Location of farm woodlands in Denmark: a quantification of the results of the scheme for field afforestation in Ribe and Vejle counties

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Abstract

The article analyses the results of the scheme for field afforestation (EU-regulation 2080/92) in Denmark. The purpose is twofold, firstly to document the afforestation on arable land taking place both within the scheme and outside the scheme for field afforestation. The former is documented in Ribe and Vejle counties whereas the latter is documented in three smaller areas: Varde, Vorbasse, and Vejle. Secondly, the article argues that in order to evaluate the afforestation not only the location within designated areas but also the spatial parameters and configuration of new woodlands must be considered. Two methods – 'forest-pictures' and 'gradient-pictures' – are presented and applied in order to quantify the spatial configuration of new woodlands in the landscape.

Keywords

Location of woodlands, Field afforestation, EU-regulation 2080/92, Denmark.

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The European countryside in the end of the 20th century is not only considered a place of production but also a place for recreation, nature values and as a safeguard of our environment. Enhancing and securing these new values is linked to new types of production, which integrate agriculture within broader rural economic and environmental objectives (Ilbery and Bowler, 1998). Forestry is part of this development and post-industrial forestry is today seen as a way to secure and increase the new values of the countryside (Mather, 1998). An important actor in this process has been and still is the agricultural policies of the EU. With the McSharry-reform of the CAP in 1992, environmental issues were formally introduced within the agricultural policies through environmentally oriented subsidy schemes (Baldock and Lowe, 1996). The integration with agricultural policies has been continued with Agenda 2000. Cross-compliance, modulation, and national envelopes are concepts that are meant to combine agricultural practice more directly with environmental conditions and socio-economic needs (Wilson et al., 2000). However, we are only now beginning to see the results of the implementation of the first voluntary environmentally oriented schemes. In research, the focus has mainly been on the schemes under EU-regulation 2078/92 where evaluation has been extensive, to mention a few: Whitby (1996), Wilson et al. (1999), Buller et al. (2000), Winter (2000). In Denmark this regulation has been implemented as the 'agri-environmental programme', and also researched, see e.g. Primdahl (1996), Andersen et al. (2000). Minor attention has been allocated to the scheme for field afforestation (EU-regulation 2080/92) also introduced with the McSharry-reform, which is the focus of this article.

In Denmark, the scheme for field afforestation has been implemented as part of the national afforestation programme with the goal to double the forest area within a 100-year period. Afforestation of former agricultural fields supported by different policies is not a new phenomenon in Europe (Jensen, 1976; Watkins, 1984; Selby, 1993; Mather, 1996), although, forestry is often seen as being in opposition to the profession of agriculture. Initial resistance to the introduced field afforestation scheme in Denmark was considerable, particularly among farmers associations but also in agricultural society in general (e.g. Jensen, 1991). Yet, the uptake has increased in recent years despite a slow start with very low uptake in the first years, and the scheme is today promoted as an integrated part of the environmentally oriented agricultural subsidy schemes.

This article looks at the spatial issues of the woodlands being afforested under the scheme for field afforestation in Denmark. The counties have designated two types of areas

where farmers are supported with varied levels of grants depending on the location of woodland within the types of designation. The article analyses the location of new woodlands in relation to these designated areas in order to document the planning system's ability to secure the location of woodlands within the designated areas. The article builds upon the argument that in order to reach the goals of the afforestation programme the spatial configuration of the new woodlands in the landscape is of importance (Jensen, 1999). Hence, not only the location of woodlands within designated areas is important, but also spatial parameters like the size, the number, and the distribution of the new woodlands in relation to the existing forest pattern are of importance for evaluating the location of new woodlands under the scheme for field afforestation. Therefore, the article further analyses and documents these spatial parameters of the new woodlands and finally touches upon the application of simple methods –'forest-pictures' and 'gradient-pictures'– to quantify the spatial configuration of woodlands in the landscape. In order to discuss the afforestation under the scheme for field afforestation in relation to the general afforestation of the countryside the spatial parameters and configuration of woodlands afforested outside the scheme are also analysed.

Study area

The study area consists of the counties of Ribe and Vejle in the western part of Denmark, shown in Figure 1. They have been selected because the two main types of forest development in Denmark: the eastern and the western can be found within the area. In the eastern parts of Denmark the forest areas have been rather stable while the western parts of the country have experienced a radical increase in the total forest area within the last 200 years (Jensen, 1976; Jensen, 1997; Fritzbøger, 1994). Further, empirical studies of field afforestation have previously been carried out in the area (Jensen, 1976), which are drawn upon in describing the history of afforestation on arable land in the area.

Within the study area, three smaller areas – named Varde, Vorbasse, and Vejle – have been selected for detailed analyses of both the afforestation within the scheme and outside the scheme for field afforestation. These three areas have been chosen in order to describe the afforestation in the different types of forest developments and are therefore located respectively in the eastern type, the western type, and in the transition zone between these two types. Further, the three areas have been selected in order to analyse if a relation between the stability of land use and the location of new woodlands can be observed. The subsequent selection within different types of land use stability has therefore been based on the classification of cultural landscape dynamics in Denmark developed by Jensen et al. (1987). In this, the following descriptions of the three areas are given:

Varde: '...old heath land with formerly scattered houses. It has been resettled within the last 100 years; 2/3 has become agricultural fields, the remaining area is either medium-sized coniferous plantations or heath. Especially towards the west and the north the land is threatened by wind erosion every year, meaning that the stability of land use locally is very low' (1987:189, own translation).

Vorbasse: '...consists of old, sand-drifted agricultural enclaves, now surrounded by large coniferous plantations on former heath and dune areas. Afforestation started in the middle of the last century... about half the area is today covered by plantations or heath land. The land use of agricultural lands is very unstable due to poor soil quality and considerable wind erosion. Additional afforestation and urbanisation must be expected' (1987:191, own translation).

Vejle: 'Old, totally cultivated fertile agricultural area with coastal forests and other solitary old forest areas. Soil quality has given a stable land use, but in the last 25 years urbanisation has spread from the urban centres...' (1987:184, own translation).

In addition, in the selection of the three areas it was attempted to ensure that woodlands under the scheme for field afforestation were found in the selected areas, and further

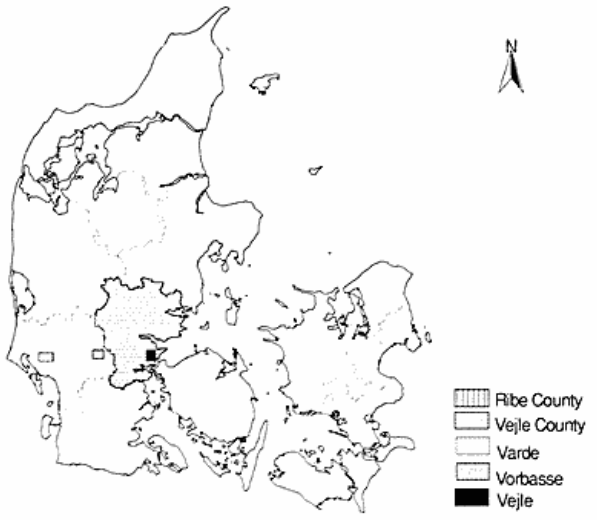

Figure 1. *Study area. The demarcation of the three areas: Varde, Vorbasse and Vejle are given by the list of used aerial photos which can be found in the end of the reference list.*

that the areas were sufficiently large to document the afforestation outside the scheme. In order to fulfil these requirements the areas differ in size: 61.2 km^2, 49.2 km^2, and 48.7 km^2 for Varde, Vorbasse, and Vejle, respectively.

Methods

To perform the analysis two sets of data have been established; a digital ArcView map of new woodlands applied for through the scheme for field afforestation in the counties of Ribe and Vejle in the period 1994-1997, and a digital ArcView map of woodlands outside the scheme in respectively 1983 and 1995 in the three smaller areas of Varde, Vorbasse, and Vejle. The two sets of data are presented and discussed in the following.

The woodlands under the scheme for field afforestation

The locations of new woodlands under the field afforestation scheme in the period 1994-1997 have been digitised within a geographical information system based on the landowners' drawings of maps included in the application form combined with the digital Land Register of Denmark. 94 landowners in the study area applied for an afforestation grant between 1994 and 1997. Information on applicants and the area applied for have been drawn from a national database on subsidy schemes (The LEC-database). Data on actual planting is based on telephone-interviews with the landowners in the spring of 1999, and readings of application files administrated by the National Forest and Nature Agency. In total, only 74 landowners have been included in the analysis due to a combination of missing information in the application files, in the Land Register, or landowners not willing to participate in the telephone interviews.

To obtain data on the grant-aided field afforestation might appear easy. However, in practice, the use of different data sources (The LEC-database, the application forms, and the application files) and data forms indicating the area of afforestation (hectares of new woodland, hectares of new 'fredsskov', and landowners' indication of the areas on maps) open several possibilities for inconsistencies. For example, when applying for a subsidy the landowner indicates the area of woodland he wants to place under the rules of 'fredsskov' (a declaration securing that the area remain forests in all future), which can include already existing woodlands, and therefore this area is not always identical with actually new woodland. In this article, the area of afforestation used in situations of inconsistencies is taken from the LEC-database because this contains the most updated data. Further verification of these data could be done by GPS-measurements in the field, however this was beyond the time limits of this study. Of the 74 landowners, 42 have received a grant via the field afforestation scheme. However, studies have showed that obtaining a grant does not necessarily mean that the area is planted and, on the other hand, that not obtaining a grant means that the area is not planted (Madsen, 2001). Therefore, all 74 landowners have been included in the analysis.

To analyse the spatial configuration of the woodlands under the scheme for field afforestation a method termed 'forest-pictures' has been developed and applied in the article. This method is described and discussed in the analysis; however, in order to analyse how the new woodlands are related to the existing forest pattern this pattern must be known. For this purpose, the existing Top10Dk has been used. Top10Dk is a digitised land use map 1:10,000 based on aerial photos and is currently the most recently updated digitised land use map of Denmark. In the study area, aerial photos used to classify the land use on the Top10Dk have been taken in the period 1994-96 with the main part in 1994, and forest has been defined as 'an area grown with trees' with a minimum area of 2,500 m^2 and wider than 10 m (Kort og Matrikelstyrelsen, 1999).

The woodlands outside the scheme for field affore station

To analyse if the woodlands under the schemes for field afforestation are located differently than other new woodlands in the landscape this afforestation is analysed in the areas of Varde, Vorbasse, and Vejle shown in Figure 1.

Several studies of the landscape elements of Denmark have shown the difficulties concerning the classification and assessment of the size of landscape elements in the analysis of landscape changes (e.g. Brandt and Holmes, 1995; Højring and Caspersen, 1999; Kristensen and Caspersen, 1999). The problems often stem from the fact that the available data originate from different data sources and changes in land use therefore become difficult to detect. In an attempt to overcome this problem, it has been chosen to use data from the same data source namely aerial photos. But, this approach has on the other hand the effect that only a limited area and only two points in time have been analysed due to the time-consuming task of establishing these data in a digital form. The fact that only smaller areas are analysed is seen as a drawback because some types of afforestation patterns therefore can be missed. The fact that only two points of time (1983 and 1995) have been used to analyse land use change results in the problem of missing in-between change references, as discussed by Antrop (1998).

To document the development of woodlands outside the scheme for field afforestation two digital maps were established based on two sets of aerial photos from respectively 1983 and 1995 (a list of the aerial photos used can be found in the end of the reference list – these demarcate the three surveyed areas). The 1995 photos existed in a digital version whereas the 1983 photos were digitised from a paper version. In practice, in establishing the digital map of 1995, the forest theme on the Top10Dk map was used as the starting point, and supplementary forest areas found on the aerial photos from 1995 were digitised. Paper aerial photos from 1983 were used to establish a forest map of 1983. In practice, the digitised forest map of 1995 was used as the basis and a visual interpretation of the 1983 aerial photos was undertaken to establish whether the forest areas also existed in 1983.

The two sets of aerial photos have been chosen firstly because the aerial photos from 1995 are the most recent obtainable digitised photos of the three areas. Secondly, the 1983 photos were chosen due to the time-delay in viewing forest on aerial photos. The time-delay means that afforestation is not detectable on aerial photos in the first couple of years after planting (Jensen, 1976). The forest map of 1995 therefore shows the afforestation started in the beginning of the 1990s, corresponding to the time the scheme for field afforestation was introduced. It was therefore not possible to relate the afforestation under the scheme for field afforestation to the afforestation outside the scheme occurring in the same period because the data to document this afforestation are not at hand. Instead it was chosen to relate it to the previous 10 years period.

The present field afforestation related to former afforestation of arable land

Considerable land use changes have taken place in the Danish countryside during the last century and the present afforestation on arable land seems negligible in this light. However, in order to discuss the effects of the present field afforestation a comparison of the former and present afforestation on arable land might be valuable. Such a comparison is given in the following.

The forest areas in the developed market economies are today generally stable or increasing in extent, and Denmark is no exception (Mather, 1998). The Danish countryside has, however, almost since the beginning of agricultural use experienced a general deforestation (Fritzboger, 1994) and as a result Denmark today has one of the lowest coverage of forests in Europe (European Communities, 1998). Yet, since the beginning of the 1800s the forest area has been increased from only 2 % of the total area to the present 12 %. The spatial distribution of this afforestation is differentiated with the main afforestation taking place in the western part of the country and being mainly coniferous plantations. The development is reviewed by Jensen (1976), (1993), Fritzboger (1992), (1994), and Helles and Linddal (1996). Jensen (1976) researched afforestation of arable land in Denmark (1870-1965) in the mid- 1970s. In his study, covering most of the different landscape types in Denmark, it is shown that afforestation of arable land first became common in the late 1800s. The previous increase in forest area can mainly be ascribed to heath land plantations. In the study area of the study, covering a cross section of Jutland, it is estimated that 1/3 of the afforestation between 1881 and 1965 occurred on arable land. A division between an eastern and western afforestation pattern is drawn along the main stationary line of the ice sheet of the last glacial period with a transition zone demarcated to the east by the East Jutland ice-margin line (Jensen, 1976, 1986, see Figure 2). The location of this early afforestation on arable land has mainly been concentrated in the transition zone. East of the transition zone, afforestation on agricultural land has been very sparse whereas the moderate afforestation west of the transition zone has been concentrated along the main stationary line. This location pattern has been ascribed to the different physical conditions and thereby related to the stability of agricultural production (Jensen, 1976 & 1986).

In the 1980s, field afforestation received an increasing public attention due to the debate about marginal land use in Denmark. Here a range of works: Niels-Christiansen (1985), Barrensø (1986), Skov- og Naturstyrelsen (1987), building on the work of Jensen (1976) gives a picture of the extent of the afforestation in the 20th century. These studies indicate that afforestation on former arable land makes up a minimum of 37,000 hectares which corresponds to at least 16 %, and more likely 20-25 %, of the total afforestation in the century, with the remaining afforestation still being heath land plantations. These studies also give an indication of the spatial distribution of woodland areas in the landscape. There seems to have been two types of afforestation of former arable land: scattered areas of afforestation and afforestation in connection with already existing forest.

In a recent report, The National Forest and Nature Agency evaluates the first 10 years (1989-1998) of the Danish afforestation programme (Skov- og Naturstyrelsen, 2000). The afforestation with the scheme for field afforestation is estimated to be 13 % of the total afforestation in the period,

which equals 2,293 hectares of new forest. However, in these figures private afforestation without subsidies is estimated to be 63 % of the total afforestation in the period, a number subject to some uncertainty. If we look only at the figures for the subsidised afforestation, the afforestation in Ribe and Vejle counties is respectively 337.3 ha and 204.3 ha, which together equals 24 % of the total field afforestation in Denmark and puts them in the lead of counties obtaining new woodlands through the subsidy scheme. The forest area in Ribe increased in the period from 9.9 % to 10.1 % whereas the increase in Vejle has been from 12.1% to 12.6 %. Looking at the time frame, the numbers of new woodlands established under the scheme is limited in the first years with a slight increase in mid-1990s. However, despite the integration of the subsidy scheme with a grant for twenty years' withdrawal of arable land in environmentally sensitive areas (part of the EU-regulation 2078/92), numbers first really increased when the scheme for field afforestation was supplemented with a 20 year compensation rate in afforestation areas in 1997 (Jespersen et al., 1996). Hence, the afforestation in 1997 and 1998 together make up 66 % of the area of total field afforestation in the period.

To compare the afforestation under the scheme for field afforestation with former afforestation of arable land is not quite straightforward. If we look at the numbers from the report of The National Forest and Nature Agency, the afforestation under the scheme in the first 10 years constitutes 13 % of the afforestation in Denmark, and 25 % of the afforestation in the study area. This can be compared to former afforestation on arable land which as mentioned was estimated to be 20-25 % in Denmark (Barrensø, 1986) and 33 % in the study area (Jensen, 1976). Adding the estimated afforestation from private landowners without subsidies from the report of The National Forest and Nature Agency, the afforestation on arable land constitutes 76 % of total afforestation in Denmark and thereby the afforestation of arable land can be said to have increased dramatically in the latest 10 years. It must be noted that behind this calculation lies the assumption that afforestation under the scheme for field afforestation and afforestaion undertaken by private landowners without subsidies are occurring on arable land. The remaining afforestation is public afforestation (undertaken by state and local authorities) of which some is occurring on arable land. It has unfortunately with the available statistics not been possible to get information of the magnitude of this type of afforestation. A comparison of the afforestation both within and without the scheme for field afforestation with the numbers of former afforestation on arable land can be said to be more reasonable than only looking at the afforestation under the scheme, because afforestation both within and outside the scheme takes place on arable land. Yet, the fact that the afforestation without subsidies is estimated and therefore is subject to some uncertainties makes such a conclusion premature. The same picture arises if we look at the actual hectares of new woodlands. Under the scheme for field afforestation 2,293 ha in 10 years equal to 229 ha/year have been planted which cannot be said to match previous afforestation of arable land where 37,000 ha were planted in 80 years equal to 463 ha/year. But if the afforestation outside the scheme for afforestation is added the actual hectares planted are 1,332 ha/year and the present afforestation seems impressive. Further, one has to bear in mind the uneven distribution of hectares afforested over the years, which makes such comparisons even more complex.

Therefore, in summing up it can be said that it is difficult to compare the present afforestation with former afforestation on arable land, especially due to the uncertainty of afforestation outside the scheme for field afforestation. Depending on which numbers are used, the present afforestation of arable land is either below or above former rates of afforestation of arable land.

In relation to the following analysis, it must be noticed that analysing the actual planting of new woodlands under the scheme for field afforestation is also not as straightforward as it may sound. This is due to the fact that no direct relation exists between obtaining a grant and actually planting, and not obtaining a grant and not planting, in the data. See Table 1.

The numbers of grants for field afforestation in Ribe and Vejle counties show that 57 % of the applicants have received a promise of a grant, while 43 % were refused a grant. When looking at the actual planting, 41 applicants have planted and an additional 3 have partly planted which

Table 1. *Applications for grants for field afforestation in Ribe and Vejle counties 1994-1997.*

	Vejle		Ribe		Total	
	no	ha	no	ha	no	ha
Applications	29	214.0	45	547.6	74	761.6
Promise	21	147.5	21	288.4	42	435.9
Of this planted	16	109.6	17	265.0	33	374.6
Refusal	8	66.5	24	259.2	32	325.7
Of this planted	3(3)	18 (26.8)	5	59.5	8(3)	77.5 (26.8)
Total planted	19(3)	127.6 (26.8)	22	324.5	41(3)	452.1 (26.8)

( ): indicates the number and area of additional landowners who have partly planted.

together corresponds to 478.9 hectares on 63 % of the applied area. However, when analysing the area actually planted it appears that both landowners who received a promise and a refusal have planted. Looking at the numbers, 1/5 of the applicants receiving a promise did not plant, whereas 1/3 who received a refusal planted the whole area or part of the area anyway. This can be understood by analysing the landowners' motives for afforestation, inasmuch as landowners interested in the woodland more often plant whether obtaining a grant or not, whereas landowners only interested in the grant only plant if it is obtained (Madsen, 2001).

The location of new woodlands according to designated areas

The goals of afforestation programme have changed through the first 10 years from being mainly an alternative to agricultural production to being promoted by environmental and recreational arguments. Hence, today the scheme for field afforestation under the afforestation programme is promoted in order to meet the current goals of protecting groundwater resources, securing urban recreational needs and supporting and enhancing biological variety in the landscape (Skov- og Naturstyrelsen, 1999). Throughout the period, the location of new woodland areas has been controlled by the planning system by allocating the subsidies for field afforestation to designated areas. Designation of afforestation areas is completed by the individual counties and is used in the Forests and Nature Agency's allocations of subsidies for field afforestation (Jensen, 2000). In the designation of afforestation areas, the counties must follow the directions given by the Ministry of Environment and Energy, which are given in order to reach the changing goals of the afforestation programme. Therefore, one way to measure the fulfilment of the goals of the afforestation programme is to look at the location of field afforestation within the different types of designated areas.

Two different types of designated areas exist: afforestation areas and negative areas where afforestation is, respectively, wanted and not allowed. Further, neutral areas exist where afforestation is allowed. It is possible to obtain grants through the scheme for field afforestation in afforestation areas and neutral areas with the highest subsidy given in the former. The location of woodlands subsidised under the scheme for field afforestation in the period between 1994 and 1997 according to these three types of areas is shown in Table 2.

Table 2 shows that 200 ha have been planted in afforestation areas, 73.5 ha in neutral areas, and 14.5 ha of new woodland in negative areas. Further, 190.9 ha woodland has been located in more than one type of designated areas; this is shown in the column called 'combined' in Table 2. However, 70 % of these woodlands have their main part of the area within designated afforestation areas. If we look at

Table 2. *The location of field afforestation in Ribe and Vejle counties 1994-1997 within the different types of designated areas.*

	Afforestation area				Neutral area			
	promise		refusal		promise		refusal	
	no	ha	no	ha	no	ha	no	Ha
Ribe	10	137.5	13	120.0	2	4.9	3	30.7
Vejle	7	63.3	4	30.2	9	45.4	1	6.0
Total	17	200.8	17	150.2	11	50.3	4	36.7
Actual planted	11	158.5	4*	41.5*	10	46.2	3*	27.3*
Total actual planted	15 planted = 200ha				13 planted = 73.5ha			

	Negative area				Combined			
	promise		refusal		promise		refusal	
	no	ha	no	ha	no	ha	no	ha
Ribe	1	3.3	1	11.2	8	142.6	7	97.3
Vejle	0	0	0	0	5	38.8	3	30.3
Total	1	3.3	1	11.2	13	181.4	10	127.6
Actual planted	1	3.3	1	11.2	11	166.6	3	24.3
Total actual planted	2 planted = 14.5ha				14 planted = 190.9ha			

* Includes partly planted: in afforestation areas 2 areas of 20.8 ha and in neutral areas 1 area of 6.0 ha.

	Afforestation area		Neutral area		Negative area		Total	
	ha	%	ha	%	ha	%	ha	%
Varde(61.2 km²)								
outside scheme	2.7	13	16.1	75	2.6	12	21.4	100
with scheme	93.6	94	0	0	5.8	6	99.4	100
Vorbasse(49.2 km²)								
outside scheme	6.2	5	117.5	94	1.3	1	125	100
with scheme	14.6	55	12.0	45	0	0	26.6	100
Vejle(48.7km²)								
outside scheme	0.6	2	24.6	80	5.1	17	30.3	100
with scheme	2.7	100	0	0	0	0	2.7	100
Total								
outside scheme	9.5	5	158.2	90	9	5	-	-
with scheme	110.9	86	12.0	9	5.8	5	-	-

Table 3. *The location of new woodlands in Varde, Vorbasse and Vejle 1983-1995.*

Table 2, three issues need a comment. Firstly, the success rate of obtaining a grant, according to the designated area. 50 % of landowners in afforestation areas who applied in an afforestation area have succeeded, whereas the number is 73 % in neutral areas and 57 % in combined areas. If we instead analyse the granted afforestation area the numbers are 57 %, 58 %, and 59 % respectively. One could expect that the planning system would ensure that the percentage of promises and area supported were higher in afforestation areas. A possible explanation can be that the scheme for field afforestation is administrated at the national level and in its priorities seeks a geographically even distribution of subsidies among the counties (Jensen, 2000). This means that if the number of applications in afforestation areas in one year is low, applications in neutral areas will be granted, whereas in years with a high number of applications in afforestation areas, not all in these areas will get a promise. Secondly, a higher rate of refusals in neutral areas could be expected due to the priority of applications located in afforestation areas. However, it has been found that the local forest district often functions as a screening of potential applications (Jensen, 2000). If a landowner wants to apply for a grant not located in an afforestation area, he is often told that chances are minimal, and in this way, the numbers of applications outside afforestation areas are diminished, affecting the percentage of refusals in these areas. Thirdly, it seems strange that afforestation located in areas where afforestation is not allowed has received subsidies under the scheme for field afforestation. This could, despite the fact that it only concerns one application, indicate a lack of coordination between the different actors implementing the goals of the afforestation programme.

The above analysis deals with the afforestation occurring where landowners have applied for afforestation grants; but what about the location of afforestation occurring outside the scheme for field afforestation? By looking at the forest dynamics in the three areas Varde, Vorbasse, and Vejle, we get an indication of this. In Table 3 the numbers and hectares of woodlands afforested both within the scheme and outside the scheme are given. In all three areas, afforestation under the scheme for field afforestation mainly occurs in afforestation areas, whereas the afforestation outside the scheme mainly occurs in neutral areas. This can be ascribed to the fact that landowners wanting to plant in neutral areas do not find it worthwhile applying, and therefore plant without a subsidy whereas landowners in afforestation areas are advised to apply. Further, the figures indicate that even though the planning system does not directly control the afforestation outside the scheme for field afforestation this type of afforestation is not common in negative areas.

A step further than just looking at the location of new woodlands in the different designated areas is to analyse the spatial configuration of new woodlands in the landscape. Such an analysis can be used to further evaluate the present location of new woodlands in the landscape. In Jensen (2000), it is discussed how the planning framework for field afforestation ignores the opportunities for taking spatial parameters such as e.g. the distance to other woodlands into account. As long as the woodland is located within the designated area, it seems to be satisfactory, and thereby the benefits of a spatially oriented approach of location are ignored. It is difficult to measure the consequences of the current planning approach because it deals with missed oppor-

tunities for guidance of afforestation based on spatial considerations. However, one way is to look at the spatial characteristics that the goals 'demand' in order to be fulfilled and then evaluate the present afforestation according to these. In Jensen (1999), a list of spatial parameters of importance for nature conservation, recreation, and landscape amenity has been outlined. According to this, the size, shape, distance, and numbers of woodland patches in the landscape are of importance and further the concepts of corridor, network, connectivity, cover, scale, unity and diversity are important for the location of the new woodland if the goals are to be fulfilled. Evaluation of this is not simple and demands a more comprehensive data set and development of methods not available within the limits of this study. However, the approach is important if future afforestation should be evaluated according to the present goals of the afforestation programme. Therefore, a minor step is taken in this direction in the following analysis by documenting the spatial parameters and configuration of both the afforestation within and outside the scheme for field afforestation and further by discussing the application of simple methods ('forest-pictures' and 'gradient-pictures') to quantify the spatial configuration of woodlands in the landscape.

Spatial parameters and configuration of the new woodlands

The woodlands under the scheme for field afforestation

Analysing the location of new woodlands, the afforestation can be interpreted according to the earlier mentioned division into the western and eastern type of forest development. Figure 2 shows the result of a former study of afforestation on arable land (1870-1965) in the study area (Jensen, 1976) combined with the applications of new woodlands under the scheme for field afforestation. The main division between the eastern and western type of forest development along the East Jutland ice margin line still seems important for the location of new woodlands. Only 8 % of the applications are found in the eastern part while 92 % are found in the western part. If we look at the area of new woodlands the average area increases towards the west, from 3.7 ha east of the East Jutland ice margin line, 5.3 ha in the transition zone, to 9.7 ha west of the main stationary line of the last ice sheet. The study of Jensen (1976) shows the percentage of abandoned and afforested arable land and cannot be compared directly with the data in this study. However, it seems that the present interests in afforestation under the scheme mainly correspond to the former afforestation except in the western part, where the number of applicants indicates that present afforestation exceeds former afforestation on arable land. Looking at the actually planted woodlands, 12 % lie east of the East Jutland ice margin line and 88 % west of this line, whereas the increase in average areas of the new woodlands towards the west are respectively 3.7 %, 6.0 % and 10.0 %. Summing up, these figures indicate that the location of new woodlands in the landscape still seems to be related

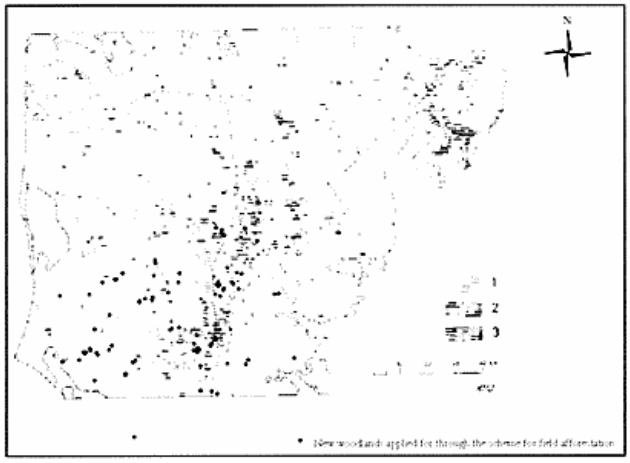

Figure 2. *The location of field afforestation 1994 -1997 in relation to former afforestation and the main stationary line of the last ice sheet and the East Jutland ice-margin line with a transition zone in between. The distribution of abandoned and afforested arable land throughout the last hundred years. 1: 5-10 %, 2: 10-20 %, and 3: more than 20 % of the area is abandoned and afforested arable land. The dotted line indicates the main stationary line of the last ice sheet, while the dashed line shows the East Jutland ice-margin line (Jensen 1976). Note that an application can include more than one individual woodland.*

to the different physical conditions for production due to the glacial period in Denmark.

By analysing the number and area of existing woodlands in zones around the new woodlands, a quantification of their location in the local landscape can be given and thereby an indication of their potential ecological value (cf. Jensen, 1999). The method proposed here is simple and easy to handle within the planning system. Yet, the ecological value of the location of new woodlands in the landscape is complex and it must be highlighted that the suggested method only deals with the spatial considerations and further only some of the spatial considerations. Looking at all applications, the majority of woodlands (80 %) are either an extension of already existing forests or connect existing forest areas, whereas only 20 % are new separate woodlands in the landscape. By applying the method of 'forest-picture' the spatial configuration that the new woodland enters into

Figure 3. 'Forest-pictures' of planted woodlands in 500m around the new woodland. 1 = Forest cover under 10 %, 2 = Forest cover between 10-25 %, 3 = Forests cover over 25 %.

in the landscape can be quantified by categorising the new woodland according to whether it is located within a 'forest-empty' or 'forest-covered' landscape. Estimating the woodland cover within 500-metre buffer zones around the woodland is a way to do this and three examples of such 'forest-pictures' are shown in Figure 3. The distance around the woodlands that are analysed can be varied according to the scale of interests, which is important because different plant and animal groups are dependent of very different landscape structures and thereby different scales of analysis (e.g. literature review by Hammershøj and Madsen 1998).

Allocating the new woodlands to the different forest-pictures, it appears that 50 % of the planted woodlands are located in areas where the forest cover is under 10 %, 41 % where the forest cover is between 10-25 %, and 9 % where the forest cover is over 25 %. Remembering that the forest cover of Denmark is 12 %, whereas it is 10.1 % in Ribe, and 12.6 % in Vejle counties (Skov- og Naturstyrelsen, 2000) this means that in the local landscape, the new woodlands often are located in areas with a low forest cover.

Comparison between new woodlands within and outside the scheme for field afforestation

The three smaller areas of Varde, Vorbasse, and Vejle are each placed in one of the three different types of forest development: Varde in the western, Vorbasse in the transition zone and Vejle in the eastern. These three areas are used to analyse and compare the spatial parameters and configuration of new woodlands both within the scheme and outside the scheme.

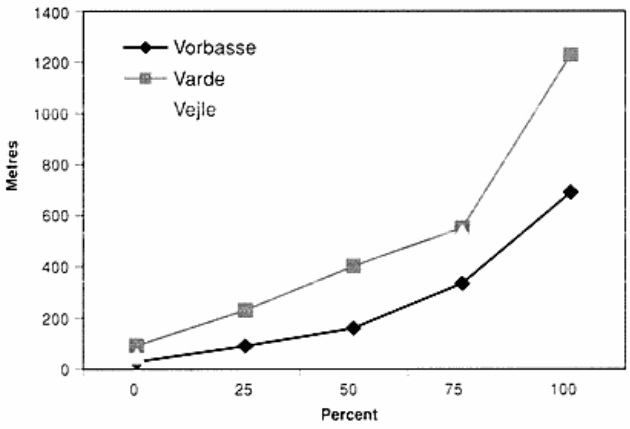

Figure 4. 'Gradient-pictures' of Varde, Vorbasse, and Vejle.

In order to analyse the spatial configuration of the new woodlands the forest pattern must be quantified. In Varde, it consists of a few large areas of forests and considerably more small woodland areas scattered in the landscape. However, some areas are rather empty of forest. Further, the area is dominated by large connected wetlands. In the area of Vorbasse large, medium and small woodland areas are scattered more evenly in the area. Vejle consists of forest areas mainly along the fragmented wetlands and further a relatively large forest area in the southern part. The difference between the three areas can be quantified by applying a method developed to show the distribution of the forest in the landscape (Jensen et al., 1998). By calculating the distance from the individual points in a web of evenly distributed points to the nearest forest patch and then showing the accumulated distances in a 'gradient-picture' a quantification of the distribution of forest patches in the landscape can be obtained. In the 'gradient-picture' an inclination that approaches zero indicates an even distribution and vice versa (see Jensen et al., 1998 for more detailed explanation). The gradient-pictures of forest in the three areas are shown in Figure 4. Here it can be seen that Vorbasse has by far the most even distribution of forest areas in the landscape and that the areas, which are rather empty of forest in Varde, are shown as a very steep gradient for the last 25 % of forests. Vejle follows the gradient-picture of Varde for 75 % of the forests, though it does not reach the same level of the distances to nearest forests for the last 25 %. Varde is thereby the area with the most isolated forest areas of the three.

The increase in forest area due to afforestation outside the scheme for field afforestation between 1983 and 1995 in Varde, Vorbasse, and Vejle is shown in Table 4. Here it can be seen that in all three areas the forest dynamics have resulted in an increase in the forest area between 1983 and 1995. The increase of forest area has been most marked in Vorbasse (14 %) located in the transition zone but also to some extent in Vejle (6 %) in the east, whereas it has been more limited in Varde (2 %) in the west. However, the increase is not simple: it covers new woodland areas, increased and decreased areas of the existing forests and dis-

Table 4. Forest dynamic in Varde, Vorbasse, and Vejle between 1983 and 1995.

	Varde (61.2 km²)		Vorbasse (49.2 km²)		Vejle (48.7km²)	
	ha	%	ha	%	ha	%
Forest 1983	780.3	12.8	853.3	17.3	424.5	8.7
Forest 1995	796.2	13.0	976.4	19.8	451.9	9.2
Increase	15.9	0.2	123.1	2.5	27.4	0.5
No change	711.6	89	580.6	59	351.9	78
Changes:	Number		Number		Number	
New individual woodlands	10		27		19	
Increased woodlands	9		27		20	
Decreased woodlands	2		1		2	
Disappeared woodlands	3		4		0	
Woodlands located differently	0		0		1	

appeared forest areas, as also shown in Table 4.

In all three areas, the increase in forest area is furthermore due to both new individual woodlands and extension of existing forests. In Vorbasse the percentage increase of forest has been considerably high compared to the two other areas of Varde and Vejle: a 2.5 % increase compared to 0.2 % and 0.5 % respectively. Vorbasse is located in the transition zone between the eastern and western type of forest development and the fact that afforestation is especially high in this area further indicates that present afforestation follows the pattern of former afforestation.

The 'gradient-picture' has been calculated for both 1983 and 1995 in order to quantify whether the increase in forest area has resulted in a different distribution of woodlands in the landscape. However, the increase in forests does not influence the distribution of forests in the landscape to such a degree that the gradient-pictures change considerably. The maximum distance from a random point in the landscape to the nearest forest patch has increased in Varde, whereas it is the same in Vorbasse and it has decreased in Vejle. This quantification can be interpreted as an indication that the increase in forest area only in Vejle has led to a more even distribution of forest in the landscape, whereas in Varde the differences between forest-empty and forest-covered areas have been magnified and the situation in Vorbasse is status quo. However, the differences in distances are too small to draw such conclusions, but are discussed here to illustrate how the method can be used in the comparison of bigger changes in forest development.

In order to compare the spatial parameters of the new woodlands outside the scheme with woodlands planted under the scheme, the number and hectares of the latter are shown in Table 5. Here, it can be seen that the area of woodlands planted under the scheme between 1994 and 1997 varies considerably between the three areas, and has increased the percentage of forest in Varde with 1.6 %, in Vorbasse with 0.6 % and in Vejle with 0.1 %. This means that in Vorbasse and Vejle the area of afforestation outside the scheme exceeds the afforestation under the scheme while the opposite is the case in Varde (cf. Table 4). Especially in Varde and Vorbasse, the difference is marked with an opposite sign. In Varde, the area of woodlands under the afforestation scheme far exceeds the increase of forest area outside the scheme, whereas in Vorbasse the picture is completely the opposite. The difference may result from a combination of a prioritising of nearness to urban areas in the selection of grant-aided woodlands, which is the case for woodlands located in Varde, and more interest in afforestation in the rather unstable area of Vorbasse which is located in the transition zone.

In comparing the spatial parameters of the new woodlands within the scheme and outside the scheme, it can be seen that they are different in both area and in their location in the landscape. In Varde 60 %, in Vorbasse 70 %, and in

Table 5. Field afforestation between 1994 and 1997 in Varde, Vorbasse, and Vejle.

	Varde		Vorbasse		Vejle	
	no	ha	no	ha	no	ha
Applications	7	99.4	5	101.7	1	2.7
Grant-aided	7	99.4	1	14.6	1	2.7
Actual planted	7	99.4	2	26.6	1	2.7

Vejle 100 % of the woodlands under the scheme lie in immediate connection to existing forests, compared to 38 % in Varde, 46 % in Vorbasse and 48 % in Vejle for the new woodlands outside the scheme occurring in the areas between 1983 and 1995. It must be remembered that the total numbers for especially the woodlands under the scheme are limited. Likewise, a difference also exists in the average area, which is considerably higher for woodlands under the scheme than for woodlands outside the scheme. In Varde, the average area for woodlands outside the scheme for field afforestation is 1.7 ha compared to 17.9 ha for woodlands under the scheme, in Vorbasse the numbers are respectively 2.3 ha compared to 13.3 ha, and in Vejle 0.8 ha compared to 2.7 ha. From a visual interpretation of the aerial photos from 1995, it can be stated that the woodlands outside the scheme for field afforestation more often consist of corners, wedges, small pieces along roads or in other ways small areas inconvenient for agricultural production as opposed to the woodlands under the scheme, which most often are former fields or larger parts of fields. This difference is most explicit in Varde and Vejle, whereas in Vorbasse some of the woodlands outside the scheme for field afforestation are of the same character as the woodlands under the scheme.

Conclusion

The article documents that the woodlands subsidised under the scheme for field afforestation are primarily located within designated afforestation areas and secondarily in neutral areas, whereas for woodlands afforested outside the scheme the picture is the opposite; they are primarily located in neutral areas and secondarily in afforestation areas. The main division between the eastern and western types of forest development along the East Jutland ice margin line is found to be important for the location of new woodlands in the landscape. Thereby the location, as also found in earlier studies, still seems to be related to the different physical conditions for production due to the glacial period in Denmark. In the local landscape the subsidised woodlands are often located in areas with a low forest cover and thereby contribute to the enhancement of the forest pattern in low forest covered areas. In the comparison between woodlands afforested with the scheme and outside the scheme it was found that the former exceed the latter in Varde (western part), whereas the picture is the opposite in both Vorbasse (transition zone) and Vejle (eastern part). Further, the average area is considerably lower for woodlands outside the scheme than for woodlands within the scheme. The former are often located as corners, wedges, small pieces along roads or other small areas inconvenient for agricultural production, whereas the latter often consist of larger areas of former fields or larger parts of fields. This difference is most explicit in Varde and Vejle, whereas in Vorbasse some of the woodlands outside the scheme are of the same character as the woodlands under the scheme.

The article points at the importance of being able to quantify the spatial parameters and configuration of the new woodlands if we are to evaluate their benefits according to the goals of the afforestation programme. In such an evaluation, it is not sufficient to look at the location of new woodlands inside or outside a certain designated area. We need to be aware of the spatial configuration of woodlands in the landscape both in order to evaluate the present afforestation but more importantly, to be able to guide future afforestation into areas where the benefits, be they ecological, recreational or something else, are considerable. A minor step in this direction is the 'forest-pictures' and 'gradient-pictures' used in this paper. The first interprets the location of new woodlands in relation to the existing forest pattern and indicates the benefit of the new woodland regarding the spatial distribution of forests in the landscape whereas the second can be used to quantify the different woodland patterns occurring due to new woodlands under the scheme for field afforestation.

An interesting discussion of the fulfilment of the goals of the afforestation programme is the possibility of achieving such different goals as protecting groundwater resources, securing urban recreation needs, and supporting and enhancing the biological variety in the landscape by the relatively simple system of subsidies in use today. The system is based on voluntary subsidies, which are prioritised according to the location within designated areas. One could argue for using the scheme for field afforestation to secure specific goals such as enhancing the ecological network in the landscape and for securing other goals by state afforestation. In such an approach, one could argue for a differentiated subsidy system prioritising the applications for field afforestation in relation to the spatial configurations of the woodlands in the local landscape. In a discussion of the future of the present subsidy system for field afforestation in Denmark and its evaluation, an approach based on spatial considerations is found important.

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Aerial photos used:

1983: 8304, 1:25.000

Varde:

H481, H480, H479, H478, H477, H476, H475, H474, H473, H472, H471, H470 G33, G34, G35, G36, G37, G38, G39, G40, G41, G42, G43 F253, F252, F251, F250, F249, F248, F247, F246, F245, F244, F243, F242

Vorbasse

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Vejle:

H413, H412, H411, H410, H409, H408 G99, G100, G101, G102, G103, G104 F186, F185, F184, F183, F182, F181

1995: DDO-95, 1:10.000

Varde:

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Vejle

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