Geography as "landscape ecology"

Jesper Brandt

Abstract

The tradition of geography as "human ecology" introduced to Danish geography by Sofus Christiansen is taken as a departure for an evaluation of present endeavour to promote geography as "landscape ecology". The modest role in "human ecology" of human adaptation to landscape structure and dynamics is stressed. The challenge for geography in the development of a transdisciplinary landscape ecology as foundation for the planning and management of landscape ecological aspects of local and regional sustainability is emphasised.

Keywords

Human ecology, landscape ecology, landscape analysis, landscape heterogeneity, landscape perception, cultural landscapes, infield-outfield, agricultural systems.

Jesper Brandt: Department of Geography and International Development Studies, Roskilde University, P.O.Box 260, 4000 Roskilde. Denmark. Email: brandt@ruc.dk.

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Geography as "human ecology"

In 1967 Sofus Christiansen wrote a short review on *Geography as "human ecology"* in Geografisk Tidsskrift (Christiansen, 1967a). Starting with the description of the basic meaning of the term ecology within biology from Häckel (1868) (with links back to Darwin) and up to Odum (1959), Christiansen reviewed the many attempts to develop fruitful conceptual analogies by transferring the concepts of biological ecology to a human ecology, especially within medicine, psychology, sociology, anthropology and geography. A special emphasis was given to the American school of human ecologists within sociology that developed after the First World War, since this school of sociology, emphasising the territorial aspects of social organisation developed an approach close to many geographical studies - especially within urban geography (Theodorson, 1991). The criticism of the very often one-sided territorial approach of this school of human ecologists was referred to, but also the revival of the school in the 1950s, where Quinn (1950) and Hawley (1950) were adding socio-economic moments to the human ecology - also at the sub-social level. Hawley is referred for the standpoint that human ecology focuses on *'the study of the structure of society, reflecting the way, activities for reproduction are organised in a certain environment. Those activities, least bearing the disadvantages of a removed location due to loss of time and energy, are localised centrally'*. This broad interpretation of human ecology was emphasised, and subsequently Christiansen corrected D. Whittlesey (1954) for the postulate that human ecology - understood in contradiction to geography - was only dealing with the man/man relationship.

According to Christiansen, ecology probably formed the common base for anthropology and geography evolved from a time when the two disciplines were taught together, and was still playing a basic role by the functional viewpoints dominating the anthropology of the 1960s.

Without using the term, ecological thinking has its deep roots also within the history of geography. Geography as the study of the man/nature-relationship, traditionally expressed in the catalogue methods of regional geography, was clearly expressed by the first Danish professor in geography E. Løffler. Christiansen traced it back to Malte-Brun in his "Precis de la Géographie universelle" from 1710, and described its dominating role by Friedrich Ratzel over Ellen Semple to Vidal de la Blache, probably the first geographer that tried to investigate the possibilities of using ecology as a model for geography, with deep impact on later French regional geography. There were

some trends in the same direction in modern American geography (C. Sauer, D. Whittlesey, W.C. Thomas). According to Christiansen these formed a minority due to the showdown with environmentalism and determinism (Eyre, 1965) and the sociologists' monopoly of "human ecology", giving room in American geography for the success of "geography as the study of area differentiation" (Hartshorne, 1959). However, at the same time the status of biological ecology considerably increased in the wake of the publication of E. Odums "Fundamentals of Ecology". In the first half of the 1960s many requests among geographers to use an ecological approach turned up, among those S. R. Eyre and G. R. J. Jones' collection: *Geography as Human Ecology. Methodology by example* (1966). The review of Sofus Christiansen ended up by stressing the potentials of quantitative ecological modelling based on the monistic, structuring, functional and general characteristics of ecosystems. Stoddard (1965) described this as a tool for the development of a regional method that might lead to the synthesis that he considered to be the final goal of geography.

Human ecology and areal differentiation

It is no coincidence that in this connection Christiansen referred to Stoddard especially emphasising Fosberg's description of an atoll (Fosberg, 1961) as an extraordinary good example of the use of the ecosystem concept, relevant also for the inclusion of man: In the same issue of Geografisk Tidsskrift a first report on Christiansen's work from Bellona that later formed his Doctoral Thesis (Christiansen, 1975) was published, showing how this debate of the early 1960s developed parallel to the development of his own geographical research. In this first report, it was underlined how the agricultural system of Bellona *"shows many similarities to what is known from biological ecosystems"* (Christiansen, 1967: 72). With focus on the complicated land use, development aspects were briefly discussed and signs of overexploitation related to a period of settlement concentration with corresponding distance-dependant intensity of land use, rather than to growing population pressure.

This distance-dependent variations in intensity of agricultural land use are, however, not just to be seen as a spatial barrier for an adaptation to the ecological potentials. In fact, Sofus Christiansen has often turned back to the ecological interpretation of the efficiency and stability of the use of such variations, and he generalised it into his studies of infield-outfield systems, among the most widespread types of systems within pre-industrial agriculture (Christiansen, 1978). The efficiency has primarily been related to the saving of time and energy in the spatial arrangement of land use intensity and the stability due to its ability to replace nutrient-ion losses. A mathematical description of the system based on this interpretation was presented by Rasmussen (1979).

The role of landscape heterogeneity

However, although distance-savings and nutrient-replacement are important general aspects of these systems, actively implemented into the spatial structure of land use, the adaptation of the agricultural system to heterogeneous landscape conditions might be just as important an aspect. Classical within Danish agricultural geography is the description of the infield-outfield system of the river valleys in Western Jutland (Jensen & Jensen, 1979) focusing on the combination of nutrient transport in the agricultural system and the related landscape system.

This landscape adaptation aspect is especially relevant in the study of those few infield-outfield systems that have survived the industrialisation of agriculture.

A primary inspiration for Sofus Christiansen's studies of the infield-outfield system was the investigation of the Faroese agriculture representing a well-preserved example of the infield-outfield system, predominating European medieval agriculture. This system, including its characterisation of property and taxation, has survived not due to the general spatial advantages of an infield-outfield system, but due to the fact that this type of space- and time-differentiated land use was the most efficient - and probably until recently, the only possible - agricultural adaptation to the agriculturally marginal climate and especially to the heterogeneous landscape characteristics of the Faroes.

A closer look on the land use of a traditional Faroese village shows how the main differentiation in the land use intensity has been related to different physical-geographical conditions and resultant differences in biomass productivity. A delicate balance in the total land use system has to be maintained in the infield-outfield system. At the same time, the overall landscape structure does not leave much room for substantial variations in the relation

between the different land use categories (Brandt, 1973). So, even if in general the infield has been used for the intensive production of winter fodder for the cows, and the outfield for extensive grazing of sheep, a spatial overlapping seasonal production cycles of the total system has kept the infield and outfield together within rather narrow limits. This certainly results in a declining land use intensity from the village to the more remote outfields. It can be interpreted as a sign of a distance-dependant regularity of the infield-outfield system. But it can just as well be seen as a systematic adaptation of the agricultural system to the marked landscape-dependent variations in the potentials for an agricultural use of the heterogeneous landscape related to every Faroese village.

Geography as the study of areal differentiation

In Sofus Christiansen's later "human ecological" studies of agricultural systems (Christiansen, 1977 & 1978) it is interesting to see, how the theoretical emphasis is put on the differences in land use intensity in interdependence of working distance under different climatic conditions, but without drawing landscape heterogeneity and landscape adaptation into the theoretical framework. This might be explained in different ways: Science of the 1960s and 1970s was heavily oriented towards nomotetic activities. Without doubt the success of the paradigm: *Geography as the study of areal differentiation*, stressing basic spatial concepts like space, distance, agglomeration, accessibility etc., influenced the school of ecologically oriented geographers. It was in a time when most other disciplines, including ecology, in their nomotetic endeavour were primarily time- and not space-oriented, since the space-dimension was still looked upon as a realm of uniqueness that might be described, but was generally seen as noise for the nomotetic endeavour. However, also the division in human and physical geography has to be taken into account: Even if modern "Geography as human ecology" has been inspired of modern ecology as a pure nature scientific activity, it has nevertheless first of all developed as a cultural or even economic geography fundamentally dealing with the material metabolism of society, the "real" economy, namely cost-benefit in time, energy and matter. The spatial theoretical focus of the man-land (use)-landscape complex has been on the man-land-relationship, in general leaving the landscape of the complex to the applied physical geography - partly also to the humanity-oriented social geography (Olwig, 1986 &1987). However, in Denmark , such a physical-geographical oriented landscape approach to the man-land-landscape complex has been weak due to a pronounced specialisation within physical geography. Up to the last years only few physical geographers have been dealing with applied complex landscape geography (Kingo Jacobsen, 1971), although the geomorphological studies of Axel Schou were often of a complex landscape-oriented character (Schou, 1949 &1965).

In Denmark this diversification process has been somewhat counteracted by the new tradition within agricultural geography (Jensen 1976; Jensen &Jensen, 1979; Jensen & Reenberg, 1986; Madsen et al. 1992).

Since the end of the 1960s much has changed and the landscape aspects of the man-land(use)-landscape complex have come internationally in focus, not only in geography, but in many other disciplines as well.

The environmental crisis and the "human ecology"

Looking back on Sofus Christiansen's paper from 1967, we have to bear in mind that 30 years ago, ecology although formally 100 years old, was still primarily an academic term, and until the 1960s often looked upon with some scepticism since the broad and describing approach and the rather limited possibilities of quantification within ecology did not fit into the prevailing causal and quantitative paradigm of modern science. The reputation of ecology raised somehow within science during the 1960s due to the empirically-based system oriented work of Odum and others (Odum, 1959), and the review of Sofus Christiansen reflects the status and prospects at that time. However, from the end of the 1960s, a dramatic change occurred, since ecology within a very short period became a vernacular term in connection with the development of an environmental movement spreading all over the world (Agger and Brandt, 1972). This movement started first of all as a concern among natural scientists and the environmental problems were correspondingly also at the beginning seen as problems which solutions were primarily linked to a better understanding of the nature of our environment and to the development of better technical management of the man-nature-relationship. Not until the publication of the Brundtland-report, and in the course of the subsequent Rio-process, it was gradually acknowledged in the

broad public that the social and political aspects of ecological problems had to be taken into account; very often both the roots and solutions of environmental problems were to be found in a better understanding and management of the social organisation of the use of nature, as well as a better understanding of how different groups of people and interests perceive the environment, develop notions and ideals concerning the future of the environment, and react to different proposals or tendencies in the use and planning of the environment. In this way ecology developed from a primarily biological concept to a more or less political issue, related to interdisciplinary studies based on a holistic attitude towards environmental problems and their solutions (Odum 1997). Certainly it had its impact on the development within the different schools of human ecology as well as within ecologically oriented geography. Within biology a certain revival of 'human ecology' as an autecology of the human beings developed, especially in Germany (Freye, 1978). The anthropological interest was strengthened around the international journal *Human Ecology*. A sociologically oriented human ecology, however, with a much broader interdisciplinary participation than within the Chicago school developed, e.g. in The Nordic Society for Human Ecology (See *Humanekologi - meddelanden från Nordisk Förening för humanekologi*). In Denmark, the ecologically oriented geography very much influenced the establishment of Geography at Roskilde University under these new conditions. Here ecology was emphasised as an important integrating concept within geography, constituting one of three main centres of the discipline. At Roskilde University a human ecology developed as an ecologically oriented revival of the classical regional description. It focused on the systematic description of the conditions for production processes in a regional context with the purpose of isolating different types of problems related to the realisation of a regional production potential (Brandt & Rasmussen, 1979; Brandt 1980).

The development of landscape ecology

With a delay of two decades to the historical development of a spatially oriented 'human ecology', a spatially oriented 'landscape ecology' developed with roots in central Europe going back to the Second World War and spreading rapidly over the rest of the world from the middle of the 80s (Leser, 1976; Neef, 1982; Naveh & Lieberman, 1984; Schreiber 1990; Forman, 1990; Zonneveld, 1990 & 1995; Forman, 1995; Farina, 1998).

The first time the term 'landscape ecology' turned up was probably in 1939 in an article on 'air photos and ecological soil science' written by the German biogeographer Ernst Troll. In this article he elaborated extensively on the perspectives of air photo interpretation with many examples from all over the world. Towards the end he put 'landscape ecology' into a concluding remark, only once and almost offhandedly, saying: *Luftbildforschung ist zu einem sehr hohen Grade Landschaftsökologie. Die Luftbildforschung wirkt außerdem in hervorragendem Maße wissenschaftsverbindend [Air photo research is to a great extent landscape ecology. In addition, air photo research integrates science extremely well]* (Troll, 1939). For Troll the goal was a broad marriage of geography and biology. Within physical geography a geo-ecological school developed in central Europe uniting the different subdisciplines into a landscape study with emphasis on integrated structural studies with the most important result being the distinction between the topological and the chorological dimensions and the classification and hierarchical ordering of landscape types in the chorological dimension (Neef, 1956). This was closely paralleled by a bio-ecological tradition among botanically oriented biologists, which was the result of a development within a spatially oriented vegetation science (Tüxen, 1968). Although differences still exist in the terminologies and foci of these studies, it is clear that a geo-bio-ecological integration has been established and that landscape ecology as an interdisciplinary field has furthered this integration into what Zonneveld has called the ecology **of** the landscape (Zonneveld, 1995).

Zoologists, however, went in quite another direction. Starting their landscape ecological interest with the practical perspectives of conservation biology, their interest for the spatial aspect developed rapidly in the wake of the incipient island-bio-geography of the late sixties (MacArthur & Wilson, 1967), which resulted in the development of dispersal ecology and metapopulation theory (Gilpin & Hanski, 1991).

Up until the last few years, however, this development can also be seen as an internal specialisation within biology - as the introduction of the spatial dimension in biology - rather than as a result of an interdisciplinary cooperation (Merriam 1995). Zonneveld has called this spatial biology for ecology **in** the landscape, stressing the difference from the former geo-bio-ecologically oriented

ecology **of** the landscape. An important goal in modern landscape ecology has been to integrate especially these two traditions in the study of landscape functions often considered to be the core of landscape ecology. The integration of these two trends Zonneveld calls Landscape ecology *sensu strictu*.

Around this core of landscape ecology sensu strictu a 'theoretical foundation' for landscape ecology has been formulated and the contribution of different disciplines and applied sciences to this theoretical foundation has been mentioned (Forman & Godron, 1986; Zonneveld, 1990 & 1995; Forman. 1995; Farina 1998) . Much emphasis has been put on the development of quantitative spatial landscape ecology which dominates the rapidly developing US-landscape ecology, as well as the international journal Landscape Ecology.

Parallel to this, and especially within the recent history of the field that is, after the foundation of The International Association of Landscape Ecology (IALE) in 1982, it has been stressed how new perspectives, especially within cultural aspects of landscape ecology have widened the universe of landscape ecology (Naveh & Liebermann, 1994). This has partly been due to IALE-initiated activities involving scientists interested in landscapes, who come from social sciences and the humanities (Svobodová, 1990; Svobodová & Uhde, 1993), and partly due to a steady involvement in landscape ecology from especially American landscape architecture and planning (Fabos, 1981; Ahern, 1991; Nassauer, 1997). An additional paradigm of global co-operation among all types of disciplines with relevance to landscape studies has been formulated, stating that landscape ecology is a science not just 'combining' sciences (which is *multi-disciplinarity*), not 'in between' (which is *interdisciplinarity*), but above a series of sciences and integrating them: namely a *transdisciplinary* science for the study of the Total Human Environment. Especially Zev Naveh the brothers Isard and Jan Zonneveld have put much effort into the formulation of a meta theory for this transdisciplinary science based on general system theory, biocybernetics, information theory, fuzzy set theory, hierarchy theory, etc. (Naveh & Liebermann, 1984 & 1994; Zonneveld, 1985; Naveh, 1998; Zonneveld, 1995).

This shift in the general opinion on the strategic goals of landscape ecology is clearly expressed in the mission statement, published by IALE (IALE Mission Statement, 1998: 1):

"The International Association for Landscape Ecology (IALE) aims to develop landscape ecology as the scientific basis for the analysis, planning and management of the landscapes of the world".

"Landscape ecology is the study of spatial variation in landscapes at a variety of scales. It includes the biophysical and societal causes and consequences of landscape heterogeneity. Above all, it is broadly interdisciplinary."

"The conceptual and theoretical core of landscape ecology has become distinct and recognised, effectively linking natural sciences with related human disciplines. Landscape ecology can be portrayed by several of its core themes:

1) the spatial pattern or structure of landscapes, ranging from wilderness to cities,
2) the relationship between pattern and process in landscapes,
3) the relationship of human activity to landscape pattern, process and change,
4) the effect of scale and disturbance on the landscape."

Having changed the focus of Landscape Ecology from a mere marriage of physical geography and spatial ecology to a broad transdisciplinary science, the presented history of landscape ecology ought to be revised. For the present status of landscape ecology it is not that important that Troll used the phrase 'landscape ecology' for the first time in 1939, and certainly not all important roots of modern landscape ecology are to be found within central European biology and geography. Instead one should stimulate scientists from all disciplines related to the transdisciplinary science of landscape ecology to write the history of landscape ecology from their disciplinary point of view: What theories, methods and ways of practice relevant for landscape ecology have developed historically within the single disciplines, and how can these traditions contribute to the transdisciplinary co-operation within landscape ecology?

This is certainly also an important job for geography. Geographers joining landscape ecology should make it clear, how they can be expected to contribute to the transdisciplinary co-operation within landscape ecology.

"Landscape ecology" and the disciplines

The overall practical role of landscape ecology in our modern society in general is to support a sustainable development by giving a scientific basis for a better adjustment of our land use

- to the natural structure and dynamics of our landscapes,

- to the preservation of biodiversity at the different landscape levels, and
- to the development of more sustainable needs within the future organisation of society in our landscapes,

We can distinguish between three basic tasks that have to be dealt with:

1. The study of basic landscape structures and types of landscape dynamics that express the landscape potential to which society should purposefully adjust its land use to ensure a rational resource management and at the same time prevent unsustainable types of landscape management.
2. The study of actual (and historical) land use and land cover to elucidate present (and historical) landscape interrelations and barriers in the landscape.
3. The study of social landscapes and landscapes in the minds of groups and interests in society, and how the ecology of our landscapes is perceived among individuals and groups. This will contribute to the understanding of landscape ecological conflicts in society, and assist the development of an ecological planning, management and use of our landscapes, as part of a sustainable development.

These three types of studies are related to three very different types of landscape concepts. To stress these landscape conceptual differences we could name them in parallel as the study of:

- The primary landscape structure and dynamics, comprising the geo-ecology and the potentials of our landscapes,
- the secondary landscape structure and dynamics, consisting of land cover, land use and their dynamics, and
- the tertiary landscape structure and dynamics, dealing with the landscapes of our minds and interests so essential for land users and the decisions of landscape planning and management.

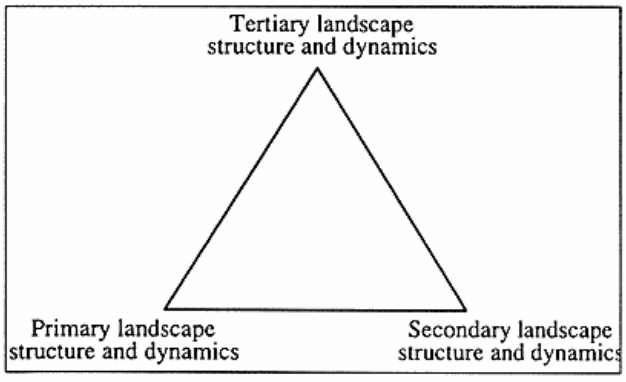

Figure 1: *Types of landscape structures and dynamics related to landscape ecology.*

At first glance, these study areas can be recognised as a division of labour between three major disciplines that have already joined landscape ecology, namely 1) physical geography (and plant ecology), 2) spatial (bio)-ecology and 3) landscape architecture, planning and landscape perception. There is, however, much overlapping, and especially geography will have much to offer all three areas.

The essential by the division is, on the one hand, that these three types of landscape structure and dynamics are based on very different ways of looking at landscapes, and on the other hand that these differences are complementary, supporting each other in the landscape ecological analysis for the planning and management of our landscapes. It is probably even this complementarity that constitutes the rationality of trying to merge together a transdisciplinary landscape ecology.

The primary landscape structure and geography

The study of the primary landscape structure and dynamics has mainly developed within physical geography (but also within applied sciences such as agriculture, forestry and engineering), putting emphasis on the integrated study of the structure and dynamics of the abiotic components in the landscape: the integration of parent material, geomorphology, climate, soil and water. A parallel school of landscape science developed within vegetation science, where the study of natural and semi-natural vegetation could add a biotic component to the geo-complex studied by the physical geographers. Due to human disturbances, the linkages between vegetation and the geo-ecological components are not pronounced in intensively used landscapes, but the relation of the vegetation scientists to the geo-ecologists has been maintained also in the study of such types of landscapes through the mapping of potential vegetation.

This development in geo-bio-ecology has been most pronounced in central Europe, where the loosening of the integration in geography – including bio-geography – has been much less pronounced than in Scandinavian and Anglo-American geography. This probably also helped to keep the integrated complex character of the analysis of

landscapes, when growing planning-needs during the 1960s forced geographers and conservationists towards more detailed studies. In central Europe, the deductive landscape studies, based on landscape division into still smaller landscape entities, were more or less turned upside down by introducing the inductive landscape analysis. Here emphasis was put on the detailed quantitative characteristic of the landscape content in the *topological dimension*, studying the vertical interrelation between the geo-components at a given spot. This was extended to the *chorological dimension*, studying the horizontal relations between different types and patterns of topological and hierarchical ordered chorological units.

This gave rise to a specific frame of reference concerning landscape interpretation within central European geo-ecology and plant sociology. Namely that landscapes are composed of different types of basic land units that can be considered homogeneous with respect to their more stable abiotic components, and can be grouped in a spatial hierarchy of characteristic heterogeneous compositions at different levels (Neef, 1956; Zonneveld, 1995; Klijn, 1997). In this tradition focus has been on the structure, dynamics and functions of the complex units, where the components of parent material, relief, water, soil, etc. has been seen as analytical tools, abstract in the sense that they cannot be isolated from the complex landscape units. In Nordic and Anglo-American geography the ongoing specialisation and dissolution of complex geography has probably furthered the interpretation of the geo-components as the real base of the physical environment, leaving the complex character of landscapes as a sort of 'synthesis', often considered to be a pure mental construction – in opposition to the supposed material character of the components. This has probably been one of the main reasons behind the modest interest in landscapes in the modern Anglo-American physical geography, as well as in its rather inferior involvement in the development of landscape ecology.

The secondary landscape structure and geography

The secondary landscape structure and dynamics deal with the actual or historical land cover and land use. Traditionally these studies have been split up into studies of the structure and dynamics of the main types of human land use, such as agriculture, forestry, urban areas and infrastructure, and the study of the structure and dynamics of different types of land cover with natural and semi-natural vegetation. Economic geographers in general, and more specifically agronomists, foresters, urban planners and engineers have dealt with the first part, whereas biologists and conservationists are concerned with the other part, which, in fact, constitutes a good deal of what is mostly considered the object of modern landscape ecology. Forman's definition of a landscape as "a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout" (Forman & Godron, 1986) is based on an analysis of the actual land cover, however, with priority given to the study of natural and semi-natural types of ecosystems, embedded in a matrix of a dominating land use. The relation between biodiversity and the structure and heterogeneity of land cover and land use is a central issue of these studies.

There has been an explosion of literature during recent years concerning biologically oriented studies of spatial ecology linked to island theory, metapopulation theory and the study of connectivity in fragmented landscapes (see Forman, 1995; Farina, 1998). However, since the general landscape ecological purpose of these studies should be to find ways for more ecologically sound ways of land use, such studies should link to other traditions within landscape ecology. Here, geography has much to offer.

The study of the matrix, especially the intensive forms of land use, should be part of landscape ecology, not only the remnant natural and semi-natural habitats for wildlife. As a consequence, economic geographers ought to engage more in landscape ecology than they do today, thereby forming an alternative to agronomists, foresters and sector planners that, to a growing extent, are involved in such studies. The basic problem by these sector-oriented technicians is that specialists within sector oriented land use traditionally follow goals of one-sided intensification and homogenisation of land use. Additionally, a rather unholy coalition between dominant land users and conservationists has often developed, leaving marginal areas to the conservationists in exchange for the security of an unlimited intensification of the use of the matrix. This segregation model of landscape planning is seldom a sustainable way of landscape management. Instead, the total landscape should be studied both from a land use point of view and a biotope or habitat point of view. Focus should be on new ways of land use that can combine an extensivation of single types of land use with other land use functions in a multiple landscape adapted form (Cook & van Lier, 1994).

Economic geographers can have an important role here as generalists not biased towards a special land use sector.

The tertiary landscape structure and geography

The tertiary landscape structure and dynamics relate to the structure and change of landscapes in the minds of human individuals and groups. It is a delicate task, since in this context it becomes clear, how "the landscape concept embodies several unresolved conflicts: between collective belonging and individual control, between the subjective and the objective, and between the mental and the material" (Jones, 1991: 234).

The classical concept of the *noosphaere* (Vernadsky, 1945) is important for landscape ecology not just in the sense that the majority of our landscapes are of heavily cultural influence, that is "reflect the superposition of all attempts man made to adapt the environment to improve his living conditions" (Antrop, 1998: 34). It also represents the conscious materialisation of mental landscape constructions, which makes the study of human landscape perception to a fundamental task for a planning- and management-oriented landscape ecology (Brandt, 1998).

Geographers have contributed to the elucidation of the different perceptions and evalutations of landscapes among different groups of people (e.g. Andersen et al., 1977), but have also dealt with the very different use of the landscape concept among different disciplins and traditions. Jones (1988) identified seven differing ways the concept of cultural landscape has been used in the Norwegian academic literature, which he later grouped into the following three main categories (Jones, 1991:231):

1) Landscape modified or influenced by human activity.
2) Valued features of the human landscape which are threatened by change or disappearance.
3) Landscape elements with meaning for a human group in a given cultural or socio-economic context.

Each of these usages is characterised by very different approaches and methods, which it will be an important task for geographers to clear up in the transdisciplinary cooperation within landscape ecology.

Although the first is primarily oriented towards understanding the forces which have formed our physical surrounding in the past and present through ecological analysis and historical-geographical interpretation, all three uses are directly or indirectly involved in problems of landscape values. From an instrumental point of view landscape values *are* not: they *become*, in the sense that they are assigned by man to objects he evaluates for their existence or usefullness. Accordingly, Antrop (1998) assigns the following 4 types of landscape values:

Value 1: the natural framework
Value 2: the historical and cultural inheritance
Value 3: the aestetically well-feeling
Value 4: social-cultural meaning

Obviously these valuations are important for planning, management and daily landscape practise, thereby having a considerable influence on the ecological functionality of our landscapes.

Time and the degree of imperative concerning the future sustainable development in the use of our landscapes will show how far this instrumental way of understanding landscape values will cover the future needs. Or if a development of more intrinsic types of landscape values must be expected: Slowly we are recovering our status as part of nature. Will we also one day accept that we might be part of our landscapes, and that our landscapes might be part of us?

Links between the three areas of landscape ecology

Close linkages between the three described areas exist and should be furthered systematically if the integration in landscape ecology shall succeed.

A systematic comparison of the land use and land cover with the primary landscape structure and dynamics is needed, especially in landscapes that have been subject to an intensive and one-sided land use. It can be accomplished through the comparison of a geo-ecological survey with a historical reconstruction of land use and biotope patterns. This can be done in both a systematic and quantitative way, since there exists a spatial parallel between the landscape concepts related to the primary and secondary structures (Brandt, 1992; Meyer, 1997). Although Forman's landscape definition is primarily related to the actual land cover structure, the definition: "A heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout" is so broad that it can also be interpreted geo-ecologically as a definition of the chorological levels of the geo-ecological hierarchy. For the contemporary discussion on biodiversity this is very important since it can relate the concept of biodiversity to

land use diversity and landscape heterogeneity. Combining diversity studies of the primary and secondary landscape structures is central to the description of what Naveh has called eco-diversity.

Problems of adaptation of the land use to the primary landscape structure in Faroese sheep farming have been subject to landscape ecological studies (Brandt, 1992). Through interviews with old shepherds 87 traditional pasture grounds at the Eastern part of Sandoy were charted together with information on the traditional carrying capacity of ewes in each flock, in faroese called 'skipan'. Classified vegetation units within each pasture were used as basic topological units for a landscape ecological analysis. Based on the assumption that the land-use has been adjusted to the geochorological structure of the landscape and that each vegetation type reflecting this structure presented a uniform biomass productivity, the productivity of the ingoing topological units could be estimated by use of least-square-method and linear programming, and the ability of the grazing system to use the biological potential calculated. It was showed how different chorological landscape structures offered different solutions for an optimal land use, only partly able to adjust to an efficient use of the local biomass potentials.

The method used can be considered an "opposite geo-ecological analysis", since it takes its departure in historically developed experiences on the potential use of the landscape that is traced back to its geo-ecological conditions, in opposition to the classical geo-ecology, seeing the potential use as the goal or synthesis of the geo-ecological investigation. It is an example of the mutual benefits that geography as a discipline related to both nature and social science can offer landscape ecology.

From a transdisciplinary point of view one of the biggest challenges for landscape ecology is how to integrate the study of the tertiary landscape structure in landscape ecology. There is an enormous gap between the dominating physical-geographical and bio-ecological concepts of landscapes as concrete material systems of the environment and the concepts of landscape dominating humanities and social sciences as pure mental constructions of the mind, only to be understood and handled in a social and historical context.

However, examples of convergence can be found. So, even from a strict bioecological viewpoint mental constructions are more and more recognized to be of great landscape ecological importance, e.g. within dispersal ecology, where the study of species-dependent differences in landscape perception has proved to be indispensable for the understanding of animal behaveour and movement in different types of landscapes (Farina 1998; Baudry & Burel, 1998). On the other hand, the growing incorporation of environmental and landscape resource problems in social sciences and humanities, provoked by the continuing ecological crises, are challenging the tendency of handling landscapes as mere social constructions, although opposing trends, e.g within post-modern sociology and social geography, can be observed, too.

Practitioners, such as landscape architects and planners have an important mediating role to play. So have geographers - at least as far as they can overcome their internal division and tendency to affiliate either to a social og nature science tradition.

Conclusion and outlook

Geography as human ecology, liberated from the narrow roots in American sociology between the two world wars, developed rapidly in the 1960s, strongly supported by progress within modern model-oriented quantitative ecology. Obviously the opportunity to develop a functional and general description of human ecosystems as a tool for the development of a regional method that might lead to the synthesis, considered to be the final goal of geography, was a strong motive for many geographers, hoping for a revival of the old geographical ambition of a more integrated understanding of the man-nature relationship.

However, the resistance against such a development within geography seems to have been too strong during the 1970s, where the specialisation and division of geography have been dominating trends. Landscape research, once an important part of geography, seems to have lost rather much during this process, probably also due to a dominating paradigm of geography as the study of spatial differentiation.

At the same time, a growing need for integrated research on the geographical environment has developed, especially since the time of the Brundtland-report, focusing on the social aspects of environmental problems.

Landscape ecology has developed internationally during the 1980s from very different disciplins and fields of application as a transdisciplinary science with the ambition to link natural sciences with related human disciplines in

the search for a better understanding and management of our landscapes.

By tradition the contribution of geography to landscape ecology primarily owns from physical geography, especially where this tradition has been linked to more integrated approaches to the physical geographical studies of the geo-complex. But the present emphasis on the transdisciplinary aspects of landscape ecology makes other aspects of classical geography relevant in an interesting way. Land cover studies, necessary for providing structural basis for spatial ecology, are a fundamental part of geography and especially important for landscape ecology to relate spatial ecological oriented land cover studies to land use and land use changes. This is a classical part of traditional agricultural geography, and contains without doubt the closest link of landscape ecology to the tradition of geography as human ecology. However, landscape ecology should cover many other types of landscapes than agricultural landscapes. Other aspects of land cover/land use-studies related to economic geography will be relevant for the future development of this dimension in landscape ecology. Most important is the development of land use and land cover studies for the complex multiple use of our landscapes. To the third dimension of Landscape Ecology, perception geography as it has developed from cartography and social geography is certainly relevant. But also cultural and historical geography in general will have much to offer landscape ecology due to the linkage to social science and humanities, and the tradition for empirical studies of the human environment, based on interviews and interpretation of topographic descriptions and geo-statistics.

The common nominator for all these different geographical contributions to transdisciplinary landscape ecology will be the acknowledgement of the landscape as the main object in landscape ecological studies. This might sound trivial, but it is not: If the geographical subdisciplines only follow their own specific goals, the co-operations will hardly further the development of landscape ecology. The contribution to the transdisciplinarity will only be possible as far as the co-operating scientists have a strong interest in the common understanding or practical change of the landscapes under investigation. This seems to be the case in general among the scientists from different disciplines that up to now have joined landscape ecology. But due to the strong specialisation, the marked dispersion in goal orientation and the low unifying status of the landscape concept within modern geography, it is not at all clear if geography as a united discipline will be able to fully use this opportunity to offer a strong integrating function within landscape ecology. On the other hand, landscape ecology is under strong development these years and might as well develop to an area that can further a future reunification of geography.

So, geography cannot only add much to the development within landscape ecology, but landscape ecology can also be an important tool for the development of a more integrated geography than we have seen during the last decades.

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