INFLUENCE OF LAND-USE CHANGES ON SOIL MICROBIAL COMPOSITION AND FUNCTION IN THE NILE RIVER WATERSHED IN UGANDA
(PhD Research Proposal)

PETER OKELLO ALELE
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ECOLOGICAL EVOLUTION LAB; XISHUANGBANNA TROPICAL BOTANICAL GARDEN (XTBG); GRADUATE UNIVERSITY OF THE CHINESE ACADEMY OF SCIENCES (GUCAS)

Research Advisors:
Charles Canon, Prof.
Douglas Sheil, PhD

Background

Relationship between the ecosystem and microbes

What is the diversity and function at community level?

Enzyme activity and analysis

Anthropogenic activity

Land-use – human employment of land.

Land-use changes - human modification of Earth's terrestrial surface

Uganda's land-use systems

Percent of total land area covered by:	Uganda	Africa	World
Forests	4%	15%	24%
Shrublands, savanna, and grasslands	44%	50%	37%
Cropland and crop/natural vegetation mosaic	35%	15%	20%
Urban and built-up areas	0.0%	0.0%	0.2%
Sparse or barren vegetation; snow and ice	1%	18%	16%
Wetlands and water bodies	16%	2%	3%

Change in Forest cover

Change in forest area	Uganda	Sub-Saharan Africa	World
Total, 1990-2000	-18%	-9%	-2%
Natural, 1990-2000	-18%	X	-4%
Plantations, 1990-2000	4%	X	3%
Original forest {b} as a percent of total land area {c}	70%	X	48%
Forest area in 2000 as a percent of total land area {c}	17%	20%	29%

Source: http://earthtrends.wri.org/pdf_library/country_profiles/for_cou_800.pdf

Soils and Ecosystem

- Link between ecosystem function and biodiversity
- Soil microbial diversity and ecosystem
- Seasonal changes and alterations
- Functional diversity
- Microbial diversity
- Enzyme activity

Research problem

Land use requirement of a growing population and land use changes

- ☐ Conversion of natural habitats and species population and decline
- ☐ 40% forest cover reduced globally with 14.6 million ha/year

The Nile River watershed situation (fig 1 and 2)

- ☐ 3.3% annual population growth rate in Uganda
- ☐ Unsustainable utilization of resources

Objectives of study

To determine ecosystem resilience by relating land-use changes to soil microbial community and function; and

Specifically;

To study the richness and distribution of different microbial communities in chosen land-use classification types

To determine the effect of land-use change on richness and distribution of microbial species

To determine microbial functional diversity in different land-use systems and effect of land-use change on functional diversity

To compare soil enzymatic activity as an indicator of soil health in the different land-use categories

Research Questions

- What are the dominant microbial species in the chosen land-use classification systems in Uganda's Nile River watershed?

- How are these populations distributed in the different land-use classification types?

- How are these populations distributed at different altitudes in the Tropical High Forest?

- What is the impact of land-use change on the dominance and distribution of these species?

- What is the change in functional diversity when these ecosystems are disturbed?

Significance of study

- Economic, social and ecological importance of the Nile River
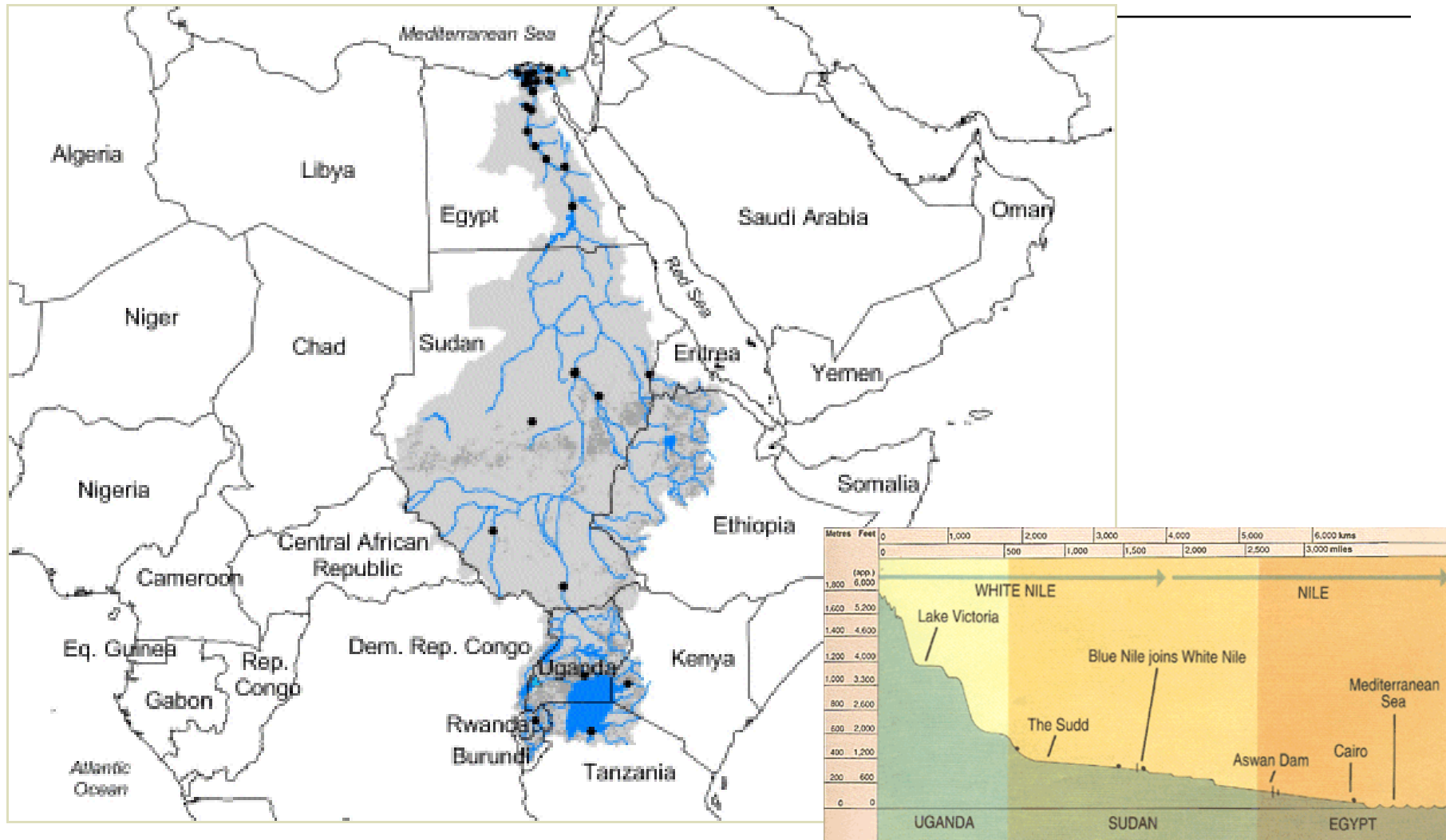
  10% of area of Africa, with 44people /sqkm, 5% is protected area, About 80% of the population depend on agriculture
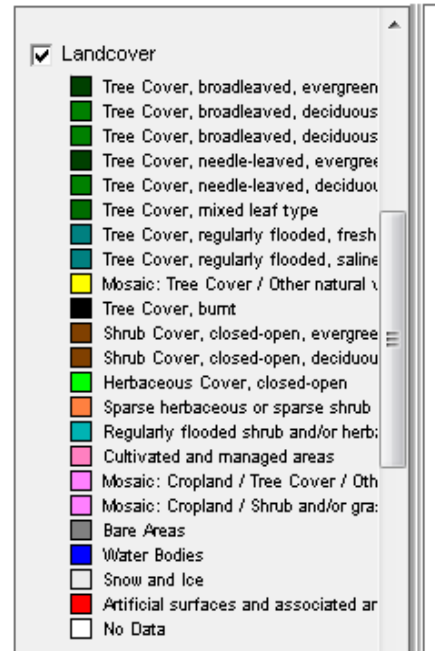
- To the science community
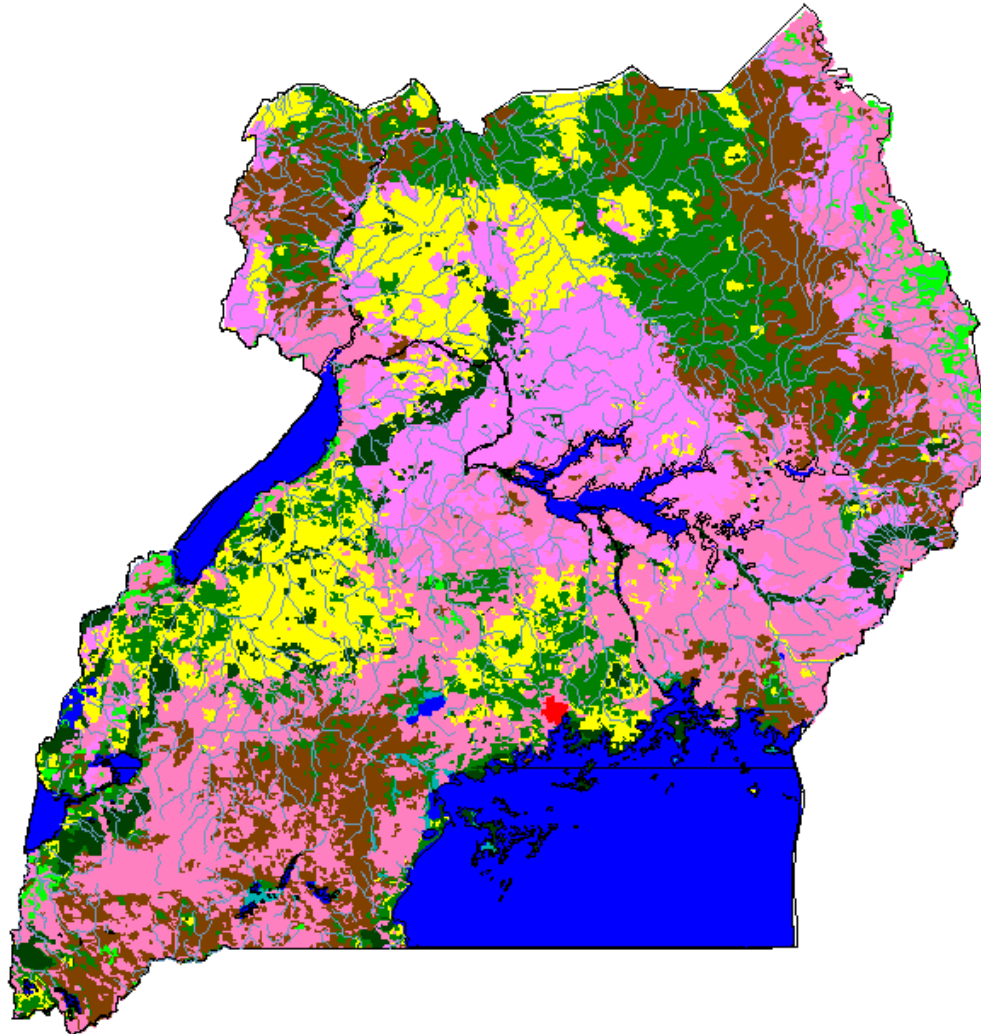
  Extent of disturbance, how ecosystem is adapting to disturbance, resilience of the ecosystem

METHODS

Site Location

Uganda land use

Landcover
- Tree Cover, broadleaved, evergreen
- Tree Cover, broadleaved, deciduous
- Tree Cover, broadleaved, deciduous
- Tree Cover, needle-leaved, evergree
- Tree Cover, needle-leaved, deciduou
- Tree Cover, mixed leaf type
- Tree Cover, regularly flooded, fresh
- Tree Cover, regularly flooded, saline
- Mosaic: Tree Cover / Other natural v
- Tree Cover, burnt
- Shrub Cover, closed-open, evergree
- Shrub Cover, closed-open, deciduou
- Herbaceous Cover, closed-open
- Sparse herbaceous or sparse shrub
- Regularly flooded shrub and/or herb
- Cultivated and managed areas
- Mosaic: Cropland / Tree Cover / Oth
- Mosaic: Cropland / Shrub and/or gra
- Bare Areas
- Water Bodies
- Snow and Ice
- Artificial surfaces and associated ar
- No Data

Treatments

Woodlots
- Plantations and woodlots; deciduous trees/broadleaves ("hardwood")
- Plantations and woodlots; coniferous trees

Natural Forest
- Tropical High Forest (THF); normally Stocked
- Tropical High Forest (THF); depleted/encroached

Natural or managed Bushland or shrubland
- Woodland; trees and shrubs (average height > 4m)
- Bushland; bush, thickets, scrub (average height < 4m)
- Managed/grazed grassland; rangelands, pastureland, open Savannah; May include scattered trees shrubs, scrubs and thickets.

Natural wetland and managed/disturbed wetlands
- Natural wetlands; wetland vegetation; swamp areas, papyrus and other sedges
- Disturbed wetlands, adjacent to urban areas
- Managed wetlands, with active cultivation

Tropical High Forest
- Different altitudes of a normally stocked tropical High forest

Sampling method

Land use categories

There will be 3 replicates (plots) from each land use category.

A 1000m2 plot will be established to represent each replicate.

Top soil (0-15cm) samples collected from 10 subplots within each plot.

samples mixed together and a 100g sample collected from the mixture, sieved and packed for DNA extraction.

Altitudes

 3 replicates required for each treatment (altitude).

Three 1000m2 plots will be established at intervals of 200m above sea level.

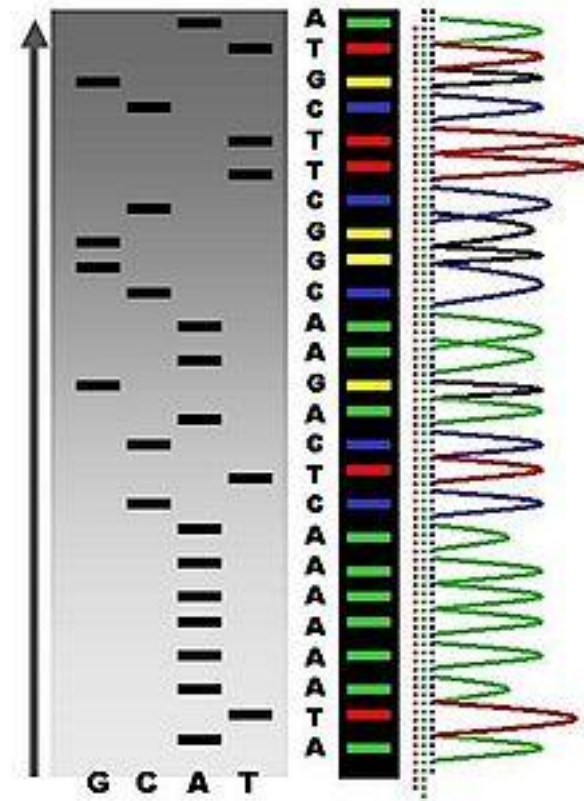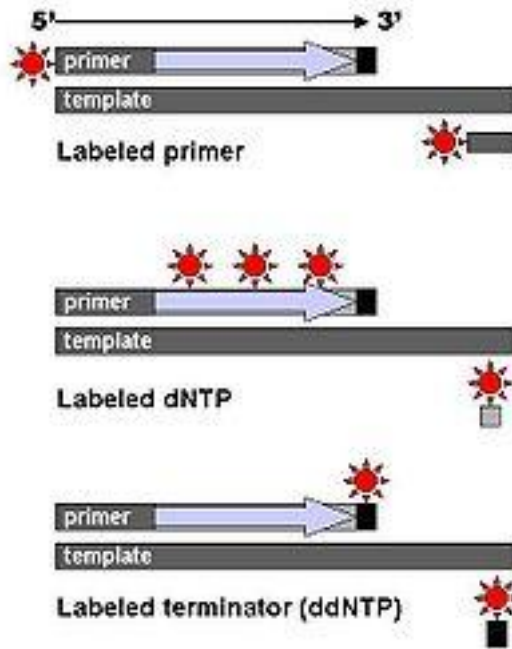Top soil (0-15cm) samples collected from 10 subplots within each plot.

Samples mixed together and a 100g sample collected from the mixture,
 sieved and packed for DNA extraction.

Metagenomics

- DNA extraction

- PCR

- DGGE
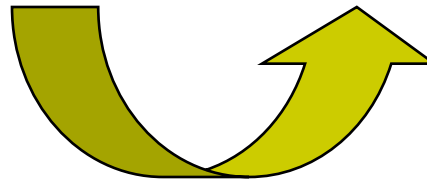
DNA sequencing

Pyrosequencing

070418SH - Well F4
Entry: DC-SIGN -336 GG+G
Sample: 80
Position 1: G/A (Passed)
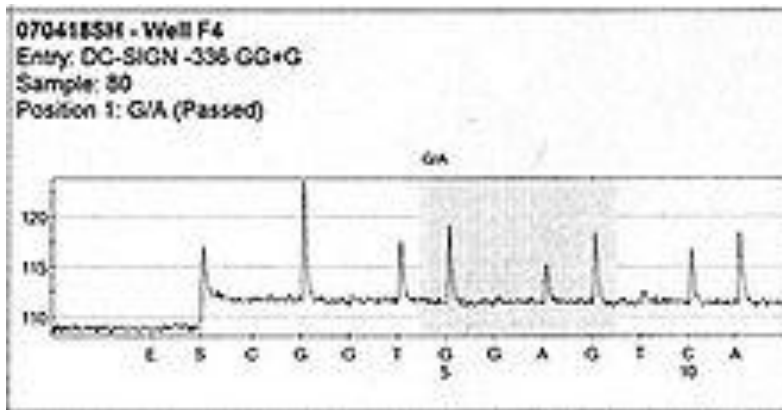
Pyrosequencing is a method of DNA sequencing (determining the order of nucleotides in DNA) based on the "sequencing by sequencing" principle. It differs from Sanger sequencing, in that it relies on the detection of pyrophosphate release on nucleotide incorporation, rather than chain termination with dideoxynucleotides.

Enzyme analysis

- Fungal activity

- Studied by examination of indicators of activity of enzymes; peroxidase and phenol oxidase.

- Oxidation of DOPA measured as optical density at 460nM using a spectrophotometer.

GIS

□ GIS techniques will be used to determine land-use changes occurring through out the study area.

□ Images from the past 40 years will be analyzed.

Outputs

Study will provide an insight into the impact of anthropogenic activity on renewable natural resources such as forests and soils.

It will help provide a rough guide on the opportunity costs of making alterations to the environment

Many studies have shown that microbial diversity and activity increases with increased nutrient availability and stability of natural environments. Disturbance is therefore generally expected to reduce diversity. But how about at different altitude of a THF with climate change? Do we get surprises?

How do these microbial species adapt to change in habitat conditions?

Do they migrate/immigrate or evolve?

How about at the community level?

This will be determined by pyro-sequencing. We shall use this technique to assess dominant subsystems (metabolic reactions that sustain a species).

THANK YOU
FOR
LISTENING