

**An Ecological Investigation of Global Climate Change,
Using GLOBE Protocols on Mount Kilimanjaro, Tanzania, Africa.**

A Student Investigation Report by
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Abstract

Using MUC Field Guide Classifications, as well as GLOBE Land Cover and GPS Protocols, students in the Xpedition project will gather baseline data of the distinct biozones and flora of Mount Kilimanjaro. This data will allow future GLOBE students to examine the effects of climate change that threaten the entire ecosystem of this World Natural Heritage Site.

Xpedition students will review existing data on the vegetative components of the various altitudinal zones of Mt. Kilimanjaro, as it may exist, and convert this data to the MUC Field Guide Classification. Similar to the GLOBE Seasons and Biomes Project, this endeavor will contribute scientific measurements to validate previous research on the regional climate change of East Africa and serve as a comparative baseline for future study areas.

The most vital segment of Xpedition involves its global-to-local educational aspects:

- Xpedition website (www.tigersonline.org/kilimanjaro) providing current information, educational activities and community forums focused on the issue of global climate change using GLOBE protocols, including a 5-day curriculum outline.
- Xpedition students and faculty, through public speaking events, will share observational insights and information relating to the science of global warming with local students in grades 6 through 12, spurring further interest and study of this critical environmental issue and promoting local student research projects dealing with seasonal changes within identified biomes.

Hypothesis

As global temperatures rise, the melting glaciers of Mt. Kilimanjaro have become a “calling card” of the global warming phenomenon. Yet, beyond its melting glaciers, Expedition students wondered if there were other significant changes taking place on Kilimanjaro that support the diagnosis of global warming. Specifically, we are interested in assessing the effects of climate change on Mt. Kilimanjaro’s distinct, climate and vegetative zones.

Mt. Kilimanjaro offers the unique opportunity to observe and collect data pertaining to the land cover of the major vegetative zones (cultivated areas; rain forest; heath zone; moorland; alpine desert and summit) – and to use that data not only for comparative analysis with data that may already exist, but to establish data sets that can serve as reference points for future study. Our data collection and analysis will allow us to make in-roads to finding answers to a remarkably important question:

Are vegetative changes occurring within the major altitudinal biomes in the Mt. Kilimanjaro region and might these changes serve as further confirmation of world-wide climate change?

We are interested in studying two aspects of global warming as it pertains to the biomes of Mt. Kilimanjaro:

1. Whether the elevation boundaries classically associated with the MUC altitudinal biomes are in the process of shifting; and,
2. Whether the major types of plant species within these MUC altitudinal biomes are changing. By assessing vegetative component species at varying altitudes, we would like to determine whether there is a trend towards different species types within each zone over time.

Materials and Method

Our study of the effects of global climate change on the land cover of Mt. Kilimanjaro involves the conversion of previously collected data to the GLOBE MUC Classification System as well as on site field observations and data collection using GLOBE Protocols.

The unique climatic and ecological zones encountered on the slopes of Africa's tallest mountain have been well documented, but never classified in the GLOBE MUC System. Our first goal is to take existing data collected by the United Nations Foundation's Community Management of Protected Area Conservation Project and convert it to established MUC Classifications. This would involve analyzing the data in respect to climate zone, altitude, temperature, precipitation, land cover and plant species. This conversion of data should provide an outline as to what we should expect to encounter in the field.

In the summer of 2008 our team of 20 high school students, 8 faculty members and 2 university professors will visit and attempt to summit Mt. Kilimanjaro using the Lemosho – Machame western approach route (figure 1). The use of this route will allow us to spend at least one day in each of the six unique ecological zones on the mountain and will give each member of the team the best chance to acclimate to the altitude and reach the summit.

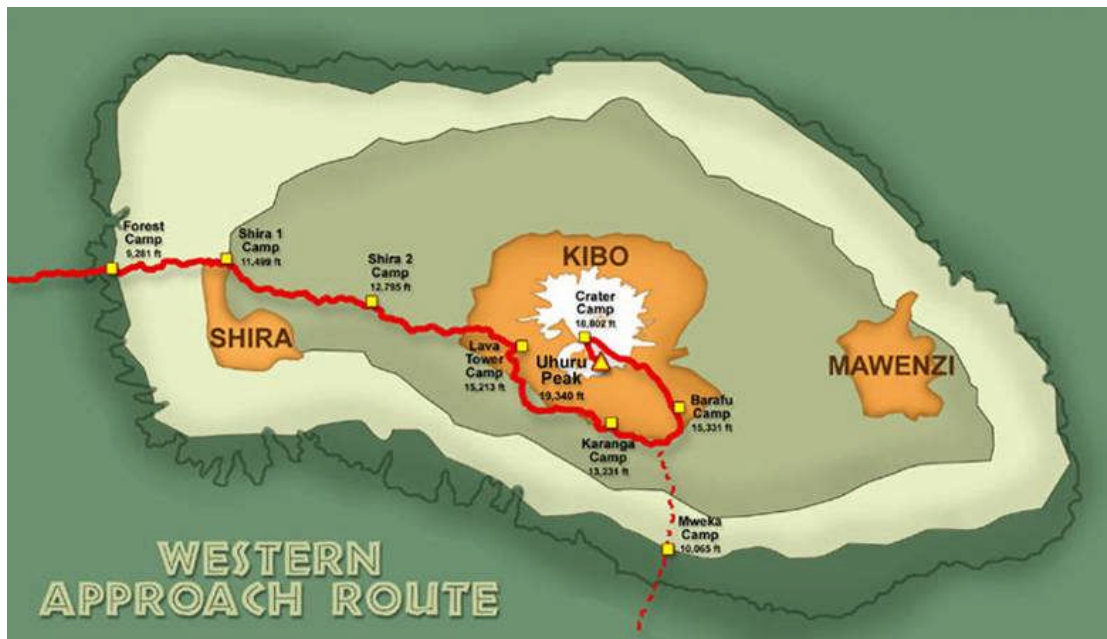


Figure 1: Lemosho-Machame Route, Mt. Kilimanjaro¹

To collect our data we will be utilizing the GLOBE Land Cover Sample Site Protocol as well as the GLOBE GPS Measurement Protocol. Working in 3 groups of 7 students and 3 faculty members, each group will collect data using a hand held GPS unit and the GLOBE Land Cover Sample Data Sheets (figure 2). Each group will also be asked to collect a series of pictures to establish a visual reference of each sample site. We believe the collection by 3 different groups will allow for a more accurate description of the land cover and climate zone. Each group will record the exact latitude and longitude of the sample area as well as altitude, temperature, current precipitation, extent of land cover as well as plant species. Our goal is to spread out the locations of the sample site areas to establish the most accurate locations of each vegetation zone. When all data is collected and analyzed we should have a very accurate and reliable MUC classification of one of the most unique ecosystems on Earth for future GLOBE students to use.

¹ 7 Summits, map of the western approach of Mt. Kilimanjaro.

Land Cover Investigation

Mt. Kilimanjaro Data Sheet

The Xpedition – St. Xavier High School, Louisville, Kentucky

Measurement Date _____ Time: _____

Recorded By: _____

LOCATION

Site Name:

Latitude		Longitude		Elevation
_____		_____		_____
decimal degrees		decimal degrees		meters
North	South	East	West	

MUC TO THE MOST DETAILED LEVEL

MUC Class: _____ MUC Land Cover Type Name: _____

METADATA (Comments, Current Precipitation, etc.)

.. PHOTO NUMBER AND ORIENTATION

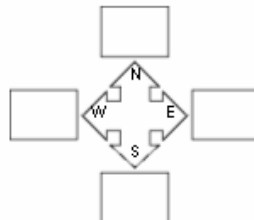
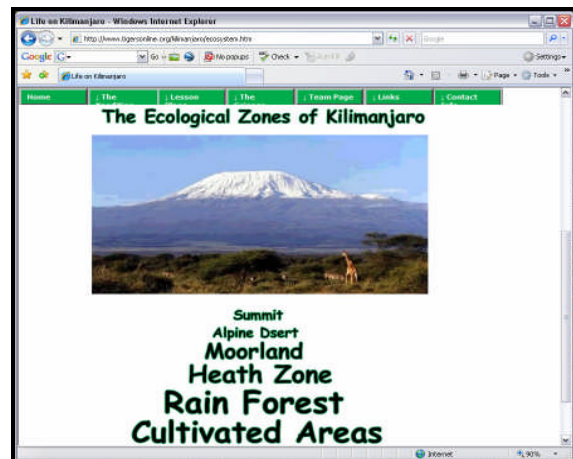


Figure 2: GLOBE Land Cover Investigation Sheet

Data Summary

The following data from the United Nations Foundation's Community Management of Protected Area Conservation Project and presented in Aerial Survey of the Threats to Mt. Kilimanjaro's Forest, January 2002² (Table 1) was used to develop the summary for each ecological zone. These zone descriptions were used to start our MUC conversion and all information is displayed on our team's education web page under, "Ecological zones of Kilimanjaro"³ (Figures 3 & 4).



Figures 3 & 4: The Xpedition Web Site www.tigersonline.org/kilimanjaro

² Aerial Survey of the Threats to Mt. Kilimanjaro Forest. (2002). Division of Early Warning and Assessment. United Nations Environmental Program.

<http://www.unep.org/dewa/assessments/EcoSystems/land/mountain/Kilimanjaro/index.asp>

³ See <http://www.tigersonline.org/kilimanjaro/ecosystem.htm>.

Vegetation	Altitude (m asl)	Location
Savanna bushland with <i>Acacia</i> , <i>Terminalia</i> , <i>Com bretum</i> , grassland and pasture with <i>Cyperus niveus</i> , <i>Bothriochloa insculpta</i> , <i>Eragrostis sup erba</i>	700 – 1,000 (south) 1,400 – 1,600 (north)	All around the mountain
Densely populated Chagga home gardens (agroforestry system) with a sparse tree layer of <i>Albizia schimperiana</i> ,	1,000 – 1,700	South/ East
<i>Ocotea-Agauria</i> forest, consisting of <i>Ocotea usambarensis</i> associated with <i>Agauria salicifolia</i> , <i>Macaranga kilimandscharica</i> and <i>Polyscias fulva</i>	1,600 – 2,100	South / South East
<i>Ocotea-Podocarpus</i> forest, consisting of <i>Ocotea usambarensis</i> associated with <i>Podocarpus latifolius</i> and the tree fern <i>Cyathea manniana</i>	2,100 – 2,400	South / South East
<i>Podocarpus-Ocotea</i> forest with prevailing <i>Podocarpus latifolius</i>	2,400 – 2,800	South / South East
<i>Croton-Calodendron</i> forest with <i>Olea europaea</i> ssp. <i>africana</i> , <i>Croton megalocarpus</i> , <i>Calodendrum capense</i> and	1,300 – 1,600 1,600 – 2,000	West North
<i>Cassipourea</i> forest with <i>Cassipourea malosana</i> , <i>Teclea simplicifolia</i> , <i>Fagaropsis angolensis</i> and <i>Olea capensis</i>	1,600 – 2,200 2,000 – 2,400	West North
<i>Hagenia-Podocarpus</i> forest with <i>Podocarpus latifolius</i> , <i>Hagenia abyssinica</i> and <i>Prunus africana</i>	2,800 – 3,100	South / South East
<i>Juniperus-Podocarpus</i> forest with <i>Juniperus procera</i> , <i>Podocarpus latifolius</i> and <i>Hagenia abyssinica</i>	2,400 – 2,800	North Around the
<i>Erica</i> forest consisting of pure stands of <i>Erica excelsa</i>	2,800 – 3,500	mountain

Table 1: United Nations - Mt. Kilimanjaro Major Vegetation Types

Analysis

The following are the zone descriptions developed by our team of 20 students with the help of Dr. Keith Mountain, Chair, Department of Geography and Geosciences, University of Louisville. The descriptions help classify the 6 distinct vegetative zones of Mt. Kilimanjaro (figure 5) using the MUC Field Guide, as well as the United Nations data set description information and Vegetation Map (figures 6 & 7). Each zone was broken down by elevation, average precipitation, average temperature, soil conditions, types of vegetation present, as well as a description of each zones dominate vegetation.



Figure 5: Mt. Kilimanjaro, Tanzania, Africa (photo: 7 Summits)

Zone 1: Cultivated Areas**Altitude: roughly 2,600 to 6,000 feet**

Kilimanjaro's rich volcanic soils, irrigated by water from the rain forest higher up, have attracted farmers to settle on the mountain's lower slopes. Today, crop and grasslands have replaced the natural bush and lowland forest.

Zone 2: Rain Forest**Altitude: roughly 6,000 to 9,200 feet**

Accumulating about six and a half feet of rain each year, the rain forest is dripping, humid, and bursting with life. The temperature generally ranges between 70°F and 80°F throughout the year. A thin layer of poor soil covers a thick layer of clay on the forest floor. There are a number of different tree species in the forest. In the lower forest, sycamore figs and palms festooned with hanging mosses crowd river gorges, while higher up, huge camphorwood trees soar to 130 feet. The branches of the trees interlock to form a canopy above the forest. Mosses, lichens, ferns, and orchids are other common plants. At about 8,000 feet, a layer of cloud often forms, which blankets the forest throughout most of the day. These clouds are an important source of water for the areas below the mountain.

Zone 3: Heath**Altitude: roughly 9,200 to 11,000 feet**

Above the forest line, porous soils and lower rainfall result in much sparser vegetation. The lower altitudes of this region are characterized by a wide, rolling meadow with giant heath plants and many small wild flowers. Heavy mists often cover the area. These areas may get about 30 or 40 inches of rain a year. The many grasses that abound here are vital for safeguarding the soil and conserving the fleeting moisture. They also harbor all manner of everlasting flowers, from the leathery-leaved, artichoke-like Protea to the red-hot poker, a tall, striking plant with red or yellow tubular blossoms.

Zone 4: Moorland**Altitude: roughly 11,000 to 13,200 feet**

At higher altitudes, the region is much drier, getting only about 20 inches of rain per year. There is also a greater fluctuation in temperature, with high temperatures during the day, and freezing temperatures at night. This region has several distinct plants, including dwarf camphor trees and giant lobelia and senecio (groundsel), which are found nowhere else in the world. The lobelia, which grow up to 10 feet high, have hollow stems and tall flower-like spikes. In order to protect the sensitive leaf buds from the nighttime temperatures, the lobelia close their leaves around the central core, while secreting a slimy antifreeze-like solution. The giant groundsel, some more than 200 years old, can reach 16 feet high with a crown of large leaves and a 3-foot long spike of yellow flowers. The groundsel uses its old dead leaves as insulation around its trunk.

Zone 5: Alpine Desert**Altitude: roughly 13,200 to 16,500 feet**

This is a harsh, dry, windy region, consisting mostly of bare rock and ice. The temperature of the area ranges from below freezing at night to over 100°F during the day. The air is very thin, and radiation from the sun is intense. It rains less than 10 inches per year, and the zone's thin soils retain little of what does materialize so there are very few plants, mostly lichens and small mosses.

Zone 6: Summit**Altitude: roughly 16,500 to 19,340 feet**

The summit is an arctic zone characterized by freezing cold nights and burning sun during the day. At the top, the oxygen level is roughly half that found at sea level, and the thin atmosphere offers little protection against the fierce rays of the sun. This region receives less than 4 inches of precipitation per year, usually in the form of snow. Even in this desolate climate, there are a few red and gray lichens adapted for survival. The massive glaciers that cover one-third of the mountaintop are remnants of the ice cap that covered the entire summit area thousands of years ago. However, the glaciers are disappearing at such a rapid rate that there is concern that the ice cover may disappear completely within the next 20 years.

Conclusion

The statement that the earth's climate is changing is not in dispute. Often when discussing the effects of global warming, the disappearance of the glaciers of Mt. Kilimanjaro is cited as visual proof of this tragic phenomenon. While certainly there could be few more concrete and visible examples of the impact of climate change on the earth, we are curious about the more subtle, less obvious changes that are occurring—changes that, unless documented now, may go unnoticed until it is too late to combat the forces causing them.

Analysis of existing information points toward a change in both temperature and precipitation that we assume would precede a change in vegetation and land cover. We believe that changes are occurring in biomes and these changes would further the case of world-wide climate change. We are looking forward to continuing our data collection and research on site next year.

The research, conducted over nine days while summiting Mt. Kilimanjaro, is intended to serve as a correlate to other research being conducted on the effects of global warming. It may seem unrealistic to consider that such conclusions might be able to be derived on one nine-day trip; however, if global warming is affecting the land cover of Mt. Kilimanjaro to the same degree that it is the glaciers of the mountain, it is quite possible that we will observe these changes outright. If we are unable to conclude that there have been changes, certainly, if nothing else, there is value in observing and measuring what is there now so that future GLOBE students can use the information we gather as a baseline for continuing to watch for vegetative changes.

Discussion

In participating in this project, the Xpedition team expects to learn many lessons beyond the empirical data we will gather about the land cover on Mt. Kilimanjaro. Once we arrive in Tanzania, we will spend time exploring the culture of the country, interacting with the native Tanzanians, eating local food, listening to local music, and learning about the customs of the country. We plan to visit a school in Tanzania and share our story, as well.

Perhaps most importantly, the Xpedition does not end when we leave Africa. In fact, in many ways, we will be embarking on a new journey once we arrive back home, as we implement our plan to share what we've learned about climate change, about Africa, about Tanzania, and about ourselves with other students throughout the Louisville Community. A major goal of the Xpedition project is to raise public awareness about one of our generation's most serious issues, global warming, by educating the youth of Louisville about the effects of human actions upon the global climate, empowering individual choices and supporting grassroots efforts that lead to community reform.

This outreach program includes several unique components:

- A student-developed interactive website, www.tigersonline.org/kilimanjaro, provides current, balanced and easily understandable information, educational activities and community forums focused on the crucial issue of global climate change. But more significantly, it offers thought-provoking interaction and practical solutions for young people. The site shares information about the impacts of global warming on our planet, and specifically on the glaciers on Mt. Kilimanjaro, Africa's tallest mountain. The website offers significant information and resources, including:

- Technology that will bring the Xpedition into homes and classrooms around the world with video, images, sounds and journal entries from the Kilimanjaro expedition.
- Latest News and Events about global warming, renewable energy and related topics updated daily.
- An Online Bulletin Board with posts from high school students who will produce their own monthly on-line global warming-focused magazine including current events, fieldwork and class projects, student activism, and responses to the Xpedition team.
- Educational Activities and Lesson-Plans freely available to any educator, parent or community leader with integrated online collaboration and networking.
- Several Resource Pages. These pages provide an opportunity for young people to gain background knowledge on Global Warming and find resources for slowing its impact. The Resource Pages will also include an extensive look at the locations the Xpedition will visit in Africa as well as an in depth look at one of the most ecologically diverse regions on our planet, Mt. Kilimanjaro.
- Highlights of other Educational Expeditions and activities undertaken by other GLOBE Schools, clubs and individuals, with an emphasis on global ecological issues and discovery learning will be spotlighted.
- A five-day global warming curriculum plan for use by educators. Lesson plans include coverage of such topics as: Life on Kilimanjaro, Climate & Weather, What is Global Warming?, Global Warnings, Alternative Energy, The Big Deal, and How to Make a Difference.
- Classroom presentation: An Expedition Outreach Educator and several Student Team members will present to classes grade 6-12 on grade level. Presentation includes

information on the Science of Global Warming, as well as background and updates from the 2008 Kilimanjaro Xpedition. This presentation could also serve as the kick-off to the five day curriculum noted above. Through these presentations, students and educators who participate in the Xpedition project will share eyewitness accounts of the unique ecological community of Kilimanjaro. These presentations will put a face on a complex and sometimes seemingly remote issue of climate change and illuminate the connections between changes on the far side of the world and changes we may come to experience in our own backyards. Through these exchanges, young people throughout our community will come to appreciate the interconnected world in which we live:

To date, we have been in contact with over 300 educators who have expressed interest in participating in this outreach project. Administrators with both the Jefferson County Public School system (the school district of Louisville, Kentucky and surrounding areas) as well as the Archdiocese of Louisville have expressed urgent interest in insinuating the educational component into their respective classrooms. Along with this educational component of the Xpedition, we hope to promote research projects dealing with seasonal changes in identified biomes for students to take part in to learn more about their local environment, and its relationship to other biomes. We hope to expand this project beyond the borders of our local community to schools across the United States and schools around the world.

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