Biology 3

Biology 3

Ecology

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NOTICE

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I. Biology 3, Ecology

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Alpine vegetation on Mt.Kenya©John Mworia

II. Prerequisite Course or Knowledge

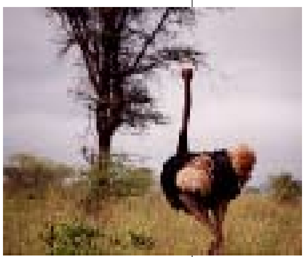
You should have completed secondary school and have done biology with introduction to ecology. You should also have meet minimum university entry requirements for a degree

III. Time

120 hours (84 more)

IV. Materials

To successfully complete this module you should have access to a computer. Internet connection will be necessary. simple tools to enable you conduct a basic fieldwork will also be necessary. Some of these material includes tape measure, meter rule, string, quadrat (1X1m), sweep nets, pitfall traps and markers.



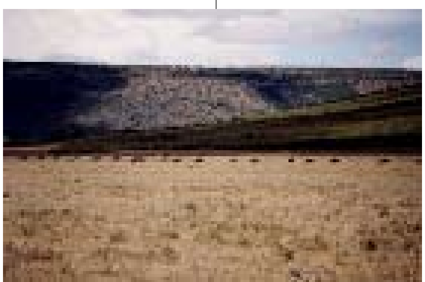
Ostrich courtesy of John Mworia

V. Module Rationale

In this module you will learn how organisms interact with one another and how they interact with the environment. Key ecological concepts in the organisation of organisms, population growth and community dynamics which are important components of pre-university ecology curriculum will be also covered. The module is tailored for delivery using ICT and on completion you will be ready to design relevant courses in ecology and to undertake further studies in environmental sciences.

VI. Overview

The module consists of 5 units, each with at least 4 learning activities. First you will be introduced to ecology by defining its various branches and terminology. You will then learn how organisms are organised into populations and communities and factors governing their change over time. Organisms interact with one another in ways that affect their populations we will therefore study the various types of relationships between populations and their implications. Having understood how organisms are organised at population and community levels you will proceed to look at their interaction with the environment by studying two key ecosystem processes namely the flow of energy and the cycling of nutrients. You will then apply the ecological concepts learned to analyse the structure and function of key African vegetation communities. We will conclude our study by assessing ecological effects of human activity that lead to habitat degradation characterised by deforestation, desertification, and loss of biodiversity.



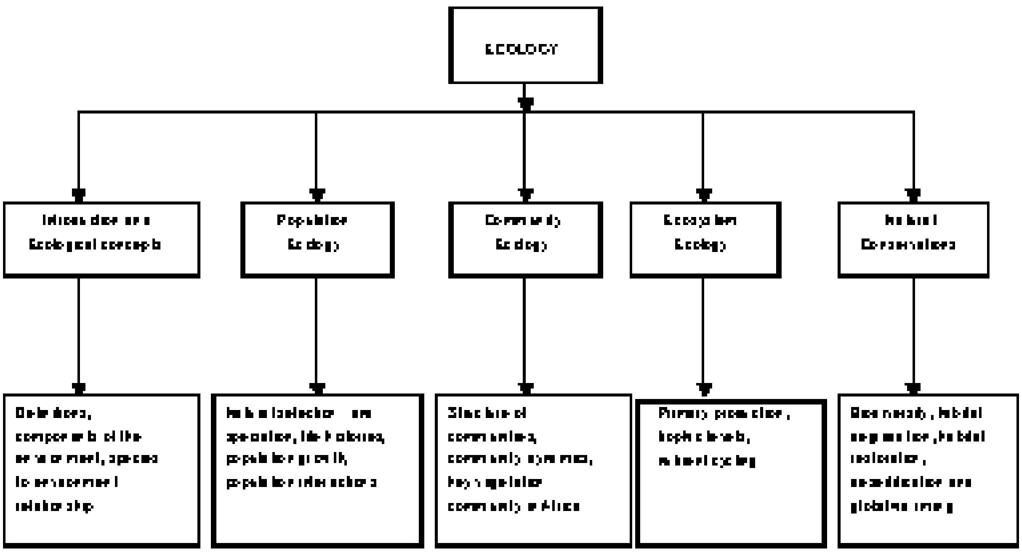
Wildebeest Courtesy of John Mworia

6.1 Outline

Unit	Number of Hours
1.0 Introduction to ecological concepts	20
2.0 Population ecology	30
3.0 Community ecology	30
4.0 Ecosystem ecology	30
5.0 Natural resource conservation	10

Ecology students courtesy of John Mworia

6.2 Graphic Organizer



VII. General Objective(s)

To achieve the specific objectives listed in the following paragraph we have broken down the general objectives into 3 sections. They are the following;

a. Basic concepts in population and community ecology
b. The contribution of environmental factors to species distribution
c. Basic principles of natural resource conservation

Ecology students courtesy of John Mworia

VIII. Specific Learning Objectives (Instructional Objectives)

Unit 1: Introduction to ecological concepts

When you have completed this unit you should be able to;

- Define the science of ecology and describe its branches
- Identify the key components of the environment both biotic and abiotic
- Comprehend how the key environmental components influence species distribution

Unit 2: Population ecology

When you have completed this unit you should be able to;

- Comprehend the basic principles of natural selection and speciation
- Explain conceptual and mathematical models that describe the growth of populations
- Describe types of interactions between populations including competition, predation and symbiosis.

Unit 3: Community ecology

When you have completed this unit you should be able to;

- Describe the structure of communities
- Describe stages in plant community dynamics
- Characterize the structure and adaptations of key vegetation communities in Africa

Unit 4: Ecosystem

When you have completed this unit you should be able to;

- Articulate factors that influence terrestrial and aquatic primary production
- Explain the concept of trophic levels in ecosystems
- Describe the process of nutrient cycling in terrestrial ecosystems

Unit 5: Natural resource conservation

When you have completed this unit you should be able to;

- Define biodiversity and enumerate its measurement indices
- Outline common forms of habitat degradation in Africa and methods of restoration
- Outline the processes of desertification and global warming

IX. Teaching and Learning Activities

9.1 Assessment of prior knowledge in ecology

Rationale :Effective learning depends on what one knows about the subject before attempting to master new material. You are going to a short test to assess your knowledge on the content of this module.

Common Waterbuck courtesy of John Mworia

QUESTIONS

1. The term 'population' as applied in ecology refers to …

   a) Any one individual of one species in one area.
   b) Many individuals of many species in many areas.
   c) All individuals found in a given area.
   d) All individuals of one species in one area.

2. Commensalism is the relationship between two organisms whereby…

   a) Both organisms gain from the relationship.
   b) Both organisms lose as a result of the relationship.
   c) One gains but the other is not affected.
   d) One gains while the other loses.

3. Plants require nutrients, what class of nutrients are referred to has 'macronutrients'?

   a) Those extracted from the soil.
   b) Those stored in the stem.
   c) Those required in large quantities.
   d) Those lost through excretion in large quantities

4. What does the term 'food chain' in ecology mean?

a) The use of Photosynethically Active Radiation (PAR) to produce food.

b) Illustration of the transfer of food starting with the primary producer.

c) Stages through which nutrients passes before being used to produce food.

d) Illustration of the movement of water in the ecosystem

5. Which of the following factors has no effect on plant growth?

a) Amount of nutrients in the troposphere.

b) The prevailing atmospheric temperatures.

c) Amount of water in the soil.

d) Level of carbon dioxide in the atmosphere.

6. When do ecologists consider a species to be extinct?

a) When it can longer be found in the forest.

b) When less than 10 individuals are left.

c) When it migrates away from its original habitat.

d) When it no longer exists on the earth.

7. What is a climax plant community?

a) The plant community at the top of the mountain.

b) The plant community that grows after cutting a forest.

c) The final plant community during succession.

d) The first plant community in the process of succession.

8. Which statement is TRUE about eutophic water bodies?

a) Have Magnesium as the only nutrient.

b) Are poor in nutrients.

c) Have calcium as the only nutrient.

d) Rich in nutrients.

9. What does the term 'Net Primary Production' mean, as applied in ecology?

a) Total primary production per annum.

b) Gross primary production plus energy used in respiration.

c) Total primary production per day.

d) Gross primary production less energy used in respiration.

10. What is the role of plant litter in nutrient cycling?

a) Litter does not play any role.

b) Litter acts as a store for nutrients.

c) Transfers nutrients from plants to the soil.

d) Transfers nutrients from the plant to the leafs.

11. Species diversity of an area refers to …

   a) The total number of individuals in the area.
   b) The average number of species in the area.
   c) The total number species in the area
   d) The total number of individuals of each population.

12. An animal that displays territorial behaviour means that …..

   a) It has no home range.
   b) It defends part of its home range.
   c) It is confined to one habitat.
   d) It does not migrate.

Students working in groups courtersy of John Mworia

9.2 Answer Key

1. D: The word population refers to individuals of one species
2. C: This one type of symbiotic relationship
3. C: Some macronutrients include Nitrogen while micronutrients are those required in small amounts
4. B: An example of a food chain would be grass ‡ antelope‡lion
5. A: The troposphere is outermost layer of the atmosphere of which plants have no access
6. D: A species extinct when it neither in captivity nor in the wild anywhere on earth
7. C: The climax community is final product of plant succession and it represents a stable self-perpuating entity.
8. D: Eutrophic water bodies have high amounts of nutrients especially as result of agricultural or industrial pollution
9. D: Gross primary production is the total energy captured while net primary production is that which is left after respiration
10. C: When litter falls it is decomposed releasing nutrients to the soil.
11. C: When considering diversity the total number of species is critical
12. D: Territorial behaviour is whereby an individual animal or group defend a section of the home range

9.3 Pedagogical Comment For The Learners

The preassessment is drawn from your secondary biology. The area of community dynamics which is tested in question 7 is very wide and it's expected to have been exhaustively covered in secondary school level. If you score below 60% it is recommended that you review your high school level biology before proceeding with this module.

X. Key Concepts (Glossary)

SPECIES
A population that is compatible reproductively

POPULATION
a group of individuals belonging to the same species in geographical area

COMMUNITY
all individuals in interacting populations in a given area.

ECOSYSTEM
community of organisms together with the biotic and abiotic factors that surround and interact with them

PRIMARY PRODUCTIVITY
Rate at which organic matter is produced or radiant energy is bound, through photosynthesis per unit area per unit time.
Unit: g m^{-2} yr^{-1} or g m^{-2}

BIOLOGICAL DIVERSITY/ BIODIVERSITY
These terms refer species richness or species number and genetic variation

FAUNA
The term that refers animals in an area collectively

FLORA
Plant or bacterial lifeforms or an area

EDEMIC
A taxa or species that is restricted to certain geographical area and can not found anywhere else. Such a species is said to endemic to the area.

BIOTA
The total aggregation of organisms in a specific. This includes both plants and animals

GROSS PRIMARY PRODUCTIVITY
(Pg) The total organic matter created (including that used for respiration) in a unit area per unit time (g m-2 d-1).

SUCCESSION

This is the orderly process of one plant community gradually or rapidly replacing another. Pioneer communities modify the habitat making it more for others to invade which eventually replaces them.

CONSERVATION

This is the management of natural resources aimed at restoration and maintenance of balance between human demands and requirements of other species. Conservation can focus on individual species, ecosystems, biomes or even the biosphere

XI. Compulsory Readings

Reading 1

Complete reference : http/en.wikibooks.org/wiki/Ecology/introduction

Title: Introduction to basic ecology

Date visited: 28th August 2006

Abstract : The following abstract was retrieved from the above mentioned reference: *Ecology is the study of animals and plants in their relations to each other and to their environment*. The term *oekologie* (ecology) was coined in 1866 by the German biologist, Ernst Haeckel from the Greek oikos meaning "house" or "dwelling", and logos meaning "science" or "study"—thus, ecology is the "study of the household of nature". Ecology is regarded as multidisciplinary so broad is its potential scope. But we need not, in defining it, get caught up in its ultimate complexity. Ecology incorporates and overlaps with many other disciplines in both the biological and physical sciences. Certainly on one level, there is no information about the natural environment that does not have some applicability to ecology. Ecology is both a biological and an environmental science, something that should certainly be evident from the definition provided above. Many environmental sciences are minimally concerned with biology (meteorology, for example) and others (environmental toxicology, for example) necessarily combine physical and biological sciences

Rationale: The first chapter of this book gives you a definition of ecology and how it linked to other sciences. It also gives you a brief history of ecology. This reading is important in that it helps you understand the scope of ecology.

Reading #2

Complete reference : http/en.wikibooks.org/wiki/Ecology

Title: Basic ecology

Date visited: 28th August 2006

Abstract : Chapter 1 commences by explaining to you the essence of eclology as science: It (Ecology) is regarded as the study of animals and plants in their relations to each other and to their environment. The first chapter will explain how 'oekologie' (ecology) was coined in 1866 by the German biologist, Ernst Haeckel from the Greek oikos meaning "house" or "dwelling", and logos meaning "science" or "study" — thus, ecology is the "study of the household of nature". But ecology is also regarded as multidisciplinary - so broad is its potential scope. Ecology is both a biological and an environmental science, something that should certainly be evident from the definition provided above. Many environmental sciences are minimally concerned with biology (meteorology, for example) and others (environmental toxicology, for example) necessarily combine physical and biological sciences. You will notice that chapter 2 focuses mainly on the biological organization development stage covering important issues such as basic definitions, the Gaia Theory and information on species and habitat (More information on these topics are contained in the second and third readings to follow in this module). We also thought it important for you to become acquainted with developmental stages associated with environmental response and encourage you to work very carefully through chapters 3 and 4 where these issues are dealt with and explained. Although the expected outcomes of the module do not necessarily expect from you to study the rest of the book in great depth, it would be benificial for you to work through its content and gain a good understanding of the principles and practices underpinning ecology as science.

Rationale: The inclusion of this book as compulsory reading will give you the foundational knowledge required to understand ecology as science and also come to terms with the principles and practices associated with this field of specialisation. It not only defines ecology, but also explains how it links to other sciences. The reader will also povide you with a brief history of ecology, and and also explain to you its rules and applications. Knowledge of these foundations remain fundamental to the practical manifestations of the science.

Reading #3:

Complete reference: URL : http:www.//marinebio.org/oceans/conservation/moyle/ch3.asp

Title : Climatic determinants of global patterns of biodiversity (Douglas A. Kelt, 2004)

Date: August 2006

Abstract : I recommend that you read the following sections of this article; *Introduction, earth's seasons, why does it rain so much in the tropics?, why are deserts located at 30o latitude.* This article gives an analysis of the global distribution of biodiversity and shows the distribution of the major terrestrial systems. Two main classes of factors have led the distribution of biodiversity at a global scale. The first class are as historical factors while the second are ecological. Our concern in this module is ecological factors. The article explains why there is unequal distribution heat on the globe. This includes the spherical nature of the earth, inclination of the earth's axis, rotation and revolution. The article also explains the global variation in rainfall. Finally it links these to variation in biodiversity.

Rationale: The link gives you an assessment of the relationship of climatic factors to the distribution of plant species distribution. The relationship of physical components of the environment to plant distribution is a key objective in this unit.

XII. Multimedia Resources

Resource # 1

Complete reference : Jeanne, Robert, Jan Cheetham, and the Transforming Teaching Through Technology (T4) Project staff. (2006). Evolution/Species and speciation. Retrieved November 2006. http://www.merlot.org/merlot/viewMaterial.htm?id=83573

Abstract : This tutorial/simulation consists of three topics. In topic 1, students look at 5 frog populations to decide whether they should be considered separate species using criteria of three of the species concepts: biological, morphological, and phylogenetic. Students will: 1) describe why species are continuous over time and space; 2) review definitions of three species concepts with strengths and weaknesses of each; 3) analyze traits to sort populations into species based on 3 species concepts; and 4) gain familiarity with: 3 species concepts, phylogenetic trees, and reproductive isolation. In topic 2, students will think about speciation events at several points along the phylogeny of the plant genus Fuchsia. Students decide whether vicariance, dispersal, or both are plausible explanations for past and current distributions. Students will: 1) interpret phylogenies and geographical distributions to determine speciation patterns; 2) integrate understandings of continental drift with speciation; 3) analyze hypotheses as they seek to explain patterns of speciation; and 4) become familiar with the terms: allopatry, sympatry, adaptive radiation, gene flow, vicariance, and polyploidy. In topic 3, students look at speciation case studies.

Rationale: This multimedia resource takes you through the species concept and speciation which are key topics in unit 2.0 of this module.

Resource #2

Complete reference : Jeanne, Robert, Jan Cheetham, and the Transforming Teaching Through Technology (T4) Project staff. (2006). Evolution/Species and speciation. Retrieved November 2006. http://www.merlot.org/merlot/viewMaterial.htm?id=83565

Abstract : This simulation/tutorial consists of three topics. In topic 1, students conduct a study of a zebra mussel population in a fictitious lake and present their findings during a virtual teleconference. Students will: 1) review qualitative descriptions of growth curves for the exponential and logistic models, selecting one to test at the lake; 2) collect and plot data, and determine which of the models the data fits; 3) answer questions about populations at other localities by calculating rmax, t, and N using their data. In topic 2, students review the math and biology behind the logistic growth model with the help of a fish population. Students will: 1) complete interactive explorations of density-dependence and carrying capacity, the difference between r (realized intrinsic rate of increase or per capita, growth rate), rmax, (maximum intrinsic rate of increase and dN/dt (population growth rate), how growth rate changes over time while r decreases; and 2) summarize and compare properties of exponential and logistic growth. In topic 3, students follow the growth of the Kruger National Park elephant population from 1903-1996. While following the history of the population, students calculate values using the logistic equation. Students will complete a case study in which they: 1) learn the biological and sociopolitical history of the KNP elephants; 2) calculate dN/dt, N, and 1-(N/K) over time; 3) explain how assumptions of logistic growth affect the shape of the curve; and 4) evaluate how well the KNP population fits the logistic model.

Rationale: This resource discusses in detail the logistic growth model an important aspect in population ecology covered in unit 2.0.

XIII. Useful Links

Useful Link #1

Title: Ecosystems

Complete reference : http://en.wikibooks.org/wiki/Ecosystems

Date: August 2006

Description: In attempting to understand any interactive, complex system, especially one as elaborate as even a simple ecosystem, it is helpful to break the system down into various component parts. By this mental process we can arrive at some understanding of the specific system and can make comparisons with other systems to further our understanding of ecosystems in general. An ecosystem consists of many component structures and this function together in various ways, suggesting an initial approach to describe any ecosystem is to consider separately its structural and functional aspects

Rationale: This brief article gives shows how the interrelationship of organisms and resources are critical to ecosystem. It also explains the importance of physical conditions in which the organisms live. It also shows that physical conditions can also be from biotic sources such the modification microclimate by forests. Finally the article shows how you divide the ecosystem into its functional components (abiotic components, producers, consumers and decomposers)

Useful Link #2

Title : Resources

Complete reference : http://en.wikibooks.org/wiki/FHSST_Biology/Contents/Index/ES/Ecosystems/Resources/Biotic_%28living%29_and_Abiotic_%28non-living%29_resources

Date: August 2006

Description: Describes the biotic and abiotic resources of the earth and examines trends and impacts of human exploitation

Rationale: This article gives you a good indication of the serious negative impact of uncontrolled or overexploitation of resources

Resource # 3

Title : Ecosystems (2)

Complete reference :

Description: The article defines the term ecosystems, its components and functions. It also gives examples including some from Africa such as Sibanya in Kwazulu Natal

Date: August 2006

Rationale: The article will broaden your understanding of key concepts in ecology and how they apply in Africa.

Useful Link #4

Title : Low pressure

Complete reference : http://en.wikipedia.org/wiki/Low_pressure_area

Date: August 2006

Description: This is a one page article that basically defines and explains the phenomena Inter Tropical Convergence Zone (ITCZ).

Rationale: The ITCZ as a great influence on rainfall patterns in Africa. Some sections of Africa such as much of East Africa receive bi-modal rainfall that is two rainfall seasons per year. Other parts have a unimodal rainfall pattern such as South Africa. We have seen that environmental factors such as rainfall influence the distribution and abundance of species hence the importance of understanding the ITCZ.

Useful Link #5

Title : Principles of ecology

Complete reference : http://www.marinebio.org/oceans/conservation/

Date: August 2006

Description: The article begins defines populations, communities, and biosphere. It dwells largely on ecological interdependence and the role fire. Fire is important in natural ecosystems because it influences composition and structure of vegetation communities.

Rationale: In this article it is shown that not only are environmental factors such soils, climate and water important in influencing plant distribution but also events such as fire and other human activities.

Useful Link # 6

Title : Peppered moth

Complete reference : http://en.wikipedia.org/wiki/Peppered_moth

Date: August 2006

Description: The **peppered moth (Biston betularia)** is a temperate species of night-flying moth often used by educators as an example of natural selection. The first carbonaria morph was recorded by Edleston in Manchester in 1848, and over the subsequent years it increased in frequency. This evolution was attributed to natural selection.

Rationale: The article takes you through the Peppered moth study to illustrate natural selection and distinguishes it from genetic drift. The article also reviews views forwarded by critics of the theory.

Useful Link # 7

Title : Habitats

Complete reference : http://www.panda.org/news_facts/education/university/habitats/index.cfm

Date: August 2006

Description: The site contains adequate description of the worlds major habitats categorised into terrestrial, fresh water and marine. Our interest here is mainly terrestrial habitats which range tundra, temperate forests, tropical forests, and grasslands

Rationale: The articles describe the structure, patterns of biodiversity and environmental characteristics which is important in our study of community structure.

Useful Link # 8

Title : Mangroves

Complete reference : www.unep-wcmc.org/resources/publications/ss1/WCMC-Mangrovesv11_1.pdf

Date: August 2006

Description: The article describes structure and composition, the fauna, the threats and the future of mangroves. It lays particular emphasizes on East African mangroves. It is however appreciated that the general trend in threats is similar across Africa.

Rationale: Mangroves are an important marine community in Africa. They have multiple uses and play a key role in the livelihoods of many coastal peoples.

Useful Link # 9

Title : Habitat Conservation

Complete reference : http://marinebio.org/Oceans/Conservation/Moyle/ch7.asp

Date: August 2006

Description: The article dwells on the niche theory and the habitat. It differentiates various concepts of the niche and distinguishes them from the habitat. It describes factors that influence the distribution of species and their implications on conservation. It finally relates the concepts of the niche and habitat to conservation.

Rationale: The article is great in reinforcing your understanding of the niche theory and how it relates to conservation. Thus even though the niche theory and conservation are covered as separate topics in our learning activities this article will help interlink.

XIV. Learning Activities

Activity 1

Title: Introduction to ecological concepts

Specific Objectives

(1) Define the science of ecology and describe its branches
(2) Identify the key components of the environment both biotic and abiotic
(3) Comprehend how the key environmental components influence species distribution

Summary of the learning activity

In this activity, I firstly provide an introduction to the topic by defining ecology and its branches, components of the environment and basic concepts of ecology. You will do a number of activities to help you understand the topic better. The unit is organised as follows;

1.1 Introduction to the content:
  1.1.1 What is ecology,
  1.1.2 Levels of organization
  1.1.3 Branches of ecology
  1.1.4 Basic concepts
1.2 Access the Internet: Read more about Biomes
1.3 Writing Assignment: Effects of unequal distribution of heat on species distribution
1.4 Fieldwork: Conduct a Life form Classification exercise in a natural community

Key Concepts

Ecology is defined as the science that deals with the interrelationships of animals, plants and the environment.

Levels of organization of organisms are; individual, population and community

The main branches ecology can broadly divided into four; Ecophysiology, Populaton Ecology, Community Ecology, Ecosystem Ecology and Landscape Ecology.

The ecosystem is the interacting system comprising of community of organisms and their non-living physical environment. The components of the environment can be divided into biotic and abiotic

Physical-chemical components of the environment influence species distribution and diversity through its effects on plant growth and functioning.

Form and structure of living things is highly correlated to their adaptations to the environment.

Key words

Synecology, Autecology, Environment, Ecosystem, Biome, Life form

List of Compulsory readings

Wikipedia. (2006). Ecosystems. Retrieved October 20 from http://en.wikipedia.org/wiki/Ecosystems

WWF. (2006). Habitats. Retrieved September 2006 from http://www.panda.org/news_facts/education/university/habitats/index.cfm

Wikipedia. (2006). Biomes. Retrieved September 2006 from http://academickids.com/encyclopedia/index.php/Biome

Douglas, A. K. (2004). Climatic determinants of global patterns of biodiversity. In P.Moyle & D. Kelt (Eds.), Essays *of wildlife conservation* Retrieved September 20, 2006 from http://marinebio.org/Oceans/Conservation/Moyle/ch3.asp

Wikipedia. (2005). Intertropical Convergence Zone. Retrieved October 20 from http://www.answers.com/topic/intertropical-convergence-zone-1

Wikipedia. (2005). Low pressure. Retrieved October 20 from http://www.answers.com/topic/low_pressure_area

List of optional readings

Chapman, J.L., & Reiss, M.A. (1999). *Ecology: principles and applications*. Cambridge University Press.

Berg, L.R. (1997). *Introductory Botany: Plants, People and the Environment*. Harcourt, Inc.

Chapman, J.L. & M.A. Reiss. (1999).*Ecology: principles and applications*. Cambridge University Press.

Beeby, A. & A. Brennan. 2003. *First ecology*. Oxford University Press pp352.019926124

Barbour, M.G., J.H. Burk & W.D. Pitts. (1980). *Terrestrial Plant Ecology*. The Benjamin/Cummings Publishing Company, Inc.

1.1 Introduction to the content

1.1.1 What is ecology?

You have observed that many animals including man rely on plants for their food while some even use plants as their homes. Similarly you might have seen reports to the effect that livestock overstocking or too many animals in an area lead to soil erosion or degradation. Ecology is the science that deals with interactions of animals and plants in their natural environments. This interactions affect abundance and distribution of organisms. The term ecology is derived from words 'oikos', which means home or habitat and logos meaning study.

1.1.2 Levels of organization

In studying ecology we will view organisms to be organized at 3 main levels, which can be briefly stated as individual, population and community.

(a) The individual is the fundamental unit of populations, communities, ecosystems and biomes.

(b) A population is composed of all the members of a single species that occupy a particular area

(c) A biological community consists of all populations of different species of organisms that exist together in an area.

1.1.3 Branches of ecology

Ecology is broad and is considered a multi-disciplinary subject since it encompasses the interrelationships of the organism and its environment that requires an input from other branches of science such as geography, meteorology, soil science etc.

(a) Ecophysiology (or Physiological ecology) when referring to plants and behavioural ecology in the case animals deals with adaptations of the individual. It may for example involve studies in tolerance limits and phenology

(b) Autecology or population ecology concentrates on one species. it deals with aspects of population size and dynamics, breeding behaviour and speciation.

(c) Community ecology or synecology concentrates on studies at the community level. It has several branches some of which include paleoecology that is the study plant communities in he geologic past and community dynamics that is the change of communities over time.

(d) Ecosystem ecology here ecologist studies the processes that involve communities and the environment such nutrient cycling and the flow of.

(e) Landscape ecology is the broadest and focuses interrelationships and processes that across ecosystems.

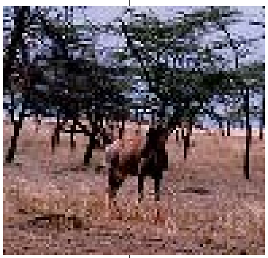
Learning tip: *you will come across terms such as insect ecology, animal ecology etc. This are terms that describe various specializations in ecology and fall into one or more of the basic branches of ecology.*

1.1.4 Basic concepts

Ecosystems

The ecosystem concept is central in the study of ecology. We have already defined a community, ecosystem is more inclusive term and encompasses a community and its environment. An ecosystem therefore includes interactions among the organisms of the community as well as interactions between organisms and their physical environment. An ecosystem ecologist may for example study the relationship between soil salinity and species distribution in a swamp. Thus the swamp is the ecosystem. How big is an ecosystem? An ecosystem could be of variable size, for example a forest could be studied as one ecosystem but also a decomposing log in the forest could also be studied as an ecosystem. There are two very important processes that link the components of the ecosystem this are energy flow and nutrient cycling in the ecosystem.

In course of this module we will take a detailed look at each of the components and processes of the ecosystem.



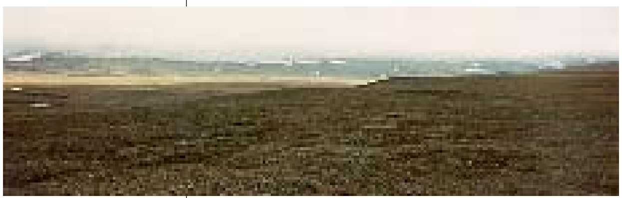
Biomes and biosphere

A biome in terrestrial ecology is next level of organization above the community and ecosystem. The biome is large and relatively distinct region characterized by a particular combination of soils, plants, animals and climate. The characteristics should be largely wherever the specific biome occurs in the world. The boundaries of the biome largely coincide with climate barriers with temperature and precipitation being the most important determinants. Temperature is the most important factor towards the poles while precipitation is more important temperate and tropical regions.

Learning tip: On how many biomes are there?
Ecologists do not seem to agree on how many biomes there are. This is not suprising since the 'biome' is not a natural unit e.g such as a species, therefore, there is no definitive list of the earths biomes. Different authors and text will give different classifications and numbers of biomes.

Lets list the types of biomes and their key features

Tundra: The north most biome.



From http://en.wikipedia.org/wiki/Tundra

It exists in the north most latitudes it is exposed to long harsh winters and very short summers. It is dominated by mosses, lichens, grasses and sedges

Taiga
This is south of the tundra and is dominated conifers. It is also referred to as boreal forest. It is a huge evergreen in Northern America and Northern Europe. Dominate plants consist of spruce, fir and pine

Temperate Rain forest: This is biome consists of a coniferous forest that occurs in the mid latitudes where annual precipitation is high, cool weather and dense fog.

Temperate Deciduous forest: Here summers are hot, winters are pronounced and annual precipitation is 750-1250mm. It is dominated by a dense canopy of broad leaved trees with an undergrowth of saplings and shrubs.

Temperate grasslands: This biome occurs in the mid latitudes where precipitation is moderate. The dominant vegetation is grasses. This is also referred to as prairie in North America, steppe in Eurasia and veld in south Africa

Chaparral: This biome occurs on temperate environments with plenty of rainfall combined with mild winters and dry summers. This typically called the Mediterranean climate but also occurs in other parts of the world. It is characterised by thickets of evergreen shrubs and small trees.

Desert: This biome occurs where there is very little rainfall. Deserts occur in all the continents mostly along the Tropic of Capricon and the Tropic of Cancer. The worlds largest is the Sahara Desert while the Atcama Desert in Chile is the driest.

Savannah: This s tropical grassland with scattered trees. Africa has the world’s largest savannah but is also found in South America, Australia and India. The African savannah is rich wildlife and is largely used by pastoralists.

Savannah Courtesy of John Mworia

Tropical rain forest: This biome occurs where the temperatures are warm throughout the year and precipitation is high and uniformly distributed. The soils are nutrient poor and most trees are evergreen flowering plants.

Tropical forest Courtesy of John Mworia

Alpine grasslands: These are associated with the climate high up on mountains. As we shall see in unit 3.0 the climate here is challenging to plant life as result of low temperatures, high incoming shortwave radiation among other factors. They occur on in New Guinea and East Africa, paramo in South America, , steppes of the Tibetan plateaus and other similar subalpine habitats around the world.

Alpine grassland courtesy john Mworia

Note: We will study the structure and function of key plant communities in Africa in greater detail in Unit 3.0.

2.1 Access the internet: Read more about biomes

Visit the sites given below and review

WWF. (2006). Habitats. Retrieved September 2006 from http://www.panda.org/news_facts/education/university/habitats/index.cfm (Read section on terrestrial habitats)

Wikipedia. (2006).http://academickids.com/encyclopedia/index.php/Biome (read sections on Tundra, Taiga and Rainforests)

Self-assessment

1. What are the trends in soil fertility across the biomes
2. What are the trends in biodiversity? Is there any relationship with latitude, temperature and precipitation

Biosphere
The biosphere consists all communities of the earth that includes all organisms. The biosphere interacts with atmosphere, hydrosphere which is earth's water supply and lithosphere which is the soil and rock

Abiotic and Biotic components of the environment
You have heard the term environment being used widely, the term simply refers to the surrounding. It is therefore a complex of many factors that interact not only with the organisms but also among themselves. The environment includes aspects of the soil and climate and it is of great importance to an ecologist because it influences plant growth and development hence determines distribution and abundance

We can divide the environment into two major components; Physical/chemical and Biological. Some components of the environment are given below

Physical-chemical	Biological
Radiation	Fauna and flora including
Temperature	Trees, grasses and shrubs
Surface and ground water	Decomposers
Gases and Wind	Birds, reptiles and mammals
Soils/Nutrients	Parasites
Geology	Symbionts
Topography	

How do environmental factors influence plant distribution
Most of the physical-chemical environmental factors listed above can influence plant distribution and abundance. Here I will briefly discuss the effect of temperature on distribution and abundance (For the others especially radiation, water and topography you will find references in the reading section)

Temperature
Temperature is indication of the amount of heat energy in the system. Temperature is closely related to radiation this is because a great percentage of solar radiation (>70%) absorbed by the plants is converted into heat energy. Plants unlike us cannot regulate their own temperature effectively hence they tend to assume the temperature of the environment. We therefore refer to them as poikilothermic or Lectothermic organisms. That is their body temperature changes markedly with the changes in external temperature

Plants in varying temperature conditions will have various adaptations. For example some plants in the alpine zone of high mountains will have trunks covered by a dense layer of dead dry leaves to insulate their inner tissues. In unit 3 we shall look in more details on various plant adaptations to temperature

Temperature strongly influences the growth and functioning of plants by regulating rates of numerous physical and biochemical processes such transpiration, photosynthesis, respiration and other metabolic processes. Normally plant growth is halted at temperatures close 0°C and increases rapidly with a rise in temperature up to an optimum range of 20-30°C . Beyond the optimum range of temperatures the growth rate begins to level out and subsequently begins to decline.

3.1 Writing Assignment: Effects of unequal distribution of heat on species distribution

You will do this writing assignment based material given in learning activity 1.1 and the references given to you below

Douglas, A. K. (2004). Climatic determinants of global patterns of biodiveristy. In P.Moyle & D. Kelt (Eds.), *Essays of wildlife conservation* Retrieved September 20, 2006 from http://marinebio.org/Oceans/Conservation/Moyle/ch3.asp (Read sections; Introduction, Earth's seasons, Why does it rain so much in the tropidcs, and Why are deserts generally located at about 30° latitude?)

Wikipedia. (2005).Intertropical Convergence Zone . Retrieved September 20, 2006 from http://www.answers.com/topic/intertropical-convergence-zone-1

Wikipedia. (2005). Low pressure. Retrieved September 20, 2006 from http://www.answers.com/topic/low_pressure_area

Write a brief essay (600-800 words) titled: Effects of unequal distribution of heat on plant distribution and diversity

In your essay make sure you adress the following issues

1. Nature of solar radiation, its composistion and how its partioned on reaching the earth's troposphere
2. Causes of unequal distribution of heat on globe
3. The Inter tropical Convergence Zone (ITCZ) and its influence on the rainfall pattern of Africa, unimodal and bimodal rainfall

Mt. Kilimanjoro Courtesy of John Mworia

Life form classification

Adaptations to environmental conditions are primarily reflected by **form** and **structure** living things. The study of form and structure in the natural plant communities is termed as **Physiognomy**.

In the sections above we have seen the extremes of envionmental conditions experienced in the different biomes. There are many types of plant classification systems e.g. habitat classification, functional classification etc, however in this activity let look at one that links physionomy to climate.

Christen Raunkiaer a Danish botanist used growth forms that had some adaptive value as a means of quantitatively relating vegetation structure to climate. We now refer to this as Life forms. Raunkiaer used a single principle characteristic that is the height of the **perennating tissue** from the **ground surface**. A perennating tissue is defined as the **embryonic (meristematic) tissue** that remains inactive during adverse spells (winter and dry season) and then resumes growth with the return of favourable conditions (spring, summer or rainy season). Perennating tissues include buds, seeds, rhizomes, tubers, bulbs etc. That means the position which you see the flower or fruit is an indication of the perennating tissue height.

We know that the perennating organ makes it possible for the plants to survive during unfavourable seasons, therefore, the location of this tissue is an essential feature of the plants adaptation to climate. The harsher the climate the lesser the plant species are likely to have buds far above the ground surface where they will fully exposed to the cold or drying power of the atmosphere.

This tells us that species with exposed perennating organs will be more prevalent in wet and warm climates than cold or dry climates. On the other hand adaptations to winter climate or dry season of varying severity is achieved by life forms in which the perennating organs are borne closer to the ground or buried in the soil. The extreme case is represented by annuals which survive only in the highly resistant form of dormant seeds

Let us now look at the major life form categories developed by Christen Raunkiaer

Phanerophytes –These are aerial plants for example trees, shrubs and lianas with the perennating organs (buds) >25cm above the ground.

Epiphytes – These are aerial plants with no roots in the soil and are supported by other trees and shrubs, thus they are mainly parasites.

Hemicryptophytes –These are perennial herbs and grasses with the perennating tissue on or just below the soil surface.

Chamaephytes – These are small or dwarf shrubs, herbs, mosses or ferns with the perennating bud 0-25cm from the ground

Cryptophytes – These are plants with the perennating bud under the soil or water. water.

Therophytes – These are annuals or ephermerals that survive unfavourable seasons as seeds. For example seasonal grasses.

After you classify plants in particular community you then develop a life form spectrum.. When you convert the numbers of species in each of the life forms categories in a community or geographic area into percentages, then you have a life forms spectrum.

4.1 Field work: Lifeform classification

You will now condudct a practical to enable you relate climatic factors to vegetation type.

Procedure:

1. Identify a location in your area with natural vegetation, that is, one that has not been greatly disturbed. Disturbance here means cuting of trees or agriculture
2. Walk through the area and identify all the species, where you do not know the species name use an appropriate symbol. Do not count a species more than once.
3. Allocate each species into its appropriate lifeform catergory. For most species this may be determined by direct observation of its height and posistion of perennating bud or flower.
4. Tabulate your results to show the total of species in each life catergory and then express as a percentage (e.g if you identified 10 annual grasses which are therophytes and total number of species was 40 then lifeform catergory will read 25)
5. Fill your results in the table below

Marine ecology students courtersy of John Mworia

Life form relation to Climate	Life form spectra					Characteristics
	Ph	Ch	H	Cr	Th	
Phanerophyte climate Seychelles	61	6	12	5	16	Hot moist all year
Therophyte climate Mojave desert USA	26	7	18	7	42	sub-trop, hot + long dry spells
Hemicryptophyte climate Denmark	7	5	55	9	21	Temp-moist + cold water
Chamaephyte climate Spitzbergen N. of Norway	1	22	6	15	2	Artic- Alphine, short + erratic
Your Area						

Ph=Phanerophytes, Ch=Chaemophytes, H=Hemicryptophytes, Cr=Cryptophytes, Th=Therophytes.

Questions:

1. Using the data presented above and your data can you identify any relationship between the environmental variables and vegetation type
2. What biome do you think your area falls into?
3. What area would expect the highest frequency of phanerophytes?, therophytes?, hemicryptophytes?

Activity 2

Title: Population ecology

Specific learning objectives

(1) Comprehend the basic principles of natural selection and speciation
(2) Explain conceptual and mathematical models that describe the growth of populations
(3) Describe types of interactions between populations including competition, predation and symbiosis.

Summary of the learning activity

In this activity, you are introduced to the topic by explaining the theories of natural selection, speciation, population growth and interaction between populations. You will also conduct a number of activities to help you understand the topic.

The activities that you will conduct in this unit are organized as follows:

2.1 Introduction to the content.
- 2.1.1 Natural selection
- 2.1.2 Speciation
- 2.1.3 Population growth
- 2.1.4 Interaction between populations

2.2 Case study: Access Internet to review natural selection in peppered moth.
2.3 Knowledge application: Use an hypothetical case of turtles to predict effects of environmental change on speciation
2.4 Listing and problem solving: What barriers lead to genetic isolation?
2.5 Case study: Access internet to review symbiosis and its linkage to evolution

Key concepts

Natural selection is the process that leads to adaptation of a population to its environment, the modern concept emphasizes differential reproduction rather than survival

There are 3 types of natural selection namely stabilizing selection, directional selection and diversifying selection.

Speciation takes place when a section of the population is isolated over a long period of time and diverges sufficiently to become a distinct species

Isolation barriers that lead to speciation could be due to genetic isolation, geographical isolation or extremities in climatic differences.

Exponential growth model describes the growth of population in the absence of resource limitation

The logistic growth model describes the of a population with limiting factors. The equilibrium density is K or the carrying capacity that cannot be exceeded permanently.

Interaction between species can classified into competition, predation and symbiosis. Symbiotic relationships can be further classified into ammensalism, mutualism, parasitism, or commensalism.

Key words

Natural selection, speciation, population growth, symbiosis

List of compulsory readings

Wikipedia. (2006).Peppered moth. Retrieved September 20, 2006 from http://en.wikipedia.org/wiki/Peppered_moth

Farabee, M.J. (2001).Biological diversity. Retrieved September 20, 2006 from http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookpopecol.html

Wikipedia. (2006). Symbiosis. Retrieved September 20, 2006 from http://en.wikipedia.org/wiki/Symbiosis

List of optional readings

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Beeby, A. & A. Brennan. 2003. *First ecology*. Oxford University Press

Barbour, M.G., J.H. Burk & W.D. Pitts. (1980). *Terrestrial Plant Ecology*.

Wiens, J.A. and M.R. Moss. (2005). *Issues and perspectives in landscape ecology*. Cambridge University Press 404pp.

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2.1 Introduction to the content

In this activity you will study the key concepts of population ecology. We will start by looking at natural selection that is the process that ensures individual organisms with favourable traits are more likely to survive and reproduce than those with unfavourable traits. We will then look at the theory of speciation that is the process that leads to development of new species. Population size is not static, we will look at models of population growth. To conclude the learning activity you will learn the types of interrelationship that exist between populations that include competition, predation and symbiosis.

2.1.1 Natural selection

The theory of natural selection was put forward by Charles Darwin and articulated in his 1859 book titled 'On the origin of species by means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life'. This is basically the process that results in adaptation of a population to the biotic and abiotic environments. Darwin described natural selection as process by which well-adapted individuals are selected by natural processes against the poorly adapted ones. The core of the concept is that well-adapted individuals or species survive to reproduce and contribute to the population gene pool. What this essentially means is that only the **fittest** survive. Survival for the fittest is manifested through competition for critical resources essential for survival of an individual. Note that Natural selection occurs within and between species that share the same space or resource.

The modern concept of natural selection emphasizes differential reproduction rather than differential survival. In this view factors that bring about differences in **reproductive success** or the number of surviving offspring contribute to natural selection of species. Factors that contribute to differential reproduction are survival, longevity (life span), fertility, competition, sexual selection (whereby in some species the female can produce males in good times and more females in bad times). Other factors include behavioural patterns such restricted habitats or selective feeding.

How does natural selection operate

Individuals in a population are unique except when a **zygote** (fertilized egg) splits to produce identical twins or in non-sexual reproduction whereby clones are produced. Thus there is genetic diversity within the population of a species. This is necessary for natural selection to occur. Natural selection occurs when a **selective pressure** such as an environmental condition selects for certain characteristics of individuals and selects against those of others.

Types of Natural selection
There are 3 types of natural selection

Stabilizing selection

This acts against extreme variants thus favouring intermediate phenotype. This type of selection reduces variation and improves the adaptation of a population to aspects of the environment that remain relatively constant (Blake et al.2002). For example, studies have shown that in human babies mortality tends to be high in babies weighing 1.5kg and 4.5kg, with the optimum birth weight being 3.4 kg.

Directional selection

This is common when there is environmental change taking place. This type natural selection favours phenotypes at one extreme over the other and results in the distribution curve of phenotypes shifting in that direction (Blake et al.2002). For example directional selection shift took place in the horse as it evolved from the size of a dog adapted to forests to its current size adapted to grasslands.

Diversing (Disruptive)selection

Takes place when the extremes of phenotypic differences are favoured relative to intermediate phenotypes. A good example is adaptive changes in body shape as we see in stick insects (Praying mantis) and butterflies.

2.1.2 Speciation

Dispersal of offspring leads to plants and animals changing their location over time through the of their offspring. It is possible that a section or several sections of the population may be isolated from each other for many generations. The isolated section of the population becomes adapted to its environment. This leads to species exhibiting local adaptations and phenotypic traits are known as races. Populations that have been isolated may diverge sufficiently to become distinct species and hence, cannot interbreed with the original population. Forms of barriers include genetic isolation that could be due to lack of compatible partners. Secondly geographical barriers such as oceans Mountains that separate parts of a single population. Thirdly large differences in temperature or moisture between areas. Large changes in climate between wet and dry or cold and hot periods.

2.1.3 Population growth

Populations of living organisms including human beings are dynamic: they are always changing. What processes account for change in population size?. We shall population growth in two situations.

(a) The first is the hypothetical situation of population growing with all resources available and no limitation and the

(b) Population growth in the realistic situation of growth with resources limited.

Unlimited population growth

The key processes include birth and immigration (movement of individuals into the population), both of which lead to expansion in size. Secondly there is death and emigration (movement out of the population). This factors can expressed in a word equation as

$$\text{Population Growth Rate} = \frac{(\text{Birth Rate} + \text{Immigration}) - (\text{Mortality Rate} + \text{Emigration})}{\text{Population Size}}$$

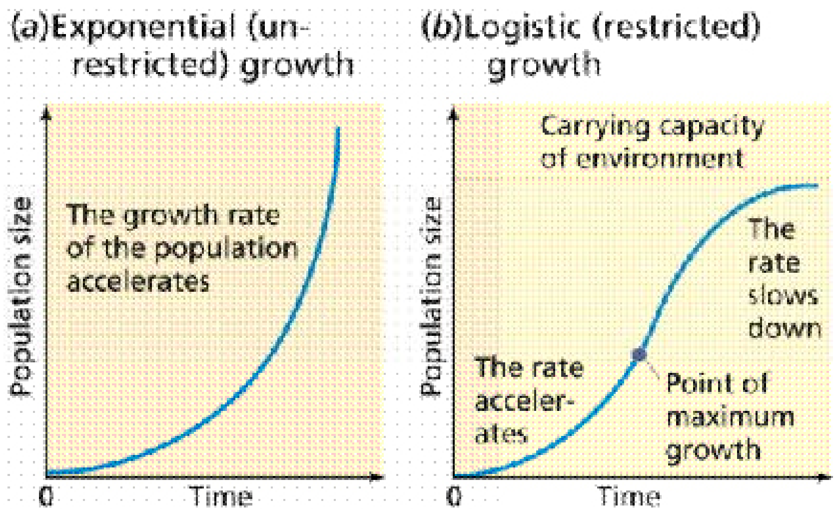
The birth rate and death rate are often collectively called vital rates of the population. The net growth rate is equal to the birth rate minus the death rate. Simple expressions of the vital rates

(a) Birth rate(b)= Number of births per unit time/Average population

(b) Death rate(d)=Number of deaths per unit time/Average population

(c) Growth rate (r)=Number of births-number of deaths/average population in time interval

The actual change in population numbers (πN) over any span of ime (πt) is equal rN. If r were constant, the population growth would be exponential (see Figure 1a)



Farabee, M.J. (2001).Biological diversity. Retrieved September 20, 2006 from http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookpopecol.html

Figure 1a : Shows population might grow if resources are un-limited resources

Figure 1b: Shows how a population might grow where food or resources are limited

The **exponential growth model** allows us to calculate population growth rates that do not follow simple binary fission. The equation for this model can be stated as follows

$N_t = N_o (e^{rt})$

Where **e** = base of natural logarithms (=2.718) and **r** = a constant for a particular population under specific environmental conditions.

The value r is different for every species and it is known as the **biotic potential** or the **intrinsic rate of natural increase** of a population in the optimum environment for the species. The intrinsic rate of natural increase (r) can be easily calculated when natality and mortality rates are known, e.g if a population has natality=0.028 and mortality=0.008 then r= 0.028 – 0.008 per year =0.02 per year

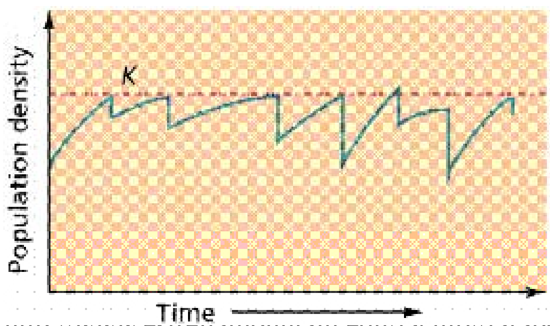
No population can exponentially very long and r is never constant. Because r is the difference between birth and death rate, changes can result from variation in either or both of those rates.

Limited growth
For many organisms the birth rate and death rates are related to population density. If the density is high, the birth rate is low, because of inadequate nutrition and other factors associated with crowding. Thus the population will tend to grow exponentially at first but will encounter a limiting factor that will cause the exponential growth to stop. The population growth slows and may eventually stabilizes at a fairly constant population size within some range of fluctuation. This model fits the logistic growth model (see figure 1b). The logistic growth model is characterised by an equilibrium density or carrying capacity represented by K.

Using differential calculus the equation is represented as

dN/dt=rN(K-N/K)

Where r=biotic potential or intrinsic rate of natural increase and represents the growth of the population without resource limitation, K= the carrying capacity, dN/dt = change in population size with time.



rieved September 20, 2006 from http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookpopecol.html

Limiting factors
What factors limit the growth a population leading population stabilization

around a range? (see Figure 2). The factors can be broadly divided into physical environment and biological environment. The categories are collectively referred to as environmental resistance. Lets look at some of them.

Physical

(a) Availability of raw materials: e.g plants require nitrates to produce protein while water is required for transport
(b) Space availability
(c) Light in the case of plants
(d) Shetler
(e) Accumulation of waste.

Biological

Organisms in natural environment will always interact with one another, this interactions include competition, predation and symbiosis. This interactions that can act as limiting factors are discussed in detail in the next section (2.1.4)

Shortcomings of the model

Contrary to expectations the logistic growth model is common in natural populations. This because the model makes the following assumptions

(a) That the environment is constant, therefore r and k are constant. This is not true since the environment changes constantly.
(b) That growth is continuous and age structure does not change. This not true because population growth is not continuous and its age structure changes with successive generations.
(c) That requirements and responses of individuals to density are the same. This is not true since the two attributes vary with age and sex.

It follows therefore that the logistic model cannot be directly employed to predict population change in natural communities

2.1.4 Interactions between populations

No species exists independent of other organisms. Species interact with one another in variety of ways. The interactions can be within a species referred to intraspecific or between different species referred to as interspecific. Predation, competition and symbiosis are the main types of interactions among species in an ecosystem.

Competition
Competition occurs between two organisms when they require a single resource that is usually in limited supply. Competition can be either intraspecific or interspecific

Predation
Predation is the consumption of one species (the prey) by another (the predator). This includes herbivores eating grass and carnivores eating other animals. Predation has an important role in evolution as predators develop more efficient strategies to catch the prey and the prey develops better strategies to escape.

Symbiosis
Symbiosis describes an association between individuals of two or more species. The partners in this relationship are called symbionts. The types of symbiosis ca be classified as; mutualism, commensalism and parasitism. Theoretically populations may interact in combinations that are; beneficial (+), detrimental (-) or have no effect (0). This can be summarised as follows:

Type of interaction	Species 1	Species 2	Nature of interaction
Amensalism	-	0	Population 1 is inhibited while 2 is not affected
Parasitism	+	-	Population 1, the parasite benefits and is generally smaller than 2
Commensalism	+	0	Population 1, the commensal gains, the host population 2 is not affected
Mutualism	+	-	The interaction is favourable to both populations


Oxpecker on Buffalo Courtesy of John Mworia

2.2 Case study:Peppered moth

Review the classical peppered moth(Biston betularia) study which shows how the proportions of some inherited charateristics in population change in response to changes in the environment

Wikipedia. (2006).Peppered moth. Retrieved September 20, 2006 from http://en.wikipedia.org/wiki/Peppered_moth

Formative evaluation

1. Did individuals change color in their lifetime
2. Explain the term 'selective pressure'

2.3 Knowledge application: environmental change and speciation

Global climate change is leading to ocean currents that are consistently colder. Take an hypothetical case of a water turtle in the East African coast. Discuss possible shifts in its population in relation to their body fat. Consider successful reproduction, directional shift ,and number of alleles for higher body fat in the population.

2.4 Listing and problem solving: Genetic isolation

1. List possible barriers that can lead to genetic isolation
2. The afroalpine flora of East and Central Africa was found to have a very high degree of endemism (80% of the taxa) in view of what have learnt in this activity discuss possible causes

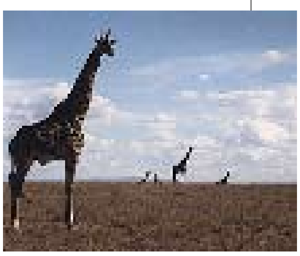
2.5 Case study: Symbiosis

To understand the symbiotic relationships you will review documented studies on Symbiotic relationships

Wikipedia. (2006). Symbiosis. Retrieved September 20, 2006 from http://en.wikipedia.org/wiki/Symbiosis

Formative evaluation

1. Is the relationship between the oxpecker and the buffulo parasitic or mutualistic, explain.
2. What is the linkage between symbiosis and evolution.



Giraffes in Maasai Mara Courtesy of John Mworia

Activity 3

Title of Activity : Community ecology

Specific Learning Objectives

(1) Determine and describe the structure of communities
(2) Describe stages in plant community dynamics
(3) Characterize the structure and adaptations of key vegetation communities in Africa

Summary of the learning activity

In this activity, you are provided with an introduction to the topic by explaining the concepts community structure and dynamics, after which we take look at the structure and function of key vegetation communities in Africa. Activities to help you understand the topic are structured as follows;

- 3.1 Introduction to the content
    - 3.1.1 Habitats and niches
    - 3.1.2 Community structure
    - 3.1.3 Community dynamics
    - 3.1.4 Structure and function of key African vegetation communities
- 3.2 Field practical to determine structure of a plant community
- 3.3 Case study: Ecological succession
- 3.4 Writing assignment: Description of various types of savannas
- 3.5 Reading Internet: Types and distribution of forests in Africa.
- 3.6 Literature search. The distribution and uses of mangroves in Africa
- 3.7 Writing assignment: Factors that influence zonation of mangrove swamps

Key Concepts

The term habitat indicates where a species dwells while niche refers to its functional role and position. Fundamental niche refers to its niche in the absence of competition while realized niche is its niche in the presence of competition.

Community structure is term community attributes such as composition, abundance or density, frequency, and additionally dominance and canopy structure plant communities

Ecological succession is directional and cumulative change in species over time culminating in climax plant community.

Structure in plants is closely linked to function hence structural adaptations are related to adapting to environmental constrains.

The afroalpine zone has low temperature, intense short radiation and drought conditions are the main challenges. Plants have adapted by having shiny leaf surfaces, pubescence, leaf rosettes etc.

African savannah types consist various proportions of grass and woody plants ranging from bushland to wooded grasslands. The structure of African savannas is mainly governed by factors such grazing, fire and shifting cultivation.

A forest is a formation of trees forming a continuous canopy of complex structure. Forests centres of biological diversity, maintain watersheds and aid in the stability climatic patterns. They distinguished into lowland forests, montane forests, and other types.

Wetlands are areas permanently or temporarily waterlogged. In Africa we can distinguish seasonal floodplains and inland deltas, lake and riverine edge swamps, valley swamps and high altitude swamps. Seasonal flooding causes both changes in plant communities and soil chemical conditions.

Mangroves are trees of several species that grow in the marine intertidal zone in sheltered estuaries and inlets. Mangroves have developed adaptations to high salinity, unstable substrate, anoxic mud environment and wave action. Mangroves distinct zonation dependant on plant adaptations

Keywords

Community structure, ecological succession, savanna, forests, afroalpine, wetlands

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Wiens, J.A. and M.R. Moss . (2005). *Issues and perspectives in landscape ecology*. Cambridge University Press 404pp.

3.1 Introduction to the content

3.1.1 Habitats and Niches

The Habitat
Habitat is latin word that means to 'it inhabits' or 'it dwells'. For some species the habitat can be readily described e.g the mountain gorilla which inhabits tropical secondary forests. Other species have a wide range of habitats e.g the African elephant found in forests and savannas. Thus the word habitat refers to where a species is found. Read on the habitat further on
http://marinebio.org/Oceans/Conservation/Moyle/ch7.asp

The Niche Concept
The modern day concept of the niche is combination of two previous concepts. The first by Charles Elton (1927) who perceived the niche as the fundamental role of the organism in the community, that is, how it relates with its food and enemies. The concept by Joseph Grinnell saw the niche as a the section or portion of the environment occupied by organism. The modern concept combines the two and views the niche as the functional role of the organism in the ecosystem plus its position and space.

Learning tip: *You will easily understand the niche concept if you visualized the ecosystem as the modern day human society, in which case the specialization or profession of an individual (e.g. teacher, mechanic) would be the role while his/her adress would give the posistion and space.*

The concept of the niche is also explained by viewing the community as an aggregate of environmental variables each of which can be represented in infinite dimensional space, the **hypervolume**. The hypervolume for a species would be the lower and upper limits of all the variables which the species can exist. Lets take an hypothetical example of an afroalpine species such Lobelia if though it's a high mountain species it has temperature limits as well as limits to other variables such as soil pH, rainfall etc. the concept of the hypervolume is demonstrated below;

Figures from internet on tolerance limits for species in relation to fundamental niche

The hypervolumes of all the species that make up the community constitute the **community hypervolume**. Now lets differentiate the fundamental and realized niche.

Fundamental niche versus realized niche
If you take a community and remove all the other species and leave one species the fraction of the community hypervolume it will occupy is called the **fundamental niche.** That is in the absence of intereference from all species. However in the presence of all other species **competition** with other species e.g for moisture or nutrients will arise, this will lead the original species to constrict the portion of the hypervolume it occupies. Thus the portion of the hypervolume each species actually occupies in the face of competition from other species is called the realized niche.

Figures from internet on fundamental and realized niche

3.1.2 Community structure

The structure of a plant or animal community refers to attributes of its composition, stratification, species abundance, and diversity. Other attributes used to describe the structure of a community include of complexity of trophic food webs, which indicates the importance of primary producers, herbivores, predators and decomposers.

How can you describe and determine the the structure of a plant community. The parameters used to describe the structure of plant community include;

1. The **abundance or density** of a species in relation to others, density is usually expressed as individuals /hectare.
2. The **frequency** of a species expressed as a percentage or fraction.
3. The basal area of a species relative to others which is computed from tree stem diameter. This usually is expressed as m^2/hectare and is sometimes referred to as **dominance**.
4. The above 3 parameters can be summed (relative density + relative frequency + relative dominance) to obtain the **Importance Value** of a particular species in the community.
5. The **canopy structure**, which involves description of the height structure or vertical stratification of the community. This frequently expressed by drawing profile diagram of the upper, middle and lower stratum.

3.1.3 Community dynamics

Plant communities are **not static** entities. Their **structure** In the process of community dynamics one community is replaced by another community. The process is defined as ecological succession. We can define ecological succession as the process of **change in community** species composition over time following natural or anthropogenic disturbances (human related). Plant succession is a **directional** and **cumulative** change in species over time culminating in **climax community. changes** over both time and space.

Historically ecologists have distinguished between **primary succession** on sites without existing vegetation and **secondary succession** on sites previously occupied by vegetation.

Shortcomings of Clements succession theory

We have seen that Clements(1916) viewed succession as a directional change in vegetation communities leading to a climax. He emphasized the role of a plant community in modifying the environment for the next one. In this view a plant community is compared to a superorganism with its own emergent properties, hence it's referred to as the **organismic view**. Immediately after Clements paper Gleason (1917) wrote one totally disputing the concept. Gleason argued that whether a species increased or decreased in succession was not dependent on other species but on its environmental requirements, this is known as the **individualistic view** of community development.

Scientist have pointed out other shortcomings of the classical succession theory (Clements) which include;

(a) The theory emphasizes replacement of communities by one another yet there **no clear-cut stages**. Succession is the result of gradual population changes.

(b) The importance of **site modification is overemphasized** because most species in disturbed sites were present buried in seeds, roots etc.

(c) Hence subsequent changes were due to different rates of growth, reproduction and survival.

(d) No two patches of vegetation are similar in composition hence the seed composition in the soil is also different. Therefore succession of **different patches** of disturbed ground in the same area will **proceed differently**.

(e) Current **climatic variation** are set to continue in future throwing into doubt the probability of any really long-term stability in vegetation.

(f) **Natural catastrophic events** such as drought fire and floods prevent stability on a time scale longer than that of the dominant species.

(g) Vegetation is being increasingly and markedly influenced by **man's activities** such **pollution**, **global warming**, **harvesting** etc making the idea of "natural" climax increasingly redundant

3.1.4 Structure and function of key African vegetation communities

We know that distribution of vegetation is governed by climate, topography and soils. You have already studied the key factors of the physical environment that influence plant function and distribution. In this we unit you will learn about the structure and function of the main communities by studying their **physiognomy** and **adaptive** trends to prevailing environmental challenges.

The diversity of climates and landforms leads to great diversity in Africa leads to a great vegetation types. We will start with afroalpine vegetation on high mountains, then go down to forests, grasslands, fresh water communities and marine communities.

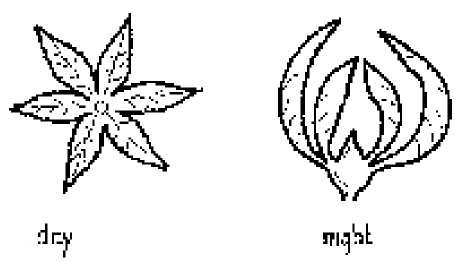
Afroalpine Flora

This is the vegetation you find on high African mountains usually **3500 to 5000M** Examples include Mt.Kenya (5200m), Mt. Kilimanjaro (5895m), Mt.Ruwenzori(5108) etc. Afroalpine vegetation has two key features firstly it is very **distinct** from the lowland vegetation because it has very **specialised life-forms**. Secondly it is characterised by a high degree of endemism e.g. of 278 taxa of vascular plants in afroalpine flora, **81% are endemic to the Eastern Africa** mountains.

Adaptative trends
Structure in plants is closely linked to function, thus structural adaptations are related to overcoming a given constrain e.g. low temperature. Afroalpine environment is severe, the most crucial being Intense incoming shortwave radiation, low temperature and drought.

a) Adaptations to intense shortwave radiation include light coloured hairy cover called pubescence on one or both sides of their leaves. Species with such pubsescence are particularly numerous in the genera *Alchemilla* (A. elgonensis, A.argyrophylla) *Helichrysum, Senecio (S. brassica, S.telekii*,). Some plants also have very shiny leaf surfaces to reflect incident radiation eg *Haplocarpa rueppellii*, some Giant senecios for example *S. adnivalis* and *S. keniodendron*. The **shiny leaf surface** is often combined with a thick hypodermis.
b) Adaptations to low temperature:

   Giant leaf rosettes: This adaptation is mainly among the Giant senceios and Gant Lobelias. These plants are characterized by thick and unbranched or sparsely branched woody or herbaceous stems, each carrying a continuously growing huge **leaf rosette**. This leaf arrangement or rosette protects the **primordia** from low temperatures. During the day the leafs spread outwards and flatten while during the night they fold forming what is called a 'night bud' which close at night.



Temperatures of +3.0°C have been inside the rosette while outside the rosette temperatures were –5.0°C. Species that show this adaptation include *Lobelia keniensis, Lobelia telekii, Senecio brassica, Senecio keniodendron*

Some plants have a **layer of persistent dead leaves** on the trunk and branches and these insulate the internal water storage and water conducting tissues. These include the *Senecio keniodendron, Lobelia elgonensis*

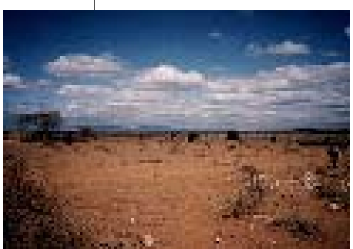
Big grass tussocks. This structure is formed of stems intermingled with dead and more or less decaying leaves and stem bases forming a dense mass (see picture).

The grass tussock protects and buffers growing apices from harmful temperature variations. Insulation is also given by leaf sheaths, dead and decaying leaf and stem bases. Such grasses include *Festuca pilgeri, Andropogon amethystinus, Agrostis trachyphylla*

Big grass tussocks: courtersy John Mworia

SAVANNAS

Structure and classification
Africa rarely has pure grasslands such as the prairies of N. America but will usually have scattered trees or shrubs and therefore referred to as **savannas**. They also are sometimes referred to as rangelands or Arid and Semi-Arid Lands (ASALs). They experience **frequent drought** (see picture) and are utilized mainly by wild life and livestock and occupied largely by pastoral tribes.

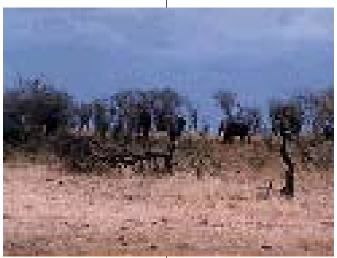


Effects of drought in savannah Courtesy of John Mworia

Factors that govern the structure of African savannas
We have seen in learning activity 3.4 that the ratio trees to grasses determines the type of savannah e.g a wooded grassland as few trees while a woodland as a higher tree density.

Species composition, abundance and cover in savannas is strongly influenced by a number of factors, which include: **physical factors** (rainfall, soils and temperature) **grazing**, **fire** and **cultivation**. In learning activity1.0 we looked at the role of physical factors, here we shall look at grazing, fire and cultivation.

(a) *Herbivore Grazing and Browsing* – grazers and browsers have profound effects on the grassland community structure depending on **herbivore density** and **movement patterns**. Grazers influence the **composition** and **diversity** of grasses mainly because herbivores graze selectively in that certain species of animals prefer certain species of plants. Extremely **heavy grazing** also favours the **increase of shrubs** over grasses leading to **bush encroachment.** Physical destruction of vegetation especially by elephants can have enormous effects on structure (see picture)



Trees broken by elephants, coutersy John Mworia

(b) *Fire/burning* - Fire is traditionally applied by our pastoralists to **stimulate fresh grass growth** for grazing and also **decrease tick** and other parasite populations. Fire stimulates renewed growth of **fire adapted/resistant species** such *Themeda triadra*, in this way fire influences grassland composition. Fire also severely damages some woody plants and is used control **bush encroachment**.

(c) *Shifting cultivation* - This is the clearing of plant communities using traditional bush fallow system and is a common phenomena in Africa. This reduces the diversity of the vegetation and favours woodlands over forests and **grasslands over woodlands**

FORESTS IN AFRICA

You have seen a forest but how would you describe it?. A forest community consists of trees with crowns touching and intermingling to form a **continuous canopy of complex structure**. An important characteristic of the structure of a forest especially the rainforests is vertical stratification of the canopy layers. The three basic vertical layers or strata are;

(a) **Upper Stratum**; this occurs at 30 to50m above the ground. In some places the upper canopy layer may be discontinuous consisting of scattered trees called emergents that have very wide crowns

(b) **Middle Stratum**; this occurs at around 20 to 30m. Some discontinuities occur but the gaps in its canopy generally occur below the emergent trees. The crowns in this stratum are narrower than those of the upper stratum. An important property of forests is that the upper and middle strata together form a more or less **continuous canopy**

(c) **Lower Stratum**; The layer occurs at 10 to 20m, it is continuous and consists of many mainly young trees with narrow crowns and densely packed together. Below the lower canopy there is undergrowth of saplings, shrubs, herbs, grasses and seedlings

Note: the height stratification given above may vary depending on the type of forest.

Importance of forests

In forest ecosystems trees are important in maintaining watersheds, preventing flooding and erosion and aiding in the stability of long-term climatic patterns. Forests are also centres of biological diversity, with tropical forests estimated to harbour 50% all plant and animal diversity.

WETLANDS IN AFRICA

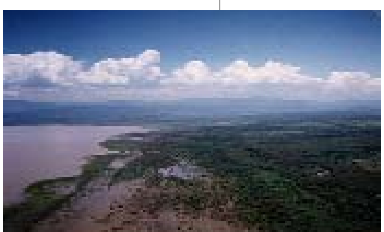
These are communities that you find associated with freshwater lakes, river valleys and areas that are permanently or temporarily waterlogged. These areas are also referred to as **wetlands.**

Types of wetland

Just like forests and savannas there are many systems of classifying wetlands. The type of wetland formed is the result of combined factors of altitude, hydrological patterns, geology and soil mineral content. Lets briefly look at the major types of wetlands in Africa:

(a) *Seasonal floodplains and inland deltas.* These are flat plains surrounding lakes or bordering river systems. They are dry for most part of the year but flooded after rains. Seasonal floodplains occupy **large parts of Africa**, for example the Sudd, on the river Nile occupies seasonally flooded grasslands occupy 17,000km^2, while in Botswana the Okavango swamp covers about 15000km^2. Grasses dominate the vegetation of seasonally flooded areas and the **plant structure** is maintained by **grazing from livestock and wildlife**.

(b) *Lake and Riverine edge Swamps*: These are characterised by the presence of tall vegetation that is flooded to a **shallow depth permanently** or for most of the year.



Lake edge swamp courtersy of John Mworia

(c) *Valley swamps:* These type of swamps are similar to lake-edge swamps but are different in size and are largely used for **agricultural projects**.

(d) *High altitude swamps.* These include **mires or bogs** found in **high altitudes** and characterised by **low rates** of organic matter decomposition. These swamps have high peat accumulation and the water is acidic (pH 3.5-4.5).

High altitude swamp Courtersy of John Mworia

THE MANGROVE COMMUNITIES

Mangroves are trees of several species that grow in sheltered **estuaries** and **inlets** and are **collectively** termed mangroves. Some species of mangroves include *Rhizophora mucronata, Ceriops tagal, Bruguiera gymorhiza,Avicennia marina,Xylocarpus granatum, Heritiera littoralis, Lumnitzera racemosa, Sonneratia alba*. In Africa they are found between 27^0N in **Egypt** and 30^0S near **Durban**, South Africa. Mangroves serve as **ecotone** between the land and the sea, at high tides they are partially **submerged** in by water and at low tides they are **exposed**.

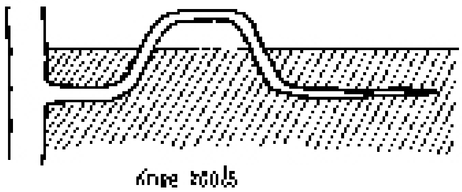
Adaptive trends

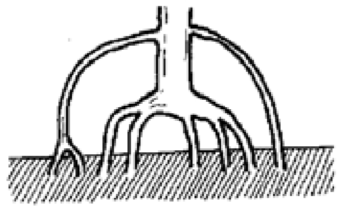
This unique environment is characterised by the following conditions that are a challenge to plant growth and function; water of high salinity, unstable substrate (shifting sand), anoxic substrate, presence of tides, and wave action. Lets now to sme adaptations;

(a) Salinity: Mangroves are essentially **halophytes.** Some adaptations to high salinity include (i) **salt excretion**; excretion of salts is done through special glands, e.g. *Avicennia marina* (ii) Tolerance; without injury high internal concentrations of salts, e.g . *Rhizophora mucronata*. (iii) **salt accumulation**; some mangroves e.g. *Rhizophora mucronata* accumulate salts in the leaves and thereafter shed their leaves at regualar intervals.

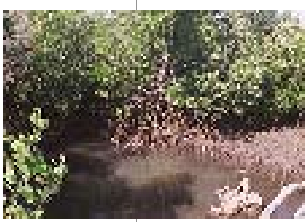
(b) Unstable substrate: Shifting mud sediments are a result of tides and waves. In addition the mud is always waterlogged and anoxic (lacking aeration). These conditions pose a problem to seed establishment, plant support and aeration. To overcome these mangroves: (i) **Seed establishment**: seeds require a firm aerated soil substrate to allow and shoot development, conditions which are lacking intertidal zone. To overcome this condition mangroves are the only **true viviparous plants** in the ecosystem. Vivipary is the condition where seeds germinate while still attached to the fruit and the fruit still attached to the mother plant. The seeds germinate into a **protruding embryo** with a **long**

hypocotyl and finally fall from the trees. If the seedling falls in low tide it **lodges itself upright** into the soft mud because of the sharp hypocotyls and proceeds to grow and establish very fast. If seedlings fall during the high tide they **float** along and when water recedes they stick in the soft mud. (ii) *Aeration and support* to overcome the problem of lack soil air in the mud sediments mangroves have roots that are specialised to secure O_2 and attain





This include; (1) **Prop roots**: These roots arise form the stem and support the trees and help in aeration (2) **Aerial roots**: these arise from branches and are used for aeration(3) **Pneumatophores**: These are horizontal roots protrude erect out the mud for aeration- see picture (4) **Knee roots**: horizontal root grows upwards until it breaks through the soil, then turns downwards again forming a bent "knee" for aeration.



Pneumatophores Courtersy of John Mworia

3.2 Fieldwork: Determination of community structure

Select a woody site or forest to conduct this practical, and do the following

A. Lay out a 10m transect line, using a tape measure. Along this line count the number of individuals of each species that fall within 0.5m either side and measure the diameter (at breast height for trees or at the base for other plants). Now divide the line into 10 one meter segements and record the presence or absence of each species. Repeat this transect analysis. Include all trees, all herbs and all shrubs.

B. Calculate the following

a. **Density:** The number of individuals of each species in transect (10m x 1m = $10m^2$) to convert to number/ha multply 1000.

Relative density =Density of one species/Total number of all plants/ha X 1000

b. **Dominance:** Convert stem Diameter at Breast Height (DBH) to basal area (cm^2) using πr^2 or a conversion table.

Relative dominance: Dominance of one species/Total dominance X100

c. **Frequency:** Consider each segement of the transect as a sample plot. The number of segements in which a species occurs, divided by the total number of segments, and expressed as decimal= frequency value

Relative frequency= Frerquency value of one species/Total of all frequency values X 100

d. **Importance value** = The sum of relative density, dominance and frequency.

C. Calculate the importance value for all species and fill in the table below, use the correct taxonomic names. an example of *Prunus africana* is given.

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value
1. Prunus africana				
2.				
3.				

Questions

1. A species has a high density but low frequency, is the spatial distribution clustered or uniform?
2. What is the maximum importance value a species can have?
3. What does parameter 'importance value' tell the ecologist in terms of com-

3.3 Case study: Ecological succession

In this learning activity you shall use internet resources to study documented cases of ecological succession. The theory of plant succession was first described Fredredick Clements (1916). Ecological succesion culminates in a climax community.

Wikipedia. (2006). Ecological succession. Retrieved October 20, 2006 from http://en.wikipendia.org/wiki/ecological_succession

Formative evaluation and knowledge application

(a) What are the stages in ecological succession called and what are key properties

(b) What are attributes of a climax vegetation community

3.4 Writing assignment: Types of savannas

Savannas are very widely distributed across the globe. Their classification systems vary widely. Physiognomic classification is widely used to describe African savanna types. This classification has the following classes: bushland, woodland, shrubland, bush grassland, wooded grassland, and dwarf shrub grassland. It is based on the ratio of **tree to grass**. Read the following references

1. Wikipedia. (2006). Scrubland. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Scrubland
2. Wikipedia. (2006). Savanna. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Savanna

Write a brief essay (600-800 words) titled '*Types of savannas and classification systems commonly used'*

3.5 Reading Internet: Types and distribution of forests in Africa.

To distinguish types of rainforests visit

Rhett, B. (2006). Tropical rainforests. Retrieved September 20, 2006 from Mongaby.Com http://rainforests.mongabay.com/0103.html Read the sections: rainforests, equatorial evergreen rainforest vs. moist forest, primary vs. secondary forests, and lowland vs montane

To learn the distribution of forest types in Africa visit

United Nations Environmental Programme. (2002).Forest cover and proctected areas. Retrieved October 20, 2006 from http://africa.unep.net/forest_Degrad/index.asp

Question

1. Distinguish primary from secondary forests
2. Distinguish lowland from montane forests

3.6 Literature search. The distribtution and uses of mangroves in Africa

Visit the site given below to get an understanding of the distribution and their uses

United Nations Environmental Programme. (2003). Mangroves of East Africa. Retrieved October 20, 2006 from http://www.unep-wcmc.org/resources/publications/ss1 WCMCMangrovesv11_1.pdf

Read pages 4-5

3.7 Writing assignment; Zonation of mangrove swamps

Different mangrove species have various adaptations to environmental constrains. Differing adaptations in mangrove tree species leads to their occurrence in fairly **distinct zones** depending on such factors as the **amount of water** in the mud, the **salinity** and the ability to **tolerate shade**. Review this zonation and write a brief essay (600-800 words)

1. United Nations Environmental Programme. (2003). Mangroves of East Africa. Retrieved October 20, 2006 from www.unep-wcmc.org/resources/publications/ss1/WCMCMangrovesv11_1.pdf (read pages 4-5)
2. Florida Museum of Natural History. (2006). Aquatic environments: Mangroves. Retrieved October 20, 2006 from http://www.flmnh.ufl.edu/fish/SouthFlorida/mangrove/Zonation.html
3. The State of Queensland. (2005). Department of Primary Industries and Fisheries: Mangrove Physiology and Zonation. Retrieved October 20, 2006 from http://www2.dpi.qld.gov.au/fishweb/2623.html

Self test

1. How do the factors tidal flooding, land elevation, and soil and water salinity influence zonation (Tip: consider plant adapations)
2. What other factors influence zonation in mangroves

Activity 4 Title of Activity : Ecosystem ecology

Specific Objectives

a. Articulate factors that influence terrestrial and aquatic primary production
b. Explain the concept of trophic levels in ecosystems
c. Describe the process of nutrient cycling in terrestrial ecosystems

Summary of the learning activity

In this learning activity you will first be introduced to the subject of primary production. We will then look at how the energy captured in primary production flows through the ecosystem. We conclude by studying biogeochemical cycles. To help you understand the unit better you will do the following activities

4.1 Introduction to the content
- 4.1.1. Factors that influence terrestrial and aquatic primary production
- 4.1.2 Efficiency of primary production
- 4.1.3 Trophic levels
- 4.1.4 Nutrient cycling

4.2 Knowledge application: Differences in the distribution of C3, C4 and CAM plants
4.3 Cmprehension: Compare terrestrial and aquatic production
4.4 Comprehension: Ecological pyramids
4.5 Case study : Nitrogen and Carbon cycles
4.6 Knowledge application: calculating nutrient budgets
4.7 Comprehension: Self test for the unit

Key concepts

Terrestrial primary productivity is mainly influenced by the photosynthetic type, environmental factors and herbivory. Herbivory at moderate levels stimulates primary production.

Key constrains to aquatic production are Light attenuation and nutrient availability. Primary production is accomplished in the euphotic zone. Nutrient limitation is due sinking of phytoplankton below the euphotic zone and thermal stratification.

Trophic level is a functional classification of organisms based on food acquisition. The trophic structure can be described in terms of numbers, biomass or energy.

Ecological pyramids show graphically the trophic structure. The pyramid of energy gives the best overall picture of the functional relationship of **communities.**

Biogeochemical cycles show the movement of nutrients in the biosphere. Nutrients enter or leave the ecosystem through geologic, meteorological or biologic pathways and are held temporarily in reservoirs or pools.

A nutrient budget shows the source, fluxes and lossses of a nutrient in an ecosystem

Key words

Primary production, euphotic zone, food chain, trophic level, plant nutrient

List of compulsory readings

Wikipedia. (2006). Primary production. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Primary_production

Wikipedia. (2006). Crassulacean acid metabolism. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Crassulacean_acid_metabolism

Wikipedia. (2006). C4 plants Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/C4_plants

Wikipedia. (2006). C3 carbon fixation. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/C3_carbon_fixation

Wikipedia. (2006). Ecological pyramid. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Ecological_pyramid

Wikipedia. (2006). Biogeochemical cycles. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Biogeochemical_cycle

Wikipedia. (2006). Nitrogen cycle. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Nitrogen_cycle

Wikipedia. (2006). Carbon cycle. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Carbon_cycle

List of optional reading

Baronmark, C. & L. Hansson. (1998). *The biology of lakes and ponds*. Oxford University Press

Beeby, A. & A. Brennan. (2003). *First ecology*. Oxford University Press

Barbour, M.G., J.H. Burk & W.D. Pitts. (1980). *Terrestrial Plant Ecology*. The Benjamin/Cummings Publishing Company, Inc.

Chapman, J.L. & M.A. Reiss. (1999).*Ecology: principles and applications*. Cambridge University Press.

4.1 Introduction to the content

4.1.1 Factors That Influence Terrestrial And Aquatic Primary Production.

Terrestrial Primary Production
In this section you will be introduced to some factors that influence terrestrial primary productivity namely; Photosynthetic type, Canopy structure, environmental variables (water, temperature, and nutrients) and herbivory.

Photosynthetic type:
there are three fundamentally different types of photosynthesis. which are distinguished mainly by the initial biochemical products of photosynthesis. This are C_3 plants, C_4 plants and Crassulacean Acid Metabolism (CAM) plants. C_3 is the most widely distributed type of photosynthesis occurring all algae and most vascular plants. The C_4 plants generally exhibit high rates of photosynthesis and have high optimal temperatures for photosynthesis and require high light intensities for photosynthetic saturation. CAM plants have unusual property in that they can assimilate carbon dioxide at night because the stomata close during the day and open at night.

Environmental factors.
In learning activity 1.0 we looked at environmental factors can influence plant distribution. The key variables namely light, water, temperature and soil nutrients also influence photosynthesis.

Herbivory:
Herbivory to the extent of overgrazing lowers primary production. However effects of herbivory on primary productivity and individual plants are not always detrimental, moderate levels of grazing may a stimulatory effect on primary productivity in what is referred as grazing optimization.

Aquatic primary production
Unlike terrestrial production where production is accomplished through macrophytes, aquatic production is accomplished by **phytoplankton** e.g. diatoms, scenedesmus, chlorella e.tc. The key factors that affect primary production in these conditions include;

Light:
All primary production is accomplished on a lighted vertical zone called the **Euphotic Zone.** As light penetrates the water body it undergoes attenuation. This means that as depth increases light is reduced both and intensity. This tells us that photosynthesis will consequently reduce with depth. At a certain depth photosynthesis just **balances** respiration at about where light is 1% of full light. This depth is called the **compensation point** and above this point is the euphotic zone.

Nutrients:
Phytoplankton just like the plants in terrestrial ecosystems hold a large proportion of nutrients in their skeletons and protoplasm. phytoplankton do constantly **sink below the euphotic zone**, taking away nutrients which reduces production. The loss of nutrients from the euphotic zone is intensified by the presence of stratification or layering of water due to differential temperature especially in tropical waters. The upper warm layer referred to as the **epilimnion** and is denser than the lower layer known **hypolimnion** as the this prevents **up welling** or mixing of water which would bring nutrients to the lighted more productive zone. This explains why temperate waters are more productive than tropical waters

4.1.2 Efficiency Of Primary Production

We often ask the question how **efficient is a plant or community** in primary production. Only a small fraction of incoming solar radiation is converted into primary production. Much of the radiant energy is in the **ultraviolet** and infrared portions of the spectrum which are not effective in photosynthesis. Only about 45% of the total radiant energy lies in the spectrum (400-700mm) which can be absorbed photosynthetic pigments. This leaves about 55% of total energy unusable

This brings us to the concept of **efficiency of primary production**. This is the ratio of rate of production of organic matter to the rate of input of solar radiation.

Estimates of efficiency of primary production under field conditions vary but generally always low **about 2% or less**. These low efficiencies are attributed to the fact that much of the solar energy striking the earth's surface is not available for primary production. For example some of the solar radiation incident on the earth's surface heats up the surface, air and soil below the surface.In terrestrial ecosystems significant amounts of energy go into evaporation

Now let us look at a practical case and calculate the production efficiency of **Cyperus papyrus**. Papyrus is a very productive plant and has been known to attain growth rates of 125 g m^{-2} day $^{-1}$. We can estimate net efficiency of solar energy conversion by papyrus by relating the energy content of papyrus biomass to the incident global radiation in the swamp.

The coefficient of solar energy conversion (η) on yearly basis is calculated as follows

η(%)= (Energy bound in papyrus biomass m^{-2} yr^{-1} **divided** by energy of global radiation m^{-2} yr^{-1}) X100

The **calorific value** of papyrus has been estimated to be 20MJ Kg^{-1}

The **annual net primary productivity** is 6.61Kg m^{-2} yr^{-1} in our swamp.

Hence the amount of energy bound in papyrus biomass per annum is 132.2 MJ m^{-2} (i.e. 6.61Kg m^{-2} yr^{-1} X 20MJ Kg^{-1})

The **solar radiation** received above papyrus canopy is 18.2 MJ m^{-2} day^{-1} or the coefficient of solar energy conversion

The coefficient of solar energy conversion is therefore calculated as

η=(132.2 MJ m^{-2} $yr.^{-1}$ / 6643 MJ m^{-2} $yr.^{-1}$)X 100

η=2.0% (of global radiation)

The above coefficient when corrected for energy receipt in the wavelengths of photosynthentically active radiation (PAR), 400-700μm which represents 45% of the global radiation is 4.4% (2 x100/45)

hence η(PAR)=4.4%

4.1.3 Trophic Levels

You can study organisms in their surrounding using several approaches, in this section we will take the perspective of feeding relationships. Here we group species into autotrophs or producers, herbivores, carnivores, decomposers etc. Each of this is called a trophic level. Lets look at of the trophic levels;

Autotrophs: This are organisms that do not require organic compounds as their source of energy. Autotrophs can be divided into 2 groups (i) Photoautrophs or photosynthetic organisms who obtain their energy from the sun (ii) Chemoautotrophs: this can defined as organisms in which energy is obtained solely from the oxidation of inorganic electron donors without the use light (Chapman and Reiss, 1999). Chemosynthentic organisms are restricted to one kingdom, the prokaryotae. E.g. *Nitrosomonas* and *Nitrococcus.*

Decompsers: Decompsers are next to producers in importance because without them nutrients including carbon, nitrates would accumulate in dead remains and run out. The simplest self-perpetuating community would therefore consist autotrophs and decomposers. Litter decomposition is important in terrestrial ecosystems. Breakdown of litter is dependent on physical and biological factors e.g. it faster in the tropical forests because they are hot and humid conditions suitable for decomposers.

Herbivores and carnivores: Even though the distinction between the two terms is clear the limitations may not be very clear e.g. some ecologists will consider a herbivore to be predator if it consumes all the plant (Chapman and Reiss, 1999). Predators are taken to be one of the factors that regulate prey population size.

Omnivores: this are organisms that feed on both plants and animals and are be definition generalists e.g. humans.

Learning tip:

Trophic literally means feeding hence trophic level is a feeding level.

Food chains and food webs

The linear one-way directional passage of energy through the ecosystem is known as energy flow. Energy flow in the ecosystem is traced through food chains. Producers form the beginning of the food chain, while herbivores and omnivores obtain energy from the producers. At the end of the food chain are the decomposers. At each transfer a large amount or proportion of energy is lost as heat (80-90%) as such the number of links is limited. Food chains are simple and very rarely occur.

A food web depicts an inter-connected collection of food chains demonstrating the flow of energy throughout the community. Food webs unlike food chains are more realistic and show the positions of parasites and omnivorous organisms. Even though food webs are realistic a major disadvantage is that they fail to show the relative importance of different food chains.

Trophic structure and ecological pyramids

(a) The interaction of food chain phenomena and size-metabolism relationship results in communities having a definite trophic structure. This structure varies with the type ecosystem e.g that of lakes differs from forests. Trophic structure may be measured and described either in terms of standing crop or energy fixed per unit area per unit time at successive trophic levels.

(b) Ecological pyramids: This the depiction of trophic structure and function graphically whereby the first or producer level forms the base and successive levels the tiers which make up the apex. Ecological pyramids may of three general types; (i) Pyramid of numbers (ii) Pyramid of biomass and (iii) Pyramid of energy.

4.1.4 Nutrient Cycling

Out of the 100 or so elements found on the earth's crust , 30-40 are required by the organism for their normal metabolism Out of the 100 or so elements found on the earth's crust , 30-40 are required by the organism for their normal metabolism. Elements tend to circulate in the biosphere in characteristic pathways are referred to as biogeochemical cycles. A general model of nutrient cycling has 3 important characteristics

(a) Within the ecosystem a nutrient is found in compartments or pools/resevoirs such the atmosphere, soil or organic pool.

(b) Nutrients flow between compartments along characteristic pathways such as nutrient uptake, decomposition of organic matter

(c) A nutrient cycle in a particular ecosystem is connected to the larger biogeochemical cycles by meteorologic, geologic, and biologic vectors that move nutrients across ecosystem boundaries.

Input and output processes

Here we describe there are three ways in which nutrients are added to the ecosystem, namely.

Geologic-Dissolved or particulate matter may be carried into an ecosystem by moving water. That is either by runoff or seepage

Meteorologic- Nutrients do enter an ecosystem through atmosphere. This involves addition of: gaseous material dissolved or particulate matter in precipitation, and f dust particles.

Biologic: It includes the importation of materials gathered elsewhere as fecal material. This pathway is particularly important in African savannas characterised by frequent concentration of wildlife and livestock around permanent water sources, the inflow of nutrients through fecal material to such systems is highly significant

The output of nutrients follows similar pathways.

Nutrient Budgets

We have seen that in any biogeochemical cycle there is movement of nutrients from one pool to another. Pools do not release nutrients at the same rate some nutrients may get bound in a pool for long periods of time and are therefore not available for circulation. In order to understand the nutrient cycle better we need to know the **source** of the nutrients, their **fluxes** (exchange rate) and their **loss**. When such an arrangement is done it is referred to as **Nutrient budget**.

Before going further let define some terms used describing nutrient budgets

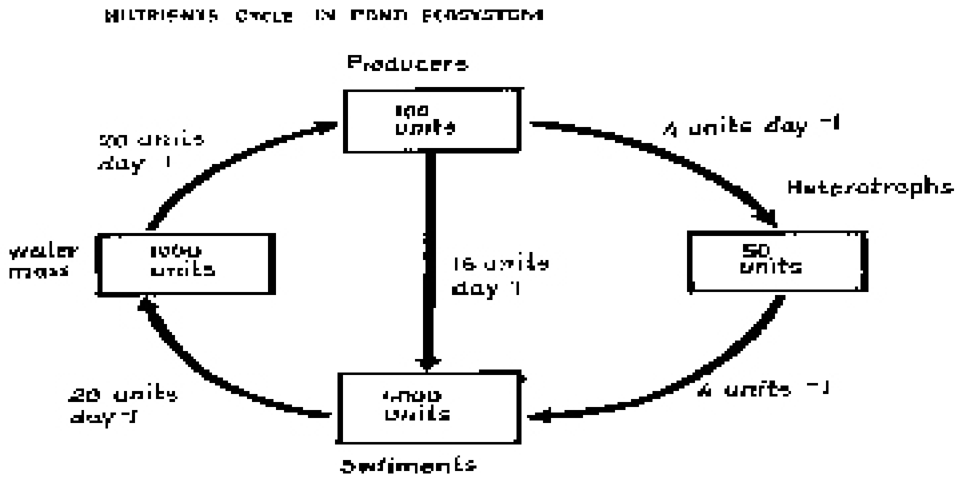
Flux rate describes the quantity of material passing from one pool to the next per unit time per unit area or volume

Turnover rate: **-** this is the fraction of the total amount of a substance in a pool which is being released in a given time interval

Turnover time:- This is the time required to replace the total amount of the substance in a pool

Now let us look at a simple example of an ecosystem and build a nutrient budget, lets take a pond measuring 4Ha

In this lake the quantity of phosphorus in the **lake water** is one pool. The quantity of phosphorus in the **sediments** constitutes another pool. There is also a phosphorus pool in the **producers** such as phytoplankton and **heterotrophs** such Zooplankton. All these pools are interrelated by the processes that transfer nutrients from one pool to another.



As an example let us describe the transfer of phosphorous from the water pool to the producers i.e. water → producers

(a) Absolute flux rate= 20unit day^{-1}/4 ha =5 Units ha^{-1} day^{-1}

(b) Turnover rate= 20unit day^{-1}/1000 = 0.02

(c) Turnover time = 1000 units/20unit day^{-1} =50 days

The influence of the hydrologic cycle on nutrient budgets

Nutrient budgets in terrestrial ecosystems are strongly influenced by the hydrologic cycle simplified below as:

P=E+T+R+I

P=precipitation, E=evaporation, T=transpiration, R=runoff, I=infiltration (downward entry of into the soil). Nutrient budgets are strongly correlated with the hydrologic cycle in that precipitation carries nutrients in solution, runoff and infiltration remove nutrients from the system or move them down the soil column, and evapotranspiration of water concentrates and conserves nutrients. We know that several land use factors such **erosion**, **vegetation removal**, **overgrazing** etc influence the hydrologic balance hence they also influence nutrient budgets

4.2 Knowledge application: Distribution of C3, C4 and CAM plants

The type of photosynthensis governs conditions in which the plant is most adapted hence distribution. Further material on type photosynthesis can be obtained at:

Wikipedia. (2006). Crassulacean Acid Metabolism. Retrieved October 20, 2006 from
http://en.wikipedia.org/wiki/Crassulacean_acid_metabolism

Wikipedia. (2006). C4 plants. Retrieved October 20, 2006 from
http://en.wikipedia.org/wiki/C4_plants

Wikipedia. (2006). C3 carbon fixation. Retrieved October 20, 2006 from
http://en.wikipedia.org/wiki/C3_carbon_fixation

Question

Given the properties of C_3 plants, C_4 plants and CAM in what type climatic conditions do expect to find each of this catergory plants in Africa. Explain

4.3 Comprehension: Compare terrestrial and aquatic production

Review

Wikipedia. (2006). Primary production. Retrieved October 20, 2006 from
http://en.wikipedia.org/wiki/Primary_production

Write a brief essay (600-800 words) : A comparison of aquatic and terrestrial production

4.4 Comprehension; Ecological pyramids

The three types of ecological vary in their usefullness and effective description of the functional nature of communities. Review their comparison

Wikipedia. (2006). Ecological pyramid. Retrieved October 20, 2006 from
http://en.wikipedia.org/wiki/Ecological_pyramid

Self test

1. Why is the three pyramids of number considered the least descriptive (Tip; compare a forest and an aquatic ecosystem)
2. Which of three pyramids best describes the functional relationship in ecosystems

4.5 Case study : Nitrogen and Carbon cycles

You have been introduced to the general nutrient cycling model and its key components. Here you will review internet resources and write a brief essay (600-800) on two important nutrients namely **nitrogen** and **carbon**

http://en.wikipedia.org/wiki/Biogeochemical_cycle
http://en.wikipedia.org/wiki/Nitrogen_cycle
http://en.wikipedia.org/wiki/Carbon_cycle

Self test

1. Briefly discuss the ways in which carbon is taken from the atmosphere and released back to the atmosphere.
2. How is carbon transerred within the biosphere
3. Describe ways in which atmospheric Nitrogen is converted to chemically active nitrogen

4.6 Knowledge application: calculating nutrient budgets

Using the above example complete the table by describing the transfer phosphorous between the following pools; Heterotrophs → sediments and Sediments → water fluxes and fill in the table below.

Learning tip: Remember the size of the pond is 4ha

Transfer rates flux rate	Absolute rate	Turnover time	Turnover
From →To	Units ha^{-1} day^{-1}	unit $unit^{-1}$ day^{-1}	(days)
Water → producers	5	0.02	50
Producers → sediments	4	0.16	6.25
Producer → heterotrophs	1	0.04	25
Heterotrophs → sediments	**A**	**B**	**C**
Sediments → water	**D**	**E**	**F**

Calculate the values A, B, C, D, E and F.

4.7 Comprehension: Self test for the unit

1. The mass of organic matter on forest floor of the tropical Congo forest was found to 2tons/ha while that of shrub tundra was found 85tons/ha, explain
2. What are the differences between energy flow and nutrient cycling
3. Briefly outline the nutrient cycling model
4. Outline 3 pathways of nutrient input and output
5. Differentiate flux rate from turnover rate.
6. How can man influence nutrient budgets

Activity 5

Title of Activity : Natural resource conservation

Specific Objectives

a. Define biodiversity and enumerate its measurement indices
b. Outline common forms of habitat degradation in Africa
c. Outline the processes of desertification and global warming

Summary of the learning activity

In this learning activity you will first be introduced to the natural resource conservation, including the concepts of biodiversity, species and habitat conservation, and degradation of key habitats in Africa. You also conduct a number activities to aid your understanding of the topic.

5.1 Introduction to the content
 5.1.1 Biological diversity
 5.1.2 Principles of conservation
 5.1.3 Habitat degradation
5.2 Writing assignment: Biodiversity its definition, measurement and distribution
5.3 Case study
5.4 Self assessment

Key concepts

Species diversity measurement and expression of is commonly based on two important components namely species richness and eveness

Biodiversity is a wider term that encompasses genetic diversity, species, subspecies, communities and ecosystems.

Conservation is the management of natural resources aimed at restoration and maintenance of balance between human demands and requirements of other species. Conservation can focus on individual species, ecosystems, biomes or even the biosphere.

Risk of extinction of species can be categorised into rare, vulnerable, endangered or extinct.

Destruction of habitats is the most important threat to bidiversity today

The savannah an important biome in Africa is largely used for pastoralism which has both positive and negative impacts but is clearly sustainable land use form.

Threats to the intertidal marine communities of Africa are largely from overexploitation, human and industrial waste disposal and improper location of hotels, houses and other structures.

Key words

Species diversity, conservation, habitat degradation, pastoralism, marine communities

List of compulsory readings :

Wikipedia. (2006). Simpson index. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Simpson_index

Wikipedia. (2006). Shannon index. Retrieved October 20, 2006 from http://en.wikipedia.org/wiki/Shannon_index

United Nations Environmental Programme. (2002). Forest cover and protected areas. Retrieved October 20, 2006 from http://africa.unep.net/forest_Degrad/index.asp

List of optional readings :

Chapman, J.L. & M.A. Reiss. (1999). *Ecology: principles and applications*. Cambridge University Press.

Wiens, J.A. and M.R. Moss . (2005). *Issues and perspectives in landscape ecology*. Cambridge University Press 404pp.

Pullin, A.S. (2002). *Conservation biology*. Oxford University Press pp358.

5.1.1. Biological Diversity

What is biodiversity

The term biodiversity generally refers to biological diversity. From the onset you should know that the meaning of the term diversity has had varied, so have been methods of measurement and interpretation.

Species diversity strictly speaking refers to the number of different species in a particular area (species richness) weighted by some measure of abundance such as number of individuals.

Currently biodiversity is an all inclusive term that refers to the totality of the richness of biological variation ranging from population based genetic variation through sub species and species, to their communities, and ecosystem. Genetic diversity here refers the number of gene alleles within a population.

Alpha and Beta diversity
You also find the terms alpha and beta diversity. Alpha diversity is the number of species within a selected area or community. While Beta diversity is the difference in species diversity between different areas or communities. Beta diversity is also referred to as habitat diversity because it represents the differences in species composition between two different communities (Kent and Coker, 1992).

Measurement of diversity
Diversity contains to principle notions

(a) That of richness or number of species
(b) That of evenness of distribution or the relative abundances of the individuals within each species

The number of species in a sample is generally called species richness and is important in characterising a biological community. Species richness alone is not sufficient since the pattern of distribution within the community is also important. 'Evenness' is the term used to describe relative distribution. The number of species and eveness of relative abundance are two statistical properties used to quantify species diversity (Diversity indexes).

The common diversity indexes include;

(a) Simpson's index (http://en.wikipedia.org/wiki/Simpson_index)
(b) Shannon-Weiner index (http://en.wikipedia.org/wiki/Shannon_index)

5.1.2 Principles Of Conservation

Why conserve
Conservation is the management of natural resources in such a way as to maintain the balance between the needs of human beings and other species. What are natural resources ? natural resources include soil, water, wild animals and plants.

Today man enormously utilizes the earth's **physical resources** and **biological resources**. In many occasions the **processes of extraction** used by man or the by-products are harmful to the environment and biological communities. Today the number of people alive and their demands on the Earth's resources continue to increase.

The continued exploitation places species, ecosystems and even biomes under pressure and leading to reduction in biological diversity. This has led international, National, local and group efforts to conserve biodiversity

Species conservation
Fossil record shows that in geological species are continually becoming extinct and new ones evolving. The records also indicate there are events that lead to major extinctions such as changes in climate, loss of habitat or giant meteors. During this extinction events it is estimated that only about 15-30 species went extinct per year, from a geological perspective the events appear instantaneous.

In conservation we are concerned with impacts of man on species extinction. The rate of species extinctions as a result of human activity has been increasing. The human evolved as a hunter and gatherer and in last 10000 a number prey animals including the wholly mammoth, flightless birds and predators have gone extinct. In the last 400years some 150 extinctions have been recorded. Since for every recorded extinction there many unrecorded ones it now estimated that there 4000 to 300000 extinctions per year (Chapman and Reiss, 1999).

Four categories of risk are recognised by the world conservation Union (IUCN)

Rare: Species have small populations usually within restricted areas and are in danger of becoming rarer not extinct.

Vulberable: These are under threat or decreasing in number or populations that have not recovered from past depletion

Endangered: species have very low population sizes and are in considerable danger of becoming extinct.

Extinct: species are believed to no longer exist and cannot be found in its habitats.

Conservation measures should be taken when the population of a species is declining rather than wait until it is threatened with extinction. This is often hindered by

(a) It is difficult at times to detect declining population trends in natural communities because a population can undergo considerable fluctuation in size and it can not be readily determined whether the population is declining or increasing.
(b) The time-scale required to conclusively determine whether a population is increasing or decreasing may be longer than the species has left if it is severely depleted.
(c) Monitoring population trends is costly and requires adequately trained personnel

Some of the methods applied to conserve endangered species include

(a) Captive breeding programmes in zoos and botanic gardens. These are sometimes taken as a last resort to conserve the species. However the biggest challenge is that no one zoo or botanic garden can hold populations that are large for the maintenance genetic diversity.
(b) Re-introductions involve re-introducing the species to the wild. The major challenge is that species habitat may not exist any more due to land use changes. Re-introductions are also attempted to boost numbers in an area or where local extinction has occurred.

Conservation of ecosystems
Destruction of existing natural ecosystems is the most important threat to species diversity today (Chapman and Reiss, 1999). An ecosystem contains populations, communities their genes, and the physical environment. If a habitat is disappearing and with it whole communities then the best form of conservation is to protect the whole habitat. This preferred means of biodiversity conservation in Africa.

When setting up a nature reserve there a number of important considerations;

(a) The reserve should be large enough to hold viable populations of the target species so as to maintain genetic variation. The shape of the reserve in addition to the size is also important
(b) If the species is migratory then consideration for more than one reserve should be given with breeding and feeding sites in mind.

5.1.3 Habitat Degradation In Africa

In this section we shall look at the influence of man on key habitats in Africa. The study of the impacts of man on the environment is very wide field of study and we can only browse it briefly. We saw in unit 1.0, that both plants and animals interact among themselves and their environment. It follows that the alteration in any of the component affects the other. Each organism has its **own limit of tolerance** of various environmental factors and alteration of these factors affects the ability of the species to survive.

The major impacts of man on African ecosystems include deforestation, unsustainable agriculture, overgrazing, pollution and eutrophication.

We will look some of these impacts briefly;

Impacts of pastoralism on savannas
Pastoralism is a very old form of land use, e.g. in East Africa it goes back 4000 or 5000 years. Pastoralism is mainly a subsistence production system, that is, the goal is survival of the pastoralist and his livestock. Let us now look at the effects of pastoralism

(a) Pastoralism almost always **alters plant community structure**. For example the Ngisoyoka pastoralists of South Turkana keep large number of goats and camels, which are browsers this tends to decrease woody species in favour of grasses. Grazing can also convert perennial grasslands into annual grasslands
(b) A traditional view is that **grazing lowers productivity** by removing leaves and causing an increase an increase in woody plants however as we saw in learning activity 4.1 **low to moderate** levels of grazing may **increase net productivity**.
(c) Because pastoralists move their livestock often, this leads to **transportation of nutrients in the ecosystem** (that is, through fecal deposits). This has effect of altering spatial patterns of soil fertility with concentration around watering points and bomas. This favours increase in plant diversity.

(d) Areas that are repeatedly **overgrazed become degraded** (see pictures). Overgrazing generally leads to circle of events characterised by reduction in herbaceous cover, reduction in palatable plant species, increase soil compaction, increase soil erosion and eventually decline in productivity. However its been shown that degradation is **not a universal and unavoidable** consequence of subsistence pastoralism.

Overgrazing Courtersy Jonn Mworia

Deep gullies from erosion Courtersy John mworia

From the points we have discussed above it is evident that pastoralism has both positive and negative effects on plant communities and on the environment however its 4000 years existence clearly demonstrates its sustainability

Degradation of African forests

Africa has large expanses of forests, considering all types of moist forest we have approximately 21% of Africa, closed forest represents 9% of the land cover, while open and fragmented forests represent 12% (Unep, http://africa.unep.net/forest_Degrad/index.asp).

The forests have the following functions in African ecosystems: temperature regulation, flood control, regulates nutrient cycling, regulate soil erosion and water cycles. Their extreme importance is thus evident.

The major threat to African forest is deforestation. Deforestation is carried for the following reasons;

(a) To provide land for agriculture, urbanization and the construction of physical infrastructures.
(b) To provide timber for building
(c) To provide charcoal and firewood
(d) To provide raw materials for paper pulp.

Deforestation can lead to;

(a) Recurrent floods and disruption of local climatic patterns
(b) Increased soil erosion and loss of forest soil fertility
(c) Loss of biodiversity

Threats to African marine communities

In unit 4.0 we looked at the structure and adaptive trends of inter-tidal communities. This community in recent past has come under **great threat** due to human activities. The activities include;

(a) **Over exploitation** of inter-tidal resources. These include over cutting of mangroves leading to excessive soil erosion and subsequent loss of habitat

(b) Excessive **human and industrial waste disposal**. This is mainly to fast growth of coastal towns of which high concentrations lead to plant and animal death

(c) I**mproper location** of houses, hotels, industries and aquaculture farms increasing soil erosion and reducing productivity. Hotels are often located too close to the beaches without regard buffer zones to protect sand dune plants and turtles and birds that they host.

(d) **Damming of rivers and estuaries** and extraction of water from underground aquifers causes changes in sediment deposition, salinity and erosion patterns leading ecological stress.

5.2 Writing assignment: Biodiversity its definition, measurement and distribution

In the last 2 decades the world has greatly on focused biodiversity and its importance. Review the sites given below and write a brief essay (800-1000) '*Biodiversity its definition, measuremen, rolet and distribution*'.

http://en.wikipedia.org/wiki/Biodiversity

XV. Synthesis Of The Module

By the end of this module you are expected to differentiate the levels of organization used in ecology including the individual, population, community, ecosystem and biome. You are also expected to understand the important concept of the ecosystem which consists of an interacting system of communities and their non-living physical environment. From the second unit on population ecology you are expected to understand the process of natural selection which leads to a population adapting to its environment through differences in reproductive success. Speciation which is due to sections of the population being isolated as result of a barriers such as geographical barriers. In population ecology you also studied models of growth namely exponential growth model and logistic model. You should also know the interactions between populations which include competition, predation, ammensalism, mutualism, parasitism, or commensalism. Unit three was community ecology. Parameters that are used to define the structure of a community include composition, abundance, dominance, stratification and trophic structure. A community is dynamic and you studied the process of ecological succession, which proceeds through stages referred to as seres and culminates in a climax community. You also studied the key vegetation communities of Africa, concentrating on their adaptive trends and factors that govern their structure and function. This included afroalpine vegetation, savannas, forests, wetlands and mangroves. In the fourth unit you studied ecosytem ecology. From this unit you are expected to understand the factors that influence both terrestrial primary production such as photosynthentic type, environmental factors and herbivory while those of aquatic systems include light, nutrients and thermal stratification. You also expected to understand the concept of trophic levels and energy flow through the ecosystem. Nutrients unlike energy move through the ecosystem through characteristic pathways called the biogeochemical cycles. The important components of the biogeochemical cycle include pools, nutrient pathways such as intake and decomposition. Nutrients enter and leave the biogeochemical cycles trough geologic, meteorological and biologic pathways. In the last unit you studied natural resource conservation. From this unit you are expected to understand the terms species diversity and biodiversity. We looked at types of species conservation of including captive breeding programmes and re-introductions. We also looked at ecosystem conservation through nature reserves and important considerations in their creation such as size and migration. You also expected to understand patterns of degradation in key African habitats such savannas, forests and marine communities.

XV. Summative Evaluation

Unit 1.0 Introduction and basic concepts

(a) Define an ecosystem and give an example
(b) Briefly discuss Raunkiar's system of plant classification
(c) Outline how solar radiation reaching the earth's troposphere is partitioned
(d) Describe the 5 main branches of ecology
(e) Discuss the Inter Tropical Convergence Zone (ITCZ) and its influence on rainfall patterns in Africa

Unit 2.0 Population ecology

(a) What is selection pressure?
(b) State three factors that can lead to population isolation or fragmentation
(c) State the Darwinian theory of natural selection, how does relate to the modern concept
(d) How does commensalism differ from mutualism?, how do predation and parasitism differ.

Unit 3.0 Community ecology

(a) Define the term niche and distinguish between fundamental and realized niche
(b) List the shortcomings of Clements deterministic succession theory
(c) Discuss morphological and physiological adaptations of mangroves
(d) Outline the factors that determine the structure of African grasslands
(e) Outline the adaptations of afroalpine flora to low temperature
(f) To assess the vegetation structure of Ngororo a transect measuring 5m x 10m was laid out and divided into 5 equal quadrats from which the following data was collected

Species	Quadrat No.	Basal area (cm2)
Commiphora baluensis	1	10
Commiphora baluensis	1	10
Maerua triphyla	1	20
Maerua triphyla	2	5
Balanites aegypitiaca	2	10
Commiphora baluensis	3	20
Balanites aegypitiaca	4	5
Maerua triphyla	5	10
Maerua triphyla	5	10

(Note that each species recording indicates a single individual, also the basal area has already been calculated)

1. Determine tree density (individuals/ha) of Maerua triphyla - show your computational procedures clearly.
2. Determine Importance Value of **Commiphora baluensis** - show your computational procedures clearly

Unit 4.0 Ecosystem ecology

(a) Outline the hydrologic cycle in terrestrial ecosystems. How does it influence nutrient budgets How do humans alter the hydrological cycle?
(b) What is a trophic level in a community of organisms
(c) List and explain the five steps in the nitrogen cycle.
(d) Papyrus in was found to have a calorific value of 20mj/kg, its net primary production was 6.6kg/m2/yr and solar radiation at the site was 18.2mj/m2/day. Determine the efficiency of primary production of papyrus.
(e) In a pond measuring 6ha the producers contained 100 units of Nitrogen while the water contained 1000units. The transfer rate from the water to the producers eas 20units/day. Determine the absolute flux rate, turnover rate and turnover time.

Unit 5.0 Natural Resource Conservation

(a) Differentiate between alpha and beta diversity
(b) Describe the four levels of risk to extinction recognised by world conservation union (IUCN)
(c) Outline the impacts of pastoralism on community structure, productivity and nutrient cycling
(d) What the key functions of African forests and what would be consequences of deforestation

Answers To Summative Evaluation

Unit 1.0 Introduction and basic concepts

(a) An ecosystem consists of communities and their environment. Interactions at the ecosystem level include those among the organisms of the community and those between the organism and the physical environment.
(b) Raunkiar's system of plant classification: Raunkiaer used the height of the perennating tissue from the ground surface as an indicator of adaptation to the environment. The classes obtained include; Phanerophytes , Epiphytes Hemicryptophytes Chamaephytes Cryptophytes and Therophytes
(c) Partitioning of solar radiation: On reaching the earth's troposphere 42% is reflected from clouds and dust particles, 48% reaches the earth's surface and 10% is absorbed by the atmosphere.
(d) The 5 main branches of ecology include; Ecophysiology (or Physiolo-

gical ecology), Autecology or population ecology, Community ecology or synecology, Ecosystem ecology, and Landscape ecology.

(e) The Inter Tropical Convergence Zone (ITCZ): (1) This is the low-pressure zone where cold winds from high-pressure belts converge (2) Convergence of winds at the ITCZ brings about precipitation (3) The ITCZ is not confined to the equator it moves from latitude 15∞S to 15 ∞N following the movement of the sun as moves from being overhead the tropic of Capricorn to that of Cancer but with a time lag of one month.

Unit 2.0 Population ecology

(a) Selective pressure: This are factors such environmental conditions that select for certain characteristics of individuals and selects against those of others.

(b) Factors leading population isolation: lack of compatible partners, geographical barriers and large differences in temperature or moisture between areas

(c) Darwinian and modern concepts of natural selection: Darwinian concept emphasizes that well adapted species survive to reproduce and contribute to the population gene pool while in the modern concept of natural selection emphasizes is on differential reproduction rather than differential survival.

(d) In commensalism one population gains and the other is unaffected while in mutualism both populations benefit. In parasitism one population, the host, loses while the other population the parasite gains while predation is the consumption of one species (the prey) by another (the predator).

Unit 3.0 Community ecology

(a) The niche: The niche is the functional role of the organism in the ecosystem plus its position and space. The fundamental niche refers to the fraction of the community hypervolume a species occupies in the absence of competition while the realized is one occupied in the face of competition from other species.

(b) Short comings of succession theory: (1) No clear cut stages between stages (2) The role of site modification is overemphasized (3) No two patches of vegetation are similar hence succession proceeds differently (4) Natural catastrophic events prevent stability (5) man's activities also prevent stability

(c) Morphological and physiological adaptations of mangroves: Adaptations to high salinity: salt excretion through special glands, tolerance without internal injury, salt accumulation in leafs and dropping them. **Adaptations to unstable substrate**: For seed establishment, mangroves are viviparous developing a long hypocotyl that lodges itself upright. For aeration and support mangroves have; prop roots, aerial roots, pneumatophores and knee roots.

(d) Determinants of structure of African grasslands: (1) **Physical factors**; such as rainfall, soils and temperature (2) **Grazing**; factors such as herbivore density, movement, composition (3) **Fire**; its frequency and intensity (4) **cultivation**

(e) Adaptations of afroalpine flora to low temperature :Plants have following adaptations (1) Giant leaf rosettes whose leaf arrangement protects the primordia (2) Layers of persistent dead leafs on the stems (3) Big grass tussocks

(f)

a. Density of *Maerua triphhyla* = 10000 x 4/50 = 800 individuals/ha

b. Importance value of *Commiphora baluensis*:

i. Relative density= 600/1800 x 100 = 33.3%,

ii. Relative dominance= 40/100 x 100= 40%,

iii. Relative frequency= 0.4/(0.4+0.6+0.4)= 42.8%.

iv. Importance Value= Relative density+relative frequency+relative dominance= 33.3+42.8+40=116.1

Unit 4.0 Ecosystem ecology

(a) Hydrologic cycle and its influence on nutrient budgets: hydrologic cycle simplified below as:P=E+T+R+I. Where P=precipitation, E=evaporation, T=transpiration, R=runoff, I=infiltration (downward entry of into the soil). Nutrient budgets are strongly correlated with the hydrologic cycle in that precipitation carries nutrients in solution, runoff and infiltration remove nutrients from the ecosystem or move them down the soil column, and evapotranspiration of water concentrates and conserves nutrients.

(b) Trophic levels: The result of grouping species based on feeding relationships, the feeding levels include Autotrophs, Decomposers, Herbivores and carnivores, and Omnivores.

(c) Steps in the Nitrogen cycle: (1) Nitrogen fixation; this is the conversion of atmospheric nitrogen to chemical compounds (2) Uptake and protein synthesis: Nitrates are taken by plants from the soil water solution and subsequently incorporated into protoplasm in the process of protein synthesis (3) Ammonification: After death plants and animals undergo the process of decomposition. Ammonia is produced from the amino acids by the action ammonifying bacteria. (4) Nitrification: This is the biological oxidation of ammonia to nitrites and nitrates. (5) Denitrification: Nitrogen is returned to its atmospheric form in the process.

(d) Efficiency of primary production: Energy bound = 6.6kg/m^2 x 20mj kg^{-1}; Energy received per annuam = 18.2mj m^{-2} day^{-1} x 365 days; efficiency of primary production= 132.2/6643 mjm^{-2} yr^{-1} = 1.98%

(e) Calculation of flux rates: Absolute flux rate= 20 units day^{-1}/6 ha = 3.3 units ha^{-1} day^{-1}; Turnover rate= 20units/1000=0.02; Turnover time= 1000 uints/20units day^{-1}= 50days

Unit 5.0: Natural resource conservation

(a) Alpha and Beta diversity: Alpha diversity is the number of species within a selected area or community. While Beta diversity is the difference in species diversity between different areas or communities.

(b) Levels of risk extinction: (1) Rare; species have small populations in restricted areas and becoming rarer (2) Vulnerable; species under threat or population has not recovered from previous over exploitation (3)Endangered; species has a very low population size (4) Extinct: species no longer exists

(c) Impacts of pastoralism: pastorallism has both negative and positive impacts depending on the grazing intensity (1) Alters plant community structure because animals graze selectively (2)Alters productivity; at low to moderate levels of grazing may increase net productivity while at high grazing intensities productivity is lowered. (3) Transportation of nutrients in the ecosystem (that is, through fecal deposits) this alters spatial patterns of soil fertility and favours increase in plant diversity (4) When overgrazing occurs it leads to increase soil erosion and eventually decline in productivity

(d) Key functions of forests and effects of deforestation: Functions include temperature regulation, flood control, regulates nutrient cycling, regulate soil erosion and water cycles. Effects of deforestation include; recurrent floods and disruption of local climatic patterns, increased soil erosion and loss of forest soil fertility and loss of biodiversity.

XVII. References

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XVIII. Students Records

Name of the EXCEL file :

Name of student	Score in learning activity 1	Score in learning activity 2	Score in learning activity 3	Score in learning activity 4	Score in learning activity 5	Score in the summative evaluation

XIX. Main Author of the Module

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