ECSU's Computational Science - Scientific Visualization Center

http://cssvc.ecsu.edu

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

Computational Science - Scientific Visualization

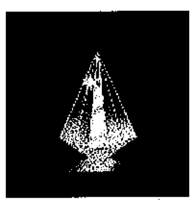
Algorithms
(Computational Modeling)
(Numerical Methods

Applications
(Science / Technology)

Architecture
(Computer Programming)
(Computer Visualization)

"A Scientific Resource Center for the School of Mathematics, Science & Technology"

The CSSV Center is a Center specializing in "an interdisciplinary approach to research, problem solving and visually displaying of data in the mathematical sciences, natural sciences and technological applications." The Center provides user friendly support services for students and faculty who are pursing research or educational endeavors which make significant uses of computational mathematics-numerical methods, mathematical modeling, high performance computer programming, using specialized computer application packages, and/or computer visualization tools and techniques.



"The mind is not a vessel to be filled but rather a flame to be ignited; when permitted to reach its potential, it is like a polished diamond radiating magnificent light"

(ECSU's CSSV CENTER)
The School of Mathematics, Science and Technology
Elizabeth City State University
Elizabeth City, North Carolina 27909; USA
URL: http://cssvc.ecsu.edu;

Johnny L. Houston, Ph.D.; Director
Senior Research Professor, jlhouston@mail.ecsu.edu
Dept. of Mathematics and Computer Science

Farrah J. Chandler, Ph.D.; Associate Director
Associate Professor - fjchandler@mail.ecsu.edu
Dept. of Mathematics and Computer Science

Randolph Harris, Technology Specialist

Voice: (252) 335-3272/335-8549/335-3361; FAX: (252) 335-3651

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

Weekly Schedule

for

ECSU's Computational Science - Scientific Visualization Center [ECSU's CSSV Center]

"A Scientific Resource Center
for
ECSU's School of Mathematics, Science and Technology"

Located in Room 138, Lane Hall, ECSU

Monday - Friday:	**9:00 am - 5:00 pm**
Evenings and Weekends:	**By Appointments Only**

ECSU's COMPUTATIONAL
SCIENCE-SCIENTIFIC VISUALIZATION CENTER

Johnny L. Houston, Ph. D.
Director

Senior Research Professor
jlhouston@mail.ecsu.edu

Farrah J. Chandler, Ph.D.
Associate Director

Associate Professor
fjchandler@mail.ecsu.edu

Mr. Randolph Harris
Technology Specialist

Technology Specialist
rharris@mail.ecsu.edu

Voice: (252) 335-3272/335-8549/335-3361; FAX: (252) 335-3651

ECSU's Computational Science - Scientific Visualization Center
http://cssvc.ecsu.edu

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

Computational Science - Scientific Visualization

Applications
(Science / Technology)
(Computational Modeling)
(Numerical Methods)

Algorithms

Architecture
(Computer Programming)
(Computer Visualization)

What is Computational Science - Scientific Visualization?

Computational Science-Scientific Visualization is an approach to the study of scientific and real world phenomena by extensive use of Computational/ mathematical modeling, numerical methods and simulation; as well as computer programming and computer visualization techniques. Computational Science-Scientific visualization is not an academic area of study itself. Instead it is a methodology used to study any number of academic discipline areas; especially those that encounter situations involving large or complex data or phenomena which needs to be analyzed, interpreted or visually displayed. Computational Science-Scientific Visualization works well in four major areas of investigations; those involving phenomena or data items considered to be:

(A) Too Small/ Too Large

(B) Too Fast/ Too Slow,

(C) Too Complex

(D) What if?

**Today's high-performance computers, combined with better understanding of computing environments as well as advances in computer graphics- computer visualization, have permitted the emergence of Computational Science -
Scientific Visualization (CSSV), which has put the solving of many formally intractable problems/investigations within our reach.**

YEAR-ROUND RESEARCH ACTIVITIES OCCURING IN ECSU's CSSV CENTER

A. Academic Year Faculty Research
A Research Project in Computational Science is pursued by two or more Faculty members each academic year in the CSSV Center.

B. Academic Year Student Research Teams
Two or more different student teams pursue research activities in the CSSV Center each year.

C. Academic Year CSSV Center Visiting Scientists Seminar - Colloquium Series
During the Academic Year approximately eight (8) visiting scientists are invited to ECSU's School of Mathematics, Science & Technology to make a scholarly seminar or colloquium presentation involving Computational Science - Scientific Visualization activities; while visiting they relate to faculty and students interested in research in their area of expertise.

D. Academic Year Faculty Education/Training Workshops
During the Academic Year, the CSSV Center provides educational training for faculty and students in CSSV on a monthly basis (upon request). In the Spring of the year Faculty Workshops in CSSV are provided for some fifteen (15) to twenty-five (25) faculty participants during a Regional Conference.

E. Summer Research Institute in Computational Science - Scientific Visualization
An Institute is held during the last two weeks in May each year in the CSSV Center. Three-five teams, consisting of three - five students and one - two faculty mentors develop research projects during the Institute.

F. Summer Session Faculty/Student Research Projects
A Research Project in Computational Science is pursued by one or more faculty members each summer at the CSSV Center. Moreover, two-four students develop research projects with a faculty member each summer in the CSSV Center.

G. Extramural Summer Faculty/Student Research Projects
Two or more faculty members related to the CSSV Center are involved in extramural research projects each summer. Moreover, at least six students are involved in extramural research summer projects each summer.

H. Monthly, Technical and Research Support
The CSSV Center provides Technical and Research Support for ECSU faculty and students in the School of Mathematics, Science & Technology as well as for Science and Mathematics Faculty at NAM Institutions.

ACTIVE RESEARCH TEAMS IN THE CSSV CENTER

Research Team A: Numerical Methods, Algorithms and Visualization for Solving Systems Of Equations

Faculty Leaders: J. L. Houston

- Using Computational Methods to solve systems of equations, using iterative methods.
- Using Computational Methods to solve systems of partial differential equations, using multi-grid techniques.
- Using Computational Methods to solve systems of equations of various types.

Research Team B: Computational Modeling of Optimization Problems

Faculty Leaders: J. L. Houston, Farrah Chandler and Andrea Lawrence

- Using Computational Techniques to solve and model optimization problems in one variable.
- Using Computational Techniques to solve and model optimization problems in several variables.

Research Team C: Computational Modeling of Probabilistic and Statistical Data

Faculty Leaders: J. L. Houston, A. Lawrence, and F. Chandler

- Using Computational Techniques to model and analyze probabilistic behavior.
- Using Computational Techniques to model and analyze statistical data.

Research Team D: Numerical Modeling of Data Using Searching and Sorting Techniques

Faculty Leaders: J. L. Houston and Andrea Lawrence

- Using Computational Techniques to search and organize data.
- Using Computational Techniques to sort and display data.

Research Team E: Pattern Recognition in Genomic Data

Faculty Leaders: J. L. Houston

- Using Computational Science Techniques to search Genomic Data for patterns and exceptions to patterns.
- Using Computational Science Techniques to search for rare phenomena, unexpected patterns and outliers.

Research Team F: Data Mining and Visualization of Data

Faculty Leaders: J. L. Houston, Andrea Lawrence and Farrah Chandler

- Using Computational Science Techniques to analyze data for association and influences.
- Using Computational Science Techniques to guide what to visualize and how to visualize it.

ECSU's Computational Science - Scientific Visualization Center
http://cssvc.ecsu.edu

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

ELIZABETH CITY STATE UNIVERSITY
SCHOOL OF MATHEMATICS, SCIENCE AND TECHNOLOGY
Announces

Research Week 2008

February 4 – 8, 2008

Theme: Enhancing Research, Education and Outreach

All units in the school of MST will be participating in one or more of the following ways......

- A motivating look at ECSU faculty research & scholarly activities
- Colloquium presentations by well-known scientists and researchers
- Displays and posters from various departments and agencies
- Pre-College & Community College session
- Student Science Bowl Competition
- Student research poster session
- Panel presentations
- Research fair

For more information or to learn how to participate please contact:

Dr. Ronald Blackmon, Vice Chancellor for Academic Affairs, (252) 335-3710, rhblackmon2@mail.ecsu.edu
Dr. Cynthia Warrick, Dean of the School of Mathematics, Science and Technology, (252) 335-3189, cawarrick@mail.ecsu.edu
Dr. Linda Bailey Hayden, Associate Dean of the School of Mathematics, Science and Technology, (252) 335-3696, haydenl@mindspring.com

****

Announcing Applications Available for

ECSU - NAM's 2008 Computational Science Workshop Mini-Grants to attend Computational Science Workshops at NAM's 2008 Regional Faculty Conference on Research and Teaching Excellence; April 4 – 5, 2008

Hosted by Bennett College, Greensboro, NC

Faculty Education / Research Training Workshops will be conducted in Computational Science—Scientific Visualization

For application for Mini-Grant, see page 8.

ECSU's Computational Science & Scientific Visualization Center

http://cssvc.ecsu.edu

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

ECSU - NAM 2008 SUMMER RESEARCH INSTITUTE IN COMPUTATIONAL SCIENCE-SCIENTIFIC VISUALIZATION

May 12 – 23, 2008

This Institute is an intense two-weeks program where participants learn research skills by tutorials, presentations by experts and by actual research experiences.

The Institute's focus is:

"To Explore and Engage in Research Activities that are of interest to DoE and To Enhance Increased Involvement and Productivity in future DoE Related Research."

The Institute is designed to enhance the research skills of students for summer internships and graduate study.

Sponsored by Elizabeth City State University's CSSV Center and the National Association of Mathematicians, Inc. (NAM) and with funding support from the Dept. of Energy (DoE).

Participation Limited: 20 students, 4 faculty; application-selection-acceptance required. Conference participants will receive lodging, a food allowance for meals and a $500 stipend (students). A stipend will also be provided to faculty participants. (A maximum of $300 is provided for travel to and from the Institute.)

Computational Science - Scientific Visualization

Applications
(Science / Technology)

Architecture
(Computer Programming)
(Computer Visualization)

Algorithms
(Computational Modeling)
(Numerical Methods)

A. **Length of Time:** Two (2) Weeks
B. **Institute Dates:** May 12 - 23, 2008
C. **Generic Institute Structure:** Tutorials -Lab Assignments-Presentations-Project Dev.
D. **Participants:** Twenty (20) Student Mathematics/Computer Science Majors, Four (4) Mathematical Sciences Faculty Mentors - Team Leaders, {Four (4) Research Teams; 5 students - 1 faculty, per team}

For application/information, contact Johnny L. Houston at (252) 335-3361, Fax: (252) 335-3280 (email: jlhouston@mail.ecsu.edu or visit the CSSV Center Website http://cssvc.ecsu.edu

NAM's 2008 Regional Faculty Conference On Research and Teaching Excellence

Hosted by Bennett College, Greensboro, NC, April 4-5, 2008

Application - Registration for Conference/Mini - Grant Support

For Mini-Grant Support Consideration, Please Return By March 7, 2008

Please Print in Ink or Type the Following Information:

Name (Dr.__ Prof. __ Mr. __ Mrs.__ Ms.__) ____________________

Position ____________________ Institution ____________________

(Please use address where you would like Conference information to be mailed)

Mailing Address ____________________

City____________________ State______ Zip Code __________

Telephone: Day ( )____________________ Evening ( )____________________

E-Mail ____________________ Fax Number ( )____________________

Application for ECSU – NAM Computational Science Workshop Mini-Grant Support ($400.00 per applicant)

Please complete the section below **only** if you are requesting a Mini Grant for Conference Support.

Conference Grant Support is designed to cover travel, lodging, food and registration.
Persons requesting grant support should include a one page letter/application stating how this conference would enhance them professionally.

For selected participant, the Participant will receive a check for $400.00 for travel and lodging.

Travel Support

Travel support covers a maximum of $300 for an economical round-trip airfare, a rental car or for the use of a personal car up to this amount at a rate of $.40 per mile.

I will travel (check one): ____ by car _____ by air ___other

My airport and city of departure ____________________

Lodging Support - Local Travel

Lodging support – local travel covers a maximum cost of $100.00. Colleagues who desire to share a room are encouraged to submit both applications together and should arrange your reservations accordingly.

Signature ____________________ (Required for funding)

SSN ____________________(Required for funding)

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

ECSU-NAM 2008 STUDENT RESEARCH INSTITUTE IN COMPUTATIONAL SCIENCE-SCIENTIFIC VISUALIZATION May 12, 2008—May 23, 2008 STUDENT APPLICATION

NOTE: Funding guidelines require participants to be U.S. citizens or permanent residents. This Institute is designed for rising seniors and graduating seniors who plan to do an internship during the summer of 2008 and who plan to attend graduate school after graduation.

To apply, you should be at least a junior (2007-2008 Academic year) with a GPA of 3.0 or higher:

(a) complete this form
(b) briefly describe (on the back) your mathematics/computer science interests and career goals
(c) send a copy of your current college transcript (unofficial copy is acceptable)
(d) include one letter of reference (from a mathematics/science professor) with your application.

The complete application, along with required materials, should be sent by **April 9, 2008** to:

The CSSV Center
Elizabeth City State University
Campus Box 959
Elizabeth City, North Carolina 27909
Fax: (252) 335-3651 Alt. Fax: (252) 335-3487

Name ____________________
Social Security Number ____________ Birth Date ____________
Expected date of graduation ____________ Current/Exptected GPA ____________
Name of your Institution ____________________
College Phone Number ____________ Home Phone Number ____________
College Address ____________ City ________ State ________ Zip ________
Home Address ____________ City ________ State ________ Zip ________
Email Address ____________________
2008-2009 Fall Semester Classification: # of hours earned by May 2008 ____________

Name, address and phone number of person writing reference (should be a college math/science professor who has taught you)

Name ____________ Phone Number ____________
Institution ____________________
Address ____________________

Please provide the following information (applicant):

Gender: ☐ Male ☐ Female

Race: ☐ African America ☐ Hispanic American ☐ Native American ☐ Asian American ☐ Caucasian ☐ Other

Deadline: April 9, 2008
Page 2, Student Application

I. Classes Completed: Give titles of college mathematics/computer science courses completed by 5/15/08.

II. Career Goals: Briefly describe your mathematics/science interests and career goals.

III. 2008 Summer Plans: What are your plans for the summer of 2208 between 6/1/08 & 8/15/08?

IV. Do you plan to do a 2008—2009 academic project?

V. What discipline area do you plan to study in graduate school?

Signature ______________________________ Date ______________________

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

The CSSV Center's Visiting Scientist Seminar – Colloquium Series

The School of Mathematics, Science, and Technology

As a method to heighten awareness of different kinds of scientific knowledge, to stimulate research interest in different knowledge areas, to provide experts to dialogue with ECSU/NAM's institutions researchers, and to permit students to relate to external role models in different areas of mathematics, science, and technology, there is a monthly Visiting Scientists / Seminar-Colloquium Series. For four months during the fall semester (August – November) and four months during the spring semester (January – April), plans and arrangements are made to have a visiting scientist to come to the campus of Elizabeth City State University to make a seminar presentation for a large and varied audience and possibly one or two specialized lectures for a smaller audience. As often as feasible, the visit is one that a professional, a researcher, group of researchers (at ECSU or at some NAM institution) or a discipline area (at ECSU) would be interested in having a dialogue. The monthly seminar-colloquium presentations are scheduled for Thursday afternoons so that the Visiting Scientists may arrange to spend 1-3 days during a visit. During the summer months visiting scientists are invited to present to the Summer Institute participants. On the website **http://cssvc.ecsu.edu**, one may learn additional details by selecting Colloquium Series link from the menu and then selecting the desired year. .

Academic Year 2007 - 2008, Summer 2008
Academic Year 2006 - 2007, Summer 2007
Academic Year 2005 - 2006, Summer 2006
Academic Year 2004 - 2005, Summer 2005
Academic Year 2003 - 2004, Summer 2004
Academic Year 2002 - 2003, Summer 2003
Academic Year 2001 - 2002, Summer 2002
Academic Year 2000 - 2001, Summer 2001
Academic Year 1999 - 2000, Summer 2000
Academic Year 1998 - 1999, Summer 1999

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

Elizabeth City State University

Dr. Cynthia Warrick, Dean of the School of Mathematics, Science and Technology

On behalf of the Students, Faculty & Staff in the School of Mathematics, Science and Technology, I would like to thank all participants of Research Week 2008 at Elizabeth City State University. This year's theme, "Enhancing Research, Education and Outreach" promotes research and learning through partnerships with Academic Alliances, State and Federal Agencies, Private Industry community.

Research Week 2008 was funded by a grant from the North Carolina Space Grant Informal Education and Public Outreach Program. Through NC Space Grant Funding we were able to bring Dr. Bernard Harris as our key note speaker on Friday, February 8. He will address more than 400 undergraduate and local high school students and talk about his motivation on becoming a physician, astronaut, as the first African American to walk in space. We want to acknowledge NC Space Grant for their support and participation in making this year's event a huge success.

We also want to acknowledge support from The Federation of American Societies for Experimental Biology (FASEB) Minority Access to Research Careers (MARC) Visiting Scientist Program that is funding the presentations by Dr. Howard G. Adams on Tuesday, February 6. Dr. Adams will address ECSU undergraduate students on choosing graduate school and he will also address the ECSU faculty on "How to Mentor Students."

The Department of Energy funded Computational Science – Scientific Visualization Center (CSSV) provided the support to bring Dr. Leona Harris from the College of New Jersey Department of Mathematics & Statistics. Dr. Harris will share her research on modeling the fate and transport of human exposure to perfluorinated chemicals in the environment.

The ECSU Component of the Virginia – North Carolina Louis Stokes Alliance for Minority Participation (VA-NC LSAMP) program and The Center of Excellence in Remote Sensing Education and Research's aim is to increase the number of underrepresented minorities in Science, Technology, Engineering & Math (STEM). VA-NC LSAMP and The Center of Excellence in Remote Sensing Education and Research also contributed resources to support student researcher participation in Research Week 2008.

Our Annual Research Fair will bring over 15 graduate programs and organizations to share information about graduate study, research opportunities and summer internships spanning from North Carolina and Virginia to Georgia, Florida, and Texas. Research Week 2008 demonstrates the collaborations and partnerships that the ECSU School of Mathematics, Science & Technology has developed and nurtured over the years.

Because February is Black History Month, Research Week 2008 celebrates the accomplishments of African Americans and HBCU scientists who have made significant contributions in math, science and technology. Our goal is to enhance excitement and enthusiasm about science to our students, faculty, partners, and especially to the local community and future students at Elizabeth City State University, to create new knowledge to improve the lives of our residents through academic excellence, economic development and collaborative research partnerships.

ECSU's Computational Science - Scientific Visualization Center

http://cssvc.ecsu.edu

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

Research Week - Schedule of Events

Monday, February 4, 3-5:00 pm
MST Panel Presentation
Room 206, Student Union Center
Presiding - Dr. Gary Harmon
Welcome - Dr. Ronald Blackmon
The Occasion—Dr. Cynthia Warrick

"Major African American Contributors in Mathematics, Science and Technology"

African-American Contributions Panelist:
Farrah Chandler (Math/Computer Science)
J. Anthony Sharp (Technology/ Aviation)
Josiah J. Sampson, III (Biology)
Guana Dixon (Physics)
Anthony Emekalam (Pharmacy)

Tuesday, February 5, (two sessions)
Mentoring and Graduate School Seminars
Dr. Howard Adams
H. G. Adams and Associates, Inc.

"Why You Should Choose Graduate School"
11 am - 12:20 pm (student session)
Room 206 Student Union Center
Presiding - Dr. Linda Hayden
Welcome - Dr. Cynthia Warrick
Introduction of Speaker - Dr. Ali Khan

"How To Mentor Students"
2—3:30 pm (faculty session)
Room 138 Jenkins Science Center
Introduction of Speaker: Dr. Margaret Young

Wednesday, February 6, 3 - 4:00 pm
Room 206 Student Union Center
Presiding - Dr. Mehran Elahi
Welcome - Dr. Cynthia Warrick

Wednesday, February 6, 3 - 4 pm (continued)
Introduction of Speaker -
Dr. Johnny Houston/Dr. Farrah Chandler

Dr. Leona Harris
The College of New Jersey, Department of Mathematics and Statistics
"Modeling the Fate and Transport of a Common Household Chemical in the Body Following Oral Exposure"

Thursday, February 7
Room 206 Student Union Center
Research & Graduate School Fair
11 am - 4 pm Student Poster Displays
Presiding - Dr. Jayfus Doswell

MST Science Bowl Competition
2:00 - 3:30 pm
Presiding— Dr. H. Leon Pringle

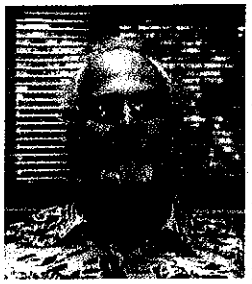
Friday, February 8
Presiding - Dr. Darnell Johnson
Welcome - Dr. Willie Gilchrist
Introduction of Speaker -
Dr. Cynthia Warrick

Demonstrations - 9 - 11 am
Virginia Air and Space Center
K. E. White Graduate Center

Dr. Bernard Harris
"An Astronaut's View: The Power of the Dream"
11:30 am - 1 pm
Mickey L. Burnim Fine Arts Center

ECSU's Computational Science - Scientific Visualization Center
http://cssvc.ecsu.edu
2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

2007— 2008 Seminar/Colloquium Series



September 2007

"The Application of Photonics to Biosciences and Medicine" by Dr. Dennis Matthews

Abstract: In this presentation the presenter discusses several research projects and associated applications of photonic to science and medicine. There will also be a discussion of how the various projects at the University of California – Davis' Center for Biophotonics Science and Technology, especially discussing how college students, graduate school students, and external professionals are involved in their implementation.

Brief Bio: Dr. Matthews is Program Leader for the Medical Technology Program at Lawrence Livermore National Laboratory as well as professor within the UC Davis Department of Applied Science and School of Medicine. He is also an Associate Director of the UC Davis Integrated Cancer Program. He received his Ph.D. in Physics in 1974 from the University of Texas at Austin. Dr. Matthews is an expert on the radiative properties of ions in plasmas as well as in the conversion of laser light into X-rays. Dr. Matthews has also worked for short periods at the Hahn Meitner Institut in Germany, Rutherford-Appleton Laboratories in Great Britain, the University of Paris-Orsay and the Centre d'Etudes de Limeil-Valenton in France. He directly supervises ~50 scientists, engineers, 8 graduate students, a 25 student summer intern program and 8 other support staff. Dr. Matthews is responsible for the development of industrial and medical applications of Lawrence Livermore National Lab Technology, especially for the prevention, screening, diagnosis and treatment of diseases such as diabetes, stroke, brain trauma, chronic pain and cardiovascular disease. Dr. Matthews is also responsible for founding a biomedical technology stem of research and teaching curriculum within the Department of Applied Science. Current projects and those already successfully transferred to industry include: an opto-acoustic recanalization device for treating ischemic stroke; a miniature x-ray source which is mounted on a microcatheter and used to treat coronary artery restenosis; micropower impulse radar for numerous medical diagnostics including differentiating hemorrhagic vs. ischemic stroke; an implantable, continuous glucose monitor and ultra-short-pulse laser microsurgery devices. Dr. Matthews is a co-Principal Investigator on a Department of Energy funded Center of Excellence for Application of Lasers to Medicine and on a NIH Unconventional Innovations Program Grant to Develop Compact Light Sources for Mammography and Radiotherapy.

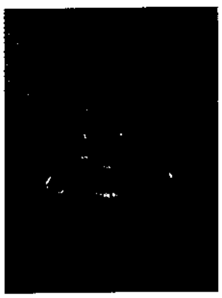
"Research and Professional Services in Private Industry" by Dr. Mave T. Houston,

Abstract: In this presentation the presenter will discuss research professional services. How these services are provided on a contract basis by (usually licensed) professionals – software development, accounting, law, engineering, management consulting, etc. – and are often offered by limited partnerships, where customers are clients and companies are firms. Specific discussions will be directed as to how computer science and engineering graduates can effectively serve in research centers for private industry.

Brief Bio: Dr. Mave T. Houston is a User Experience Researcher for the Center for Advanced Research at PriceWaterhouseCoopers in San Jose, CA. She is responsible for ensuring that her project development adheres to a User Centered Design process. Her role includes testing the usability of current research prototypes and determining how to make the software more efficient and effective for users. While completing a Postdoctorate at IBM Almaden Research Center in San Jose, CA, she conducted numerous user studies involving Ethnographic Coding and Analysis, benchmarking, and video coding. Her work centered around making sense of large document collections and she is well-versed in visualization techniques as they relate to the sensemaking of complex information for business and government intelligence analysis. Dr. Houston received her doctoral degree in Computer Science and Software Engineering in 2005 from Auburn University, where she was an active member of the Intelligent and Interactive Systems Group. She received her Master of Science degree in Computer Science and Computer Engineering from Auburn University in 1997,and her Bachelor of Science Degree from Spelman College in 1995.

2007 - 2008 Newsletter, Volume I: September 2007 - February 2008

2007— 2008 Seminar/Colloquium Series



February 2008

"Modeling the Fate and Transport of a Common Household Chemical in the Body Following Oral Exposure"

Dr. Leona Harris, The College of New Jersey,
Department of Mathematics and Statistics

Abstract: Perfluorooctane sulfonate (PFOS), a member of a class of perfluorinated chemicals used in a variety of consumer products as oil, water, and grease repellants, has been shown to be toxic in laboratory animals. Because PFOS has also been shown to be widely distributed throughout the environment, there have been growing concerns about its potential health risk to humans. The mathematical model to be presented describes the pharmacokinetics (absorption, distribution, metabolism, and elimination) of PFOS in the body following single and repeated oral exposures and provides a framework for dose-response analyses needed to help assess the risk that exposure to PFOS might have on human health and the environment.

Brief Bio: Dr. Leona A. Harris attended Spelman College in Atlanta, Georgia where she participated in the Scholars in Mathematics at Spelman Program. She graduated magna cum laude from Spelman in 1995 with a B.S. in Mathematics, and earned her M.S. and Ph.D. in Applied Mathematics from North Carolina State University in 1999 and 2001, respectively. After completing her postdoctoral work in August 2004 at the National Health and Environmental Effects Research Laboratory of the U.S. Environmental Protection Agency (EPA), she joined the faculty at Bennett College as an Assistant Professor of Mathematics. In 2005, Dr. Harris was given the honor of presenting the MAA-NAM David Blackwell Lecture on her research at Mathfest in Albuquerque, New Mexico. In August 2006, Dr. Harris joined the faculty at The College of New Jersey as an Assistant Professor of Mathematics. Dr. Harris specializes in Mathematical Biology and has continued her work with EPA scientists in the National Center for Computational Toxicology. Her current research involves the development and utilization of mathematical models that describe the fate of a toxic chemical in the body following some sort of external exposure to the chemical (e.g. inhalation, ingestion).

March 2008

"Proximity of Weighted and Exponential Distributions"

Dr. Broderick O. Oluyede, Georgia Southern University,
Department of Mathematical Sciences

Abstract: Weighted distributions occur in a wide variety of settings including biometry, reliability, and stochastic processes. In this talk, results on proximity of weighted distributions and exponential distributions in the class of distribution with monotone hazard functions are presented. Some moment-type inequalities and applications are presented.

Brief Bio: Dr. Broderick O. Oluyede has been an Associate Professor of Mathematics and Statistics at Georgia Southern University since 2000. He received his Ph.D. in Mathematics, with a concentration in Statistics, in 1991, from Bowling Green State University. His research interests include survival analysis, categorical data analysis, order restricted inference, statistical computing, and multi-

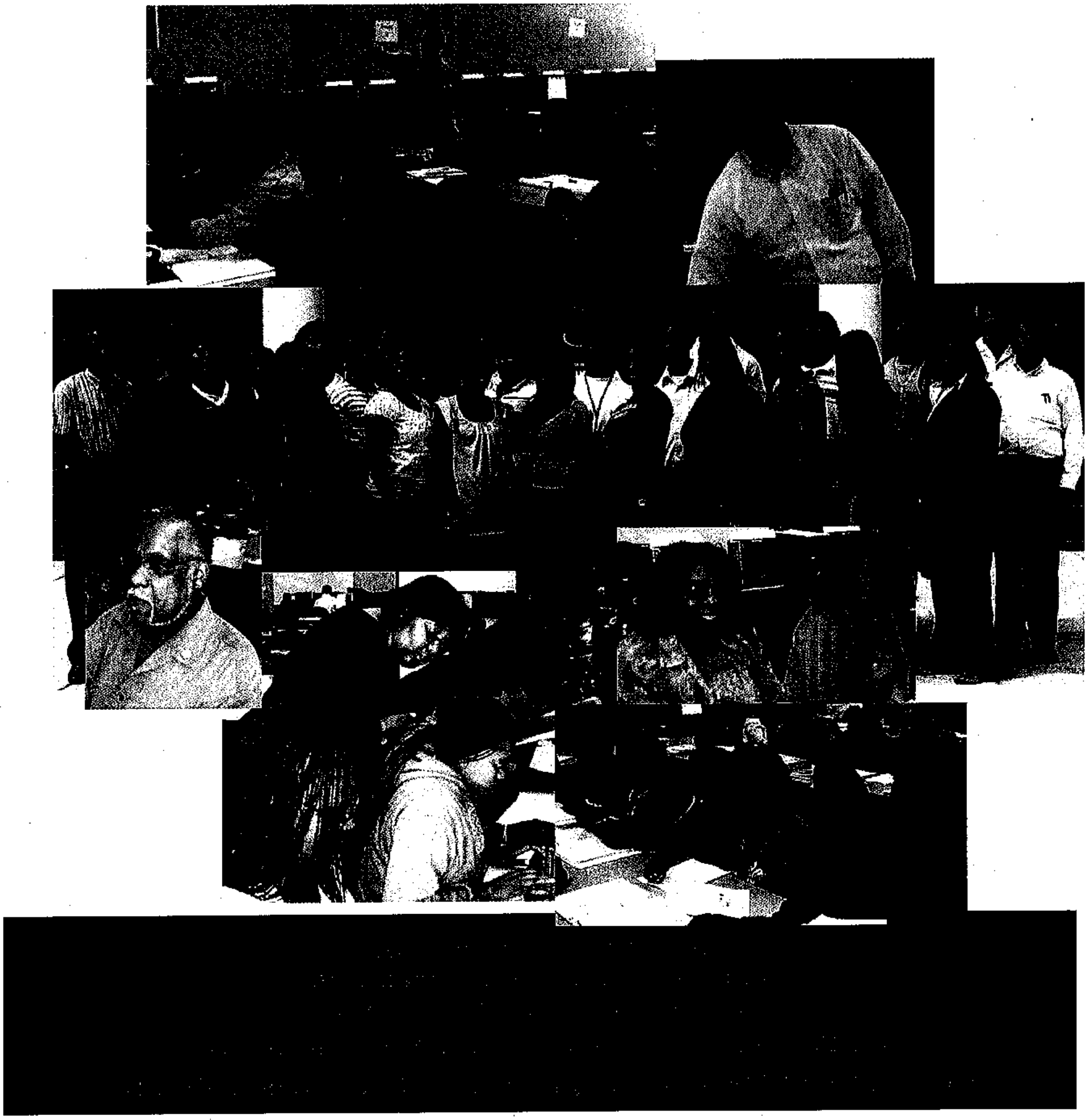
To find more details about other activities associated with ECSU's Computational Science - Scientific Visualization Center and/or activities sponsored by the Center, please visit the URL below:

http://cssvc.ecsu.edu

****

Volume II

PROCEEDINGS
OF THE
COMPUTATIONAL SCIENCE – SCIENTIFIC VISUALIZATION 2008 SUMMER RESEARCH INSTITUTE



MAY 12 – 23, 2008

Table of Contents

An Investigation of Possible Effects of Global Warming on Forest Fires in Kentucky from 1945 to 2004

Samuel J. Ivy
Morehouse College
Samj_ivy@yahoo.com

Ashley J. Sullivan
Spelman College
ajsullivan88@aol.com

Kevin Wingfield
Morehouse College
kwingfie@students.morehouse.edu

Jamika Baltrop
Elizabeth City State University
jmbaltrop@yahoo.com

Amanda Eure
Winston-Salem Sate University
aeure106@wssu.edu

ABSTRACT

This investigation seeks to find a relation between the frequencies of forest fires with acreage burned in the state of Kentucky and the factors of global warming. Under global warming, we focus on the components climate change and precipitation rate in hopes of establishing this relationship. In delving deeper into the effects of forest fires, or wildfires, we explore a mathematical model offered as a solution to optimally contain these disasters while minimizing the costs of resources and eventually recovery.

NOMENCLATURE

Symbols

t,	time where $t > 0$
$R(t) \subset \mathbb{R}^2$,	burned or contaminated region
$\mathbb{R}^2$,	two-dimensional
$F: \mathbb{R}^2 \to \mathbb{R}^2$,	the Lipschitz continuous function
$R_0 \subset \mathbb{R}^2$,	bounded set
$\dot{x} \in F(x)$,	reachable set for differential inclusion
$\dot{x}(0) \in R_0$,	initial position for differential inclusion
$\psi: \mathbb{R}^2 \to R_+$,	continuous & strictly positive function used to construct a one-dimensional rectifiable curve
$\gamma(t)$,	the portion of the wall constructed within time $t \geq 0$
σ	constant
$R^{\gamma}(t)$	reachable set determined by the blocking strategy γ
B_r	fixed ball centered at the origin with radius r.
Γ	adjacent arcs
F	free arcs
B	boundary arc

PURPOSE

The intent of this project is to investigate the relationship between the factors of global warming and the number of square acres burned in forest fires from 1945-2004 in the state of Kentucky.

Keywords
Forest Fires, Global Warming, Wild fires, Differential Inclusions.

1. INTRODUCTION

Each year millions of hectares of wild land worldwide are consumed by forest fires. From this it may seem that all forest fires are bad and unwanted, but this is not so. Forest fires are a natural and vital part of some ecosystems. Forest fires become problematic when they burn in the wrong places such as forested areas used for harvesting lumber or residential areas. When forest fires burn in these unwanted places, they become huge financial burdens on the federal and state governments. Due to the huge financial burdens imposed on state governments, the factors that increase the likelihood of more intense wild fires have moved to the forefront of the concerns of these governments.

According to a research paper [7] published in July 2006 by the journal *Science*, global warming is thought to be creating conditions that increase the likelihood of more intense wild fires. Through regression analysis and analysis of variance, we investigate some of the potential factors that may be leading to more intense wild fires throughout the state of Kentucky. In the section that follows we also investigate containment strategies for containing the spread of wild fires once they have begun using a method based on differential inclusions.

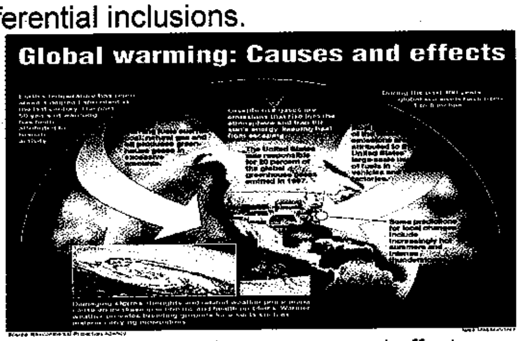


Figure 1: Global warming: causes and effects.

2. APPROACH TO SOLVING THE PROBLEM

In order to observe the relationship between global warming and forest fires several mathematical and statistical tools are used: regression analysis, ANOVA and differential inclusions. Regression analysis will yield a correlation between the particular factors of global warming and forest fires in the state of Kentucky. In addition, this analysis will lead to future predictions of the dreaded potentiality of global warming on forest fires in the state of Kentucky. A regression analysis of the data obtained (see appendix) for the number of acres burned will determine the impact of each global warming factor on the forest fires from 1945-2004. Under this investigation, we focus on the frequency of forest fires and acreage burned.

In the explanation of containing such wildfires, we use differential inclusions and optimization in calculating an optimal strategy of confining wild fires. A two dimensional differential inclusion is used to describe areas affected by fire and outside land used to seal the fires. In addition, an optimization problem is developed to eventually minimize resources, man power, and costs to prevent further forest fire expansion.

2.1 Graphical Representation

The data used is depicted as follows:

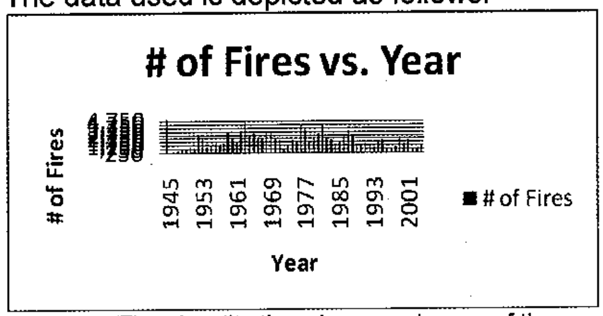


Figure 2: The visualization shows a change of the number of fires in Kentucky, ranging from 330 to 4,600 over the years of 1945 – 2004. The peak over this 60 year period was in 1963 with 4,579 fires. However, the smallest number of fires occurred in 1946 with 331 fires.

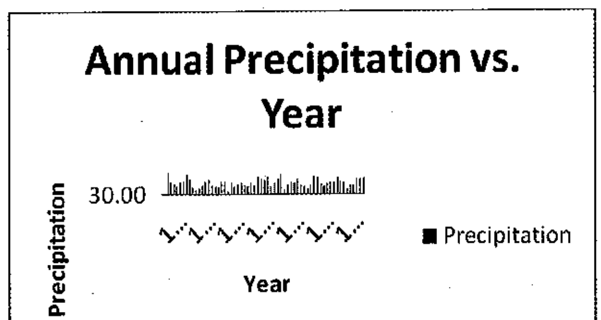


Figure 3: The visualization shows changes of annual precipitation in Kentucky, ranging from 34 to 63 inches over the years 1945 – 2004. The peak over this 60 year period was in 1950 with a precipitation of 62.93 inches. However, the smallest amount of precipitation occurred in 1963 at 34.45 inches.

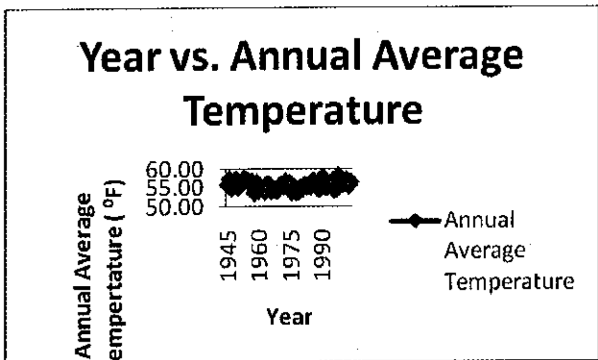


Figure 4: The visualization shows change of the annual average temperature, ranging from approximately 54 ^{0}F- 58 ^{0}F over the years of 1945-2004. The peak over this 60 year period was in 1998 where the annual average temperature was 58.25 ^{0}F and the lowest is 53.61 ^{0}F in 1958.

3. COMPUTATIONAL MODELING

3.1 Regression Analysis

3.1.1 Linear Regression Analysis: Sq. Acres Burned vs. Year

The regression equation is
Sq Acres Burned = 983113 - 458 Year

Predictor	Coef	StDev	T	P
Constant	983113	1695289	0.58	0.564
Year	-457.6	858.6	-0.53	0.596

S = 115172 R-Sq = 0.5% R-Sq(adj) = 0.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	37683227	37683227	0.28	0.596
Residual Error	58	7.69343E+11	13264529808		
Total	59	7.73111E+11			

Regression Analysis: Sq Acres Burned vs. Temperature

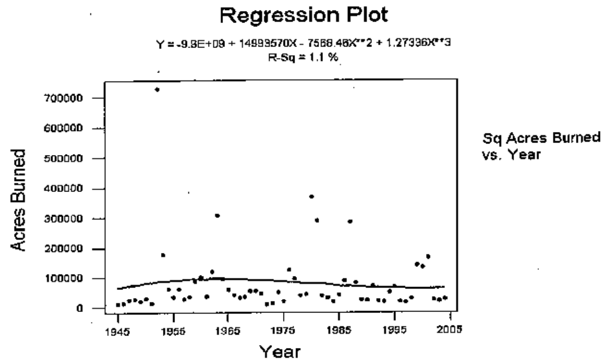


Figure 5: A cubic function of sq. acres burned over the years 1945-2005.

3.1.2 Linear Regression Analysis: Sq. Acres Burned vs. Temperature

The regression equation is
Number of Acres Burned = - 270077 + 6282 Annual Average Temperature

Predictor	Coef	StDev	T	P
Constant	-270077	737654	-0.37	0.716
Annual A	6282	13252	0.47	0.637

S = 115230 R-Sq = 0.4% R-Sq(adj) = 0.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	29842260	29842260	0.22	0.637
Residual Error	58	7.70127E+11	13278048717		
Total	59	7.73111E+11			

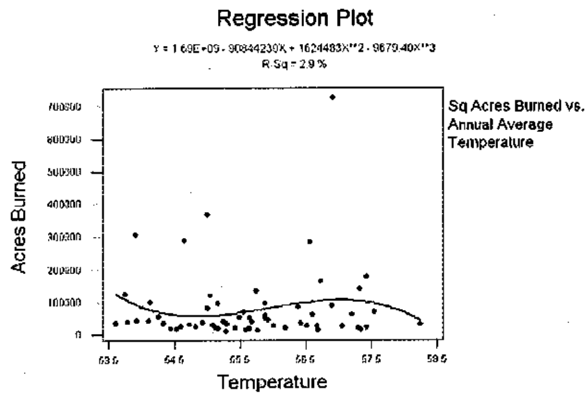


Figure 6: A cubic function of sq. acres burned as a function of temperature.

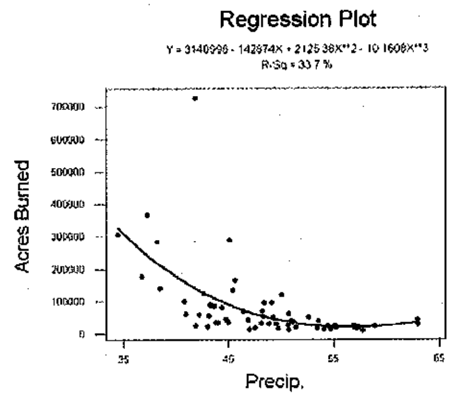


Figure 7: A cubic function of the number of sq. acres burned as a function of the annual precipitation.

3.1.3 Linear Regression Analysis: Sq. Acres Burned vs. Precipitation

The regression equation is
Number of Acres Burned = 517465 - 9073 Annual Precipitation

Predictor	Coef	StDev	T	P
Constant	517465	98998	5.23	0.000
Annual P	-9073	2034	-4.46	0.000

S = 99620 R-Sq = 25.5% R-Sq(adj) = 24.3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1.975E+11	1.975E+11	19.90	0.000
Residual Error	58	5.75597E+11	9924093455		
Total	59	7.73111E+11			

3.1.4 Linear Regression Analysis: Sq. Acres Burned vs. Precipitation and Temperature

The regression equation is
Number of Acres Burned = 238416 - 9051 Annual Precipitation + 4995 Annual Average Temperature

Predictor	Coef	StDev	T	P
Constant	238416	652471	0.37	0.716
Annual P	-9051	2049	-4.42	0.000
Annual A	4995	11541	0.43	0.667

S = 100325 R-Sq = 25.8% R-Sq(adj) = 23.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	1.993E+11	996993316	9.91	0.000
Residual Error	57	5.737E+11	10065129620		
Total	59	7.731E+1			

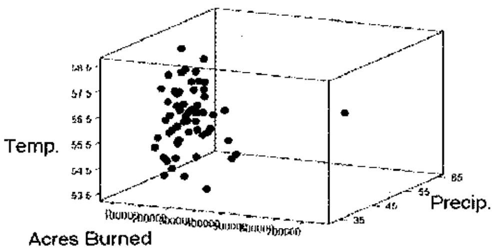


Figure 8: A 3-D scatter plot with the number of sq. acres burned along the y-axis, annual precipitation on x-axis and annual average temperature on the z-axis. The number of acres burned seam not to be affected with the temperature change.

3.2 ANOVA

3.2.1 ANOVA (5-yr. periods)

In order to determine if the means of the acreage burned in Kentucky over five-year periods are the same, we use a one-way analysis of variance (ANOVA). The average acreage burned during 1946-1950, 1951-1955…, 2001-2005 are tested using the hypotheses

$$H_0 : \mu_1 = \mu_2 = \ldots = \mu_{12}$$
$$H_a : \text{At least one } \mu_i \neq \mu_j .$$

Table 1: The output from the Data Analysis tool in Excel with five year period as a factor.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.58E+11	2	7.92E+10	7.339229	0.001458	3.158843
Within Groups	6.15E+11	57	1.08E+10			
Total	7.73E+11	59				

The P-value of the F-test is 0.419 and is more than 0.05 (for a 5% significance level). Therefore there is no significant difference between the average acreage burned across the twelve 5-yr periods.

3.2.2 ANOVA (Precip. Levels)

In order to determine if the means of the acreage burned in Kentucky over three precipitation levels are the same, we use a one-way analysis of variance (ANOVA). The average acreage burned for low (35-44 in), medium (45-54 in), and high (55-64) are tested using the hypotheses

$$H_0 : \mu_1 = \mu_2 = \mu_3$$
$$H_a : \text{At least one } \mu_i \neq \mu_j .$$

Table 2: The output from the Data Analysis tool in Excel with the precipitation levels.

The P-value of the F-test is 0.001458 and is less than 0.05 (for a 5% significance level). Therefore there exists a significant difference between the average acreage burned across the three precipitation levels. Since there exists a significant difference between the average acreage burned across the three precipitation levels, then a pair-wise T-test can be used to determine if μ_1 is significantly larger than μ_2 and μ_2 is significantly larger than μ_3.

3.3 T-test

3.3.1 T-test (Comparing Low Precipitation with Medium Precipitation)

In order to determine if μ_1 is significantly larger than μ_2, we use the T-test. The average acreage burned for low precipitation (35-44 in) and medium precipitation (45-54 in) are tested using the hypotheses

$$H_0 : \mu_1 = \mu_2$$
$$H_a : \mu_1 \neq \mu_2 .$$

Table 3: The output from the Data Analysis tool in Excel.

t-Test: Two-Sample Assuming Unequal Variances

	Low	Medium

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.49E+11	11	1.36E+10	1.050807755	0.419289	1.99458
Within Groups	6.2E+11	48	1.29E+10			
Total	7.69E+11	59				

	Precipitation	Precipitation
Mean	157732.4706	59550.62
Variance	32538046481	3.32E+09
Observations	17	29
Hypothesized Mean Difference	0	
df	18	
t Stat	2.179936306	
P(T<=t) one-tail	0.021391344	
t Critical one-tail	1.734063592	

The P-value of the T-test is 0.02139 and is less than 0.05 (for a 5% significance level). Therefore μ_1 is significantly larger than μ_2. Thus the average acreage burned for the low precipitation level is significantly larger than that of the medium precipitation level.

3.3.2 T-test (Comparing Medium Precipitation with High Precipitation)

In order to determine if μ_2 is significantly larger than μ_3, we use the T-test. The average acreage burned for medium precipitation (45-54 in) and high precipitation (55-64 in) are tested using the hypotheses

$$H_0 : \mu_2 = \mu_3$$
$$H_a : \mu_2 \neq \mu_3 .$$

Table 4: The output from the Data Analysis tool in Excel.

t-Test: Two-Sample Assuming Unequal Variances

	Medium Precipitation	High Precipitation
Mean	60247.33	21884.54
Variance	3.22E+09	65812096
Observations	30	13
Hypothesized Mean Difference	0	
df	32	
t Stat	3.618309	
P(T<=t) one-tail	0.000505	
t Critical one-tail	1.693889	

The P-value of the T-test is 0.000505 and is less than 0.05 (for a 5% significance level). Therefore μ_2 is significantly larger than μ_3. Thus the average acreage burned for the medium precipitation level is significantly larger than that of the high precipitation level.

3.4 Differential Inclusions [1, 6]

In relation to the frequency of forest fires, we change the focus slightly in an investigation on how to decrease the amount of acreage effect. We now seek a way to not only contain these natural disasters but contain them optimally. Thus, this presents the question on whether their actually exists a method to determine an optimal solution of fire containment via wall construction (or other methods if chosen). In order to continue this study, we introduce the concept of differential inclusion to measure disturbances and uncertainties within the study. A differential inclusion takes on the form $\dot{x} \in F(x)$ where F: $\mathbb{R}^2 \to \mathbb{R}^2$ is a set valued function $(Note: \dot{x} = \frac{dx}{dt})$. Moreover, $\dot{x} \in F(x)$: where F is Lipschitz with Lipschitz constant *k*: That is $dist(F(x_1), F(x_2)) \le k|x_2 - x_1|$.

Definition: Let X_0 be the initial set of the inclusion. Define reachable sets, Reach as follows:

$$Reach_F(X_0, t) = \{\varphi(t) | \varphi(0) \in X_0 \text{ and } \varphi \text{ is a solution of } \dot{x} \in F(x)\}$$

$$Reach_F(X_0, [0,t]) = \bigcup_{\tau \in [0,t]} Reach_F(X, t)$$

$$Reach_F(X_0, [0,\infty)) = \bigcup_t Reach_F(X, t)$$

Example: Consider the differential equation,

$\dot{x} = F(x) = x, \qquad X_0 = [0,4]$

$\frac{dx}{dt} = x$	$0 = ke^0 \Rightarrow k = 0$
$\frac{dx}{x} = dt$	$4 = ke^0 \Rightarrow k = 4$
$\ln(x) = t + C$	$Reach_F(X_0, t) = [0, 4e^t]$
$x = e^{t+C}$	$Reach_F(X_0, [0,t]) = [0, e^t]$

$x = ke^t \qquad \operatorname{Re}ach_F(X_0,[0,\infty)) = [0,\infty)$

The reachable set describes the area of the inclusion with time.

```
> plot(exp(t), t=0..6, x=1..10);
```

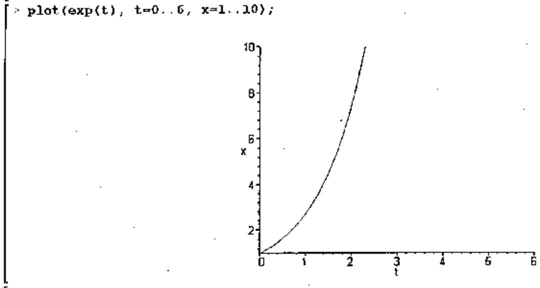


Figure 9: The solution to the example.

```
> x:=t->exp(t);
                    x := exp
> Lplot:=leftbox(x(t),t=1..3, 10, xtickmarks=3,title="Left Riemann Sum"):
> Rplot:=rightbox(x(t),t=1..3, 10, xtickmarks=3,title="Right Riemann Sum"):
> display(array([Lplot,Rplot]));
```

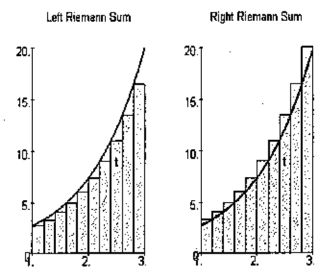


Figure 10: The graph of the reachable set using Riemann Sum.

Now, we move to the actual mathematical modeling on the containment of forest fires. Let: R(t) be the contaminated set, F(x) represents the dynamics of the flow of the fire. The inclusion is $\dot{x} \in F(x) \qquad x(0) \in R_0$

$$R(t) = \left\{ x(t) \middle| \begin{array}{l} x(\cdot) \text{ absolutely continuous }, \\ x(0) \in R_0, \dot{x}(\tau) \in F(x(\tau)) \forall \tau \in [0,t] \end{array} \right\}$$

$0 \in F(x) \, \forall \, x \in \mathbb{R}^2$

$R(t_1) \subseteq R(t_2)$ whenever $t_1 \le t_2$

First assume that the forest fire can be contained; then there exists some mechanism that could be implemented to halt further expansion of the fire. The controller can then construct a "wall", or one-dimensional rectifiable curve, that can reduce the size of the affected area. This blocking strategy γ can be defined as

$$R^{\gamma}(t) \doteq \left\{ \begin{array}{l} x(t); x(\cdot) \text{ absolutely continuous}, x(0) \in R_0, \\ \dot{x}(\tau) \in F(x(\tau)) \forall \tau \in [0,t], x(\tau) \notin \gamma(\tau) \forall t \in [0,t] \end{array} \right\}$$

where $R^{\gamma}(t)$ is the set reached by trajectories of differential inclusion at any given time τ.

Definition: A set valued map $t \mapsto \gamma(t) \subset \mathbb{R}^2$ is an admissible strategy if certain conditions are held.

Consider the following two nonnegative functions $\alpha\beta : \mathbb{R}^2 \mapsto \mathbb{R}^2$ is the value of a unit area and $\beta(x)$ is the cost of building a unit length of wall near the point x;

$dm_i = \{ i = 1,2 | i - \text{dimension} \}$.

$$J(\gamma) = \lim_{t\to\infty} \left\{ \int_{R^{\gamma}(t)} \alpha \, dm_2 + \int_{\gamma(t)} \beta \, dm_1 \right\}$$

Taking the limit essentially gives an upper bound, or supremum. The following diagram gives an instance where at time T, a blocking strategy $\gamma(t) = \gamma(T)$ and $R^{\gamma}(t) = R^{\gamma}(T)$. If constructed too close, the wall proves to be useless and perilous.

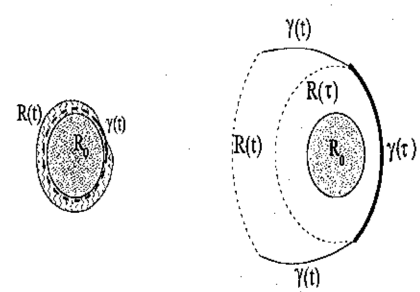


Figure 11: The left diagram shows the construction of the wall at the same time the contaminated set R_0 expands. The right diagram takes into account additional area in time $\tau > 0$ for wall construction.

In order to show that there exists an optimal solution $\gamma^*, J(\gamma)$ is minimized:

$\min_{\gamma \in S} J(\gamma)$,
where S is the set of all admissible strategies.

During this investigation, the following observations were made:

Theorem 1. For the system described above, assume

$$F(x) \subseteq B_\rho \qquad \varphi(x) \leq \frac{1}{\rho'}$$

for some $\rho'>2\rho$ and every $x \in \mathbb{R}^2$. Then, for every bounded initial set R_0, there exists r > 0 and an admissible strategy γ such that $R^\gamma(t) \subseteq B_\rho$, for all t ≥0. [1]

If there exists an optimal strategy γ^*, then at every point of a free arc $\Gamma \in \mathcal{F}_1$ there exists a corresponding vector oriented in the direction of outer normal to the minimal time function, and the vector's curvature is proportional to cost. (Refer to Theorem 3, [1]).

Let there be an optimal strategy γ^*. By constructing two boundary arcs $\Gamma_1, \Gamma_2 \in \mathcal{B}_1$ originating from the same point P in opposite directions with respect to the front of the fire and assuming that the contaminated region is encircled by walls, than this strategy is not optimal. (Refer to Theorem 5, [1]).

4. ANALYSIS/RESULTS

In the regression analysis a high P-value and a zero r-value in section 3.1.1 and 3.1.2 shows no correlation with the number of sq. acres burned and years/temperature. However, there is a negative correlation between the number of sq. acres burned and the annual precipitation based off the r-value, an increase in precipitation will result in a decrease in the number of sq. acres burned. All factors were combined in section 3.1.4 and still the analysis showed that a correlation exists but temperature plays no role in the number of sq. acres burned. ANOVA was used to determine if the means of the acreage burned in Kentucky over twelve five-year periods were significantly different and if the means of the acreage burned in Kentucky over three precipitation levels are the same. It was found that there is no significant difference between the average acreage burned across the twelve 5-yr periods. From the analysis of variance, it was however found that there exists a significant difference between the average acreage burned across the three precipitation levels.

The mathematical model using differential inclusions yields necessary conditions for the existence of an optimal strategy of containing forest fires with the presence of an admissible strategy. The construction of the wall warrants the most advantageous placement of both boundary and free arcs. Although an exact solution has not yet been determined, there exist several conditions that would clarify a possible optimal strategy.

5. CONCLUSIONS

In conclusion we found that one of the factors of global warming, high temperatures in fact has no relationship with the frequency of forest fires and the amount of acreage burned in the state of Kentucky. On the other hand, there does exist a relationship between precipitation (i.e. levels of drought) and the number of sq. acreage burned. In addition, there exists a significant difference between the average acreage burned across three precipitation levels. Additional studies show that global warming affects precipitation, therefore there exists a relationship between global warming and forest fires.

6. FURTHUR INVESTIGATIONS

This research can be further investigated by comparing the forest fires of the coastal states to the non-costal states and observing the varying effects of global warming. The same methods that were used in this research can be used to obtain similar information. Moreover, further investigations include the development of more necessary optimal condition and eventually derive and optimal strategy for fire containment.

7. ACKNOWLEDGMENTS

This research was conducted at Elizabeth City State University's Computational Science-Scientific Visualization Center (CSSVC) and is supported by grants given by the Department of Energy and the National Association of Mathematicians. In addition, we would like to make the following acknowledgements:

Dr. Luttamaguzi, our faculty mentor
Dr. Johnny Houston, Institute Director
Dr. Farrah Chandler, Associate Director
Other faculty and peers

8. REFERENCES

[1] Bressan, Alberto. Differential Inclusions and the Control of Forest Fires. Dept. of Mathematics, Penn State University. University Park, PA, 2006. 1-27.

[2] "Discover the Scientific Facts on Global Warming." GreenFacts.Org: Facts on Health and the Environment. 7 Apr. 2008. GreenFacts ASBL/VZW. 21 May 2008 <http://www.greenfacts.org/climate-change/global-warming/global-warming.htm>. ;

[3] "Forest Fire Statistics." Division of Forestry. 31 Jan. 2008. Kentucky Division of Forestry. 20 May 2008 <http://www.forestry.ky.gov/programs/firemanage/Fire%2BStatistics.htm>.

[4] "Kentucky Stats." Kentucky Virtual Library. Frankfort, KY: Kentucky Virtual Library, 2007. Kentucky Virtual Library.

[5] "Kentucky Wildland Fire Situation." Division of Forestry. 13 May 2008. Kentucky Division of Forestry. 15 May 2008 <http://www.forestry.ky.gov/situationreport/>.

[6] Puri, Anuj, Pravin Varaiya, and Vivek Borkar. Approximation of Differential Inclusions. Dept. of Electrical Engineering and Computer Sciences, University of California; Dept. of Electrical Engineering, Indian Institute of Science. National Science Foundation. 1-11.

[7] Running, Steven W. "Is Global Warming Causing More, Larger Wildfires." PERSPECTIVES 6 July 2006. 15 May 2008 <http://www.sciencemag.org/>.

[8] University of Wisconsin-Madison (2007, November 5). Wildfire Drives Carbon Levels In Northern Forests. *ScienceDaily*. Retrieved May 17, 2008, from http://www.sciencedaily.com/releases/2007/10/071031152918.htm

[9] West, Larry. "Global Warming Linked to Increase in U.S. Forest Fires." Larry West's Environmental Issues Blog. 25 May 2007. About.Com: Environmental Issues. 15 May2008<http://environment.about.com/b/2007/05/25/global-warming-linked-to-rising-number-of-us.htm>.

9. APPENDIX [4, 5]

Kentucky

YEAR	Acres Protected	# of Acres Burned	Average Size	Percent Burned	Fire Occurrence Rate	# of Fires	Annual Percipitation	Annual Average Temp
1945	1,612,714	11,614	35	0.01	206	333	50.64	55.76
1946	1,667,193	12,690	38	0.76	199	331	46.93	57.34
1947	2,321,161	23,331	39	1.01	261	605	41.88	54.82
1948	3,280,414	25,603	34	0.78	229	751	50.57	56
1949	3,927,266	20,410	21	0.52	251	984	51.38	57.3
1950	4,090,927	27,936	27	0.68	249	1,019	62.93	55.08
1951	4,639,743	13,454	18	0.29	162	752	54.71	55.58
1952	5,694,118	728,087	274	12.79	466	2,654	41.79	56.91
1953	5,694,118	175,534	82	3.08	377	2,148	36.71	57.43
1954	6,096,217	60,088	58	0.99	171	1,045	40.86	57.2
1955	5,872,559	33,537	27	0.57	209	1,225	44.97	56.42
1956	6,521,093	60,494	37	0.93	254	1,657	50.65	56.6
1957	6,881,000	26,391	20	0.38	188	1,296	55.06	56.67
1958	7,140,000	33,119	22	0.46	215	1,533	43.96	53.61
1959	7,366,000	85,197	27	1.16	427	3,144	43.58	56.38
1960	6,982,000	99,823	43	1.43	335	2,339	40.78	54.13
1961	9,173,000	36,177	21	0.39	187	1,713	51.1	54.92
1962	9,854,000	119,566	36	1.21	333	3,277	49.97	55.04
1963	9,854,000	306,253	67	3.11	465	4,579	34.45	53.9
1964	9,854,000	95,198	35	0.97	275	2,710	48.35	55.88
1965	10,212,000	58,635	20	0.57	285	2,911	42.19	55.88
1966	10,774,000	41,039	17	0.38	219	2,358	46.86	54.11
1967	11,953,000	30,158	13	0.25	197	2,352	48.78	54.72
1968	11,953,000	33,122	11	0.28	248	2,965	43.77	54.33
1969	11,953,000	54,000	18	0.45	258	3,079	43.13	54.25
1970	11,953,000	53,008	23	0.44	192	2,298	48.27	55.48
1971	11,953,000	44,567	21	0.37	180	2,153	44.71	55.92
1972	16,886,000	9,424	10	0.06	58	977	57.73	55.28
1973	16,886,000	13,396	11	0.08	74	1,258	54.02	56.68
1974	16,886,000	49,775	24	0.29	123	2,073	52.6	55.88
1975	16,886,000	19,021	10	0.11	113	1,900	57.31	56.19
1976	16,886,000	123,789	30	0.73	248	4,185	42.62	53.74
1977	16,886,000	94,106	27	0.56	206	3,485	49.06	55.16
1978	17,025,098	38,440	21	0.23	107	1,816	53.48	53.79
1979	17,037,798	41,480	18	0.24	139	2,364	62.86	53.92
1980	17,037,798	367,019	122	2.15	177	3,011	37.22	55
1981	17,037,098	287,568	67	1.69	252	4,298	45.02	54.65
1982	17,037,098	37,561	16	0.22	135	2,302	50.9	55.68
1983	16,935,948	31,702	16	0.19	121	2,041	48.07	55.29
1984	16,935,948	17,728	12	0.1	84	1,422	53.39	55.63
1985	16,935,948	40,533	23	0.24	102	1,730	44.88	55.24
1986	16,935,948	88,735	35	0.52	151	2,565	43.29	56.9
1987	16,935,948	285,036	87	1.68	194	3,283	38.19	56.56
1988	16,935,948	80,452	30	0.48	156	2,643	44.34	55
1989	16,935,498	23,755	20	0.14	70	1,188	58.88	54.59
1990	16,935,948	22,437	18	0.13	75	1,266	56.9	57.43
1991	11,641,259	68,904	46	0.59	130	1,514	46.34	57.54
1992	11,641,259	20,574	16	0.18	111	1,297	42.99	55.11
1993	11,641,259	18,126	17	0.16	92	1,068	47.47	55.16
1994	11,641,259	50,263	28	0.43	155	1,802	49.2	55.64
1995	11,641,259	67,828	32	0.58	180	2,097	48.14	55.55
1996	11,641,259	18,066	19	0.16	84	973	57.12	54.43
1997	11,641,259	14,475	16	0.12	78	913	49.66	54.53
1998	11,641,259	29,224	26	0.25	98	1,140	49.45	58.25
1999	11,641,259	139,110	58	0.81	206	2,396	38.41	57.32
2000	11,641,259	133,347	86	1.15	138	1,545	45.35	55.74
2001	11,641,259	163,327	81	1.4	195	2,010	45.56	56.73
2002	11,641,259	23,542	24	0.21	86	976	54.41	57.06
2003	11,641,259	19,681	21	0.17	82	926	55.17	55.42
2004	11,641,259	25,916	18	0.24	129	1,470	56.9	56.51

[4,5]

5 Yr Period	# of Acres Burned in 5 yr Period				
1946-1950	12,690	23,331	25,603	20,410	27,936
1951-1955	13,454	728,087	175,534	60,088	33,537
1956-1960	60,494	26,391	33,119	85,197	99,823
1961-1965	36,177	119,566	306,253	95,198	58,635
1966-1970	41,039	30,158	33,122	54,000	53,008
1971-1975	44,567	9,424	13,396	49,775	19,021
1976-1980	123,789	94,106	38,440	41,480	367,019
1981-1985	287,568	37,561	31,702	17,728	40,533
1986-1990	88,735	285,036	80,452	23,755	22,437
1991-1995	68,904	20,574	18,126	50,263	67,828
1996-2000	18,066	14,475	29,224	139,110	133,347
2001-2005	163,327	23,542	19,681	25,916	51,565

[4,5]

Precipitation Range	# of Acres Burned						
35-44	306,253	175,534	367,019	285,036	139,110	99,823	60,088
45-54	80,452	44,567	40,533	33,537	287,568	133,347	163,327
44-64	13,396	23,542	13,454	26,391	19,681	22,437	25,916
35-44	306,253	23,331	58,635	123,789	20,574	54,000	88,735
45-54	80,452	41,039	12,690	18,126	31,702	67,828	53,008
44-64	13,396	19,021	9,424	23,755	41,480	27,936	
35-44	306,253	33,122	33,119				
45-54	80,452	30,158	94,106	50,263	29,224	14,475	119,566
44-64	13,396						
35-44	306,253						
45-54	80,452	11,614	60,494	37,561	36,177	20,410	49,775
44-64	13,396						

[4,5]
Anova: Single
Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
35-44	17	2681452	157732.5	3.25E+10
45-54	30	1807420	60247.33	3.22E+09
44-64	13	284499	21884.54	65812096

[4,5]
Anova: Single
Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
1946-1950	5	109970	21994	34798321.5
1951-1955	5	1010700	202140	90384068739
1956-1960	5	305024	61004.8	1017027275
1961-1965	5	615829	123165.8	11511838669
1966-1970	5	211327	42265.4	121199811.8
1971-1975	5	136183	27236.6	346167312.3
1976-1980	5	664834	132966.8	18419994152
1981-1985	5	415092	83018.4	13152033132
1986-1990	5	500415	100083	11644157594
1991-1995	5	225695	45139	609740679
1996-2000	5	334222	66844.4	4045523402
2001-2005	5	284031	56806.2	3703285736

An Investigation of Energy Consumption of 25 Universities in Measuring a Carbon Footprint Based on Carnegie Level Classification

La' Trent Brock
Mississippi Valley State Univ.
lbrock@mvsu.edu

Michelle Burke
Howard University
maburke03@gmail.com

Brittany Maybin
Spelman College
bmaybin@spelman.edu

Alvin McClerkin
Mississippi Valley State University
mcclerkin@mvsu.edu

Unquiea Wade
Elizabeth City State University
ubwade@gmail.com

ABSTRACT
At various institutions of higher education all across the United States there is a substantial contribution of CO_2 emissions to the environment because of excessive amounts of energy consumption. These CO_2 emissions can be calculated by using a carbon footprint algorithm which finds the measurement of the impact of human activities on the environment as it relates to energy consumption and greenhouse gases produced. The standard of Carnegie classification will be used because of its attributes of classifying universities by undergraduate and graduate curriculum profile, enrollment profile, and the size/setting profile. This allows comparisons to be established between classification levels of Carnegie distinctions of universities.

Our team will try to find connections between energy consumption and CO_2 emissions. Our team will also evaluate amounts of emissions for a range of Carnegie Level Institutions.

Keywords
Carbon Footprint, Greenhouse Gases, Carbon Dioxide Emissions, CO_2, School Neutral, Clean Air Cool Planet, Carnegie Classifications

1. STATEMENT OF THE PROBLEM
Institutions of Higher Education across the nation emit a significant amount of CO_2 into the environment each year. Many of the colleges and universities are not aware or conscious that they are producing such an enormous amount of CO_2, with their daily, weekly and yearly actions and activities. Thus, they leave behind a carbon footprint higher than absolutely necessary.

2. INTRODUCTION
There has been a growing concern that greenhouses gases emitted into the earth's atmosphere have produced detrimental effects on the environment. The emissions of greenhouse gases have led to an increase of the earth's temperature.[1] Average global temperature has increased by almost 1°F over the past century; scientists expect the average global temperature to increase an additional 2 to 6°F over the next one hundred years. Dangerously high levels of greenhouse gas emissions can be lethal to humans, plants, and animals because of the changes in the earth's climate.

Scientists claim that greenhouse gases are emitted into the atmosphere through natural processes and human activities. Research has proven that an individual's activities contribute to the percentage of greenhouse gas emissions being released into the atmosphere. A carbon footprint is a representation of the effect human activities have on the climate in terms of the total amount of greenhouse gases produced (measured in units of carbon dioxide). The factors that influence a carbon footprint are electricity, natural gas and transportation usage. Each individual has a carbon footprint that is measured by his or her effects on the environment as related to energy waste and consumption.

Large centers and institutions like college campuses use large amounts of energy contributing to the emission of carbon dioxide and other greenhouse gases that accelerate the rise in temperature. Some colleges contribute to higher levels of greenhouse gas emissions than others.

2.1 Gasoline Usage

Gasoline is one of the most important fuels that is used in the United States as a type of energy for automobiles.[2] Gasoline is mostly carbon by weight, so a gallon of gas might release 5 to 6 pounds (2.5 kg) of carbon into the atmosphere. The U.S. is releasing roughly 2 billion pounds of carbon into the atmosphere each day. The gas that is being generated is one form of a greenhouse gas. The gasoline that is used produces a large amount of the C02 emissions and these emissions are used in conjunction with other factors to calculate the carbon footprint.

Transportation emissions are caused from the burning of fossils fuels like petroleum and diesel which are responsible for climate change and air pollution. Transportation is a vital aspect of an individual's life because it is convenient and time efficient as a basis for travel. Many college students use cars as a source of transportation for arrival and departure from their home institutions. Some students that commute daily use their cars for a source of transportation. Many of the commuter students do not carpool as a means of energy reduction or gasoline reduction. Buses are used as a secondary means of transportation on college and university campuses. Most college and university campuses use buses and shuttle vans to transport students around campus. Buses have a higher emission rate than cars because of the amount of gas that is needed to fuel a bus instead of a car. Thus buses cause more carbon emissions to be emitted into the atmosphere.

2.2 Electricity Usage

Electricity is a source of energy that is created from coal, oil, and other natural gases. The use of electricity in the United States contributes to a large amount of greenhouse gas emissions released into the atmosphere. College and universities waste an efficient amount of electricity daily. Electricity is used in classrooms, research laboratories, offices, and buildings. Electricity is used for a source of energy to power these facilities by providing them as a source of light and a power supply source for appliances, computers, and heating/cooling. College and universities waste a large amount of electricity daily just by not properly turning off computers, lights, and appliances when they are not being used.

2.3 Natural Gas Usage

Natural gas is mainly composed of methane but also has other hydrocarbons like pentane, ethane, propane, and butane in its composition. [6] Natural gas ranks number three in energy use, behind petroleum and coal. Twenty-three percent of the energy we use in the United States comes from natural gas. On a university campus natural gas is used for many purposes such as heating for buildings, heating for water, cooking, and electricity. Natural gas contains less carbon than other fossil fuels but still produces methane emissions.

2.4 Project Aims

2.4.1 Influencing University Communities

Growing awareness of the issues associated with the increasing emission of greenhouse gases has pushed companies, organizations, and higher level institutions worldwide to implement energy saving practices. The desire to reduce individual and collective emissions has grown with more evidence showing the detrimental effects that increased levels of greenhouse gas emissions have on the environment and climate. The increase in greenhouse gases has accelerated changes in the Earth's temperature and climate affects the health of animal, plant, and human life. Each year companies and schools use increasing amounts of nonrenewable energy with disregard for its effects on the environment. The purpose of this report is to analyze the sources of these emissions at various universities and colleges in order to establish goals and identify strategies for the reduction of greenhouse gas emissions.

2.4.2 Increasing Awareness

Universities nationwide use energy in a variety of ways in order to supply students with electricity for heating and cooling, transportation, and water. With a need for universities and colleges to supply fully functioning learning environments for their faculty and staff while being environmentally conscious, it is important to find ways for schools to implement energy saving practices. Colleges are unaware of the large amounts of greenhouse gases emitted into the atmosphere due to the use of energy consumed through the use of steam, electricity, natural gas, and chilled water. Students and faculty contribute to large amounts of energy consumption unknowingly. Using energy in the dormitories, in computer labs, and in their travel to and from school, students emit carbon dioxide and other harmful greenhouse gases into the atmosphere. Faculty members use sizable amounts of electricity to power and run computers, projectors, science labs, and lights for the classroom, and commuting to school. All universities and colleges have a distinct carbon footprint that can be measured and the measurements can be used to reduce carbon emissions in the atmosphere and increase awareness among other institutions of their carbon footprint.

With students having more knowledge about greenhouse gas emissions and their university's carbon footprint, they will make a conscious effort to use energy saving practices to improve the environment. As universities become more knowledgeable and conscious of reducing their carbon footprint, they will implement practices that save money while helping to save the environment such as switching to energy efficient light bulbs, providing shuttles for students, and installing automatic sensor switches to turn off lights when the room is not occupied. Educating college students to have a wider knowledge about carbon footprints can lead to future solutions of energy efficient practices. Students will become more conscious of their everyday activities and lifestyles by cutting back on energy usage such as turning off lights and television when exiting the room, cutting down on excess water usage, and carpooling.

The goal is to educate students and faculty about energy saving practices so that they will use them every day. With efforts to reach higher level institutions in the United States and spread awareness about the importance of reducing the amount of energy consumption and greenhouse gas emissions, these individuals will further educate younger generations. Increased awareness among universities will help in the reduction of greenhouse gas emissions produced by large institutions.

2.5 What is a Carbon Calculator?

Carbon Calculators available online such as those made by School Neutral or Clean Air Cool Planet use several common factors to determine total carbon emissions. In addition to measurement of energy bought and used by an individual or organization, each calculator uses state standards related to energy for the calculations. They also take into account energy coming from renewable sources which are significantly better for the environment.

For transportation, they even take into account mileage and type of vehicle used. This is necessary because even if two cars are made by the same company, the amount of emission per mile depends on the model. Carbon calculators are useful ways to determine one's negative impact on the environment and the best ways to reduce that impact. Manipulation of the values placed into the calculator can show the best ways to reduce a carbon footprint. For example, suppose natural gas and electricity consumption are 100,000 therms and 7 million KWh per year. An organization can calculate their carbon footprint first using half as much natural gas and then again using half as much electricity. The calculations that show the lowest emission number represent the better way to reduce the carbon footprint. These are only a few uses for the carbon calculator.[10]

3. METHODS TO SOLVING THE PROBLEMS

3.1 Discovery of the Variables

Several variables were factors in the study of the carbon footprint of the selected universities. The more variables used and plugged into the calculations, the more accurate and efficient the results will be in finding the amount of carbon dioxide emitted by the universities and colleges. [6]

One of the first variables needed for calculations is the state in which each particular college institution is located. The reason why this is such an important factor is, that certain states are governed differently. Each state has its own set of rules and laws on how they govern renewable and non-renewable energy consumption. Each state has its own distinct geographical location, thus exposing each university to a variety of environmental issues and sources. For instance, if a school is located near water or a dam, it might get some of its energy from hydro power as opposed to a nuclear power plant. The carbon footprint calculator that is used in this study, also take into account the fact that each state has a certain limit on electricity usage of average pounds of CO_2 per KWh.

The number of students attending each institution of higher learning is needed for calculations. For one, it is a determining factor for the classification of the Carnegie level. Also, the total number of students, whether graduate, or undergraduate was also used when calculating certain transportation data. The three main variables of computing the carbon footprint of a given college institution are natural gas, transportation, and electricity consumption. As we all know, the use of the automobile or some form of energy consuming transportation is prevalent everywhere. While calculating the transportation factors, one has to take into account that gasoline and diesel have different burning and emissions rate. Thus, we have to separate the two. The total miles traveled by each school also must be calculated. The miles traveled by plane, train, automobile or any means transportation are taken into account into the total miles. [3,9]

The second variable of the big three is electricity consumption. Knowing that we are dealing with a college setting, there is already an understanding that a great deal of electricity will be consumed to perform general activities of a college campus. Since tests, memos, notifications and many other documents are needed, one must use a copy machine to print all of these materials. Class rooms must be well lit, a comfortable setting must be provided for learning, so there has to be some form of central heating and cooling. Students and faculty members who choose to eat on campus will lean towards the cafeteria, where there is heating food in oven and microwave, cooking on stoves, and keeping food refrigerated. Another source of electricity consumption is the various computer labs and libraries that a campus has, where the computers are left running for extended periods of time. All of these everyday actions and routines require a great deal of electricity to be consumed.

Natural gas is the third main variable of the three. In college institutions there are three main uses for natural gases. Though electricity plays a role in heat and cooling, the use of natural gas is needed for the heating the building to desired temperatures. Like the heating and cooling systems, the cafeteria uses electricity as well as natural gas. In many kitchens, there is the use of natural gas for the cooking process. Science classes have labs everyday across the nation with some experiment or testing using a natural gas. This consumption of gas may be small in parts, but if you think about the many classes that have these labs each day, and tally them up for a year, the figures will be quite high.

3.2 Carnegie Levels

The universities and colleges selected were grouped with respect to their Carnegie level classifications. Carnegie level classifications are designed to assist researchers in studies of higher education. Universities' and colleges' Carnegie level help compare them based upon their similarities and differences. The classifications do not rank schools or exploit their differences. The Carnegie Level Classifications were created in 1970 by the Carnegie Foundation. The Carnegie Foundation's intentions were to use the classifications to compare very similar structured institutions. All accredited and degree awarding institutions of higher learning are eligible for Carnegie classification. [3]

Alterations to the Carnegie classifications were made in 2000, because in 1970 there were only about 2800 institutions of higher education. Currently there are about 4400 universities and colleges. Several factors contribute to the classification of a university or college. What is taught, to whom it is taught, and what is the setting in which it is taught are bases for classifying the institutions of higher education. [5]

The selected institutions in this research varied in classifications for which they were listed. The majority of the institutions in this research were classified as Doctoral/Research Universities and Baccalaureate Colleges. A list showing the Carnegie levels of the institutions and how the Carnegie levels are distinguished are located in the appendix. [1]

To conduct research on carbon emissions, factors that are used to classify the institutions are required. The number of students, the location, the level of research conducted and the Carnegie level classification of the institution all are important contributing factors to explaining why the carbon dioxide emissions are so large at the selected universities.[9] To make comparisons, the data from the selected universities and colleges will be grouped by their Carnegie classifications. Through this research it will determined if the factors that contribute to their Carnegie classification can also help to explain why the carbon dioxide emissions at the selected institution are so high.

3.3 Steps taken to obtain data

Research was done courtesy of the Internet to find a database that contained data from colleges that had already conducted energy consumption research. The Association for the Advancement of Sustainability in Higher Education provided a list of institutions of higher learning that had already conducted research on their respective universities' greenhouse emissions. With each addition to the list, the universities and colleges provided the data collected from their studies. To make this data available each institution supplied links to their research. [8]

There were several variables from each university that were desired. The amount of electricity used in kilowatts per hour, the number of students, the state of location, the amount of gasoline used in a year, the amount of diesel used in a year, the amount of natural gases used in a year, the amount of miles traveled in a year and the emissions of electricity, transportation, and natural gases in metric tonnes. These variables will all be used to make comparisons and determine whether the factors that

[1] Refer to the Appendix B to see the Carnegie Classifications levels and the institutions classifications.

determine their Carnegie classification also influence the size of emissions that a university or college has.

4. ANALYSIS

Figures 1.2 and 1.4 graph consumption by emission for electricity and transportation. A quick glance at the data points show that there is likely no linear nor logarithmic trend to the data. Another way to find a correlation between consumption and emission is to use a polynomial. Higher degree polynomials produce better approximations. Microsoft Excel's highest degree when calculating a polynomial trendline is six. The trendline represented in Figure 1.2 is $y = 4x10^{-10}x^6 - 3x10^{-7}x^5 + 9x10^{-5}x^4 - .011x^3 + .689x^2 - 19.14x + 212.3$. The trendline represented in Figure 1.4 is $y = -3x10^{-8}x^6 + 1x10^{-5}x^5 - .001x^4 + .081x^3 - 2.29x^2 + 29.15x - 114$.

5. RESULTS

The results of this paper show the levels of CO_2 emissions based on factors for selected universities. They also show the relationship between energy consumption and emissions totals. These results will be displayed in the following charts.

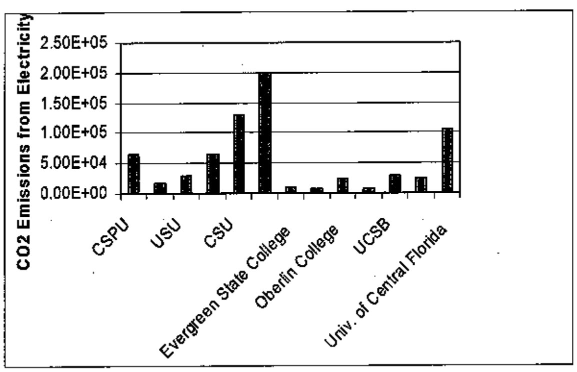


Figure 1.1 This chart displays the CO_2 emissions produced by colleges as a result of electricity consumption.

According to the data, three of thirteen colleges have carbon emissions levels below 9,000 tons. Rice University, Evergreen State College and Middlebury College have the lowest emission numbers. Duke University had the highest carbon emissions out of the thirteen colleges/universities selected.

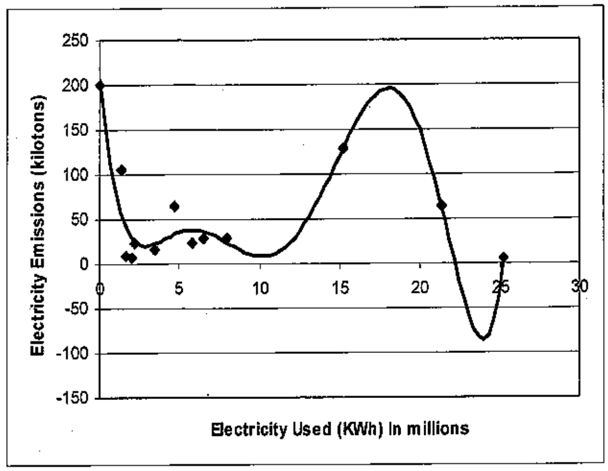
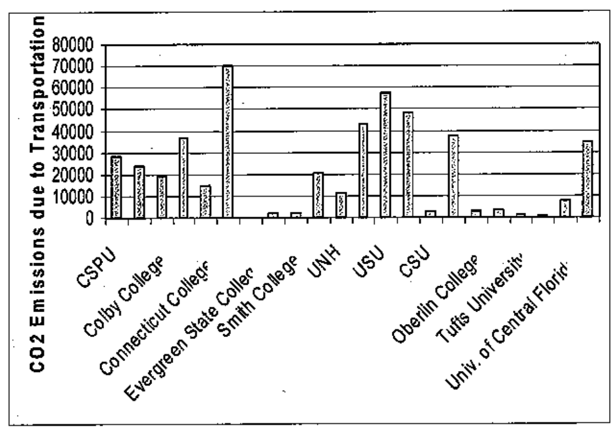


Figure 1.2 This chart displays the electricity emissions produced for a given amount of electricity used by colleges and universities.

The spread of data points in Figure 1.2 shows that there is not a set pattern for electricity used versus CO_2 emissions. We can conclude that there must be factors other than electricity usage that influence the total amount of electricity emissions. The trend line calculated in Excel is a polynomial and is the best fit line for this graph. This trend line has inaccuracies in the values ranging from twenty to twenty five where the polynomial gives negative emissions value.



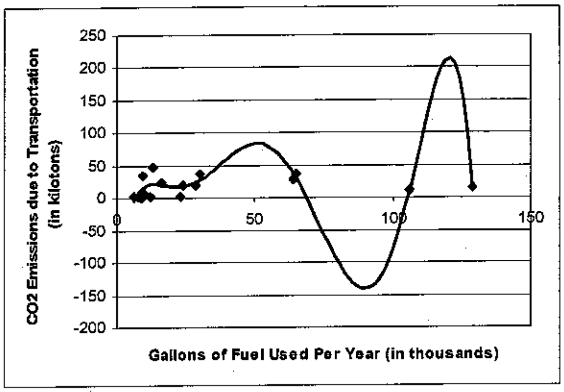


Figure 1.4 The data points on this chart display the transportation emissions produced for a given amount of fuel used per year by colleges and universities.

Similar to the curve of Figure 1.2 the best fit equation relating the gallons of fuel used and transportation emissions is calculated to be a sixth degree polynomial. However, again the polynomial is inaccurate because it gives negative emission values for some values of fuel consumption.

The following graphs relate the Carnegie levels of included universities to the amount of CO_2 emissions they produce. In Figure 1.5, the Carnegie Levels 16, 21, and 32 are significantly underrepresented in the number of colleges as compared to the other represented levels. The average total emissions of levels 15 and 16 are similar and level 32 is drastically lower than all other levels. The graph relating Carnegie classification and natural gas emissions shows that level 15 has approximately 16 thousand tons more emitted per year than the other Carnegie level represented. The natural gas data was not available for schools in level 32.

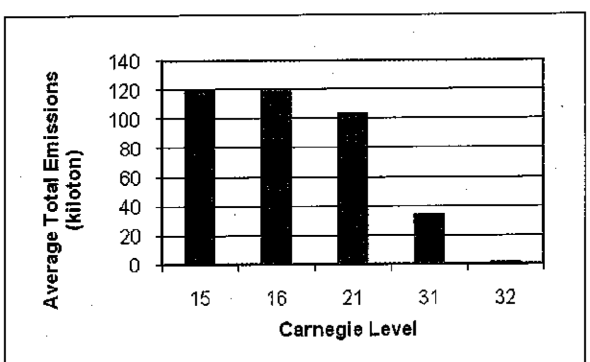


Figure 1.5 This graph shows the average total CO_2 emissions at each represented Carnegie Level.

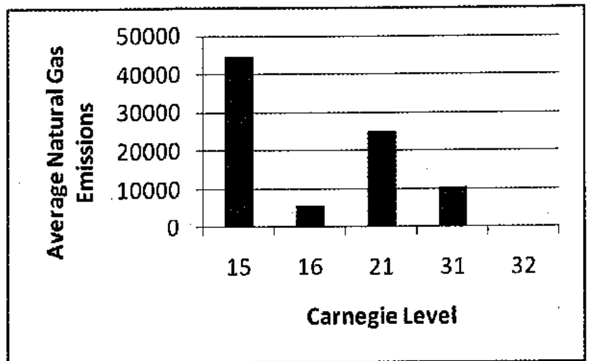


Figure 1.6 This graph shows average natural gas emissions per Carnegie level.

6. CONCLUSIONS

Carbon footprint is a representation of the effect of human activities. Electricity, natural gas, and transportation usage are three main factors that tie into ones carbon footprint. College and universities across the nation emit a large amount of CO_2 into the environment every day. Most institutions are not even conscious of the quantity of their emissions. We noticed that the upper level Carnegie level institutions had the highest total amount of CO_2 emission. This is mainly because there are more people, and there is more research going on that requires a great deal of resources.

Even at schools which have larger student populations, there are many ways to reduce a carbon footprint. Installing automatic lights and energy saving bulbs is a simple way to waste less energy. Students and faculty alike can practice energy saving practices such as enjoying shorter showers, not printing excessively in computer labs, and using school shuttles or public transportation instead of driving short distances or carpooling to campus. They can also unplug electric devices and appliances when not in use and prominently place recycle bins around campus. Finally, an important way to reduce wasteful energy usage is setting appropriate temperatures on thermostats and making the most of heat/air by keeping building insulation up to date and using fans instead of central air whenever possible.

The instrument used to calculate the emissions was very useful and impressive. There are some restrictions and inflexibility in the software, however, useful results were obtained. As the knowledge of this subject and the awareness of the general citizens increases, we may expect better and more efficient calculators and instruments to be introduced.

7. FUTURE WORK

There is much that can be done to improve this research. The five main ideas that have been brought to attention are:

- Provide a more flexible, but extensive carbon calculator, to provide an even higher efficiency.
- Form a live supported database with information necessary for calculation of carbon footprint for every college and university.
- Find better correlation of Carnegie levels and CO_2 emissions.
- Determine which factors would be sufficient to achieve the greatest reduction in carbon emission.
- Tie in an Arima model and SVM, to give institutions a look at what could be in a future time span at their current rate.

8. ACKNOWLEDGEMENTS

Special thanks go to Dr. Johnny L. Houston for the opportunity to conduct research at the 2008 Elizabeth City State University Computational Science-Scientific Visualization Institute. Also thanks to Dr. Constance Bland and Dr. Andrea Lawrence for their commitment to providing the necessary advisement the group required. To Alvin McClerkin, La' Trent Brock, Michelle Burke, Brittany Maybin and Unquiea Wade, special thanks to ourselves for our commitment to making this research engagement a very productive and beneficial project. And last but not least, thanks are given to God. Without God, this would have not been possible.

9. REFERENCES

[1] "Greenhouse Effect", Climate Change, United States Environmental Protection Agency, 2006 October 23, [cited: May 19, 2008], DOI= http://www.epa.gov/climatechange/kids/bigdeal.html

[2] Brian, Marshall 2008. How Gasoline Works. How Stuff Works, Problems with Gasoline, [cited May 19, 2008], DOI= http://science.howstuffworks.com/gasoline5.html

[3] The Carnegie Foundation for the Advancement of Teaching, Classification Descriptions, 2007, [cited May 17, 2008], DOI= http://www.carnegiefoundation.org/classifications/index.asp?key=785

[4] The Carnegie Foundation for the Advancement of Teaching, Institution Lookup, 2007, [cited May 17, 2008], DOI= http://www.carnegiefoundation.org/classifications/index.asp?key=782

[5] Carnegie Classifications of Higher Institutions, Academia, Wikipedia 2007 November 27, [cited May 16, 2008], DOI= http://en.wikipedia.org/wiki/Carnegie_Classification_of_Institutions_of_Higher_Education#General_description

[6] Carbon FootprintCO_2 Reduction, "Your Carbon Footprint", Reducing Your Impact, 2008, [cited May 16, 2008], DOI= http://www.carbonfootprint.com/minimisecfp.html

[7] Sweitzer, S., Talberth, J., "Carbon Footprint Analysis for Kaiser Permanente Food Procurement Alternatives in Northern Caliafornia", Prepared for the Community Alliance with Farmers, 2006 August, cited [cited May 18, 2008], DOI= http://www.sustainable-economy.org/uploads/File/Final%20Report%20CSE.pdf

[8] Association for the Advancement of Sustainability in Higher Education, AASHE Resource Center, 2005 – 2008, [cited May 19, 2008], DOI= http://www.aashe.org/resources/resourcecenter.php

[9] Footprint Measurement Methodology, The Carbon Trust, 2008, [cited: May 17, 2008], DOI= http://www.carbontrust.co.uk/NR/rdonlyres/6DEA1490-254B-434F-B2B2-21D93F0B0C98/0/Methodology_summary.pdf

[10] Carbon Footprint, Online Document Wikipedia 2008 May 21, [cited: May 16, 2008], DOI= http://en.wikipedia.org/wiki/Carbon_footprint

[11] Carbon Emissions Inventory,Association for the Advancement of Sustainability in Higher Education, AASHE Resource Center, 2005 – 2008,[cited May 19, 2008], DOI= http://www.aashe.org/resources/ghd_inventories.php

Appendix A

Year: Year data is collected in
Students: Number of students enrolled (required for some carbon calculators)
Elec.: kWh of electricity used
Mileage: total miles covered in transportation to or from the school
Gasoline: gallons of gasoline consumed
Diesel: Gallons of diesel fuel consumed
Nat. Gas: amount of natural gas consumed (mmBtu)
Elec. Em.: Tons of CO_2 emissions due to electricity
Trans. Em: Tons of CO_2 emissions due to transportation
Gas Em.: Tons of CO_2 emissions due to natural gas usage
CLC: Carnegie Level Classification for 2000

Figure 1.2

School	Elec.	Elec. Em.
CSPU	4.70E+07	6.40E+04
UIC	34113000	16072
USU	65257723	28693
UC Berkeley	2.13E+08	65000
CSU	1.52E+08	128740
Duke University	375903	200000
Evergreen State College	16459000	8954
Middlebury College	19915255	8000
Oberlin College	21664988	23703
Rice University	2.52E+08	6100
UCSB	79133909	28941
UNH	58103616	23913
Univ. of Central Florida	13671016	105950

Figure 1.4

School	Trans. Gallons	Trans. Em.
CSPU	6.40E+04	28000
Carleton College	1.61E+04	24000
Colby College	2.88E+04	19000
College of Charleston	6.52E+04	37000
Connecticut College	1.29E+05	15000
Yale University	9.10E+03	34904
Evergreen State College	8.97E+03	292
Middlebury College	8.02E+03	2.00E+03
Smith College	6.35E+03	2.00E+03
UCSB	2.40E+04	20436
UNH	1.06E+05	11615
UC Berkeley	1.30E+04	48000
CSU	2.30E+04	2816
Harvard	3.00E+04	37324
Oberlin College	1.20E+04	2919
Univ. of Central Florida	1.00E+04	7928

Consumption and Emissions Data:

School Name	Year	State	Student	Elec.	Mileage	Gasoline	Diesel	Nat. Gas	Elec. Em.	Trans. Em.	Gas Em.	CLC
CSPU	2005	CA	28000	4.70E+07				2.10E+05	64000	28000	11000	21
Carleton College	2004	MN	1966						13000	24000	22000	31
Colby College	2003	MA	1700						23000	19000	6000	31
College of Charleston	2001	SC	11332						30000	37000	39000	21
Connecticut College	2002	CT	1905						12000	15000	13000	31
Duke University	2003	NC	14075	375903		2.00E+05	190000		200000	70000	80000	15
Evergreen State College	2007	WA	4470	16459000	31790	25550	6240	115753	8954	292	6135	31
Middlebury College	2000	VT	2406	19915255	9970000	70221	71520	560712	8000	2000	7000	31
Pomona College	2007	CA	1550	2.30E+07				130000				31
Smith College	2007	MA	3113						10000	2000	15000	31
UCSB	2004	CA	20347	79133909	14423984	107490	6200	304315	28941	20436	16112	15
UNH	2005	NH	13165	58103616	2704756	148230	13014	82604	23913	11615	32562	15
UIC	2006	IL	13148	34113000				163105	16072	43271	163105	15
USU	2007	UT	18337	65257723	41324782	3799196	194910	60639	28693	57233	30753	15
UC Berkeley	2005	CA	23482	2.13E+08	2293064	100650	3390	238879	65000	48000	13000	15
CSU	2007	CO	26884	1.52E+08	16610943	251947	19718	2732810	128740	2816	16137	15
Harvard	2007	MA	6715			520000	10139		94174	37324	47127	15
Oberlin College	2000	OH	2762	21664988					23703	2919	4645	31
Penn. State	1999	PA	43048		200371							15
Rice University	1998	TX	5213	2.52E+08					6100	3400	2800	15
Tufts University	1998	MA	8058						9100	1500		15
Unity College	2006	ME	552						434.45	1043.36		32
Univ. of Central Florida	2007	FL	48000	13671016				895187	105950	7928	5837	16
Yale University	2005	CT	10206							34904		15
Lewis and Clark College	2003	OR	1960	15493177		9797			142094 62	152128 92	674581 8	31

Appendix B

The 2000 Carnegie Classification includes all colleges and universities in the United States that are degree-granting and accredited by an agency recognized by the U.S. Secretary of Education. The 2000 edition classifies institutions based on their degree-granting activities from 1995-96 through 1997-98.

Doctorate-granting institutions

Doctoral/Research Universities—Extensive: These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate. During the period studied, they awarded 50 or more doctoral degrees[1] per year across at least 15 disciplines.[3]

Doctoral/Research Universities—Intensive: These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate. During the period studied, they awarded at least ten doctoral degrees[1] per year across three or more disciplines,[2] or at least 20 doctoral degrees per year overall.

Master's Colleges and Universities

Master's Colleges and Universities I: These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the master's During the period studied, they awarded 40 or more master's degrees per year across three or more disciplines.[2]

Master's Colleges and Universities II: These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the master's degree. During the period studied, they awarded 20 or more master's degrees per year.

Baccalaureate Colleges

Baccalaureate Colleges—Liberal Arts: These institutions are primarily undergraduate colleges with major emphasis on baccalaureate programs. During the period studied, they awarded at least half of their baccalaureate degrees in liberal arts fields.[3]

Baccalaureate Colleges—General: These institutions are primarily undergraduate colleges with major emphasis on baccalaureate programs. During the period studied, they awarded less than half of their baccalaureate degrees in liberal arts fields.[3]

Baccalaureate/Associate's Colleges: These institutions are undergraduate colleges where the majority of conferrals are at the subbaccalaureate level (associate's degrees and certificates). During the period studied, bachelor's degrees accounted for at least ten percent but less than half of all undergraduate awards.

Associate's Colleges

These institutions offer associate's degree and certificate programs but, with few exceptions, award no baccalaureate degrees.[4] This group includes institutions where, during the period studied, bachelor's degrees represented less than 10 percent of all undergraduate awards.

Specialized Institutions

These institutions offer degrees ranging from the bachelor's to the doctorate, and typically award a majority of degrees in a single field. The list includes only institutions that are listed as separate campuses in the *Higher Education Directory.* Specialized institutions include:

Theological seminaries and other specialized faith-related institutions: These institutions primarily offer religious instruction or train members of the clergy.

Medical schools and medical centers: These institutions award most of their professional degrees in medicine. In some instances, they include other health professions programs, such as dentistry, pharmacy, or nursing.

Other separate health profession schools: These institutions award most of their degrees in such fields as chiropractic, nursing, pharmacy, or podiatry.

Schools of engineering and technology: These institutions award most of their bachelor's or graduate degrees in technical fields of study.

Schools of business and management: These institutions award most of their bachelor's or graduate degrees in business or business-related programs.

Schools of art, music, and design: These institutions award most of their bachelor's or graduate degrees in art, music, design, architecture, or some combination of such fields.

Schools of law: These institutions award most of their degrees in law.

Teachers colleges: These institutions award most of their bachelor's or graduate degrees in education or education-related fields.

Other specialized institutions: Institutions in this category include graduate centers, maritime academies, military institutes, and institutions that do not fit any other classification category.

Tribal Colleges and Universities

These colleges are, with few exceptions, tribally controlled and located on reservations. They are all members of the American Indian Higher Education Consortium.

2000 Carnegie Classifications

Category	Frequency	Percent
Doctoral/Research Universities—Extensive	151	3.8
Doctoral/Research Universities—Intensive	110	2.8
Master's Colleges and Universities I	496	12.6
Master's Colleges and Universities II	115	2.9
Baccalaureate Colleges—Liberal Arts	228	5.8
Baccalaureate Colleges—General	321	8.1
Baccalaureate/Associate's Colleges	57	1.4
Associate's Colleges	1,669	42.3
Specialized Institutions	766	19.4
Tribal Colleges and Universities	28	0.7
Total	3,941	100.0

Values (In Database)	Carnegie Classifications
15	Doctoral/Research Universities—Extensive(Level 1)
16	Doctoral/Research Universities—Intensive(Level 2)
21	Master's Colleges and Universities I (Level 3)
22	Master's Colleges and Universities II (Level 4)
31	Baccalaureate Colleges—Liberal Arts (Level 5)
32	Baccalaureate Colleges—General (Level 6)
33	Baccalaureate/Associate's Colleges (Level 7)
40	Associate's Colleges (Level 8)
51	Specialized Institutions—Theological seminaries and other specialized faith-related institutions (Level 9)
52	Specialized Institutions—Medical schools and medical centers (Level 10)
53	Specialized Institutions—Other separate health profession schools (Level 11)
54	Specialized Institutions—Schools of engineering and technology (Level 12)
55	Specialized Institutions—Schools of business and management (Level 13)
56	Specialized Institutions—Schools of art, music, and design (Level 14)
57	Specialized Institutions—Schools of law (Level 15)
58	Specialized Institutions—Teachers colleges (Level 16)
59	Specialized Institutions—Other specialized institutions (Level 17)
60	Tribal colleges and universities (Level 18)

A Comparative Study of Energy Usage by America and Japan Over a Ten Year Period

Joanne Kibaara
Lincoln University
1570 Baltimore Pike P.O.Box 179
Lincoln University, PA 19352
joanne_mukami@yahoo.com

Anisah Nu'Man
Spelman College
350 Spelman Lane
Atlanta, Ga. 30315
anuman@spelman.edu

Donnell Terry
Shaw University
118 East South St.
Raleigh, NC 27601
donnellterry@shawbears.com

Jessica Wilson
Tennessee State University
3500 John A. Merritt Blvd.
Nashville, TN 37209
msjwil08@aim.com

Lee Smalls, Jr.
Elizabeth City State University
1704 Weeksville Rd.
Elizabeth City, NC 27909
cmdallstar18@yahoo.com

ABSTRACT
In this study a comparison of consumption of various forms of energy by America and Japan, is made for the years 1996 through 2005. The existing data of annual usage of oil, natural gas, coal and electricity by America and Japan, will be prorated for 1000 population and a regression analysis is performed, for each form. It is found that per 1000 population for oil, natural gas and coal there is a negative trend in consumption by both America and Japan and electricity consumption trend is positive. The correlation coefficient for these trends is not significant to conclude that a pattern exists for comparison.

10. INTRODUCTION
The significance of energy in our economy today is the motivation for our project. We live in a time where energy prices are escalating and energy sources are becoming scarce. Although current energy prices are reasonable, we as Americans are experiencing this trend first hand at the gas pump. The same phenomenon is occurring with electricity, natural gas, coal, oil and all other facility energy sources. Energy plays a very important role within our economy today.

The project will be a comparison of electricity, natural gas, coal and oil. Electricity is the most widely used type of energy in the world, and its main providers are light and heat. Electricity is defined as a physical phenomena arising from the behavior of electrons and protons that is caused by the attraction of particles with opposite charges and the repulsion of particles with the same charge [1]. Natural gas is one of the cheapest forms of energy available to the residential consumer, and is most commonly used for cooking and residential heating. Natural gas is defined as a mixture of hydrocarbon gases that occurs naturally beneath the Earth's surface, often with or near petroleum deposits containing mostly methane but has varying amounts of ethane, propane, butane, and nitrogen [2]. Coal has many important uses, but most significantly in electricity generation, steel and cement manufacture, and industrial process heating. Coal is defined as a natural dark brown to black graphite-like material used as a fuel, formed from fossilized plants and consisting of amorphous carbon with various organic and some inorganic compounds [3]. Oil is used for gasoline, aviation fuels, diesel and heating oil, residual fuel oil, asphalt and lubricants. Oil is defined as any of numerous mineral, vegetable, and synthetic substances that are generally slippery, combustible, viscous, liquid or liquefiable at room temperatures, soluble in various organic solvents such as ether but not in water [4]. Since these sources of energy play such an important role in our daily lives, we hope this project will encourage people to take precaution when using energy.

In our project we will be evaluating the energy usage of both America and Japan. We will consider consumption per 1000 population for each year for USA and Japan. Through the use of Minitab we will find regression analysis for prorated consumption data, which tells whether or not there is a correlation between the data for America and Japan.

11. METHODS AND APPROACH

First we had to find data on energy usage by the two countries, from 1996 to 2005. There are different sources of energy used by the two countries. The common sources were oil, natural gases, coal and electricity. We compared how Japan and America used these sources from 1996-2005. Since the populations between the two countries differ, we computed consumption for every 1000 people. A linear regression was used to find the equation of line that best fit the scatter plot of complied data. We used the correlation coefficent to determine whether a relation exists between energy usage of America and Japan. Furthermore, with this equation we were able to determine the slope of the line, which indicated whether a positive or negative relation exists.

11.1 Computational Science and Scientific Visualization Tools

Using the Minitab software we plot the graphs of consumptions of each forms of energy from 1996 to 2005 by both the USA and Japan for the prorated data. We use the prorating formula for consumption per thousand population for each form of energy.

Consumption per Thousand =
(Consumption/Population) × 1000

The prorated data is now good to be used for comparison for each form of energy. We then plot a scatter plot with a fitted line; using the correlation coefficient we concluded whether a comparison exists between the USA and Japan energy usage. We also wrote a C++ Program as a computational tool to compute the prorated energy consumption. This program was written to verify our results from Minitab and Excel.

12. ENERGY CONSUMPTION BY USA

Data has been collected over a ten year period for the energy consumption of the United States of America. Within this study we primarily focus on energy in the form of Oil, Natural Gas, Coal, and Electricity. We chose these forms of energy because a large amount of data was available.

12.1 Annual Energy Consumption by USA

Table 1. Annual Energy Consumption for USA [5]

Year	Oil	Natural Gas	Coal	Electricity
1996	5739.5	2390.1	142.2	916.9
1997	5697.2	2439.5	148.3	944.1
1998	5498.2	2534.8	140.6	949
1999	5614.5	2735.6	153.1	953.9
2000	5495.4	2832.9	168.8	946.3
2001	5394.4	2830.6	173.2	930.5
2002	5301.3	2927.6	179.2	949.9
2003	5415.9	3044.6	185.3	936.8
2004	5290.6	3131	203.4	965.9
2005	5305.1	3080.8	196.3	974.2

12.2 Graphs of Consumption of Various Forms of Energy by USA

Once data was collect for energy consumption by the USA, we then individually graphed the energy consumption of oil, natural gas, coal, and electricity.

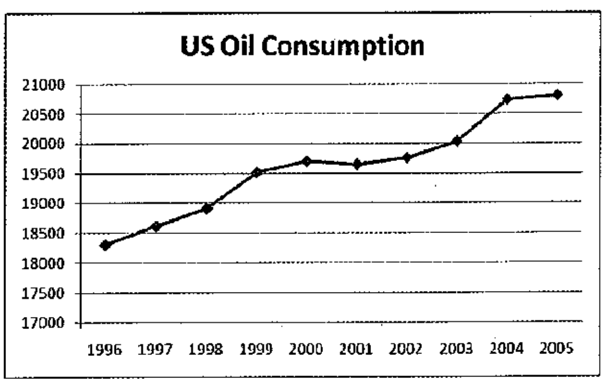


Figure 1. Total Oil Consumption from 1996-2005.

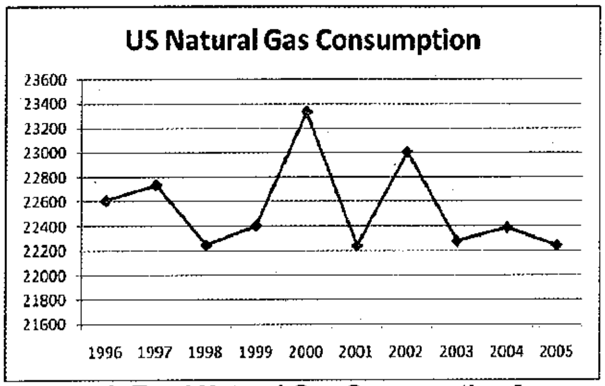


Figure 2. Total Natural Gas Consumption from 1996-2005.

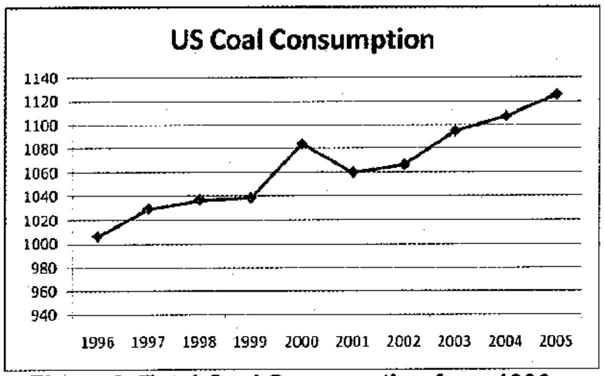


Figure 3. Total Coal Consumption from 1996-2005.

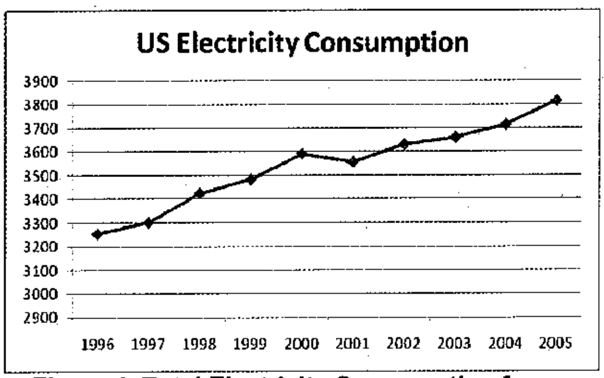


Figure 4. Total Electricity Consumption from 1996-2005.

13. ENERGY CONSUMPTION BY JAPAN

Data has been collected over a ten year period of the energy consumption of Japan. Within this study we primarily focus on energy in the form of Oil, Natural Gas, Coal, and Electricity. We chose these forms of energy because a large amount of data was available.

13.1 Annual Energy Consumption by Japan

Table 2. Annual Energy Consumption for Japan [6]

Year	Oil	Natural Gas	Coal	Electricity
1996	18308.9	22610	1006.3	3253.8
1997	18620.3	22737	1029.5	3301.8
1998	18917.1	22246	1037.1	3425.1
1999	19519.3	22405	1038.6	3483.7
2000	19701.1	23333	1084.1	3592.4
2001	19648.7	22239	1060.1	3557.1
2002	19761.3	23007	1066.4	3631.7
2003	20033.5	22277	1094.9	3662
2004	20731.2	22389	1107.3	3715.9
2005	20802.2	22241	1125.5	3815.7

13.2 Graphs of Various Forms of Energy Consumption by Japan

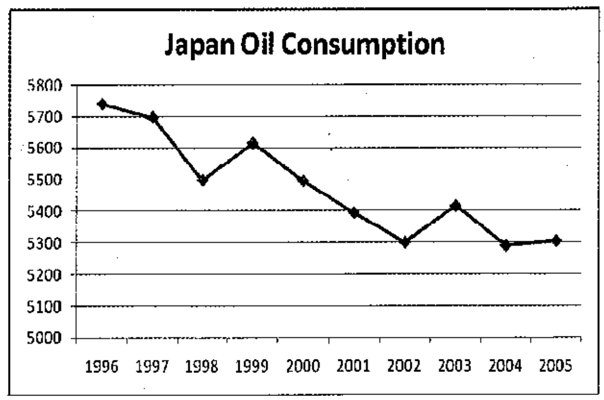


Figure 5. Total Oil Consumption from 1996-2005.

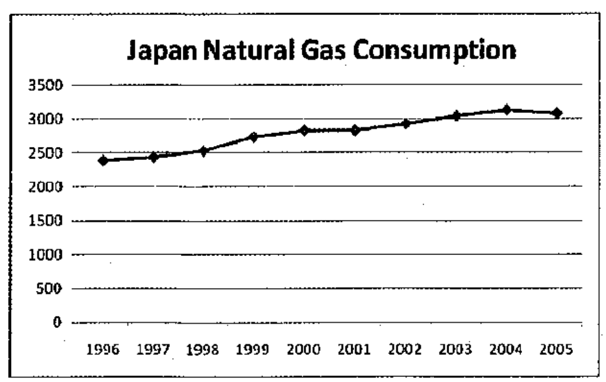


Figure 6. Total Natural Gas Consumption from 1996-2005.

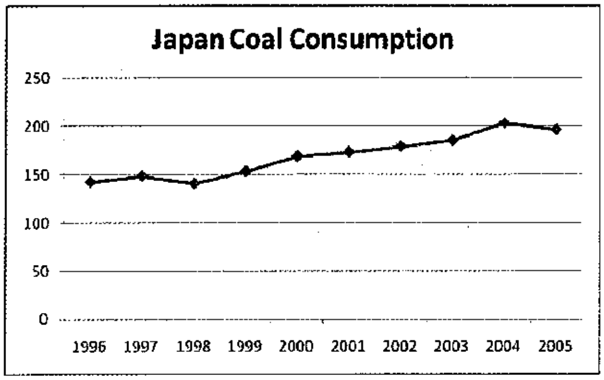


Figure 7. Total Coal Consumption from 1996-2005.

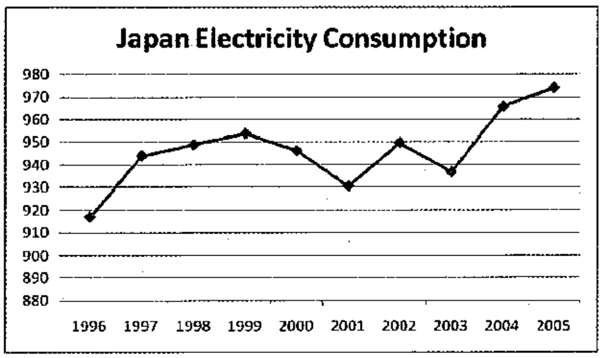


Figure 8. Total Electricity Consumption from 1996-2005.

14. PRORATED CONSUMPTION BY USA

We initial collected the population of the USA from 1996-2005. We then calculated the energy consumption for the USA for every one thousand population.

14.1 Table of USA Population from 1996-2005

Table 3. USA Population from 1996-2005 [7]

Year	USA
1996	263,814,032
1997	267,954,764
1998	270,311,756
1999	272,636,608
2000	275,562,673
2001	278,058,881
2002	280,562,489
2003	290,342,554
2004	293,027,571
2005	295,734,134

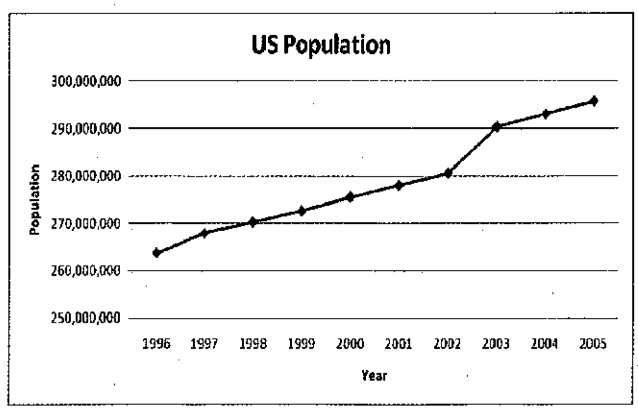


Figure 9. US Population from 1996-2005 per 1000 population

Table 4. Prorated Energy Consumption by USA

Year	Oil	Natural Gas	Coal	Electricity
1996	0.0694	0.0857	0.0031	0.01233
1997	0.0695	0.08485	0.0034	0.01232
1998	0.07	0.0823	0.0034	0.01267
1999	0.0716	0.08218	0.0031	0.01278
2000	0.0715	0.08467	0.0033	0.01304
2001	0.0707	0.07998	0.0031	0.01279
2002	0.0704	0.082	0.0038	0.01294
2003	0.069	0.07673	0.0037	0.01261
2004	0.0707	0.07641	0.0038	0.01268
2005	0.0703	0.07521	0.0031	0.0129

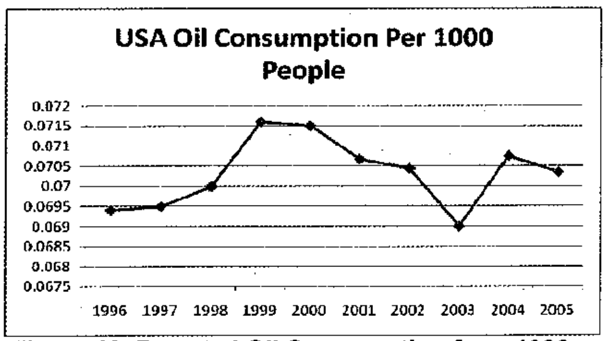


Figure 10. Prorated Oil Consumption from 1996-2005.

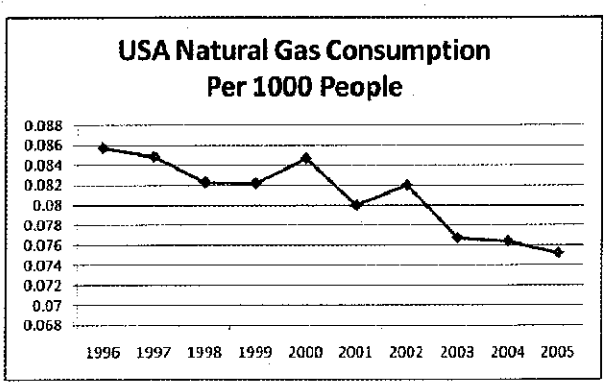


Figure 11. Prorated Natural Gas Consumption from 1996-2005.

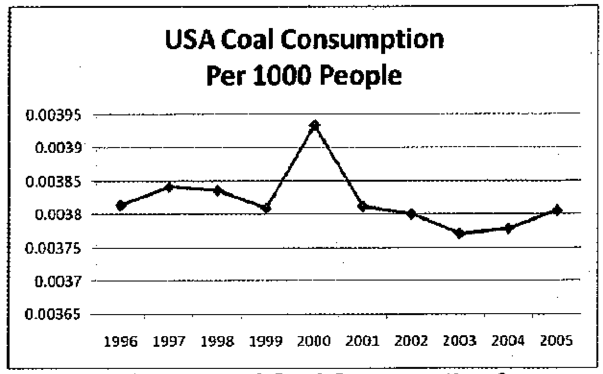


Figure 12. Prorated Coal Consumption from 1996-2005.

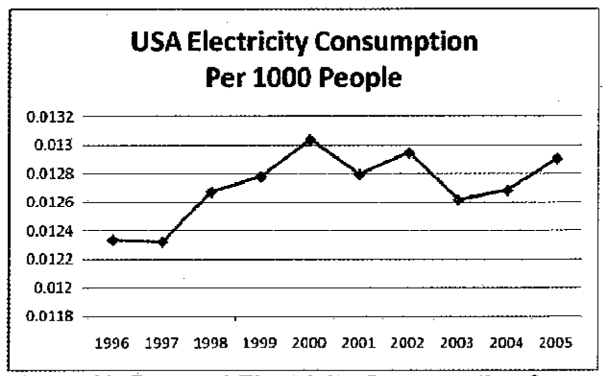


Figure 13. Prorated Electricity Consumption from 1996-2005.

15. PRORATED CONSUMPTION BY JAPAN

We initial collected the population of Japan from 1996-2005. We then calculated the energy consumption for Japan for every one thousand people.

15.1 Table of Japan Population from 1995-2006

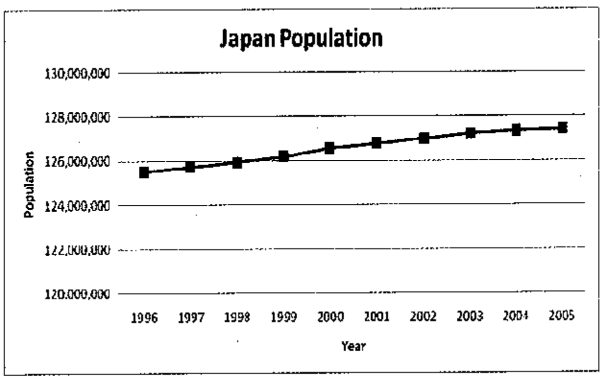
Table 5. USA Population from 1995-2006

Figure 14. Japan Population from 1996-2005 per 1000 people

Table 6. Prorated Energy Consumption by Japan

Year	USA
1996	125,506,492
1997	125,732,794
1998	125,931,533
1999	126,182,077
2000	126,549,976
2001	126,771,662
2002	126,974,628
2003	127,214,499
2004	127,333,002
2005	127,417,244

Year	Oil	Natural Gas	Coal	Electricity
1996	0.0457	0.01904	0.00113	0.00731
1997	0.0453	0.0194	0.00118	0.00751
1998	0.0437	0.02013	0.00112	0.00754
1999	0.0445	0.02168	0.00121	0.00756
2000	0.0434	0.02239	0.00133	0.00748
2001	0.0426	0.02233	0.00137	0.00734
2002	0.0418	0.02306	0.00141	0.00748
2003	0.0426	0.02393	0.00146	0.00736
2004	0.0415	0.02459	0.0016	0.00759
2005	0.0416	0.02418	0.00154	0.00765



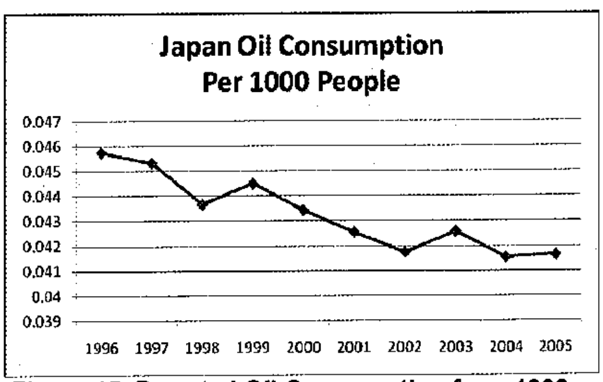


Figure 15. Prorated Oil Consumption from 1996-2005.

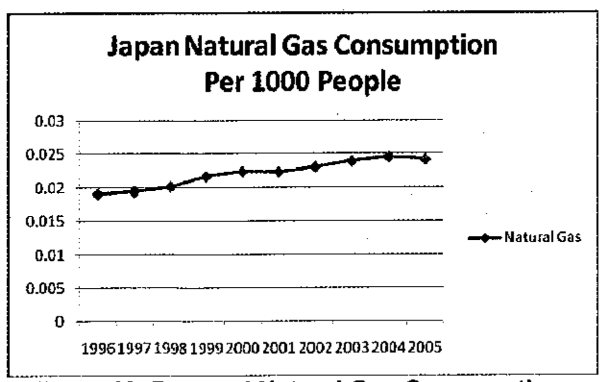


Figure 16. Prorated Natural Gas Consumption from 1996-2005.

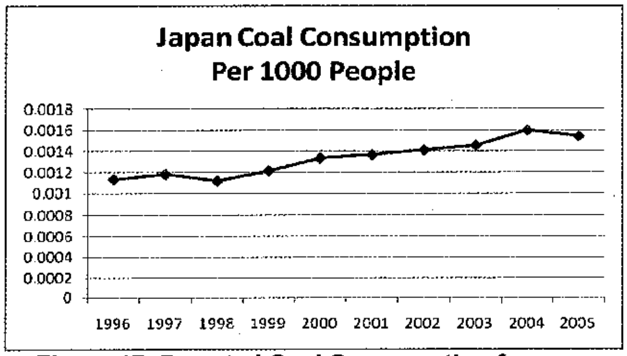


Figure 17. Prorated Coal Consumption from 1996-2005.

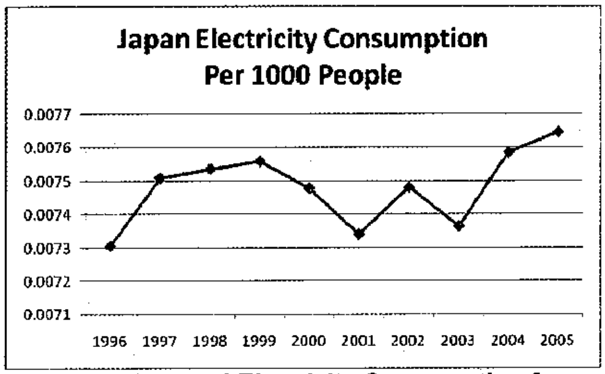


Figure 18. Prorated Electricity Consumption from 1996-2005.

16. C++ as a Computational Science Tool

Just like Minitab, the C++ program below can also be used to compute the prorated energy consumption by Japan and USA. Using data that is saved on a text file, the program will first locate the data, loop through it, calculate the prorated consumption and save the results in a different text file. Two text files are used, one for Japan and the other for the USA.

Each of these two files contains data on the actual energy consumed and the country's population for the ten years. The following formula is used;

Prorated Energy Consumption =

$$\frac{\text{Actual Energy Consumed}}{\text{Population}} * 1000$$

7.1 C++ Program

```
#include<iostream>
#include<iomanip>
#include<fstream>
using namespace std;

int main()
{
   ifstream infile;
   ofstream outfile;

float  USAOil, USANG, USACoal, USAElec,
USAOPT,  USANGPT, USACPT, USAEPT;
float  Oil,JNG, JCoal, JElec, JOPT, JNGPT, JCPT,
JEPT;
int Year, USAPop, JPop;
  infile.open("c:\\project1\\USAinput.txt");
  outfile.open("c:\\project1\\USAoutput.txt");

if (!infile) {
          cout << "Cannot find file"<< endl;
          }
else
outtfile<<"The prorated data for USA is as
follows"<<endl;
 outfile<<endl;
outfile<<"YEAR"<<setw(20)<<"OIL"<<setw(20)
<<"NATURALGAS"<<setw(20)<<"COAL"<<
setw(20)<<"ELECTRICITY\n";

for(int i=0; i<10; i++) {
infile>>Year>>USAPop>>USAOil>>USANG>>
USACoal>>USAElec;

          USAOPT = (USAOil/USAPop)* 1000;
          USANGPT = (USANG/USAPop) * 1000;
          USACPT = (USACoal/USAPop)* 1000;
          USAEPT = (USAElec/USAPop)* 1000;

outfile<<Year<<setw(20)<<USAOPT<<setw(20)
<<USANGPT<<setw(20)<<USACPT<<setw(20)<<U
SAEPT<<endl;
}
infile.close();
outfile.close();

 infile.open("c:\\project1\\JAPANinput.txt");
 outfile.open("c:\\project1\\JAPANoutput.txt");

if (!infile) {
          cout << "Cannot find file"<< endl;
          }
 else
outfile<<"The prorated data for JAPAN is as
follows"<<endl;
outfile<<endl;
outfile<<"Year"<<setw(20)<<"JOPT"<<setw(20)<<"J
NGPT"<<setw(20)<<"JCPT"<<setw(20)<<
"JEPT\n";
```

```
for(int j=0; j<10; j++)
{infile>>Year>>JPop>>JOil>>JNG>>JCoal>>
JElec;

        JOPT = (JOil/JPop)* 1000;
        JNGPT = (JNG/JPop) * 1000;
        JCPT = (JCoal/JPop)* 1000;
        JEPT = (JElec/JPop)* 1000;

outfile<<Year<<setw(20)<<JOPT<<setw(20)<<
JNGPT<<setw(20)<<JCPT<<setw(20)<<JEPT
<<endl;
}

infile.close();
outfile.close();


return 0;
}
```

7.2 Prorated Energy Obtained By the C++ Program

USAoutput - Notepad

File Edit Format View Help

The prorated data for USA is as follows

YEAR	OIL	NATURAL GAS	COAL	ELECTRICITY
1996	0.0694008	0.0857043	0.00381443	0.0123337
1997	0.0694905	0.0848539	0.00384207	0.0123222
1998	0.0699825	0.0822976	0.00383668	0.0126709
1999	0.0715938	0.0821781	0.00380942	0.0127777
2000	0.0714941	0.084674	0.00393413	0.0130366
2001	0.0706638	0.0799795	0.0038125	0.0127926
2002	0.0704346	0.0820031	0.00380094	0.0129444
2003	0.0689995	0.0787266	0.00377106	0.0126127
2004	0.0707483	0.0784058	0.00377883	0.0126811
2005	0.0703409	0.0752061	0.00380578	0.0129025

JAPANoutput - Notepad

File Edit Format View Help

The prorated data for JAPAN is as follows

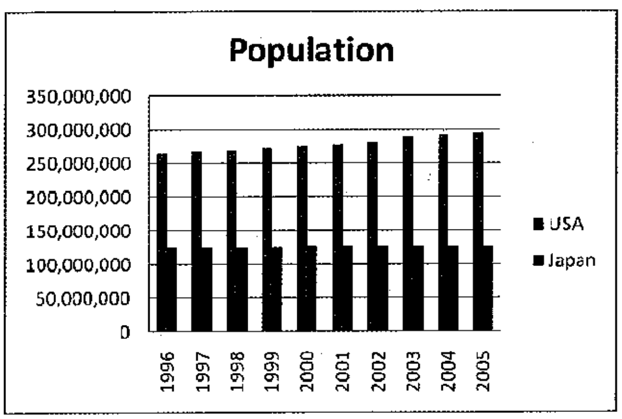
YEAR	OIL	NATURAL GAS	COAL	ELECTRICITY
1996	0.0457307	0.0190436	0.00113301	0.0073056
1997	0.0437292	0.0194023	0.00117949	0.00750878
1998	0.0445837	0.0201284	0.00111648	0.00753584
1999	0.0435514	0.0216798	0.00121333	0.00755971
2000	0.0426266	0.0223856	0.00133386	0.00747768
2001	0.0418177	0.0223283	0.00136624	0.00733997
2002	0.0426534	0.0230566	0.00141131	0.00748102
2003	0.041588	0.0239328	0.0014566	0.00736394
2004	0.0416632	0.0245891	0.00159739	0.00758562
2005	0.0404922	0.0241788	0.00154061	0.00764575

17. COMPARATIVE ANALYSIS

In statistics, regression analysis examines the relation between two variable. Regression analysis is used to get a mathematical equation that closely fits a set of data points. Within this study we used regression analysis to test the relationship between US energy consumption and Japan's energy consumption. A linear regression was used to calculate the equation that best fits a straight line from compiled data. We used Minitab and Excel, computer programs, to calculate equation of a regression line.

Using the prorated table of energy consumption for the US and Japan we plotted a fitted line scatter plot for each form of energy. We held the USA prorated energy consumption as the y value and Japan's prorated energy consumption as the x value. Next the correlation coefficient was calculated to conclude whether the consumption of each form of energy from both countries is random or a type of relation exists.

Table 7. USA and Japan Population from 1995-2006



17.1 Prorated Oil Regression Plot

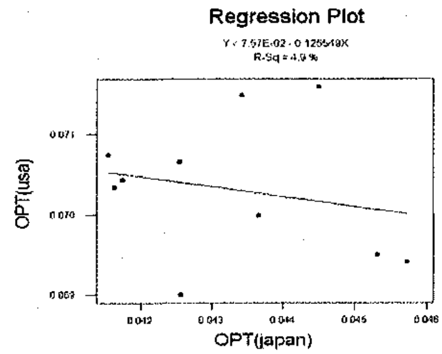


Figure 19. Best Fit Line of Oil Consumption.

The prorated oil consumption scatter plot shows that the consumption of oil by the US and Japan is random. Therefore a comparison does not exist.

8.2 Prorate Natural Gas Regression Plot

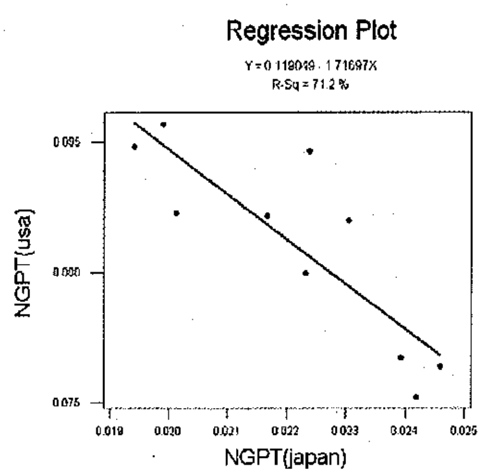


Figure 20. Best Fit Line of Natural Gas Consumption.

The prorated natural gas consumption scatter plot shows that there exists a moderate relation between consumption of natural gas by the US and Japan.

8.3 Prorated Coal Regression Plot

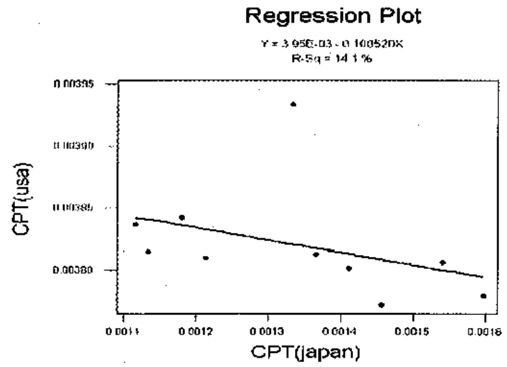


Figure 21. Best Fit Line of Coal Consumption.

The prorated coal consumption scatter plot shows, with exception of one point, that there exists a negative relation between consumption of coal by the US and Japan.

8.4 Prorated Electricity Regression Plot

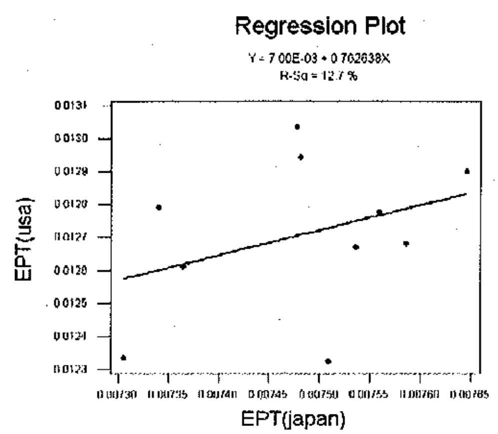


Figure 22. Best Fit Line of Electricity Consumption.

The prorated electricity consumption scatter plot shows that the consumption of electricity by the US and Japan is random. Although no relation exists, the trend is positive.

18. RESULTS AND CONCLUSION

We used data from the Energy Information Association (EIA) to compare the energy consumption of the US and Japan. In order to find the consumption for every one thousand people, we took the consumption for each source of energy, and multiplied by one thousand. After getting the results, we then divided by 1000, which gave us a level field for comparison. From the data we collected we can identify a trend of how much energy is being used by both nations. The data shows that as the population increased year by year, the consumption of most energy sources increased also. The US consumption of coal, electricity, and oil has increased since 1996. Natural gas consumption is the only source of energy that has decreased since the mid 90's. In contrast to the US, Japan's oil consumption has steadily been decreasing from 1996 to 2005. On the other hand Japan's usage of coal, natural gas, and electricity has been increasing. With the consumption of energy for every one thousand people we were able to compare the consumption of energy for both countries by using regression plots. The regression plots allow us to determine whether a correlation exists between the energy usage of Japan and the US. Overall we were able to conclude that no systematic comparison can be made between the energy usage of Japan and America. In addition we concluded that there exist similar trends in the scatter plots of natural gas and coal usage between American and Japan. From 1996-2005 It is found that per 1000 population for oil, natural gas and coal there is a negative trend in consumption by both America and Japan and electricity consumption trend is positive. The correlation coefficient for these trends is not significant to conclude that a pattern exists for comparison.

19. ACKNOWLEDGEMENTS

Our thanks to Elizabeth City State University's CSSV Center, the National Association of Mathematicians Inc. (NAM), the Department of Energy (DoE), Dr. Johnny L. Houston, Dr. Krishna H. Kulkarni, Dr. Farrah Chandler, Dr. Constance Bland, Dr. John Alexander, Dr. Andrea Lawrence, Dr. Jamiiru Luttamaguzi, Mr. Kevin Jones, Mr. Lee Hayden, and Ms. Dadryn Johnson for allowing us to participate in this Undergraduate Research Program.

20. REFERENCES

[1] *The American Heritage® Dictionary of the English Language, Fourth Edition.* Houghton Mifflin Company, 2004. Retrieved May 20, 2008. <Dictionary.com http://dictionary.reference.com/browse/electricity>.

[2] *The American Heritage® Dictionary of the English Language, Fourth Edition.* Houghton Mifflin Company, 2004. Retrieved May 20, 2008. <Dictionary.com http://dictionary.reference.com/browse/natural gas>.

[3] *The American Heritage® Dictionary of the English Language, Fourth Edition.* Houghton

Mifflin Company, 2004. Retrieved May 20, 2008. <Dictionary.com http://dictionary.reference.com/browse/coal>.

[4] *The American Heritage® Dictionary of the English Language, Fourth Edition.* Houghton Mifflin Company, 2004. Retrieved May 20, 2008. <Dictionary.com http://dictionary.reference.com/browse/oil>.

[5] Energy Information Administration. United States Energy Profile Retrieved May 15, 2008 http://tonto.eia.doe.gov/country/country_time_series.cfm?fips=US

[6] Energy Information Administration. Japan Energy Profile Retrieved http://tonto.eia.doe.gov/country/country_energy_data.cfm?fips=JA

[7] Retrieved May 21, 2008, from http://www.theodora.com/wfb/

A Study of the Correlation between Air Quality and the Number of Visitors of the Great Smoky Mountain National Park between 2002 and 2006

Diaminatou Goudiaby
Elizabeth City State University
ladydiamila@hotmail.com

Benjamin Harvey
Mississippi Valley State University
bsharvey@mvsu.edu

Shatina Morgan
Winston Salem State University
smorgan106@wssu.edu

Ashley Rouser
Jackson State University
arouser09@yahoo.com

Darius Wheeler
Delaware State University
dariuswheeler@verizon.net

ABSTRACT

Everyone is affected by the quality of our air. Negative environmental impacts due to energy creation include massive air pollution, and the release of heavy metals and other contaminants into the air, water, or on the land .Those pollutants are affecting the body's respiratory system and the cardiovascular system. Using six common criteria pollutants, ozone, particular matters 2.5 and 10, carbon monoxide, sulfur oxides, and nitrogen oxides, this study will try to find a relationship between air quality in areas surrounding the Great Smoky Mountain National Park and the annual number of visitors to the park. Linear Regression will be used to establish a correlation between air quality and the number of visitors to the park.

Specifically we: (1) Obtained field data from the EPA (US Environmental Protection Agency) on the air quality from selected areas surrounding the Great Smoky Mountain National Park between 2002 and 2006. The areas selected were Knox County, Tennessee, Polk County, Tennessee, and Asheville, North Carolina. (2) Established a correlation between the air quality and the number of visitors to the Great Smoky Mountain National Park using Linear Regression. (3) Used Lagrange Polynomial and Newton's divided difference polynomial interpolation method to predict 2009 air quality in the Great Smoky Mountain and tried to predict visitation trends as the pollution takes place.

Keywords

Pollutants

Lagrange Interpolating Polynomial

Linear Regression

Non Linear Regression

Air Quality

Newton Divided Differences formula

21. INTRODUCTION

The Great Smoky Mountains National Park (GSMNP) was established in 1934 and was dedicated on September 2, 1940 by President Franklin D. Roosevelt. Half of the park is located in North Carolina and the other half in Tennessee. The GSMNP contains about 800 square miles and 521,490 acres. This park is known as America's most-visited national park due to its diversity of plant and animal life, the beauty of its ancient mountains, and the history of the Southern Appalachian mountain culture. [1] Each year between eight to ten million people visited the park. In a 1996 survey, seventy-four percent of the summer visitors to the Great Smoky Mountains said the clean air was "extremely important" to them during their stay in the park; eight-four percent said scenic views were "extremely important".

Air pollution is one of the environmental factors that affect the quality of the air and the scenery of the park. "Monitoring and research conducted over the past twenty-eight years at the Great Smoky Mountains National Park has shown that air pollution is significantly affecting park resources, visitor enjoyment and public health." [1] The park experiences the most air pollution of any national park in the U.S. In 1970, the Congress passed the Clean Air Act which establishes a national policy for preserving, protecting, enhancing air quality and the six "criteria" pollutants.

Air pollution contains a mixture of chemicals with various harmful effects on the human body, wildlife, plants, and climate. A daily index calculates air pollutants. The highest of the index values for that day is the air quality index (AQI) value, and the pollutant responsible for the highest index value for that day is known as the main pollutant. The pollutants that are used to define the air quality index value each day are carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, particular matter smaller than 2.5 micrometers, and particular matter smaller than 10 micrometers. The AQI are arranged in categories of potential health effects that are in relation to the AQI values. The health effects categories are good when the AQI is 0-50, moderate when AQI is 51-100, unhealthy for sensitive groups when AQI is 101-150, unhealthy when AQI is 151-200, very unhealthy when AQI is 201-300, and hazardous when the AQI is 301-501.

Carbon monoxide (CO)

Carbon monoxide (CO) is a colorless, odorless gas or liquid. It is formed from incomplete oxidation of carbon in combustion and burns with violet flame. This pollutant is mostly found in cars. Carbon monoxide does cause some health effects including fatigue in healthy people, impaired vision, headaches, dizziness, confusion, and flu-like symptoms. In addition, those whom have heart disease could experience chest pain if they come in contact with this pollutant.

Sulfur Dioxide, or SO2

Another pollutant is sulfur dioxide, or SO2. This pollutant belongs to the sulfur oxide gases that dissolve easily in water. Sulfur is found in all raw materials such as crude oil, coal, and ore that contain aluminum, copper, zinc, and iron. High levels of exposure to sulfur can be life-threatening for humans. Some of the health effects that may result from SO2 involve burning of the nose and throat, severe airway obstructions and breathing problems. Animals also experience respiratory effects.

Nitrogen Dioxide

Nitrogen dioxide is another pollutant that is a reddish-brown gas that comes from the burning of fossil fuels. It has a strong, nasty smell at high levels. This pollutant mainly comes from power plants and cars and is formed by lightning, plants, soil, or water. This pollutant actually contributes to the formation of photochemical smog, which has important impacts on human health. The main source of nitrogen dioxide is the burning of fossil fuels, which are coal, oil and gas. Petrol and electricity generation from coal-fired power stations also contribute to nitrogen dioxide. Gas heaters, cars, and combustion are major sources of this pollutant. Nitrogen dioxide can affect the human body by inflaming the lining of the lungs and or reducing the bodies' immunity to lung infections, which can cause problems such as wheezing, coughing, colds, and bronchitis.

Ozone

Another pollutant is the ozone, which is a gas that can be found near the ground (the troposphere), and is a major part of smog. The harmful ozone in the lower atmosphere should not be confused with the protective layer of ozone in the upper atmosphere (stratosphere), which screens out harmful ultraviolet rays. The ozone is the main ingredient of the air that is known as "smog". The ozone is highly reactive and is formed in the atmosphere through complex chemical reactions between hydrocarbons and nitrogen oxides, in the presence of sunlight (which is why it is mostly found in summer). High levels of the ozone can irritate the nose, throat and respiratory system, and also construct the airways of the body. This pollutant can also affect asthma, bronchitis, and emphysema; and it damages trees agricultural crops, and other plants.

Particular Matter- PM2.5 and PM10

Particular matters are different particles that float around in the air, and most of them cannot be seen. These particles come in almost any shape or size but are divided into two major groups. The first group is known as Particular Matter 10 (PM10), which are the bigger particles and are between 2.5 and 10 micrometers. The second group are the Particular Matter 2.5 (PM2.5), which are the smaller particles that are less than 2.5 micrometers. PM10 are coarse particles that are dirt, smoke, dust from factories, mold, spore, and pollen. They are made by the crushing and grinding of rocks and soil and are blown by the wind. PM2.5 are fine particles that are toxic organic compounds and heavy metals. They are formed from driving automobiles, burning plants (forest fires or yard waste), and smelting metals. When a person inhales, they breathe in particles that are in the air, which ultimately travel into one's respiratory system. The farther the particles go, the worse. Smaller particles can pass through smaller airways in the body, therefore they go farther into the body. The bigger particles are more than likely to stick to the sides of the body. PM2.5 will have the worse health effects because it travels deep into the lungs and their particles are more toxic. Particular matter causes coughing, wheezing, aggravated asthma, lung damage, and shortness of breath.

22. MATERIALS AND METHODS

We located the GSMNP on a county by county map to determine its geographic location. Due to its location, we chose to focus on Knox County, TN., Polk County, TN., and Asheville, NC. We obtained field data from the Environmental Protection Agency (E.P.A) for the overall air quality, and it was given in daily increments over the course of the five years studied. The data for the overall air quality was partitioned by pollutant (CO_2, NO_2, O_3, SO_2, $PM_{2.5}$, PM_{10}), and then averaged by month. The averaged data was then analyzed using linear regression. The purpose was to determine if there was a correlation between visitors to the GSMNP and the air quality in that geographic area.

We then used the data in three different mathematical models to try and predict the future trends in air quality as well as visitation to the park. The first was a model using Lagrange polynomials. The second was a model using Newton's Divided Difference formula. This model was used not only to predict the future, but was also used as a way to check the accuracy of the first model. The final method used to predict future trends was a model using non- linear regression (see Appendix). We obtained park visitation information which was given per month over a five year period from 2002 - 2006. Test data was first analyzed analytically, and was then analyzed using a JAVA based program to test the accuracy of this model.

22.1 JAVA forecasting program

There was then an attempt to predict future trends in air quality and population. We were unable to predict any trends in population or air quality using Lagrange or the divided difference models. This was due to the functions involved, as well as the nature of interpolating polynomials. However, we were able to predict population using non- linear regression. Analytically we were able to test a JAVA based program successfully. This JAVA program was then able to predict the future population and air quality trends.

The general process for creating a prediction equation involves gathering relevant data from a large, representative sample from the population. In a prediction analysis, the computer will produce a regression equation that is optimized for the sample. The samples will then be entered into the program then computed by the equation. The program then presents a graph to represent the trends that the free, forced, and the actual data computed by the equation alone. Because this process capitalizes on chance and error in the sample, the equation produced in one sample will not generally fare as well as in Gamma is a mean squared error estimator. Error estimators play a central role in statistical reasoning. Statisticians use them to answer questions such as "Do I have enough data?", "How accurate are these results?", and "Which of my input variables are important for prediction? In this case (i.e., R-squared in a subsequent sample using the same equation will not be as large as R-squared from original sample), a phenomenon called shrinkage is used to force the relevant data from a large, representative sample from the population into the equation. The most desirable outcome in this process is for minimal shrinkage, indicating that the prediction equation will generalize well to new samples or individuals from the population or historical data examined.

Prediction equation:

```
// computed in evaluate(): Y = Yforced+Yfree
//dU = Historical Data
```

To force the historical data in to the equation:

```
//Yforced [0]= (Start with .5) /2 = .25 +.5 = .75 *
Historical Data (dU)
//Yforced [1]= (Start with .75) /2 = .375 +.5 = .875 *
Historical Data (dU)
//Yforced [2]= (Start with .875) /2 = .4375 +.5 = .9375
* Historical Data (dU)
```

To use the equation with set variables or leave it free:

```
//class variables
final double Up1 = 1.0;
final double Up2 = 1.0;
final double Y0 = 0.0;
//Yfree[0] = 0.75 ( which is .75/2) *Up1 + 0.125
*Up2 + 0.125 *Y0;
//Yfree[1] = 0.875 ( which is .75/2) *dU[0]+ 0.0625
*Up2 + 0.0625 *Y0;
//Yfree[2] = 0.9375*dU[0] + 0.03125 *Up2 + 0.03125
*Y0;

// computed in evaluate(): Y = Yforced+Yfree
//dU = Historical Data
```

The actual function to predict 12 future months of data:

```
void evaluate() // Y = V*dU + Yp, Yp = ...
  {
        U[0] = Up1 + dU[0];
        for (int i=1; i < 12; i++)
```

```
   U[i] = U[i-1] + dU[i];
Yforced[0] =   0.5 *dU[0];
        Yforced[1] =   0.75 *dU[0] +   0.5
*dU[1];
Yforced[2] =  0.875 *dU[0] +  0.75 *dU[1] +
0.5 *dU[2];
Yforced[3] = 0.9375 *dU[0] + 0.875 *dU[1] +
0.75 *dU[2] + 0.5 *dU[3];
Yforced[4] = 0.96875 *dU[0] + 0.9375 *dU[0]
+ 0.875 *dU[1] + 0.75 *dU[2] +      0.5 *dU[3];
Yforced[5] = 0.984375 *dU[0] + 0.96875
*dU[0] + 0.9375 *dU[0] + 0.875 *dU[1] + 0.75
*dU[2] + 0.5 *dU[3];
Yforced[6] = 0.9921875 *dU[0] + 0.984375
*dU[0] +0.96875 *dU[0] + 0.9375 *dU[0] +
0.875 *dU[1] + 0.75 *dU[2] + 0.5 *dU[3];
Yforced[7] = 0.99609375 *dU[0] + 0.9921875
*dU[0] + 0.984375 *dU[0] +0.96875 *dU[0] +
0.9375 *dU[0] + 0.875 *dU[1] + 0.75 *dU[2] +
0.5 *dU[3];
Yforced[8] = 0.998046875 *dU[0] +
0.99609375 *dU[0] + 0.9921875 *dU[0] +
0.984375 *dU[0] +0.96875 *dU[0] + 0.9375
*dU[0] + 0.875 *dU[1] + 0.75 *dU[2] + 0.5
*dU[3];
Yforced[9] = 0.9990234375 *dU[0] +
0.998046875 *dU[0] + 0.99609375 *dU[0] +
0.9921875 *dU[0] + 0.984375 *dU[0]
+0.96875 *dU[0] + 0.9375 *dU[0] + 0.875
*dU[1] + 0.75 *dU[2] + 0.5 *dU[3];
Yforced[10] = 0.9995117188 *dU[0] +
0.9990234375 *dU[0] + 0.998046875 *dU[0] +
0.99609375 *dU[0] + 0.9921875 *dU[0] +
0.984375 *dU[0] +0.96875 *dU[0] + 0.9375
*dU[0] + 0.875 *dU[1] + 0.75 *dU[2] + 0.5
*dU[3];
Yforced[11] = 0.9997558594 *dU[0] +
0.9995117188 *dU[0] + 0.9990234375 *dU[0]
+ 0.998046875 *dU[0] + 0.99609375 *dU[0] +
0.9921875 *dU[0] + 0.984375 *dU[0]
+0.96875 *dU[0] + 0.9375 *dU[0] + 0.875
*dU[1] + 0.75 *dU[2] + 0.5 *dU[3];

Yfree[0] =   0.75 *Up1 +   0.125 *Up2 +
0.125 *Y0;
Yfree[1] =  0.875 *dU[0]+ 0.0625 *Up2  +
0.0625 *Y0;
Yfree[2] = 0.9375*dU[0] + 0.03125 *Up2 +
0.03125 *Y0;
Yfree[3] = 0.96875*dU[0] + 0.015625 *Up2 +
0.015625 *Y0;
Yfree[4] = 0.984375*dU[0] + 0.0078125 *Up2
+ 0.0078125 *Y0;
Yfree[5] = 0.9921875*dU[0] + 0.00390625
*Up2 + 0.00390625 *Y0;
Yfree[6] = 0.99609375*dU[0] + 0.001953125
*Up2 + 0.001953125 *Y0;
Yfree[7] = 0.998046875*dU[0] +
0.0009765625 *Up2 + 0.0009765625 *Y0;
Yfree[8] = 0.9990234375*dU[0] +
0.00048828125 *Up2 + 0.00048828125 *Y0;
Yfree[9] = 0.9995117188*dU[0] +
0.000244140625 *Up2 + 0.000244140625
*Y0;
Yfree[10] = 0.9997558594*dU[0] +
0.0001220703125 *Up2 + 0.0001220703125
*Y0;
Yfree[11] = 0.9998779297*dU[0] +
0.00006103515625 *Up2 +
0.00006103515625 *Y0;


    for (int i=0; i < 12; i++)
       Y[i] = Yforced[i] + Yfree[i];

    evalMinMax();
}
```

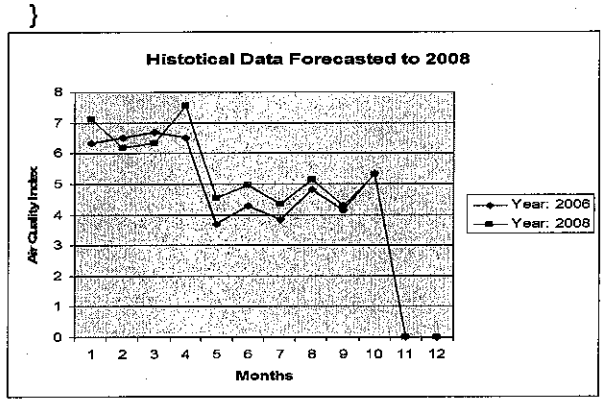


Figure 3: Correlation of Historical data forecasted to 2008 compared to 2006

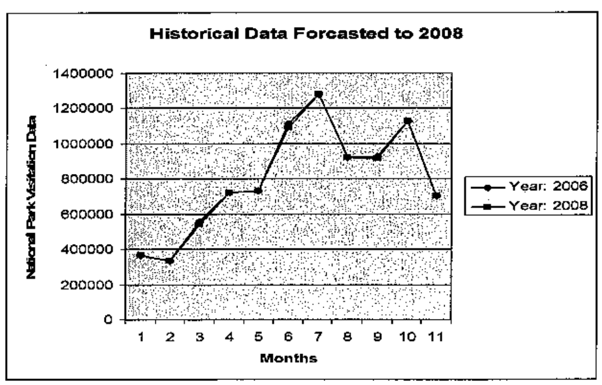


Figure 3. Correlation of Air Quality Index data forecasted to 2008 compared to 2006

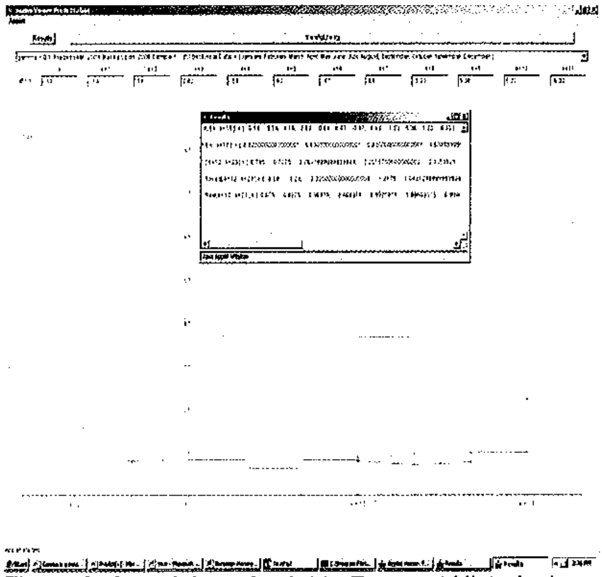


Figure 3: Actual Java Applet to Forecast Historical Data with graph to show correlation between forced, free, and the actual prediction from the equation. With separate interface recording forecasted data

23. ANALYSIS AND RESULTS

The air quality data was compared to the population data to determine if there was a correlation between the two. These comparisons were done based on geographic area, year, and season. The comparisons were done on a Cartesian coordinate system. The x-axis was the park attendance and the y-axis was the air quality index. Park visitation ranged from approximately 200, 000 to approximately 1.35 million. The air quality ranged from 0 -100. The air quality is considered "good", when its value is between 0 and 50. The air quality is considered "moderate", when its value is between 51 and 100.

A linear regression was done for the three regions Knox County, Polk County, and Asheville, North Carolina. The 2002 analysis for Polk County is given below. The analysis for Polk County based on the seasons Fall (September, October, November), Winter (December, January, and February), Spring (March, April, and May), and Summer (June, July, and August) is also given. The analysis for Polk County (2003-2006), Knox County and Asheville county can be found in the appendix.

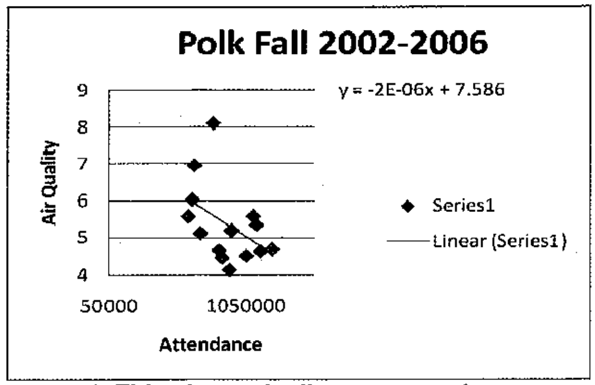


Figure 1. This shows the linear regression between the air quality and the attendance of Polk County in the fall. As shown in the graph, there exists no correlation between the attendance and the air quality.

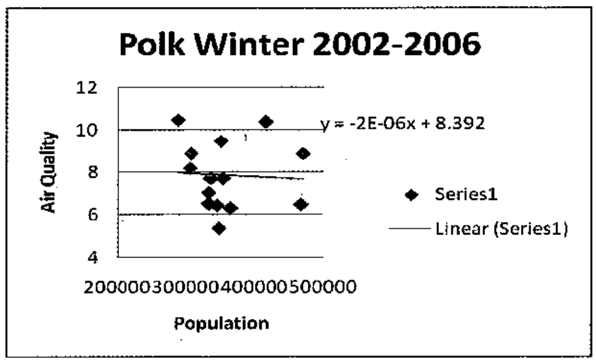


Figure 2. This shows the linear regression between the air quality and the attendance of Polk County in the Winter. As shown in the graph, there exists no correlation between the attendance and the air quality.

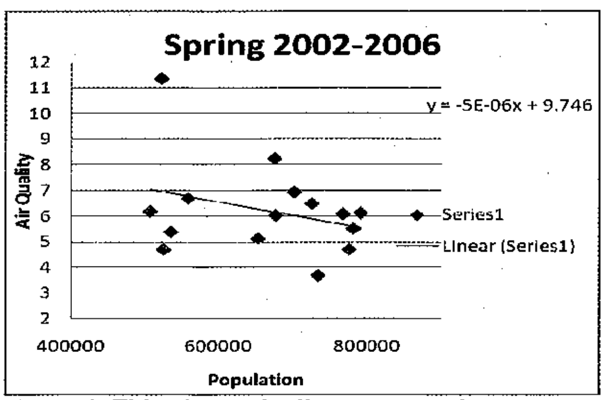


Figure 3: This shows the linear regression between the air quality and the attendance of Polk County in the spring. As shown in the graph, there exists no correlation between the attendance and the air quality.

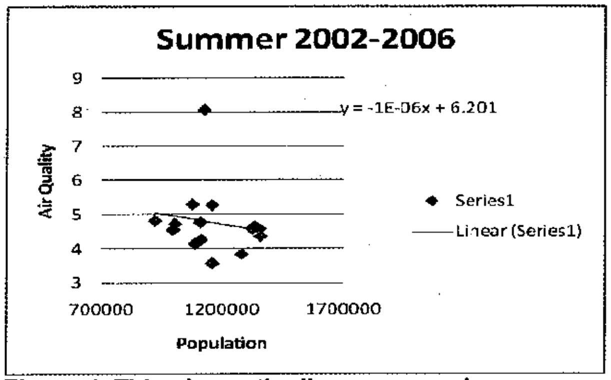


Figure 4: This shows the linear regression between the air quality and the attendance of Polk County in the Summer. As shown in the graph, there exists no correlation between the attendance and the air quality.

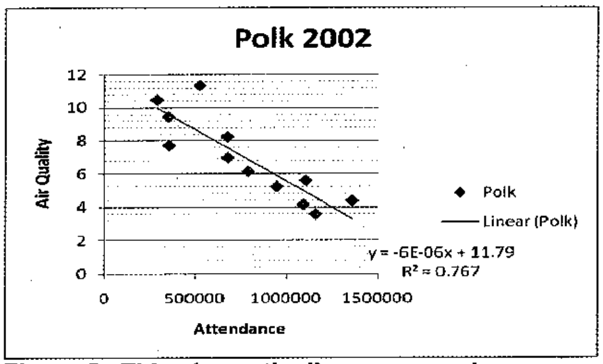


Figure 5. This shows the linear regression between the air quality and the attendance of Polk County in 2002. As shown in the graph, there exists a correlation between the attendance and the air quality. As the air quality decreases, the attendance increases.

23.1 Polk County, TN

In Polk County located in Tennessee, the air quality ranged from 0 to 12, which meant that the air quality was considered "good" during the entire study. There was a negative correlation between attendance at the park and the air quality index when compared by year. This showed that there was a higher attendance at the park when there were fewer pollutants in the air, which matched our initial hypothesis. Initially, we hypothesized that there was a correlation between attendance and air quality when compared by season. The data showed no correlation between attendance and air quality when compared by season. The data showed that the air quality had no affect on the park attendance. This is due to the air quality being "good" for the duration of the study.

23.2 Knox County, TN

In Knox County located in Tennessee, the air quality ranged from 0 to 90, which meant the air quality fluctuated between "good" and "moderated". There was a positive correlation between attendance at the park and the air quality index when compared by year, which did not match our initial hypothesis. This showed that there was a higher attendance at the park when there were more pollutants in the air. Initially, we hypothesized that there was a correlation between attendance and air quality when compared by season. The data showed no correlation between attendance and air quality when compared by season. This showed that the air quality had no affect on the park attendance. The data showed that the air quality had no affect on the park attendance. This is due to the air quality being either "good", or "moderated" for the duration of the study.

23.3 Asheville, NC

In Asheville, North Carolina, the air quality ranged from 0 to 76, which meant the air quality fluctuated between "good" and "moderated". There was a positive correlation between attendance at the park and the air quality index when compared by year, which did not match our initial hypothesis. This showed that there was a higher attendance at the park when there were more pollutants in the air. Initially, we hypothesized that there was a correlation between attendance and air quality when compared by season. The data showed no correlation between attendance and air quality when compared by season. This showed that the air quality had no affect on the park attendance. This is due to the air quality being either "good", or "moderated" for the duration of the study.

Table 1. Results of the linear regression analysis of air quality and the number of visitors to the park

Geographic Location	By Season	By Year
Polk County, TN	No correlation	Negative correlation
Knox County, TN	No correlation	Positive correlation
Asheville, NC	No correlation	Positive correlation

24. DISCUSSION AND CONCLUSION

The air quality data was compared to the park attendance data to determine if there was a correlation between the two .The data for the linear regression was compared based on geographic area, year, and season. The air quality in all geographic areas ranged from 0 to 76, which meant the air quality fluctuated between "good" and "moderate". The data showed no correlation between attendance and air quality when compared by season. Any correlation found in the study, had no real significance. This proved that the air quality had no affect on the park attendance. One possible reason there is no correlation in the data is because some people may have previously planned to visit the park on a certain day and regardless of the air quality they are unwilling to change their plans. Another reason may be that visitors to the park may live in worse air quality than the park, and thus the park's air qualities would not bother them. Lastly some people are healthier than others; therefore the air quality in the park may not affect them as much as the elderly or people with health issues.

The Lagrange, and divided difference methods were unable to accurately predict any future trends. All predictions made outside of the range of known values had significant error, which made the predictions invalid. This was mainly due to the oscillations by the polynomials and the nature of interpolating polynomials with these methods. It was shown that the polynomial was oscillating by evaluating the polynomials between know data points and observing the polynomials behavior. These oscillating polynomials made it impossible to extrapolate the data. The use of cubic splines would have solved the problem of interpolation, but would have been useless in extrapolating any data. The non-linear regression model was used since it is better at predicting functions that behave in this manner. The non- linear regression method was more accurate, but solving problems were time consuming. Due to time constraints, we were unable to do an extensive study of our topic. We could have had a more accurate correlation if we had more data points. There was no correlation between the data used. Possible future research should involve more variables, which may lead to a correlation between park visitation and these new variables. Some variables may include looking at each pollutant individually, including more surrounding counties, and including data over a larger period of time. Another possible improvement is to compare the park visitation data with the air quality data by month instead of by year. Lastly, if the distances of the counties were equal distances from the park, then the results may have showed more of a correlation. The non-linear regression method should be used to predict any trends.

25. ACKNOWLEDGMENTS

The Team D of the ECSU NAM 2008 Summer Research Institute in Computational Science-Scientific Visualization would like to thank Dr Farrah Chandler for her assistance and her dedication to the team. Our thanks also go to Dr Johnny Houston, director of the ECSU CSSVC (Computational Science-Scientific Visualization Center) for his sponsorship and also all the other professors who provided us with valuable information during the learning section of this program.

26. REFERENCES

[8] http://www.nps.gov/grsm

[9] http://www.epa.gov/air/

[10] http://www.environment.gov.au/

[11] http://airinfonnow.com

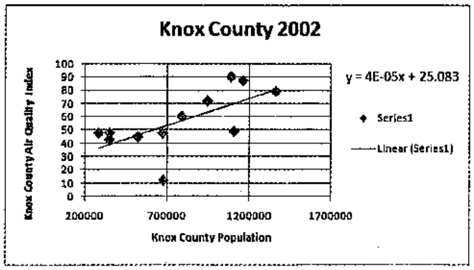
[12] http://www.infoplease.com/

[13] http://www.nps.gov/grsm/parkmgmt/upload/visitation-07.pdf

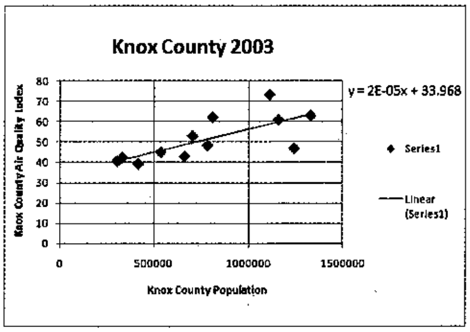
[14] Richard L. Burden, J. Douglas Faires, Numerical Analysis—6th edition, 1997, BROOKS/Cole Publishing Company

APPENDIX

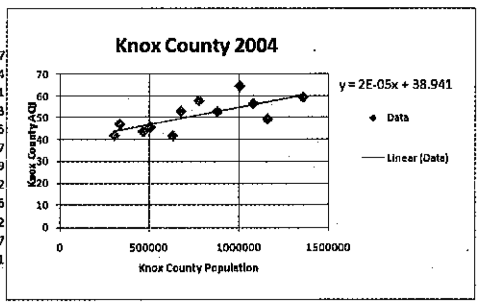
2002		
JAN	287353	48
FEB	350391	43.11
MAR	522267	45.19
APR	674470	47.43
MAY	789882	60.48
JUN	1159339	87.33
JUL	1359477	78.84
AUG	1090431	90.03
SEP	947207	72.2
OCT	1104852	48.77
NOV	676504	12
DEC	354249	47.71
Correlation	0.6575123	



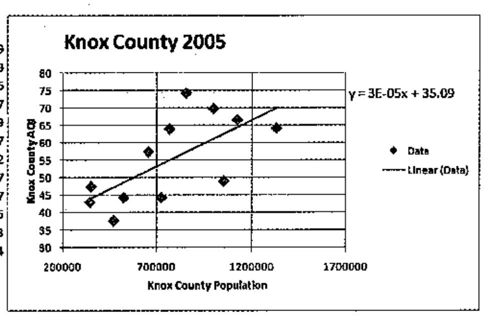
2003		
JAN	305430	40.65
FEB	332223	42.36
MAR	533896	45
APR	701080	53.03
MAY	780366	48.32
JUN	1156774	60.97
JUL	1326666	63
AUG	1109676	73.29
SEP	807827	62.2
OCT	1239051	46.87
NOV	658929	42.9
DEC	414927	39.23
Correation	0.733148329	



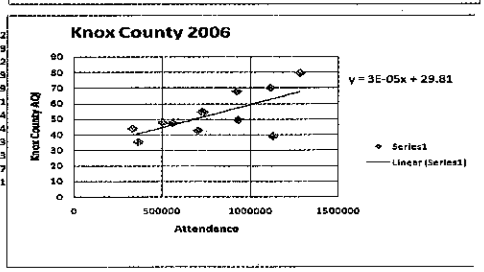
2004		
JAN	307017	41.87
FEB	336212	47.14
MAR	506804	45.71
APR	675350	52.83
MAY	774049	57.65
JUN	1076888	56.37
JUL	1355683	59.29
AUG	1002046	64.42
SEP	876758	52.6
OCT	1158267	49.32
NOV	630539	41.77
DEC	467433	43.81
correlation	0.726612513	



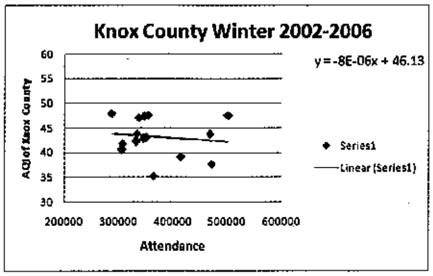
2005		
JAN	345009	42.9
FEB	347144	47.39
MAR	524650	44.26
APR	652265	57.57
MAY	767056	64.19
JUN	1124130	66.7
JUL	1333994	64.42
AUG	997352	69.77
SEP	854342	74.37
OCT	1054311	49.06
NOV	721684	44.3
DEC	470540	37.74
correlation	0.675475031	



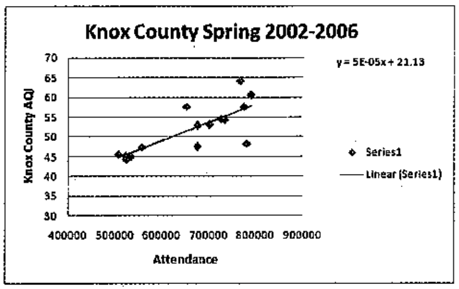
2006		
JAN	363998	35.32
FEB	332912	43.89
MAR	557555	47.42
APR	725298	54.59
MAY	732978	54.29
JUN	1113186	70.1
JUL	1280865	79.74
AUG	920331	67.84
SEP	928487	49.43
OCT	1128927	39.03
NOV	702589	42.7
DEC	502089	47.61
Correlation	0.67151813	



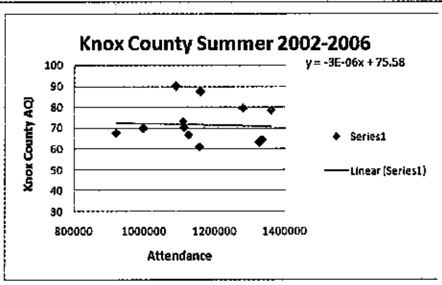
DEC	354249	47.71
JAN	287353	48
FEB	350391	43.11
DEC	414927	39.23
JAN	305430	40.65
FEB	332223	42.36
DEC	467433	43.81
JAN	307017	41.87
FEB	336212	47.14
DEC	470540	37.74
JAN	345009	42.9
FEB	347144	47.39
DEC	502089	47.61
JAN	363998	35.32
FEB	332912	43.89
correlation	-0.13142996	



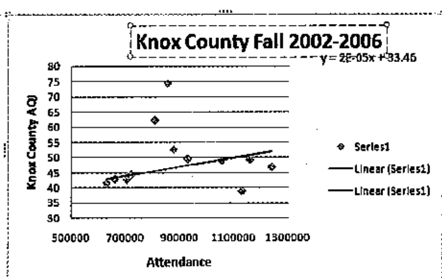
MAR	522267	45.19
APR	674470	47.43
MAY	789882	60.48
MAR	533896	45
APR	701080	53.03
MAY	780366	48.32
MAR	506804	45.71
APR	675350	52.83
MAY	774049	57.65
MAR	524650	44.26
APR	652265	57.57
MAY	767056	64.19
MAR	557555	47.42
APR	725298	54.53
MAY	732978	54.29
correlation	0.781600727	



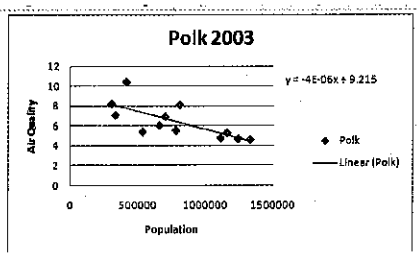
JUN	1159339	87.33
JUL	1359477	78.84
AUG	1090431	90.03
JUN	1156774	60.97
JUL	1326666	63
AUG	1109676	73.29
JUN	1124130	66.7
JUL	1333994	64.42
AUG	997352	69.77
JUN	1124130	66.7
JUL	1333994	64.42
AUG	997352	69.77
JUN	1113186	70.1
JUL	1280865	79.74
AUG	920331	67.84
correlation	-0.05503724	



NOV	676504	12
SEP	807827	62.2
OCT	1239051	46.87
NOV	658929	42.9
SEP	876758	52.6
OCT	1158267	49.32
NOV	630539	41.77
SEP	854342	74.37
OCT	1054311	49.06
NOV	721684	44.3
SEP	928487	49.43
OCT	1128927	39.03
NOV	702589	42.7
correlation	0.222325071	



2003 Polk		
305430	8.19	
332223	7.04	slope
533896	5.39	-3.59763E-06
701080	6.93	
780366	5.52	y-intercept
1156774	5.27	9.215701601
1326666	4.58	
1109676	4.77	correlation
807827	8.1	-0.721546321
1239051	4.68	
658929	6.03	
414927	10.39	

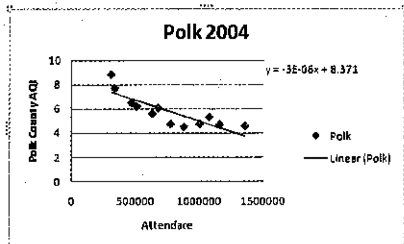


2004 Polk	
307017	8.84
336212	7.69
506804	6.19
675350	6.03
774049	4.71
1076888	5.3
1355683	4.58
1002046	4.71
876758	4.47
1158267	4.65
630539	5.57
467433	6.48

slope=
-3.40816E-06

y-intercept
8.37189857

correlation
-0.835109737

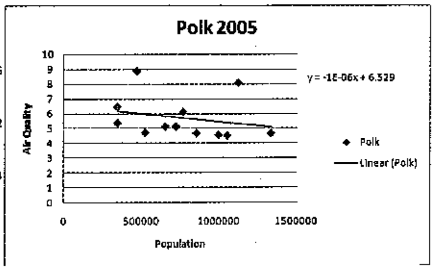


2005 Polk	
345009	6.45
347144	5.36
524650	4.71
652265	5.13
767056	6.1
1124130	8.07
1333994	4.65
997352	4.55
854342	4.67
1054311	4.52
721684	5.12
470540	8.87

slope=
-1.10508E-06

y-intercept
6.529867842

correlation
-0.242490953

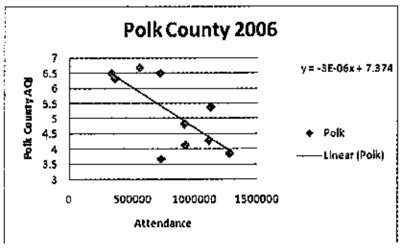


2006 Polk	
363998	6.32
332912	6.5
557555	6.69
725298	6.5
732978	3.68
1113186	4.27
1280865	3.84
920331	4.81
928487	4.13
1128927	5.36

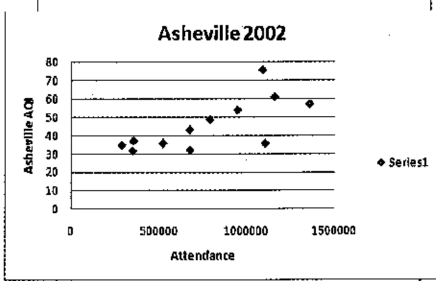
slope=
-2.6774E-06

y-intercept
7.37455291

correlation
-0.716314167



	2002	
JAN	287353	34.7
FEB	350391	31.5
MAR	522267	35.7
APR	674470	43.03
MAY	789882	48.74
JUN	1159339	61.03
JUL	1359477	56.93
AUG	1090431	75.74
SEP	947207	53.86
OCT	1104852	35.54
NOV	676504	31.9
DEC	354249	37

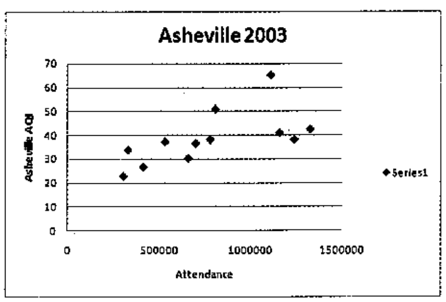


Slope =
2.79055E-05

y-int=
23.80758678

Coeff of correlation=
0.715710288

	2003	
JAN	305430	22.9
FEB	332223	33.88
MAR	533896	37.27
APR	701080	36.6
MAY	780366	38.25
JUN	1156774	41.06
JUL	1326666	42.48
AUG	1109676	65.16
SEP	807827	50.96
OCT	1239051	38.22
NOV	658929	30.41
DEC	414927	26.8

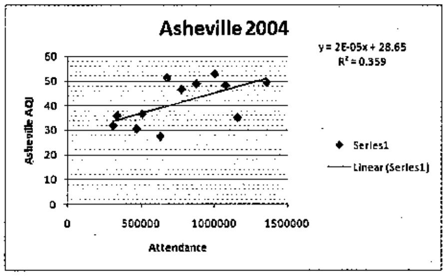


slope=
1.94956E-05

y-int=
23.44815542

Coeff of correlation=
0.625739876

	2004	
JAN	307017	31.79
FEB	336212	35.75
MAR	506804	36.58
APR	675350	51.3
MAY	774049	46.58
JUN	1076888	48.26
JUL	1355683	49.61
AUG	1002046	52.96
SEP	876758	48.9
OCT	1158267	35.03
NOV	630539	27.4
DEC	467433	30.38

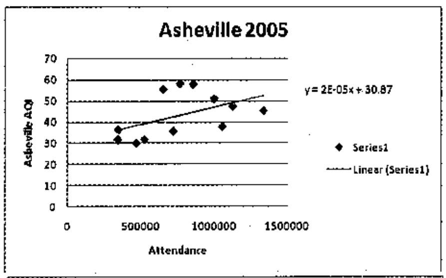


slope=
1.64314E-05

y-int=
28.65936363

Coeff of correlation=
0.599703218

	2005	
JAN	345009	31.5
FEB	347144	36.28
MAR	524650	31.64
APR	652265	55.53
MAY	767056	58.29
JUN	1124130	47.4
JUL	1333994	45.32
AUG	997352	51.22
SEP	854342	58
OCT	1054311	37.77
NOV	721684	35.53
DEC	470540	29.82

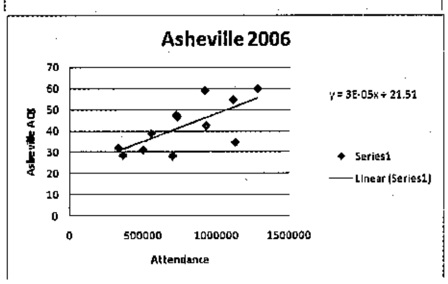


slope=
1.60824E-05

y-int=
30.87189549

Coeff of Correlation=
0.474940794

	2006	
JAN	363998	28.64
FEB	332912	32
MAR	557555	38.87
APR	725298	47.36
MAY	732978	46.74
JUN	1113186	54.76
JUL	1280865	59.93
AUG	920331	59.12
SEP	928487	42.56
OCT	1128927	34.74
NOV	702589	28.36
DEC	502089	31.23



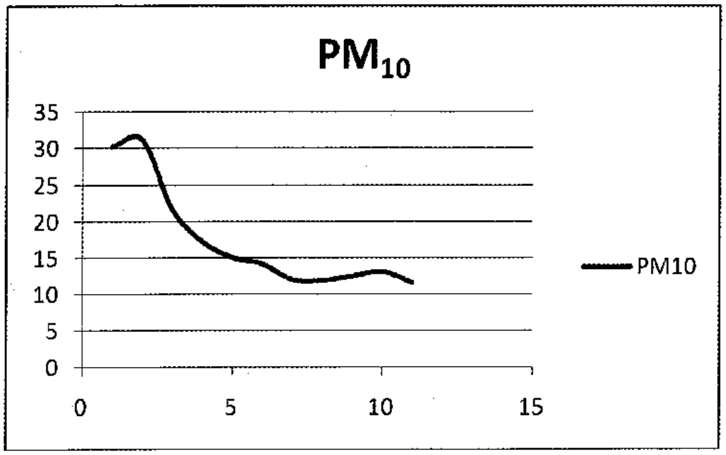
Slope=
2.64952E-05

y-int=
21.51584178

Coeff of Correlation=
0.702850925

NON – LINEAR REGRESSION

The average number of days that PM_{10} was the main pollutant



The graph of PM_{10} looks like: $y = Ce^{-ax}$

$\rightarrow \ln y = \ln(Ce^{ax})$

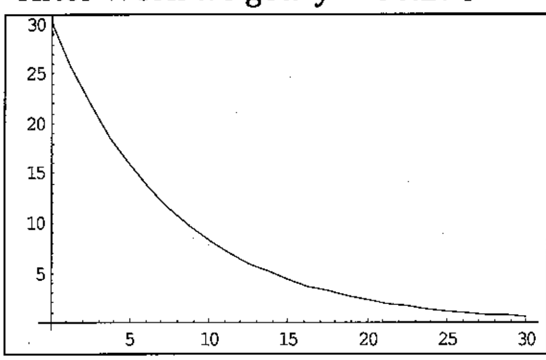
$\rightarrow \ln y = \ln C + \ln e^{Ax}$

$\rightarrow \ln y = Ax + \ln C$

$\rightarrow \hat{Y} = A\hat{X} + B$ (linear fit)

$\rightarrow \hat{Y} = \ln y\, , \hat{X} = x\, , B = \ln C$

After Work we get: $y = 30.27e^{-.18x}$



X	Y	$\hat{x}$	$\hat{y}$
0	30.27	0	3.41
1	31.27	1	3.44
2	21.81	2	3.08
3	17.36	3	2.85
4	15.17	4	2.72
5	14.27	5	2.66

ECSU – NAM 2008
SUMMER RESEARCH INSTITUTE
COMPUTATIONAL SCIENCE – SCIENTIFIC VISUALIZATION

Director

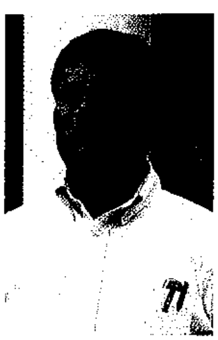
Dr. Johnny L. Houston

Mentors

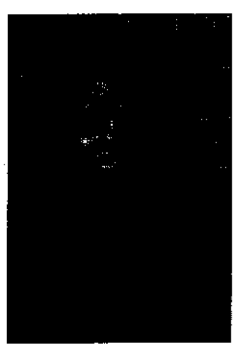
Dr. John W. Alexander

Dr. Constance G. Bland

Dr. Farrah J. Chandler, Associate Director



Dr. Krishna H. Kulkarni

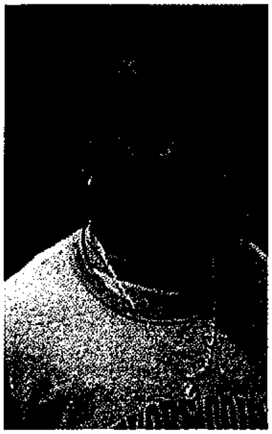


Dr. Andrea W. Lawrence

Dr. Jamiiru Luttamaguzi

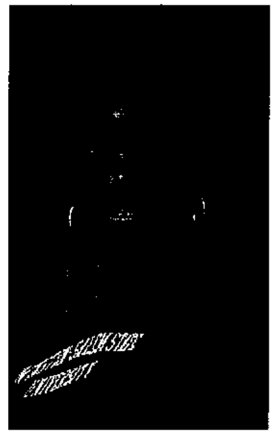
STUDENTS

Jamika Baltrop
Computer Science



La'Trent Brock
Computer Science

Michelle Burke
Mathematics



Amanda Eure
Mathematics

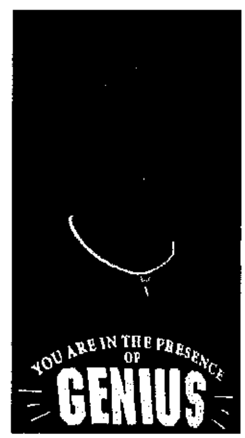
Diaminatou Goudiaby
Computer Science

Benjamin Harvey
Computer Science

Samuel Ivy
Mathematics

Joan Kibaara
Computer Science

Brittany Maybin
Mathematics & Engineering



Alvin McClerkin
Computer Science

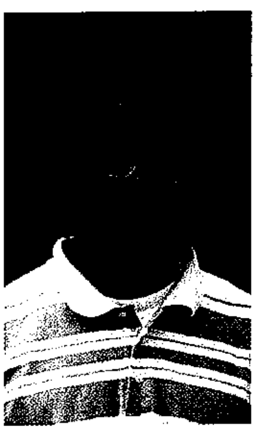
Shatina Morgan
Mathematics

Anisah Nu'Man
Mathematics

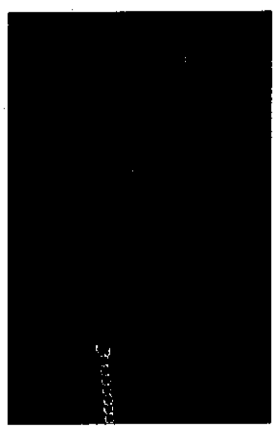
Ashley Rouser
Mathematics

Lee Smalls
Computer Science

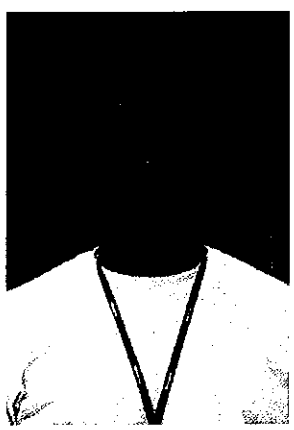
Ashley Sullivan
Mathematics



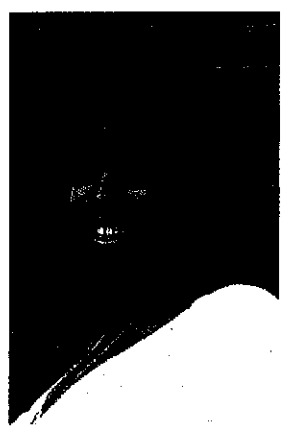
Donnell Terry
Physics



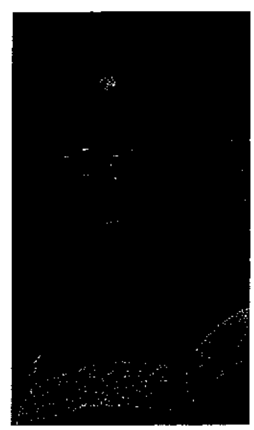
Unquiea Wade
Computer Science



Darius Wheeler
Mathematics



Jessica Wilson
Mathematics



Kevin Wingfield
Mathematics

This work was partially funded by a grant from the U.S. Department of Energy (DOE).