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Publication date:
1991

Document Version
Early version, also known as pre-print

Citation for published version (APA):
Brandt, J., & Agger, P. W. (1991). *Changes in land-use and biotope pattern in Danish agricultural landscape during the 80ties*. Roskilde Universitet.

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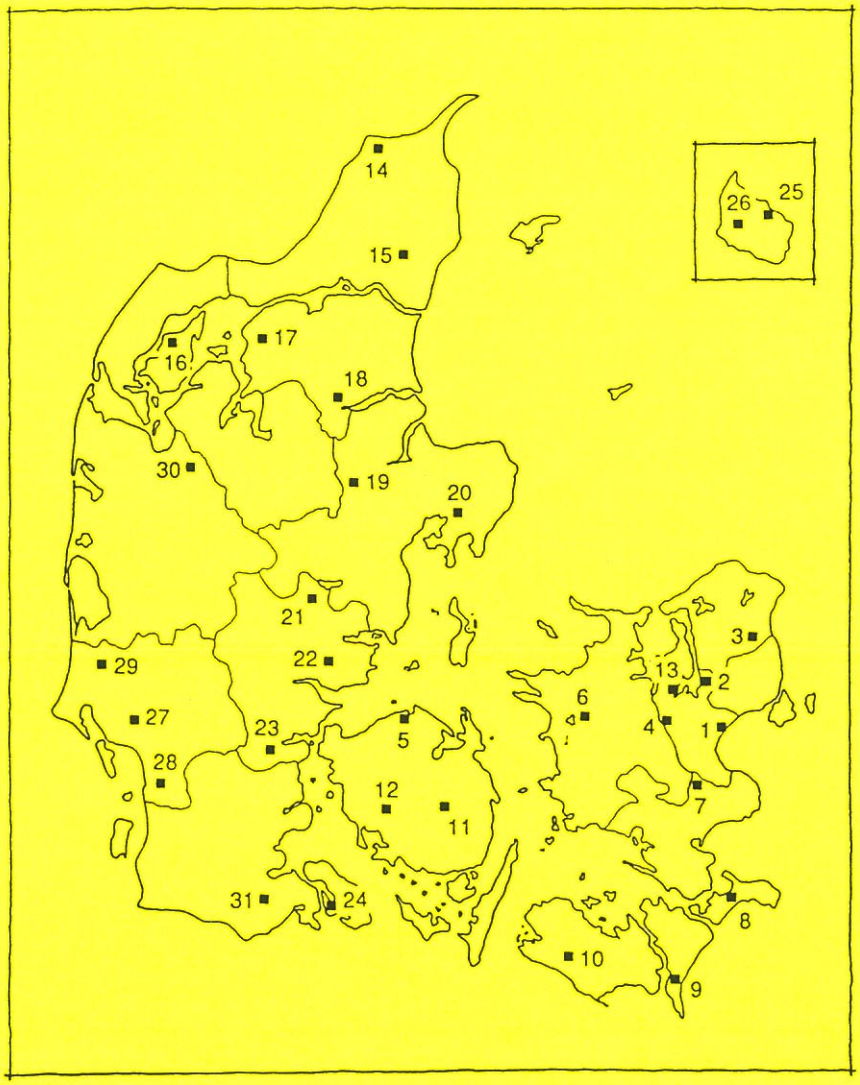

PUBLIKATIONER FRA INSTITUT FOR GEOGRAFI, SAMFUNDSANALYSE OG DATALOGI

ARBEJDSPAPIR NR. 108 1991

ISSN 0106-5920-108

Paper presented at the World Congress of Landscape Ecology, Ottawa, Canada 12-25 July 1991.

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Changes in land-use and biotope pattern in Danish agricultural landscapes during the 80'ties.

1. Abstract

Due to changes in market conditions and environmental policy a dramatical change in the composition of the Danish agricultural land-use has been expected since the middle of the 80'ties. Based on studies of biotope pattern and related agricultural structure in a number of test areas in 1981, 1986 and 1991, the differentiation in the development of the pattern of small biotopes will be analyzed and the impact of changing land-use will be demonstrated. The first preliminary result from the not yet finished investigations show remarkable little change in the biotope pattern dispite the changes in agricultural land-use. The differentiation process will be related to a detailed landscape survey in the test area to see, if the ongoing process can be interpreted as an environmental adaptation towards a more close relation between land-use, landscape type and biotope pattern.

1. Introduction

The Danish small Biotope Studies started for more than 10 years ago. The methodology was developed in the end of the 70ties and a comprehensive study in 13 2x2 km test areas was carried out in 1981. Basically this campaign consisted of a detailed field registration of all line-biotopes and patch-biotopes less than 2 ha within the open land. Interviews with farmers concerning general agricultural conditions, the functions of the small biotopes and their future plans for their biotopes and an historical analysis of the development of small biotopes in 5 of the test areas, based on map and and air photo interpretation, were also included.
The field campaign has now been repeated 10 years after: The methods used are almost the same, but the number of areas has been increased to 32, covering all parts of Denmark (see fig. 1), and a general land-use mapping and survey of landscape units in all test areas has been added..
The biotope registration and land-use-mapping has been done in May,June, and July and a relational database based on Oracle /SQL has been created to handle the data and adjusted especially to fulfill the needs for spatial analysis. But the interviews (including spatial information on ownership) as well as surveys of landscape-units have not been finished yet. So only some very preliminary results based on hand-made calculations and impressions from the campaign done so far can be presented.

2. Changes in the scope of the investigations

Due to the narrow relation between science and planning within this branch of landscape ecology the scope of the investigations have changed somewhat during the years:

The project was started at the end of the 70ties with the scope of giving empirical information on the structure (composition and geographical pattern) and development of the small uncultivated landscape elements within the agricultural landscape, and the processes behind.

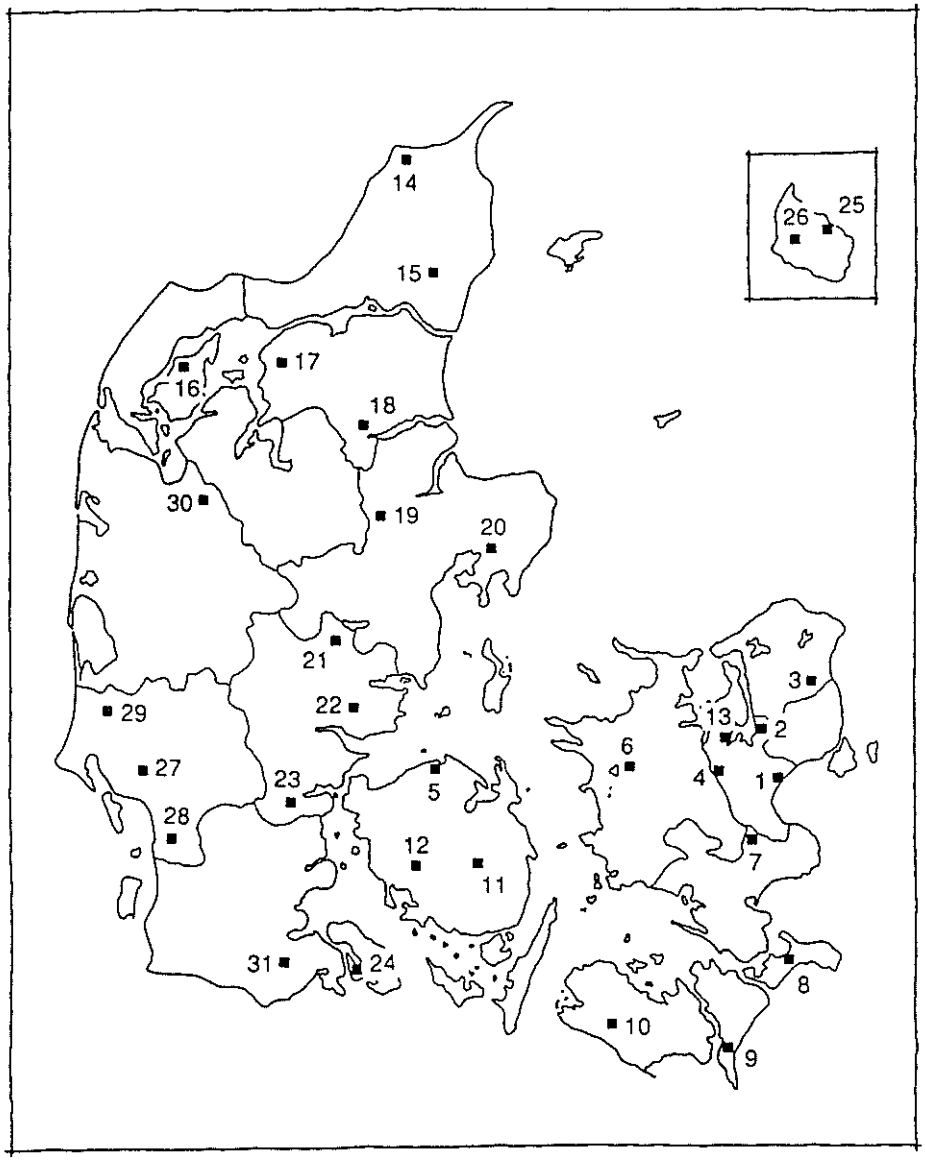

Fig. 1. The location of the 2x2 km test areas for field investigations

Much effort was put into developing a classification and field registration method as reproducible as possible, especially to ensure that changes in the composition and pattern could be registered with a high reliability .The classification of small biotopes use vernacular names (see fig. 2), but the types of biotopes are defined strictly to permit repetition of the fieldwork. Some problems related to the classification are discussed in Agger and Brandt (1984 and 1988).

Line-biotopes	Patch-biotopes
00 Field road verge 01 Gravel road verge 02 Paved road verge 03 Avenue verge 04 Field divide 05 Hedgerow 06 Stone wall 07 Hedgerow on stone wall 08 Dyke 09 Hedgerow on dyke 10 Slope 11 Dry drainage ditch 12 Wet drainage ditch 13 Canal 14 Brook 15 River 32 Embankment verge 43 Treerow 44 Treerow on drainage ditch 45 Treerow on dyke 46 Hedgerow on drainage ditch 47 Footpath	16 Wet marl pit 17 Other wet pit 18 Artificial pond 19 Bog 20 Natural pond or lake 21 Village pond 22 Alder swamp 23 rain water basin 24 Dry marl pit 26 Other dry pit 27 Barrow 28 Plantation for game 29 Other plantations 30 Natural thicket 31 Solitary tree 33 Ruderal area 34 Vegetation under power pylons

Fig. 2. Classification of small biotopes

The dynamics of pattern of small biotopes were in focus already in the investigations in 1981. The classification system and field methods developed could hardly however be evaluated for dynamic purposes at that time, since the historical development was mostly based on map and air photo interpretation. These are sources that only to a limited degree can fulfill the ecologically oriented classification system.
So the 1991 campaign will be the first chance for a strict evaluation of the method for the detection of the development of the whole range of small biotope types within the Danish agricultural landscapes, and their relation to first of all the agricultural structure and development.
The scope changed in 1986, where the registration method was used as a main source of information on status and development of marginal land within the intensively used Weichsel moraine landscapes in Denmark. Here, the small biotopes can be seen as almost the only areal resource for agricultural expansion; and management as well as re- and new-establishment of small biotopes will be a relatively important part of a marginalization within these areas. Buffering zones could be an important tool for a marginalization process, too.
A somewhat simplified registration of small biotopes in the 13 test areas plus another 13 new areas of eastern Jutland, was carried out. These investigations proved, that the development of the small biotopes can be a sensitive indicator for the intensification/extensification of agricultural land-use. (Brandt and Agger, 1988). But it also proved, that it preferably should be linked closely to a parallel incorporation of information on the development of the general land-use, such as changes in the proportion of tilled land to woodland, grassland, wetland, fallow and build-up-areas.

The 1991 campaign is related to a somewhat new scope: Namely to the general monitoring of the wildlife in the agricultural landscapes: In 1987 the registration method was incorporated in a guide on registration of small biotopes to be used by the Danish counties for surveys within typical agricultural areas of the counties. (Tvevad, 1988) The ongoing campaign has been carried out in cooperation with the Ministry of Environment to serve as a part of the general national monitoring programme.

3. Biotope development as target for monitoring

Wildlife is heavily dependant on the small uncultivated habitats within and between the fields. This is certainly true in a country like Denmark where 2/3 of the area is intensivly cultivated. Therefore the monitoring of the development of the pattern of small biotopes is a good indicator for the development of wildlife. But it is also reasonable to monitor the pattern for its influence on the ecological processes and its value for the scenery of the landscape.

Monitoring of development of small biotopes have therefore been included in the farsighted national monitoring programme in Denmark (Agger 1991). This is added to monitoring programmes for other (larger) types of habitats in and outside the agricultural landscapes and selected species or group of animal and plant species.

The purpose of the national programme is

- to supply the society with comprehensive and up-to-date knowledge on the state of the environment,
- to serve as a warning system and
- to make evaluation of the effect of former actions both in the case where these have had a management objective and also where the purpose has been something else but where impacts as a side effects might be seen in the environment.

The biotope project presented here should fulfill all three purposes. It has given a description of the general trends. It has supplied us with quantitative estimates of which types of habitats that are most threatned most (Agger and Brandt 1988). And by now being repeated it form a base on which the effectiveness of recent management can be evaluated.

4 Results of the 1991-campaign

As described above all test sites were visited May-July 1991. The bulk of data have not yet been analyzed but some general observations may be unveiled if they are taken with caution.

1. The **marginalization of soils** has been less than expected. Five years ago it was estimated that up to 20% of the agricultural area would be taken out of agricultural production within a decade or two. Today the expectations are moderated to 9% - 16% or 0.6 to 1.2% averagly per year.

In 1981 no cases of newly abandoned or afforested fields were found in the 13 test sites in Eastern Denmark we visited already that year. Five years later 7 cases of abandoning and 2 of afforestation making up 0.21% of the cultivated land were found. After another 5 years this percentage rose to 0.98%. One of the 7 set aside areas had disappeared but 20 new have appeared together with 4 cases of afforestation. The average decrease per year in cultivated land in the two periods have thus been only 0.04 and 0.20% respectively

In the 13 test sites in western Denmark that were visited first time in 1986 the average decrease in cultivated land due to set aside and afforestation were found to 0.11% per year

over the period 1986 to 1991. This gives an average for all 26 test sites from 1986 to 1991 of 0.15% which is below the expected 0.6 to 1.2% per year.

Instead of comparing the area set aside with the area of cultivated land it can also be compared with the area already covered by small biotopes. This was in 1986 3.54%. And as also the development of small biotopes already existing have been moderate, the new input has raised the percentage to 3.7%.

It should be added that some small areas within 4 of our test sites have been designated as Environmentally Sensitive Areas within EECs ESA-programme. This programme has first started in 1990. It should be further added that the EEC induced set aside programme just has started to be implemented in Denmark this year. A preleminary evaluation of the programme has indicated a very limited interest among the danish farmers and their organizations for the programme, contrary to the development in other EEC-countries e.g. Germany and Italy. Therefore the rather modest rate of development in the biotope pattern and in the marginalization process can't be explained by the function of these extensivation schemes.

2. The **differentiation among regions** has seemingly continued. In 1986 we could observe three directions of development in the agricultural landscape in Denmark:

A) On the best soils in the most intensive cultivated areas the intensification went on removing the remnants of what might have been left of small biotopes.

B) On poor soils and / or in hilly landscapes near urban areas an extensivation of the agricultural production could be observed leaving space for more pasture land and small biotopes. Status quo or even a slight improvements could be seen.

C) On poor soils and / or in hilly landscapes far from urban influence newly afforestation or abandoning of land could be seen in 3 of the 26 testsites.

In 1991 these three trends were still visible and the difference between them somewhat deepened in the way that the changes in the biotope pattern seemed to have been moderated or almost stopped over the five years in the majority of test sites, whereas it has continued or even enhanced in the few extreme sites (of "A)" and "C)").

3. The **main cause** for biotope removal seems still to be a continued strong structural change in the agricultural sector. Still more specialized production is concentrated on still fewer but larger farms (Agger 1991). (The "half-life period" for number of agricultural holdings in Denmark is for the time being only 19 years!). Larger holdings have larger fields and averagely fewer field- and farm boundaries per hectare. But there are also factors that tends to maintain or even increase the size and number of small biotopes. Four of them should be mentioned here.

A tendens of extreeme monocropping developed during the 1960-ies and 70-ies where especially barley often continously was grown for fodder, covering 2/3 of the total agricultural area. Now it is displaced by a renewal of a systematic rotation of crops. Thereby the internal division of holding into several fields has somewhat stabilized the biotope pattern. This has specially importance in areas dominated by minor holdings.

Another main cause for biotope restoration and maintenance are the hunting interests which leads to better maintenance of the existing habitats, planting of coverts for pheasants and digging of ponds for mallards.

A third thing to mention is the large scale renewal of live hedge that is going on mainly in the western part of the country on the poorer (less on the poorest) soils. Especially old worn out live hedges consisting of a single row of Picea glauca or Sorbus intermedia are replaced by hedges consisting of three to five rows of a mixture of broad leaved species of trees and bushes. Oak, elm, ash and alder will in the long run be the dominant elements in these new hedges.

Finally there has been a change of consciousness probably among the farmers and certainly in the municipalities and county councils. Management and restoration programmes for small biotopes especially ponds have improved the situation in many existing ponds and the rate of removal has probably gone down. This is not only caused by years of biotope removal but has also to be seen as a response to the many other environmental problems connected with modern agriculture (Primdahl 1991).

Optimistically this can be interpreted as a beginning change from a purely agricultural production-determined development of the countryside toward a more muliple-use oriented management and a growing incorpooration of landscape ecological arguments in the agricultural strategy.

4. Beside the general trends mentioned above some more **special cases** were met during the 1991 campaign. But even they are not general for all sites taken one by one, they may still be characteristic for the trends in the rural landscape taken as a whole:

"Towns in Denmark don't grow any more". This we often say. The reason is fundamentally economic stagnation, partly the demographic trend (total population is status quo), and partly the fact that far too much land, regulated according to the Town and Country Planning Act were set aside for urbanization in the boom in the sixties. In any way it corresponds with what can be seen in the test sites. In three of the 13 old sites urbanization took a part of the area (oin the later years ften trying to fit the biotopes into the new urban structure) in the period 1981 to 86. Whereas almost nothing have been lost between1986 to 91.

Economic development has been relatively stronger in the western part than in the rest of Denmark in the last decades. Therefore development of the infrastructure has been rather strong. In two of the test sites in Jutland roads were planned or under construction. This will have the following effect on the biotope pattern:

1) The construction will remove all existing biotopes in the track.
2) The construction itself will on the other hand represent a (complex) biotope consisting of roadside verges, eventually planted with trees and drainage ditches and may be small ponds for water management purposes on remnant land connected with approaches.
3) Sometimes (and expectedly in one of the two cases observed) roadbuilding crossing agricultural land are followed by a reallotment of land among the involved owners. This leads almost unavoidable to changes in the pattern of small biotopes - many and often old biotopes will be removed but some new ones may at the same time appear.

Afforestation is by the Ministry of Environment planned to double the Danish forest area from the present 12% to 24% of the national territory within the next tree generation (about 60 years). On average this will require 5.000 ha to be planted each year. This rate has still not been reached at a national level. In fact, only half of the budget for state afforestation in 1990 , and probably much less private afforestation has taken place. In one of the test sites a new forest of 30 ha has been planted recently, but for seed purposes, only indirectly as a result of deforestation. Except that, only 8 ha corresponding to 0.1% have been planted

within the test sites in the latest 5-year period. By this rate it will take not 60 but 600 years to reach the target.

5. **Changes within the matrix** i.e. the agricultural land-use can not be described with the same precision because a covering land-use mapping has been carried out in the test sites only in 1991. Three of the more important general trends should however be mentioned:

1. A recent regionalization proces of the agricultural production can roughly be described as cattle in western Denmark, pure plantgrowing in east, and pig production almost allover and overlapping the two others. Specialization means in general larger fields and fewer small biotopes. But it also means less crop diversity on the average hectare and less diversity in the pattern of small biotopes. In general is the temptation to remove any obstackle in the field higher the larger the field. And ponds for cattle watering are loosingf this function where cattle rising is given up (or mechanical pumps installed). Regionalization, specialization and concentration of the production is expected to continue for the next decades, with pig production having the best and plant production the poorest expectations.

2. Denmark and especially the sea around it is heavily burdened with eutrophication in these years. The largest contribution of nitrogene comes from the agriculture and therefore regulation of its production plays a central role in the actionplan for the aquatic environment the government has approved (Agger 1991). One of the means is an obligation for the farmers to have the fields covered with vegetation during the winter (especially in late autumn) in order to retain the nitrogene that else would leaque from the bare soil. This has no direct influence on the pattern of small biotopes. But as it encouraged the use of winter crops and perennial crops it gives difficulties for the researcher in intepreting of aerial photographs, and benefits for the fauna that gets more food and shelter during wintertime.

3. Loss of permanent pastures has been one of the most important depleasions of the wildlife in the agricultural landscape in the latest decades. It has been induced by the changes in cattle rising and dairy production along three ways: First to mention is the specialization that cancel the need for pastures for a still growing fraction of the farmers. Second to mention is the regionalization that not only "moves" the cattle but also the pasture land to the west. And thirdly the changes in the way of production, where cattle is kept at the stable the year around and where the meadow is "browsed" mechanically have contributed to the drastic decrease of pasture land.

In the latest couple of years the decrease seemed to have stopped and turned to a slight increase. Further are areas with permanent grassland larger than 2.500 sq.m. mentioned in the drafted revision of the nature conservation act now being read in the parliament, as a habitat type that should be conserved generally (without compensation). How welcomed such a provision ever may be its announcement have had the negative effect that many permanent pastures are said to be ploughed in these years in order to make them not "permanent" before the act comes into force. Also on this we have seen examples during the 1991 campaign.

5. The monitoring-scale problem

For monitoring purposes the method used has a major disadvantage: It is rather time-consuming in the form of field work and data storage. It can be argued, that a much larger area could be monitored without loosing much information by using only air photo interpretation. SGEOS-satellite data and spatial cadastral information concerning agricultural holdings. For these reasons a related study has been dedicated these

possibilities, using image processing of Landsat Thematic Mapper and scanned air photos on some of the test areas, thereby simulating expected higher spatial resolution of satellite data in the future (Brandt and Münier 1990). A programme package for semiautomatic deliniation and presentation of small biotopes based on selected pixel-statistics has been developed (Christiansen and Nielsen 1991). It is however doubtful how far such procedures can be developed due to some principal characteristics of the small biotopes in the Danish landscape: These can be seen as (parts of) **landscape elements** according to Forman and Godron (1986), although they are very often of minor dimension than the landscape element sdescribed by these authors ("often range from around 10 m to 1 km in width"). In fact, they often represent only parts of a landscape element, e.g. road verges, as biotopes not including the pavement. Dispite their smallnes, they can generally be recognized as heterogeneous. Their heterogeneity has been described through the use of an internal **tessera** classification, giving information on the areal proportion of woody vegetation grass vegetation, reed vegetation and open water. An important part of the remote sensing-orientated study will be to relate this information from the field work to the pixel statistics of the biotopes, to search for resolutions, that might be used for monitoring purposes (Brandt and Münier 1990).
The ability of the developed procedure to deliniate the different classes of small biotopes is given in fig. 3:

	Can be deliniated	Can possibly be deliniated	Cannot be deliniated
Fields	x		
Lakes and ponds	x		
Barrows	x		
Bogs		x	
Woodlots		x	
Game plantations			x
Paved roads	x		
Field roads			x
Hedgerows			x
Field divides			x
Ditches			x

Fig. 3: The ability of the procedure "areas" to deliniate the different classes of small biotopes (After Christiansen and Nielsen 1991).

Thus far the programme has been developed only for patch biotopes. Deliniation of linear biotope types is more complicated but might be possible throght use of directional oriented routines.

Detailed field surveys will however still be important for several reasons:
1. They will serve as necessary ground truth for a remote sensed monitoring
2. They can detect the total network of biotopes, and the whole range of biotope types, including types, that cannot be seen by remote sensing, such as narrow field divides, small ditches, solidary trees or vegetation under high power electricity-masts: Detection of these types of tiny biotopes can be important for two reasons: some of them can be fine indicators of general tendencies in the biotope pattern due to agricultural changes, and secondly they will be important to include for a characterization of the quality of the total biotope pattern. Considered generally as low quality patches and corridors they might be better than nothing, but also have a

strong negative influence on the size of metapopulations, as indicated by the simulation models set up by Henein and Merriam (1990).

3. Many studies on the dynamics of the biotope structure are based on time-series of maps or airphotos of a relatively long time-span, that gives a rather good validity although the sources are inaccurate or subject to different interpretations. But a monitoring of the general development for a time interval of 5 or 10 years within a limited number of test areas has to be based on a rather detailed and valid registration system to minimize the influence of technical errors or misinterpretations. With an average of about 200 small biotopes per test area, even a 1% annual change means changes in only 10 biotopes over a 5 years period. With very different tendencies for the many different biotope types, it does not give much room for errors and misinterpretations if a reliable type-differentiated quantitative statistics shall be obtained.

6. Landscape classification and biotope dynamics

According to Forman and Godron (1986) landscapes are heterogeneous land areas composed by a cluster of interacting ecosystems, that are repeated in similar form throughout. For intensively used agricultural landscapes these 'ecosystems' are referred as relatively homogeneous landscape elements that in practise correspond to the spatial configuration of patches, corridors and matrix of the landscape. Thus the entrance to the landscape concept and landscape classification will be the delimitation of different clusters of landscape elements. A deeper insight into the function and internal dynamic of these landscapes are obtained through supplementary studies of the differentiation in natural conditions that might reflect the landscape delimitation. But ecologically a priority is given to bio-ecological connectivity and the actual flow of matter and energy, often dominated by man-made processes reflected in the land-use structure.

According to many European landscape ecologists, the starting point for the delimitation of landscapes are rather some basic land-units, that have a (quasi-) homogeneous character or specific internal dynamics, that can be grouped together in characteristic heterogeneous chorological units due to certain functional relations within the complex of natural compounds or due to common genetic properties. Within this tradition a widespread sort of landscape ecological studies is land capability studies based on geographical comparison of landscape units with land use units. Here the priority is given to the natural flow of matter and energy, thus reflecting long-term differentiating conditions in the natural environment. Traditionally Danish agriculture has been dominated by middle-sized mixed farms (ave. 15-25 ha) with only minor regional differences, that also have been reflected in a geographically rather homogeneous pattern of land-use. Although the later specialization has given rise to a certain natural conditioned regionalization, the technological development since the 50ties has rather deepened this homogenization, since most effort was put into arrangements that could provide uniform environmental conditions serving the dominating technology, thus eliminating or at least weakening the correspondence between the structure of landscape elements and the structure of the abiotic components and the natural flow of matter and energy.

In connection with our former investigations statistical analysis of combination and density of small biotopes was done to see if characteristic types of biotope pattern could be classified and regionalized in correspondence to different landscape types (Brandt, 1986). None of the classifications gave clear results. The reason for these negative results could be of technical origin, e.g. related to the size of the 1 km squares used for the analysis, but can also be explained in a nonexisting correspondence between biotope pattern and differences in the natural conditions that exist within the eastern part of Denmark.

Nevertheless it has been planned in connection with the 1991-campaign to carry out a large-scaled survey of chorological units (at nanochore-level, according to Haase et al (1985) in all the test areas.

The thesis behind is, that a technological shift towards a more landscape-adapted land-use in the future will be furthered for environmental, bu also economic reasons through a much more differentiated range of intelligent land-use technologies, taking advantage of the differences in the abiotic structure and flow of matter and energy in the environment. If so, this should be unveiled first of all through different types of landscape changes due to different environmental conditions.
So, the somewhat different approach to landscape ecological studies dominating in Europe and North America might be damped with the tendance to a shift from structural towards dynamic studies of landscapes.

7. Conclusion

Compared with the expected dramatic changes in Danish agriculture, their has been remarkably little changes in the pattern of small biotopes in the Danish agricultural landscapes during the 1980. The reasons can probably be related to a number of diverging tendencies:
The general decrease due to the structural development within agriculture is partly counterbalanced by a growing differentiation in the combination of crops and the reintroduction of a systematic rotation of crops. This is technologically conditioned, and economically determined, but also in harmony with some of the endeavor to counter the serious pollution of the Danish seas.
The tendencies of extensive marginalization within the EEC has not (yet) appeared due to political resistance and low economic compensations.
Game interests are playing a growing role as positive stabilizing factor, and the same seems to go for the growing public effort in conservation and re- and new-establishment of biotopes, that probably tends to develop with a growing support among farmers.
The rather time-consuming detailed monitoring by fieldmethod will probably have to stay as an important sensitive instrument especially within shorter time-intervals, but cheaper methods based on remote sensing to ensure greater areal coverage should be developed.

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