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Lundhede, Thomas; Thorsen, Bo Jellesmark

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DEPARTMENT OF FOOD AND RESOURCE ECONOMICS
UNIVERSITY OF COPENHAGEN

# IFRO Commissioned Work

## Estimation of costs for the establishment of hedges and smaller woodlots in the landscape

*Thomas Hedemark Lundhede*
*Bo Jellesmark Thorsen*

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Estimation of costs for the establishment of hedges and smaller woodlots in the landscape

Authors: Thomas Hedemark Lundhede, Bo Jellesmark Thorsen

Scientific quality control: Niels Strange

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Department of Food and Resource Economics
University of Copenhagen
Rolighedsvej 25
DK-1958 Frederiksberg
www.ifro.ku.dk/english/

**0. Summary:**

This short report presents the results of an analysis and estimation of the likely direct cost ranges of establishing hedges and smaller woodlots in the open agricultural landscape. The calculations are structured to enable the subsequent formulation of a new Danish grant scheme, designed to provide incentives for establishing hedges and smaller woodlots.

The calculations are targeting measures of direct costs of establishment per hectare, for a given number of plants per hectare with the associated direct costs of tending to the hedges and woodlots during the first years to secure establishment. The tending need is caused in part by the restricted choice of species, which focus on native species of value to biodiversity. The calculations rely on best available data obtained from market transactions. Cost models for planting hedges and smaller woodlots are developed to resemble the structure of cost models for afforestation and parameterized using extensive material obtained from market agents revealing unit and hectare costs of established hedges and smaller woodlots.

We develop a base scenario for the current practice in the sector, enabling us to calculate ranges of unit cost of plants and planting per plant and ranges of unit costs per hectare of site preparation and establishment related tending to the hedges and woodlots. On that basis we provide ranges of costs for scenarios of establishing hedges and smaller woodlot plantings in line with the requirements of the suggested support grant scheme; notably the range of the required number of plants per hectare.

Results of the empirical data analysis show a large variation in costs. They show that costs of plants, planting and replacement planting are comparable and in cases even in the lower end of costs reported in standard forest economic models for reforestation measures. Costs for clearing vary considerably and so does soil preparation costs. Upper ranges of clearing costs are well beyond typical forest models, but may reflects costs related to clearing existing hedges including roots. Costs of tending and weeding in the first three years are, however, the element where the empirical data show the largest deviation from cost models applied for afforestation and reforestation models. These costs reflect higher annual frequencies of mechanical and occasional pesticide based weeding and tending than typical for young forest stands. The reason for this practice is undoubtedly that these hedges are an element in the agricultural landscape that implies a stronger attention to weed competition.

Based on these data, we develop a set of cost models with associated cost ranges for the suggested hedge and woodlot model of 3.000, 4.000 and 5.000 plants/ha. The models carry over these features with fairly modest costs of plants, planting and replanting. Costs of soil preparation, clearing and in particular establishment related tending and weeding remain higher, and with great variation.

## 1. Introduction:

The planting of hedges and smaller wood lots in the agricultural landscape has been practice for several decades in Denmark. These landscape structures provide shelter for the immediate surroundings, and habitat and corridors for wildlife. Several of these values represent externalities and do not directly benefit the owner of the land upon which hedges and woodlots are established, to an extent sufficient to motivate their establishment. For that reason, support grants for establishing hedges and small woodlots in the landscape have been available in several periods in the past. The Danish government is about to re-design the current support grant scheme for hedges and smaller woodlots with a targeted objective of enhancing biodiversity in the open agricultural landscape.

This short report presents the calculations of likely ranges of direct costs of establishing hedges and smaller woodlots in the open agricultural landscape including the establishment related tending of these during their first three years. The calculations are structured to enable the subsequent formulation of a revised Danish support grant scheme, designed to provide incentives for establishing hedges and smaller woodlots.

## 2. Method and data:

The calculations are targeting measures of direct costs of establishment per hectare. The calculations rely on best available data. Cost models for planting hedges and smaller woodlots are developed to resemble the structure of standard cost models for afforestation and parameterized using extensive material obtained from market agents revealing unit and hectare costs of established hedges and smaller woodlots. The material have been obtained by requesting from market agents (HedeDanmark 2016; Plantning & Landskab 2016) documented actual offers and contracts on plantings of hedges and smaller woodlots of

various forms and sizes, enabling the setting up of a cost model of the current practice in the sector. The total material encompasses contracted plantings of more than 10 larger planting cooperatives for more than 600.000 plants corresponding to likely more than 100 kilometers of hedges and number of smaller woodlots.

On that basis, we develop a base scenario for the current practice in the sector, enabling us to calculate ranges of unit cost of plants and planting per plant and ranges of unit costs per hectare of site preparation and establishment related tending to the hedges and woodlots. The latter can be compared in principle to the standard models of afforestation and reforestation costs, but will differ due to the different ecological context.

From this base scenario we develop a model of establishing hedges and smaller woodlots that are in line with the requirements of the suggested support grant scheme; notably the scenarios of minimum 3.000, 4000 and 5.000 plants per hectare with either 0,5 meter or 1,0 meter of free space along each side of the hedge or woodlot. Drawing upon the base scenarios parameters, we provide estimated scenario ranges of costs for these new models, which are believed to encompass likely cost ranges for establishment.

## 3. Results and applications:

We first present the model based on and encompassing the ranges of the underlying data and derive from that model per hectare estimates of central cost elements of relevance to the new scheme design too.

### *3.1 A model of the base scenario based on current practice and cost ranges*

In Table 1 below we present a rough model of the cost elements eligible for partial compensation through the planned support scheme. The Table expresses the costs in DKK/plant as is currently common practice in the sector when setting up offers and making contracts.

We see that within each cost element there is a large variation. Some of this variation is possibly site specific and thus caused by the specific circumstances influencing measures to be taken and their frequencies at the different cases studies where from we have gathered data. This would include costs of soil preparation and clearing. Another feature causing variation is the part of the hedges planted in organic farming land where the tending costs are considerably higher due to the absence of pesticide use.

| Cost element | Central estimate DKK/plant | Lower DKK/plant | Higher DKK/plant |
|---|---|---|---|
| Soil preparation | 2,43 | 1,68 | 3,70 |
| Clearing | 1,49 | 0,00 | 7,00 |
| Cost of plants | 4,49 | 3,51 | 6,43 |
| Planting | 3,13 | 2,23 | 4,48 |
| 1st year tending | 3,62 | 2,53 | 5,67 |
| 2nd year tending | 3,00 | 1,72 | 5,51 |
| 3rd year tending | 1,84 | 1,10 | 2,84 |
| Replacement planting | 1,50 | 0,72 | 2,65 |

Table 1: Empirical cost per plant

The estimated costs of plants, planting and replacement planting can be compared to those applied in standard afforestation cost models (Danish Forest Association 2009). A comparison shows that the costs reported in Table 1 are very similar in size and range to the plant and planting costs in standard reforestation models in forest economic models. Thus, this is not where the practices differ in spite of a higher number of different species to be handled in specific patterns in the planting of hedges and often also smaller woodlands. We now turn to estimating per hectare measures of the remaining establishing related cost elements.

The material gathered regarding the current planting practices suggests that current planting distances in the hedges and woodlots are 1,0 m by 1,25 m or 1,25 m by 1,25 m. Assuming that we can allow for either 1,0 additional meter of free space (0,5 meter on each side) or 2,0 meter of free space (1,0 meter on each side) along the hedges, this would correspond to between 6.900-8.600 and 5.300-6.700 number of plants per total hectare, respectively assuming the use of a 3-row hedge. Below in Table 2 and Table 3 we present estimations of per hectare costs of hedges based on the per plant estimates from Table 1. Table 2 uses an approximate midpoint of the first range of 7.750 plants per hectare, not accounting for additional free land along the hedges. Table 3 uses an approximate midpoint of 6.000 plants per hectare, accounting for 1.0 meter of free space along each side of the hedges

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 18.853 | 13.020 | 28.675 |
| Clearing | 14.411 | 310 | 54.216 |
| Cost of plants | 34.771 | 27.203 | 49.850 |
| Planting | 24.230 | 17.283 | 34.720 |
| 1st year tending | 28.049 | 19.608 | 43.954 |
| 2nd year tending | 23.270 | 13.330 | 42.703 |
| 3rd year tending | 14.231 | 8.525 | 21.977 |
| Replacement planting | 11.644 | 5.556 | 20.538 |
| Total | 189.263 | | |

Table 2: Calculation of per hectare cost for the case of 7.750 plants per hectare, accounting for **0,5 meter** of additional free space on each side of the hedges

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 14.596 | 10.080 | 22.200 |
| Clearing | 11.157 | 240 | 41.973 |
| Cost of plants | 26.920 | 21.060 | 38.593 |
| Planting | 18.759 | 13.380 | 26.880 |
| 1st year tending | 21.716 | 15.180 | 34.029 |
| 2nd year tending | 18.016 | 10.320 | 33.060 |
| 3rd year tending | 11.017 | 6.600 | 17.014 |
| Replacement planting | 9.015 | 4.301 | 15.900 |
| Total | 146.526 | | |

Table 3: Calculation of per hectare cost for the case of 6.000 plants per effective hectare, accounting for **1,0 meter** of additional free space on each side of the hedges

The per hectare cost estimates reported in Table 2 and Table 3 differ from standard cost models of reforestation as cost elements are generally higher. Cost of clearing and soil preparation varies considerable here and the lower end estimates are well within the ranges of reforestation models. Higher end estimates of clearing resembles more the cost of clearing after windthrows, which reflects that in some cases existing old hedges needs to be removed including stumps and roots.

Turning to the cost of tending to the hedges in the first years, reforestation models have cost usually less than half the size found here. This reflects a significant difference in the effort needed to keep hedges clean from the often intense competition from grasses and shrubs in the fertile agricultural soils. In the first year, practice is to use mechanical weeding of grasses and other competing weeds some four to five times each season, possibly supplemented with occasional manual use of pesticides (conventional farms) or mechanical (organic farms). This requires moving men and machinery to each hedge 4-6 times per year, suggesting that the costs per treatment are within the range of costs reflected in standard

afforestation and reforestation models. Intensity and frequency of tending and weeding falls over the three years as the hedge starts to close and reduce competition pressures naturally.

*3.2 A model simulating a new scheme structure's likely cost ranges*

In the current suggested support grant scheme, the number of plants has been proposed to a number ranging between 3.000 - 5.000 plants per hectare. In Table 4-9 below, we calculate the cost per hectare for hedges with this minimum of 3.000, 4.000 and 5.000 plants per hectare. Table 4, 6 and 8 utilize the calculations accounting for 0,5 meter of additional free space along the hedges (as in Table 2) and Table 5, 7 and 9 utilize the calculations where the free space along the hedges is 1,0 meter on each side (as in Table 3).

We assume that soil preparation, clearing and tending are not affected by the number of plants and therefore we use the calculations made in Table 2 and 3, for costs linear in hectares depending on the amount of free space on each side of the hedges. Cost of plants, planting and replacement planting is on the other hand assumed linear in the number of plants and these cost elements are adjusted accordingly.

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 18.853 | 13.020 | 28.675 |
| Clearing | 14.411 | 310 | 54.216 |
| Cost of plants | 13.460 | 10.530 | 19.297 |
| Planting | 9.379 | 6.690 | 13.440 |
| 1st year tending | 28.049 | 19.608 | 43.954 |
| 2nd year tending | 23.270 | 13.330 | 42.703 |
| 3rd year tending | 14.231 | 8.525 | 21.977 |
| Replacement planting | 4.507 | 2.151 | 7.950 |
| Total | 126.160 | | |

Table 4: Calculation of per hectare cost for the case of **3.000 plants** per effective hectare, accounting for **0,5 meter** of additional free space on each side of the hedges. Note that soil preparation, clearing and tending costs are assumed unaffected by number of plants and therefore similar to the cost reported in Table 2.

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 14.596 | 10.080 | 22.200 |
| Clearing | 11.157 | 240 | 41.973 |
| Cost of plants | 13.460 | 10.530 | 19.297 |
| Planting | 9.379 | 6.690 | 13.440 |
| 1st year tending | 21.716 | 15.180 | 34.029 |
| 2nd year tending | 18.016 | 10.320 | 33.060 |
| 3rd year tending | 11.017 | 6.600 | 17.014 |
| Replacement planting | 4.507 | 2.151 | 7.950 |
| Total | 107.307 | | |

Table 5: Calculation of per hectare cost for the case of **3.000 plants** per effective hectare, accounting for **1,0 meter** of additional free space on each side of the hedges. Note that soil preparation, clearing and tending costs are assumed unaffected by number of plants and therefore similar to the cost reported in Table 2.

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 18.853 | 13.020 | 28.675 |
| Clearing | 14.411 | 310 | 54.216 |
| Cost of plants | 17.946 | 14.040 | 25.729 |
| Planting | 12.506 | 8.920 | 17.920 |
| 1st year tending | 28.049 | 19.608 | 43.954 |
| 2nd year tending | 23.270 | 13.330 | 42.703 |
| 3rd year tending | 14.231 | 8.525 | 21.977 |
| Replacement planting | 6.010 | 2.867 | 10.600 |
| Total | 135.276 | | |

Table 6: Calculation of per hectare cost for the case of **4.000 plants** per effective hectare, accounting for **0,5 meter** of additional free space on each side the hedges. Note that soil preparation, clearing and tending costs are assumed unaffected by number of plants and therefore similar to the cost reported in Table 2.

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 14.596 | 10.080 | 22.200 |
| Clearing | 11.157 | 240 | 41.973 |
| Cost of plants | 17.946 | 14.040 | 25.729 |
| Planting | 12.506 | 8.920 | 17.920 |
| 1st year tending | 21.716 | 15.180 | 34.029 |
| 2nd year tending | 18.016 | 10.320 | 33.060 |
| 3rd year tending | 11.017 | 6.600 | 17.014 |
| Replacement planting | 6.010 | 2.867 | 10.600 |
| Total | 112.964 | | |

Table 7: Calculation of per hectare cost for the case of **4.000 plants** per effective hectare, accounting for **1,0 meter** of additional free space on each side of the hedges. Note that soil preparation, clearing and tending costs are assumed unaffected by number of plants and therefore similar to the cost reported in Table 2.

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 18.853 | 13.020 | 28.675 |
| Clearing | 14.411 | 310 | 54.216 |
| Cost of plants | 22.433 | 17.550 | 32.161 |
| Planting | 15.632 | 11.150 | 22.400 |
| 1st year tending | 28.049 | 19.608 | 43.954 |
| 2nd year tending | 23.270 | 13.330 | 42.703 |
| 3rd year tending | 14.231 | 8.525 | 21.977 |
| Replacement planting | 7.512 | 3.584 | 13.250 |
| Total | 144.391 | | |

Table 8: Calculation of per hectare cost for the case of **5.000 plants** per effective hectare, accounting for **0,5 meter** of additional free space on each side of the hedges. Note that soil preparation, clearing and tending costs are assumed unaffected by number of plants and therefore similar to the cost reported in Table 2.

| Cost element | Central estimate DKK/hectare | Lower DKK/hectare | Higher DKK/hectare |
|---|---|---|---|
| Soil preparation | 14.596 | 10.080 | 22.200 |
| Clearing | 11.157 | 240 | 41.973 |
| Cost of plants | 22.433 | 17.550 | 32.161 |
| Planting | 15.632 | 11.150 | 22.400 |
| 1st year tending | 21.716 | 15.180 | 34.029 |
| 2nd year tending | 18.016 | 10.320 | 33.060 |
| 3rd year tending | 11.017 | 6.600 | 17.014 |
| Replacement planting | 7.512 | 3.584 | 13.250 |
| Total | 122,079 | | |

Table 9: Calculation of per hectare cost for the case of **5.000 plants** per effective hectare, accounting for **1,0 meter** of additional free space on each side of the hedges. Note that soil preparation, clearing and tending costs are assumed unaffected by number of plants and therefore similar to the cost reported in Table 2.

Tables 3-9 indicate ranges of likely per hectare costs for establishing hedges and smaller woodlots in the agricultural landscape. Considerable variation may be expected depending on the specific contexts. Removal of existing hedges drives clearing costs (although a return on chipping sometimes can be expected), and in part soil preparation costs too. The use of deep-ploughing is more expensive and would tend to increase soil preparation costs towards the higher ranges. On the other hand, deep ploughing implies reduced competition from grasses, herbs and other weeds in the early years, thus in turn reducing intensity of tending and weeding activities. Thus, higher end clearing and soil preparation costs may correlate to some extend with lower end tending and weeding costs.

We note that the range of costs for plants, planting and replacement planting (approximately 27-45.000 DKK/hectare) are well within or in fact at the lower end of corresponding ranges of afforestation costs. This may be due to soil preparation and clearing, where costs are from low end (around 10.000 DKK/ha)

to quite high (>70.000 DKK/ha) in particular for clearing cost, when compared to standard forest economic models.

The largest differences in costs are found when considering establishment related tending and weeding around the newly planted hedges. Here the cost in empirical data ranges from 30.000 DKK/ha over the three years to potentially as high as 100.000 DKK/ha per year. These cost variations may cover differences in contexts, e.g. competition, soil, organic or conventional farming restrictions and other aspects. Nevertheless even the lower end cost ranges are considerably higher than typical tending and weeding costs in standard forest economic costs models. As explained above, the overall higher level is likely also a result of the higher frequency of mechanical and other weeding and tending activities within each of the early years.

## 4. Caveats and limitations

There are number of caveats and limitations that need to be mentioned and considered when reflecting on the above results.

Initially, it should be noted that costs reported in the empirical data regarding consultancy fees (project management and sales) to entrepreneurs have been excluded from the above calculations.

The empirical data used for calculating the costs per plant are based on hedges planted where the typical planting distance is 1,0 m by 1,25 m, which means that the number of plants per hectare will range between 6.700 and 8.600 depending on additional free space on each side of the hedge. Furthermore, the majority of the empirical data represents plantings of hedges at non-organic farms, indicating the use of pesticides in the tending and weeding along with standard mechanical measures.

In our simulated models, the lower range of plants, and the implied ban on pesticide use will undoubtedly affect the establishment related tending cost. A lower number of plants will increase competition pressures from grass on the plants in later years due to less shadow on the ground. This means that costs of tending and weeding for the first three years as presented in Table 4-9 would be increased towards or beyond the higher ranges, notably for the models with lower plant numbers.

Furthermore, in the possible absence of deep plowing as a soil preparation option, it is likely that extensive mechanical tending will be called for and thus increase the tending cost towards the higher end of the above ranges.

## 5. Concluding remarks

The report has documented the large variation in empirical costs of establishing hedges and smaller woodlots in the agricultural landscape. Based on empirical data, we develop a couple of cost models with associated cost ranges for the suggested hedge and woodlot model of 3.000-5.000 plants/ha. The models carry over features present in the empirical data, with fairly modest costs of plants, planting and replanting. Costs of soil preparation, clearing and, in particular establishment related tending and weeding remain higher and with great variation.

The calculations are assessed to be suitable for the development of a new support grant model compensating parts of reported costs, e.g. as a percentage of documented direct costs, potentially coupled with a cap on total support.

## 6. References:

Danish Forest Association, 2000: Skovøkonomisk Tabelværk [Forest Economic Standard Models].

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