# Walter’s Vegetation of the Earth

The Ecological Systems of the Geo-Biosphere

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# Introduction and Remarks

## 1 Aims of Ecological Science

From our present knowledge, life occurs only on Earth within the solar system, and depends on processes involving open cycles of fluxes of matter coupled with energy fluxes, i.e. the synthesis of materials, driven by solar energy, and the degradation of the material with the accumulated energy usually released as heat.

The smallest autonomous unit of life is the cell. Its structure and function are investigated by the sciences of molecular biology, biochemistry and physiology, which include analysing ultrastructures with the latest techniques as well as the understanding and manipulation of genetic material.

Green plants, algae and bacteria, which photosynthesise, are autotrophic and their metabolism leads to the accumulation of matter and energy in the biosphere. In contrast to all other organisms (including non-green plants, fungi, bacteria and others), which are heterotrophic and their metabolism leads to the loss of matter and energy from the atmosphere. Single cell micro-organisms are the primary targets of the science of microbiology; fungi are now usually classified as a separate group of organisms and are the subject of the discipline of mycology. The next level of organisation is the multi-cellular organism with its tissues and organs.

Ecology, as a biological science, deals with the interactions of organisms and their environment. Ecological factors affect the different levels of complexity, of course, even at the molecular level (Table 1) and cause certain effects and interactions. At the level of the individual, adaptation results from modification, mutation and selection, the topic of investigation of **autoecology.** At the level of ecosystems, these adaptations are expressed as continuously changing structures of populations and continuously changing dynamics of metabolic cycles and energy flows. Populations are investigated in the field of **population ecology.** Whilst **synecology** considers communities and their composition (static analysis), **ecosystem biology** researches the dy-

**Table 1.** Different levels of complexity and examples of what affects them

| Level of complexity | Example of responses, possible effects of environmental conditions |
|---|---|
| Interactions and effects in biomes within the biosphere (large scale ecosystems) | Cycles of materials, balances of matter, energy fluxes, sedimentation, accumulation of eroded material in basins, geomorphic long-term processes |
| Interactions and effects in ecosystems | Acquisition, cycles, balances and accumulation of materials, species composition (frequency and dominance) |
| Effects on populations | Reproduction, age distribution, competitive ability, selection |
| Interactions with intact, whole plants, individuals | Mineral metabolism, fitness and vigour, water balance, adaptation of growth, developmental stages, hormone balances |
| Interactions with cells | Developmental effects, changes in differentiation, accelerated senescence |
| Interaction with tissues | Effects of stresses (e.g. osmotic and ionic concentration) on development, including damage |
| Effects on cell organelles | Respiration, photosynthesis, biosynthesis of secondary plant metabolites |
| Effects on biomembranes | Permeability, changes in potential |
| Biological effects on macromolecules | Gene regulation, enzyme activity, changes to DNA |

namics of communities and, thus, the characteristics which cause energy flows and metabolic cycles.

The highest units of life are the communities of organisms, plants and animals which, together with abiotic environmental factors (climate and soil, see p. 19, 33), form ecosystems. These are characterised by a continuous cycling of material and flow of energy. Ecology, in the widest sense of the word, is the science of these ecosystems, from the very smallest to the global level – the biosphere.

This book is intended to serve as a brief comprehensive introduction to this global ecological system.

Walter, the initial author of this book, expressed the relation between human beings and biosphere as follows:

> “The biosphere comprises the natural world in which man has been placed and which, thanks to his mental capacities, he is able to regard objectively, thus raising himself above it. On the one hand, he is a child of this external, apparent world, and dependent upon nature, but on the other hand, through the world within himself, has access to the divine.

> Only an awareness of both sides of his nature enables man to develop into a wise and harmonious being with the hope of divine fulfilment upon death. It is not the sole calling of man to use nature to his own ends. He also bears the responsibility for maintaining the earth's ecological equilibrium, of tending and preserving it to the best of his ability."

If man is to fulfil this task and not exploit the environment in a way which, in the long run, jeopardises his own existence, he has to recognise the ecological laws of nature and act upon them, even if, at times, there are people who believe that they can do away with nature and rely completely on technology.

We shall limit our observations to the conditions in natural ecosystems, since it would be beyond the scope of this book to embark upon the consideration of secondary, man-made ecosystems and to consider the various degradation stages in detail. Ecological laws of nature can be better understood in natural ecosystems, which are also in a dynamic equilibrium. Natural ecosystems are the model and the reference point for sustainability. They have become optimised over millions of years of evolution.

## 2 Significance of Present-Day Ecology as a Philosophy

Ecology is a part of biology, namely the science of the management of nature and – as formulated by HAECKEL (1866) – the science of the relation of organisms to their surrounding environment.

The population, as a whole, has only become aware of the importance of ecology during the last two decades. However, ecology has changed completely with the advance of the "green movement". The prefix "eco" has been added to terms which are not at all related to the science of ecology and has, in part, become embellished as a type of saviour religion. In ecology there are no value judgements: a natural catastrophe is, in the ecological sense, nothing bad. A hurricane, a tsunami, hail, invasion of savannas by woody vegetation, fires in the steppe, all these are natural processes. They are part of the natural dynamics, which, however, man can now significantly modify and thus affect nature beyond the local scale via global mechanisms.

These processes are immediately awarded value judgements if they negatively change the conditions of life and the environment of humans. To understand the laws of

Scientific ecology is now defined comprehensively as the "science of the interactions of organisms with each other and with their environment".

The term 'ecological' is commonly used in advertising to imply healthy and wholesome (organic) foods and ways of production and living. It is frequently only make-believe or deception for the general public. Where is the rational thinking against consumerism and indoctrination by advertising?

ecology it is important to first consider situations in the abstract and only in a second or third step evaluate the "ecological effect on humans".

Today, it appears even more important to work with clearly defined terms and concepts which, if at all possible, should be used by all biologists and natural scientists, otherwise it is impossible to avoid misunderstandings. The handbook of ecology (Kuttler 1995) is an important step forward in this area.

## 3 Human Impact on Ecosystems

The human impact on ecosystems, world-wide, is now very substantial and rapid with the loss of habitats for organisms which have adapted to particular conditions over very long periods, This has resulted in reductions in the extent of ecosystems and a huge decrease in the number of individual organisms, loss of biodiversity in ecosystems and extinction of species. This trend is exemplified by the impact of humans on tropical ecosystems and particularly forests.

No other community on our continents is so colourful and varied with in such an unbelievable richness of species and interlinked processes as the tropical rain forest. Indeed, tropical ecology is of great importance for research and teaching. The twentieth century is characterised by the accelerated destruction of tropical forests: monotonous fields, pastures for grazing, banana or coffee plantations and settlements have eaten into the forests. The exploitation is well documented. Biodiversity is being lost at an increasing rate. Many species will be lost forever without ever having been recognised and researched or they have already become extinct. The conviction that tropical forests must be maintained because of their enormous genetic potential and their global importance for climate and soil is only slowly gaining ground.

A fraction of the research spent world-wide for nuclear physics, gene technology or research in the Antarctic would greatly improve the situation of tropical ecology in developing countries.

The discipline of ecology was largely developed in temperate climates, initially in Europe. The importance and fascination of tropical forests were recognised early; for example, Alexander von Humboldt paved the way for modern developments on this topic (Schaller 1993). However, current interest and research in tropical ecology are still relatively small, given the magnitude of the problem. A large scientific effort is required to understand the often much greater biodiversity and the enormously varied interactions associated with tropical ecosystems. Tropical ecology should be significantly strengthened through its own university departments and centres of research. Without a broad basis in tropical ecological research there will be no well-founded teaching relating to this vital area of global ecology.

Ecological principles can, of course, also be understood in temperate climates, for example in Europe, an area which has only been sparsely colonised by plants since the last ice age. However, this understanding helps students little in the tropics with the variety of species and the complex interactions, particularly in tropical forests.

Ecological principles should now be part of our general education and tropical ecology is an important part of this discipline, as it touches the basis of human life. A corresponding system of education is required to enable objective and comprehensive actions.

Ecology, including tropical ecology, should be a core subject in universities, not only for natural scientists.

## 4 Significance of Systematics and Taxonomy for Biology

The destruction of tropical ecosystems not only increases degraded areas and renders them infertile because of erosion, much more important is the loss of biodiversity (Boerboom & Wiersum 1983). This destruction leads to an over-proportional loss of plant and animal species on our globe and the corresponding finely tuned communities of organisms. The rate of loss of species through the destruction of jungles is proceeding much faster than the extinction of the dinosaurs or the changes during the ice ages.

At present, about 1.5 million animal and plant species have been described, i.e. scientifically documented. This is probably only a fraction of all the species living on the globe. Using different methods of determination, the diversity of particular areas can be established through extrapolation leading to values of 5 to 10 million species. Other attempts, such as fractal geometry, result in a value of 30 million. It is difficult to evaluate real numbers, but the material from every new expedition to the tropics leads to a wealth of new species. Scientific evaluation of the material often limps years behind. The number of specialists with detailed knowledge of animal and plant groups is so small that they cannot cope with processing the material, and most of it remains unanalysed. Systematic grouping, exact taxonomic descriptions and especially the phylogenetic connections are known only roughly for many animal groups. The scientific assessment is significantly better for higher plants and this is because there are fewer species. However, many more new species are to

Systems and taxonomy are the essential basis of understanding between biological disciplines. Systematics brings order into diversity. Systematics must provide a fixed framework for the understanding, but also a flexible framework for progress in phylogenetics. Without well-funded methods in systematics and taxonomy not only ecology but all biology drifts without a point of reference.

be expected for algae, and even more so for fungi, so it is important that teaching and research into systematics should be considerably enhanced and re-introduced where lost. Although all biologists work with organisms, some researchers give the impression that they do not know with which organism they are actually working, and the importance of phylogenetic connections.

As GAMS states: "All knowledge of different sub-disciplines of biology, and where possible all characteristics, should, in the end, be used to arrive at a better understanding of how organisms function in the natural world" (personal communication).

Systematics is the biological science of the future. However, it remains questionable, whether world-wide there is sufficient investment in the topic. Perhaps the international umbrella organisation DIVERSITAS will help to reduce some of the gaps.

## 5 Importance of Scientific Documentation

Museums have the responsibility to collect and mark material and, above all, to document it and describe relationships and processes scientifically and present the importance of it to the public.

Documentation is very important for the systematic taxonomic analysis of biodiversity. The material upon which the description of a species is based, the type of specimen, must be kept as an important basis for documentation in museums or large herbaria.

Catalogues and taxonomic listings, keys for identification, aerial maps of distribution etc. may be stored electronically and provide ready access via the internet or other means. The speed and extent of these developments will depend on the number of scientists engaged in this area and thus on the priorities and the political will.

There are still many amateur scientists who deal with certain groups of organisms in their leisure time. Many of these private collectors possess valuable small collections which would enhance existing museum collections. However, museums must be able to accept these, either as donations, or even purchase them; this is often not possible because of financial constraints or the lack of personnel and space resources. Much valuable material, which is perhaps no longer obtainable, is thrown away.

# 6 Importance of Excursions for Young Scientists

Students can only really understand the biology of organisms if they are given the opportunity to study organisms in their environment. Many universities no longer include excursions as part of the syllabus. Many biologists do not have the opportunity to participate in excursions and benefit from this intensive way of learning, which not only brings biological but also general scientific knowledge. It is insufficient to only **watch** how something is presented in a film on television. It is vital to **see**, **grasp** and **recognise** connections, for example the geological and the geomorphological situation, the possibility of agriculture and forestry in the area, fauna and flora and their interdependence, the time and space dynamics of producers, consumers and the degradation processes, phenology of the historic basis of the development of the landscape, the possibility of sustainability – all this can be explained much better to students standing on a hill. However, do faculties (or ministries) still want this nowadays? Biology without a significant part of environmental biology experienced first hand during excursions is an amputated biology. During excursions, participants stand in the midst of the events. Only then can students understand the ecology and even confront perceived dangers and take suitable preventative measures without experiencing frightened hysteria (for example against ticks). Only then do students learn to move in nature according to nature's laws.

Excursions are the most intensive form of learning. Students learn, by analysis using all the senses, to synthesise and understand the links and connections between the organism and the environment from which they develop, the concepts, vision and understanding of the whole ecosystem.

## Questions

1. *Why is basic knowledge of biological systematics indispensable for all biologists?*
2. *How many species of animals and plants exist?*
3. *What is the value of high biodiversity?*
4. *At which level of complexity in biology do ecologists work?*
5. *What is an ecological catastrophe?*
6. *What is the objective of museums of natural science?*
7. *Why are excursions a 'must' in the training of biologists?*
8. *Is it possible to classify plants and animals on the computer?*
9. *What are the differences between phylogenetics, systematics, taxonomy and nomenclature?*
10. *What are the most important differences in teaching biology in the laboratory and in the natural environment?*