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Landscape Ecology; Concept, Principles and Its Relation to Monothematic (e.g. Vegetation) Survey

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경관생태학의 개념, 원리 및 식생조사와의 관계

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ABSTRACT

Land (scape) ecology is a trans-disciplinary science studying the related systems at the earth surface, in their visual, structural and functional aspects. It serves as an umbrella under which abiotic and biotic sciences, in an integrated way, study the for each relevant land attributes and their interrelations. The spatial aspects of these relations have a special interest. Landscape ecology may have a pure scientific purpose, but usually is executed in an applied context, related to land evaluation for land use and conservation. Depending on the aim and application of the study, one of the land attributes may get special attention. Vegetation mapping may contribute to landscape ecological study but also benefit from it especially in case of reconnaissance surveys. This is because in less detailed surveys of any land attribute, like land form, soil, vegetation, one must necessarily apply landscape ecological principles in the survey methodology, including remote sensing.

Key words: Application for land evaluation, Land, Landscape approach to vegetation, Land(scape) as ecosystem, Landscape ecology, Trans-disciplinary science.

INTRODUCTION

Landscape ecology is a "trans-disciplinary" science (Naveh and Lieberman 1984). That means it serves as an umbrella under which various (abiotic and biotic) science act in an integrated way (Troll 1950). The subject is the Land or Landscape which is the recognizable three dimensional relation system at the earth surface dealing with the abiotic and biotic components and forces. The various earth science as, geology, soil science, geomorphology, hydrology, vegetation science and the various applied science dealing with agronomy, agrostology, forestry, land evaluation act under these umbrella, each dealing with the relevant land attributes and their interrelations(Fig. 1).

An important aspect is that it requires and stimulates a state of mind (Zonneveld 1995) focused on the (landscape) system as a whole rather than at the separate (land) attributes as soil, rock, vegetation etc. It is a relative young discipline nevertheless with a clear scientific and philosophical basis.

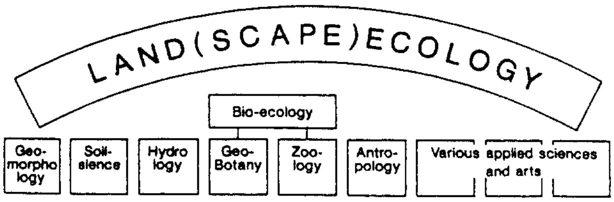


Fig. 1. The transdisciplinary science.

"It is a science because (see Cramer *et al.* 1984) it is methodological, it channels knowledge based on empirically observed facts and phenomena and is based upon understanding acquired by systematically ordering observed data and by connecting and associating these with each other via mental activity. Because there is more than one mind active in its development, there is the possibility of both consensus and also differences of opinion being stimulated to further its development. Any group of scientists must have this type of stimulus as one of their main aims whenever they associate in either a formal or an informal setting (see Zonneveld 1995). Science is generally subdivided into many areas. The boundaries between these areas are rather vague, but for practical reasons a subdivision into separate scientific fields is necessary. This scientific continuum, however, results in a rather strong overlap between science and hence between the members of scientific associations".

Apparent overlaps of ladnscape ecology with other disciplines should be interpreted, however, as a result of the mentioned "trans-disciplinary" character. The attitude and viewpoint of the scientist concerned may differ considerably from those of others dealing with related sciences with which overlap would be supposed. This might be a personal landscape ecological "paradigm" or a whole set of subjects, theories, methods assumptions applied by scientists active in particular fields.

A social network of researchers and the contacts they have with each other, is crucial for the development of any science. This contact is sustained through associations that organize written tools (articles in specialized journals, but especially through meetings, congresses, symposia (a Greek word meaning literally: "to drink together"). This social personal contact is important for creating a firm paradigm, which is often enhanced by the influence of strong personalities, who may well affect the direction of the science (Cramer *et al.* 1984, Theory Werkgroep, WLO 1986, Jan Zonneveld 1985a, Zonneveld 1995). Landscape ecology is supported by such a social network which brings scientists together from all over the world under the auspicious of the International Association for Landscape Ecology (IALE). The Korean Network of Landscape Ecology (KNLE) that brings us here is a recent member of this international grouping. A journal "LANDSCAPE ECOLOGY" has been created and many local, regional and international symposia have been organized in the mean time. The various groups in many countries communicate and encourage social interaction that provides the impetus for die development and definition of science, cultivating and cherishing a growing paradigm (Brandt and Aggar 1984, Tjallingii and de Veer 1982, Rickler and Schönfelder 1986, Slovak Academy of Science 1985, Ruzicka 1987, Zonneveld and Forman 1989, Moss 1988, Schreiber 1988).

LAND AND LANDSCAPE

The subject of study in landscape ecology is the land or the landscape, its form, function and genesis. The English word 'landscape' seems to have evolved relatively recently from the Dutch word 'landschap' through Dutch landscape painting ('Landschappen' =paintings depicting sceneries). The terms in German and Dutch, "Landschaft" and "landschap", have gradually developed from a mere indication of an area somewhere in space (the Greek *chore*-an area according to its place) to the character of an area according to its contents (Greek *topos*) (see Schmithüsen 1963, 1974 , Neef 1967). 'Landschaft' and landscape are often used synonymously with 'land' of which it has been from the beginning on a synonym and is always closely related to it and so is its English

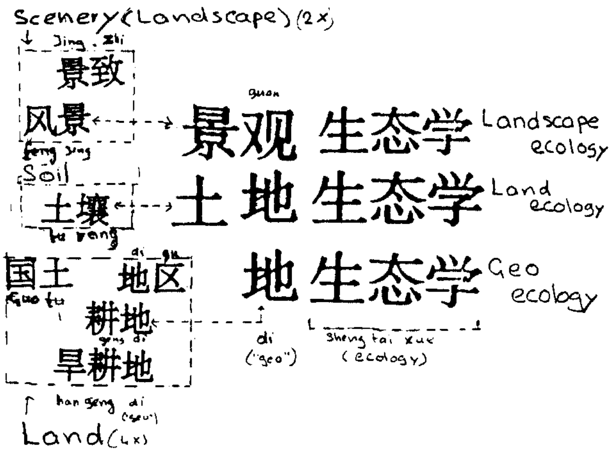


Fig. 2. Landscape, land, soil in Chinese characters.

translation "Landscape"

Still the dutch derived English term "landscape" has caused quite some confusion as it may also be synonymous to "scenery" and as such more related to the visual or even the aesthetic aspect of the land rather than the functional system aspects. This has given problems in the translation to other languages.

A good illustration of the confusion is the experience told by our Japanese colleagues. The Chinese character for Landscape ("jing") is apparently more or less synonym with "painting" or "work of art". It has nothing in common with the character for Land or soil or other tangible aspect of the correlative complex ("geng", "di", "tu", see' Fig. 2).

Aspirant students attracted by the suggestion of art and beauty, become disappointed, after the first lecture, about abiotic and biotic relations in the land ecosystem.

Contrary but equally mislead by the term landscape, my own students and colleagues, coming from developing countries, were reluctant to follow lectures on landscape ecology, as they considered aesthetic for their countries a luxus. After an explanation, we agreed on "LAND ECOLOGY", a term that I still use ever since as a synonym (see Zonneveld 1995). It is however too late to propagate to abandon the term LANDSCAPE ECOLOGY for that.

Not only the bias about aesthetics (mainly the perception aspect) has been a burden. Also the restriction to horizontal (flat) heterogeneity (pattern), can be dangerous: It would cut out the heart of our discipline including its major applications fields as land evaluation. There have been indeed periods that I together with more colleagues of our generation were worried about a paradigm-shift to that too "flat" (two dimensional) approach.

It can however be observed that the increased attention for the study of relations between the horizontal pattern elements, has also greatly stimulated the exact study of land(scape) as the correlative complex at the earth surface. The Island Theory came just in time to support this development.

Hence some confusion about the double-Dutch term "landscape" did not only work negatively. Also it opened the eyes of many landscape architects who found a firm concise scientific base for their applied work. It contributed to the fruitful very diverse composition of the membership of IALE.

A similar conclusion can be drawn from the also existing confusion about the term "ecology". The geographer Carl Troll, who introduced the term "Landschaftsökologie" (Landscape ecology) as used in the classic German philosophy where it is not strictly confined to the household ("oikos") in strict biological sense but also includes relations of abiotic nature (compare also "eco"nomy) (Troll 1950). It attracted because of that term however quite some pure biologist including zoologist (Merriam 1984, 1987, Forman 1982, Opdam 1988) and many more, who developed bright ideas about the biological processes at landscape scale. Vegetation scientist (who naturally are already more "earth bound") contributed from the beginning on.

Landscape ecologists are, concerned about land or landscape from three different points of view that however cannot really be separated.

The first of these is the perception (mainly visual) aspect of landscape (the German "Landschaftsbild") or landscape as scenery. This viewpoint is dominant in that type of landscape architecture that is focused

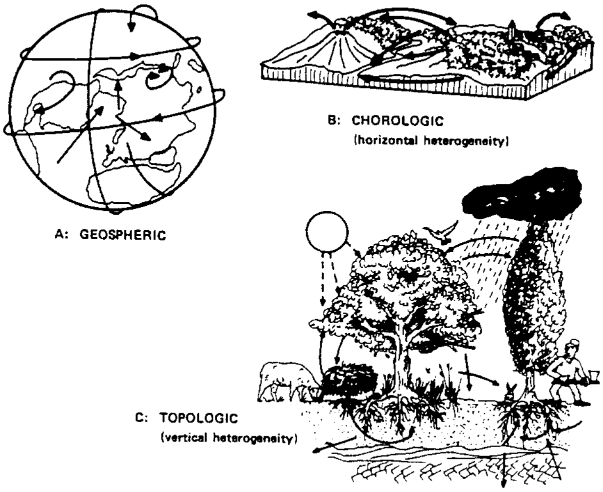


Fig. 3. Landscape ecology dimensions.

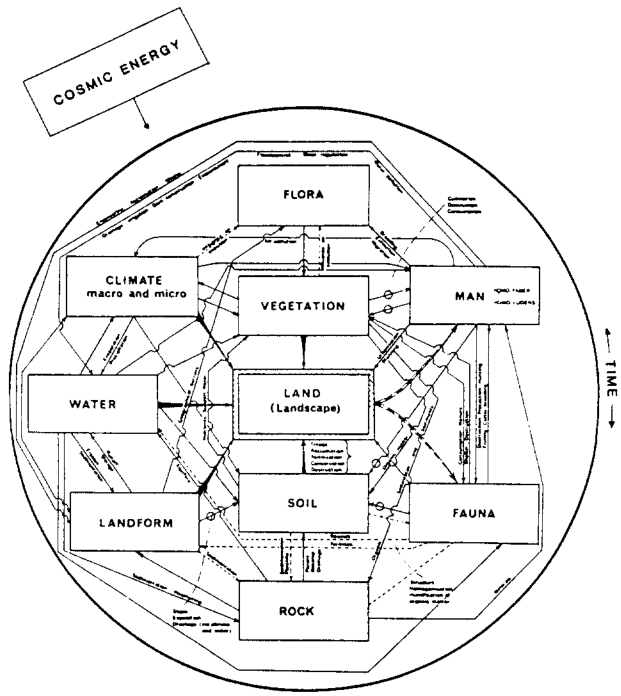


Fig. 4. Land(scape) as ecosystem.

on the aesthetic aspect. It has become, moreover, an important diagnostic characteristic of land (Bartkowsky 1984, Zonneveld 1995).

The second viewpoint is the chorologic aspect presented by a conglomerate of land attribute units or map patterns (Fig. 3.b).

In the various earth sciences, as well as in vegetation science, the concept of landscape is used to indicate the pattern of individual surface patches belonging to each of the land attributes that are the subjects of thew sciences.

Surveyors used since long ago already to speak about geologic-, soil- and vegetation- landscape, indicating map units on a relatively small (generalized) mapping scale. These remain the units of relatively small-scale map legends.

The third point of view is that of the landscape as an ecosystem (Fig. 4, Jan Zonneveld 1985b). This is the most comprehensive concept and includes the first and second one. It expresses the open system at the Earth's surface formed by all factors acting there, the physical as well as the biological and noospheric ones. They form complex three dimensional phenomena, which can be recognized visually as showing both a horizontal pattern of mutually related elements, the units of land ("land units"), and vertically, interrelated strata, the so-called land attributes. These land attributes are the atmosphere/climate, rock, landform, soil, water, vegetation, fauna and the noospheric aspect of humans. The mentioned three-dimensional units may change in time and thus also have a forth dimension.

While each separate science (geology, soil science, etc.) selects a stratum for study and considers the others as 'forming factors' for its own selected attribute, landscape ecology takes the vertical heterogeneity formed by all land attributes as a holistic object of a study. This is one of the main characteristics of the subject of landscape ecology. That system-(holistic) approach includes also the chorologic pattern. That is a equally important characteristic of our trans-disciplinary science. The spatial heterogeneity within that whole, horizontally as well as vertically, is the major subject of studies in landscape ecology (Fig. 5).

This approach may also be viewed as a translation of the way farmers, hunters, herder and other outdoors people perceive land. Their notion of the

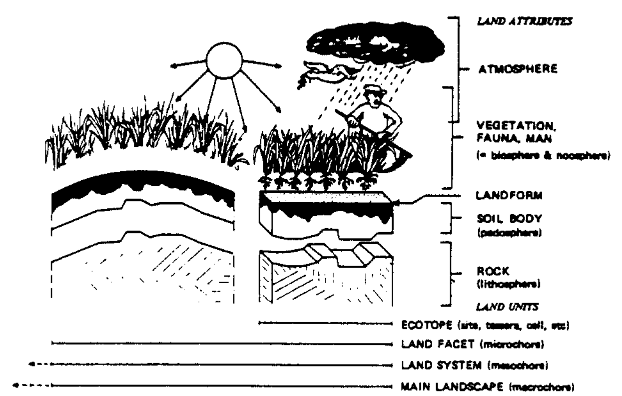


Fig. 5. Horizontal and vertical heterogeneity in landscape as the subject of landscape ecology.

land is synonymous with the 'landscape as an ecosystem' viewpoint and represents a very old concept which has developed gradually since early humans became aware of their dependence on the environment. Along the same lines the landscape units recognized from a pre-scientific era can still be used by modern science. They may even bear names dating from before recorded history. Many of the older toponyms in all languages refer to land units as defined by a combination of landform, vegetation, soil condition and often also land use.

Toponymic studies often reveal landscape ecological information. Toponymes can also derive from languages that disappeared long ago. From the many thousands of such land unit toponyms some examples of typical river landscape terms would include "dambo"(Swahili), "fadama"(Hausa), "waard" (Dutch). Dutch topography has inspired a number of more discriminative toponyms including "schor" and "kwelder", for marine or estuarine tidal foreland with a closed halophytic to brackish vegetation. For a relatively dry area within raised peatbogs (often a former land dune ridge, with a humic podzol, the term "haar" is common.

Alp in German is a grazed mountain meadow. Many of these are short words, even monosyllabic, suggesting that they have been in use for a very long time. von Humboldt, the early geographer defined landscape very concisely as "das Totalkarakter einer Erdgegend (the total character of a patch of the earth). Only in the last century did we learn to study landscape by following the methods of the more analytical, but separate, science. Then the study of the land as a total system became neglected. It is only now being revived by modern landscape ecologists.

THE MAIN SCOPE OF LANDSCAPE ECOLOGY AND ITS RELATIONSHIP TO OTHER DISCIPLINES

Scientists embracing this emerging paradigm come from quite different directions and, in the beginning, their only point of contact was the term 'landscape ecology'. They did however usually have quite different ideas about the concept of 'landscape' as well as the concept of "ecology", nevertheless the origin of landscape ecology as a discipline can be traced back to Troll (1950). It can be described as a marriage of geography and biology. Troll, after studying biology, became a geographer, he was impressed by the ecosystem concept as defined by the biologist Tansly, and by the comprehensive view of landscape units as depicted in aerial photographs. Since Troll, geographers as well as biologists can be found in the network, and so too are landscape architects, soil scientists, regional planners, foresters, agronomists and conservationists of all kinds. Each necessarily brings his or her own biased view on what land, landscape and ecology are, and consequent what the term landscape ecology means to them.

This heterogeneity is not a drawback, it is core of the paradigm, because a comprehensive view of the land(scape) is stimulated by this diversity, provided that this heterogeneity centuries around a basic concept. This concept is necessarily the holistic view of the landscape as an ecosystem. In the past, the vertical and horizontal heterogeneity of landscape split the study of land into many disciplines served by a variety of sciences. In landscape ecology, however, this vertical and horizontal heterogeneity within landscape is the principal subject of study, indeed the essence of landscape ecology (Risser *et al.* 1984). On the one hand there is the definition, the description of structure, function and change of smallest units of land as tangible ecosystem. In a horizontal sense these basic units are relatively homogeneous, but they are spatially defined, and any study requires cooperation among at least soil science, vegetation science, hydrology and often other disciplines in the holistic assessment of vertical relationships within the units. Yet if the topologic study of the vertical relationships of a single land unit were the main aim of study, it would still require at least comparison with other land units for the sake of classification.

Without mapping, such topologic studies would be of little value. Every vegetation (and soil-) surveyor knows that the study of pattern - distribution relative to other land attributes - is one of the most essential avenues for understanding the ecologic relationships among soil, vegetation and (topo) climate in each single element of those patterns. This is a clear prove that the study of both the horizontal (chorologic) vertical (topologic) relationships together is essential for landscape ecology.

(Also the relation between landscape ecology and methodology in vegetation survey is clear from this, see blow).

Landscape systems, moreover, are open systems, so a single unit can be described successfully only if the influences of other spatially linked components are also considered. Vegetation-and soil scientists became aware of this long ago, and among them a many landscape ecologists "avant la lettre", acting before they realized they were "committing" landscape ecology. A clear example of this is the European school of the French-Swiss phytosociologist Braun-Blanquet, with important exponents such as Tüxen, Ellenberg, Westhoff. Despite the special attention given to vegetation, landscape ecology under the name Phytosociology, vegetation science or even plantsociology, was practised and flourished long before the name landscape ecology as such was mentioned. (see Doing 1974, Zonneveld 1960). The same holds for Edelmans school of soil science in Wageningen, the Netherlands: with special attention to the soil, land was, and is, studied as an entity, thus giving this group a leading position in soil surveys for practical applications (land evaluation), as illustrated by their work with FAO.

Similar developments can be observed among geomorphologists in the development of the Land system concept of Christian and Stewart (1968), Leser (1984) and others. The Land system concept has been applied in holistic land surveys in Australia, also in the British Department of Oversees Surveys (cf. Brunt 1967, Zonneveld 1979, 1995), and also in the practical ecological land surveys undertaken in Canada by the, Lands Directorate (Thie and Ironside 1976), as well as in similar activities elsewhere. Such work reflects the integration of knowledge and survey methodology from geomorphology, soil science and vegetation science. They each represent forms of landscape ecology study and application, although the name landscape ecology was not applied in the beginning when these approaches were developed.

From the preceding, it is clear that landscape ecology must be multidisciplinary. The study of a tract of land requires many disciplinary. However it is not just a combining of the methods of various science but an integration, on a higher level, that in turn influences, even embraces, other disciplines in its basic philosophy and application. Therefore Naveh and Liebermann (1984) used the already mentioned term: 'Trans-disciplinary' science. This means that scientists belonging to those different disciplines can at the same time be landscape ecologists in their trans-disciplinary activities. The wide and complex field makes it almost impossible for one person to be just a landscape ecologist perse without being a specialist in one of the componant sciences.

THE ROLE OF HOLISM AND SYSTEMS THEORY IN LANDSCAPE ECOLOGY

The basic assumption of landscape ecology, and what makes it different from other disciplines, is the supposition that a specific tract of landscape is a holistic entity, including all the heterogeneous components. Holism is essentially a philosophy formulated by Smuts (1926) and continued by many ecologically minded scientists and philosophers. It states that reality consists of wholes in a hierarchical structure in the sequence : atoms, molecules, minerals, organisms, human society, the world as a total ecosystem, the galaxy, the cosmos. Each whole is a system, i. e., an organized set of relationships in a relatively steady state or uniform motion (Boulding 1956, von Bertalanffy 1968).

That steady state or uniform motion may break up, however, and change or accelerate to develop into another. The mechanism of maintaining the steady state is called 'homeostasis', that is, self-regulation by a set of positive and negative feedback factors that keep the system in a dynamic equilibrium. Narrowly related, and often indistinguishable on a short time scale is the concept of 'homeorhesis'. This points to an evolutionary stability. There is change in a uniform motion, but it is stabilized ; that is, it is protected from strong fluctuations by feedback mechanisms similar to in homeostasis.

The essential aspect of holism as a scientific assumption is that it provides the basis for studying certain wholes or systems (for example, an organism), without knowing all the details of its internal functions. It removes the necessity of first defining all elements and their relationships before defining the whole. The successes in biology, and especially in its practical applications in agronomy and medicine, have proven the great practical value of this approach.

The principles of classification established to recognize a total whole by a limited number of abstracted properties (called 'diagnostic characteristics') are based on holism. For many purposes the entities described in the classification can be used as 'black boxes' and need be studied only according to their input and output without knowing details of the processes occurring inside. This has enabled scientists to develop knowledge of a more comprehensive character and a wider scale. It has opened possibilities for formulating theories, or at least valuable empirical generalizations, as a framework for fruitful research and application.

Thus holism permits the simplification of scientific activity by making use of the possibility of a reduction of analytic observations, in order to understand more fully the function of very complex structures and processes. At the same time, it warns against attempting to study wholes by analyzing them in separate pieces without connecting them with each other. Criticism of holists would be justified if those holists denied the usefulness of gradually making the black boxes more transparent, by undertaking all kinds of further analytical study wherever that is possible. The importance of holism is that it helps in overcoming the problems caused by complexity of the object of study. In our case landscape is so complex that real understanding gained by working from the basic elements upwards will be extremely difficult, time-consuming and hence expensive, if it is even possible. Odum and Polunin (1986) pointed this out in relation to regional planning. Holism is, however, sometimes misinterpreted to indicate the need to study all details. This would be prohibitive in terms of both human and financial resources, and would suggest that the system character of the whole is not yet fully understood.

Landscape ecology plays a role, beside the use in the scientific methodology, also in the basic philosophy. It can be used indicate and stimulate a state of mind (Zonneveld 1989), a basic philosophy, a perception of land as a holistic entity that must be considered, studied and treated (managed) as a system and which cannot, without danger to humans themselves, be treated or studied in pieces. This then becomes a matter of practical wisdom to warn against too narrow analysis and action in science as well as in management.

From general philosophy, however, it is just a small step to ideology. Discussions within environmental movements often take on an emotional intensity similar to as with religion, with doomsday prophets versus the merry faithful and dogmatic precisionists (fundamentalists) versus the moderates. It is often obvious that scientific and philosophic reason have given way to almost religious fervour. Although this does have also a positive value, we should carefully exclude, such an approach when discussing methodology problems in landscape ecology. Moreover, the basic, philosophy of homeostasis and homeorhesis requires continuous attention, amendment, reconfirmation or rejection.

Holism gave an impetus to the development of general system theory (see von Bertalanffy 1968, Boulding 1956) and to the more mechanical branch of it, what is provided in computer modeling, an important tool to bridge the gap between the pure analysts and the holists. Under influence of the system theory and related basic philosophy (Phipps 1982, Kwakernaak 1986) introduced to landscape ecology the concept of "information" and gave some examples of how to us this in a quantitative approach to classification and relation study. Recent developments in hardware and software for e.g. geographic information systems offer important opportunity to extend modeling with cartographic input and output (Burrough 1986, Meijerink *et al.* 1988, Toxopeus 1996). Such systems allow the integration of different land attributes and are also magnificent tools for analyzing holistically surveyed geo-data.

In considering holism as a basic philosophy for landscape ecology, it is important to realize that the concept of landscape with its hierarchical structure does not occur at all in classical publications on general systems theory (e.g. von Bertalanffy 1968, Boulding 1956 neither in Smuts' (1926) holism nor in Capra's (1982) or Lovelock's (1979) philosophies. In general ecology, in describing hierarchies such writers jump from the organism (sometimes from the associations or land attributes spheres) to the world as a whole. Smuts places human society as an important holistic entity in between, but the concept of land or landscape as a whole does not appear. Traditional ecology, certainly since Tansley used the, term "ecosystem", tends to omit defining boundaries. Ecosystems are often described as environments around special organisms of interest within a sufficiently homogeneous minimum area : the ecosystem of human, of a certain animal, etc. However, soil science, vegetation science and geomorphology have stimulated classifications and thinking in terms of specific units, and thus have paved the way for landscape ecology. Through these disciplines we have learned to speak of ecosystems as specific and mappable units. It is from this point on that we have dealt with land(scape) ecology.

However, it is the basic holistic hypothesis, at the borderline between science and philosophy, that is the main challenge for pure, scientific landscape ecology research. Its foremost and most critical task is to study the mechanisms of homeostasis and homeorhesis, that is, the study of the relationships among all factors acting at the Earth's surface and which result in the horizontal and vertical heterogeneity of landscape features. At the same time, a knowledge of these mechanisms is an essential basis for application to conservation, in its various meanings from sustained production to pure nature protection, and for all aspects of land use planning.

THE MAIN FIELDS WITHIN THE SCIENCE

The preceding discussion indicates that the task of landscape ecology is to gain knowledge of the relationships between the building stones of the landscape and, from these, about the functioning of the landscape as a system. This knowledge, in turn can be used as a basis for managing land and the improvement and planning of land use and conservation.

But before discussing relationships within a system it is necessary to describe and order the elements of the system. This leads to the following fields, each of which has its own specific set of methods :

- Land(scape) morphology (the description of the structure and its elements)
- Landscape classification (systematic ordering)
- Land(scape) chorology (the study of spatial patterns, -variation, -heterogeneity)

- Land(scape) chrology (the study of temporal variation)
- Land(scape) ecology (in the narrow sense) : The study of relationships in order to understand the functioning of the system. This is also the scientific basis for land evaluation.

Readers familiar with vegetation science, soil science, or geomorphology may recognize analogies with research fields with in each of these science. Also, in each of these disciplines is to be found :1) description, leading to 2) classification, 3) mapping and study of the mosaic aspects (e.g vicinisme etc.), 4) succession studies and 5) studies of interrelationships. This sequence finally leads to application.

The important role of the first four fields would seem to be a valid reason to call the science as a whole "landscape science" rather than landscape ecology. Indeed, this is sometimes done (Troll 1950, Jan Zonneveld 1985a, 1985b, Zonneveld 1979, 1995, Theory Werkgroep, WLO 1986). Within the paradigm described here, however, it has become common practice to use the term land(scape) ecology for all five fields together. In the English speaking world, at least, an analogous development can be seen in the use of the term (biological) "ecology" to include all branches of vegetation science: for example, syn-taxonomy, syn-chorology, syn-ecology etc. A valid reason for this is that the five fields are not independent; study of relationship needs description of the form and structure, and usually also an appropriate classification system. But classifications and mapping also require, in turn, reasoning about the relationships between the attributes and elements. This interdependence in particular must also include the study of change.

This is not the place to go into detail about the content of morphological study and the classification and chorological study of land. These studies are, however, required to provide the basic material for the final aim of landscape ecology; that is, the understanding of land(scape) as a system, through the acquisition of some knowledge of relationships. Suggestions have been made to refer to the interrelationships between attributes within one (the smallest) element or ecotype as "physiology" and to reserve the term "ecology" for relationships between land(scape) units (Rowe 1988). Remote sensing techniques, which range from direct observation, via classical aerial photography, to electromagnetic sensing of light, heat, or radar, from a fixed platform or using aircraft satellites, are indispensable tools for such studies. The comprehensive, overall perspective provided by remote sensing has considerably stimulated the holistic view of landscape as did conventional mapping before it already. It is in this activity that the inseparable link between vegetation mapping and land(scape) ecology is given. In fact the methodology of reconnaissance vegetation-(and also soil-) survey and vegetation survey is virtually identical (Küchler and Zonneveld 1988, Zonneveld 1988a, 1988b). Only nuances, depending on the aim of the survey, in attention for the land attributes to be expressed in the legend, may differ. The landscape concept however cannot be missed in vegetation survey, the vegetation in turn can not be missed in land(scape) survey as an important land attribute determining the character of the land, and at the same time an important diagnostic criterion for the land units. This holds for landscape study based on direct holistic land(scape) surveys as well as for landscape study making use of existing thematic separate land attributes maps.

A most important aspect of chorologic descriptions in the context of relationships, is the study of the configuration of the structure of land elements, patches and corridors in relation to the flow of information through the land (in minerals, plants, animals, humans, etc.). The studies of Forman and Gordon (1986), Forman (1982), Merriam (1984), Vos *et al.* (1982), Opdam (1988), Harms and Opdam (1989), Risser *et al.* (1984). All demonstrate important perspectives for understanding this aspect of landscape function, management and planning. Connectivity is a key concept in this context. (Schreiber 1988).

The study of landscape change is also an important exponent of landscape ecology. The practical questions put to landscape ecologists almost always deal with either the stimulation (development) or with the prevention of change (conservation). Studies of landscape change and landscape relationships are closely related. Experimental research is also possible here. Landscape architecture in its various forms, from pure agricultural and urban planning and engineering to environment care and building aesthetics, is in fact often an experiment on a one-to-one scale from which, we can derive landscape ecological knowledge about the functioning of landscape and the character of landscape change.

Neef (1967) distinguished three dimensions in which landscape ecological studies can be carried out (Fig. 3).

1. A study in the topologic dimension emphasizes the land-ecosystems of a relatively homogeneous area (ecotope). The knowledge about the landscape ecological character of this is derived from cooperation between the various disciplines of geomorphology, vegetation science, soil science, zoology, etc. It differs from other ecologic studies in that biology (including vegetation science) is not the dominant discipline but is of equal importance with each of the others (Fig. 3c)
2. In the chorologic dimension landscape ecological relationships between the ecotopes is the focus. This does not, however, neglect the topologic knowledge already acquired. This tends to be the most characteristic landscape ecological study (Fig. 3b).
3. In the geospheric dimension, study focuses on the main lines of relationships on continental and global scales. These tend to include, the general ecological studies of the "Gaia" type (Lovelock 1979), but also here equal attention is given to all attributes, not only those with human life as the subject (Fig. 3a).

APPLICATION OF THE SCIENCE

Landscape ecology has been stimulated and is growing largely because of practical demands. Concern about quality of the land as a resource and a part of the living environment creates questions to which landscape ecologists are trying to give answers, specific answers that evolve from holistically oriented studies. The type of questions, and therefore the types landscape ecological research, differ considerably, and depend on the society from which the questions emerge.

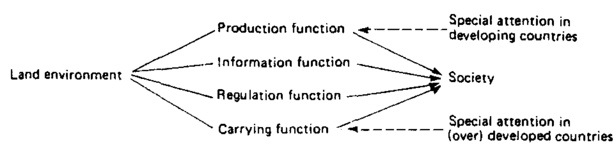
The four main functions of landscape for society are outlined in Fig. 6.

The production function includes agricultural crops, but also hydraulic energy, any mining product, etc. The information function includes all information the environment gives to society, ranging from the purely abiotic and biological (physiological, ecological) incentives to the purely aesthetic aspects.

The regulation function is supplied by the various direct cybernetic loops keeping the environment suitable(stabile) for, society, despite the negative influences of that society on the environment.

The carrying (or support) function, but points especially to the support society receives in space and physical support to build houses, grow crops, store waste and destroy poisons, etc.

The production function receives priority in developing countries where there is still an overwhelming need for basic material prosperity. In international cooperative and technical development projects this function tends to dominate, even to the extent that the other functions may be endangered. Determination of the production potential of land in combination with the avoidance of degradation are therefore the main land ecological activities requested by these countries. Thus the activities, the consulting,



Source: Maarel and Dauvellier 1978

Fig. 6. The four main function of landscape for society (from Maarel van der and Dauvellier 1978).

the courses and studies undertaken at our International Institute for Aerospace Survey and Earth Science (ITC) as well as our Wageningen University, for developing countries have been focussing for a considerable part still on production and on conservation to preserve production. An important tool here is land evaluation, in which a tract of land (at any scale) is described in terms of its suitability for various land uses (see FAO 1976, Beek 1978, Zonneveld 1979, 1995, Vink 1980, 1982, Ruziska and Miklos 1982, Siderius 1984, Haber 1987, Maarel van der and Dauvellier 1978). Originally mainly topologic information was used in the evaluation process ; but now modern landscape ecology is contributing invaluable chorologic data (fluxes of horizontal information, influences of the pattern shape and scale etc.). One of the important tasks of landscape ecology is, therefore the selection of the proper differentiating characteristics of each landscape as a regional unit (Zonneveld 1979, Vink 1982, Haase 1984). But this also implies that the relationships between these units also become a function of land use and a basis for that evaluation and for further fundamental study (Zonneveld 1963, 1989, 1995). The relationship of social, technological and economic aspects in land evaluation is shown in Fig. 7.

The evaluation of land suitability for migrating

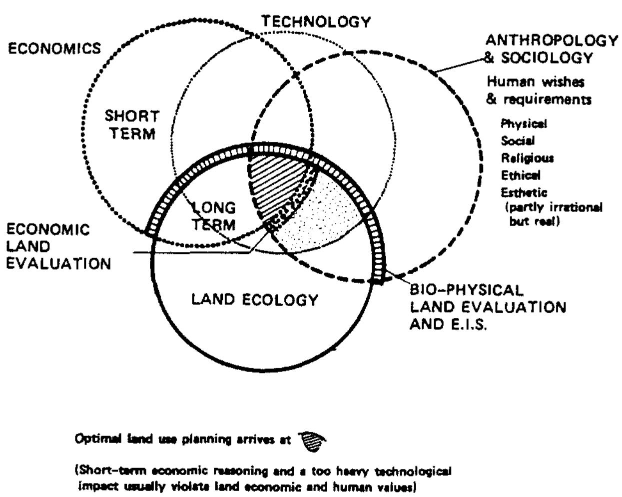


Fig. 7. The interplay of the disciplines involved in land evaluation for land use planning.

animals (for transhumance and extensive grazing) is one example that illustrates the need for developing further such chorologic landscape ecological concepts as "connectivity" between units of land with different suitabilities in time and space (Küchler and Zonneveld 1988, Schreiber 1988, Zonneveld 1989). In developed (or overdeveloped) countries such as the Netherlands production is less important, as far as agricultural aspects are concerned. In fact there is even overproduction. Here the regulation function in combination with the carrying function, must receive due attention, as does the more purely scientific aspects of information and regulation in the landscape as a system. In nature conservation, all functions are important, depending on the type of area. Protection of information function is the aim of pure nature conservation. Protection of the regulation function is always involved, especially in conservation of natural values in cultural landscapes.

The wide scope of land(scape) ecology is well demonstrated in the content of the various national and international ecology journals and the congress proceedings. There we encounter theoretical papers on structure of pattern, and fluxes of energy and information through the landscape alternating with information about methodology of mapping, environmental impact assessment, pollution, sustainable agriculture, forestry and fishery, land evaluation, carrying capacity for cattle and man, discussion on functional aspects of the land(eco)system for nature protection and environmental management etc. As such there is quite sone overlap with the subjects in journals and proceedings belonging to the science for which Landscape ecology serves as a transdisciplinary umbrella. This holds especially for the applied aspects.

This is unavoidable and even a favorable circumstance. Is not a main task of Landscape ecology to warn against to strong dominance of or even restriction to one disciplinary specialization in environmental management?. To often in the past, mono-disciplinary application had necessarily to fail. Also often vegetation and soil scientist where able to find the good solutions because they automatically, incorporated landscape ecological thinking in there discipline, without necessarily using that term.

The narrow relation between vegetation science and landscape ecology comes forth from that attitude of most applied vegetation scientist. In fact many of the practisting landscape ecologist are vegetation scientist from procession. The rise of landscape ecology in the last decades is stimulated e. g by the attention to landscape ecology of the International association for vegetation science (IAVS) and plant geography. On a famous conference organized by Tüxen in Stolzenau, Carl Troll got the opportunity to show his concepts and views further (see Zonneveld 1988a, 1988b, 1989, 1995). This appeared to be an important turning point.

Also a narrow link exist between vegetation mapping and landscape survey. I remarked already, that at not to detailed scales vegetation mapping and landscape mapping are quite similar. Because at that scale one maps, rather then vegetation, land units, that then are translated into vegetation units in one or another structural or syntaxonomic legend (Fig. 8).

More detailed mapping for landscape ecology purposes, especially in strongly anthropogenic influenced areas it may still be worthwhile to strive after mono-thematic maps of vegetation as well as soils and other land attributes, because the relation between vegetation and soil is, due to management

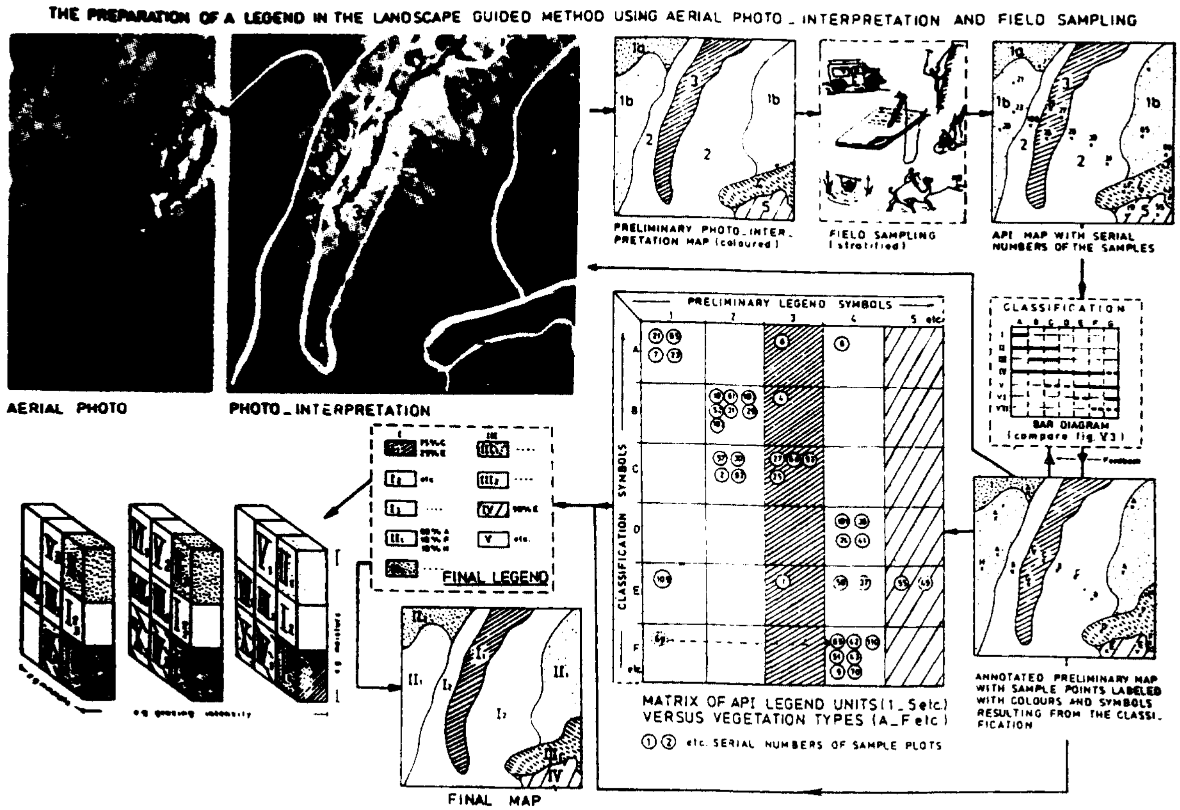


Fig. 8. In this figure is shown how vegetation mapping (as well as soil survey), just as in holistic landscape survey, starts with recognizing land units on aerial photographs by photointerpretation. The stereo image as total, relief, landform and vegetation texture and structure (pattern) are the main criteria here. The units then are sampled in the field, stratified by the photo-interpretation and random within the land units. Then vegetation, soil, landform are classified on the base of the sampling results. The land-(mapping) units now can be described in the legend using the classification units either as pure or as complex (mosaic) units. In this case the legend is expressed in a three dimensional diagram.

More details can be found in Zonneveld (1988b) and other chapters in küchler & Zonneveld (1988) and Zonneveld 1995.

much more complicated then in natural areas. For the landscape ecology study and land evaluation the soil and vegetation map can be combined later. Modern Electronic Geo-Information systems are useful tools for as well combining existing maps, as well as analyzing full integrated comprehensive land unit maps into separate mono-thematic maps of land attributes or even elements there of.

It would not be good if all land attributes science, in spite of the need for integration would merge to one comprehensive science. Soil science, geomorphology, plant geography and vegetation science, contrary, have been derived from the general Geography of the era of von Humboldt. It was then necessary that the study of the various land attribute developed a bit more independently. In spite of the need for integration in fundamental as well as applied sense one should not go back to the original unity. Instead of mixing we need integration. For integration the components must remain recognizable and hold their own identity (as in a real good gastronomic meal the components should not be mixed up but individually integrated in such a way that the whole is more delicious then the single components if tasted apart).

So also in journals and congresses of the various land attribute sciences there must be place for own developments in science, including also the not specific spatial/system aspects. They are the latter aspects that determine the character of our trans-disciplinary science. As such our science serves in its scientific action as well as its more philosophic and ideologic character as a feedback focusing on integration versus mono-disciplinary overspecialisation in the study of out environment. The interest shown the last decades in the scientific as well as the applied world show that the existence of our discipline is fully justified.

적 요

경관생태학은 지구 표면에 존재하는 서로 관련된 제반 시스템들을 시각적, 구조적 그리고 기능적인 측면에서 연구하는 학제간 학문이다. 물질과학과 생물과학을 포함하는 경관생태학은 통합적인 방법으로 개개의 토지 속성과 그들의 상호관계를 연구한다. 공간적 측면의 상호 관계들은 경관생태학의 특별한 관심사항이다. 경관생태학은 순수학문의 성격을 갖지만 일반적으로 토지의 이용 및 보전을 위한 토지평가와 관련된 응용분야의 연구를 추구하고 있다. 연구의 목적과 응용 여하에 따라 토지의 속성은 중요한 의미를 가질 수 있다. 식생도의 작성은 경관생태학 연구에 기여할 뿐만 아니라 어떤 지역을 개략적으로 조사하는데 특히 도움을 준다. 토지유형, 토양 및 식생과 같은 토지속성에 대한 개략적인 조사에서는 필연적으로 원격탐사기법을 포함한 야외조사 방법에 경관생태학의 원리가 반드시 적용되어야 하기 때문이다.

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