public Affairs. University of Washington. www.washington.edu/about/environmentalstewardship/UW_GHG_inventory_2005.pdf (accessed March 14, 2008).
Facilities Gross Square Footage:
University of Washington. Planning and Budgeting: Office of Institutional Studies. University of Washington Factbook. Facilities and Space. Table G2: University of Washington Assignable and Non-Assignable Square Feet by

Campus. www.washington.edu/admin/factbook/tablg2.pdf (accessed March 19, 2008).

Utah State University

GHG Emissions Inventories:

Utah State University. *Greenhouse Gas Inventory Calculation, Summary, and Analysis Workbook.* 2006-2007. Clean Air Cool Planet Campus Carbon Calculator v5.0. www.aashe.org/resources/ghg_inventories.php (accessed 03/17/08).

Facilities Gross Square Footage:

Ibid.

Washington & Lee University

GHG Emissions Inventories:

Washington & Lee University. Excel Spreadsheet: “CY 2006 Utility Use and Associated Greenhouse Gas Emissions” and “CY 2006 Environmental Projects and Emissions Reductions”. E-mailed by John C. (Chris) Wise, Environmental Management Coordinator, Washington and Lee University, Facilities Management. (03/03/08).

Facilities Gross Square Footage:

(John C. (Chris) Wise, Environmental Management Coordinator, Washington & Lee University, March 3, 2008, e-mail message to author.)

Wellesley College

GHG Emissions Inventories:

Environmental Studies 300. *Audit of Wellesley College’s Greenhouse Gas Emissions.* www.aashe.org/resources/ghg_inventories.php (accessed 03/18/08).

Facilities Gross Square Footage:

(R. Michael Dawley, Assistant Director of Facilities, Wellesley College, March 19, 2008, e-mail message to author.)

Western State College of Colorado

GHG Emissions Inventories:

Western State College of Colorado. *Greenhouse Gas Inventory Calculation, Summary, and Analysis Workbook.* 1998-2006. A Draft. Clean Air Cool Planet Campus Carbon Calculator v5.0. E-mailed by Jessica R. Young , Associate VP of Academic Affairs (02/28/08).

Facilities Gross Square Footage:

Ibid.

Yale University

GHG Emissions Inventories:

Buttazzoni, Marco, Kathleen Campbell, Brandon Carter, Seth Dunns, Trish Eyler, WoonKwong Liew, Elizabeth Martin, Nalin Sahni, and Kate Zyla. 2005. “Inventory and Analysis of Yale University’s Greenhouse Gas Emissions.” Working Paper Number 7. Yale University. Yale School of Forestry and Environmental Studies. Yale Climate Initiative. www.aashe.org/resources/ghg_inventories.php (accessed March 18, 2008).

Facilities Gross Square Footage: Ibid.

Appendix A

Beside sources mentioned in Chapter 2, there are three other potential sources of information about IHE GHG emissions inventories - Clean Air – Cool Planet, Sustainable Endowments Institute's College Sustainability Report Card, and The New Jersey Higher Education Partnership for Sustainability.

Clean Air – Cool Planet

Clean Air – Cool Planet's Campus Climate Calculator has been in use by more than 150 campuses across North America. CA-CP reserves the right to see the results of an inventory when letting an institution to download GHG emissions calculator. The information is not accessible currently by an outside researcher, however, because CA-CP keeps information confidential. According to its website[1], CA-CP collects the data in order to aggregate U.S. campus inventory results. Therefore, possibly in the future an analysis of the results will be available and could be used to compare to other IHE.

Sustainable Endowments Institute's College Sustainability Report Card

Sustainable Endowments Institute's[2] College Sustainability Report Card looks at 200 IHE in U.S.A. and Canada with the largest endowments and analyzes their achievements in terms of sustainability. I believe these institutions are more likely to have completed a GHG emissions inventory because they are under more scrutiny and pressure to do so as wealthier institutions.

The New Jersey Higher Education Partnership for Sustainability

The New Jersey Higher Education Partnership for Sustainability consists of 46 New Jersey higher education institutions. NJHEPS's mission is to promote the implementation and integration of sustainability into higher education in New Jersey. Participating institutions had all signed the pledged to participate in the NJHEPS' Greenhouse Gas Action Plan which commits institutions to a reduction of greenhouse gas emissions to 3.5% below 1990 levels by 2005.[3] While committing to emissions reduction does not necessarily mean that an institution needs to complete an inventory, many do undertake a complete Scope 1 and 2 GHG emissions inventory using a calculator developed by the NJHEPS. The data is not yet publicly available.

[1] Clean Air – Cool Planet. Climate Action Toolkit. *Conduct an Emissions Inventory.* www.cleanair-coolplanet.org/toolkit/content/view/43/124 (accessed April 2, 2008).

[2] Sustainable Endowments Institute. 2008. *College Sustainability Report Card. A Review of Campus and Endowment Policies at Leading Institutions.* www.endowmentinstitute.org (accessed April 2, 2008).

[3] The New Jersey Higher Education Partnership. GGAP Emissions Measurement Worksheet. www.njheps.org/projects/protocol.html (accessed April 2, 2008).

Appendix B

Institutional Name	State	ACUPCC Signatories (last checked April 12, 2008)	Control of institution	Carnegie Classification 2005: Basic	Hospital
Bates College	ME	ACUPCC	Private not-for-profit		
Berkshire Community College	MA	ACUPCC	Public		
Bridgewater State College	MA	ACUPCC	Public		
Bristol Community College	MA	ACUPCC	Public		
Brown University	RI		Private not-for-profit	Research	
Bucknell University	PA	ACUPCC	Private not-for-profit		
Bunker Hill Community College	MA	ACUPCC	Public		
California State Polytechnic University-Pomona	CA	ACUPCC	Public		
California State University-Chico	CA	ACUPCC	Public		
Cape Cod Community College	MA	ACUPCC	Public		
Carleton College	MN	ACUPCC	Private not-for-profit		
Clark University	MA	ACUPCC	Private not-for-profit	Research	
Colby College	ME				
College of Charleston	SC	ACUPCC	Public		
Colorado State University (all 6 campuses)	CO		Public	Research	
Connecticut College	CT	ACUPCC	Private not-for-profit		
Dakota County Technical College	MN	ACUPCC	Public		
Duke University (and its Medical Center)	NC	ACUPCC	Private not-for-profit	Research	Hospital
Eastern Oregon University (OSUS)	OR		Public		
Fitchburg State College	MA	ACUPCC	Public		
Fort Lewis College	CO	ACUPCC	Public		

Framingham State College	MA	ACUPCC	Public		
Goddard College	VT	ACUPCC	Private not-for-profit		
Greenfield Community College	MA	ACUPCC	Public		
Hamilton College	NY	ACUPCC	Private not-for-profit		
Harvard University (Cambridge/Allston and Longwood)	MA		Private not-for-profit	Research	
Holyoke Community College	MA	ACUPCC	Public		
Ithaca College	NY	ACUPCC	Private not-for-profit		
Lane Community College	OR	ACUPCC	Public		
Lewis & Clark College	OR	ACUPCC	Private not-for-profit		
Los Angeles Community College District Office (9 colleges)	CA	ACUPCC	Public		
Massachusetts Bay Community College	MA	ACUPCC	Public		
Massachusetts College of Art	MA	ACUPCC	Public		
Massachusetts College of Liberal Arts	MA	ACUPCC	Public		
Massachusetts Institute of Technology	MA		Private not-for-profit	Research	
Massachusetts Maritime Academy	MA	ACUPCC	Public		
Massasoit Community College	MA	ACUPCC	Public		
Middlebury College	VT	ACUPCC	Private not-for-profit		
Middlesex Community College	MA	ACUPCC	Public		
Mount Holyoke College	MA		Private not-for-profit		
Mount Wachusett Community College	MA	ACUPCC	Public		
North Shore Community College	MA	ACUPCC	Public		
Northern Essex	MA	ACUPCC	Public		

Community College					
Oberlin College	OH	ACUPCC	Private not-for-profit		
Occidental College	CA		Private not-for-profit		
Oregon Institute of Technology (OSUS)	OR	ACUPCC	Public		
Oregon State University (OSUS)	OR	ACUPCC	Public	Research	
Pennsylvania State University-Main Campus	PA		Public	Research	Hospital
Pomona College	CA	ACUPCC	Private not-for-profit		
Portland State University (OSUS)	OR	ACUPCC	Public	Research	
Quinsigamond Community College	MA	ACUPCC	Public		
Roxbury Community College	MA	ACUPCC	Public		
Salem State College	MA	ACUPCC	Public		
Smith College	MA	ACUPCC	Private not-for-profit		
Southern Oregon University (OSUS)	OR	ACUPCC	Public		
Springfield Technical Community College	MA	ACUPCC	Public		
St. Lawrence University	NY	ACUPCC	Private not-for-profit		
Stanford University	CA		Private not-for-profit	Research	Hospital
SUNY at Buffalo	NY	ACUPCC	Public	Research	Hospital
The Evergreen State College	WA	ACUPCC	Public		
The University of Tennessee (Knoxville campus and Agricultural campus)	TN	ACUPCC	Public	Research	Hospital
Tufts University (all 3 campuses)	MA		Private not-for-profit	Research	
Unity College	ME	ACUPCC	Private not-for-profit		
University of California-Berkeley	CA	ACUPCC	Public	Research	
University of California-Los	CA	ACUPCC	Public	Research	Hospital

Angeles					
University of California-Merced	CA	ACUPCC	Public		
University of California-Riverside	CA	ACUPCC	Public	Research	
University of California-San Diego	CA	ACUPCC	Public	Research	Hospital
University of California-Santa Barbara	CA	ACUPCC	Public	Research	
University of California-Santa Cruz	CA	ACUPCC	Public	Research	
University of Central Florida	FL	ACUPCC	Public	Research	
University of Connecticut (main campus - Storrs)	CT	ACUPCC	Public	Research	
University of Florida	FL	ACUPCC	Public	Research	
University of Illinois at Chicago	IL	ACUPCC	Public	Research	Hospital
University of Massachusetts Amherst	MA	ACUPCC	Public	Research	
University of Massachusetts Boston	MA	ACUPCC	Public	Research	
University of Massachusetts Dartmouth	MA	ACUPCC	Public		
University of Massachusetts Lowell	MA	ACUPCC	Public	Research	
University of Massachusetts Medical School (Worcester)	MA	ACUPCC	Public		
University of New Hampshire-Main Campus	NH	ACUPCC	Public	Research	
University of North Carolina at Asheville	NC		Public		
University of Oregon (OSUS)	OR	ACUPCC	Public	Research	
University of Pennsylvania	PA	ACUPCC	Private not-for-profit	Research	Hospital
University of Redlands	CA	ACUPCC	Private not-for-profit		
University of Vermont	VT	ACUPCC	Public	Research	

University of Washington - Bothell Campus	WA	ACUPCC	Public		
University of Washington - Seattle Campus	WA	ACUPCC	Public	Research	Hospital
University of Washington - Tacoma Campus	WA	ACUPCC	Public		
Utah State University	UT	ACUPCC	Public	Research	
Washington and Lee University	VA	ACUPCC	Private not-for-profit		
Wellesley College	MA		Private not-for-profit		
Western Oregon University (OSUS)	OR		Public		
Western State College of Colorado	CO	ACUPCC	Public		
Westfield State College	MA	ACUPCC	Public		
Worcester State College	MA	ACUPCC	Public		
Yale University	CT		Private not-for-profit	Research	

Appendix C

University of North Carolina-Asheville GHG Inventory Emissions Sectors and Sources[4]:

UNC-Asheville GHG inventory emissions sectors and sources*

Sector	Upstream Sources	Operations Sources	Downstream Sources
Electricity	**Fuel production** **Coal**: feedstock, recovery, processing, refining, transportation, distribution **Natural gas**: (same) **Residual oil**: (same) **Fuel combustion** **Coal boiler** **Natural gas turbine/boiler** **Residual oil boiler**	none	none
Natural Gas	**Feedstock, recovery, processing, refining, transmission, distribution**	**Combustion**: HVAC, water heating, *cooking* ***On-site Leakage***	none
Transportation	**Fuel production for gasoline and diesel**: feedstock, recovery, refining, transportation, storage, and distribution ***Vehicle manufacture emissions***	**Fuel combustion, exhaust, evaporation**: travel from faculty/staff/student commuting, residential students, university business by car, athletics, fleet, delivery services, bus service, *university business by plane/train/boat, construction* ***A/C CFC leakage***	***Vehicle disposal***
Materials Stream	**Raw- and Recycled-content materials (Al, Steel, Glass, Plastic 1 & 2, Cardboard, and Paper)**: acquisition, manufacturing, and transportation ***All other materials (doorknobs, rubber bands, computers, etc.)***	none	**Recycling**: transportation, reprocessing, offsets **Landfilling**: transportation, methane recovery offsets, carbon sequestration **Composting**: anaerobic decomposition, offsets
Food	**Beef and Dairy products**: enteric fermentation, manure management, *agricultural inputs*, transportation (see 'Transportation') ***Other food products***	none	**Food waste** (see 'materials stream' above)
Water	**Water supply**: electricity for treatment	none	**Wastewater treatment**: electricity **Wastewater and sludge**: decomposition
Land Use	**Fuel production for gasoline and diesel**: feedstock, recovery, refining, transportation, storage, and distribution ***Equipment manufactures (mowers, tractors, tillers, etc.)***	***On-site fuel combustion, exhaust, evaporation (equipment)*** **Forest sequestration**	***Equipment disposal*** ***Yard trimmings***

*excluded sources in italics

[4] The University of North Carolina at Asheville. Department of Environmental Studies. Larson, Clark and Matthew Raker. "A Methodology to Advance National College Climate Response." Paper presented at the National Conference on Undergraduate Research by UNC Asheville students. www.unca.edu/craftcampus/Climatefootprint.htm (accessed March 17, 2008).

An excerpt of a table from Yale University's GHG Inventory report demonstrating different levels of uncertainty[5]:

Table 5.2 Summary of YCI GHG Inventory, 2002

TIER	Description	WRI Category	GHG Emissions Best Estimate	Percentage of total Emissions	Uncertainty (High)	Uncertainty (Low)	GHG emissions (High)	GHG emissions (Low)
			Tons CO_2e	%	%	%	Tons CO_2e	Tons CO_2e
Tier 1	*Power plants*							
	Central power plant	Scope 1	120,655	42.4%	14%	-14%	137,592	104,092
	Pierson-Sage power plant	Scope 1	194	0.1%	15%	-15%	224	164
	Sterling power plant	Scope 1	78,473	27.6%	10%	-10%	86,033	70,929

[5] Buttazzoni, Marco, Kathleen Campbell, Brandon Carter, Seth Dunns, Trish Eyler, WoonKwong Liew, Elizabeth Martin, Nalin Sahni, and Kate Zyla. 2005. "Inventory and Analysis of Yale University's Greenhouse Gas Emissions." Working Paper Number 7. Yale University. Yale School of Forestry and Environmental Studies. Yale Climate Initiative. www.aashe.org/resources/ghg_inventories.php (accessed March 18, 2008).

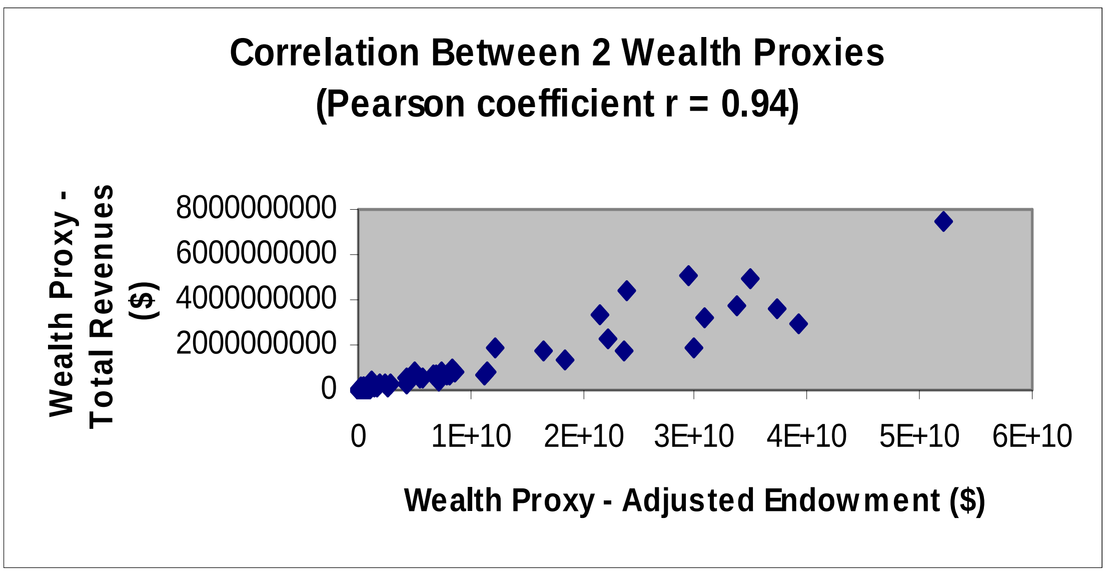
Appendix D

IPEDS Variables Used to Constrict Two Wealth Proxies			
FASB variables		GASB variables	
1. Wealth Proxy - Cash Flow-Adjusted Endowment			
Endowment	*F2H02*	Endowment	*F1H02*
Appropriations: • Federal • State • Local	*F2D02* *F2D03* *F2D04*	Appropriations: • Capital • Federal • State • Local	*F1B20* ***F1B10*** ***F1B11*** ***F1B12***
Grants & Contracts: • Federal • State • Local	*F2D05* *F2D06* *F2D07*	Operating grants and contracts • Federal • State • Local	***F1B02*** ***F1B03*** ***F1B04***
Private gifts, grants, and contracts	*F2D08*	Capital grants and gifts	*F1B21*
		Non-operating grants • Federal • State • Local	***F1B13*** ***F1B14*** ***F1B15***
		Gifts, including contributions from affiliated organizations	***F1B16***
2. Wealth Proxy - Total Revenues			
Total revenues and investment return	*F2D16*	Total All Revenue and Other Additions	*F1B25*

Pearson Correlation Between Two Wealth Proxies

		TOTAL REVENUES	TOTAL ADJUSTED ENDOWMENT
TOTAL REVENUES	Pearson Correlation	1.000	.947**
	Sig. (2-tailed)		.000
	N	96.000	96
TOTAL ADJUSTED ENDOWMENT	Pearson Correlation	.947**	1.000
	Sig. (2-tailed)	.000	
	N	96	96.000

**. Correlation is significant at the 0.01 level (2-tailed).



Appendix E

Table E-1. Descriptive Statistics for the Total Sample.				
Total Values	**Total Emissions in a Reported Year** (MTCO2-e)	**Total Revenues/1000**	**GSF/1000**	**FTE**
Average	59,936	$688,517	4,144	9,996
Max	431,651	$7,488,944	22,300	63,501
Min	673	$7,814	135	547
Total	5,753,853	$66,097,643	397,837	959,579
Values Normalized by Student	**Emissions per Student** (MTCO2-e per FTE)	**Revenues/Student** ($/FTE)	**Campus Density** (GSF/FTE Student)	
Average	6	$66,141	451	
Max	96	$752,614	2,754	
Min	0.44	$9,637	63	
Values Normalized by GSF	**Emissions per GSF** (MTCO2-e per GSF)	**Revenues/GSF** ($/GSF)		
Average	12,079	$119		
Max	34,784	$430		
Min	1,299	$38		

Table E-2. Descriptive Statistics for the Total Sample Controlled For Research Activity and Institutional Control (separately).							
Average Values	**Non-Research** (63 IHE)	**Research** (33 IHE)	**Factor** (research/non-research)		**Public** (67 IHE)	**Private** (29 IHE)	**Factor** (private/public)
Total Emissions	13,994	147,643	10.6		53,818	74,071	1.4
Emissions/FTE	6	8	1.3		5	10	2.0
Emissions/GSF	10,767	14,583	1.4		11,632	13,113	1.1
FTE	4,581	20,333	4.4		11,920	5,551	0.5
Revenue/1000	123,748	1,766,713	14.3		486,835	1,154,473	2.4
Revenue/FTE	49,466	97,974	2.0		41,912	122,118	2.9
Revenue/GSF	98	158	1.6		105	151	1.4
GSF/1000	1,218	9,731	8.0		4,056	4,347	1.1
Campus Density *(GSF/FTE)*	421	508	1.2		321	751	2.3

Table E-3. Descriptive Statistics for the Total Sample Broken into 4 Institutional Cohorts.

Average Values	**Non-Research Public** (43 IHE)	**Non-Research Private** (20 IHE)	**Research Public** (24 IHE)	**Research Private** (9 IHE)
Total Emissions	11,091	20,236	130,371	193,703
Emissions/FTE	4	8	5	15
Emissions/GSF	10,687	10,940	13,323	17,942
FTE	5,597	2,396	23,247	12,561
Revenue/1000	107,265	159,185	1,166,897	3,366,224
Revenue/FTE	40,033	69,748	45,279	238,493
Revenue/GSF	100	92	112	281
GSF/1000	999	1,687	9,534	10,258
Campus Density *(GSF/FTE)*	279	726	396	807