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REGISTRATION METHODS FOR STUDYING THE DEVELOPMENT OF SMALL SCALE BIOTOPE STRUCTURES IN RURAL DENMARK

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Abstract

In densely populated countries where agriculture is undergoing a process of industrialization with rationalisation and enlargement of fields there is in a broad landscape ecological sense a need for management of even the small scale structural elements as hedgerows, drainage dykes and marlpits in the rural landscape. In Denmark there is no long tradition for this type of management. It is necessary to develop a better knowledge of the dynamics of the small uncultivated areas. As a first approach this study tries to discuss how the changes in the biotope pattern in rural areas in Denmark can be studied. By the use of old maps, aerial photographs, field surveys and interviews, changes since the second half of the 19th century havebeen studied. Some of the difficulties that arise interpreting data from these sources are demonstrated. The need for comparative studies of the development of biotope patterns in countries with different agricultural development is stressed.

Scope

In Denmark as in other North-West European countries the agricultural landscapes have been exposed to a remarkable decline in small scale structural elements, the small biotopes such as hedgerows, drainage dykes, marlpits and other uncultivated areas often situated in the boundaries between the fields.

These changes; the biotope pattern changes together with the changes within the field itself altogether alter the living conditions for the wild flora and fauna and the visual amenity of the landscape to a considerable degree. The decrease in diversity and the decline in number of uncultivated areas in the rural landscape persevere while at the same time the need for recreational use of the rural areas by the rest of the society tend to increase.

Therefore it is essential that the further development of small biotopes is not let alone with the single purpose planning for agriculture, which has previously been the case. A more long sighted and comprehensive planning which integrates the different interests in the countryside in a multipurpose plan is needed in order to counteract the tendency towards a strong segregative land use that already can be observed in Denmark today.

Before such planning and management can be started a better understanding of the dynamics of the biotope pattern and its consequences for flora, fauna and visual amenity of the landscape should be achieved.

Statement of the problem

This study only deals with the first part of the question, the dynamics of the biotope pattern. The results of this investigation are now almost available, but in this paper only the methodological problems met in the study will be presented. How can reliable information on the distribution, density and character of small biotopes ranging from 100 years ago up to the 1980'ies be obtained?

Previous work

Dealing with interstitial habitats in the field boundaries and the small scale elements that may remain within the field, we are at a micro level which has previously only been studied sporadically.

The majority of previous studies have been motivated by a supposed decline in number of habitats. These consequences for flora and fauna have been discussed on the basis of registration of the species content in the remaining habitats (i.e. Cripps et al. 1974, Pollard, Hooper and Moore 74, Ruthsatz, 1982).

But there is not only a oneway decrease in the number and area of all types of small biotopes. As demonstrated in the present study there is a complex restructuring of the landscape going on. Even as there is an overall decrease, some types may increase while others decrease (especially the smallest and the wet biotopes). Primarily the changes are initiated by structural changes in the agricultural production. An understanding of the productive functions of the small biotopes is therefore crucial. Changes in land use with the area as the common denominator seems to be a convenient measure and clue to the understanding of the changing biotope pattern.

Several other authors also deal with this side of the problem. Generally speaking they are people attached to reallotment projects (i.e. in BRD and the Netherlands).

As the changes in the biotope pattern are closely attached to the structural changes in agriculture they are also strongly attached to the historical development in the local county or region studied. And the observations can therefore not be transferred uncommented from one area to another or from one country to another. As the methods chosen and the problems met are dependant on these historical features the history of the agriculture will be given briefly.

Agriculture in Eastern Denmark

Today the agriculture in Eastern Denmark is changing from previously mixed farming with grain, dairy production and pigs on the same farm to an increased specialized production with one dominant production (grain, pigs, cattle, seed etc.) on each farm. Cattle are disappearing from the fields either because dairy production is terminated on many farms in Eastern Denmark or because the cattle are kept in the stable all the year round. Fields and farms tend to increase in size. An average of the farm size has increased from 17 hectars in 1965 to 17 ha. in 1982. The average field size seems to have doubled (to approx. 7 ha.) during the same period.

In contrast to the majority of other European countries a profound reallotment was carried out already in the 1780'es and the following half century. This means that the whole period studied (from the 1860'es to 1980) has had a clear definition of all the areas attached to the private ownership of a single farm, with the farm itself usually situated in the middle of its belongings. This landscape is quite different, and probably easier to study than the previous, which had an atomized field pattern and extended commons with weak undistinct boundaries, i.e. from pasture to forest, in correspondence with the more function-related, rather than territorial oriented ownership.

Today the appearance of the landscape is derived almost entirely from this reallotment. The main events influencing the landscape before todays general dilution of all elements excl. roads in the biotope pattern have been: the reallotment construction of drainage dykes in the beginning and their later removal, marl digging leaving a multitude of small marlpits in nearly every field in the second half of the 19th century, and more continuously roadbuilding and the hereto related extraction of gravel, though the basic structures seen today were formed around the year 1800 (see fig. 1)

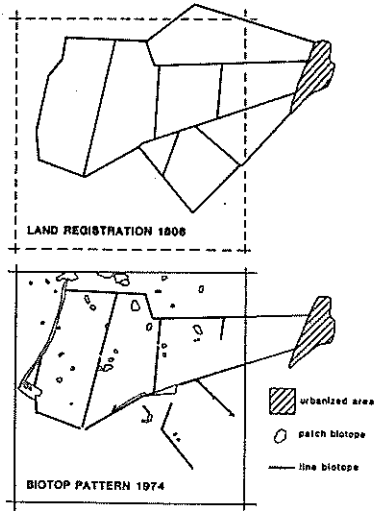


fig. 1. Correspondance between historical farm bounderies and contemporary biotope pattern. Bramsnæs, Zealand.

The biotopes we find today are confined primarily to those areas which either fulfill boundary or other protective functions or which cannot be economically cultivated and grazed. A smaller part is still situated within the fields as remnants from a former productive landscape and only a few exist as having other agricultural or no agricultural purposes as their cause of existence (i.e. game).

The definition of small biotopes in the agricultural area

The central concept in this study is what we have called "small biotopes in agricultural areas" (Danish: småbiotop). It is defined as an

uncultivated area that is permanently covered with vegatation (or water) and situated within the agricultural areas. Further the size of the area should be more than 10 square meter and less than 2 hectars (20 000 m^2) for patch-biotopes (see below) and a length over 10 meter and a width more than 0.1 m for line-biotopes.

By this definition all cultivated fields, gardens and urbanized areas around the farmsteads and villages are excluded. Also roads but not their verges are excluded, whereas grass covered farm tracks are considered as "small biotopes".

Only structures within the agricultural landscape are considered. This means for instance that the hedgerows running between the fields are considered, whereas it is not counted as a small biotope when they run along a garden or another type of urbanized area. In this sense the small biotope is identical with the concept used by Davidson and LLoyd1977 "interstitial habitats" - the habitats lying between (or within) the fields.

The size criteria have in the sample areas studied turned out to be consistent with the lower limit we have defined. Permanently uncultivated areas carrying vegatation appear very seldom as areas smaller than 10m^2 in rural areas in Eastern Denmark (in numbers they count for less than 5% of the total number af small biotopes considered.) The upper limit is not so easily defined. There is a smooth gradient upwards to spinneys (small forests), bogs and lakes above 2 hectars. The limit has been chosen for practical reasons (what could be overcome to analyse) and because biotopes above this size seldom belong to a single ordinary farm and therefore are exposed to other legislative and production wise conditions.

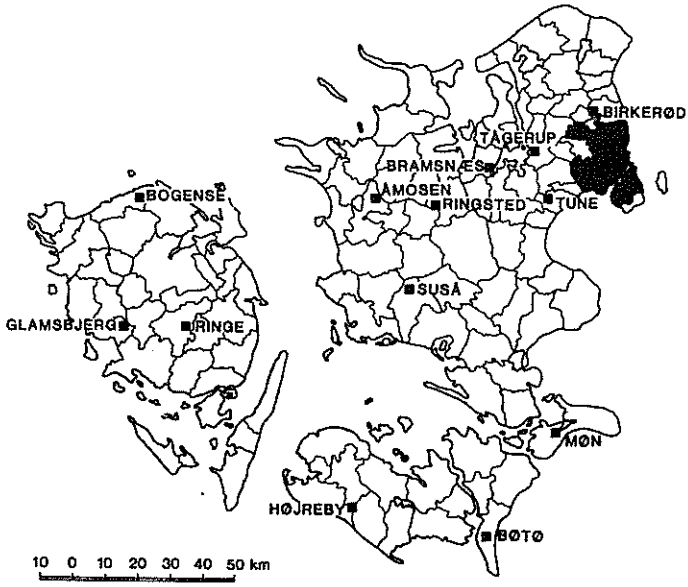
The criteria of permanent vegetation or water coverage have been chosen to exclude the multitude of especially temporary water bodies that in spring are found in the fields and which later in the year or during the next will be included in the production again.

This mode of defining the object of the investigation has been determined by the purpose of studying the changing living conditions for wildlife in rural areas.

Regionalisation

In the present study the total area of Eastern Denmark (i.e. Funen and Eastward excluding the island of Bornholm) has been studied at 3 levels:

1. On the newest 4-cm maps the signatures for small biotopes have been counted and measured according to type in each of 249 one square kilometer agricultural areas (approximately 2% of the total area) evenly distributed all over Eastern Denmark.
2. In 13 2x2 km sampling areas all biotopes have been registered in field studies and their owners interviewed about the agricultural production on the farm and their use and plans for their small biotopes. (see fig. 2)
3) In five of the 13 sampling areas the content of biotopes have been followed back to the oldest ordenance maps, or more precisely from the oldest maps up to the date of the field study.



Where the 249 squares at level 1 have been chosen at random, the 13 sampling areas have been selected using a stratified sampling scheme related to a previous regionalisation. The five chosen for historical analysis have been selected in a way that the major types of landscapes have been represented.

As detailed inductive mapping of special landscape types is missing in Denmark, a biotope-relevant regionalisation has been made in an attempt to economize with the limited resources for field work. This was made by a cluster analysis followed by a principal component analysis based on three types of information containing in all 15 sets of relatively easily obtainable data of supposed relevance for the small biotopes. All the data were related to 115 municipalities of in average 110 km^2 each.
These data were:

I Physical geographical data:

1. The area of lighter soils in percentage of all soil types.
2. The area of clay soils in percentage of all soil types.
3. The area of organic soils in percentage of all soil types.
4. Summed length of brooks (in 100 m pr. hectar).

II Agricultural data:

5. Cultivated area in percentage of total area.

6. Summed area of farms greater than 50 hectars in percentage of all cultivated areas.

7. Area of permanent grassland in percentage of all cultivated areas.

8. Number of cattle per km^2.

III Urbanizational data:

9. Population pr. hectar.

10. Urban population in percentage of total population.

11. Town area in percentage of total area.

The result has been that the total area could be separated into 8 regions (strata) within which the sampling intensity has been sought made proportional to the size of the region. Later in the project this regionalisation will be tested for its biotope relevance by comparing with the results obtained from the 249 readings at level 1 and the field studies at level 2.

Material and methods

Apart from what already has been mentioned the material and methods can briefly be described as:

In the 13 sampling areas:

A) A recording in the field of all small biotopes of the position (according to UTM-coordinates), type, size, level, tree and shrub coverage, water bodies' size and depth, an estimated percentual distribution of water, reeds, herb and tree coverage, possible signs on actual use and management and the accessability of the biotope.

B) In a specified minor part of the biotopes carrying trees and shrubs a sample for estimation of species composition (frequency and abundance) was taken.

C) For minimum 50% of the area within each sampled area the landowners or tenants were interviewed concerning farmsize, land use, animal production, mechanization, game- and other types of recreational use of the belongings and a question on the contemporary use and plans for each small biotope.

In the 5 of these areas selected for historical analysis:

D) A recording was made of position, type and size of the different signatures or biotope types on 3 series of old ordenance maps (scale 1:20,000): 1865-1885; 1910-1920; 1935-1945, on the newest 4-cm map (scale 1:25,000): 1972-1974, and on two series of aerial photographs from 1954 and 1967. Including the field study in 1981 this gave seven registration years for each area.

The sampling areas are indicated in fig. 2. In total the area with only map analysis has been 249 km^2, with field survey: 52 km^2 of which 20 km^2 has been covered by a detailed historical analysis. On average 6.3 km of line-biotope and 11 patch-biotopes (covering 1.8 ha) have been found in each square kilometer field surveyed agricultural land.

Classification of biotopes

Superficially the small biotopes in rural Denmark seem to be easily distinguishable in types: Hedges, field divides, marl-pits etc. However, coming upon a field a multitude of mixtures appear. For instance a biotope may start as a hedge at one end and gradually change to a drainage dyke in the other. Biotopes which are a cross between a pond and a bog or between a bog and a spinney are other examples.

A strict set of criteria for separating the biotopes into types (approximately 40) have therefore been attempted. In this classification several aims have been followed and compromises chosen:

A The set of criteria should correspond (include) with the definitions of signatures on the map.

B The classification should allow the fieldwork to be done within reasonable time.

C The classification should as far as possible correspond to the common classification expressed in the vernacular names for the different types of biotopes in Denmark, but on the other hand be strictly objective to allow a repetition of the fieldwork after a period.

First of all there has been made a general distinction between what has been called line-biotopes and patch-biotopes, which matches the terminology used by Formann and Gordon (1981). The former are all such structures that on the maps are given a true length but no true width: Roads, dikes, hedgerows, drainage dykes, brooks, rivers, railways and narrow steep slopes. The patch-biotope include alle the others, those that on the maps are given an area-true signature or a point signature (i.e. a solitary tree).

The further segregation into types has been based on physical features that could be registered in the field such as height, depth percentage covered with trees and shrubs, herbs and water and signs of a certain function of the biotope such as installations for game, outlet of sewage, carrying of masts etc.

For instance a hedge is defined as 20 meters of a line biotope where a 50% is covered with trees or shrubs and where the ground of the biotope is between ÷ 0.25 and + 0.75 meter above the surrounding fields. If the ground had been lower we would have had the biotope type "hedge on dyke". Had it been above we would have counted it as "hedge on hummock". This distinction has been used because it appears on the older maps. These maps were made predominantly for military purposes, and the distinction mentioned has been made to show which line structures in the landscape that were considered able to hide a soldier with his pack. The distinction has however, also landscapeecological relevance.

In the same way different signatures are used for boulevards (here defined as any stretch of road, pathway or landscape lined with equidistant planted trees) and hedgerows to distinguish structures passable for the artillery with their horses and carts and those that were not passable. This distinction has consequently been maintained in our classification.

In order to overcome the fieldwork, rather crude criteria have been used for instance in distinguishing the type "bog" from small ponds. Here all patch-biotopes with permanent water covering less than 50% of the biotope area have been classified as bogs. All those with more water have been classified as one or another of the types: marlpit, gravelpit, claypit, fire reservoir, water hole or small lake. The first three can rather easily be identified by how they are situated in the landscape, their size and soil structure. Fire reservoirs and water holes are defined by their location and form, and small lakes by having none of the specific characteristics carried by the former types.

In the classification problems we were also met by the question of what should be considered as an individual biotope. Some cases gave no problems, i.e. a small marlpit in the middle of a field. But often biotopes are conglomerates of different types. i.e. a small pond neighbouring a spinney. This could either be classified as a pond or bog (depending on the relative size of the two components) or it could be classified as one individual complex biotope (depending on how clearly the components were distinguishable) and marked with a (biotope)number i.e. 27 . Each component has then in the same time been given a letter i.e. 27A (the pond) and 27B (the spinney).

Other problems have been the line-biotopes that often make complicated networks where the level of survey makes a geographical bonding of such biotopes meaningless.

Again the way of registration has been determined by the purpose, which has been to enable the history of biotopes indicated at the oldest maps to be followed up to date and for the biotopes at the newest to be traced backwards in time. Therefore in principle it can be said that what has been defined as an individual biotope is the largest stretch of biotope which has had a unite history from the oldest map up to now. Generally an individual patch-biotope correspond to the patch and an individual line-biotope corresponds to any biotope given by a continuous unbroken and unchanged line-signature on the map.

Related to the maps, a biotope is defined as any signature indicating what can be considered as an uncultivated area (of right size) surrounded by areas that can be considered as cultivated (excl. gardens and fruit plantations). The choice of definition and classification of biotopes has been aimed at making a transformation of all biotopes to number and area of each type per unit area of arable land possible. Thereby obtaining an index of the content of marginal arable land and an index of the potential content of wildlife.

Validity of maps

The question of choice of signatures has already been touched. The main problem in this respect has however been the interpretation of what

has been the character of the areas indicated with signatures for bogs, leys and wet meadows, and the distinction between permanent pastures and pastures in cultivation. On some occasions these signatures come in and out over the period studied which might indicate a change in classification rather than a change in the landscape. But the general feeling is that these wet and semi-wet areas have been very abundant and have now been reduced to insignificant remnants, but with the problems mentioned, it cannot be said exactly to what extent.

The problem with the use of older maps can be divided into two:

A) The choice of signatures: How have the biotopes been classified?

B) The power of dissolution of the maps: How large a biotope has to be to be registered?

Apart from what has already been mentioned the use of maps involves also another more basic set of problems:
Precisely how were the criteria for classification in previous time, and how carefully have they been followed from person to person and from period to period?

Partly because we have not found ways to test it, the intersubjectivity in the registrations from the old days have been considered as non existent. But one observation indicates that changes in the ways of classification do exist from period to period. On the series of maps from 1920-1930 the signature for boulevard is extremely abundant in comparison both with the series of maps from the period previous (around 1900) and the series after (the 1940'es). As we have found no other indication that corresponding changes should have appeared in the landscapes over the period, the changes in the abundance of this signature might be taken as a change in classification.

The question of that which is given a signature is also highly relevant. The criteria in use in contemporary mapping subscribes that only line-biotopes longer than 50 meter and patch-biotopes larger than 25m^2 should be registered. Furthermore, drainage dykes along roads are not included, neither are field divides with a level less than 3/4 m. These rules are not, however, followed too strictly. Many structures with a bottom level far below 3/4 m are still recorded, probably because they havebeen so on previous maps, and there may have had the necessary height.

Many structures which in the fieldwork and on the aerial photographs can be recognized as biotopes that are not indicated on the maps, even when these have been issued in between the date of the photographs and the field observations done. This is understandable in the cases where the structures are smaller than the size criteria used in the official mapping. It is estimated that 60% of all line-biotopes (mainly narrow field divides) and 70% of all patch-biotopes (mainly small ponds) are excluded from the maps. On some occasion it has further been observed that maps have not been as up to date as claimed. This has for example been the case where a marlpit has been indicated on a map even though it was definitely not on the foregoing aerial photograph. However, the general impression is that on Danish maps this is a problem of minor importance only.

Concerning the suitability of old ordenance maps in Denmark with the scale of 1:20,000 and the modern 4-cm-maps for studies of the dynamics of the biotope pattern it may be concluded that:

For those biotopes indicated on the oldest maps they can be considered to give very valid information about the location and size of the biotopes. The type of biotope is considered to be valid only to main classes of biotopes (i.e. ponds, bogs, hedges etc.) Special problems are attached to the interpretation of signatures for wet meadows and bogs. On one occasion it has been observed that unrecorded change in the way of classification (hedgerow/boulevard) has appeared on a series of maps. In a number of cases a delay has been observed on maps that have indicated biotopes as existent many years after they actually have been removed.

For those biotopes that are so small or narrow that they are not included in the types of structures the maps intend to show, it is often observed that they never the less are indicated. Usually this is caused by a lack in the updating of changes in the biotopes, i.e. a ditch that has now become too low to be correctly recorded as such.

Validity of aerial photographs

Relying solely on aerial photographs in the available quality and size for the interpretation of biotope structures one would soon meet problems. In Denmark the photographs have earlier been taken every 7th year on a sunny day in the spring. Especially during this time it is difficult to distinguish temporary water bodies from permanent ones. And it can be even more difficult to distinguish narrow herbcovered field divides running in or along a grass field.

Having maps from neighbouring periods and possible field observations one is on much firmer ground. In the present study it is considered that all biotopes could be properly localized and measured. One of the problems has been to get a precise measurement of the tree- and shrub coverage which is disturbed by shading from the vegetation. By comparing maps, photographs and field observations it has been estimated that the total tree and shrub coverage in line-biotopes on aerial photographs is underestimated with an average of 12%.

The historical analysis

It has already been described how the definition of the biotope concept and the classification of biotopes have been influenced by requirements from the historical analysis. Also the definition of sampling areas has been influenced. Broadly these have been all the cultivated land with its small biotopes in the selected sampling areas on the oldest maps.

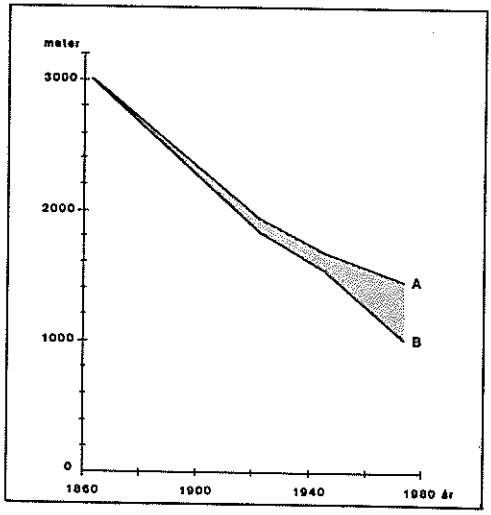
The analysis has then been to follow these areas and trace the biotopes up towards our time. A Considerable part of these biotopes have disappeared from the agricultural landscape either by being removed or by being urbanized i.e. together with the surrounding landscape being included in urbanized area. To distinguish between these two types of disappearance and to distinguish biotopes being born as a new creation from those being born as a result of fragmentation of a former larger

biotope a system of coding has been used.

Starting with the oldest map each biotope has been given a number (and a letter in case of a complex biotope) the number being attached to the locality (i.e. 13,2,27 for biotope number 27 in the second quadrant of area 13), a code for the type of signature (i.e. 16 for a marlpit) and a size measure (meters or square meters).

Going to the following map period the locality is looked up and eventual changes in type of signature, size and existence is indicated. This could be either "unchanged", "disappeared", "disappeared by having melted together with a neighbouring biotope", "disappeared from agricultural land by being included in un urbanized area" or "disappeared and the locality now being urbanized". Finally any new biotope appearing on this map was then recorded. And the procedure was repeated on the map from the following period.

By this rather complicated way of recording it has been possible to keep track of localities on any map, photograph or field, having been observed as carrying a biotope. Instead of crude indices for the brutto change in the biotope content in the landscape (that in some cases has changed surprisingly little) the way of recording allows the fate of every single biotope to be recognized and thus the dynamic changes also between types of biotopes to be described. (see fig. 3)



A: Changes in the total length in km of signatures for hedges per km^2 from 1863-1974 on ordenance maps and 4 cm maps in a 4 km^2 agriculturalarea, Glamsbjerg Funen.
B: The total length of those hedges indicated at the oldest map. The shaded area indicates the hedges that have been established during the period.

Outlook

This study has demonstrated the importance of a very careful analysis of the maps to be used even if they by a first glance seemed to be easily interpreted. Even more important and difficult is this where the dynamics and historical development of the biotope pattern is studied. Trying to explain the present composition of a landscape will nearly always require both the cultural (historic) and the natural "side of the coin"

to be understood. Having studied only one or a selection of rather uniform landscapes the distinction between these two sources of influence may be difficult.

In the present study we have worked in a relatively homogineous set of landscapes: Intensive farming on small holdings on clay soils in vaguely undulating post glacial landscapes all with a common history.

It would be interesting to compare the results of this study with other similar studies carried out in areas which have had another history for example the English estate landscape, French agricultural districts with small holdings and areas with large collective farms in DDR and other countries in Eastern Europe. This might be an idea for IALE to discuss. If such comparisons should be quantitative it will obviously be very difficult and like this paper demonstrates, a detailed analysis of the historical and methodological background in all the involved landscapes will be a precondition.

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