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Brandt, Jesper; De Blust, Geert; Wascher, Dirk

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Recommendations for future research

Monitoring multifunctional terrestrial landscapes

J. Brandt[1], G. De Blust[2] & D. Wascher[3]
[1] *Roskilde University (RUC), Denmark*
[2] *Institute of Nature Conservation, Belgium*
[3] *Alterra Research Institute for the Green World, The Netherlands*

1 Introduction

Despite the fact that in some countries a great deal of experience concerning terrestial landscape monitoring has been gained and, in some cases, one might even talk of a "tradition" having been established, for the most part the monitoring remains at an embryonic stage. This stage has been characterised by its goal oriented context where biologically oriented terrestial monitoring has been undertaken in relation to forming nature policy.

However, the monitoring will, in all probability, become more widespread since, in recent years, there have been many important trends, which have merged in their interest for monitoring at the landscape level. It is important to be aware of these other trends that might support monitoring, which is often an expensive, time-consuming and an organisationally complicated activity. Among these trends the following should be mentioned:

1. The growing understanding of the connection between a variety of environmental problems on the one hand, and land use processes on the other, has now been recognised at the political level. This has resulted in different types of direct or indirect regulations concerning land use and the intensity thereof. Since this connection however obviously differs from one type of landscape to another and at different geographical levels, the linkage

of thematic environmental monitoring to landscape oriented land use and land cover monitoring has been increasingly recognised.

2. The landscape is related to regional and local differences in population density, in intensity of economic activities as well as in traditions concerning the management of the culturally transformed landscape. These differences offer a variety of opportunities for and obstacles to solving environmental problems. The resulting differentiation in economic activities and environmental problems will give rise to economic, social and political tensions that must also be investigated in the context of on-going changes in landscape structure and function.
3. Recent changes in agricultural policy seem to give rise to a general shift in land use strategy in many types of agricultural landscapes, sometimes described as 'the post-productivist transition'. Within this framework, a productivist phase of intensification, concentration and specialisation has resulted in a growing number of contradictions between the natural structure and dynamics of the landscape and a mono-functional and homogeneous type of agricultural land use. This phase seems to be being gradually replaced by a trend towards the extensification, diversification and dispersion of land use activities. This furthers a more multifunctional land use, where each function is less intensive and consequently more adapted to the landscape than has hitherto been the case. It is, however, probable that the productivist and post-productivist strategies will develop parallelly and combined with each other. This in turn will deepen the need for systematic studies of the trends that in both of these two cases will influence and be influenced by the different conditions presented by different types of landscapes. In general, a supposed parallel development of 'productivist' and 'post-productivist' trends at different spatial levels also implies a change in focus from (post)productivism towards the (multi)functionality of spatial units.
4. The technological changes linked to the productivist phase of modern agriculture were often characterised by labour saving investments, which were not sensitive to differentiations in environmental and landscape conditions. So, in general, this type of 'non-spatial' technology has often focused on the shaping of common environmental conditions, not only furthering the segregation of land use and monotonisation of agrarian landscapes, but also ignoring the landscape component within planning and management in general. The development of information technology in particular has recently changed this situation, so that today's land use technology is much more oriented towards the economic as well as ecological advantages of adapting the land use processes to landscape

conditions. Indeed, this development will also influence the trend towards a multifunctional land use strategy.

5. Regional planning in the productivist phase often supported 'non-spatial' technology by providing economic support for the homogenisation and adaptation of environmental conditions. This support came in the form of amelioration, farm amalgamations, etc., as well as zonal legislation, giving regional or local priority to intensive mono-functional types of land use. At the same time as the shift towards 'the post productivist transition' and the changing technological possibilities, there has also been an increasing endeavour to develop more sophisticated types of land use regulations, direct or indirect, which have gradually replaced the earlier planning tradition which had emphasised segregated land use. The fulfilment of this endeavour is, however, only possible if a better understanding of the relations of land use to differences in landscape conditions are known and recognised, and the conflicts related to these matters are better regulated.
6. Finally, urbanisation processes have tended towards much more dispersed settlement patterns and economic activities. This is primarily related to the current developments in transport technology and networks. In addition, the growing use of information technology, the increasing amount of leisure time, and the dissatisfaction with environmental and social conditions in existing urban areas have given rise to an urban sprawl that, in a variety of ways, calls for a more multifunctional use of our landscapes.

All these trends have led to considerable changes in land use and land cover as well as in the natural and social functions of our landscapes. Whether these changes are moving land use in a direction that is more sustainable, is an open question. It should, however, be suspected that both positive and negative trends can be found. Nevertheless, the natural, socio-economic and cultural characteristics of landscapes and their interrelations at different levels are always involved. An overall goal for terrestrial landscape monitoring should, therefore, be the detection of such trends in a systematic and reliable way. Furthermore, the monitoring of multifunctional terrestrial landscapes depends on the thesis that the systematic monitoring of different aspects of landscape functionality might add to the understanding of ongoing landscape changes and widen the possibilities for the formulation of policies which would lead to a more sustainable use of our landscapes.

The landscape ecology oriented research into landscape surveillance, which gradually developed towards a 'first-generation terrestrial landscape monitoring', provided a great deal of experience that allow us to formulate some preliminary guidelines for improving the monitoring of multifunctional terrestrial landscapes. Based on the above, we can make recommendations for future research relating to three areas:

a. The need for **strategic conceptualisations** regarding the monitoring system, making it possible to integrate variables and indicators so as to support policy or management goals.
b. The need for the development of a **landscape model** which would be relevant to policy formulation. The model should be related to basic categories of landscape (multi)functionality.
c. The need for organisational models (**'handbooks'**) for multifunctional landscape monitoring systems that can assimilate the variety of detailed knowledge and important experience concerning the development and maintenance of such monitoring systems.

2 Strategic objectives for landscape monitoring

To support policy and management goals, a landscape monitoring system should go beyond the detection of changes in the state of the landscape. **Above all, it should encapsulate information about landscape processes including socio-economic aspects.** Although landscapes, including historically developed cultural landscapes, are integrated systems where all parts are mutually dependent on each other, problems of landscape management can nevertheless often be conceptually linked to causal environmental disturbance chains. This should be reflected in the monitoring system. Models like the OECD's Pressure – State – Response (PSR), or the Driving forces – Pressures – State – Impact – Responses (DPSIR) used by the European Environmental Agency (EEA) and applied in many European countries, are examples of models which could be transformed and used in **a landscape context as a basis for classifying and selecting appropriate variables and indicators**. When doing so, the spatial scale of the monitoring should be considered in detail. Variables and stressors act at different spatial scales that are not always covered by the original monitoring layout. Hence, up- and downscaling for landscape monitoring purposes requires considerable attention in the future.

When adopting these models as the structuring rationale, landscape monitoring will be more in line with the current organisation of environmental policy and, as a consequence, will automatically gain importance. However, the mere adoption of one of the models is not enough to increase policy relevance. Equal attention should be paid to the selection of the indicators. Currently, various independent attempts are being made to define indicator requirements (e.g. EU, OECD, CoE). Preferably, we should arrive at the situation where **key indicators are agreed upon between these different institutions.**

Although short-termed specific policy goals might often dominate the immediate demands upon and the contents of a landscape monitoring system, they should be subsidiary to broader goals linked to a farsighted maintenance of the landscape monitoring system, which as a result will increase its value considerably. Related to this is the decision about the **frequency of the monitoring.** This **should be a compromise between the time span of the policy cycle on the one hand (users) and the expected dynamics of the variables on the other**. Ideally, monitoring fits the frequency of the most dynamic variable.

However complex the monitoring may be, not a single programme can cover the whole (landscape ecological) system, even though the aim is to obtain a fully integrated monitoring system. Therefore, **linking landscape oriented monitoring schemes to already existing thematic monitoring programmes is highly recommended.** In combination with this, landscape monitoring not only yields the classical landscape features and land use data, but also provides a sound and accurate spatial foundation for the thematic monitoring programmes: the "anchor function". Finally, to achieve an optimal, integrated monitoring scheme that allows for the explanation of the cause-effect chains, a combined analysis with other data sources is equally needed. As such, all monitoring activities at the European level should make active use of and provide linkages to existing European data as provided by the EEA, JRC, Eurostat and other European agencies.

The **institutional cooperation of stakeholders** is a strategic element that contributes substantially to the success of an integrated landscape-monitoring programme. Close cooperation with national agencies and authorities is imperative. Reliance on exclusively academic or NGO related methodologies, processes and data sources is likely to detach landscape monitoring from relevant public activities and hence run the risk of isolation. Equally, funding institutions, of which many are linked with well established independent agencies, must be prepared to work together. Still, it is far too often the case that co-operation is hampered by competence conflicts and 'territory fights' that characterise the current situation between sectors active in the countryside. Establishing a joint landscape-monitoring programme can thus contribute to integrating the objectives of previously separate sectors of the rural areas.

Involvement of stakeholders and users is crucial when defining the efficiency of any monitoring programme. Indeed, given a fixed amount of resources, is it preferable to aim for strictly statistically sound results and hence increase the number of sites but monitor only a limited number of variables, or is it better to monitor many variables at a restricted number of sites, with, as a consequence, more but statistically and spatially weaker results? Users' objectives can be decisive in this respect.

Close cooperation with policy representatives is also important for achieving the adoption of monitoring results, which can be a basis for policy decisions. Quite often, policy decisions are made on a partly irrational base, hardly taking all the scientific facts into account. If that is the case, one may raise the question of whether or not it can be justified to put so much effort into reaching statistical accuracy and consequently, again given a fixed amount of resources, extend the monitoring frequency. Delayed delivery of results, however, may hamper a close link with policy timing, which in the end can lead to the abandonment of monitoring results as a base for environment and land use policy.

Finally, at the moment it appears that the monitoring of land use and landscape features is perceived by the people living and working at the monitoring sites as a control, as an instrument that in the first place is meant to search for deviations from the standards. Under these conditions, monitoring has a negative connotation. Therefore, **efforts should be made to turn it into a more positive tool**, one that elucidates positive developments taking place and yields new insights into ways to manage the land and to use the natural resources in a more sustainable way. If this can be achieved, **monitoring will allow us to learn how people succeeded in reaching goals, rather than simply assessing whether or not goals set are reached.**

3 Principles relating to an operational landscape model

Although there has been a considerable accumulation of knowledge over the past few decades, it was felt necessary to increase the understanding of the natural spatial variability of landscapes features in order to design optimal monitoring strategies. However, this is still insufficient to construct an operational landscape model, which can be the basis for the comprehensive and integrated monitoring of landscapes.

If we are to place emphasis on possibilities of including functionality shifts and other functionality considerations in the monitoring system, these aspects will have to be integrated at all levels. Basically, it will be necessary to develop:

a. A **hierarchically structured classification of landscape functions** with a basic division into ecological functions for the maintenance of the integrity of the landscape system and related ecosystems, and socio-economic and cultural functions related to different types of land use more or less adapted to the landscape.
b. A **functionality relevant landscape classification system** of natural land units, land cover, and land use, supporting a time dimension in the allocation of spatial functionality.
c. A system for the analysis and description of the functional potentials of natural land units that allows for a **systematic analysis of the spatial conformity of land use and management to the natural conditions** (see the former land evaluation).

These building blocks allow the strategic goals of a landscape model to be fulfilled: functional conflicts can be elucidated and the monitoring of policy implementation will be established.

As a prerequisite for reaching a broader public and policy makers, it is necessary that the elements of such an operational landscape model, and hence the issues of landscape monitoring (i.e. biodiversity, land use, soil, water, productivity, recreation, culture, etc.), are **communicated in transparent and consistent ways.**

Integrating the classification of landscape functions in a time sensitive landscape model will allow for a spatial distinction between three main types of multi-functionality:

a. Multi-functionality as a spatial combination of different (mono)functions related to separate land units.
b. Multi-functionality as different functions related to the same land unit, but separated in time, typically in a certain cycle.
c. Multi-functionality as the simultaneous or partially co-terminus integration of different functions, at the same or overlapping land units.

Since segregation strategy for land use is based on a systematic implementation of type 'a' – possibly related to zoning that furthers a simplification of the spatial land use pattern – it will express a certain multi-functionality that increases with the spatial level of registration.

However, it would be more beneficial if a land use integration strategy followed the technical and social possibilities for the spatial integration of functions based on flexible, 'soft', or extensive ways of using land, thus of type 'c', where the degree of multi-functionality is less related to the spatial level of registration. Still, this assumes **a shift in the dominant paradigm** from "the optimal yield is reached by mono-functional goal orientation" which is the basis **of current mono-functional thinking**. The principles of sustainability prompt for such a shift. Indeed, according to these principles, environmental objectives, including the conservation of nature, should always be embodied in sectorial considerations. Hence, multi-functionality is not only a spatial concept, but also a principle of sustainability, which is valid for each function or sector.

Due to chorological interrelations between most functions related to landscapes, the integration of or conflicts between different functions will exist in all three types of multi-functionality. The degree of multi-functionality is, therefore, much related to the chorological structure of the land units. Therefore, **the analysis of spatial interrelations and of boundary conditions between different functions in the landscape ('functional boundaries') forms an integral part of a landscape monitoring scheme.**

4 Guidelines for multifunctional landscape monitoring systems ('handbooks')

A system for the monitoring of multifunctional terrestrial landscapes has to b based on extremely strict scientific principles. Due to the complex character, an to the complicated organisational mode of data collection and storage, there wil be a strong need for the systematic collection of experience from scientifi practises devoted to the development of landscape monitoring systems. Thes experiences should be compiled in well-structured 'handbooks' that can serve a the basis for the development of new landscape monitoring programmes. Amon the guidelines already formulated, the following should be mentioned:

a) The **scope for the monitoring should be all inclusive** and hence all type of landscapes, including, for example, urban fringe areas and suburbanise regions (of great importance in Europe), should be covered.

b) Although landscape monitoring is the prime concern, it should be stresse that its **integration with other environment monitoring information an socio-economic data, such as agricultural statistics, is of the utmos importance**. However, to be successful in exploiting existing monitorin data, the **development of appropriate statistical methods, includin methods for the integration** of partial coverage (e.g. sample derived) an full coverage (e.g. satellite image derived) should be encouraged.

c) It can be difficult to standardise and integrate the very different approache to monitoring, which range from remote sensing to detailed ground photos and from field surveys to interviews and archive searches. It is, nevertheless important to **combine different sources of information to maximise thei strengths**. This can be obtained by the reclassification of data an corrections to data based on errors found at a later date. The use of differer information sources (e.g. air and ground photos) can also be beneficial.

d) The combination and integration of very different variables as well a objectives, requires that the 'question of scale' is explicitly addressed. makes sense to **propose a clearly defined hierarchy of scales related t the assessment, with different objectives and functions attached to eac level of scale**. For example, at the local level, field work assessment i undertaken at a rather close-up level of m². At national level there is th increasing trend to use 1-km² sites for multi-factor analysis. In order to lin up with the decision-making context at farm level, sites of 4 km² have bee proposed. Finally, driving force analysis clearly goes beyond this scale an looks at extended regional units. Each level should form the basis of relational database as part of a coherent GIS in order to avoi methodological problems when aggregating data.

e) Remotely sensed earth observation data are an indispensable source for landscape monitoring. Either aerial photos or recently developed satellite data with high geometrical resolution are indispensable tools for the detailed preparation of the survey, for the survey itself, and for the extrapolation of the results derived from the landscape monitoring system. Nevertheless, a **landscape monitoring system essentially has to be performed through detailed field surveys**. This is due to the detailed character of much ecological oriented landscape information and to the need of integrating functional information related to land use.

f) The extent and components of the total landscape being monitored must be explicitly stated as **a baseline for the monitoring**, to sharpen the scope, accuracy and statistical confidence in any results or descriptions.

g) For economic, time, and organisational reasons, landscape monitoring has to be mostly based on a very limited sample of the total area surveyed. The targeting of samples is crucial in order to maximise returns on effort and to ensure statistical reliability, and should, in general, be related to an appropriate and statistically rigorous stratification. **Survey efficiency, the making of regional estimates, and modelling will gain greatly when based on such stratification.**

h) All land units, land covers, and land uses within each sample area should be **surveyed in a mutually exclusive way to allow for comparable time series analysis**. No types of units should be omitted.

i) The **same sample locations should be revisited during each monitoring round**, so that real change can be recorded. The time between surveys should be long enough to allow for change. Programmes should build on the long-term assurance of basic standard monitoring methods to ensure that apparent changes are not detected merely because of the requirements imposed by the monitoring methods.

j) **All terms and methods should be fully explained in a field handbook** as surveys are usually conducted by interdisciplinary teams having different backgrounds and experiences and whose members change from one survey to the next. Furthermore, clear communication between all involved should be established and controlled, for instance through field training courses that can ensure a standard level of expertise for surveyors and interpreters.

k) Standard recording methods that minimise modifications, additions and subjective decisions and judgements among the field workers should be established for all types of information collection. Decisions should be made in the field, not during data storage. Furthermore, it is important to ensure that there is **a clear distinction between data collection and analysis on the one hand, and valuation statements on the other**. The latter is more the domain of policy. In the same vain, it is necessary to ensure that there are **as few value-laden qualifiers** added to the survey keys as possible. T greatest degree of objectivity is desirable.

l) **Data control should be an inherent part of the monitoring system.** Tl should not only be related to field survey checks, but also by systema control in connection with the data storage. Integrated GIS-layer models tl can support detailed time series analysis of the monitored data, can be important tool for the successive control and improvement of data qual among different stages of the monitoring process.

m) By result communication, accuracy should be tested through qualii assurance exercises and results guided by descriptions of confidence whe possible. Due to the complex character of landscape dynamics, **resu should preferably be presented in terms of raw variables that have be monitored in combination with a set of indices.**