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Introduction to the Occasional Papers Series

Richard L. Wolfel, Ph.D.
Executive Editor

The papers included in this volume represent examples of Cadet term papers from the upper division courses in the Geography program at the United States Military Academy (USMA). Each instructor submitted the top paper in their class and then that paper was put through an editorial process similar to the review process of a journal. The result is a set of papers that represents the quality of faculty instruction at USMA, and more importantly, the exceptional quality of cadet scholarship. Each of the cadets, whose work is displayed here, has my sincere congratulations. They completed the revision process outside of their regular coursework, in the semester after they completed the course. It is my hope you will enjoy reading these papers as much as I enjoyed working with the cadets and mentoring them through the review process.

Launching this Occasional Papers series has been a challenging task, one which many people helped see through to publication. LTC (ret) Frank Galgano originally developed the idea. He passed this idea onto COL Laurel Hummel who wholeheartedly endorsed the idea and kept me on task to complete this volume. I would like to personally thank the instructors for the courses who recommended articles for inclusion. Finally, several members of the Geography program acted as reviewers for the articles and graciously gave of their time to help complete this project. LTC Steve Oluic, MAJ Jon Bushman, MAJ Brian Dunmire, MAJ Jason Ridgeway and MAJ James Chastain gave willingly of their time and didn't protest when I imposed deadlines for completion. Their comments created the outstanding papers you see here. Our hope is to continue this series twice a year with outstanding cadet papers from upper division courses and honor's theses. The papers provide a tangible example of cadet academic achievement and their dedication to achievement at the highest level.

Geothermal Energy in the US

Craig Baer, Class of 2008

Connor Lawrence, Class of 2008

Anna Wilson, Class of 2008

Introduction:

When a person wakes up in the morning they expect the lights to come on when they flip a light switch; they expect the food and beverages in the refrigerator to be cold when they remove them; and they expect to see programs when they turn on the television. All these actions and many others are everyday occurrences for the majority of Americans and are expected to remain so. That is because the United States has enough power to meet the demands of the entire population. However, will this always be the case? America continues to depend on foreign energy sources, and other energy sources that have negative effects on the environment. On April 20, 2005, President Bush commented on how the United States is becoming ever more reliant on foreign energy sources, while at the same time, "the global demand for energy is growing faster than global supply."[1] The United States needs to find a new sustainable energy resource.

U.S. Population is increasing. For the first time all fifty states reported an increase in population. The state of Nevada reported the largest population growth with a percentage increase in the population of 66.3%. [2] Along with this growing population, there is going to be a growing need for energy. Cities are going to grow and require more power. This is going to put an even greater strain on our limited resources, unless the United States starts to use renewable energy resources. Fortunately for this country, there is a relatively untapped solution that could ultimately provide a large amount of energy—geothermal energy. Geothermal energy is an energy source that collects the natural energy of the earth through the hot core of the globe. The natural heat is sent through a power plant that converts this heat to usable energy. This requires much work through extraction of the heat, but in many areas that need the energy, this is a feasible system. For example, many of the Western states, including Nevada with the largest growing population, have easy access to the energy due to the minimal depth needed to drill in these areas. The minimal depths make drilling possible with a greater cost-benefit possibility. Geothermal can and should be used as a primary source of energy in the United States, due to its minimal effects on the environment, easy access, prevalence

[1] USINFO.STATE.GOV, "Bush Calls for Reduced U.S Dependence on Foreign Oil", available from < http://usinfo.state.gov/xarchives/display.html?p=washfile-english&y=2005&m=April&x=20050420173252ESnamfuaK0.5317804>

[2] GIS LOUNGE, "State Level Population Trends", available from <http://gislounge.com/reference/features/us-census-2000-population-trends-mapped/>

across the country, and the fact that the benefits outweigh the costs as a renewable energy source.

The concept of geothermal energy dates back to the dawn of civilization. Early Romans, Greeks, Chinese, and Mexicans used geothermal energy for everything from heating baths to heating their homes, mainly through the use of hot springs. In North American, Native Americans used these same natural hot springs for heated water used in daily cooking and bathing. In the 1890s, citizens in Idaho pumped water from hot springs in order to heat their homes and businesses. The first actual geothermal power plant, however, was not created until 1904 when Prince Piero Ginori Conti opened it at a steam field in Italy. [3] Today, geothermal power has become a refined system with many possibilities and great potential, but serves less than one percent of the world's energy. In the United States, geothermal power plants are opening throughout the West, but we (we ?) have yet to meet its full potential, and much more can be done to ensure that this renewable energy source becomes more prevalent.

Analytical Research:

To fully grasp the potential of geothermal energy you need to have a basic understanding of how geothermal plants produce energy. The over arching concept of geothermal energy is to use heat from the Earth's core to generate steam. The heat comes from a geothermal reservoir, found in "geothermal systems," which are regionally contained settings where the Earth's naturally occurring heat flow is near enough to the earth's surface to bring steam or hot water to the surface.[4] A couple famous geothermal systems are the Geysers Region in Northern California and Yellowstone Region in Idaho, Montana, and Wyoming.[5] There are three basic methods that a geothermal plant can use to produce electricity. Based on the site of the plant, they can use one of the three methods: dry steam, flash steam, or a binary cycle.

A plant that uses dry steam is situated on a geothermal reservoir of steam[6]. A well is drilled into a geothermal reservoir and pumps out the steam which is used to turn turbines and generate electricity.[7] The excess steam passes through a condenser and then pumps the water into a cooling tower. The water from the cooling tower is injected in another well to refill the geothermal reservoir and some is used to condense the steam back into water. A great example of dry steam plants are in the Geysers of Northern California.[8]

The flash steam plant is situated above geothermal reservoirs that contain water. A well is drilled into the reservoir and pumps out the water under high pressure, when the water reaches the generation equipment it undergoes a sudden reduction in pressure, allowing some of the hot water to convert or "flash" into steam. The steam is then used to power a turbine which produces electricity. Similar to the dry steam plant the steam is then passed through a condenser and to a cooling tower. The excess water that did not

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[3] Idaho National Laboratory, Geothermal Energy, available from < http://geothermal.id.doe.gov/what-is.shtml>.
[4] Idaho National Laboratory, Geothermal Energy, available from < http://geothermal.id.doe.gov/what-is.shtml>.
[5] Ibid
[6] Ibid
[7] Ibid
[8] Ibid

"flash" into steam can be used for direct heat, or sent back into the reservoir with the other water from the cooling tower.[9]

The binary cycle, like flash steam, pumps water from a geothermal reservoir, but what makes it different is the pumped water is never sent through the turbine unit. Instead, the hot water is used to heat a "working fluid" which vaporizes into steam and turns a turbine to generate electricity.[10] The water from the ground is then pumped back through another well into the reservoir. The great thing about the binary cycle is that the "working fluid" usually has a lower boiling rate than water so it works at lower steam temperatures. A binary cycle plant does have a condenser and cooling tower to remove the steam generated by the working fluid, but the air emission is just water vapor.

With this understanding of how geothermal plants work, it is easy to see the importance of location for the plant to be successful. Are these geothermal reservoirs located everywhere? The answer is yes because the earth is always heated, but not all of these reservoirs are accessible. A large amount is too far below the earth's surface; however, there are significant accessible, reservoirs located in the United States. At lower depths there are higher temperatures, but with the drilling technology it is very difficult to get that far down. However, on the West Coast, in Alaska, and in Hawaii, there are hot temperatures at accessible depths. This is due to their location on fault lines where heat is able to flow closer to the surface.

There are already geothermal plants in several locations. Alaska has one plant at the Chena Hot Springs Resort sixty miles north of Fairbanks, which provides 0.4 MW of electricity. Additional small power units are expected to be installed at the site that will provide power and heat for the entire resort that serves 70,000 visitors each year.[11] Hawaii has only one plant, but it delivers an average of 25-35 megawatts of firm energy on a continuous basis, supplying approximately 20% of the total electricity needs of the Big Island and its over 162,000 residents.[12] In 2005, Nevada had fifteen power plants, with a capacity of 297.4 MW. Together, these fifteen plants produced a net-total of 1,268.7 GWh during the year and there are plans to develop nineteen more potential plants.[13] California is leading the way in the development of geothermal power plants. In 2005, five percent of California's electric energy generation came from geothermal power plants. This amounted to a net-total of 14,379 GWh. In 2005, California's geothermal capacity exceeded that of every country in the world. California currently has 2492.1 MW of installed capacity, with more under development.

Due to several factors, the best area for geothermal plants is in the Western United States. To justify increasing the number of geothermal plants there would have to be an increase in demand for electricity. What states are consuming the most energy? California, which has the largest number of geothermal power plants, and the greatest potential, is producing 199.5 million megawatthours of electricity. This is the second largest amount of electricity generated, based on 2001 data. Texas is the first with a significantly larger production rate of 365.8 million MWh, but fortunately also has

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[9] Idaho National Laboratory, Geothermal Energy, available from < http://geothermal.id.doe.gov/what-is.shtml>.
[10] Ibid
[11] Idaho National Laboratory, Geothermal Energy, available from < http://geothermal.id.doe.gov/what-is.shtml>.
[12] Ibid
[13] Ibid

potential for geothermal plants, based on ground temperatures. Arizona and Washington also have relatively high electricity outputs. This research shows that these states are generating a considerable amount of energy, and if they could change the method for producing the electricity to geothermal energy, they could not only save money, but also save the environment.

The western states are producing a considerable amount of energy and this will continue. The population trend has always been a shift towards the west, but the Eastern United States has always had a larger population. This could change in the future based on population data. A majority of the western states have seen a population increase between 13.2 to 66.3 percent between the years of 1990 to 2000. This significant increase in population will also require an increase in energy demand. The western states will have to meet this increase demand and the US already depends too much on limited fossil fuels. It would be more beneficial for states to take the large initial investments to develop more geothermal plants and then benefit from all the economic and environmental benefits later in the future.

There are numerous economic benefits for private companies investing in geothermal energy. While the initial cost of starting a geothermal plant from nothing is high, the long run cost would greatly offset that initial investment. Researchers must dig wells, a task that is hardly exact. Finding the best location for a well can be extremely difficult, and thus costly. Investors must install piping as well, and then design the plant.[14] This initial process is the most expensive part, but once completed, the maintenance costs are much lower. The initial cost per kilowatt in the United States is around $2500, whereas the maintenance and operating costs are between $0.01 and $0.03 per kilowatt-hour.[15] Another economic impact would be the loss of reliance on foreign oil, which has been increasing.

Renewable resources, such as wind, nuclear, solar, hydro, biomass, and geothermal energy, are all more environmentally friendly than non-renewable resources. Oil produces a large amount of emissions, whereas geothermal energy has far less. Currently, the United States and China are the leaders in carbon dioxide emissions, which deteriorate the atmosphere because of pollution. Geothermal plants produce one-sixth less carbon dioxide than natural gas-fueled plants.[16] The gaseous emissions from geothermal plants can be considered a "net zero."[17] These emissions are not created during the energy production, rather they are "natural trace constituents" found in any geothermal system.[18] Noise pollution would be high for the initial construction because of the drilling. However, the location of the sites are not usually near largely populated areas and the drilling is only temporary. At a binary geothermal power plant, there is also no need for water disposal because the water is injected back into the ground. In general, at a geothermal plant, there are no storage or back-up requirements.[19]

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[14] US Department of Energy: Energy Efficiency and Renewable Energy;
[15] Ibid,.
[16] Ibid
[17] Nevada Geothermal; http://www.nevadageothermal.com/i/pdf/GeothermalBrochure.pdf, 7.
[18] Ibid,.
[19] "MIT-led panel Backs 'Heat Mining' as Key U.S. Energy Source." 1-26.

As mentioned before, there are a few different alternatives for renewable energy. Each source has its benefits, but in certain areas, geothermal plants have a clear advantage. After visiting Indian Point Power Plant along the Hudson River in New York, there are some security concerns present. The plant places its nuclear waste on a lot behind the reactors, a seemingly easy terrorist target.[20] At a geothermal plant, waste is limited and does not create a security concern. In Cape Cod, private companies want to create a wind farm that will completely take Cape Cod off the grid. Although the residents realize the environmental benefits, they do not want to change the land use. They value the scenery more than the benefits of wind energy. A geothermal plant can have mixed land uses; it can double as an agricultural area or a wildlife refugee area.[21] As mentioned before, the majority of production in the United States occurs in the West, namely Nevada, California, Utah, Alaska, and Hawaii.[22] This is because these areas have a naturally high heat flow associated with tectonic plate boundaries.[23] Geothermal energy would obviously be best suited in the western region, but recent studies show that low-permeability sediments and basement rock can create energy.[24] These rock formations are found all across the United States, evidenced by a "green" apartment complex opening in New York City that will use geothermal energy.[25] Geothermal energy could be further expanded with the Enhanced Geothermal System. Once developed, these systems could harness energy from any region in the country. This would make the energy more commercialized and allowing people to use it in their homes.[26]

Conclusion:

The United States needs to find a legitimate renewable energy source that can help to solve our energy needs, and although many options are available and should be used, Geothermal Energy is one of the best options. Other options, while important to ending our dependence on nonrenewable resources, require expensive systems and are not a constant source. However, geothermal energy supplies constant power and uses relatively simple techniques to extract the power and change it to a usable energy source. Whether it is used for space heating, snow melting, aquaculture, greenhouse production, or if we decide to use it as our main power source, geothermal energy provides us with a clean option that can solve our energy crisis. This power source has been used throughout time due to the obvious fact that it is located everywhere, and it is easy to make into a crude energy source. But with modern technology, geothermal energy has become an extremely beneficial power source, especially for states in the West who have the power so close to the surface. With energy being important to our survival as a nation, and our dependence on foreign oil increasing greatly, why not look to the most natural power source available to humans—the power of the earth.

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[20] Field Trip to Indian Point Power Plant, 5 November 2007.
[21] Nevada Geothermal, 7.
[22] Geothermal Energy Association; http://www.geo-energy.org/information/plants.asp
[23] "MIT-led panel Backs 'Heat Mining' as Key U.S. Energy Source." 1-10.
[24] Ibid,. 1-11.
[25] Field Trip to The Solaire, 9 November 2007.
[26] "MIT-led panel Backs 'Heat Mining' as Key U.S. Energy Source." 1-8.

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Washington DC Congestion

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Introduction

Washington, D.C., considered a focal point of the world's political power and the most brilliant minds in the world is daily brought to its knees by transportation issues. During workdays, parking in downtown D.C. is nonexistent (Washington DC Transportation). Even among cities with greater populations, Washington is considered to have the third-worst traffic in the nation (Worst Cities for Traffic). A typical Washingtonian spends an average of three days stuck in traffic a year, according to a national study conducted in 2004. One of the contributors to this traffic problem is land use planning: houses are built in areas serviced by roads already congested. More roads, innovative managed facilities and incentives for drivers using roads during off-peak hours and limits on growth in suburban areas would all help—but politics prevents much greatly-needed change. Granted that new technological measures that help improve traffic flow and reduce the number of accidents, Washington D.C. was still ranked 12th in the nation in the use of those tools in 2004 (D.C. Area Traffic Heavier, Costlier). There is still much work to be done—work that is going to take significant political cooperation. This paper will first provide background information on the congestion problem in D.C., including previous and current ideas for addressing that problem. It will then discuss the method used to answer the research question. Next, it will provide supporting evidence for the thesis, and finally, it will conclude by explaining how this study contributes to the science of land use planning.

Background

Ironically, Washington D.C. was originally an extremely well planned city. Located on the Potomac River, and sharing its borders with the state of Maryland and the Commonwealth of Virginia, Washington, D.C. was originally designed by Peter Charles L'Enfant, a city planner and engineer. Instead of taking shape piece by piece, D.C. was organized into four quadrants: Northwest, Northeast, Southwest, and Southeast. In addition, the streets were built on a grid to enable easier navigation of the city. Streets running north to south were numbered, while streets that run east to west were labeled using the alphabet. While L'Enfant's plans were modern for the late eighteenth century, the current population has outgrown his vision (Fromers: Travel Experts). Since the 1800's larger roads and highways have been added in order to service the nation's capital. To aid the current capacity of drivers, engineers built modern day beltways, highways, and freeways to support automobile traffic. Running through Washington D.C. is Interstate 95 which connects the capital to, Baltimore and Atlanta. Circling around the city is the I-495 Capital beltway as well as the other freeways which include I-295, I-66, and I-395. While these previous ideas have been well thought out and executed, the population continues to grow past 4,920,000 people in 2000 (Washington D.C.

Population Profile). Higher congestion plays the role of one of the results of a growing population and Washington D.C. roadways gain increased use due to the amplified amount of urban sprawl over the past decades.

Currently, in Washington D.C., there have been multiple attempts to reduce traffic going to and from the city. The D.C. Metro was built in 1967 and services approximately 3.5 million people who live in the suburban Maryland, Montgomery, Prince George's, Fairfax, Loudoun, Alexandria, and Falls Church counties (Metro Facts Online). There are 86 stations and 5 different colored lines that run between 5-20 minutes in wait time. Although the metro system in place is effective, there is potential to increase the usage and encourage higher transit numbers. For example, in Boston, Massachusetts, the T is offered at multiple other locations that help commuters get closer to their destination. Increasing the number of stops not only brings in new clients, but allows others to travel closer to work and school. Other current ideas include park and rides, and high occupancy vehicle (HOV) lanes. The park and rides are locations allocated to allow commuter's a place to park their cars in designated locations to increase carpooling. Currently, Washington D.C. is the national leader in using HOV lanes, which promote carpooling. With these types of implementations, DC's traffic congestion has decreased, but still continues to be a problem with commuters who travel two or more hours a day to get to work.

Method

In order to reduce traffic congestion, we will encourage a culture change through a renovation of public transportation means. Specifically, these renovations will focus on the way the public sees these transportation means. Subways and buses, for example, will be given a "classy" feel—a relaxing and social environment. Subway and bus routes will also become more extensive and timely, rendering the system more reliable and convenient. Instead of shunning upper class citizens, it will eventually become the norm to use public transportation for work. Improving the look and feel of subway and bus interiors will help. Ultimately, it will be certain elite members of society leading the way that will begin that culture change. Education of these governmental employees is the only means to this end. An international example of a successful employment of these techniques is Japan. There, it was feasible to encourage bicycle use through the "Provision of secure bicycle storage at rail stations, development of bicycle-friendly street networks, and the creation of a climate of community opinion supportive of bicycling." This (Replogle, Michael) has given Japanese city residents the ability to walk and bicycle to and from their public transportation means, which is a far cheaper alternative to driving to a bus or subway station. Other benefits of increased usage of bicycles are byproducts of reduced automobile usage: lower air pollution emissions, decreased space requirements for parking during the workday, and the elimination of the high costs of automobile park-and-ride systems (Replogle, Michael). These bicycle-friendly systems have been successfully implemented in Japan because in their culture, walking and bicycling is considered the norm for traveling to and in cities and towns. During the environmental movement of the 1970s, "attitudes towards the bicycle as a mode for the poor began to be replaced by new attitudes viewing it as appropriate for middle and upper middle class mobility" (Replogle, Michael, 1992: 5). As American use of automobiles skyrocketed in the 1980s, the Japanese reduced traffic congestion by increasing user fees for automobile use and making new residential areas bicycle and pedestrian-friendly. They also made

available secure parking conditions for bicycles at rail stations. As a result of these efforts, bicycle use gradually because the norm for citizens—including middle and upper class citizens.

American culture could not be more different. It is rare for a community to include bicycle and pedestrian-friendly street networks or bicycle parking in city planning. Washington D.C. is no exception. Bicycles play an almost nonexistent role in public transportation. And where bicycles use could alleviate traffic problems, high rates of bicycle theft or vandalism discourage bicycle usage discourage their use. D.C., as well as the majority of American cities, have much to learn from Japanese success in the area of traffic congestion reduction. The city could make street networks more bicycle and pedestrian-friendly, build bicycle parking structures near train and subway stations, work to reduce bicycle theft and vandalism, and most importantly, encourage citizens to use bicycles and walk to access public transportation means. Convincing the middle and upper classes to use bicycles is critical to the success of this movement. A promotion campaign, education, and incentives will all encourage this culture change.

Additionally, increasing the price of driving a private vehicle will help encourage citizens to use other public transportation options. The cost of tolls and parking could be increased to such an extreme extent that public transportation is far cheaper than driving a private vehicle. As New York debates the possibility of 'congestion pricing,' certain political issues have been highlighted. This could force some businesses out of D.C. as the gap between those who can and cannot afford to travel into D.C. widens. Conversely, because increasing toll prices increases the necessity for public transportation improvements, they could actually help those who cannot afford to buy vehicles. Regardless, specialists still claim that in London, congestion pricing has drastically decreased congestion levels and improved quality of life there (Boyle, 2007). Obviously, even after these changes, there will be some individuals that insist on driving a car into D.C., despite the cost. The increased revenues from their use of highways into D.C. will be used to counter the cost of subway and bus renovations, as well as implementation of the bike-and-ride systems.

Analysis

In order to support a transportation culture change in higher income areas, opinions and narrow-mindedness must be set aside. To encourage more use of the metro, buses, and carpooling money needs to be invested into advertising. Campaigns like those targeted at teenagers to quit using drugs, or ads similar to promoting safe driving can also be aimed at increasing awareness towards the transportation issue. The ads can focus on environmental aspects of lowering pollution levels, or the commercials can focus on new ways to cut down commute time. Using celebrities or politicians in the local D.C. area can easily help promote the idea of commuting quicker and easier. Once the middle and higher social classes lose the need for the autonomy that a car brings, the greater chance that the DC area can promote using public transportation.

The best way to help bridge the gap and encourage all social classes to use public transportation would be to improve all aspects of the transportation system. If local transportation would invest more into the cleanliness and accessibility of the transportations systems then it would encourage more individuals to make use of public transportation. While the metro in Washington D.C. is currently a clean facility, other

options can be used as well. For example, offering services that cater to the working class commuter like wireless access, quiet cars (metro cars that are kept quiet in order to allow reading, work or sleep), and additional routes would encourage non-users. Since a large population of commuters are workers, offering food cars to help those on the go and places like Starbucks would surely increase morale on the ride to and from home. It is important to note that this would be a major change in Metro policies as food and drink are currently not allowed on the metro.

Another way to implement new ideas, like those being used in Japan, would be to encourage school children to ride their bicycles to school. If riding bicycles was supported and advocated by families and the community, children would be more likely to make a lifelong change and continue to commute to closer locations like metros and buses using bicycles. As children learn that biking can be fun, environmentally friendly and healthy, the easier it will become to convince the soon-to-be adults that bicycles are often an effective means of transportation. Of course, the city will have to create bicycle lanes alongside car lanes, which create safety concerns that the public will have to be made aware of. As the city transitions to more common bicycle use, local law enforcement must be especially wary of the dangers presented by crosswalks and actively mitigate against possible collisions and other accidents. Actively trying to change the culture of our society and making a push towards new implementations will eventually help solve our problems. While introducing new campaigns towards bicycles might not automatically solve the traffic problems in Washington, D.C the new changes will gradually help modify individual's outlooks and offer alternatives that were previously ignored. Over time new implementations will ideally led to helping fix problems like traffic congestion.

As a last step the government of D.C. could charge taxes for driving. The world revolves around money, so why shouldn't the D.C. transportation issue take full advantage of the situation? For those who are not willing to use the public transportation, a fee could be taxed for driving into the city daily. The tax could be rationalized by taking an environmental or safety outlook. Issues arise since the increased number of cars on roads also amplifies the number of police and firemen needed as well as the number of accidents that take place. This has been proven to work in other cities like London, England. In 2003 London introduced a tax on cars that needed to drive into the city. The tax resulted in 30% less traffic and an increased usage of 20% on buses (Ruben-Salama, Celine). For the Washingtonians who can afford to sit in two hours of traffic a day, they can also afford to shell out $7-8 a day which eventually would strongly persuade many individuals' checkbooks. Taxing individuals would also provide the funding necessary to make roads safer by being able to afford additional police forces and being able to fix neglected roads and signs. The money could also be used to create extra car pooling parking lots and more metro stops. Taking more extreme measures like taxing drivers would rely heavily on a solid transportation network already in place. This would work in conjunction with adding additional metro locations, increasing Metro and bus frequent stops and a more user friendly rail system.

Conclusion

Changing the public's attitude towards public transportation, by renovating those means of transportation and discouraging the use of private vehicles, is the key to solving D.C.'s congestion problem.

D.C.'s traffic problems are certainly not unique to one city—many other cities share the same traffic struggles. As a city already in the national spotlight, D.C. has great potential to lead the way in congestion reduction. Understanding that public transportation use is the key to reducing congestion, more importance would be placed on subway, train and bus accessibility and convenience as land use decisions are made. The successful implementation of the Japanese bike-and-ride systems is a perfect case study to model: in the end, "residents of Japanese cities use one-tenth as much gasoline per capita as residents of US cities, enhancing Japan's economic competitiveness" (Replogle, Michael, 1992: 7). Land use planners would have to begin factoring in the public's access to bus stops, train stations, or subway portals. If they are not within walking distance from residential areas, or if they do not come within close proximity to where they work, citizens will not use them. The implications for land use planners are of great importance. The benefits of changing this aspect of commuter culture are obvious.

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Yankee Place and Space

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Introduction

The Yankees are constructing a new stadium in South Bronx. The new stadium is to be located across the street from the existing one. However, the plan entails more than just constructing a new baseball field. The Yankee's plan calls for the redistribution of green space and parking space, and for improvements to the aesthetics of the surrounding neighborhood. The land use changes in South Bronx will impact the environment as well as the economic and social layout of the area. This paper will consider these environmental, social and economic impacts of the new Yankee Stadium on South Bronx. Ultimately, the proposed project to redevelop the Yankee's stadium and the surrounding areas of South Bronx will have positive economic and environmental effects, but a negative social effect on the area.

The changes on the landscape of South Bronx are significant because of the controversy that the project has caused in both New York City and the Bronx. Taxes will affect local citizens of the Bronx because they will bear much of the financial burden of the stadium's construction. Moreover, the entire layout of the land surrounding the stadium will change, affecting the people who live and work in the area. These changes include the redistribution of parks, recreation space, retail businesses, and parking.

This study begins with an introduction to the Yankee Stadium project and the land use changes in South Bronx. Following this introduction is an analysis of the past and current land use situation. This section includes an explanation of the current use of the land altered by the project, the current economic, social and environmental situations in South Bronx, other proposals for a new Yankee Stadium, and feelings about the current land use situation in South Bronx. The next section examines the environmental, social and economic affects of the proposed land use changes. Finally, the conclusion presents a summary of the results and a discussion of how the land use changes of the new Yankee Stadium contribute to the greater study of land use planning and management.

Background

Currently, South Bronx land use is composed of heavy commercial and industrial regions to the east and south, and dense residential areas to the east and west. The area is highly developed with few city parks providing green space for the area. The Bronx has one of the highest asthma rates in the country—a result of the scarce green space and lack of fresh air (Schwartz, 2006). The proposed renovations will encompass the current Yankee stadium, Macombs Dam Park, Mullaly Park, Bronx Terminal Market (BTM), waterfront parks, two partially occupied warehouses, and several parking lots. A total of 22.4 acres of park and recreational facilities including a tree lined continual park space in the residential area, four baseball diamonds, two basketball courts, 16 tennis courts, one soccer field, and 32 handball courts are included in the scope of the proposed stadium change. The parks and recreation areas are all in poor condition because the parks department has not provided funding to replace them (Schwartz, 2006).

The original Yankee stadium was built in 1923. This 84 year old stadium has inefficient and scattered parking that often flows into surrounding neighborhoods (Yankee Stadium Project: Final Environmental Impact Statement, 2006: S-1). Not only is parking an issue for the community, according to Yankee management, the aesthetics and the seating capacity for the stadium are also subpar. The Yankees would like to build a new, modern stadium that would not only seat more people, but also attract a higher-end crowd.

Since 1998, the Yankees and New York City planners have worked to develop plans to either move or renovate the stadium. George Steinbrenner, the Yankees previous owner, wanted to move the stadium out of the Bronx because "crime, grime and an antiquated stadium kept annual attendance at home games well below two million" (Bagli, 2004: 1). He proposed to relocate the stadium to New Jersey; however, Mayor Giuliani suggested that the stadium be rebuilt in Manhattan because of the prosperity of the downtown area (Chanayil, 2002: 876). He argued that it would not only be a tourist and entertainment attraction in downtown, but would also act as a multiplier of city revenues. However, the Manhattan proposal was eventually rejected because the benefits that Mayor Giuliani predicted were unrealistic. Economists argued that moving Yankee Stadium to Manhattan would result in minimal economic gains; any money brought in because of the stadium is money that tourist would have spent throughout Manhattan if the stadium were elsewhere (Baade, 1996: 16). The public rejected both plans to relocate the stadium out of the Bronx. Citizens of greater New York City area felt that city officials were ignoring issues of job retention and infrastructure redevelopment in the boroughs and the locals wanted to see redevelopment in these boroughs.

Method

This analysis uses several different techniques to evaluate the environmental, social and economic effects of building a new Yankee Stadium in the Bronx. By using different and even conflicting sources of information, it is more likely that this project will present a clearer picture of what the true effects of the new stadium may be.

To measure the environmental effects we had to consider how the stadium would change the Bronx. An environmental impact statement (EIS) (Yankee Stadium Project: Final Environmental Impact Statement, 2006) prepared for the project was used to analyze the effects of the proposed project. The EIS contains a discussion of everything from habitats to species affected by pollution and serves as the primary source for assessing the impact this project will have on the environment. In addition, maps of the current and proposed green space are examined in order to calculate the total loss or gain of green space in acres.

To measure the social effects of the project we looked in several other places. One of the best sources of information proved to be the New York Times, which ran articles quoting the local citizens and counsel members about their opinions on the construction of a new stadium. Additionally, information was available from a public counsel meeting where citizens voted on the proposal, reveling if the majority of people were in favor of this project. Finally, if interest groups formed to oppose the project or if any petitioning took place, it would reveal social opposition to the project. These would be a strong indication that at least factions of the local community are opposed to the

construction of a new stadium and believed it would negatively affect them in some way (Bagli, 2004: 1-2).

Finally, the economic effects of the construction of a new Yankee Stadium must be considered. More specifically, the number of jobs created because of this project, through development of retail space, will be used as the main indicator or economic effect because this would have obvious economic and even social impacts on the community in the Bronx. Additionally, the money that both the construction and the existence of a new stadium will cost and bring to the community will indicate local economic effects.

Analysis

The environment of the South Bronx will undergo many changes. Some of these changes include new and relocated parks and green space. The Yankee Stadium Project will not only maintain the original acreage of park/recreation land, it will increase the total area in the South Bronx by 4.63 acres (Yankee Stadium Project: New York Yankee Redevelopment). The negative impact that this project has on the environment is that much of this new parkland will be relocated or completely created on land that is currently cityscape such as piers 1, 2 and 3 just west of the Major Deegan Expressway. Construction on the parks will not begin until after the stadium and adjacent parking lots are completed and renovations of the current Yankee Stadium are underway. This process is expected to last longer than five years meaning that the city will have lost substantial parkland for two years and will not see an increase in the parkland for at least another three years. While there is a short-term loss in the amount of parkland and green space in South Bronx, the project has effects that are beneficial to the environment overall. For example, the parkland created on top of the parking garages will help reduce the effect of an urban heat island in South Bronx. While the project boasts an obvious net-gain in parkland, which is positive for the environment in South Bronx, some of these environmental gains generate negative social effects.

The Yankee Stadium Project's intent is to have a positive social effect in South Bronx; however, we believe that the changes will ultimately be negative for the community. The creation of more than 3,000 parking spaces will help alleviate tension in the community by reducing game day overflow parking into local neighborhood streets (Yankee Stadium Project: New York Yankee Redevelopment, 2006: 1-15). Another positive aspect is that the project will create a significant amount of parkland for nearby residents and game day visitors. The 4.63 acres of parkland will compliment the relocated parks' no net-loss relocation strategy. All of these new parks will be open to public use and several are being built for specific use by nearby public schools, which would otherwise lack resources to field scholastic sports teams. For example, three new baseball fields will be constructed specifically for Public School 29 and the West Bronx recreation center.

While the creation of new parks is an obvious plus for the residents of the area, a major concern for the people of the Southwest Bronx communities is the location of the new parks. Much of the new and re-located parkland will be in places not accessible to the community now utilizing the current parks. For example, the new parkland that created on piers 1-3 just west of the Major Deegan Expressway is to be located much farther from the community that uses it. It is also less accessible because a major interstate highway divides the community from the proposed location of the new parks.

There is no space for parking in the proposed plan so users will need to cross under the freeway to use this recreation area. Even the new baseball fields proposed for PS 29 and the West Bronx recreation center are very far away from their intended users. Moreover, the existing parks are replaced mostly by rooftop parks, which are less accessible to the community than those at ground level. On a city forum, one citizen noted, "almost all of that green space is inaccessible locally to the residents of the South Bronx" (New York City, 2007).

The intended economic effects in the South Bronx will overall be positive on the surrounding area. The parking areas and renovation of the area in the immediate vicinity of the new stadium will yield a net gain of greater than 12,000 gross square feet (gsf) of street-level retail space (Yankee Stadium Project: Final Scope of Work). Another positive economic effect for the South Bronx is that the area will play host to a brand new stadium with all the amenities of a modern ballpark. These amenities (restaurants, stores, ect.) will draw more spectators to the area bringing business to local merchants. One negative impact on the economy is at the micro scale: businesses that once thrived on stadium spectators during the pre- and post-game festivities will no longer benefit from their location. Bars, restaurants and merchants on all but the northern and western side of the currently existing stadium will lose business due to their reliance on their current vicinity to Yankee Stadium. Another negative impact is the project's estimated cost of $1.02 billion. New York City is publically financing $220 million of the project (Munsey and Suppes, 2007). The upfront cost is huge to the city and its taxpayers, but planners hope to make up the cost through profits brought in from the new park. The Impact Report estimated that the city would receive over $73.3 million in tax revenue from the completed project (Yankee Stadium Project: Final Environmental Impact Statement, 2006: 22-7).

Conclusion

The proposed project to redevelop the Yankee's stadium and the surrounding areas of South Bronx will have a positive environmental and economic impact but will negatively impact the region socially. While there were short term negative aspects to the environment of South Bronx, this redevelopment will ultimately help the area develop more green space in a region which is lacking in that area. Economically, this plan intends to create business space and attract higher-end fans who will add to the economic prowess of the area. The biggest issue with this project is that it fails to address the usability issues regarding the green space and parks it creates. The parks created are not easily accessible, and therefore less beneficial to the community.

This study is important to land use planning because when rebuilding an area, there are many factors you must consider. This case study reveals that even though planners tried to create economic, environmental and social benefits in the community, they did not examine the geography of the area in which they were planning, resulting in a plan that is ultimately negative for the community. It is particularly important to note that some changes made to land use will positively affect one aspect of the community while hurting another. For example, the creation of parks and green space is positive environmentally, but has subsequent negative social affects. Ultimately, a change in land use must fulfill the needs of the community it concerns. In the case of the Yankee

Stadium Project in South Bronx, planners did not fulfill the social needs of the community so the land use changes will not reach their full potential.

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Siberia: A Source of Decline or Promise?

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During the eighteenth century, one of Russia's most renowned scholars Mikhail Lomonosov said of his growing country, "Russia's power will grow with Siberia."[27] Today, as Russia continues to rebuild from the collapse of the Soviet Union, Lomonosov's bold statement has never been truer. Containing the large majority of Russia's oil, natural gas, coal, and vast amounts of other mineral and timber resources, Siberia is undoubtedly Russia's "treasure trove."[28] As it was during the time of Lomonosov, Siberia and its resources are still contributing immensely to Russia's growing prosperity. However, while the core of Russia is enjoying an economic boom due to Siberian resources, Siberia itself continues to struggle. Siberian cities, besides being forced to deal with almost uninhabitable weather conditions, are poor and none are "economically self-sufficient."[29] Instead, these cities have to rely on governmental financial help and an underwhelming amount of investment capital that has resulted in old technologies and infrastructures. Socially, the population is aging as the elderly outnumber those able to work. Adding to these demographic problems, an AIDS epidemic is beginning to spread throughout Siberia. However, despite the climatic, economic, and social problems in Siberia, the region still possesses the vast majority of Russia's resources and wealth, and as Russia continues to utilize these resources, Putin and his government are taking steps to correct the problems in Siberia and expand Siberia's energy sector.

Siberia is the largest geographic region of Russia. Starting east of the Urals and extending all the way to the Pacific Ocean—albeit, Russia's Far East has recently become its own geographic region—the region encompasses over 5 million square miles of land. Because of its high latitude and Russia's inherent continentality, Siberia has historically been exposed to horrendously cold weather conditions. Siberian cites especially are forced to deal with average January temperatures of -15 to -45 degrees Celsius.[30] One geographer, Clifford Gaddy, puts Siberia and Russia's cold temperatures in perspective: "A list of the 100 coldest Russian and North American cities with populations of more than 100,000 would have 85 Russian, 10 Canadian, and 5 U.S. cities."[31] These cold

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[27] Fiona Hill, "Siberia: Russia's Economic Heartland and Daunting Dilemma," f*rom* Current History, October 2004 [The Brookings Institution]; available from <http://www.brookings.edu/views/articles/hillf/20041013.htm>; accessed on 16 September 2007.

[28] "Siberia," f*rom* MSN Encarta 2007 [online encyclopedia]; available from <http://encarta.msn.com/encyclopedia_761556603/Siberia.html>; accessed on 7 October 2007.

[29] Hill.

[30] Clifford Gaddy and Fiona Hill, "The Siberian Curse: Does Russia's Geography Doom its Chances for Market Reform?," f*rom* The Brookings Review, Fall 2003 Vol. 2 [The Brookings Institute online]; available from <http://www.brookings.edu/press/review/fal2003/hill.htm>; accessed on 16 September 2007,.

[31] Clifford Gaddy and Fiona Hill, The Siberian Curse: How Communist Planners Left Russia Out In the Cold. (Brookings Institution Press: Washington D.C., 2003) 227.

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temperatures ensure all three of Siberia's large rivers – the Ob, Yenisey, and Lena – are frozen six to nine months of the year.[32] Furthermore, northern Siberia is primarily Tundra and seemingly uninhabitable, while the southern three-fourths of Siberia are primarily taiga, or vast expanses of large, swampy forests. This taiga provides almost no agriculture and is extremely difficult to develop. All in all, Siberia's climate poses its most significant problem as this harsh climate and terrain make Russia's task at developing Siberia extremely difficult. Although the Soviet Union was able to develop the region for its command economy, the cessation of the Soviet central planning has left these cities in the cold and victims to more than just a harsh climate.

Because of the efforts of Soviet Russia, the Siberian landscape is dotted with cities. Soviet Russia used these cities as industrial hubs and for forced mass settlement populations. These were planned cities intended to meet the industrial needs of the USSR and not the local people. When the USSR failed, the industries of Siberia also failed, leaving the local people with little work. Furthermore, the Soviet government headed the planning and development of these cities, leaving the municipal governments unprepared for economic sustainment and development in the region when the Soviet Union collapsed.[33] This Soviet legacy left the cities of Siberia completely economically isolated, which severely inhibits the region's economic geography. One study by The Brooking Institution claims, "Inadequate road, rail, air, and other communication links hobble efforts to connect the population centers, promote interregional trade, and develop markets,"[34] Because the cities themselves are failing economically and there remains a lack of economic centralization in the region, Siberia must rely on "central government subsidies for fuel, food, and transportation."[35] However, these subsidies are low and investment in the region, as one report for the U.S. Congress claims, is "insufficient."[36] Compounding this lack of capital is the cost of living and industrial costs in the region, which are four times higher than anywhere else in Russia. These steep costs and little opportunities for work led to high levels of unemployment. As the economy of Siberia continues to struggle, it poses several problems for Russia as they attempt to utilize Siberia's natural resources. In essence, Siberia does not possess and cannot afford "the most modern western oil and gas exploration, development, and production technology."[37] With all of the economic problems in Siberia itself, it seems contradictory that Siberia is Russia's economic heartland.

Adding to the economic struggles of Siberia are the devastating social problems currently plaguing the region. With a low population density of two people per square kilometer, Siberia is struggling to provide enough workers to sustain its labor markets.[38] Because the Soviet Union used forced migration to supply its labor force in the region's industrial cities, there was previously adequate labor to support the command economy's

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[32] "Siberia."
[33] "The Siberian Curse: Does Russia's Geography Doom its Chances for Market Reform?"
[34] Ibid.
[35] Ibid.
[36] Bernard A. Gelb, "Russia Oil and Gas Challenges," f*rom* The Congressional Research Service, 3 January 2006 [The Library of Congress]; available from <http://fpc.state.gov/documents/organization/58988.pdf>; accessed on 16 September 2007, "Summary".
[37] Ibid.
[38] "Siberia."

industrial cities in Siberia. However, because Russia no longer practices forced migration and Siberia's harsh weather and economic conditions provide bleak labor opportunities, migration into the region has essentially stopped, and while the vast majority of those forced to live in Siberia by Soviet Russia continue to live there—they do not possess the means to move—the demographics of the region are becoming a concern. Today, Siberia contains an aging population with many residents too old to work jobs in Siberia, or any other Russian location.[39] Furthermore, despite having higher crude birth rates than the majority of Russia, the birth rates are still too low to effectively replace the older populations. Thus, the Siberian labor force is too old to fulfill the region's labor requirements and growing too slowly to replenish the growing void in labor. There is an important ethnic dimension to these birth rates. Compouding this demographic and labor problem in Siberia is a low life expectancy. Siberia has the lowest life expectancy of any Russian region. One case study by the University of Aberdeen, studied the social conditions of West Siberia, one of Siberia's most economically and socially successful provinces. The study found that the male and female life expectancies were 58 and 71 respectively, only 47% of the population considers "Life as bearable," and the total population is declining by .4%.[40] The effect of these demographic phenomena is an aging population, unable to find work, and unhappy. As The Brookings Institution reports, "The biggest challenge [for Siberia] will be dealing with the many residents of Siberia who are too old or too unskilled to find jobs elsewhere. Their assets in the region are worthless and cannot be sold to finance their relocation."[41] Not only are Siberia's demographics affecting its labor force, but the Russian government has to support financially the aging population who cannot find work.

In addition to an aging population, AIDS stemming from I.V. drug use is now amajor health concern. It is speculated that around 40,000 Siberian residents have been clinically diagnosed with AIDS, with "three to four times as many" infected, but untested. The epidemic is getting so bad that it has been compared with the initial spread of AIDS in Africa.[42] Moreover, the lack of monetary resources in the region is preventing those infected with the necessary treatment. AIDS, in addition to an aging population, is contributing to massive social problems within Siberia.

Despite the dire climatic, economic, and social problems within Siberia, the region is still Russia's treasure chest for raw materials and will continue to act as the catalyst for Russia's increasing economic power. As mentioned previously, Siberia possesses the majority of Russia's natural resources. Around 80 percent of Russia's oil, 85 percent of its natural gas, 80 percent of its coal, and the majority of Russia's mineral, metal, and timber resources.[43] From a global perspective, Siberia is an energy giant. Russia has more natural gas and exports more natural gas than any other country in the world. Furthermore, Russia has the second largest proven oil reserves and is the second

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[39] "The Siberian Curse: Does Russia's Geography Doom its Chances for Market Reform?"

[40] "West Siberia," f*rom* Centre for the Study of Public Policy [University of Aberdeen]; available from <http://www.abdn.ac.uk/cspp/West-Siberia-2.shtml>; accessed on 28 November 2007.

[41] "The Siberian Curse: Does Russia's Geography Doom its Chances for Market Reform?"

[42] Anita Srikameswaran, "HIV Epidemic Hits Hard Across Siberia," f*rom* The Pittsburgh Post-Gazette, 14 June 2005 [online newspaper]; available from <http://www.post-gazette.com/pg/05165/521174.stm>; accessed on 16 September 2007.

[43] "The Siberian Curse: Does Russia's Geography Doom its Chances for Market Reform?"

largest exporter of oil in the world. Over 80% of Russia's energy resources are located in Siberia "between the Ural Mountains and the Central Siberian Plateau."[44] Siberia's resources are so important to Russia and its economy that the U.S. Congressional Research Service claims that the Russian economy is completely dependent on Siberia's oil and natural gas exports.

With its dependency on Siberia's energy resources, Russia's future will depend on Siberia. Vladimir Putin has recognized this and is currently expanding Siberia's energy markets in addition to their thriving markets in Europe, which bodes well for Siberia's future. In 2006 alone, Russia invested $650 million into Siberia's energy infrastructure and implemented plans to increase energy exports to India, China, and the U.S.[45] Earlier this year, Russia's largest energy company Gasprom cooperated with India to create more facilities to handle and process more oil and gas between the countries.[46] Russia is also working to increase exports with China. Currently, Russia exports 200,000 bbl/d to China. However, this will drastically increase as China recently pledged to invest $12 billion into Russia's energy infrastructure by 2020. These investments will include new pipelines into China. Russia's expansion of Siberia's resources will have the most benefits for the United States as it will lessen their dependency on oil from the Middle East. Russia is currently working on plans to construct pipelines that would carry oil from Siberia to the port city of Murmansk. According to the CRS, these new pipelines "would enable 1.6-2.4 million bbl/d of Russian oil to reach the United States via tankers in only nine days, much quicker than from the Middle East or Africa."[47] While all of this investment in Siberia revolves around energy, the investments will also help Siberia in "the development of the social sphere, the oil and gas sector in East Siberia, the transports infrastructure (railways and highways), coal deposits, and agriculture."[48] So, not only will Russian and foreign investments in Siberia boost Russia's overall economy, but it will greatly improve Siberia's social and economic problems.

Conclusion

Currently, Siberia is struggling. Much of this is due to the harsh climate in the region. The cold temperatures produce rough and almost unusable terrain and prohibit any travel on frozen rivers. This climate also drastically reduces immigration into the region. Furthermore, while the core of Russia is experiencing an economic boom, the Siberian economy is in a dire state. The Soviet legacy of a command economy left isolated and run down cities disconnected from each other and the Russian core. Lack of investment in the region and the high cost of living has led to high levels of unemployment. The social aspects of Siberia may be the most alarming. Population decline and an AIDS epidemic have hit Siberia. However, despite all of its problems, Siberia remains the heart of Russia's overall economy and its future prosperity that is strongly tied to resource extraction. Through Russia's dependency on Siberia and their expansion of Siberia's energy resources, Russia, India, China, the U.S., and others are

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[44] Ibid.

[45] Igor Tomberg, "Future Oil and Gas Development in Siberia and the Russian Far East," f*rom* Pacific Environment, 24 January 2006 [online database]; available from <http://www.pacificenvironment.org/article.php?id=893>; accessed on 15 October 2007.

[46] "Russia, India Set To Draft Comprehensive Cooperation Act," f*rom* RIA Novosti, 12 October 2007; available from <http://en.rian.ru/russia/20071012/83655637.html>; accessed on 15 October 2007.

[47] Ibid.

[48] Tomberg.

investing great amounts of capital in the region. In doing so, they hope to rebuild Siberia's infrastructure and correct the economic and social problems in the region. Thus, as Russia grows, so will Siberia.

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The Calamitous Effects of a Supervolcano Eruption

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Introduction

In 1981, Mount St. Helens erupted with amazing intensity and violence, spewing one cubic kilometer of material into the air. Even though residents in the area were warned of an imminent eruption, fifty-seven people still perished (McGuire, 2002). However, there is a type volcano that dwarfs Mount St. Helens. These massive volcanoes are termed supervolcanoes. The Volcano Explosivity Index (VEI) is used to classify a volcano eruption on an exponential scale from one to eight (see table 1). Mount St. Helens was classified as a VEI 5 eruption, but a supervolcano produces VEI 8 eruptions, which is an eruption at least 1,000 times more powerful than Mount St. Helens (McGuire, 2002)! About 75,000 years ago, there was a supervolcano event that erupted 2,800 cubic kilometers of volcanic rock and ash, and released 10 billion metric tons of sulfur dioxide (Weber, 2007). The explosion left a caldera 100 kilometers across, easily visible from space today ("Mystery of the Megavolcano," 2006). That caldera is known today as Lake Toba, located on the island of Sumatra. The eruption of the Toba supervolcano is the only VEI 8 eruption to occur since hominids appeared, and it might have brought the earliest humans to the brink of extinction. How do we know this catastrophic event actually happen? What effect did the eruption have on the climate and subsequently life on the Earth? I believe that a supervolcano eruption today will cause a severe drop in the average global temperature and lead to a mass extinction of plants and animals.

Background

Climatologists stumbled upon the Lake Toba supervolcano eruption while reconstructing the past climates, a field of study called paleoclimatology. The Earth's climate is notoriously difficult to model and predict. It is a complex system that acts in ways climatologists sometimes do not understand, stemming from the fact that there are too many variables for humans to account for in computer models. However, climatologists can use past climates and events to model and predict future conditions. In essence, the past proves to be the best model of the future. This is especially true of catastrophic events. Catastrophic events are short, violent events that severely change the physical landscape as well as the Earth's climate. In addition, catastrophic events are rarely, if ever, observed by humans. Therefore, the first step in answering the effect of a supervolcano eruption, is answering this question: how do we know that a massive eruption occurred at Lake Toba over 70,000 years ago?

The first piece of the puzzle is the physical evidence of a volcanic eruption, volcanic ashes and lava flows. Volcanologists have the ability to trace volcanic rocks and ash back to the specific volcano from which it was erupted. Volcanic ash has a certain composition of material and minerals. If an eruption is explosive, it will have

rock fragments torn from the bedrock around the site. In addition, volcanic ash will be formed from the magma. The magma contains a unique balance of minerals derived from the melted source rock that composes the magma ("Mystery of the Megavolcano," 2006). Volcanic ash, which was spread over 4,000 miles, was linked to Lake Toba. In addition, volcanologists can date the volcanic ash through examining unique signatures etched on volcanic glass by the decay of Uranium-238 ("Mystery of the Megavolcano," 2006). The age of the volcanic ash is about 75,000 years-old. Scientists use the area that the volcanic ash covers and the depths of the ash in certain places (which is nine meters deep in Malaysia and six meters in southern India) to determine that approximately 3,000 cubic kilometers of material was erupted in this single event (Weber, 2007). Lake Toba also produced a lava flow that reached from the Malacca Straits to the Indian Ocean (Garthorne-Hardy and Harcourt-Smith, 2003), and covered around an area around 30,000 square kilometers with 50 to 150 meters of lava (Weber, 2007).

Ice core samples from the Greenland Ice Sheet Project 2 provide another piece of evidence for the Toba supervolcano eruption. Snowflakes capture air bubbles when they form and fall. On ice sheets, where the snow never melts from year to year, the layers of snow are compressed into ice over time, trapping the air bubbles. Then, scientist drill cores from the ice sheets, and conduct analysis on the composition of the air bubbles. The GISP2 ice cores provided 110,000 years of data (Weber, 2007). From these studies, scientists have mapped the concentration of sulfate in the air. About 75,000 years ago, there was a sudden spike in the atmospheric concentration of sulfate (Garthorne-Hardy and Harcourt-Smith, 2003). The only plausible cause for a dramatic rise in sulfate is an enormous volcanic eruption. When linked with the enormous volume of volcanic ash from the same time period, the sulfur dioxide was almost certainly ejected from the Toba supervolcano. Volcanologist determined that the Toba eruption released twenty-five times the sulfuric acid than industries across the world release in one year ("Mystery of the Megavolcano," 2006).

The remaining caldera at Lake Toba is additional, convincing evidence. Normal lake beds slowly gain depth as distance increases from the shore. However, Lake Toba's bottom drops to hundreds of feet immediately off the shore. This sharp drop, along with steep cliffs along parts of the shore, gives Lake Toba the distinctive shape of a caldera that remains after a volcanic explosion. The caldera, which measures 100 km by 30 km, is so massive that volcanologist only correctly classified it recently ("Mystery of the Megavolcano," 2006). There are also signs of volcanic activity throughout the caldera, such as hot springs and geysers. These are characteristics that Lake Toba shares with another supervolcano, the one that lays beneath Yellowstone. Another sign of volcanic activity is the resurgent domes that form Samosir Island, which lies in the middle of Lake Toba, and the Uluan Peninsula. These resurgent domes have been lifted up about 450 meters from the floor of the caldera as a result of magma refilling or being redistributed in the voided magma chamber after the Toba event (Aldiss and Ghazali, 1984).

Analysis

There is strong evidence that Lake Toba produced the largest volcanic eruption in the last two million years, but the more important question is: what were the climatic

effects of the eruption? Paleoclimatologists do have quantifiable methods to determine the temperature of the Earth, and once again the ice cores play a key role. There are two naturally occurring isotopes of oxygen in the atmosphere, oxygen-16 and oxygen-18. In colder air or water, there is more oxygen-18. Therefore, past temperatures can be determined from the ration of oxygen-16 to oxygen-18 in the trapped air bubbles in the ice cores (Weber, 2007). The same thing can be applied to ocean cores, which are composed of layers of sediment, except the ratio of the two oxygen isotopes is measured in the fossilized shells of tiny sea creatures, called foraminifera ("Mystery of the Megavolcano," 2006). The Toba eruption caused an average global air temperature drop of three to five degrees Celsius, during the six-year volcanic winter, and sixteen degrees Celsius in Greenland over 140 years. The oceans lagged behind the air, dropping three to five degrees over a few thousand years. This is still an extremely quick drop given the normal rate of global change in oceans. Yet the short term effects of the supervolcano eruption could have been even more devastating. Since supervolcanos kick up rocks, ash, and sulfur dioxide into the stratosphere much like a nuclear explosion, data formulated for a nuclear winter can be used to model the effects of a volcanic winter (Kirby, 2000). Studies of a nuclear winter event suggest that beneath the volcanic cloud, the temperature would plummet about fifteen degrees Celsius initially (McGuire, 2002). The initial cooling effect is larger than the long term cooling effect as a result of the volcanic aerosols. Large particles, like tephra, are deposited quickly, but fine pieces of sediment would create a dense cloud that would obscure the sun. This dense cloud dropped the temperatures an astounding fifteen degrees for a short period, until the winds dispersed the cloud or the particles fell back to Earth (Kondratyev, 1988).

Volcanoes release large quantities of sulfur dioxide, which reacts with the water in the atmosphere to create sulfuric acid. Sulfuric acid reflects solar radiation back into space, preventing the radiation from warming the ground normally. Sulfur dioxide also increases amounts of ozone in the stratosphere. In fact, after a volcanic eruption, the surface will cool because of lower insolation, but the atmosphere will warm because it absorbs more radiation (Kondratyev, 1988). After the El Chinon volcanic eruption in Mexico, there was a seven percent decrease in solar radiation (Kondratyev, 1988). The Toba supervolcano released hundreds of times more sulfur dioxide than El Chinon. It is believed that insolation could have been cut by as much as seventy-five percent as a result of such an eruption (Weber, 2007)!

What would these changes in temperature and insolation have on vegetation? Dimming the sun by ten percent causes an eighty-five percent decrease in photosynthesis, undoubtedly damaging or killing many plants. A decrease of two degrees Celsius in average temperature will kill fifty percent of tropical plants (Weber, 2007). Even for hardy, alpine vegetation, a temperature drop of ten degrees Celsius during the length of just one growing season would wipe out half of that vegetation. The temperature dropped by sixteen degrees in Greenland after the Lake Toba event, thus alpine vegetation might not have escaped severe losses and possible extinction (Weber, 2007). Alpine vegetation survived the volcanic winter following the eruption at Lake Toba largely by shifting south and replacing the vegetation around the Mediterranean Sea, according to pollen records (Weber, 2007).

It is hotly debated whether or not Lake Toba caused what geneticist refer to as "the human bottleneck." Many scientists agree that the human population was reduced to

only a few thousand individuals (Garthorne-Hardy and Harcourt-Smith, 2003). Analysis of nuclear sequencing, the Y-chromosome, and mitochondrial DNA shows little diversity in our genetic makeup. On the other hand, chimpanzees have four times more genetic diversity than humans. Therefore, the human population must have gone through a bottleneck sometime after the two species evolved from a common primate ancestor (Weber, 2007). Some believe that the Toba eruption did not create the human bottleneck because less developed primates, which did not have tools like the modern humans, survived (Garthorne-Hardy and Harcourt-Smith, 2003). Neanderthals, who were wiped out later by the more advanced *Homo sapiens*, survived this catastrophic event (Pearson, 2007). In addition, other hominids had survived the blast a mere 400 kilometers away on the Mentawai Islands (Garthorne-Hardy and Harcourt-Smith, 2003). The answer is the distribution of *Homo sapiens* at the time of the eruption, and the fallout of volcanic ash and cloud. Modern humans had advanced out of the West African jungles of our primate predecessors and into East Africa. From there, they had just begun to advance into Asia. Due to deposition of Toba ash in the South China Sea, and evidence that the wind pattern was similar 75,000 years ago as it is today, the eruption happened during the summer monsoon season. The surface winds blew some of the exploded material north, towards Asia. The material, which was ejected higher into the atmosphere, was transported to the west by the trade winds towards Africa (Weber, 2007). Therefore, the volcanic ash most likely suffocated most of the *Homo sapiens* that lived in southern Asia ("Mystery of the Megavolcano," 2006). The volcanic cloud, which caused drops upwards to fifteen degrees Celsius, swept over West Africa, killing most of the sensitive tropical vegetation (Weber, 2007). Since energy transfer between tropic levels is incomplete due to the losses of energy in the form of heat and other inefficiency, there is naturally a cap on the number of tropic levels which can exist in an ecosystem. The widespread loss of primary producers, as a result of the Toba supervolcano eruption, reduces the amount of initial energy available to the entire ecosystem. After the loss of energy between tropic levels, there might not be enough energy in the system to sustain life in the highest tropic level. Thus, the humans, who occupy the highest tropic level, probably starved to death in West Africa due to the dramatic decrease in vegetation. West Africa was sheltered by distance from most of the effects, allowing its primate population to survive. In Europe, the Neanderthal population was already adapted to the cold environment, and like the arctic vegetation, migrated to the warmer climates on the Mediterranean coast. On the other hand, the Mentawai Islands are upwind from the Toba eruption site. Their proximity saved their inhabitants. The volcanic cloud had to encircle the entire globe, dispersing along the way, before it crossed the Mentawai Islands. Therefore, these islands felt relatively mild effects of the explosion (Weber, 2007).

Conclusion

The study of paleoclimates allows us to draw conclusions about future climates. A supervolcano eruption today would bring long-term climatic consequences. The global average temperature would drop drastically and immediately, and it would take years for it to return to pre-eruption levels. The oceans would lag behind the temperature drop on land due to a higher specific heat, and constant circulation. However, once the temperature of the ocean catches up with that of the land, it would remain at that temperature for an extend time, prolonging the cold period beyond that of a normal volcanic eruption. The flora and fauna of Earth would be severely affected as a result of

a supervolcano eruption. Humans and animals for a few thousands of miles downwind of the eruption site would have a high risk of suffocation from airborne volcanic ash. In addition, any area, over which the volcanic cloud of aerosols passes, would be subject to devastating temperature drops of approximately fifteen degrees Celsius. This would create enormous vegetation loss and a widespread state of famine in these locations. There is no doubt that many humans would die as a result of a supervolcano eruption. However, due to highly advanced technology and global distribution, humans will not experience the near extinction caused by the Toba supervolcano eruption 75,000 years ago.

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Just Deserts: Breaking the Myth of Anthropological Desertification in the Sahel

Scott Yang, Class of 2008

Introduction:

"Nothing beside remains: round the decay of that colossal wreck, boundless and bare, the lone and level sands stretch far away (Shelley)." These words by the English Poet Percy Bysshe Shelley paint a lone expanse of wind-whipped desert wasteland. In the human imagination, nothing is as hostile and foreboding as the desert. Seemingly devoid of life and inhospitable to it, these areas represent perhaps the most alien areas of the earth to man. While people labor to preserve habitats such as wetlands and jungles, efforts are taken to curb the spread of deserts.

Desertification according to the United States National Park Service is "a process of landscape change usually due to land mismanagement or climate change whereby the land becomes increasingly arid and vegetation is replaced by more dry-adapted species (nps.gov)." This definition identifies the main causes for the "growth" of deserts as climatologically based reasons with anthropogenic contributions. However, this has not always been the understanding. In the 1970s, during the height of the Sahel's "Great Drought" when a famine was causing widespread suffering in parts of Africa (Thomas 1), desertification received much sensationalized attention.

Unfortunately, because of this emotion-tinged focus, desertification became an "emotive term that has both been misused and confused with drought" rather than a process coolly and objectively analyzed (Thomas 1). Today, instead of the concept of an advancing desert that would grow to engulf the entire earth if left unchecked, the combination of a recent greening in desert borderlands in the Sahel and remote sensing studies have led to a more accurate characterization of desertification. The conclusions resulting from the examination are that the rate of desertification in the Sahel zone bordering the Sahara desert was overestimated by as much as a factor of three in preliminary reports published in the 1970s (Herrman et. al 395). While activities such as overgrazing and improper irrigation highlight the human contribution, these play a secondary role to the influence of climate, specifically precipitation, in the natural fluctuation of the Sahel between greener and more arid environments.

Background:

A Physical Perspective:
The focus of the growing desert has always been on the edges of the existing deserts. In the 1970s the point of attention was an area known as the Sahel. The Sahel is a strip of land that borders the edge of the vast Sahara desert, and the focus of this paper. It is important to develop a basic understanding of the characteristics of the Sahelian zone in order to see why its fluctuations between drier and wetter climates are not indicative of a growth of deserts.

The word "Sahel" comes from the Arabic word for "shore" (Herrman et. al. 394). This is an accurate description because the Sahel is essentially a beach to the Sahara desert that exists to its north. Geographer A.T. Grove describes the Sahel as "essentially a phytogeographical unit, a zone of grassland, scrub and thornbrush passing northwards into the Sahara and southwards into Savanna (Grove 407). The Sahel stretches from the western-most coast of the African continent near Mauretania and Senegal to the eastern-most shore of Africa on the Red Sea by Sudan and Eritrea (Grove 408). The Sahel is characterized by the strong seasonality of climates with a "long dry season and a short humid season in the northern hemispheric summer" (Herrman et. al. 395). The most important climatic constraints are scarcity, variability, and unpredictability of rainfall. These increase from south to north and are "the most important controlling factors in the Sahelian ecosystem (Herrmann et. al 395).

While a difference in mean annual rainfall of 100mm is of little importance in humid lands, in arid zones such as the Sahel with a mean annual rainfall of less than 150mm, it greatly affects the type of plant cover as well as usability of the land (Groves 409). The vegetation cycle follows the seasonality closely with "virtually all biomass production taking place in the humid summer months" (Herrman et. al. 395). To illustrate the variability that exists in the Sahel from north to south, Groves states that

> "With a mean annual rainfall of less than 150mm, the vegetation does not afford sufficient protection to prevent wind transport and such dry areas on the south side of the Sahara approach a belt of sandflow from east to west which is scarcely interrupted by highland barriers. North of the 250mm isohyet, crops can scarcely be grown in most years without irrigation and camels are better suited to the dry conditions than are cattle. Regions with over 400mm of rain, on the other hand, can be quite well-wooded and, south of the 600mm isohyet, one approaches heavily settled sorghum and cattle country in Senegal, Upper Volta, and Hausaland (Groves 409)."

Besides the regional contrasts in rainfall and resulting biomes, "the sharp seasonal contrasts are overlain by considerable fluctuations in rainfall at inter-annual and decadal time scale (Herrman et. al. 395). This makes the Sahelian region the most dramatic example of climate variability that has been directly measured (Hulme, 2001). The complexity of this region is because change exists not only in the 3rd dimension but in the 4th dimension with time as a factor. While the forces pushing these changes are not completely understood at this time, studies link the long-term fluctuations in the Sahel with "changing configurations of forcings and feedback mechanisms (Herrman et al 395).

These in turn can be induced by atmospheric and ocean circulation dynamics with global-scale effects, such as the El Niño southern oscillation (ENSO) cycles, non-ENSO-related variations in sea surface temperatures, and large-scale changes in land cover and land-atmosphere interactions" (Herrman et. al 395). To add further credence to the importance of time in considering the fluctuations of the Sahel from drier to more moist climates, it is important to examine the past conditions in the Sahel. For example, the geologic features such as the dunes in the current Sahel reflect the conditions that existed at the height of the last glaciation (20000-12500 years ago) when rainfall was less over much of the globe's surface (Grove 410). Specifically, near the end of the last glaciation, "the climate of the Sahel fluctuated but eventually became markedly wetter and, for the next five thousand years, all the closed basins of Africa for which we have information were occupied by lakes (Grove 410). Even the soils of the Sahelian region derive from the accumulated effects of the dramatic changes that occurred in the Late Quaternary Times (Groves 410).

An Anthropogenic Perspective

While research indicates that the effect of climate greatly outweighs contributions by humans to the process of land degradation (desertification), human activities in the Sahel cannot be ignored. An examination of human activity in the region is necessary to understand how people contribute to the changes started by climate. For example, during the Sahel's moist period, "savanna animals and pastoralists roamed the Sahara; pottery-using people fished in Saharan lakes" (Groves 410). Currently, the pattern of life continues as it has, following the pattern of the rains. For example, during the short summer rains, the pastoralists spread north with their herds and eventually congregate around permanent lakes, streams, and pools. The cultivators who depend on agriculture "harvest their rain fed crops between September and December and spend the latter part of the dry season at various crafts and trades, or leave to seek employment in the towns or on the plantations of the coastal lands" (Groves 409).

It is strange that these supposedly inhospitable lands were once the home to vast trading kingdoms. Although "drought and famine were unavoidable components of life in this harsh region, the people were relatively prosperous and developed agricultural and livestock practices that allowed local populations to endure and recover from extremes of nature (Brough et al 1). However, with the arrival of the European colonizers who imported their lifestyle to the area, the lifestyle that had evolved to coexist with the fragile environment was greatly disturbed. The Tuareg are a nomadic people inhabiting the Sahel who make their living primarily from trans-Saharan trade as well as cattle raising (Brough et al 1).

Although the communal ownership of pasturelands led to overgrazing at times, the cattle and, most importantly, the wells were privately owned. Use of the wells was not free and the time limit that each herd could spent at a well tended to regulate the sizes of the herds. "While a system of fully defined property rights was lacking, the system was relatively efficient and insulated its people from natural catastrophes (Brough et al 2)." However, when the French arrived, they shifted the economic focus of the area from trans-Saharan trade to export agriculture as well as east-west shipment from the interior

to Atlantic ports (Brough et al 1). As a result, many residents abandoned their traditional lifestyles for ones that would augment the drought.

Analysis:

Overview
The thesis of this paper is that desertification in the Sahel is a climatologically driven process that can be augmented by human contributions. The background section, presented a physical and anthropogenic description of the Sahelian region. From the physical description, the location of the Sahel and the fact that it is classified by precipitation should be clear. The rainfall in turn determines many features such as vegetation. From a human perspective, it should be evident that the effects of man can contribute to land degradation but will not cause it. The reason that anthropogenic causes became mislabeled as the primary cause of the desertification is the unfortunate result of shortsighted economic planning that coincided with a drought in the Sahel.

Failed Economic Planning
Because the area of the Sahel under French control was beginning to show signs of economic stagnation, the French initiated a three-pronged solution to combat the recession. They relied on digging more wells, an improved veterinary campaign, and opening new markets in the south to be the solution (Brough et al. 4). The French failed to consider the effects of their campaign on the already-established lifestyle that allowed societies to exist in harmony with fragile border ecosystems. The digging of new wells allowed a larger human and cattle population than the Sahel could sustain while the improved medical and veterinary care allowed more of these people and their herds to survive.

Although the French hoped that the nomads would slaughter their herds to earn money, the local culture that equated wealth with cattle prevented them from doing so (Brough et. al. 4). Instead, nomads attempted to maintain as large a herd as possible. The result of this increased population on the environment was massive overgrazing (Brough et al 4). The roots of trees and plants are necessary to help maintain the soil in farmlands. Without them, the soil gradually breaks down or is carried away by the wind resulting in less productive or even unproductive farmland (Brough et al 5). In an effort to gain more control over a worsening situation, the French nationalized all forest land which led to the tragedy of the commons occurring. Because families no longer owned land, no one had any incentive to replant overgrazed areas. When the French left, the post-independence African governments kept nationalized forestry in place. Corrupt and susceptible to bribes, this exacerbated the problems that already existed with the marginal control that the government exercised (Brough et al 5).

In search of lands to replace degraded tracts, nomads shifted south and began to cultivate marginal lands which in the past “had been allowed to lay fallow for as long as 20 years” while the nomads moved about (Brough et al 5). During this time, wells continued to be the favored aid project (Brough et al 5). As a result, human and cattle populations increased while land was destroyed by migrating group looking for food and water. “Life

in the Sahel is adjusted to departures of moderate magnitude from mean annual conditions" (Grove 409). However, it was not prepared for the rain deficiencies that would occur year after year in the 1970s. "In certain districts of the Niger Republic, the herds of sheep and cattle were literally decimated between 1968 and 1974" (Groves 409). The pictures of dead cattle as well as the suffering that resulted catapulted humans to the forefront as contributors towards an "expanding desert." In fact, only the oldest individuals could remember a drought of comparable severity that occurred in 1913 (Groves 409). This highlights the analysis of the next section that aims to point out the cyclical climate-driven nature of desertification.

Desertification, it comes and goes

UNEP (United Nations Environmental Program) stated in 1987 that "27 million hectares of productive land were being lost to desertification each year, at which rate not one hectare of productive land would remain on earth in 200 years time" (Thomas 318). As mentioned in the previous section, the widespread media attention that the Sahelian drought received linked the human suffering that it caused with desertification (Thomas 318). As the emotions subsided and data from long-term studies began to arise, scientists realized the problems with desertification's past representation. For example, "a clearer understanding of the relationship between drought and desertification has developed and advances in understanding dryland ecological principles have meant that issues relating to vegetation change and overgrazing are now better understood" (Thomas 319). Whereas past assessments gave numbers to indicate that "two-thirds to three-quarters if the world's drylands being desertified" recent reassessments have done much to change the concept of the advancing desert front. Recent attempts to characterize desertification describe it with a set of "D's."

The first of these is "drylands". This term excludes hyperarid regions of the world (i.e. middle of the Sahara) because it is hard to make them more desert-like (Thomas 319). Instead, the focus is on drylands which are susceptible to full desert conditions if mismanaged. These susceptible drylands occupy "almost 40 percent of the earth's land surface and support a human population of about 850 million" (Thomas 319). These drylands all experience desert like conditions to some extent such as distinct rainfall regimes, an annual excess of evapotranspiration over precipitation, skeletal or poor soils, and fragile ecosystems (Thomas 320). As described in the section regarding the effects of humans, most societies that live in these regions have adapted lifestyles to exist in harmony with the environment. However, "increasing numbers and the application of inappropriate technologies" have resulted in an overstressing of the land (Thomas 318). The next of the "D's" is degradation which means "a reduction in potential productivity" or a "reduction or destruction of the biological potential" (Thomas 321). The key distinction is that degradation requires a detrimental change to take place within the soil or soil loss to occur. This is different from short-term human induced disturbances that "do not change an environment's ability to support production" (Thomas 321). The following characterizing term for desertification is drought. Studies have attempted to split the two terms of drought and desertification which are often confused. Although "drought can be a precursor to desertification and desertification may eventually contribute to drought through feedback mechanisms," the two phenomena are distinct

(Thomas 321). Drought is usually defined in a meteorological sense as being a certain amount below mean annual precipitation. Drylands are susceptible to drought because of "the nature of the climate systems responsible for their rainfall and because of high interannual rainfall variability" (Thomas 321). The last term is desiccation which is longer-term reductions in moisture availability resulting from a dry period "at the scale of decades" (Thomas 321). Scientists show that cycles of many years below the average rainfall and then above the average are common in these (dryland) environments (Thomas 321).

Previously stated, the disaster in the Sahel during the late 60's and 70's was the result of a period of desiccation in the Sahel. In the background, it was introduced that rainfall is highly seasonal in dryland environments such as the Sahel and that the vegetation and biomass production are highly dependent on its annual fluctuations. In fact, recent NOAA satellite data analysis shows "the dynamic nature of vegetation" and therefore, the concept of the advancing desert front is incorrect. Previous definitions of a growing desert was tied to changes in vegetation. They did not account for the fact that "the size of the Sahara, as measured by biomass, directly relates to interannual rainfall variability, with both expansions and contractions occurring" and that the distribution of the "complex spatial patterns of vegetation" come in response to "patchy rainfall distribution" (Thomas 323). Simply put, earlier analysis of vegetation cover changes seems to have confused natural temporal and spatial variability change imparted by drought with long-term degradation caused by human activities (Thomas 324). The conclusion from the revised definition of desertification is that it implies detrimental change within the soil system and not plant communities alone (Thomas 324).

Vignettes in a Sahelian Country

To investigate the extent of desertification, on the ground analysis was performed in concert with remote sensing in order to gauge the effect of desertification in Burkina Faso, a country on the Southern edge of the Sahel. The four areas were selected based on their "differing soils and land use" (Lindqvist 131). The selected areas were the Kolèl, the Ménégou, the Oursi, and the Boukouma areas. After examining the selected regions physically, and comparing observations to old aerial photographs as well as recent satellite imagery, the scientists concluded that "the most severe land degradation occurred during the first of a series of droughts which started in the late 1960s" and that based on recovery, the situation has "stabilized somewhat" (Linqvist 134). Degraded areas that current still existed were found in "rangelands on the plains" which had seen disturbance from pressure exerted by cattle herds (Lindqvist 134). The researchers noted that increased rainfall since 1985 brought back uneven recovery based on the nature of soil resilience (in turn determined by use) (Lindqvist 134).

Another group of scientists decided to use remote sensing to analyze various African countries that lie in the Sahel using remote sensing. The scale that they selected was the Normalized Difference Vegetation Index (NVDI). This measured the "greenness" of an area by exploiting differences of vegetation and bare soil in the red and near-red segments of the electromagnetic spectrum (Herrman et al. 396). From the results of their study, the researchers found evidence to "refute claims of widespread human-induced

land degradation at a regional scale" (Herrman et al 402). According to the NVDI index, a greening of the Sahel was found indicating "a net increase in biomass production during the period of 1982-2003" and challenged the notion of irreversible desertification (Herrman et. al. 402). Rainfall "emerged as the dominant causative factor in the dynamics of vegetation greenness in the Sahel…" However, the researchers prudently note that the Sahel is also a cultural landscape which means that while signs of human-induced land degradation are not visible at the large scale, perhaps a closer "on the ground" investigation will uncover pockets at the local scale (Herrmann et al 402).

Conclusion:

"Is it a desert, only time will tell,
a landscape between heaven and hell.
Every ten thousand years or so,
the ice will come, the ice then will go.

In one place the ocean throws water across the land,
another place flowers beyond numbers to count grow.
In time, only a desert will tell,
the span between heaven and hell."

-Phillip Camitses

The poem above shows the dynamic nature of deserts. Current research on desertification offers a clearer description of what desertification is and is not. This paper examined desertification in the area bordering the Sahara desert known as the Sahel. By examining the various publications concerning the physical and human geography of the Sahel, research about the drought of the late 1960's and 1970's, and recent remote sensing performed on this region, it is evident that the so-called "desertification" in this area was confused with the variable nature of precipitation in dryland environments. Remote sensing at the regional scale shows a recovery of vegetation since the end of the drought. However, the ability of humans to contribute to land degradation (via the destruction of soils and disruption of fragile ecosystems) should not be ignored in our evolving understanding of desertification, (currently) a climate driven process to which humans can contribute at the local scale.

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Polygamy: Does Quantity yield Quantity

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In 2002, my high school English class read the novel The Good Earth. During one of the discussions, a student brought up the topic of polygamy, stating that she viewed it as indicative of an inferior society, as it was evidence of a large inequality between males and females. My teacher in turn replied slyly that all societies practice polygamy, in America we just do so consecutively. All humor aside, there's quite a bit of truth to the statement claiming that polygamy permeates most societies, both historic and contemporary. As such, it is the topic of much debate, ranging from the reasons behind polygamous relationships, to the stresses and conflicts resulting from multiple partner relationships. Weeks himself brings up a rather surprising and controversial claim when he states "…polygamy…kept earlier Roman growth rates lower than they otherwise might have been" (Weeks, 2008). Essentially, Weeks is stating that polygamous societies have lower birthrates than similar monogamous ones. This is counterintuitive, as the obvious assumption of one man procreating with several women would be many more children, therefore polygamy should result in higher birthrates. Thus, several questions come to mind. Where is polygamy practiced, and why? Does it really cause a reduction in the fertility rate of a population? And if so, what causes this phenomenon?

In order to study polygamy, it is necessary to first establish a foundation concerning its definition. Webster's online dictionary defines polygamy as a "marriage in which a spouse of either sex may have more than one mate at the same time" (Webster's, 2008). While technically this includes extramarital affairs, for the purpose of this paper I will be using polygamy solely to address socially accepted, multiple partner marriages. Additionally, polygamy is broken down into two distinct forms, polyandry and polygyny. Polyandry is when a woman has multiple husbands, and polygyny occurs when a husband has multiple wives (Webster's, 2008). While polygyny is much more widespread, polyandry does exist in specific enclaves, most notably in Nepal (Ross, 1984). This paper will focus mostly on polygyny, as it is by far the most common practice and thus has the greatest potential for increasing fertility rates amongst a population, therefore unless explicitly stated, polygamy and polygyny will be synonymous.

Polygamy is everywhere; it is not limited to a few fundamentalist sects of Latter Day Saints, nor does it exist solely in the lesser developed regions of sub-Saharan Africa. Rather, the practice of multiple marriages traces its roots back through most major religions, and thus exists in nearly every society to date. Social acceptance of the practice, however, varies greatly. Most modern states encourage, and even legally limit, marriages to include only monogamous relationships, while less developed, more traditional areas tend to be more open to polygamous lifestyles. The reasons for this are numerous and hotly contested, and are not the topic of this paper. Thus the underlying source of lifestyle choice will be ignored' instead I will address on the affects of

polygamy versus monogamy on fertility rates by focusing on three well known polygamous cultures: Mormons, Bedouins, and the Nepalese.

The Bedouin study was conducted in the middle of the 20th century, and included 2400 families, of which 90% were monogamous (Muhsam, 1956). The study thus examined an intact social group within which monogamous and polygamous relationships simultaneously coexisted. This greatly reduces (and potentially eliminates) possible discrepancies in fertility rates due to differences in time, culture, and distance. Muhsam found, ultimately, that in the Bedouin society, "women living in polygamous marriage have fewer children than only wives of monogamous husbands" (Muhsam, 1956). He compares this to another study conducted in the Belgian Congo, where the effective fertility rate (defined as the ratio of live births per year to the number of married women 15-45 years old) was found to be 31% lower in polygamous marriages than in monogamous ones. The Bedouins exhibit a similar trend, with a 32% decrease in fertility between polygamous and monogamous marriages (Muhsam, 1956). This fertility rate, however, is deceiving. For the Bedouins, monogamous women have on average 4.59 children, while polygamous women have an average of 3.5 children per wife. However, due to the number of wives involved, this means that the total number of children in a polygamous family exceeds the number in a monogamous one, and thus the fertility of "polygamous marriages is far higher than…monogamous marriages of the same social and cultural milieu" (Muhsam, 1956). A further factor affecting fertility rates between single and multi-marriages is the spacing between children. For monogamous women with between 2 and 7 children, the average age difference between offspring is 2.87 years. For polygamous women, this difference is only slightly greater, at 2.90 years (Muhsam, 1956). This means that within the Bedouin culture, women are having children at roughly the same rate in both types of marriages. Thus, according to this study, it would appear that Weeks's assumption that fertility rates decrease with polygamous relationships is true, however it masks a potentially disturbing fact: polygamous relationships, while exhibiting a lower individual fertility rate, do in fact contribute disproportionately to overall population growth.

A similar study, conducted by James E. Smith and Phillip R. Kunz, examined a vastly different cultural group. They focused on Mormons inhabiting Utah during the first decade of the 20th century. During this time period, the Mormon population was split between 63.8% monogamous and 36.2% polygamous marriages (Smith and Kunz, 1976). Thus, as with the Bedouin population, it was possible to compare a contemporary, homogenous cultural group's fertility rates. Not surprisingly, this group exhibits similar fertility trends. In monogamous marriages, the wife had a mean fertility rate of 7.82. This number decreased as the number of wives increased; in polygamous families the mean fertility rate per woman was 6.7 (Smith and Kunz, 1976). The research also examined the fertility rate per male, which is the average number of children per married man. While the total mean male fertility rate was 12.11, the rate for a monogamist was 7.82, while the rate for a polygamist with two wives was 16.16, and average for a polygamist with three wives was a staggering 20.11 (Smith and Kunz, 1976). Thus, polygamous males displayed a significantly higher fertility rate than their monogamous counterparts. In a populations with significantly more female members (such as the Mormons immediately following their mid-1800's cross country trek), polygamy would

serve to immediately boost the birth rate of the community, despite the typical drop in individual fertility rates amongst polygamist females.

The previous two case studies focused on polygynist societies, where a single male has multiple female partners. The last case study is the opposite; it compares a polyandry population to a monogamous one. In it, J. L. Ross examines the fraternal polyandry society of Tibet against a Hindu culture emphasizing monogamous marriage. His ultimate conclusion is that "fraternal polyandry does not affect individual fertility of married women in polyandrous vs. monogamous unions but does have a significant negative effect on aggregate fertility" because it creates a large surplus of unmarried women (Ross, 1984). Since there is only one female per family, the polyandrous Tibetan society does not experience the cumulative affect of many wives having many children. And since each woman has multiple male partners, there are fewer males available per woman, as the ratio of males to females in the polyandrous society was 51% to 49%, respectively (Ross, 1984). Thus, even though the fertility fails to follow the polygynist trend and decrease within polygamist marriages, population growth is still significantly slower in polyandrous cultures, when compared to their monogamous counterparts.

Overall, Weeks's statement declaring that polygamy is useful for decreasing fertility rates is technically accurate in traditional polygynist cultures. This surprised me, because I naturally assumed that gestation time was the primary limiting factor on pregnancies in a traditional society that ignores modern family planning methods. This indicates, however, that other factors are at play with regards to fertility. One possible explanation for this comes from Muhsam (1956), who states that some studies show that an increase is sexual partners does not necessarily prompt an increase in sexual activity. Thus, a woman in a polygamous relationship is receiving less overall attention than her counterpart in a monogamous one, as the polygamous husband is diluting his sexual activity amongst several partners, and therefore the chances of impregnation decrease for polygamous wives (Muhsam, 1956). Also, with polygamy, one man removes several women from the breeding pool, thereby eliminating (at least hypothetically) the probability of impregnation by another male. In societies with a roughly equal distribution of males and females, this would undoubtedly lead to a decrease in fertility rates, because instead of coupling a single male with a single female (and thus maximizing potentially fertile unions), a large pool of unmarried, and thus unutilized, males is created. If the polygamous male happens to be infertile, this completely removes all his wives from the breeding pool. Lastly, another potential explanation for the decrease in fertility rates could be social statues. In polygamous societies, often times marriage is used to gain or display affluence, wealth, and power. Thus, a man may have multiple wives, but only use a select few for procreation; the others serve as symbols of prestige or were the result of beneficial political unions. Once again, this shrinks the pool of available women for reproduction, thereby decreasing fertility rates.

Despite my initial skepticism, Weeks's statement regarding the decrease of fertility rates in polygamous societies proves surprisingly (and counter-intuitively) accurate concerning traditionally polygyny. He proves to be slightly off the mark with regard to polyandry, as these societies experience no significant increase or decrease in fertility rates when compared to similar monogamous communities. Regardless of this slight oversight, it seems safe to say that, in direct contradiction to my previous assumption, fertility rates and polygamy are in fact negatively related. However, the

overall population growth rate increases as can be seen in the fertility rate per male. Therefore, while Weeks is correct in the strict statistical sense, there is still a significant population increase in polygamous societies.

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