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Multifunctional landscapes—perspectives for the future

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Abstract: New methods in landscape ecology to study the link between landscape heterogeneity and landscape functionality are needed. Heterogeneity is a basic characteristic of landscape, and landscape function is the capacity to change the structural heterogeneity of a landscape system. In most developed countries the industrialisation of agriculture has in general resulted in a change of agricultural landscapes from a small-grained heterogeneous pattern towards more monotonous and monofunctional landscapes. During the 1990's this trends seems to have changed due to a diversification of rural land use and new trends in urbanisation. Weather these phases of landscape development should be expected in developing countries is a totally open question.

Dealing with the study of multifunctionality of landscapes it is proposed to distinguish between ecological functionality of landscape ecosystems, functionality pertaining to land use and social functionality. Further, the relation between function, space and scale is important by the determination of spatial and time segregation as well as spatial and time integration of multifunctionality in landscapes.

Keywords: landscape heterogeneity; monotonisation; multifunctionality; spatial segregation; time segregation; landscape development

Introduction

The idea of this presentation is to put focus on a very general trend of development in functionality of agricultural landscapes in our time, and to focus on the need to find adequate ways of describing and analysing this trend. In many agricultural landscapes of the industrialised part of the world former heterogeneous cultural landscapes have been transformed to rather homogeneous landscapes during the industrialisation process. It seems however like this process during the last decades might have turned to a renewed trend towards heterogenisation. This can be linked to a parallel development in landscape functions, where multifunctional land use has been replace by a monofunctional use during the industrialisation, but where multifunctionality again might be considered a more relevant land use strategy. We need however to find ways for a better analysis of such trends.

1 Heterogeneity and function in landscapes

Most definitions of landscapes are emphasising heterogeneity as an important characteristic. So, Forman and Godron's definition of landscapes as "a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout" (Forman, 1986), is based on the assumption of a certain differentiation of the surface within a landscape: A landscape consist of different spatial elements. Function is "the interaction among the spatial elements" (op.cit.) and thereby also the capacity to change the structure, the heterogeneity, of the system. The landscape forms a spatial unit that might have an overall ecological function in a landscape system of a higher order. Internally the different elements of the landscape will interact by playing different functions within the landscape unit. As an example, in a hilly landscape, the convex hills will serve as cascading distributor of water and nutrient, whereas the concave valleys and bottoms will collect water and nutrient. So, in general, there is a close linkage between heterogeneity of a landscape and landscape functionality. This is not only the case for the description of ecological functions of the landscape, but also for the functionality pertaining to the human use of the landscape, the land use:

A traditional Danish agricultural landscape consist of a complicated small-grained rather heterogeneous landscape with small fields of very different crops, surrounded by hedges, dykes or ditches, often with a marl pit on the field, from where the lime-rich moraine before the time of fertilizers was distributed on the field to set free the nutrients. Single farms with small gardens are spread in the landscape as well as small woods. Minor areas of permanent grassland on moist, but not too wet lowlands, were used for grazing, whereas areas with high ground water table were left as moor, showing signs of peat-digging. This heterogeneity of landscape elements was historically related to a variety of different land use functions: A small to medium size of agricultural holdings, each featuring a mixture of different agricultural products, connected in a complicated rotation system, related to the production of refined animal products for the world market that developed in Denmark during the last part of the 19th century.

Today the land cover of a Danish agricultural landscape is however much more simple. Only few types of crops are present in the agricultural land and the few small and dispersed uncultivated areas gives an

impression of a homogeneous agricultural landscape. It is a modern agricultural production landscape, where many farms have been amalgamated; the former rotation system has been abolished in favour of a fertiliser- and pesticide-supported monocropping.

To some degree there has been a historical trend from the first to the second type of landscape, not just in Denmark, but in most European and other industrialised countries.

It has obviously given rise to a variety of environmental problems. In fact, in Denmark the agricultural development has been one of the main issues in the broad public environmental discussion that since the mid-eighties has placed environmental problems as being considered the most important problems in society at all (Brandt, 1996). Among the environmental problems, pollution problems from intensive agricultural production certainly has been on the top of the list. But also the so-called "monotonisation of the agricultural landscapes" has given rise to widespread concern in the public opinion.

During the last 20 years Danish landscape ecologists have used the amount of small uncultivated elements of the agricultural landscape as a sort of indicator for this trend of "monotonisation of the landscape" in form of a still more homogeneous land cover. We call these small landscape elements for "small biotopes". They have basically been divided into two types, namely linear biotopes, comprising of different types of hedgerows, stone- and earth-walls, field divides, brooks and ditches, road verges, tree rows, partly as avenues, and patch biotopes, such as marl pits, small ponds and lakes, bogs, thickets, woodlots and game plantations, small uncultivated grasslands, e.g. on steep slopes, barrows, gardens and solitary trees. We have made detailed surveys of the content of small biotopes in 32 areas of agricultural landscape since 1981, together with collection of agricultural and land use data (Agger, 1988; Brandt, 2001). Only a minor part of these landscape elements can be traced back to a natural pre-agricultural landscape, but are in contrary an integrated part of the agricultural development. Thus, the former showed the heterogeneous agricultural landscape is a cultural historical product of agriculture, not remnants of a former natural landscape.

Correspondingly there has been a steady high dynamics of these elements, coming and going through history, closely related to the development of agricultural technology and economic structure in the agricultural sector. But in general, there has been a steady decrease during the last more than 100 years, mostly of the small and of the wet biotopes. Especially during the phase of intensive industrialisation of agriculture, from the end of the ninety sixties to the mid-eighties, there was a marked decrease in number and area of small biotopes, as can be seen from Table 1, showing the percentage change per year of linear and patch biotopes in some Danish agricultural landscapes.

So, from 1954 to 1968 the length of hedges, dykes, ditches, field divides, road verges and other linear biotopes was reduced with 0.6% every year, whereas they were reduced with 2.3% per year from 1968—1981, which in fact means that the total length of these biotopes were reduced with about 26% just within this 13 years period. The reduction of the number of patch biotopes also increased in this period.

However, interestingly, this development has changed again later, and especially during the 1990's the general trend has been the opposite way with an increase for all types of small biotopes except for wet patch biotopes that are still reducing their number.

Table 1 The net rate of changes per year of linear and area biotopes in 5 test areas in Western Denmark (20 km²) 1954—1996

		1954—68	1968—81	1981—86	1986—91	1991—96
Number of years in each period		14	13	5	5	5
Linear biotopes	% change in length, per year	-0.6	-2.3	-1.3	-1.3	0.9
	% change in area, per year	·	·	-2.9	-2.9	2.5
Area biotopes	% change in number, per year	-0.5	-0.8	-0.8	-0.8	0.3
	% change in area, per year	·	·	3.0	3.0	1.7

Similar trends——both the dramatic reduction during the 1970s and the increase during the 1990s have been observed in the UK (Haines-Young, 2000) and in other European agricultural landscapes, although certainly many regional and local differences occur.

How can we explain these marked shifts in development trend for our cultural landscapes? Environmental politicians might argue that it has been a result of the growing environmental concern and the realisation of different sorts of legislation for landscape protection and conservation. However this can hardly explain it, since the agricultural landscape with its humble types of biotopes are seldom comprised

by such type of legislation. Rather it has to be explained by two types of global processes in modern industrialised capitalist societies, namely

—by the transition from a productivist phase of industrialised agriculture, that is a period where a massive state-supported agricultural sector furthered an intensive agriculture for export to the world market, towards a phase of more multifunctional use of agricultural areas, where most rural areas will be released from the burden of intensive agricultural production and instead of that will support many other types of economic and social functions both within and outside the agricultural sector, and

—by the trends within urbanisation in developed countries to assign the rural areas to an expanding variety of urban functions, including urban settlement in form of "counterurbanisation", meaning to reverse the modern trend of population concentration in urban areas by dispersed settlement in a rural environment, considered to have the potential for a better life than urban centres, not to speak of modern monotonous commuter suburbs (Brandt, 2001).

Many of these up-coming economic and social functions are based on expected qualities of agricultural landscapes, some times related not even to existing but to qualities that are not present any more, due to the industrialisation of agriculture.

These future landscapes might in general be characterised by (1) less intensive agricultural production (extensivation); (2) smaller units of land (holdings) for production and reproduction(dispersion);(3) a more varied combination of agricultural products and services(diversification); (4) a growing amount of urban influenced types of land use (housing, different types of recreation, hunting grounds, nature conservation, infrastrucutral elements etc.) which can be expected to result in (5) a more varied (heterogeneous) landscape; (6) a more multifunctional use of the landscape, and (7) an increasing number of land use- and social conflicts and a growing need for a "social landscape engineering" to solve these conflicts.

Agricultural policy is central in the discussion of these trends (Bohman, 1999). Faced with this challenge agricultural organisations in some industrial countries——e.g. Norway and Japan——have argued that the heterogeneous character of their agricultural landscapes are produced by agriculture itself, and that the best way of supporting a heterogeneous landscape suitable for multifunctional use is to ensure a general economic support for agricultural production. They argue that their agricultural system in itself is multifunctional and that production-linked subsidies include payment for its services as landscape manages, e.g. by promoting wildlife, landscape amenity and viable rural communities.

However, precisely the production-linked subsidies can be seen as one of the reasons for the monotonisation of the landscape, since it has been the economic basis for investments in drainage systems, larger machines, intensive use of fertiliser and pesticides, removal of biotopes to enlarge the fields, and enlargement of the holdings through tenure or buy up of land. Conversely, the endeavour——partly as a pressure from the World Trade Organization——to settle the massive state support for agricultural production that has developed after the Second World War in most industrial countries, is probably a main reason behind the dwindling intensivation of agricultural production during the 1990s, and thereby also the emerging growing heterogeneity and multifunctionality of agricultural landscapes during this period.

It has to be stressed that the development is by no mean uniform. In fact, the average stabilisation and progress in small biotopes in Denmark during the 1990s, hide diverging trends of reduction and progress in different regions and local areas. In some areas a diversification and growing multifunctionality will be seen, in other areas the answer to the reduced agricultural support will be further intensivation and a resulting danger of a continued monotonisation of the landscape (Brandt, 1986). As pointed out by Wilson in a new review on the discussion about post-productivist change in agriculture, it is still an open question towards what this change is going: Alternative trends of continued productivist development must be expected both regional and local, but rather the general trend is towards a multifunctional agricultural regime with an increasing overall diversity and spatial heterogeneity in our rural areas (Wilson, 2001).

Therefore, in landscape ecology we need methods for monitoring of landscape heterogeneity, landscape functionality and the relation between indicators for both. During the last decades landscape ecologists have been working very hard on developing methods for quantitative description and analysis of landscape heterogeneity, although we also have to admit that the results concerning use and interpretation of spatial indices up to now have been rather modest. But our endeavour to develop methods for description and analysis of landscape functions have been even more humble. On an international conference on

multifunctional landscapes in Roskilde, Denmark, in October 2000 we had to conclude that very few contributions in fact were contributing to a methodological improvement of our instruments for description and analysis of landscape functionality.

In essence, landscapes can always be considered multifunctional. However, different disciplines and professions dealing with landscapes interpret landscape functionality in different ways corresponding to different definitions of landscapes and related purposes of landscape studies. Dealing with the study of multifunctionality of landscapes it is proposed to distinguish between (1) ecological functionality of landscape ecosystems; (2) functionality pertaining to land use; and (3) social functionality.

The ecosystem approach of functionality may be viewed as the traditional approach of natural sciences to functionality, regarding the landscape as a concrete combination and unity of discrete ecological systems. Landscapes may simultaneously regulate the local circulation of matter, energy and information in time and space, and act as a habitat for different organisms. The distinction of these functions are only mental abstractions, however, as they are all part of the totality of processes.

The second approach to function is strongly related to the human-ecological aspect of the landscape, generally expressed as land use. Land use comprises any human exploitation that has implications for ecological fluxes, input and output from ecosystems. Land use may be regarded as the spatial expression of human adaptation to the natural conditions of the landscape. It can be seen as a function referring to sets of material processes that are specifically linked to the specific land use, because these processes have spatial implications, which may be registered by changes in land cover. Landscapes will typically host several land uses, and in terms of land use-related functionality, landscapes will most often be multifunctional, but not always. One land use may completely cover large land areas despite substantial variation in geo-ecological units, and hence landscape may be considered monofunctional, such as this very heterogeneous outfield area at the Faeroe Islands, that however has only one land use function: sheep grazing.

If human use or interest in an area does not leave traceable impacts on ecological fluxes, we will not consider it a function related to land use, but a social function. Social functions are often associated to aesthetic, social, economic, juridical, regulative or cadastral relations, and by principle entire constructions of the human mind. We can subdivide them in designated and perceived functionality. Designations in landscapes, e.g. a zoning of urban and rural areas, as we have it in Denmark, are often very well delineated objectively and retrievable from maps and GISs. Perceived functions are most often subjective and difficult to delineate in concrete landscapes, e.g. that the rural landscape around Odense in Denmark, where H. C. Andersen was born, is a beautiful landscape.

An important consequence of this distinction between land use functions and social functions is that investigating the linkage between landscape heterogeneity and landscape functionality we should not include social functions, only their reflection in land use functionality due to its material influence. So, a designation of a nature reserve has not in itself an influence on the landscape function, but only if it results in changes in land use functions.

The study of multifunctionality of landscapes are further complicated due to the relation between function, space and scale. From an abstract spatial point of view we can define three main different types of multifunctionality: A. Multifunctionality as a spatial combination of different functions related to separate land units (spatial segregation). B. Multifunctionality as different functions devoted to the same land unit, but separated in time, typically in certain cycles (time segregation). C. Multifunctionality as integration of different functions at the same or overlapping land units, at the same or overlapping time (spatial integration or "true multifunctionality").

At one geographical level we might register the same amount or combination of functions within a given landscape unit offered by the three types of multifunctionality. But a difference between them occurs, when we change the scale of observation:

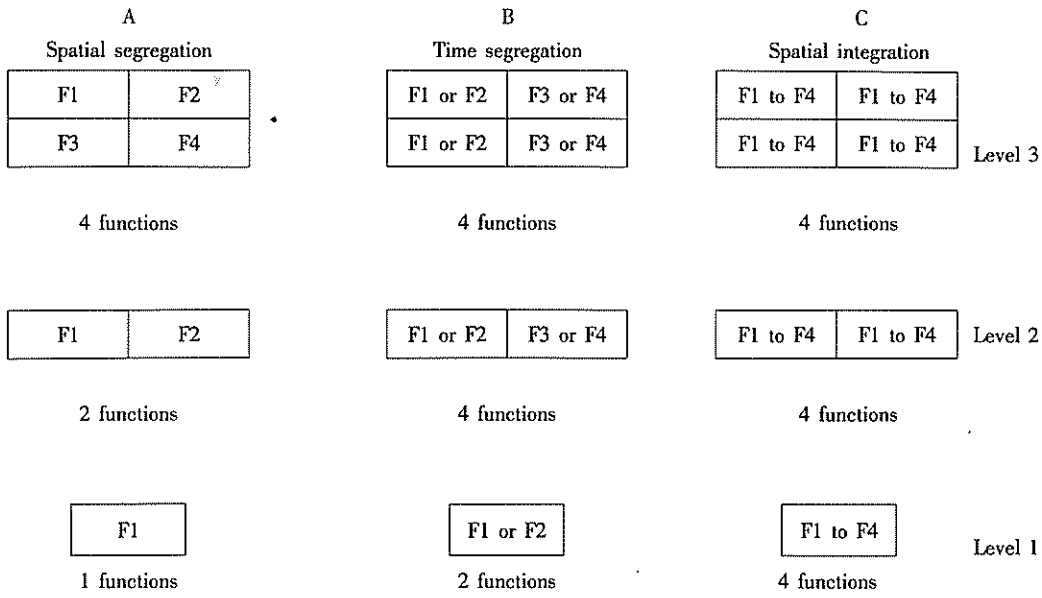

Fig. 1 Three types of multifunctionality measured at different spatial levels

A. by spatial segregation; B. by time segregation; C. by spatial integration

In level 2 we only look at the functions within the northern half of the area shown in level 3. In level 1 we only look at the functions within the western half of the area shown in level 2.

Where the first type of multifunctionality dissolves itself by a decrease in scale since only one function—and that is monofunctionality—exist at the most detailed level, the third type will stay constant independently of the geographical scale of observation.

Where the third type is linked to a true integration of different functions in time and space, the first will often be based on existing conflicts between the functions to be minimised by a spatial or time segregation of the functions.

Due to chorological connection between functions in the landscape, integration of or conflicts between different functions will however exist in all three types of multifunctionalities, and a clear distinction between them will probably be difficult in practise. Even in the extreme case of a strict monofunctionally organised use of the landscape a spatial multifunctionality at the detailed level will be present around the functional boundaries, which make the chorological structure or landscape heterogeneity to an important aspect of the landscape multifunctionality as shown in the different spatial organisation of two functions in a landscape in Fig. 2. Although a strict spatial segregation of functions are given in all cases, it is clear that the multifunctionality increases with the amount of borderline between the two functions.

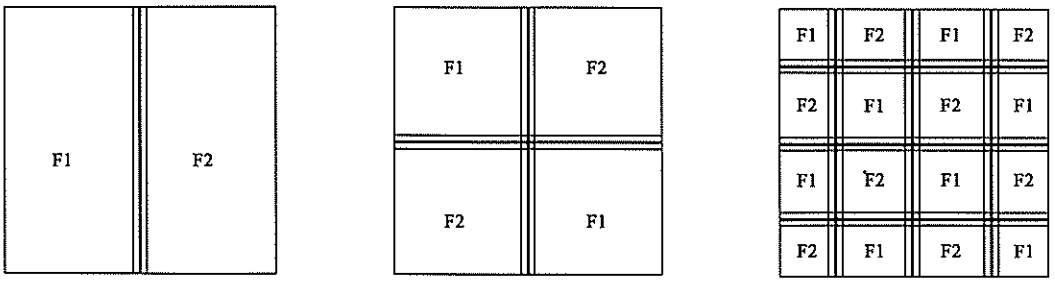

Fig. 2 The influence of landscape heterogeneity on the degree of landscape multifunctionality

F1: Function 1; F2: Function 2; ═══ Interaction between F1 and F2 ("ecotone functionality")

The different types of multifunctionality can be seen as supplementary. Multifunctionality by spatial and time segregation can be seen as possibilities for additional functions in the landscape given the necessary extent in space and time. Multifunctionality as spatial integration can on the other hand be seen as a strategy for additional functions under spatial.

2 Trends toward multifunctionality in agricultural landscapes of less developed countries?

The theory of a post-productivist phase of agriculture, opening a possibility of producing multifunctional and heterogeneous landscapes has emerged in the more developed industrial countries.

It is an open question if the theory is applicable to the situation in less developed countries. Will less developed countries have to pass a traditional capitalist industrialisation process with the consequences of landscape monotonisation and landscape ecological instability due to monofunctional types of land use——before they can proceed with a multifunctional agricultural regime, where landscape heterogeneity and stability will again have a chance on the agenda?

I do not think it is possible to give any sound answer to this question. But if landscape ecologists can have any influence on practical landscape planning and development, it will be through our ability to show light on the linkage between landscape heterogeneity, landscape stability and the dialectics between different types of landscape functionality. That might be one of our most important contributions to a sustainable development.

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