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Multifunctional landscapes – motives, concepts and perspectives

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Abstract

The concept of multifunctionality is gaining increasing attention within landscape sciences. This paper deals with the definitions and applications of multifunctionality with respect to landscapes, which are marked by human use namely cultural landscapes. Three concepts of functionality are suggested: ecosystem functionality, land use related functionality, and a reflexive and future oriented transcending functionality. Registration of land cover serves as an empirical entry to the description of all kinds of functionalities.

From a spatial point of view, we define three general types of multifunctionality which can be applied at different scales, first there is a spatial combination of separate land units with different functions, second different functions devoted to the same land unit, but separated in time, and third the integration of different functions on the same unit of land at the same time. Land cover may indicate borders of ecosystems, and help identify ecosystem function, land cover is an expression of structures and changes induced by humans; furthermore land cover may express a designation of a function in the landscape. Studies of land cover may thus serve as an important spatial link between structure, function, and processes relating to the three concepts of functionality.

Introduction

The concept of multifunctionality is receiving increasing attention not only in the landscape sciences but also in society at large. It seems to be an important paradigm within sustainable development, and may induce a shift in land use strategy, which can save costs. The new strategy is especially targeted at large areas, which are under growing land pressure and dominated by monofunctional land use due to industrialisation and the introduction of economies of scale into productive land use functions, a process, which took place during the 20th century.

In addition, multifunctionality is an important part of the ongoing debates concerning the relation between sustainable development, agricultural and environmental policies, and international trade (Bohman, *et al.* [1], Lankoski [2], Potter and Burney [3]). Within the agricultural sector, the multifunctionality of landscapes has become a central issue in the continuing process of multilateral trade negotiations within the WTO framework. Several industrialised countries claim that the externalities of multifunctional agricultural systems should exempt them from the general cut backs in or the elimination of agricultural market subsidies. The rationale behind this argument is that the positive side effects of multifunctional agricultural systems should be rewarded, whereas the elimination of subsidies will imply a loss of the benefits that agriculture provides, such as diverse ecosystems.

An international conference on multifunctional landscapes held in Roskilde, Denmark, in October 2000 demonstrated the recognition of the problems surrounding the multifunctionality of cultural landscapes, and the growing interest in applying the concept in the landscape sciences. This was particularly so when using the application of multifunctionality in landscape analysis, planning, management, and land use practice. Multifunctionality attracts the attention of landscape scientists for many reasons, not least, the relationship between functionality, landscape structure and landscape diversity. Linking landscape structures and diversity with the degree of multifunctionality seems to be a new research task, which will be addressed in the coming decade.

Approaches to the concept of Multifunctional Landscapes:

The conference was organised with a plenary programme, along with 10 parallel sessions, a poster session, and six workshops dedicated to different aspects of the theme of multifunctional landscapes. It revealed at least four very different approaches to the concept:

1. Multifunctional landscapes as an expression of the many different functions of the "natural landscape", that is the landscape seen as a concrete combination and unity of natural ecological systems. This understanding of the concept focuses on the fact that a "natural landscape" simultaneously regulates the local circulation of matter and energy in time and space, and acts as a habitat for many different organisms. The maintenance and dispersal of these different organisms is influenced by the structure of the landscape, and that structure and the different natural functions influence each other. This is the typical natural science (geo- and bio-ecological) approach to multifunctional landscapes (e.g. Gibelli *et al.*, this volume, Howard *et al.*, Degórski, Vol. 2).
2. Multifunctional landscapes are also seen as society's material-ecological links between different types of land use and related land covers. These links can be of mutual benefit (for example agro-forestry), or conflicting (for example intensive agriculture versus preservation of ground water resources). Whereas the "natural landscape approach" is linked to natural ecosystems, the second approach is more engaged with the landscape from an anthropocentric point of view. This approach may be purely scientific, but may also be seen as a study of the landscape aspects of society's material reproduction. It focuses on landscape aspects of the production of material and spiritual values for human beings, and the relation of these values to the surrounding landscape system (see for example Bastian, this volume, Wytrzerns & Pistrich, Young & Jarvis, Ling, Solon, Cristea *et al.*, Vol. 2).
3. Multifunctional landscapes are also perceived as the policy scene for problems related to competing and complementary types of land use. This understanding concentrates on the economic issues of mutual benefits, diseconomies due to different possibilities of marketing, free rider problems and so forth, and also on the juridical problems of forms of ownership related to land and resources, and different types of regulation of land use conflicts that arise from the multiple use of landscapes. Different types of social science are engaged in this approach (see e.g. Parris, this volume, Boeckmann *et al.*, Hasler *et al.*, Vol. 2).
4. This approach sees multifunctional landscapes from a cultural perspective, as a theatre for aesthetics, social communication and conflicts, and cultural interpretation. This is primarily based on landscape architectural and landscape planning traditions, but sometimes also inspired by the first and second approaches defined above, on sociological and humanistic traditions, as well as on cultural and artistic traditions and is often developed in opposition to the other approaches (see for example Russell & Bürgi, Olwig, this volume).

These four are more or less systematic approaches to multifunctional landscapes. Generally speaking, they are treated independently within different scientific disciplines, and in practical management engaged in landscape problems. They are certainly inter-linked, but in a very complicated manner. One of our main challenges is to establish rules governing the transdisciplinarity of the evolving landscape science (Naveh [4], Zonneveld [5], Klijn and Vos [6]).

Complementary to these more systematic approaches, one should add a fifth namely

5. Multifunctional landscapes seen from within an all-encompassing system which tries to integrate all the other aspects into a common frame, using different types of comprehensive systems theory. In this context, multifunctionality is the central concept, which is employed when studying self-organising systems that develop an increasingly complex functional differentiation and integration within hierarchically ordered spatial units in cultural landscapes (see Naveh, this volume).

However, during the conference it proved difficult to formulate an all-embracing definition of multifunctional landscapes. This may be due to the multi-faceted aspects of the concept, of which a strict definition may only cover a fraction. Attempts to reach a clear definition may easily be prevented by the critical examination and evaluation of an interdisciplinary audience. As such, multifunctionality does not differ from other complex, yet very useful, concepts such as biodiversity or sustainability. By refraining from defining the concept of multifunctional landscapes, however, we risk it becoming another buzzword, deprived of operational content.

Why study multifunctional landscapes?

The contemporary perspectives on multifunctional landscapes are at least partly rooted in the thesis that some of our present environmental problems are related to intensive types of land use supported by a strategy of land use segregation. This strategy has furthered a development of monofunctional landscapes that are considered monotonous. The most commonly used example is the trend towards industrialised agriculture which gives rise to the making of a monotonisation of monotonous agricultural landscapes. Similar trends can be seen within forestry as well as in the extensive monotonous zones of suburban dwellings or summerhouses.

Since the monofunctional use of landscapes tends to operate within steadily increasing land unit sizes and scales, the possibility for positive synergies between different functions has correspondingly decreased, and a growing discrepancy with the natural sizes, scales and mosaics of landscapes has developed (Gulinck, this volume). Further, monofunctional land use does not reflect the multifaceted character of the human demand on the (local and regional) environment. The general urge to stimulate the multiple use of rural areas is a common reaction to environmental problems (Agger [7]).

Since the Enlightenment, there has been a move towards the spatial segregation of land use functions in the landscapes of western culture. During the era of the industrialisation of agricultural and silvicultural production, monofunctional land use was, in general, considered the most economically efficient land use development strategy. For technical and organisational reasons, land use monofunctional intensification has excluded, not always intentionally, other types of land use. In many countries, this exclusion has been promoted politically through a policy of land use segregation based on economic incentives or land zoning strategies aiming to achieve rational land use through an intensified monofunctional (regional or local) land use. Monofunctional land use has been supported by constant technological improvements depending on the construction of spatially standardised local conditions, and resulting in a structural homogenisation of the cultural landscape, which is often in conflict with the ecological dynamics of the landscape. Although this strategy seemed economically efficient, it has resulted in an increasing number of diseconomies in the form of environmental problems. Although the technical ability to transform the environment has increased dramatically (both in intensity and in geographical scale), the ability to adapt the technology to the variations in ecological conditions has developed only recently (Huber [8]). A part of the problem related to this somewhat "clumsy" technology has been the social and organisational aspects of the land use. At a certain stage of development, land use zoning has, in some countries, proved to be an efficient tool for preventing, for example, urban sprawl. However, it has been unsuccessful in regulating land use at the local level.

The functional segregation of rural landscapes has apparently implied problems for their ecological functioning. These problems have rarely been manifested either economically or socially, due to segregation strategies that keep affected groups or interests away from or outside influence. As a consequence of the increased urban settlement in rural settings, we may expect a stronger interest in using landscape resources from non-farming residents of the countryside in the future.

Therefore, the key idea of this publication is to adopt a land use strategy that will focus on a shift from functional segregation towards functional integration.

Aims and strategies for developing multifunctional landscapes

a. Multifunctionality in intensively used landscapes

The development of multifunctional landscapes may be seen as a tool, which can be used to help overcome the negative consequences of the segregation of functions, as such, multifunctional landscapes are a condition for sustainable development (see Staljanssens *et al.*, in Vol. 2). The success of this type of strategy will depend on <u>technological skills, social will, and ability</u> among actors affecting the landscape

- to adapt different land use functions to the ecological conditions of the local landscape instead of adapting the landscape conditions to specific types of land use technologies, and
- to tailor different functions to fit each other instead of separating them.

The planning and realisation of multifunctional landscapes imply that each type of land use must be managed within certain limits, and modified to suit competing land uses and their claims on the landscape resources. To put many different claims on the landscape does not necessarily overburden its potential, in fact multifunctionality should have the opposite effect. A multifunctional land use strategy should force through technological changes and open the way for a more nuanced form of social control within the total landscape system.

Several strategies may be suggested for applying additional functions in landscapes. By mimicking functions of traditional rural landscapes, we may adopt a strategy of employing local landscapes in the production of food, energy, fibres, the needs for recreation, habitats, and aesthetic beauty which will provide a sustainable use of the landscape. If our local landscapes provide services, they too would surely be more diverse in structure. We should stress the importance of local landscapes, not only because it will allow the resource base to deliver the fulfilment of human needs, but also because a complex resource use strategy will probably function better if formulated and supported by local populations.

This will require a deeper understanding of the ecological functioning of the local landscapes as well as our social ability to master the co-ordination and conflicts related to the complex use of the landscape. In a historical perspective, this can be expressed as a trend towards making the environment more a part of our social consciousness, by accepting our landscapes as an extended part of the common human body (Brandt [9]).

This is also the motive behind Zev Naveh's description of the challenge of *"a transdisciplinary scientific revolution and the perception of landscapes as* *tangible multifunctional gestalt systems of our total human ecosystem."* (Naveh, this volume). It stresses the still more complicated character of the social formation of our cultural landscapes. Also the contribution of Haines-Young and Potschin (this volume) on "natural capital" is based on this type of thinking.

As early as the period between the two world wars, the concept of noosphere was developed to underline that the development of our world will be dominated by social decisions and practices, as the main geological force of our time (Vernadsky [10]). The concept of the noosphere is a challenge to the traditional western division between body and mind, and between nature and society. Thus the noosphere is not just "the landscape of our mind", rather the emerging materialisation of the culturally developed globe. The development of the noosphere does not depend on the realisation of our ever-changing ideals about landscapes as pure social constructions, but on our understanding of and respect for our own nature as well as the nature, which surrounds us, and our capacity to unite these two types of nature. The realisation of the noosphere will never be just a self-realisation of our "mind" or a victory over nature. It can only succeed with our reconciliation with nature. Therefore landscape planning and management has to insist on a steady improvement in our understanding of the ecology of our landscapes. Our understanding of ecology should be mirrored by and worked into a steady improvement of our understanding and communication of needs, interests and conflicts, developed, satisfied, and solved through a participatory process. This will be true transdisciplinarity in practise.

b. Multifunctionality and areas of special interests

The term "multifunctionality" should not be applied uncritically to all landscapes. Multifunctionality is primarily an alternative strategy to land use segregation in intensively used landscapes, which for the vast majority of the population is the everyday landscape. It is less relevant in nature preservation landscapes and areas of special interest, since they have been established to protect a high degree of local biodiversity or maybe just a single species. Harms, *et al.* [11] illustrated the problem of choosing between segregation and integration strategies in nature management by applying four different development strategies to the same landscape, each pertaining to an animal species, which would benefit from the strategy. The strategies were based on integration and zoning ("Godwit"), on developing networks ("Otter"), on segregation ("Elk"), and on segregation while selecting optimal sites ("Harrier"), and demonstrated that multifunctionality and multiple use strategies should be used critically.

A conscious development of multifunctional landscapes

In pre-industrial and industrial societies, the majority of agricultural landscapes are primarily results of the transformation of nature, which took place in order to rationalise the technical and spatial layout of farm units, and to enhance agricultural production. The character of cultural landscapes, those, which have been changed by humans, could primarily be viewed as a by-product of production, and not a goal in itself. However, the layout of agricultural estates has often been planned to underline the social power of the estate, though there are exceptions, especially from the end of the 18^{th} century and onwards in form of foresighted general regional landscape planning (Hirsch [12], Haber [13]). Certainly reproduction traits were present in the landscape too, such as dwellings, gardens, parks, religious and historical sites, and all sorts of nature areas. Nonetheless, production areas were dominant in the landscape, and economic progress was based on the expansion and intensification of these areas for material production, whereas reproduction and recreation was relatively absent during the period of the industrialisation of the countryside and the development of the urban fringe. With the development of modern fossil fuel driven agriculture, and the use of pesticides and fertilizers, food production has grown to a degree that has allowed alternative uses of agricultural land (Meyer and Turner II [14]).

During the last 30 years, several different trends have dramatically changed this production driven development of our cultural landscapes. The spatial range for non-productive activities has increased enormously due to developments within transport technology and the economy resulting in urbanisation and urban sprawl. The traditional social structures embodied in the local history of rural areas have been dissolved. The rise in material wealth has released an economic and political demand on land related reproduction activities putting pressure on land resources in rural areas. Finally, an increase in agricultural production above the demands, paired with a global liberalisation of the agricultural market has lowered the demand for agricultural land use in many parts of the world.

As a result, a shift not only towards multiple use, but also towards a growing pressure on non-production considerations in the planning and management of cultural landscapes is taking place. Material production as a base for the shaping of the cultural landscape is apparently weakening, and the growing heterogeneity of the rural population increases the pressure for a multifunctional land use.

The strategy for the development of multifunctional landscapes should be based on these trends, and ensure the development of sustained multiple use in regions exposed to this post-industrialisation landscape development (typically in peri-urban regions) without making fundamental changes to the structure or morphology of the landscape. Here, the mere transition of rural land into built up urban areas should not be considered a consequence of a multifunctional strategy, but rather a functional change resulting in a new landscape (Antrop, this volume).

The different approaches to functionality

In the following, we suggest some concepts of functionality, multifunctionality and multifunctional landscapes, which can be a basis for practise. Central issues include the question of scale, and the employment of information concerning land attributes (in particular land cover) in the operationalisation of functionality. Finally, we discuss where, when, and how to apply multifunctionality to landscapes.

Before discussing multifunctionality, we will focus on the core of the term the concept of functionality.

Functionality is considered to be a central concept in landscape ecology. Leser [15] refers to a functional principle, which he considers difficult to realise due to *"the character of functionally super complex landscape ecosystems"*. Forman and Godron [16] focus on structure, function, and change as the main characteristics of landscapes, defining function as *"the interactions among the spatial elements, that is, the flows of energy, materials, and species among the component ecosystems"*. Accordingly, in most landscape ecology literature, landscape functions are often described as being synonymous with landscape **processes**, without further comment.

However, although it is possible to have a sense of what is meant by "function", by describing it as "interaction" or, "process", it is clear that the concept is rather complex, and that such characteristics obviously only grasp part of the meaning, other characteristics such as "purpose" and "ability to work" are also important properties of a function. So, "interaction" focuses on the dynamics in the functional relation, but says nothing about the purpose of landscape use, or the landscapes' capacity. "Process" can describe both that the function's work is done and also that it has a purpose, but does not include the idea of it's capacity being intact, even when the process does not work. "Purpose" indicates the direction of a function, not the ability to act. "Ability to work" says something about the capacity of a function, but nothing about the direction. Finally, the different aspects of functionality are related to different (sub) systems. Whilst the purpose is given and defined in one system (such as a social system of needs and expectations), the related capacities and processes can be entirely encapsulated in another system (for example a purely natural system of dunes along a sandy beach with coastal reefs).

In general, we might understand function as **the capacity (of a driver) to maintain an entity in a certain state or change it in a given direction, i.e. the capacity to master (aspects of) an entity.**

Applied to landscapes, function can further be defined as **the capacity (of a driver) to change the land units in a more or less given direction, or the capacity to maintain the land unit in a given state that is the capacity to master (aspects of) the structure and change of a landscape.** This context has some clear and important consequences. To change the environment means to create, sustain, or dissolve differences in what is the structure of the environment. This means that there is a close connection between landscape structure and landscape function.

Based on this definition, we propose to focus on three types of functionality reflecting fundamentally different drivers of functions – as capacities to maintain or change landscapes – behind the dynamics of our cultural landscapes:

i. The functionality of landscape ecosystems reflecting the realised capacities in nature to maintain or change the environment (geo-bio-ecology),
ii. Functionality pertaining to land use (usage) reflecting the realised capacities in society for changing the environment (human ecology or "(human) landscape ecology"),
iii. Transcending functionality, reflecting the intentional capacities in society for maintaining or changing the environment (landscape planning and means of management), including reflections on the capacity of the environment to provide immaterial services in order to change or maintain (aspects of) the noosphere (e.g. beauty).

We start out by comparing this basic classification with other classifications, then the three types will be treated separately. Finally, their close relation will be demonstrated. Special emphasis will be put on the consequences of the proposed classification for the spatial analysis of shifts in type, extension, and intensity of different functions. In fact, it will be argued that the three types of functionality are not only closely related, but inseparable. If multifunctionality is seen as an "emergent property" of landscapes arising out of the interaction of ecological systems (in a natural scientific, that is a social interpretation of internal functions in nature) and human value systems, the reciprocal relationship between the systems, rather than their coexistence must be in focus (see Haynes-Young and Potschin, this volume).

So, the division into types of ecosystem, land use, and transcending functionality is misplaced in that they cannot exist in isolation. These types represent different aspects of multifunctionality.

Table 1. Functions of the natural environment (de Groot [17])

Regulation functions

- Protection against harmful cosmic influences
- Regulation of the local and global energy balance
- Regulation of the chemical composition of the atmosphere
- Regulation of the chemical composition of the oceans
- Regulation of the local and global climate (including the hydrological cycle)
- Regulation of runoff and flood prevention (watershed protection)
- Water catchment and groundwater recharge
- Prevention of soil erosion and sediment control
- Formation of topsoil and maintenance of soil fertility
- Fixation of solar energy and biomass production
- Storage and recycling of organic matter
- Storage recycling of nutrients
- Storage and recycling of human waste
- Regulation of biological control mechanisms
- Maintenance of migration and nursery habitats
- Maintenance of biological (and genetic) diversity

Carrier functions

providing space and a suitable substrate for

- Human habitation and (indigenous) settlements
- Cultivation (crop growing, animal husbandry, aquaculture)
- Energy conversion
- Recreation and tourism
- Nature protection

Production functions

- Oxygen
- Water (for drinking, irrigation, industry, etc.)
- Food and nutritious drinks
- Genetic resources
- Medicinal resources
- Raw materials for clothing and household fabrics
- Raw materials for building, construction, and industrial use
- Biochemicals (other than fuel and medicines)
- Fuel and energy
- Fodder and fertiliser
- Ornamental resources

Information functions

- Aesthetic information
- Spiritual and religious information
- Historic information (heritage value)
- Cultural and artistic inspiration
- Scientific and educational information

Within environmental science and planning, ecosystem function is often described from an anthropocentric point of view, either directly or indirectly, thus the environment is seen as cultural landscapes, a part of the Total Human

Ecosystem (see Naveh, this volume). de Groot [17], following van der Maarel and Dauvelliers [18], defines *functions of the natural environment* as the capacity of natural processes and components to provide goods and services that satisfy human needs directly and/or indirectly, and divides them into 16 types of regulatory functions, five types of carrier function, 11 types of production functions and five types of information functions (see Table 1).

This classification is, however, only to a limited extent landscape oriented. The group "carrier functions" can be linked to a "spatial tradition" where the surface of the earth is considered to be only "space" or "carrier" for some nature related social function, whereas all other nature functions are described without any concrete relation to distinct physical environments.

However, since all material human production functions are area dependent, both *carrier* and *production functions* can be considered as being closely related to the human use of the landscape, thus they are seen as *land-use-functions* expressing the material area related nature of the human reproduction system. Consequently, and to avoid confusion with the term "carrying capacity", Zonneveld [5] has proposed the designation "mechanical and spatial support" instead of "carrier function".

The *regulation functions* correspond to our category of "ecosystem functions"; from a landscape ecological point of view they are spatially related to the spatial structure of the concrete natural ecosystems.

De Groot's information functions correspond to the transcending functions of reflections on the capacity of the environment to provide immaterial services. However, the concept of transcending functions widens that of information functions to all planned (future) functions within the other categories. From a landscape point of view, such intended future functions might be clearly demarcated in the present landscape, but they will only express "potential capacities" for realisation through future usage of the landscape. Although they might represent social and future ecological conflicts, these will not be immediately ecologically detectable at the empirical level. The ecological aspects of such conflicts can only be analysed through studies of similar past or present land use functions realised in similar landscapes, or by modelling of consequences of intended types of land use under specific landscape conditions.

Antrop (this volume), goes into some depth about the influence of functional shifts on landscape structure and landscape values, his views basically seem to support de Groot, by dividing functions into "space, information, production (goods), services and so forth".

In addition, the division of functions presented by Parris (this volume), based on Bergstrom, 1998) is basically "spatial" (and restricted to agricultural areas), dividing them into biodiversity and ecosystem, soil filters and sinks, places to live, work, visit, space, agricultural functions and water supplies.

Staljannsens *et al.* (see Vol. 2) argue strongly for a strict distinction between nature (regulation) functions and land use functions, advocating that we keep the word function for the *"natural **functions** inherent to the landscape"* and instead of land use functions we should speak of *"the purpose or **usage** of the landscape". "This is essential because usage and functions should bare a different weight in our choices about the landscape and be clearly distinguished in the decision making process (...) Functions should be seen as inherent to the landscape while uses are a matter of choice where perception and interests play a role."* (Staljanssens *et al.*, Vol. 2). However, an important part of usage with close relation to the ecological functions is the intensity of use, a matter of special interest, dealing with multifunctional use of the landscape (see under ii).

Bastian (this volume) classifies landscape functions into

A. Production (economic) functions (10 subgroups)
B. Ecological functions (14 subgroups), and
C. Social functions (7 subgroups)

All of them are to be ordered into a spatial hierarchy of landscape functions. He stresses that this, *"broad spectrum of landscape functions not only produces a substantial multifunctionality"*, but also that *"Usually, there is no 'neutral coexistence' of different landscape functions, but conflicts, interferences, and synergies are common. In the process of landscape planning these problems must be solved, and conflicts should be defused to achieve a harmonious development including the protection of the landscape in such a way, which can be supported by the major part of the human society." (Bastian, this volume)*

In Bastian's classification, ecological functions correspond to the regulation function by de Groot, whereas some reproduction oriented "human-ecological functions" are classified under social functions together with "information functions".

Direct carrier functions (such as habitation and settlement) have been omitted, probably because this classification is obviously oriented towards an "ecology **of** the landscape" point of view as opposed to an ecology **in** the landscape approach Zonneveld [5].

i. Functionality of landscape ecosystems

According to ecosystems theory Barnes, *et al.* [19], Odum [20], ecosystems may be described as the interaction between living and dead biomass and the abiotic frames, which in turn may be described by fluxes of energy, matter and species in a spatial context. In a landscape ecological context, the spatial dimension of ecosystem function should be emphasised so that landscape ecosystems are understood as being hierarchically ordered, consisting of different types of spatially structured subsystems that are functionally linked. A natural landscape system can be seen as self-organising – autopoietic – systems, which Jantsch (1980) defines as follows, *"An autopoietic system is in the first line not concerned with the production of any output, but with its own self-renewal in the same process structure. Autopoiesis is an expression of the fundamental complementary of structure and function, that flexibility and plasticity due to dynamic relations, through which self-organization becomes possible"* (see also Naveh, this volume).

Due to this *"complementary of structure and function"*, the functionality of landscape systems expresses the capacity to fulfil (or regulate) processes (fluxes of energy, matter and species) that can maintain or change the structure of the landscape. Since landscape systems are hierarchically ordered the ecosystem function includes both system internal fluxes and system external fluxes. System external fluxes include exchanges of energy, matter and species with the surroundings. The *totality of fluxes* or *processes* as well as the capacities behind them constitutes the ecosystem *function*, according to biological ecosystem theory. In a strict sense, any human use of (as expressed by land use, see below) or impact on ecosystems may be described as regulations of inputs and outputs of matter, energy and species, hence human influence is merely a part of the ecosystem function (Zonneveld [5]).

By stressing the *totality* of processes and capacities, irrespective of the type and extent of human interferences with the system, the term *multi*functionality has little meaning, as far as classical ecosystem research is concerned, at the ecosystem level, as there cannot be more than one totality of processes, i.e. more than one function. In many respects, however, we may accept that the ecosystem has several functions as suggested by De Groot (Table 1). These ecosystems related functions, such as groundwater recharge and carbon sequestration, are part of the general function of the total system. In relation to humans however, they become discrete ecosystem *services,* and the delineation of the single functions is an abstraction made to serve human aspects. Characteristic for the ecosystem related function(s) is that they exist and function irrespective of human conception for instance as groundwater recharge. As the concept of ecosystem services is widely used, we suggest denoting these services *ecosystem related functions*, i.e. functions that can be described independently of human use or perception.

It should be stressed that classic ecosystem theory depends on the conception of ecosystems as tangible, well-defined entities, and does not deal significantly with spatial implications. Ecosystem research has consequently often been carried out with an emphasis on the time dimension whilst ignoring the spatial dimension. In reality, ecosystems will always have a spatial dimension, and their hierarchical ordering will be expressed in different characteristic types of spatial structures and dynamics at different scales. From an ecological point of view, landscapes are, in the main, to be understood as conglomerates of spatial units each consisting of a different ecosystem (or when the emphasis is put on the spatial aspects: ecotopes, connected within ecochores).

The general approach of natural science oriented landscape ecology to functionality regards the landscape as a concrete combination and unity of discrete ecological systems.

Whether considered as one function of an ecosystem, or different functions of sub-systems, landscape oriented ecosystem functions can, according to Gulinck (this volume), be related to *"basic, intrinsic and principally culture-free functions of the landscape"*, *"such as sink, source, buffer, corridor, habitat, conveyance of water, disturbance, visual information etc."*. So, in a hilly landscape, the convex hills will have the capacity to serve as a cascading distributor of water and nutrient (serve as a source), whereas the concave valleys and bottoms will unite in a capacity to function as collector of water and nutrients (serve as a sink).

In this description of different functions between ecosystems, or subsystems of a heterogeneous landscape, it is clear that the functions are closely related to both *structures* (for example as the geomorphology) and *processes* (for example within hydrology) that can be empirically detected "objectively" rather easily. However, the formulation of the *functions* presupposes a conceptual model of the landscape, describing it from a chosen viewpoint where "usefulness for different purposes" (Antrop, this volume) serves as leading principles for the description and analysis of structures and processes in the landscape. So, once the functions are given, the investigation of the system seems more or less like a technical, "objective" matter. But the formulation of the functions is a purpose-oriented choice. In traditional science oriented landscape ecology, such functions serve our understanding and prediction of the spatial distribution within the landscape system. So, in the case of the hilly landscape, the functions of cascading distribution or collection can be enhanced through a purpose oriented inclusion of relevant geomorphologic characteristics in the landscape classification, permitting a better understanding and prediction of the distribution of water, nutrients and vegetation, through the indication of area sources and sinks at different spatial levels.

The functional classification and analysis of ecosystem landscapes is also relevant for the analysis of the human use of the landscape, for example through the analysis of differences in agricultural growth conditions, or conditions of drainage. But often such considerations will change the functional meaning, and thereby give rise to changes in the description of the related structure and processes, for example through purpose oriented classifications. Neef [21] has called this difficult step "The transformation problem", whereby nature science categories are transformed to social science categories (see also Bastian, this volume).

It is necessary to use the concept of functionality in strict sense in connection with the ecosystem, and the concept has to be related to a corresponding classification of a landscape structure and related processes, including a description and delineation of adequate landscape units. Nevertheless, it also has to be changed to functional categories used in the social sciences. These categories are organised within a social classification of the environment related to systems of land use, and not ecosystems. At the same time however, land use materialise in the different levels of the ecosystem. From a landscape point of view, the most difficult analytical problem concerning the "transformation" is probably that of relating the integration of function, structure, and process within the ecosystem organisation of the environment, to the integration of function, structure and process in the usage as expressed in the land use organisation of the environment.

ii. Functionality pertaining to land use (usage)

The second approach to functionality 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, i.e. ecosystem inputs and outputs. Land use may be regarded as the spatial expression of humans' change of and adaptation to the natural conditions of the landscape, for example to relief, climate soil, flora and fauna.

Landscapes are exploited or used in order to fulfil material and spiritual needs. For methodological reasons we will restrict our use of the concept of land use to material processes, as these have spatial implications, which may be registered by changes in land cover. If human use does not leave traceable impacts on ecological fluxes, we should abstain from using the term land use, and instead employ definitions of transcending functionality as described below (iii).

According to the land use approach, function is the realised capacity to maintain or change the environment through human land use, and functionality refers to the set of realised and purpose oriented processes that are specifically linked to a particular land use. Two or more sets of processes each having an assigned land use, result in two or more functions, and in this context functionality may be an appropriate term used to denote the *totality of land uses*. Alternatively, multifunctionality may characterise situations with more than one land use on the same tract of land.

It seems as if land use multifunctionality is related to a reductionist view of function as compared to the ecosystem approach described above (i) as the totality of processes is divided into sets of processes pertaining to the different land uses in question. A view that needs to be complemented by a corresponding development of adequate concepts of totalities of functions for example related to concepts of landscape sustainability or landscape potentials (Mannsfeld [22], see also Staljanssens *et al.*, Vol. 2). So, different realised sub-functions in the form of specific oriented processes will often join into sets of processes related to one land use function, but they might also be related to more than one set of processes, and hence to more than one land use and its related potential. In this context, an important aspect of land use functionality or usage is the **intensity of land use** (see Wytrzens and Pistrich, Vol. 2). This influences the possibilities for additional types of land use as well as the overall potentials or capabilities of general functionality pertaining to land use.

Landscapes will typically host several types of land use, and thus landscapes will most often be used multifunctionally, however this is not always the case. One land use may completely cover large land areas despite substantial variation in geo-ecological units, and hence such landscapes may be considered monofunctional.

The distinction between the functionality of types (i) and (ii) may be illustrated by a few simple examples. Ecosystem function encompasses *all* processes, whereas land use functions concentrate on processes relevant from a societal point of view. In a forest ecosystem, all internal and external fluxes are included in the ecosystem function including functions related to structure and processes relevant to eventual insignificant organisms, whose presence are completely irrelevant to the *land use* namely forestry. The presence of a small population of birds is part of the ecosystem function, but forestry functions irrespective of the presence of a particular bird. It should be emphasised that ecosystems from a land use point of view may be considered multifunctional. Forman and Godron [16] and van der Ploeg [23] claimed that a hedgerow (which in this context must be treated as an ecosystem used by man) may possess *multiple functions* for the farmer and for society – shade, pest reduction, wildlife, competition with crops and so on. In addition, a land use type may be considered multifunctional, for instance a pasture may be used for grazing, for mowing, serve as a habitat for species, as winter sport terrain and so forth. Often the expression multiple use is employed to describe different land uses at the same landscape unit.

iii. Transcending functionality, or intended capacities in society for the maintenance or change of the noosphere, and the capacity of the environment to provide immaterial services

The third approach to functionality comprises functions that are not necessarily related to material processes per se, as required in definitions (i) and (ii). Functionality without attributed material processes may be termed transcending functionality.

Transcending functions are often associated with aesthetic, social, economic, juridical, regulative or tenure relations. Such functions are often related to specific landscapes, but not necessarily associated to well defined geo-ecological or land use units. Adding aesthetic values, or designating land areas to specific purposes are examples of transcending functions, as they only exist on maps or as conceptions.

The general category of transcending functions may be subdivided into *designated* and *perceived* functionality. Though both are entirely constructions of the human mind, differences exist between designated and perceived functions.

Designations of landscapes are typically made in order to give priority to a certain land user, a certain land use, protection measures or other requirements that calls for a zoning of the land area. Doing so, planners and developers can act so as to concentrate activities. Designations are often very well delineated objectively and retrievable from maps and GIS's.

By *perceived functions* we refer to mental abstractions, where a flow of information from the landscape is interpreted by the human brain and transformed into concepts that might be difficult to define such as beauty, or spiritual feelings, which are relations between individuals and the landscape (see also Howard *et al.*, Vol. 2). Perceived functions are generally subjective, and might be difficult to delineate spatially. The spiritual feeling may vary from person to person, or between different interest groups in contact with the same landscape. Driving through a landscape, it is often hard to tell exactly when the landscape begins or ceases to be beautiful.

Both designated and perceived functionality require a flow of information to add meaning to the functions. The transformation of information may be landscape information reproduced on a picture or a map, or in a written or oral presentation of landscapes.

Designated or perceived multifunctionality may easily arise from the mere combination of designated functions in the same landscape or land unit, or different perceptions of the same landscape. The forestry example given above may also serve as an example for the designated and perceived functions. The forest may be designated a *habitat* in accordance with EU regulations, the habita is delineated on a map and recognised by all relevant actors without even leavin a single trace in the landscape. Nevertheless, the forest has got a new functio Neither, the related forms of perceived functionality, such as the recognition th the forest is beautiful, nor that it might contain important cultural carnation imply physical changes. This perceived transcending functionality migh however, be realised in the intensity of the recreation function of the forest.

Relations between the different functionality concepts (i), (ii) and (iii)

Table 2 shows the proposed classification of functions, developed for the stud of present and future multifunctional landscapes. Landscape functions a basically divided into the three different approaches to ecosystem, land use an transcending functions, and related to the more general classifications of natu functions based on van der Maarel and Dauvelliers [18]. Only examples c functions that can be related to spatial units (weather with a (geo-bio) ecosyste or land use mapping context) have been included here. Bastian's contribution ha been particularly useful, whilst additional ideas have been culled from de Groo [17], Gulinck, Palang *et al.*, Pistrich and Wytrzens, Staljanssens *et al.*, Olwi and others contributing to this collection of papers.

As mentioned above, the three approaches represent different viewpoin about functionality, partly related to various scientific traditions. Th identification of links between the three approaches therefore seems essential fo enabling communication among interdisciplinary audiences.

However, to begin with, some crucial *differences* between the approache should be pinpointed. Firstly, ecosystem function encompasses all processe whereas land use encompasses only a fraction of these processes, as exemplifie above. Secondly, material processes are not necessarily a consequence c designated or perceived functionality.

Finally, it should be emphasised that both ecosystems and land use system may be viewed as social constructions, built on models that emphasises certai processes.

The detection and analysis of **land cover** may be a useful tool whe distinguishing between and linking (i), (ii) and (iii). Land cover is the cover c the earth's surface, empirically detectable using a variety of devices. Th detection of content and structure of the land cover does not provide muc information per se, but coupled with the concept of functionality, land cove becomes an important tool. Land cover may assist in operationalising the use c all three approaches. Land cover information is probably the most often use variable in distinguishing both ecological and land use units, and th manifestation of perceived functions in the landscape is often reflected in lan cover. Often (but certainly not always) the borders of designated functions on maps follow existing land cover boundaries, especially in old cultural landscapes.

The term land cover is used as an empirical approach to the description of both ecosystem functionality, land use functionality, and in many cases also designated and/or perceived functionality. Land cover may indicate the delineation of ecosystem borders, and help identify ecosystem function, but land cover is also an expression of human induced structures and changes, i.e. land use.

Land cover may be used to characterise and/or delineate a designation such as land ownership borders in the form of hedges and walls for instance. So, land cover may be used to visualise otherwise non-visible borders. Land cover may also contribute to perceived functions. For instance, aesthetic value is often a result of a specific distribution and/or combination of land cover type.

Perceptions and designations may be materialised in the landscapes, but usually only after an information process. National parks, nature reserves, battlefield parks are examples of designated areas that did not initially posses marked boundaries, but where differentiation in management inside and outside the designated area has gradually made the borders visible. In an urban development plan, the parcelling out of land will often result in a materialisation of borders in form of hedgerows, walls or other marked land cover differences as one of the first material consequences. In contrast, the materialisation of autonomous ecosystem processes happens irrespective of human influence.

Combining different types of functionality

If a transcending function is added to a land use function for example aesthetic beauty is added to agriculture, the area might be deemed multifunctional by definition. It is a basic assumption of our categorisation that it does not make sense simply to add functions from these different spheres. They represent different analysis approaches. Although their combination is very desirable, it cannot be in the form of a simple addition. It is therefore important to arrive at some agreement about operationalisation of the concepts functionality and multifunctionality.

As Soini [22] states, classification (and in particular mapping) of functions and multifunctionality, present landscape sciences with new challenges.

Table 2: A classification of landscape functions, relevant for the analysis of present and future landscape multifunctionality

	Existing material functions and their spatial intensity		Existing non-material functions as well as future material functions
	Ecosystem function	Land use function and intensity (usage)	Transcending functions
Production functions	• Gaming (hunting) • Fish (angling) • Gathering of natural products (food, genetic and medicinal resources, household fabrics) • Consumption of ground and surface water • Collection of renewable energy	• perennial food and fodder crops • perennial industrial crops • permanent crops • wood production • pisciculture • Extraction of non-renewable mineral raw materials and building materials	Future production oriented (e.g. neo-rural) ecosystem and land use functions and their spatial intensity
Ecological regulation functions	• Formation of topsoil and maintenance of soil-fertility • Regulation of erosion and sedimentation • Regulation of soil wetness and drying up • Resistance against compaction • Decomposition of harmful matters • Groundwater recharge • Water storage/run-off balance regulation • Natural surface water purification • Regulation of the energy balance • Regulation of the climate at different landscape and trophic levels • Self-renewal of biotic communities • Self-renewal, maintenance and regulation of populations and metapopulations within landscapes (at different levels) of sources, sinks, buffers/corridors and habitats • Conservation of gene banks • Maintenance of biological (and genetic) diversity at different landscape levels	• Storage and recycling of human waste • Regulation and maintenance of nature protection areas	Ecological regulation functions related to future (e.g. neo-rural) production oriented ecosystem and land use functions

Information functions			Perceived functions: • Aesthetic functions (scenery) • Local and regional identity • Spiritual and religious functions • Expression of social power • Ethical functions (gene fonds, cultural heritage) • Cultural and artistic inspiration • Functions for science and education • Recreative and tourist functions (social and psychological part) • Indications of environmental situation Designations: • Land registration • Land use zoning • Protected areas
Mechanical and spatial support	• Filtering and buffering functions (soil/water/air/noise)	• Human habitation and settlements • Industrial land • Infrastructures • Military grounds • Recreation and tourist functions (human-ecological part)	Future (e.g. neo-rural) human-ecological support functions and their spatial intensity

Spatial operationalisation of functionality and multifunctionality in landscapes

Obviously each approach to functionality arrives at substantially different conclusions regarding their conception of functions, and of their concept of the landscape, since there is a strong internal relation between landscape structures, processes, and functions within each of the three approaches. On the other hand, in all cases, especially the land classification and structure related mapping of landscape units will often be applied somewhat independently of the required functional relation. Therefore, problems of correspondence exist not only between the various approaches, but also between the conceptualisations of functions and structure within each approach. So, if one attempts to explicate the different functions in the landscape in a cartographic format, problems might arise in obtaining a correspondingly clear conception and mapping of landscape units and vice versa. In the process of the conceptualisation and complex mapping of landscape units, certain priorities concerning landscape functions will, implicitly, be present, though not necessarily in correspondence with the needs set by a given classification of functionality.

Nonetheless, it is not difficult to establish some central spatial aspects of the concept of a multifunctional landscape given a landscape structure which is chorologically defined as hierarchically ordered entities of heterogeneous land units, and given a corresponding classification of functions related to these units.

Combinations of functions within the same spatial unit, irrespectively of whether they are spatially well defined or diffuse, may result in a landscape regarded as multifunctional. The assignment of more than one function is very often linked to a certain scale in space or time. If a land unit appears monofunctional, it is, before realising otherwise, often just a question of scaling – or patience! If landscapes of increasing size are included in the surveys, we are eventually likely to encompass more than one function. Further, after some time the farmer may grow a different crop, or divide the field into two units, again giving rise to multifunctionality. This has probably given the impression that all landscapes are per definition multifunctional, Gulinck (this volume) stresses that apparently monofunctional landscapes commonly house "natural functions" too for example the combination of large wheat crops with source and sink functions.

From a spatial point of view, it is possible to define at least three different general types of multifunctionality:

A. Multifunctionality as a spatial combination of separate land units with different (mono)functions (spatial segregation).
B. Multifunctionality as different functions devoted to the same land unit, but separated in time, often in certain cycles (time segregation).

C. Multifunctionality as the integration of different functions in the same unit of land (or overlapping units of land), at the same time (spatial integration or "real multifunctionality").

The multifunctionality of type A – spatial segregation – disappears when the scale is narrowed down since only one function – monofunctionality – exists at the most detailed landscape level, for example the ecotope level. The multifunctionality of type C – spatial integration – will remain constant irrespectively of the spatial scale of observation.

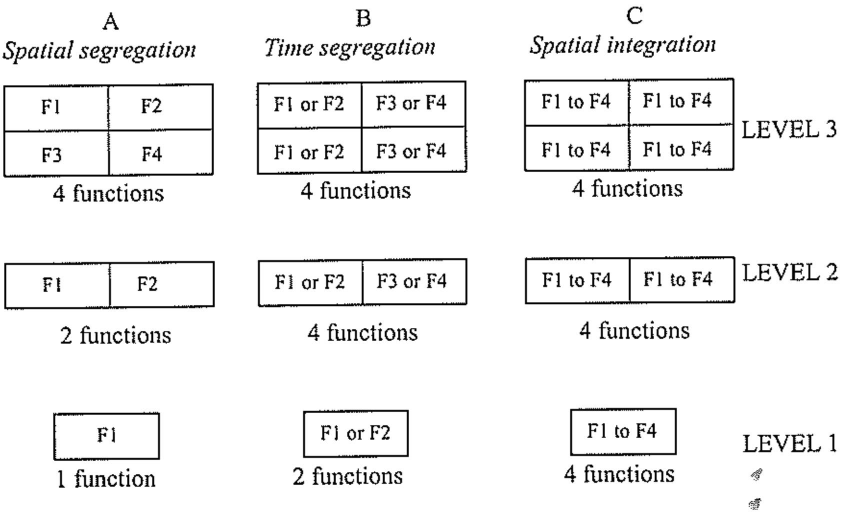

Figure 1: Three types of multifunctionality measured at different spatial and chronological levels. A: By spatial segregation. B: By time segregation. C: By spatial and chronological integration.

The type C multifunctionality is characterised by a true integration of different functions in time and space, whereas type A or B will often be a result of links or conflicts between the functions that may only be used or solved by a spatial (A) or chronological (B) segregation of the various functions.

A clear distinction between these types of multifunctionality will in all probability be difficult to establish in practice. Interaction between different functional units will exist within all three types of multifunctionality, due to the chorological connections between land units with different functions. Even in the extreme case of a strict spatial segregation of land use, a "real" multifunctionality at the lowest level will be present around the functional boundaries, often as a conflict, which turn the chorological structure or landscape heterogeneity into 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 certain spatial segregation of functions is given in all cases, it is clear that the necessity of a true multifunctionality around the borders increases with the amount of borderline between the two functions. The two functions require better adaptation to each other in the example on the right than is the case on the left. So, an ecotone, as a border or transition between two different ecosystems can be considered a device for a spatial handling of multifunctionality. With extremely detailed "heterogenisation", the ecotone functionality will develop towards the character of a general matrix related to a "true multifunctionality" of type C, dissolving the character of segregation related to the type A.

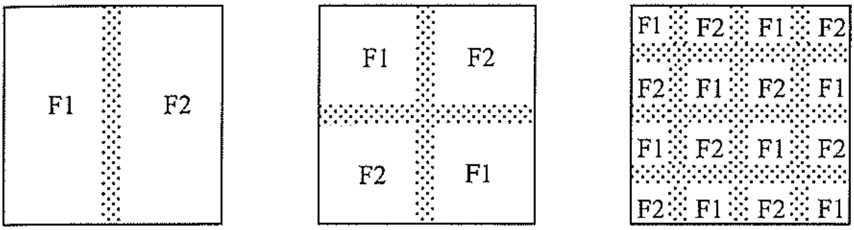

Figure 2: The influence of landscape heterogeneity on the degree of landscape multifunctionality. F1: Function 1. F2: Function 2. Dotted area: Interaction between F1 and F2 ("ecotone functionality"), increasing from 10%, over 20% to 50% of the area.

In the same way a functional segregation in time might be more or less dissolved by a finer and overlapping sequential structuring of the land use as in the case of the introduction of pre- and past-crops as additional stages in rotation plans.

Conclusions

The problems as well as the study of multifunctional landscapes are extremely diverse. A holistic system approach seems obvious to promote common concepts, connections between different relevant systems, and parallel comparable ways of functional analysis and argumentation. More "inductive" ways of integration based on very different disciplinary or practical entrances should be involved and systematically compared to deepen the understanding of landscape functionality and sharpen the goal oriented endeavour to find recommendations for a better relation between social needs in its broadest sense in the future, and the possible functionalities of our historically developed landscapes.

Multifunctional landscapes can be seen as one of many strategies for a transformation towards a sustainable development at the landscape level. The industrialised world is probably already in the course of this transformation, but we have only very few tools to document this trend, however, and we do not know how to evaluate the consequences.

In this discussion, it might implicitly be understood that multifunctionality is a good thing, and that the monofunctionality of the 20th century is an inherited burden that we must leave behind. Indeed, multifunctionality is often considered as being absolutely positive (Vos and Meekes [24]) and seen in an overall historical perspective we may support this viewpoint when applying it to production landscapes in which "competing functions" have intentionally been removed. But basically, monofunctionality is not a bad or unnatural principle. As Gulinck states (this volume), *"Not the basic principle of monofunctionality should be questioned, rather certain negative consequences of its application or the neglect of assets of multifunctionality"*. Correspondingly, we also believe that multifunctionality should be understood neutrally, and that a thorough discussion of functional values is necessary in order to circumvent futile discussions in the future. A few things should be emphasised:

1. Externalities produced by agriculture and forestry which add to the multifunctional character of these sectors may be both positive and negative. In employing strategies for multifunctional land uses, we should encourage the positive externalities and evade the negative, and be aware that negative externalities may occur.

2. There is a widespread idea that the traditional rural landscapes of Europe were multifunctional. The multifunctional landscapes that we have lost were often landscapes in which institutional violence and suppression along with strong social inequalities were a mere fact of life. The negative impacts on the environment were considerable. Future planners should be aware that the landscapes we denote monofunctional happened to develop not only along with the development of the welfare societies of the western world, but just as much as a necessary reaction to serious landscape ecological problems of former types of multifunctional land use (Fritzbøger [25], Haber [13], Kjaergaard [26]). Socio-economic structures have not always been capable of managing multifunctional landscapes in a sustainable manner, and new ways of regulating

them are indeed needed if a strategy of multifunctional landscapes as a means to and as education for a sustainable development is to be successful.

3. There are monofunctional landscapes, in the sense of land use and transcending functionality, that should remain monofunctional. In many cases, nature reserves and national parks with restricted admission should not be subjected to multifunctional strategies. We should not encourage new functions in every landscape, and we should not maximise multifunctionality just for the sake of it.

The conference in Roskilde provided useful thoughts on the concepts and strategies on multifunctional landscape and many more than expressed in this introduction are embedded in these volumes. All the contributions deal with the concepts of function, functionality, multifunctionality or related landscape aspects. The wide variety of definitions and approaches clearly demonstrates that the scientific community has not agreed on a paradigm concerning these issues. However, it is possible to aggregate various viewpoints to create a certain common ground for the discussions to come, and we strongly encourage this discussion to continue.

A variety of theoretical considerations and proposals for solutions, often based on practical cases, are presented within these volumes. During the conference common recommendations for future research within the themes were formulated and discussed. They were presented in a draft form to all authors of the papers presented in the two volumes, and have partly been taken into consideration by the preparation of the papers. On the other hand, it has been possible to cover only a small number of the research problems presented in the recommendations through the relatively few papers included. This has been taken into consideration in the final editing of the five sets of recommendations made for this publication.

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