INBO.R.2012.53

Wetenschappelijke instelling van de Vlaamse overheid

inbo

Instituut voor Natuur- en Bosonderzoek

Cost effectiveness of agri-environment schemes for biodiversity protection and ecosystem service restoration (CASPER – MKM Nature)

Report commissioned by Nature Report Policy Evaluation 2012 and Environmental Cost Model Nature

Peter Van Gossum, Astrid Sturm, Melanie Mewes, Joris Aertsens, Wouter Van Reeth, Karin Johst, Toon Van Daele, Frank Wätzold, Steven Broekx, Carine Wils

Auteurs:
Peter Van Gossum, Astrid Sturm, Melanie Mewes, Joris Aertsens, Wouter Van Reeth, Karin Johst, Toon Van Daele, Frank Wätzold, Steven Broekx, Carine Wils
Instituut voor Natuur- en Bosonderzoek

Het Instituut voor Natuur- en Bosonderzoek (INBO) is het Vlaams onderzoeks- en kenniscentrum voor natuur en het duurzame beheer en gebruik ervan. Het INBO verricht onderzoek en levert kennis aan al wie het beleid voorbereidt, uitvoert of erin geïnteresseerd is.

Vestiging:
INBO Brussel
Kliniekstraat 25, 1070 Brussel
www.inbo.be

e-mail:
peter.vangossum@inbo.be

Wijze van citeren:
Van Gossum, P., Sturm, A., Mewes, M., Aertsens, J., Van Reeth, W., Johst, K., Van Daele, T., Wätzold, F., Broeckx, S., Wils, C.(2012). Cost effectiveness of agri-environment schemes for biodiversity protection and ecosystem service restoration (CASPER – MKM Nature). Report commissioned by Nature Report Policy Evaluation 2012 and Environmental Cost Model Nature. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2012 (53). Instituut voor Natuur- en Bosonderzoek, Brussel.

D/2012/3241/318
INBO.R.2012.53
ISSN: 1782-9054

Verantwoordelijke uitgever:
Jurgen Tack

Druk:
Managementondersteunende Diensten van de Vlaamse overheid

Foto cover:
Yves Adams/Vildaphoto.net

Cost effectiveness of agri-environment schemes for biodiversity protection and ecosystem service restoration (CASPER – MKM Nature)

Report commissioned by Nature Report Policy Evaluation 2012 and Environmental Cost Model Nature

Peter Van Gossum, Astrid Sturm, Melanie Mewes, Joris Aertsens, Wouter Van Reeth, Karin Johst, Toon Van Daele, Frank Wätzold, Steven Broekx, Carine Wils

INBO.R.2012.53
D/2012/3241/318

Content

List of figures

List of tables

1 Introduction

W. Van Reeth, S. Broekx, M. Mewes, F. Wätzold, P. Van Gossum, J. Aertsens, A. Sturm, T. Van Daele, K. Johst

1.1 Importance of farmers cooperation for meadow bird protection

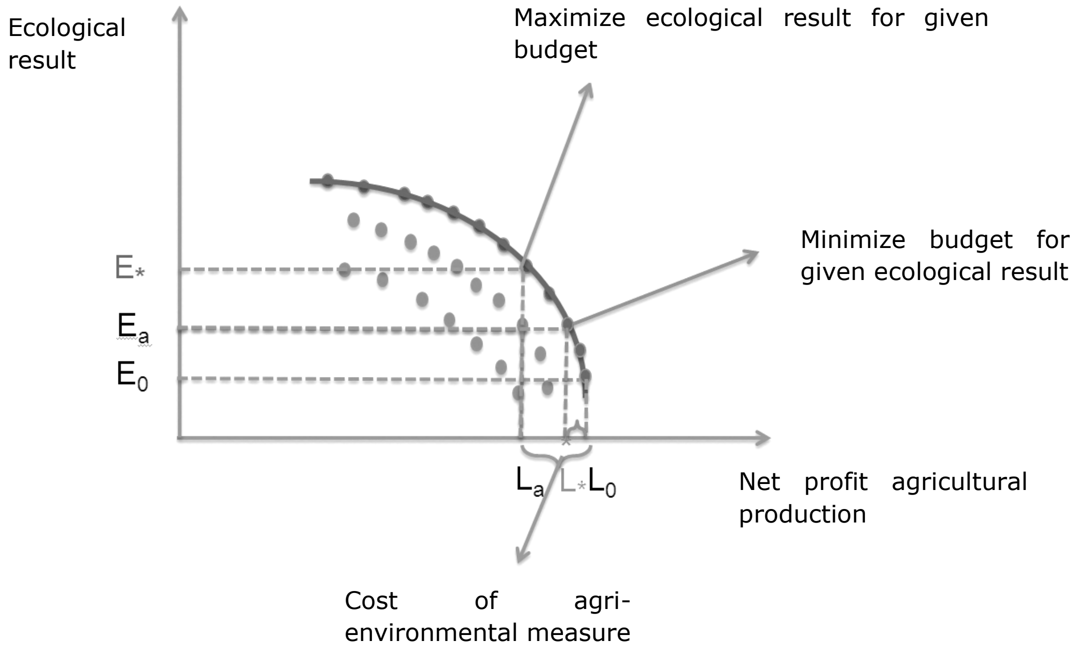
Breeding populations of ‘primary’ meadow birds in Flanders (the waders godwit, redshank, curlew, lapwing and oystercatcher) showed, after a decline in the 20th century, again stable to strong positive trends (Hens 2005). The lapwing remains stable, the godwit and curlew increased by 20-50% and the breeding population of the oystercatcher and the redshank increased by more than 50%. This trend contrasted with the European evolution, where for the wader populations a further downward trend was recorded. The increase of godwit and redshank is the result of a favourable evolution of the coastal polders and of the polders of the Scheldt river. In the Campine region the evolution is negative (Vermeersch *et al.* 2004). The results from Hens (2005) are also in contrast with a local case study by Van Impe (2004) on wader breeding success. Van Impe showed a decreasing breeding success of waders during the latest 20 years, even below the level wich is needed to sustain the population. This indicates that the Flemish population acts like a sink, whereby the state of the plots attracts also birds of neighbouring countries, although the plots can not offer the ecological conditions which the waders offsprings (egg and chicks) need to survive (Steurbaut *et al.* 2005). More recent research suggests again a decrease of the breeding populations of godwit (-22%), curlew (-26%) and lapwing (-28%) between 2007-2010, while oystercatcher (+45%) further increased (Vermeersch & Onkelinck 2011).

INBO developed a scientific map which indicates the main areas of meadowbirds in Flanders. Of these areas in 2005, 8.000 ha were managed as nature reserve, while 43.400 ha were used as farmland (Danckaert *et al.* 2009; Gobin *et al*. 2007). Thus, meadow birds protection is in Flanders to a large extent depending on the voluntarily cooperation of farmers.

Therefore, farmers can voluntarily take up agri-environmental measures to improve survival rates of ‘meadow birds’, as a part of the Flemish Rural Development Program. These management agreements may be effective (Strubbe 2010), but more survey years are required to confirm this. What has not been studied previously is the cost effectiveness of these measures. A measure is cost effective if a specific ecological goal, e.g. a breeding population of a certain size , is achieved at a lower cost than by applying other measures.

1.2 Cost effectiveness

This report examines whether the current measures for ‘meadow birds’ can be optimized. The wader measures are in essence a postphonement of the current agricultural mowing and grazing practice. This postphonement increases the survival of brood and young chicks, so that the meadow bird populations can maintain or expand. However, the postphonement has a negative effect on the economic return for the farmer. Farmers are compensated for this by the government through management agreements. So there is a trade-off between promoting the wader population and agricultural yield. Tradeoff that lends itself to the following optimization questions: "How can we with a certain government budget that is used to compensate farmers for income losses, boost up meadow bird populations in the Northern Campine region?". An alternative question might be: "How can a specific target for meadow bird populations in Flanders reach with a minimum yield losses in agriculture and thus a minimal government budget to compensate farmers?". The figure below shows for different combinations of wader measures the ecological effect (Y-axis) and the agricultural yield (X-axis). If a farmer -from the current agriculture practice- pursues a maximum commercial result, it net benefit amounts L_0 and the ecological result (e.g. survival rate of godwit offspring) equals E_0. When he closes an agri-environmental measure his net benefit drops to L_a and the ecological result increases to E_a. The budget –needed for those agri-environmental measures- is L_a – L_0 as compensation for the loss of agricultural income. The ECOPAY model investigate if alternative agri-environmental measures excist with a higer cost effectiveness (the black curve in the figure). These are measures that have a higher ecological result for the same agricultural loss or have the same ecological result with a smaller agricultural loss. In the first case, the budget stays the same but the survival rate of the offspring increase compared to the existing management agreement (point E *). In the second case, the survival rate stays the same but it is possible to save on the budget (point L *).



1.3 Model description

ECOPAY Flanders is an ecological-economical model which investigates the cost effectiveness of agri-environmental measures. It simulates a rational farmer, who will accept an agri-environmental measure when the net economic result is higher than (or equal to) zero. ECOPAY Flanders is an adaptation of the German model ECOPAY to the Flemish context.

ECOPAY Flanders takes into account the different grassland management systems:

- seasonal grazing: cattle graze in low density during a long period on the grassland,
- rotational grazing: cattle graze in high density during a short period on the grassland and moves then to another grassland,
- mowing: the grass is cut a numbers of time and used as cattle feed. In Flanders the general practice is a four cut system,
- mixed system of mowing and rotational grazing,
- mixed system of mowing and seasonal grazing.

To ensure the model implementation it was needed to assign each pixel (90 x 90 meter) to one of those five grassland management systems. The allocation was done in proportion with the Flemish distribution of those grassland systems, i.e. 10% for mowing, 12,5% for seasonal grazing, 12,5% for rotational grazing, 32,5% for mowing-rotational grazing and 32,5% for mowing-seasonal grazing.

In addition, it takes into account the spatial variability, i.e. potential suitability of a pixel for grassland production and for farmbirds (meadow and cropland birds). For grassland production the soil suitability map is used and for farmbirds the farmbird suitability map. The farmbird suitability map is a newly created map based on the biological value map, the land use map and the agricultural land use map.

ECOPAY Flanders consists of the following components or processes:

- database with the ecological data and requirements of the different meadow bird species (chapter 4), economical data (chapter 2), and large variety of agri-environmental measures (chapter 6)
- economical model (chapter 2 and 3),
- ecological model (chapter 4 and 5),
- simulation and optimalization tool (chapter 7).

ECOPAY Flanders works currently only on a regional scale (e.g. Noorderkempen and Polders) and for meadow birds. It forms a good starting point for downscaling (local scale, 100-5000 ha) or for adding other birds (e.g. croplandbirds). Nevertheless, this will require model adaptations or additions (see chapter 12).

1.4 Selected case studies

The selected case studies are: 'Noorderkempen', 'Polders ' and 'Haspengouw'. The regions consists of the following municipalities:

- 'Polders' (meadowbird case, 60x64 km, 600 x355 raster cells): Knokke-Heist, Brugge, Zuienkerke, De Haan, Gistel, Oostende, Koekelare, Nieuwpoort, Veurne, Lo-Reninge, Jabbeke, Bredene, Oudenburg, Ichtegem, Middelkerke, Diksmuide, Koksijde, De Panne, Vleteren, Alveringem, Blankenberge and Damme
- 'Noorderkempen' (medowbird case, 54 x 32 km, 600 x 355 raster cells), Essen, Kalmthout, Malle, Merksplas, Turnhout, Arendonk, Wuustwezel, Brecht, Rijkevorsel, Hoogstraten, Beerse, Ravels, Retie Oud-Turnhout, and Vosselaar
- 'Haspengouw' (cropland bird case, 73 x 30 km, 810 x 355 raster cells): Lanaken, Riemst, Borgloon, Bilzen, Tongeren, Heers, Sint-Truiden, Gingelom, Landen, Zoutleeuw, Linter, Tienen, Boutersem, en Hoegaarden , Hoesselt

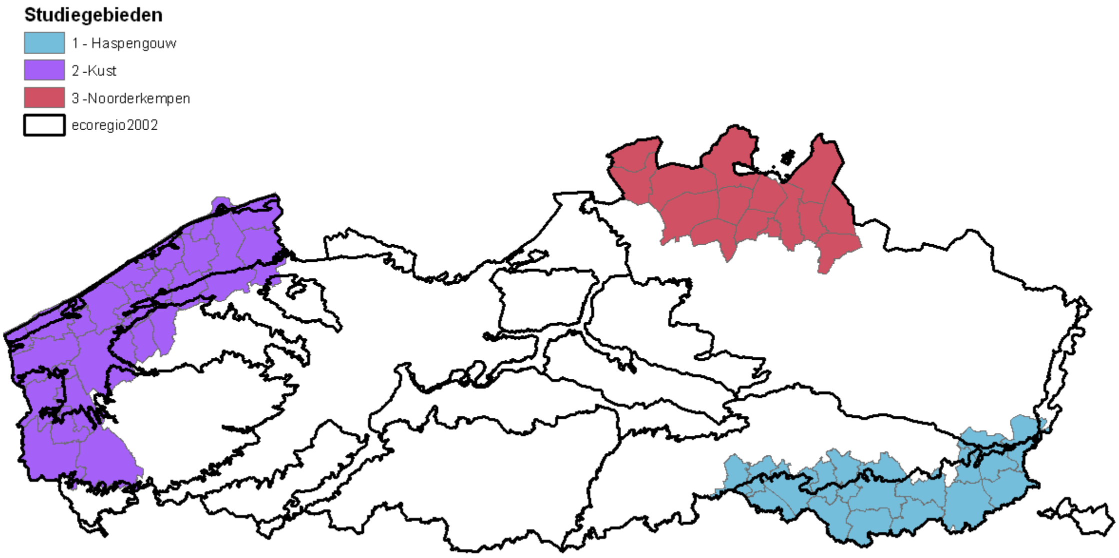


Figure 1.1.Selected case studies

2 Economic model: basic assumptions

J. Aertsens, P. Van Gossum, M. Mewes, A. Sturm, W. Van Reeth, T. Van Daele, C. Wils

2.1 Data collection

Data concerning the impact of the "meadow bird" measures on the loss of agricultural production are based on meetings with several grassland experts: An Schellekens (Hooibeekhoeve); Bert Van Gils (ILVO), Lucien Carlier (ILVO), Eddy Decaesteker (INAGRO); Dirk Reheul (UGENT) and Frank Nevens (VITO). Additionally, related literature was consulted: ASG, (2010); Geypens (S.D); Jacobs et al. (1998); Nevens and Reheul (1998a, b); PR (1986); Ternier et al. (2001); Van der Straeten et al. (2010); Van Huylenbroeck en Jacobs (1998); Verboven and Reheul (2000).

2.2 Economic concerns

2.2.1 Mowing and rotational grazing

The value of the mowed or grassed cut for the cattle is depending on the grass quality and the grass quantity.

<u>Grass quality</u>

Some grass has a higher quality than other. Grass with a low quality may have no more value for the farmers, because it can not more be digested by the livestock. The "meadow bird" measures can strongly influence the quality of the grass, especially when postponing grazing and mowing. There are some quality parameters that can be accounted for in the Ecopay Flanders model: Digestibility which determines the usability and the energy content. We explain them in more detail below.

- *Digestibility*: The older the grass, the less it is digestible. Older grass has a lower protein content (cf. Figure below). When this content is too, low the micro-organisms in the rumen (stomach) of cows will take longer or will not be able to digest it. We use the „digestibility" of the first cut to model the „usability" for an "average Flemish cattle/dairy farm". We assume that while around June 15th (QM 23), the digestibility coefficient is around 67 %, the usability on the average Flemish farm is very strongly reduced (20 %). The reason is that providing badly digestible feed to the cows will/may have negative impact on their productivity (milk/meat). In table 2.1 we have included „usability" for the first cut and in table 2.2 for the intercut period.

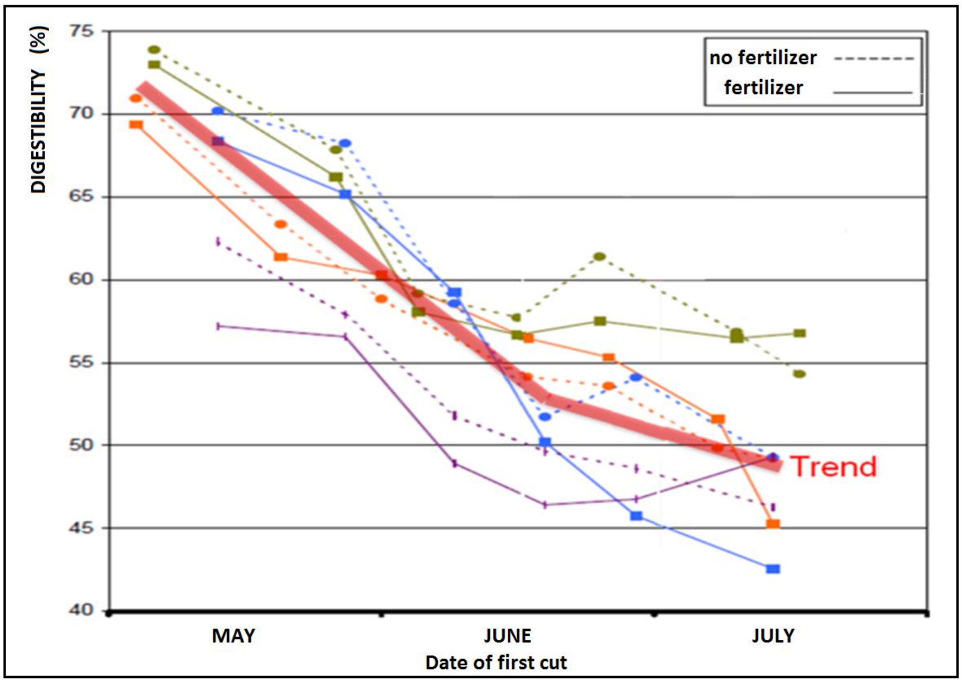


Figure 2.1: Digestibility decreases when the (first) cut is postponed (adapted based on Verboven and Reheul, 2000)

Table 2.1 Influence of increasing delay of the first cut on the grass quality parameters digestibility, energy content and protein usability

quarter_month	Usability	energy_content	Protein usability
MV13	100	1.194	100
MV14	100	1.153	100
MV15	100	1.113	100
MV16	100	1.072	100
MV17	100	1.031	100
MV18	100	991	100
MV19	90	950	100
MV20	80	909	90
MV21	60	869	80
MV22	40	828	70
MV23	20	788	60
MV24	0	747	50
MV25	0	706	40
MV26	0	666	45
MV27	0	625	50
MV28	0	584	50
MV29	0	544	50
MV30	0	503	50
MV31	0	463	50
MV32	0	422	50
MV33	0	381	50

Table 2.2 Influence of increasing intercut period on the grass quality parameters digestibility, energy content and protein usability

cut_interval	Usability	energy_content	Protein usability
4	100	1.031	100
5	100	991	100
6	100	950	100
7	90	909	90
8	80	869	80
9	60	828	70
10	40	788	60
11	20	747	50
12	0	706	40
13	0	666	45
14	0	625	50
15	0	584	50
16	0	544	50
17	0	503	50
18	0	463	50

- *Energy content*: this parameter indicates the energy richness of the grass dry matter. The energy richness or the energy content decreases also by an increasing delay of the first cut (table 2.1) and by an increasing intercut period (table 2.2).
- *Protein usability*: this parameter focus on the difficulty of cattle to extract protein from grass. The protein usability decreases by an increasing delay of the first cut (table 2.1) and by an increasing intercut period (table 2.2). Thus it gets more difficult for the cows to extract proteins.
- *Protein content*: this parameter indicates the protein richness of the grass. The protein richness decreases when less fertilizer has been applied to the meadow (cf. table 2.3) (ASG, 2010; H3: p.20).

Table 2.3 Influence of cut number and of fertilizer amount on the protein content

N fertilizer	protein_first_cut	protein_second_cut	protein_third_cut	protein_fourth_cut
N-0	82	82	81	77
N-10	83	83	82	78
N-20	84	84	83	79
N-30	85	85	84	80
N-40	86	86	85	81
N-50	87	86	85	82
N-60	88	87	86	83
N-70	89	87	87	84
N-80	90	88	88	85
N-90	91	88	88	86
N-100	92	89	89	87
N-110	93	89	89	88
N-120	94	90	90	89

In ECOPAY Flanders, the fertilization amount was made dependent on the time of the first cut and the length of the intercut period, while protein content is determined by fertilization amount. These dependencies make it possible to vary the protein content in the same way as the other grass quality parameters, thus decreasing with increasing delay of the first cut and with increasing intercut period. In addition, in the current model we decided that the farmer can use the low quality grass and therefore only the lost energy needs to be compensated. Nevertheless, this simplification can also be discussed. The low quality grass can sometimes be incoporated in the diet of young or dry standing cows or in the diet of horses. Thus the presence of these animals at the farm determines whether the low quality grass can have a certain value. Thus, it means that only a higher grant will convince some farmers for which the low quality grass has no value. To tackle this concern, information on the farmer possibility to use structure rich grass will be needed. This was not available and therefore it could not be included in the model, yet.

Grass Quantity

The quantity of grass produced is determined by the soil fertility and by the grass management. Other important parameters are:

- The seasonal variability in grass growth.
- Fertilisation: a higher fertilisation results in a higer dry matter quantity (cf. Table 2.4). Farmers need to account of the maximum allowed quantities of fertilisers (see further) and will try to optimise its application based on the moment of the first cut and the intercut period. The optimal amount applied to a cut will be lower when the the first cut is delayed or the intercut period is increased. In this way the farmer anticipates the expected lower grass quality.
- Regrowth delay: The regrowth of mowed grass takes some time. According to ASG (2010) the delay in regrowth can be modelled as being longer when the dry matter quantity of the current cut was bigger and will also increase when the targeted dry matter of the subsequent cut is bigger (cf. Table 2.6).
- Trampling reduction: Grazing causes trampling resulting less useful grass for the cows. Therfore a reduction factor needs to be taken into account.
- Soil fertility: Soil fertility determines the grass growth potential of a meadow (modelled by pixels) (soil suitability map, see economic value of grassland and cropland).

The effect of seasonal variability and the amount of fertilization on the quantities of grass produced are shown in table 2.4 and 2.5. The estimated regrowth delay based on the dry matter quantity of the current and the next cut is given in table 2.6.

Table 2.4 Influence of seasonal variability and fertilization amount (from 0 to 60 kg N) on quantity of grass (kg dry matter/ha)

Quarter month	N-0	N-5	N-10	N-20	N-25	N-30	N-40	N-45	N-50	N-60
MV14	0	0	0	0	0	0	0	0	0	21
MV15	0	20	40	102,5	133,75	165	227,5	258,75	290	329
MV16	461	497	533	583	608	633	680	703,5	727	769
MV17	608	637	666	718	744	770	815,5	838,25	861	901,5
MV18	790	822,5	855	917	948	979	1035	1063	1091	1139
MV19	844	881	918	985	1018,5	1052	1111	1140,5	1170	1221
MV20	675	704,5	734	788	815	842	889	912,5	936	977
MV21	632	659,5	687	737	762	787	832	854	876	914
MV22	632	659,5	687	737	762	787	832	854	876	914
MV23	566	591	616	661	683,5	706	746	765,5	785	819
MV24	566	591	616	661	683,5	706	746	765,5	785	819
MV25	457	477,5	498	534	552	570	602	618	634	662
MV26	457	477,5	498	534	552	570	602	618	634	662
MV27	414	432	450	483	499,5	516	545	559,5	574	599
MV28	414	432	450	483	499,5	516	545	559,5	574	599
MV29	370	386,5	403	432	447	462	487	500	513	536
MV30	370	386,5	403	432	447	462	487	500	513	536
MV31	349	364	379	407	420,5	434	459	471	483	504
MV32	349	364	379	407	420,5	434	459	471	483	504
MV33	327	341	355	381	394	407	430	441,5	453	473
MV34	327	341	355	381	394	407	430	441,5	453	473
MV35	305	318,5	332	356	368	380	401	412	423	441
MV36	305	318,5	332	356	368	380	401	412	423	441
MV37	196	204,5	213	229	236,5	244	258	265	272	284
MV38	196	204,5	213	229	236,5	244	258	265	272	284
MV39	152	159	166	178	184	190	201	206	211	221
MV40	152	159	166	178	184	190	201	206	211	221

Table 2.5 Influence of seasonal variability and fertilization amount (from 65 to 120 kg N) on quantity of grass dry matter

Quarter month	N-65	N-70	N-75	N-80	N-85	N-90	N-100	N-110	N-120
MV14	31,5	42	59,5	77	94,5	112	141	170	194
MV15	348,5	368	377,5	387	396,5	406	422,5	439	453
MV16	790	811	828,75	846,5	864,25	882	910,5	939	961
MV17	921,75	942	959,5	977	994,5	1012	1041	1070	1093
MV18	1163	1187	1207,5	1228	1248,5	1269	1301	1333	1360
MV19	1246,5	1272	1293	1314	1335	1356	1390,5	1425	1453
MV20	997,5	1018	1034,5	1051	1068	1085	1112	1140	1163
MV21	933	952	967,5	983	999	1015	1041	1067	1088
MV22	933	952	967,5	983	999	1015	1041	1067	1088
MV23	836,5	854	868	882	896	910	933	956	975
MV24	836,5	854	868	882	896	910	933	956	975
MV25	675,5	689	700,5	712	723,5	735	754	772	788
MV26	675,5	689	700,5	712	723,5	735	754	772	788
MV27	611,5	624	634	644	654,5	665	682	699	713
MV28	611,5	624	634	644	654,5	665	682	699	713
MV29	547	558	567,5	577	586	595	610	625	638
MV30	547	558	567,5	577	586	595	610	625	638
MV31	514,5	525	534	543	551,5	560	574	588	600
MV32	514,5	525	534	543	551,5	560	574	588	600
MV33	482,5	492	500,5	509	517	525	538	552	563
MV34	482,5	492	500,5	509	517	525	538	552	563
MV35	450,5	460	467,5	475	482,5	490	502	515	525
MV36	450,5	460	467,5	475	482,5	490	502	515	525
MV37	289,5	295	300	305	310	315	323	331	338
MV38	289,5	295	300	305	310	315	323	331	338
MV39	225,5	230	233,5	237	241	245	251	257	263
MV40	225,5	230	233,5	237	241	245	251	257	263

Table 2.6 Modelling the regrowth delay (in days) based on the dry matter of previous and next cut by mowing

		previous cut (kg dry matter/ha)					
		1.000	2.000	3.000	4.000	5.000	6.000
next cut (kg dry matter/ha)	1.000	0	0	2	3	4	5
	2.000	0	0	2	4	6	8
	3.000	0	0	3	6	9	12
	4.000	0	0	4	8	12	16
	5.000	0	0	5	10	15	20
	6.000	0	0	6	12	18	24

Optimal use of N fertilizer

Our starting point is that we deal with rational farmers. For a rational farmer it has no sense to use much N fertilizer when the usability of the cut is low, due to the large delay of the cut. Therefore, the fertilization amount was modelled as dependent on the time of the first cut (cf. table 2.7) and the length of the intercut period (table 2.8). However, N fertilisation can not exceed 380 kg/ha on non-sandy soils, 370 kg/ha on sandy soils and 245 kg/ha in water protection zones. Therefore, a control function has been added to the model. To save computation time we decided also to work only with two N-values (380 and 245 kg/ha.year), because the difference between 370 and 380 is limited. The indication that a parcel (pixel) belongs to a water protection zone was added to the pixel table.

Table 2.7.Optimal use of N fertiliser based on the time of the first cut

quarter_month	N_fertilizer_max
≤MV15	0
MV16	120
MV17	120
MV18	120
MV19	100
MV20	80
≥MV21	0

Table 2.8 Optimal use of N fertiliser based on the intercut periods

cut_interval	N_fertilizer_max
4	120
5	120
6	120
7	100
8	80
9	60
≥10	0

Valuation

In our model we assume that the lost energy in the grass (due to later cuts) will be compensated by the use of concentrated feed. The price of concentred feed on the market depends on the protein/energy ratio (table 2.9). As in the current ECOPAY-Flanders model the lost proteins are not calculated, we decided to use a price of 19,45 €/94.000 VEM.

Table 2.9 The cost of concentrated feed based on their protein/energy ratio

protein_energy_ratio	cost_concentrate_feed
96	19,45
112	20,2
128	21,05
160	23
191	25,45

2.2.2 Seasonal grazing

For this agriculture system the required reference data (see also figure 3.2) are the following

- End of grazing period: 31 October,
- daily energy uptake of a cattle unit: 12.308 VEM/day,

- price of concentrated feed: 19,45 €/ 94.000 VEM (to compensate the lost energy of the agri-environmental measure).

2.2.3 Reference values for energy content

In table 2.10 the available energy for cattle is given for the different grassland systems under optimal economic use. These reference values will be subtracted by the available energy for the agri-environmental measures (AEM) inorder to calculate the energy loss under the AEM which needs to be compensated by buying concentrated feed.

Table 2.10 Reference values of the different grassland uses

Name	energy_matter_ref_380N	energy_matter_ref_245N
mowing_4cut	13.654.465	12.268.913
grazing_rota4	14.138.531	12.609.411
grazing_seas	9.744.000	7.308.000
mowing_pasture_rota3	13.284.544	11.755.424
mowing_pasture_seas	11.680.451	9.144.103

2.2.4 Economic value of grassland and cropland

The economic value of the grassland and cropland is calculated based on the soil suitability map. The soil suitability map is based on the digital soil map and gives an indication of the soil suitability of a parcel for grass and for crops. The soil suitability map is a vector map and needs to be reworked to a raster map. The soil suitability of a 90x90 pixel is modelled as:

> (0,95 x area very suitable within pixel + 0,825 x area suitable + 0,65 x area rather suitable + 0,425 x area less suitable + 0,15 x area not suitable) / (total area within pixel which has a suitability class)

This calculation is done seperatly for grassland and cropland.

2.2.5 Variable and fixed cost data

<u>Costs of fertilisation</u>

A simplification we made is that we did not differentiate between different types of N, i.e. from synthetic fertiliser or from manure (animal excretions). For the economic model we assume that the N fertiliser is immediately available for the grass growth, as if it was available from synthetic fertiliser. In addition, when a farmer uses less synthetic fertilizer it can be seen as an avoided cost (and thus a saving), while the use of less organic fertilizer can be seen as an additional cost for a farmer.

The variable cost for the use of synthetic fertiliser is modelled as dependent on the amount of N, P and K that are used. The total cost of ertiliser = kg N x 1,34 euro/kg N + kg P x 1,081 euro /kg P + kg K x 0,681 euro /kg (Source: Proefcentrum (HBH-AS). These costs are attributed depending on the quantities of N applied. If there is a (reference) situation with a lower limit of N to be applied these costs will be lower (~130 euro/ha). Also depending on the method less N may be applied.

Costs for applying herbicides

Also the costs of the use of herbicides are taken into account. For instance, in the case of an agricultural measure with only 2 cuts, more herbicides will be used (0,75 kg active dose compared to 0,25 kg active dose for 3 cuts) and the costs will be consequently higher.

Variable costs for agricultural machines

The variable costs for the user of agricultural machinery is presented in the table below and based on the following sources:

1. the research institute on agricultural practices (HBH-AS)
2. data from the CRA-W (Centre de Recherche Agronomiqu-Wallone): http://mecacost.cra.wallonie.be/index.php?page=2. On this last site machine costs can be calculated based on some parameters
3. the "Landbouwcentrum voor Voedergewassen": http://www.lcvvzw.be/index.php?m=projecten

Table 2.11 machinery costs

nr	Agricultural measure	Landbouwkundige maatregel	hours per ha	diesel (eur/ha)	maintenance (eur/ha)	other (eur/ha)
1	overseeding	doorzaai	0,9	8,57	12,8	0
2	rolling/crushing	platwalsen	0,4	5,7	4	0
3	overseeding with comb	doorzaai met kam	0,36	3,56	2,98	0
4	applying fertiliser	bemesten	0,11	1,02	0,9	0
5	dragging_9m	slepen	0,3	4,9	4,3	0
6	applying plant protection	plantenbescherming	0,12	1,43	1,92	0
7	mowing	maaien	0,3	4,8	16	0
8	turning the mowed grass	keren	0,3	3,06	5,7	0
9	aligning the mowed grass	op stroken leggen	0,2	2,25	5,3	0
11	pressing bales - 2 tonnes	balen persen - 2 ton	0,48	4,7	7,64	3
12	pressing bales - 3 tonnes	balen persen - 3 ton	0,52	5,14	10,36	4,5
13	pressing bales - 4 tonnes	balen persen - 4 ton	0,63	6,23	13,46	6
14	loading and transporting the bales	laden+transport vd balen	1	19,38	10,1	0
15	transport _ 7 tonnes of harvest	transport opbrengst_7 ton	0,5	8,21	5,3	0
16	transport _ 6 tonnes of harvest	transport opbrengst_6 ton	0,5	8,21	5,1	0
17	transport _ 5 tonnes of harvest	transport opbrengst_5 ton	0,4	6,57	4,12	0
18	transport _ 8 tonnes of harvest	transport opbrengst_8 ton	0,5	8,21	5,5	0
19	transport _ 9 tonnes of harvest	transport opbrengst_9 ton	1	16,42	9,6	0
20	ensilage	inkuilen silage	0,7	11,53	5,5	0
21	secondary mowing to flatten	namaaien	0,5	8,57	8,8	0

3 Economic model: implementation

P. Van Gossum, J. Aertsens, A. Sturm, M. Mewes, W. Van Reeth, T. Van Daele, C. Wils

3.1 The economic models

The economic model ECOPAY-Flanders considers a farmer as a rational actor, which means that a farmer will only join an agri-environmental measure when his/her net economic result will be positive. Thus the agri-environmental grant needs to compensate the net income loss. The net income loss is calculated as the gross income loss, minus the saved variable costs (e.g. due to a lower use of synthetic fertiliser) plus a fixed transaction cost of €50. The model accounts for the suitability for grass cultivation wich may differ from one grass land pixel to another. The gross income loss for mowing and rotational grazing (figure 3.1) is calculated differently than for seasonal grazing (figure 3.2). In addition, there is a small difference in calculation for mowing and rotational grazing. The economic model thus has three variants. The first calculation step is the same in the three models. The applied logic is that the farmer will compensate the lost energy (thus the loss in feeding value) when applying the agri-environmental measure situation, compared to the agriculture reference situation, through the purchase of concentrated feed. The next step, the calculation of the lost energy, differs in the three models.

Figure 3.1 shows how the gross income loss is calculated in the case of mowing and rotational grazing. The energy yield for these grassland systems is calculated as the sum of the energy yields of the different mowing or grazing cuts. In Flanders, in a standard agricultural practice there are four cuts, e.g. QM18 (May 8), QM24 (22 June), QM30 (August 8) and QM36 (October 1). The energy concentration of a cut varies as the first mowing or grazing is delayed (table 2.1), or if the interval between cuts is longer (table 2.2). The same holds for the digestibility (table 2.1 and 2.2). This was already illustrated in figure 2.1.

In addition, the ECOPAY Flanders model includes the following other factors that determine the amount of dry matter:

- Fertilisation: a higer fertilisation leads to a higher dry matter production (table 2.4 and 2.5). A farmer must take into account the maximum legally permitted fertilisation. This amount varies in the ECOPAY model for the water catchments areas (245 kg N/ha per year) and for the other areas (380 kg N/ha per year). The economic model assumes an optimal use of the fertilisation. The farmer will use less fertiliser when the first cut is postphoned (table 2.7) and when the interval between cuts gets longer (table 2.8). In those cases the grass has a lower quality.
- Regrowth delay (when mowing): freshly mowed grass will have a delayed regrowth. The delay is greater when the previous cut was heavier (thus more kg dry matter, table 2.6).
- Trampling mortality (when rotational grazing): grazed grass will be partly trampled and can therefore not be eaten by the cows.

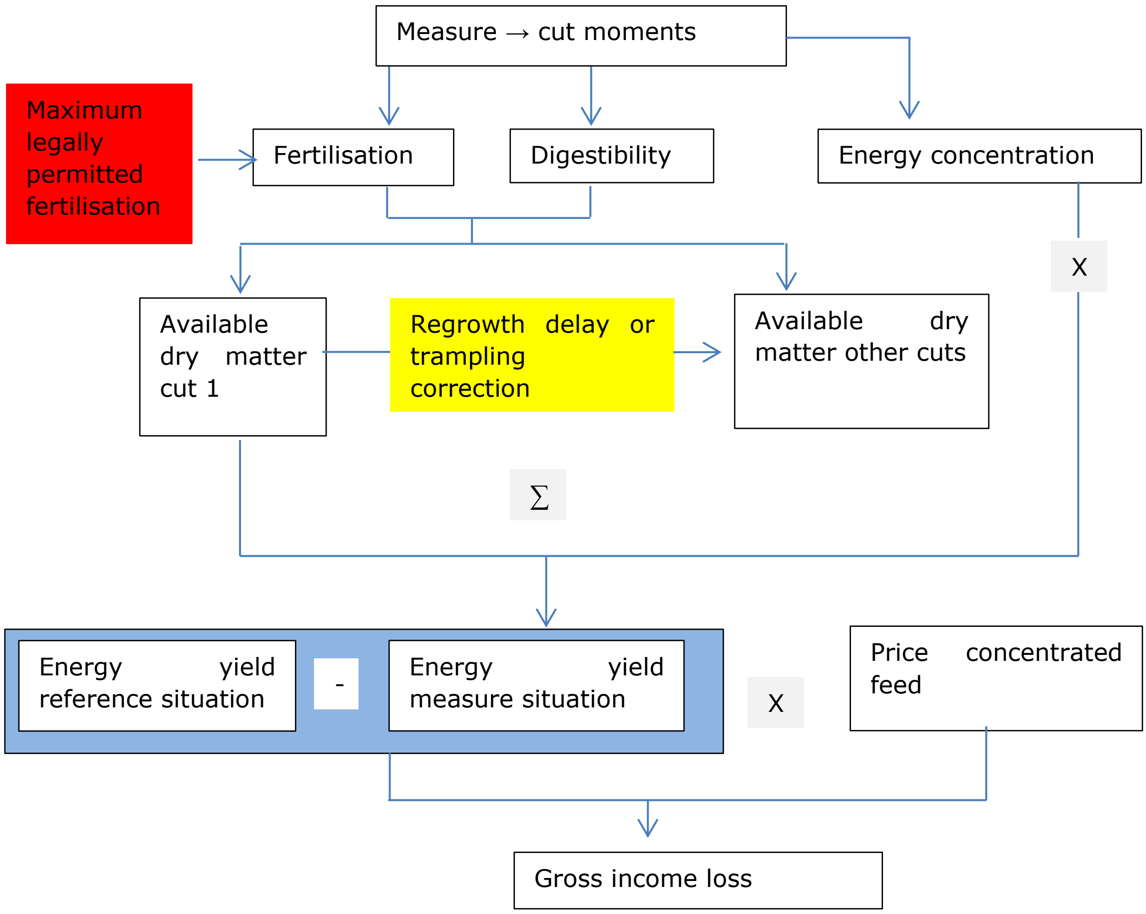


Figure 3.1 Economic model gross income loss for mowing (regrowth delay) and rotational grazing (trampling correction)

Figure 3.2 shows how the gross income loss is calculated in the case of seasonal grazing. The energy yield is calculated as the sum of the uptaken energy by the cows during resting and grazing period. The amount of uptaken energy in one period is calculated as the product of grazing days, cattle density (in cattle units) and the daily uptake by a cattle unit. Nevertheless, the energy uptake can not be bigger than the available energy of the grassland, therefore a control function was added.

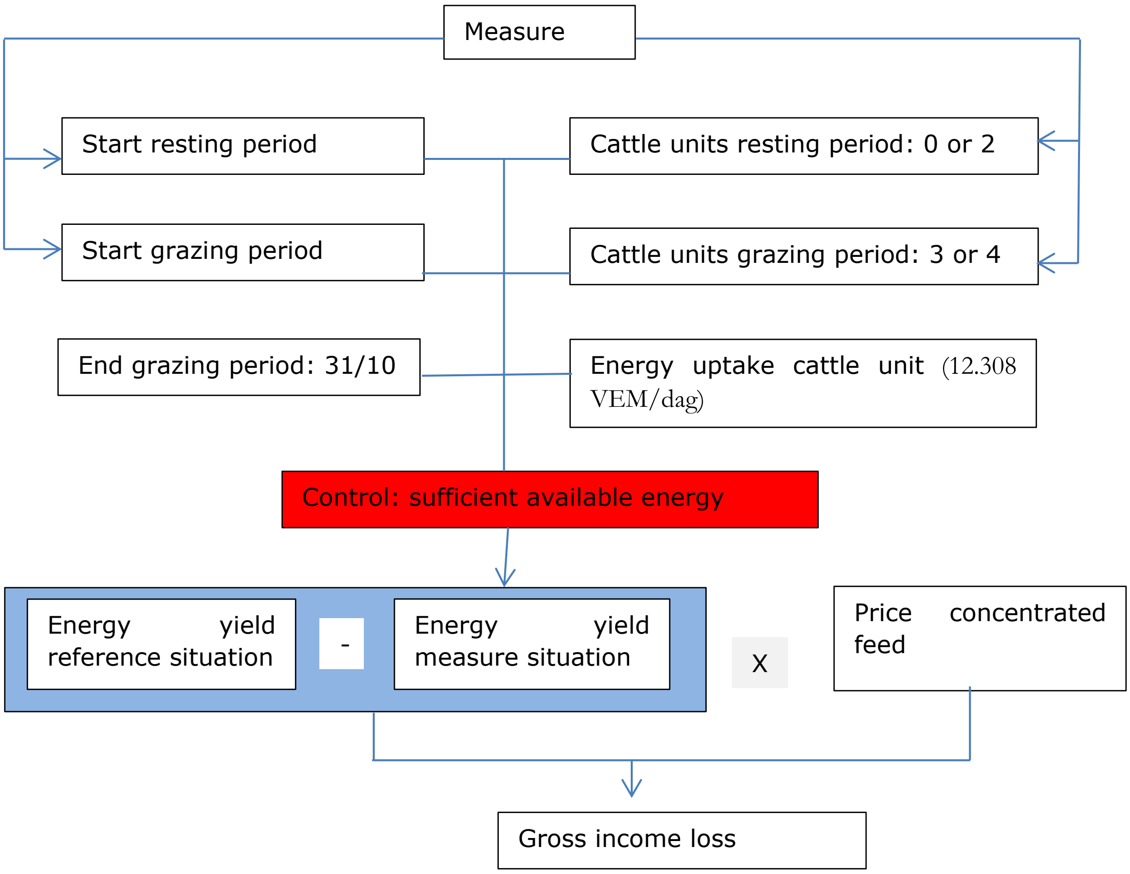


Figure 3.2 Economic model gross income loss for seasonal grazing

In the next paragrahs we will discuss the model inputs and formulas. It is important to emphasize that the chosen options will be always a simplification of the reality. Therefore it is also important to describe how our options differ from the reality.

3.2 Model formulas for mowing and for rotational grazing

3.2.1 Optimal use of N fertilizer

In tables 2.6 and 2.7 the fertilisation amounts are given based on respectively the quarter month of the first cut and the number of quarter months between cuts:

N_n^{opt} = f (MV's) or f (MV_{first})

However, N fertilizer can not exceed 380 kg/ha.year outside water protection zones and 245 in water protection zones. We take this limitation into account in our model by the following control function:

N_n= If $N_n^{opt} \leq N_{tot} - \sum_{w=1}^{n-1} N_w \cdot$ use N_n^{opt} others us $N_{tot} - \sum_{w=1}^{n-1} N_w \cdot$)

Finally, to calculate the variable costs we included an output table which saves for each measure how much fertiliser is left. If lower amounts of fertiliser are used compared to the reference situation, this means that these variable costs will be lower than in the reference situation:

$$N_{left} = N_{tot} - \sum_{w=1}^{n} N_w \cdot$$

3.2.2 Dry matter growth of cut n

The dry matter growth is always calculated for the highest grassland value. To adjust for less suitable grasslands, we assume that multiplying at the end with coefficients for lower grassland_values is sufficient to take into account that less suitable grasslands have a lower dry matter growth and also a lower dry matter growth correction.

The calculation of dry matter is done as follows:

$$DM_n = \sum_{i=startcutn}^{endcutn} QMG^{i}_{\mathrm{Nw}} \cdot w$$

with QMG^{i}_{Nn} the growth in quarter month i based on N_n – fertiliser

These quarter month growths can be found in table 2.4a and 2.4b and start cut and end cut means the interval between two cuts which can be found in the table "Measure" (distance_2use, distance_3use, distance_4use).

It is important to emphasize that when the start cut is 21 and the end cut 27 the quarter month growths of 22, 23, 24, 25, 26 and 27 are summed.

The usable corrected dry matter growth of cut n (DM_{cn}) is calculated as follows:

$DM_{cn} = (C_G \times C_M \times U_n \times DM_n)$

with, DM_n the uncorrected dry matter growth of cut n (see higher),

C_G the correction factor for grazing disturbance,

C_M the correction factor for mowing regrowth delay,

U_n the usability based on the digestibility of the cut

The usability of the first cut depends on the quarter month of the cut. The usability of the following cuts has been modelled as depending on the number of quarter months between cuts (MV's) or: U_n = f (MV's) or f (MV_{first}).

The values can be found in resp. database tables 2.2 and 2.3.

The grazing disturbance correction is calculated as follows: C_G = 0,8 if grazing and C_G = 1 if mowing (no correction needed for mowing), the C_G – value can be found in table "cut_use". This implies that we assume that for rotational grazing the usability of the grass is reduced with 20 % due to the trampling of the grass.

The mowing regrowth delay is calculated as follows:

$C_M = (QM_{days} - GD_{days}) / QM_{days}$ if mowing and C_M = 1 if grazing (thus no delay for grazing) with QM_{days} = 7 x (quarter month start cut n – quarter month end cut n)

and $GD_{days} = f(C_M \times DM_{n-1}; DM_{n,})$.

Thus based on the regrowth delay corrected dry matter of the previous and on the uncorrected dry matter of the current cut. The values are rounded to the nearest 1.000. The GD_{days}-value can be found in the table 2.5. For example, a dry matter growth of 2.500 in the first cut and 2.499 in the second cut gives a GD_{days} = f(3.000,2.000) = 2.

3.2.3 Total and lost energy

The corrected dry matter growths are a starting point for the energy calculations (in VEM). This is done as follows:

$$E_{tot} = \sum_{n=1}^{n=4} \cdot (EC_n \times DM_{cn}) \text{ with } EC_n : \text{energy content of cut n}$$

EC_n = f (MV's) or f (MV_{first})

EC_n : the energy content of the cut is based on the number of quarter months between cuts (MV's) or the quarter month of the first cut; values can be found in resp. database tables 2.2 and 2.3.

The calculation of the lost energy, due to the delay of mowing or rotational grazing of one of the four cuts, is done by the following formula:

$$E_{lost} = E_{ref} - E_{tot}$$

The reference values (E_{ref}) depend on the method and manure status of grassland/cropland (normal or water protection zone with limited quantities of N/ha). The values can be found in the database table "Method".

3.2.4 Compensation cost

We assume that the loss in energy (and proteins) due to the grassland measures will be compensated by feeding additional concentrated feed to the animals. Therefore based on the E_{lost}-values the compensation cost is calculated as follows:

C_i = $E_{lost, i}$ x 19,45 / 94.000

(VEM) x (euro/100 kg) / (VEM/100kg)

With 19,45 € the price for 100 kg concentrated feed

and 94.000 the VEM-energy value of 100 kg concentrated feed.

Finally, the required compensation price for pixel j for the measure i is:

$C_{ij} = C_i \times EVG_j$ with EVG_j the economic value for grassland (see chapter2) for pixel j

3.3 Economic model for seasonal grazing

The model for seasonal grazing calculate the VEM energy value which the cows can eat during the grazing season. It is based on following assumptions:

- A cow eats daily 12.308 VEM
- A quarter month counts 7.5 days
- The grazing season starts in the reference at quarter month 12 and ends at 40

The resulting formula for the energy calculation is:

E_{tot} = (40-QM_{start})*7.5*12.308 * GVE

To avoid non-sense values it is also important to check whether this energy value is realistic based on the estimated dry matter growth. Therefore the following check was included:

$E_{tot} \leq E_{estimated}$

Finally, The calculations for lost energy and compensation costs are done in the same way as the economic model for mowing and rotational grazing.

4 Ecological model: basic assumptions

P. Van Gossum, K. Johst, M. Mewes, A. Sturm, W. Van Reeth, T. Van Daele, O. Dochy, C. Wils

The German ecological model was the starting point of the Flemish model. Therefore it is important to discuss the assumptions behind the German model. The German model takes the following variables into account to calculate the ecological benefit of a measure for a given bird species:

- grass height and the preference of bird species of the different height classes,
- quarter month egg deposit,
- survival rate of the offspring after agricultural measures,
- birds' preference for soil moisture,
- birds' preference for structural elements,
- time independent predation,
- minimal ecological quality and
- ecological effective area.

After discussion with INBO bird specialists (Anny Anselin, Glenn Vermeersch, Robin Guelinckx, Koen De Vos, Geert Spanoghe, Olivier Dochy) the following variables were changed or added:

- birds' preference for structural elements was changed to birds' suitability values,
- time depending predation was added.

The INBO specialists based their expert judgements on the following literature: Verheyen (1944, 1948), Lippens & Wille (1972) and Willems et al. (2008).

In the next paragraphs we will describe the different variables.

4.1 Grass height

4.1.1 Birds' preferences for grass height

The grass height determines the possibility for a bird species to forage and to hide for predators. The preferred grass height can differ for adults (e.g. adults of black tailed godwit prefers short grass to forage) and chickens (e.g. godwit chickens prefer herb rich grass which is used as nesting, hiding and food habitat). Both types need to be available in sufficient quantity at short distance (less than 250 m). The later requirement is difficult to model, without a large increase of the total computing time, because if we like to calculate the ecological effect of a given measure on a given pixel we need to take into account the effect on grass height of all other measures on all pixels within the radius of 250 meter. Therefore we decide to calculate the ecological effect of the measure only on the investigated pixel. This means that we need to estimate birds' preferences for grass height classes, i.e. < 10 cm, 10-30 cm and >30 cm, regardless of the certainty that the other classes are available in the immeditately vicinity of the investigated pixel. The preferences were estimated during a bird experts focus group (Table 4.1). The bird experts give the bird preferences separately for breeding and chicks. A weighted mean value was calculated based on the length of the critical breeding period (breeding) and the non-critical breeding period (chicks)

Table 4.1 Birds' preferences for grass height

Grass height preferences	Black-tailed godwit	Curlew	Garganey	Lapwing	Meadow Pipit	Partridge	Redshank	Skylark	Eurasian oystercatcher	Nothern shoveler	Yellow wagtail	Corn bunting	Yellowhammer
<15	0,3	0,3	0,5	1	1	1	0,3	1	1	0,5	0,2	0,1	0,2
15-30	1	1	0,5	0,5	1	1	1	0,5	0,5	1	0,6	0,6	0,2
>30	0,5	0,5	1	0	0,5	0,5	0,5	0	0	1	0,9	1,0	0,8

4.1.2 Grass height

Mowing and rotational grazing

The calculation of the grass height by mowing and rotational grazing at a given moment is done by following formula:

- $H(t) = b + a (t - t_m)$ with a the grass growth coefficient, b the grass height after mowing or grazing, t the current quarter month and t_m the quarter month in which the latest agricultural use took place

The parameters a en b are in depending in the grassland type and the soil fertility. For the Flemish model we consider only the best land quality to take into account the agricultural improvements which farmers made of land with a former lower quality. The following values for a and b were used:

- a = 4 + c with c a value between 0-1 which is calculated by rolling the dice. Each grass height is calculated 10 times, the different values are added up and divided by ten. This method is used to avoid sodden jumps from one grass height class (short, medium or tall) to another.
- b =5; thus the shortest grass which is possible is 5

Seasonal grazing

The grass height by seasonal grazing is depending on the livestock density. In addition, livestock do not graze uniformly. To take this variation into account a grass height class distribution is estimated by grassland experts. This estimation was done for two livestock densities (0.5 and 4) and linear interpolated for in-between values (see table 4.2).

Table 4.2 The influence of livestock density on the grass height distribution by seasonal grazing

	grass height		
Livestock density	<10	10-30	>30
0,5	0,20	0,35	0,45
2	0,50	0,22	0,28
3	0,70	0,14	0,16
4	0,90	0,05	0,05

4.2 Quarter month egg deposit

The quarter month egg deposit values were estimated by bird experts during a focusgroup and are given in table 4.3.

Table 4.3 Quarter month egg distribution of different farmland birds

quarter month	Black-tailed godwit	Cur-lew	Gar-ganey	Lap-wing	Meadow Pipit	Part-ridge	Red-shank	Sky-lark	Eurasian oyster-catcher	Nothern shoveler	Yellow wagtail	Corn bunting	Yellow-hammer
9				0,05									
10				0,05									
11				0,05									
12	0,05			0,1	0,05								
13	0,15	0,05		0,1	0,05			0,05					0,05
14	0,2	0,15		0,15	0,15	0,05	0,05	0,05	0,05	0,05			0,1
15	0,15	0,2		0,15	0,1	0,05	0,1	0,1	0,15	0,15			0,1
16	0,15	0,4	0,05	0,1	0,05	0,1	0,2	0,15	0,15	0,2	0,1	0,05	0,1
17	0,1	0,15	0,05	0,05	0,05	0,1	0,2	0,1	0,1	0,2	0,15	0,05	0,1
18	0,1	0,05	0,05	0,05	0,1	0,3	0,2	0,05	0,1	0,15	0,25	0,05	0,05
19	0,05		0,2	0,05	0,15	0,3	0,2	0,05	0,1	0,1	0,2	0,15	0,05
20	0,05		0,2	0,05	0,05	0,1	0,05	0,15	0,1	0,05	0,1	0,2	0,1
21			0,2	0,05	0,05			0,1	0,1	0,05	0,1	0,15	0,1
22			0,15		0,05			0,05	0,1	0,05	0,05	0,2	0,1
23			0,05		0,05			0,05	0,05		0,05	0,05	0,05
24			0,05		0,05			0,05				0,05	0,05
25					0,05			0,05				0,05	0,05

4.3 Survival rate of the offspring after agricultural measures

Mowing or rotational grazing

Mowing or rotational grazing survival is different between critical breeding period and the non-crital breeding period. The critical breeding period is the period that the eggs are on the nest and the defenceless nestlings period. The total breeding period includes the period from eggs until fully fledged. We made the assumption that after mowing or rotational grazing in the critical period none of the offspring survived and in the non-critical period 50% survived. In table 4.4 the length of the critical and the total breeding period of different farmland birds are given.

Table 4.4 The length of the critical and the total breeding period (in number of quarter months) of different farmland birds

breeding period	**Black-tailed godwit**	**Cur-lew**	**Gar-ganey**	**Lap-wing**	**Meadow Pipit**	**Part-ridge**	**Red-shank**	**Sky-lark**	**Eurasian oyster-catcher**	**Nothern shoveler**	**Yellow wagtail**	**Corn bunting**	**Yellow-hammer**
critical	5	5	4	4	4	4	5	5	5	4	5	5	4
total	8	8	8	9	4	5	8	6	8	8	6	6	5

Seasonal grazing

Seasonal grazing survival is depending on the livestock type (quiet, wild), bird type (godwit like (black tailed godwit, curlew and Eurasian oystercatcher), redshank, lapwing or other) and livestock density (in livestock units) and can be calculated by following formula:

$S = (1-M_{b,l})$ ^(LU×RP)

with $M_{b,l}$ the bird mortality depending on the bird type and the livestock type (see table 4.5),

LU the number of livestock units/pixel and

RP the length of reproduction period in quarter months

Table 4.5. The influence of bird type and livestock type on the bird mortality

	Lapwing	Redschank	Godwit like	Other
Wild	0.28	0.54	0.55	0.14
Quiet	0.052	0.15	0.09	0.026

4.4 Birds' preference for soil moisture

4.4.1 Soil moisture values

The target is to determine which soil humidity classes appear within the 90 x 90 pixel. The source files is the reworked VITO land use map (see further by birds' suitability values) and the digital soil map. It is important to make a distinction between outside 'polder region' and polder region, because the soil moisture values are different in both regions.

Outside polder region

The method is first a reclassification of the 9 soil humidity classes and 8 complexes to 3 soil humidity classes and 3 complexes (table 4.6). Second, the share of the three soil humidity classes within the 90 x 90 m pixel is calculated (table 4.6). Third, the share values of each soil humidity classes are used to dedice if a soil humidity class is not present, partially present or has a main occurrence (table 4.7)

Table 4.6 Reclassification of soil moisture classes of the soil map to ECOPAY soil moisture classes

Soil moisture class (soil map)	New class	Dry	Wet	Fresh
A	Dry	1	0	0
B	Dry	1	0	0
C	Fresh	0	0	1
D	Fresh	0	0	1
E	Wet	0	1	0
F	Wet	0	1	0
G	Wet	0	1	0
H	Wet	0	1	0
I	Wet	0	1	0
A (complex a+b+c+d)	Dry-fresh (50% of each class)	0,5	0	0,5
B (complex a+b)	Dry	1	0	0
D (complex c+d)	Fresh	0	0	1
E (complex d+e)	Fresh-Wet (50% of each class)	0	0,5	0,5
F (complex e+f)	Wet	0	1	0
G (complex f+g)	Wet	0	1	0
H (complex g+h)	Wet	0	1	0
I (complex h+i)	Wet	0	1	0

Table 4.7 Calculation of ECOPAY soil moisture occurences

Share of a specific ECOPAY soil moisture class	ECOPAY-value	Legend
<10%	0	Not present
10-70%	0,5	Partially
>70%	1	Main occurence

Polders

In the 'Polders' a reclassification of the soil code to a comparable soil moisture class of the soil map is needed (Table 4.8). When the soil moisture class is known the same method as by 'outside polder region' is followed.

Table 4.8 Reclassification of the 'polders' soil code to comparable soil moisture classes of the soil map

Soil code Polders	Comparable soil moisture class (soil map)
d.A0	A
d.B1	A
d.B2	C
d.B3	D
d.C1	B
d.C2	C
d.C3	D
d.Da	D
d.Db	D
m.A0	B
m.A1	B
m.A2	C
m.A3	D
m.A4	D
m.A4l	D
m.A5	D
m.A5l	D
m.A6	E
m.Ab1	E
m.B1	E
m.B2	E
m.B3	F
m.B4	G
m.Bk1	E
m.Bk2	F
m.Bk3	F
m.C1	D
m.C2	E
m.C3	D
m.D1	B
m.D2	C
m.D3	D
m.D4	D
m.D4l	D
m.D5	D
m.D5l	D
m.Dfl	E
m.Dk4	D
m.Dk5	D
m.Dk6	D
m.Dl2	D
m.Dl3	D
m.Dl4	D
m.Dl5	D
m.Dl6	D
m.E1	D
m.E1l	D
m.F1	E
m.F2	E

m.Fc1	F
m.Fc2	F
m.Fc3	F
m.Fk1	E
m.Fk1d	E
m.Fk2	E
m.Fk3	E
m.Fk3d	E
m.Fk4	E
m.Fl1	E
m.Fl1d	E
m.Fl2	E
m.Fl3	E
m.Fl3d	E
m.Fl4	E
m.G1	E
m.G2	E
m.G3	F
m.M1	E
m.M2	F
m.M3	F
m.W1	D
m.W2	E
m.W2k	D
m.W2z	D
n.A1	B
n.A1h	B
n.A2	B
n.A2k	B
n.A2z	B
n.B1	D
n.B2	D
n.B3	D
n.G1	E
n.G1z	E
n.G2	E
n.G3	F
n.K1	E
n.K1a	D
n.K1l	D
n.K2	E
n.K2a	D
n.K3	D
n.K3z	D
r.El	D
r.Elz	D
r.Em	E
r.Emz	E
r.En	E

r.Pl	D
r.Pm	E
r.Pn	E
r.sEl	D
r.Sl	D
r.Sly	D
r.Sm	D
r.Smy	D
r.sPl	D
r.sPm	E
r.uPl	D
r.uPm	E
r.uSl	D
r.uSm	D
z.Ba	D
z.Bb1	D
z.Bb1k	D
z.Bb2	D
z.Bb2k	D
z.Bb3	E
z.Bb3k	E
z.Bc0	E
z.Bc1	E
z.Bc1k	E
z.Bc2	E
z.Bc3	E
z.H1	C
z.H2	E
z.Kv	E
z.Lk2	E
z.Lk4	E
z.Lk4v	E
OA	d/e
OC	D
OD	D
OE1	D
OE2	E
OG1	E
OG2	e/f
OL	d/e
ON	D
OO	D
OO1	D
OO2	D
OO3	D
OO4	D
OT	D
OV1	E
OV2	e/f
OZ	d/e

4.4.2 Bird preferences

The birds' preferences for soil moisture (dry, fresh, wet) were estimated by ecological experts and are given in table 4.9.

Table 4.9 Birds' preferences for the different ECOPAY soil moisture classes

soil moisture	Blacktailed godwit	Curlew	Garganey	Lapwing	Meadow Pipit	Partridge	Redshank	Skylark	Eurasian oyster-catcher	Nothern shoveler	Yellow wagtail	Corn bunting	Yellow-hammer
Dry	0	0,5	0	0,5	1	1	0	1	0,5	0	0,5	1	1
Fresh	1	0,5	0,5	0,5	0,5	1	1	0,5	0,5	0,5	1	0,5	1
Wet	1	0,5	1	1	0,5	0	1	0	1	1	1	0	0

4.5 Farmbirds' suitability values

In the German model this value indicates the birds' preferences for structural elements (water, forest and settlements). In the Flemish model we changed the structural element part to farmbirds' suitability values based on land use (cropland, grassland, cropland with naturemanagement, grassland with nature management, water, forest settlement and 'neutral' land use), the Biological Value Map (ecological grassland types) and the agricultural land use registration map (crop types). The Flemish bird suitability values are:

- WES which is a suitability value for ducks and wader birds like black-tailed godwit, curlew, garganey, lapwing, redshank, Eurasian oystercatcher and northern shoveler
- WOLA which is a suitability value for open landscape meadow and crop birds (which are no ducks or wader birds) like meadow pipet, corn bunting, yellow wagtail and skylark
- WKLA which is a suitability value for small-scale landscape birds like partridge and yellowhammer

The farmbirds' suitability values are calculated differently for grassland, crops and other land use. Therefore the first step is to determine the land use and the second step is the calculation of the suitability values. In the following sections we will describe this calculation.

4.5.1 Land use

The target is to compile a land use map which contains the required land use categories for the ECOPAY model. The following Flemish geodata was used:

- VITO land use map (15x15 m),
- Map with forests and build up area in military domains, and
- Map of cropland reserves.

The VITO land use map categorie 'Military facilities' was refined to 'forest', 'settlement' and 'military land use' (like military airports with a mix of grasslands and airfield runways). Another refining was needed for the cropland with nature targets. This VITO categorie was refined to 'cropland with nature targets' and 'cropland with nature management', i.e. the cropland reserves. For the investigated regions (Haspengouw, Polders and Noorderkempen) only minor changes where needed. After the refinement a reclassification of 34 categories to the 7 ECOPAY categories was done (table 4.10). This reworked 15 x 15 m land use map was used to upscale to the required 90x90 m. The upscaling was done based on the majority rule.

Table 4.10 Reclass land use map

VITO land use class	Code	Reworked VITO land use map	ECOPAY land use class	Code
Unknown	0	Unknown	Neutral	0
Residential/commercial buildings	1	Residential/commercial buildings	Settlement	2
Agricultural buildings	2	Agricultural buildings	Settlement	2
Industry	3	Industry	Settlement	2
Sea harbour	4	Sea harbor	Settlement	2
Airport	5	Airport	Settlement	2
Grassland with nature management	6	Grassland with nature management	Grassland with nature management	4
Production grassland with nature and environmental targets	7	Production grassland with nature and environmental targets	Grassland	3
Production grassland	8	Production grassland	Grassland	3
Cropland with nature targets (not cropland bird reserve)	9	Cropland with nature targets (not cropland bird reserve)	Cropland	5
Cropland with environmental targets	10	Cropland with environmental targets	Cropland	5
Cropland	11	Cropland	Cropland	5
Forest with nature manegement	12	Forest with nature manegement	Forest	1
Forest with forest management	13	Forest with forest management	Forest	1
Swamp with nature management	14	Swamp with nature management	Neutral	0
Heathland with nature management	15	Heathland with nature management	Neutral	0
Coastal dune with nature management	16	Coastal dune with nature management	Neutral	0
Mudflats and saltmarshes	17	Mudflats and saltmarshes	Neutral	0
Recreation and sport areas	18	Recreation and sport infrastructure	Settlement	2
Park	19	Park	Forest	1
Military facilities	20	Militair voorziening	Neutral	0
Infrastructuur	21	Infrastructuur	Settlement	2
Water	22	Water	Water	
Not-registred agriculture - grassland	23	Not-registred agriculture - grassland	Neutral	0
Not-registred agriculture - cropland	24	Not-registred agriculture - cropland	Neutral	0
Embankment, dikes and dunes	25	Embankment, dikes and dunes	Neutral	0
Swamp without nature management	26	Swamp without nature management	Neutral	0
Heathland without nature management	27	Heathland without nature management	Neutral	0
Grooves and elevated areas	28	Grooves and elevated areas	Neutral	0
Residential expension areas without buildings	29	Residential expension areas without buildings	Neutral	0
Coastal dune without nature management	30	Coastal dune without nature management	Neutral	0
Not mapped	31	Not mapped	Neutral	0
Dump	32	Dump	Neutral	0
Slag-heap (terril)	33	Slag-heap	Neutral	0
-	34	Copland with nature management	Cropland with nature management	6

4.5.2 Suitability values

Grassland

The farmbirds' suitability values are based on the share of the grassland types of the biological value map (BWK version 2). For grassland complexes which consist of more types, only the most abundant type (EENH1) is taken into account. In Table 4.11 the suitability values of the different types are given. The values are expert judgements of bird experts.

Table 4.11 The suitability of the BWK-grass types for farmland bird types (WES – ducks and waders; WOLA – open landscape meadow and cropland birds (excluding ducks or wader birds); WKLA – small-scale landscape cropland birds)

BWK-type	WES	WOLA	WKLA
Hp	0,2	0,2	0,2
Hx	-0,5	-0,5	-0,5
Hp+	0,7	0,7	0,7
Hpr	0,7	0,7	0,7
Hr	0,7	0,7	0,7
Hc-	1	1	1
Hu-	1	1	1
Ha-	1	1	1
Hj-	1	1	1
Hc	1	1	1
Hu	1	1	1
Ha	1	1	1
Hj	1	1	1
Hc+	1	1	1
Hu+	1	1	1
Ha+	1	1	1
Hj+	1	1	1
Da-	1	1	1
Da	1	1	1
Da+	1	1	1
Hm	0	0	0
Hk	0	1	1
Hn	0	0	0
Other grassland	0	0	0

Crops (including fruit trees and temporarily grassland)

The farmbirds' suitability values are based on the most abundant crop group of a given year within a pixel. The crops are found in the agricultural registration maps (EPR). The crop groups are:

- spring grain: spring wheat, malting barley, spring barley, spring oats and summer rye,
- winter grain: oats, tricale, spelt grain, winter rye, winter barley, winter wheat and other grain,
- maize: maize and grain corn,
- (fruit) trees: apple, pear, cherry, plum, nut, other perennial fruits, hop, agroforestry, afforestations, nurseries, ornamental trees and shrubs and Christmas trees,
- temporarily grassland,
- root crops: fodder beet, sugar beet, onion, potato, carrot, rutabaga, celeriac, chicory root, common chicory and beetroot,
- early root crops: early onion, early poyato and earl carrot,
- set aside: spontaneous cover and not seeded cropland,
- constructions: sheds and buildings, other buildings, mushrooms (warehouse) and grape (greenhouse)
- rape: winter rape and summer rape,
- other.

The suitability values of the crop groups are given in Table 4.12.

Table 4.12 The suitability of crop types for farmland bird types (WES – ducks and waders; WOLA – open landscape meadow and cropland birds (excluding ducks or wader birds); WKLA – small-scale landscape cropland birds)

Crop group	WES	WOLA	WKLA
Spring grain	0,2	0,8	0,8
Wintergrain	0	0,4	0,4
Maize	0.2	0,1	0,1
Fruit trees	-1	-0,5	0
Trees	-1	-0,5	0
Temporaly grassland	-0,5	-0,5	-0,5
Root crops	0	0,4	0,4
Early root crops	0	0	0
Set aside	0,5	1	1
Constructions	-1	-1	-0,5
Hop	-1	-0,5	0
Rape	0	0,7	0,7
Grassland with trees	-0,6	-0,6	-0,3
Big hedgerows	-0,4	-0,4	0,4
Other	0	0	0

Other land use

The farmbirds' suitability values for other land use are given in table 4.13.

Table 4.13 The suitability of other land use for farmland bird types (WES – ducks and waders; WOLA – open landscape meadow and cropland birds (excluding ducks or wader birds); WKLA – small-scale landscape cropland birds)

Land Use	WES	WOLA	WKLA
Forest	-1	-1	-0,5
Settlement	-1	-1	-0,5
Nature	0	0	0
Water	0,2	0	0

4.6 Predation

In several places in Europe (Engeland, Germany and the Netherlands) researchers found that predation on waders (e.g. godwit, curlew, redshank, lapwing and oystercatcher) has increased from the last decades of the last century. Predation is an important cause of loss of waders nests and chicks (Oosterveld 2011). This increases is related to the recovery of a number of predators in the current agricultural landschape, such as fox, buzzard, hawk, black crow, blue heron and stork, in interaction with various other developments. These developments are (Oosterveld 2011):

- a decrease in raptor persecution,
- the control of one predator often leads to an increase of another predator, e.g. hunting of the fox results of an increase or ermine. Ermines are a prey of the fox;
- some predators such as the fox adapt increasingly to the current landscape in which their number and range increase;
- intensification of land use:
  - a decrease of wader densities means that the effect of predation on the remaining population becomes larger. In addition, it also reduce the chance of survival because meadow birds that occur in higher densities are better able to ward off predators. Nevetheless, higher densities can also be negative if the meadow bird area is a restricted area which is unclosed by inapprpiate meadow bird habitat. In such cases, there is an ecological tap because higher densities attract predators;
  - the earlier mowing and grazing reduces the meadow bird season for oviposition, hatching and maturation of chicks. Therefore, there is a lower probability of a replacement clutch;

    - the earlier mowing result in a loss of coverage ad therefore in a greater likelihood of predation;
    - due to a decrease in crop diversity and a higher crop density the availability and accessibility of food for chicks is detoriated and the consequence of this is a higher predation risk;
    - the presence of ascending elements such as bushes and trees leads to reduction of suitable nesting habitat for waders who shun these elements. This has to do with the fact that the upright elements attract predators;
- the increased incidence of milder winters may lead to a higher survival of (semi)sedentary predators such as blue herons and crows.

In the Netherlands, fox, ermine and black crows are the main nest predator. Blue heron, small mustelids (ermine, weasel, polecat) and buzzard and possible carrion crow and fox are the main chick predators (Teunissen *et al.* 2005; Oosterveld 2011). It was lso observed that predation has a time dependent effect, i.e. predation increases from April to June (Teunissen *et al*. 2005). This later effect makes that early breeding will result in a higher egg and chicken survival.

Considering the importance of this parameter, predation was included in the ECOPAY Flanders model. The default value for predation is 0, because there are no estimates for predation values in Flanders. Nevertheless, it is possible to do scenario analysis by including predation values. The predation values can vary among the bird species. Dutch evidence shows that predation can have a high impact on meadow bird survival. Therefore, this option is important. In addition, it is possible in the model to choose between time dependent and time independent predation. For the time dependent predation the following table quarter_month_predation (table 4.14) was added in the database. The current table used an estimate of 50% egg and chicken predation. This relatively high value was chosen because it occurs in some areas in the Netherlands (Teunissen *et al.* 2005).

Table 4.14 Time dependent predation for different farmland birds (with chosen medium value of 50%)

quarter month	Black-tailed godwit	Curlew	Garganey	Lapwing	Meadow Pipit	Partridge	Red-shank	Skylark	Eurasian oystercatcher	Nothern shoveler	Yellow wagtail	Corn bunting	Yellowhammer
MV9				0,45									
MV10				0,45									
MV11				0,46									
MV12	0,44			0,47	0,34								
MV13	0,45	0,42		0,48	0,36			0,36					0,36
MV14	0,47	0,44		0,50	0,37	0,37	0,40	0,37	0,37	0,40			0,37
MV15	0,50	0,46		0,53	0,39	0,39	0,43	0,39	0,39	0,43			0,39
MV16	0,54	0,50	0,36	0,57	0,42	0,42	0,46	0,42	0,42	0,46	0,42	0,36	0,42
MV17	0,59	0,54	0,39	0,62	0,46	0,46	0,50	0,46	0,46	0,50	0,46	0,39	0,46
MV18	0,64	0,59	0,42	0,68	0,50	0,50	0,54	0,50	0,50	0,54	0,50	0,42	0,50
MV19	0,69		0,46	0,74	0,54	0,54	0,59	0,54	0,54	0,59	0,54	0,46	0,54
MV20	0,75		0,50	0,80	0,59	0,59	0,64	0,59	0,59	0,64	0,59	0,50	0,59
MV21			0,53	0,84	0,62			0,62	0,62	0,67	0,62	0,53	0,62
MV22			0,54		0,64			0,64	0,64	0,69	0,64	0,54	0,64
MV23			0,55		0,65			0,65	0,65		0,65	0,55	0,65
MV24			0,55		0,65			0,65				0,55	0,65
MV25					0,65			0,65				0,55	0,65

4.7 Minimal ecological quality

The minimal ecological quality indicates the necessary value which is minimal needed at a pixel for a specific meadow bird species to breed successfully. In the model it is possible to give for each bird species a different minimal ecological quality. This value is for most bird species absent. Therefore, this value was estimated by bird experts. The default value is 0,12. Nevertheless, for godwit it was possible to estimate this value more exactly based on the following ecological requirements:

- The basis standard not mowed grassland is for a godwit nesting pair is at least 0,7 à 1,4 ha (Schekkerman *et al.* 1998; 2005; 2008; Schekkerman & Müskens 2000; Teunissen & Willems 2004). This not mowed grassland need to be located at short distance, some godwit chicks move less than 250 m. A not met standard means that the bird chicks will be threatened in their survival because the adult birds do not find enough food to feed their chicks. There was opted for the lower limit of 0,7 ha because ECOPAY Flanders already take into account that more acres unmown grass are necessary when the grass quality is low for the selcted bird species. For example, the maximal ecologal value of a rye-grass grassland for meadow birds is 0,2, with 0 being completely unsuitable and 1 being entirely suitable.
- The basic standard for good meadow bird landscape for godwith is an occurance of 20 nesting pairs per 100 ha interconnected grassland (Laporte & De Graaff 2006). A not met standard means that the survival of the population is at risk.

This means that the minimal ecological quality of a pixel should amount at least 0,147. This was calculated as following: 21 nesting pairs/100 ha * 0,7 ha/nesting pairs = 0.147.

In addition it was assumed that the godwit value could also be used for other waders (lapwing, oystercatcher, redshank, curlew).

4.8 Ecologically effective area

The ecologically effective area is the sum of all pixels with a ecological quality $q_j^{l,m}$ of at least the minimal ecological quality and when it can be reached by an individual of the considered bird species. This it considers that a measure on a pixel is only useful for species conservation when the species can actually reach this pixel i.e. when a distribution pixel (at which the species occurs) is within a given dispersal radius around the considered pixel. We have set this radius to infinity for the birds assuming that all grid pixels can be reached by birds within reasonable time. In addition, it is also only useful from a given minimal quality. In Flanders this minimum was set on 0,147 and it was based on literature findings for the Black tailed godwit, i.e. at least more than 20 individuals on 100 ha (Laporte & de Graaff, 2006) and at least 0,7 unmowed grassland for each individual (Schekkerman et al. 1998, 2005, 2008, Schekkerman & Müskens 2000, Teunissen & Willems, 2004).

4.9 Birds‘policy data

In Flanders, it is only possible to implement meadow bird measures in certain policy defined locations (meadow bird policy areas). The same is valid for cropland birds (cropland bird core areas and activated cropland bird searching areas). The default value in the model is that it is possible in the whole investigated region. Nevertheless, the option exist to reduce the possible locations to the policy defined locations. In addition, we included in the model some additional options. It is possible to include the nature extension zones (currently not possible to join agri-environmental measures) or to extend the meadow bird policy area to the meadow bird scientific area.

The source maps of these data were the map of the nature extension zones, the meadow policy map, the meadow scientific map and the cropland bird map.

The method to get an aggregate map for meadow birds was an union of the policy and scientic map (in both maps there are pixels which not belong tot he other map). This aggregated map was used to give all pixels of a region an unique value based on the majority rule (table 4.15).

Table 4.15 Policy data on meadow bird protection

Policy status	Meadow birds
1	Occur on policy map and not on the nature extension zones map
2	Occur on scientific map, but neither on the policy map nor the nature extension zone map
3	Occur on nature extension zone map and on the aggregated meadow bird map
0	Registred agriculture outside agggregated meadow bird map

The method for the cropland birds is a reclassification of the cropland bird map (table 4.16) and given an unique value based on the majority rule (table 4.17).

Table 4.16 Reclassification of cropland bird map

Cropland bird map	ECOPAY cropland bird map
Priority core	Core
Core15000ha	Core
Core25000ha	Core
Search area	Search area

Table 4.17 Policy data on cropland bird protection

Policy status	Cropland birds
1	Cropland bird core area
2	Cropland bird search area
3	Nature extension zone (around cropland bird reserves)
0	Registreted agriculture outside copland bird areas

5 Ecological model: implementation

P. Van Gossum, K. Johst, M. Mewes, A. Sturm, W. Van Reeth, T. Van Daele, O. Dochy, C. Wils

The ecological model of ECOPAY Flanders estimated the ecologically effective area for a given bird species after implementation of the agri-environmental measure. This ecological model slightly differs for mowing/ rotational grazing and seasonal grazing. The ecologically effective area is the sum of all pixels with an ecological value of at least the minimal ecological value. This minimal ecological value is based on the literature and indicates the minimal value which is needed for a succesfull breeding of the investigated meadow bird species. The ecological value of a pixel is calculated as the product of:

- the time independent habitat quality, i.e. the soil moisture preferences and the land use preferences of the investiged meadow bird species and the time independent predation (which this type of predation is chosen),
- the time dependent habitat quality, i.e. the sum of habitat suitability of a grassland pixel for a given meadow bird species for a specific quarter month during the period March-November

The calculation of the habitat suitability of a grassland pixel for a specific quarter month slightly differs between mowing/rotational grazing and seasonal grazing. In both cases it is the product of:

- the estimated share of eggs for this specific quarter month,
- the time dependent predation (when this type of predation is chosen),
- species specific suitable grass height, i.e. the degree that the different grass heigt classes in the pixel are preferred by the investigated meadow bird specie
- the survival rate of the meadow bird specie after implementing of an agriculture practice:
    - seasonal grazing: the trampling survival chance is lower when the cattle density is higher and when cattle type is young cows. Young cows move more than adult cows and therefore the trampling chance of meadow bird eggs and chicks is higher.
    - rotational grazing/mowing: the mowing survival rate is lowest when the mowing or rotational grazing activity takes place during the critical breeding period and highest when it take place outside breeding period. The critical breeding period is the egg and not mobile chicken period.

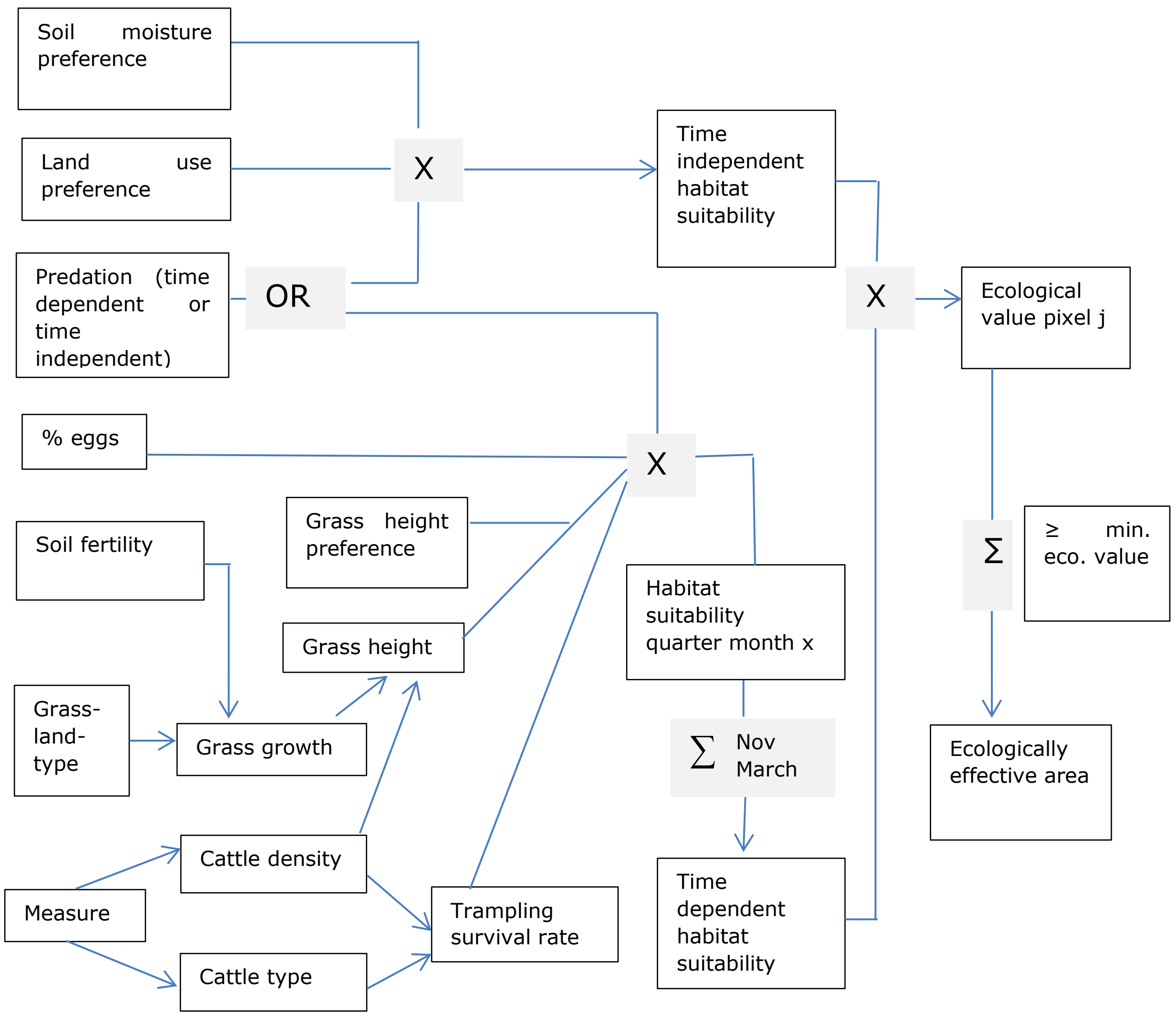


Figure 5.1 Ecologic model for seasonal grazing ECOPAY Flanders

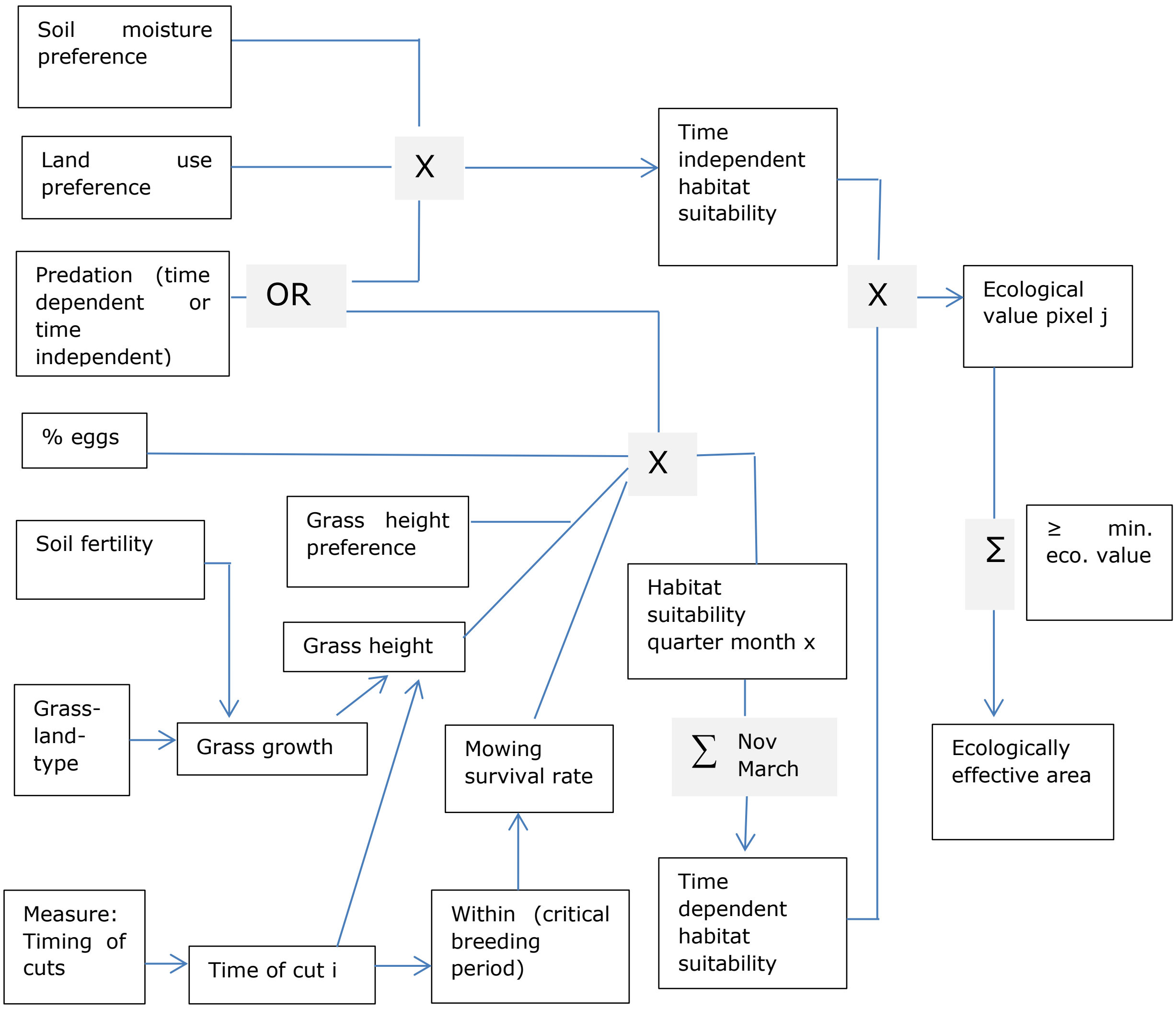


Figure 5.2 Ecological model for rotational grazing and mowing ECOPAY Flanders

6 Measures

W. Van Reeth, P. Van Gossum, J. Aertsens, M. Mewes

6.1 Introduction

The German database of the Ecopay software contains a set of altogether more than 400 different grazing and mowing regimes as possible biodiversity-enhancing land use measures for meadow birds, butterflies or grassland habitats. This chapter lists the measures that are suggested for two case studies 'meadow bird management' ('Noorderkempen' and 'Kust') and one case cropland bird management ('Haspengouw'). These measures potentially qualify as cost-effective and/or effective conservation options or as being part of a combination of measures which together provide a cost-effective or effective design option. The measures that are currently subsidized in Flanders are marked with 'SAS'. In addition to these measures, variants are included in the modelling exercise to gauge their potential for improving the cost-effectiveness of this policy programme. Measures that are only applied within nature reserves are not yet included in ECOPAY Flanders.

6.2 General characteristics of land use measures in grasslands

In table 6.1 the possible agronomic variables which could be considered to adapt to improve meadow bird populations are given.

Table 6.1 Types of land use measures considered

	Reference	Description of change	Parameter
Rolling/drag/harrow	Yes	Noncritical before breeding Permitted until end of March	-
Water logging	No	No change is considered	-
Pesticides	Yes	Considered per land use practice	-
Plough in of sward	Yes	Depending on the site	-
New sowing	Yes	No change is considered	-
P/K-fertilization	Yes	No change is considered	-
Nitrogen fertilization	Yes	No change is considered	Standard fertilizer
Mowing regime	5-cuts	1, 2 or 3 cuts during QM 13-32; 2 cuts more after QM 32	Time of mowing 1st, 2nd & 3rd cut Frequency Standard fertilization Conversion from cropland (Y/N)
Grazing	Assumptions necessary concerning vegetation structure as well as trampling		
Seasonal grazing ('standweiden')	Yes	Extensive use, standard fertilization	Start of grazing Stocking rate 1,5, 3 or 4 GV/ha (*) Type of livestock (lively/quiet)
Rotational grazing ('omweiden')	Yes	Similar to mowing: short grazing time (1 QM), long rest-period of an area	Start of grazing Frequency
Mowing/pasture combination	Yes	After mowing, use meadow as pasture (in Germany: seasonal grazing)	Time of mowing Start of grazing Stocking rate Type of livestock
Aftermath	Partly	No change is considered	

(*) The stocking rate depends on the fertility of the site. In Germany, the standard period for seasonal grazing is considered to be April 1 – October 1.

(**) Aftermath involves the mowing of the pasture after the grazing period, mainly in order to clear the grass of weeds and distribute the faeces.

In future research the range of considered measures could be extended. Possible avenues include extensive year-round grazing, reduced or zero fertilization and/or management of the water level to attract more sensitive meadow bird species like Common snipe and Ruff. As such measures are far from standard agricultural practice in Flanders, they would probably be more expensive to subsidize or would fit within conservation management within nature reserves. In addition, the effect of fertilization technique on meadow bird survival could be added to the model. This is especially important for early breeders (like Lapwing).

Table 6.2 The effect of fertilization technique on meadow bird nest survival

Fertilization technique	Multiply nest survival by
EMT (emission poor fertilization / infusion)	0.2128
Synthetic fertilization	0.7143
Undisturbed	0.9801
Grazing	0.8668
Mowing	0.0523

Source: Teunissen W.A., 1999. Predatie bij weidevogels. Vooronderzoek naar de mogelijke effecten van predatie op de weidevogelstand. Sovon-onderzoeksrapport 1999/10. Sovon Vogelonderzoek Nederland, Beek-Ubbergen

6.3 Measures for species protection: meadow bird management

In Flemish legislation the following measures for species protection – meadow bird management are subsidized (Decision Flemish Government of April 30, 2010, art.8,chapter3):

Table 6.3 Subsidised measures for meadow bird management in Flanders

Measures	Annual subsidy
Postponing mowing date June 15/QM 23 (resting period from April 1/QM 13	517 €/ha
Postponing grazing data June 15/QM 23 (resting period from April 1/QM 13	389 €/ha
Converting cropland to perennial grassland + postponing mowing data June 15/QM 23	549 €/ha
Converting cropland to perennial grassland + postponing grazing data June 15/QM 23	421 €/ha
Nest protection	40 €/nest
Refuge strips	280 €/ha

This set is extended in CASPER to allow Ecopay to investigate whether alternative measures might be more cost-effective. The general set of measures for meadow bird management investigated in CASPER is shown in Table 3. The measures discussed more in detail below.

Table 6.4 Overview of combinations and amount of measures

Name	Variables	Amount of measures
Postponement of mowing	Time of mowing 1st cut QM 17-33: 17 Distance from 1st cut: 0,4,6,8,10,12: 6 Distance from 2nd cut: 0,4,6,8,10,12:6 Fertilizer (standard): 1 Start rest period : QM 12 or 13: 2 Conversion from cropland (yes/no): 2	17*6*6*1*2*2=2448 + further reduced to 468
	Time of mowing 1st cut QM 13-16: 4 Distance from 1st cut: 0 Fertilizer (standard): 1 Start rest period QM 12 or 13: 2 Conversion from cropland (Yes/no): 2	4*1*1*2*2=16
Refuge strips	Time of mowing 1st cut QM 15: 1 Time of mowing 2nd cut QM 21: 1 Time of mowing 3rd cut QM 29: 1 Fertilizer (standard): 1 Start rest period QM 12 or 13: 2 Conversion from cropland (yes/no): 2	1*1*1*1*2*2=4
Seasonal grazing	Start of grazing / grazing period QM 19-33: 11 Stocking rate: 3, 4: 2 Stocking rate rest 0 or 2: 2 Type of livestock: 2 Fertilizer (standard): 1 Start rest period QM 12 or 13: 2 Conversion from cropland (yes/no): 2	11*2*2*2*1*2*2=352
Rotational grazing	First time of grazing QM 17-33: 17 Distance from 1st grazing: 0,4,6,8,10,12: 6 Distance from 2nd grazing:0,4,6,8,10,12: 6 Fertilizer (standard): 1 Start rest period: QM 12 or 13: 2 Conversion from cropland (yes/no): 2	17*6*6*1*2*2=2448 + further reduced to 468
	First time of grazing QM 13-16: 4 Distance from 1st grazing: 0 Fertilizer (standard): 1 Start rest period QM 12 or 13: 2 Conversion from cropland (yes/no): 2	4*1*1*2*2=16
Combination of mowing and pasture (seasonal)	Time of mowing 1st cut Distance from 1st cut Fertilizer (standard): 1 Type of livestock (lively/quiet) Stocking rate:	
Nest protection		

6.3.1 Postponement of mowing (strictly mowing)

In current Flemish legislation

- one uniform subsidy is provided for postponement of mowing between QM 13 and 23 (April 1 – June 15);
- the compensation varies, depending on whether the measure preceded by conversion from cropland.

Other conditions:

- use the parcel as multiyear grassland;
- not allowed to change the grassland to cropland;
- remove the clipping after each mowing within 15 days;

do not execute agricultural works between April 1 (QM 13) and the 1st mowing;

- do not change the hydrological conditions, thus draining and dewatering are not allowed;
- do not change the soil conditions or the (local) gradients;
- mow a first time after June 15;
- give meadow birds an escape possibility while the land is mowed, therefore do not mow from the outside to the inside;
- use the field after the first mowing only for mowing.

Annual payment (during 5 years) without prior conversion from cropland:

- compensation for yield reduction: 505 €/ha;
- additional costs: 12 €/ha.

Additional conditions in case of prior conversion from cropland:

- convert before May 1 of the first year of the agreement the cropland to grassland;
- use the parcel thereafter as multiyear grassland;
- use a seed mixture of different grass species (from an approved list);
- do not execute agricultural works between April 1 and the first mowing, which can not be done before June 15.

Annual payment (during 5 years) after prior conversion from cropland:

- compensation for yield reduction: 505 €/ha;
- additional costs: 44 €/ha.

Number & frequency of mowing cuts

Standard agricultural mowing practice in Flanders implies 5 mowing cuts: around April 20 (QM 15), June 1 (QM 21), July 15 (QM 27), September 1 (QM 33) and October 15 (QM 39). Only the first three coïncide with the period of breeding and critical habitat use by meadow birds (see table 4). As opposed to Germany, in Flanders the mowing does not need to be limited to two cuts in parcels with agri-environment schemes. Therefore a variable 'distance to second cut' needs to be added to the German database in order to be able to model alternative postponements of the third cut.

The standard mowing frequency of the three first cuts is 6. In Ecopay, we vary the alternatives by modelling for 0, 4, 6, 8, 10 and 12 cuts. When the value is 0, this implies that there is no subsequent cut.

Time of mowing 1st cut

In Germany the mowing of the first cut can vary between QM 19 (May 15) and QM 30 (August 8). In CASPER a variation to cover the resting period included in current legislation (starting on QM 13/April 1) until one week after the last week of habitat use by one of the targeted bird species (QM 33, see table 4) would require 21 alternatives for the variable 'timing of mowing 1st cut'. Together with the other variables (distance from 1st cut, distance from 2nd cut, early rest period and conversion from cropland), this would result in around 2400 postponement of mowing alternatives. Therefore we add some assumptions to make the number of alternative measures, and the calculation time required for a modelling run, more manageable.

For the resting period to be somewhat ecologically interesting we assume that it should cover at least 4 to 5 QM's. Therefore we put the first QM for mowing of the 1st cut on QM 17 (May 1) in stead of QM 13 (April 1). This already reduces the number of mowing alternatives to 2108 alternatives.

On the other hand, an early or timely harvest of the first cut (between QM 13-16), without a subsequent 2nd or 3rd cut, would economically still be interesting for the farmer, while it would only destroy a certain percentage of the nests. Therefore we add 16 alternatives for QM 13 to 16 in which only a first cut is allowed.

Distance from 1st & 2nd cut

Table 4 also indicates that postponements of the third cut have only added value, from a meadow bird management point of view, until QM 33 (September 1). Therefore measures that result in postponements after QM 33 are not taken into consideration. This reduces the number of postponement alternatives further to 468 (+16).

(!! comment extra measures with early and late mowing)

Early land use

Based on the ecological parameters, egg deposition for Lapwing already starts in the first week of March (QM 9) and for Black-tailed godwit and Meadow pipit in the fourth week of March (QM 12) (see table 4). However, Flemish subsidiy legislation permits agricultural works until the end of March (QM 13).

To test the potential cost-effectiveness of an earlier start of the rest period we add the variable 'early land use' to the German database. The value '0' corresponds with a start of the resting period in QM 13 (April 1), the value '1' corresponds with a resting period starting in QM 12 (March 22).

If the first test run would indicate that an earlier start of the rest period is typically not cost-effective compared to a later start, then the number alternative mowing postponement could be reduced further from 468 to 234 (+8).

Conversion from cropland

Flemish legislation provides specific subsidies for conversion cropland to grassland, after which mowing, grazing and mowing/grazing-mixes can be applied. Therefore a variable 'prior_cropland' is added to theh German database. The value '0' corresponds with no conversion, the value '1' with conversion.

Fertilization

While the German mowing regimes allow to choose between 'no fertilization' and 'reduced fertilization' the Flemish measures assume 'standard fertilization'. This difference is based on the following considerations:

1. The German Ecopay-application focuses on meadow birds, grassland insects and rare grassland habitats, some of which favour reduced or zero fertilization (e.g. Ruff, Common snipe, butterflies, habitats of European interest).
2. The Flemish policy context is one of 10 meadow bird species, the survival of which does not require strong reductions in the amount of fertilization. Also the Flemish agri-environment schemes for meadow bird management do not prescribe reduced fertilization.
3. Given the pressure from the cattle breeding sector to dispose their manure in grasslands (mostly semi-liquid manure or 'slurry') the requirement of zero fertilization as a measure for meadow bird management would probably not be realistic in terms of political feasibility.

4. The ecological model that underpins Ecopay does not include the ecological effect of reduced fertilization in terms of reduced vegetation height or food (insect) availability and its consequences for breeding success. To include this element in the model is not feasible within the time frame of CASPER. It would however be worthwhile to investigate and include this in the future. In addition to the quantity of fertilization also the type of reutilization (stable, liquid or synthetic) would have to be considered.
5. Adding fertilization alternatives would also require extra data collection on current practices which is also not feasible at this stage of the research.
6. Including alternative fertilization regimes would also be useful to investigate the impact on water quality (e.g. policy objectives Water Framework Directive) and on ecosystem services.

The standard fertilization scheme however does require some spatial differentiation in amount of nitrogen that can be put on grassland. The general characteristics of the fertilization limits are presented in figure 6.1.

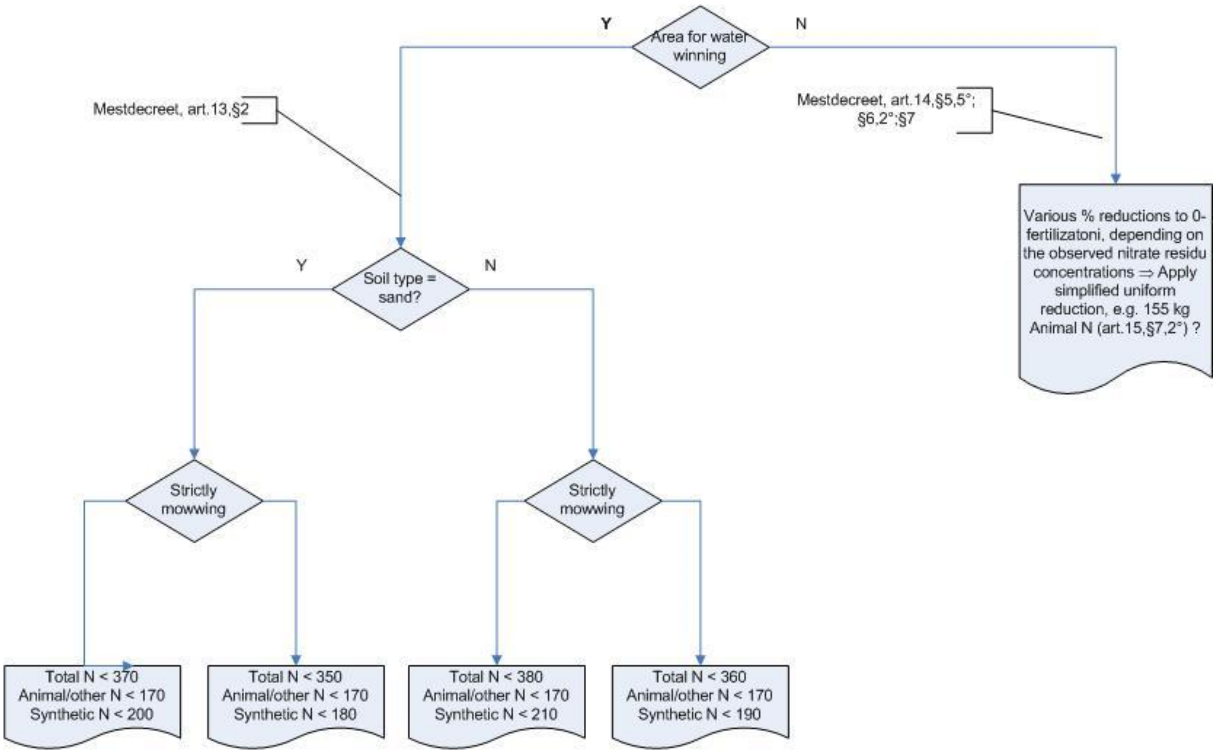


Figure 6.1 Nitrogen fertilization norms in farmland

To the extent that spatial data on the location of 'vulnerable areas for water', soil and land use type can be collected we can differentiate the N-deposition in the land use data.

According to Flemish legislation, on parcels with agri-environment schemes no fertilization or other activities can be performed between QM 13 (April 1) and 23 (June 15). As a result the application of agri-environment schemes may well reduce the amount of fertilization in practice, especially with regard to synthetic fertilization before and after the first cut. We could assume that animal fertilization would still be applied before the breeding period, but that a smaller dosis synthetic fertilizer will be applied.

6.3.2 Refuge strips

In current Flemish legislation (see table 6.2)

- a subsidy of 280 €/ha is provided for mowing while leaving refuge strips not mowed.

Other conditions:

- create refuge strips by not mowing strips of minimum 4 m wide;
- the area of these refuge strips is at least 10 % of the parcel size;
- these strips can only be mowed or grazed two weeks after this mowing of the parcel and not earlier than June 15;
- use the parcel as multiyear grassland;
- remove the clipping after each mowing within 15 days;
- mow the parcel at least once a year from the inside to the outside.

The measure can be applied to different parcels during the 5-year term of the agri-environment scheme.

Annual payment (during 5-year period):

- compensation for yield reduction: 220 €/ha;
- additional labour (late mowing): 60 €/ha.

Mowing strips are applied in Germany in the federal state Brandenburg in a period in which Corncrakes raise their chicks. In Ecopay the timing of the first cut with mowing strips can be QM 19 or 20 which corresponds with the time of mowing that is economically optimal. Leaving strips unmowed according to certain specifications should increase the probability of young chicks surviving the mowing. Ecopay assumes that applying mowing strips increases chick survival from 0 % to 25 % during the critical reproduction period, compared to conventional mowing, and from 50 tot 75 % during the reproduction period.

Time of mowing main cut

The idea of this measure in Flanders is that the entire field needn't be left untouched by the farmer in order to provide meadow birds a reasonable chance for successful reproduction. Hence up to 90 % can be mowed conventionally, provided that at least 10 % is not mowed, in order to serve as refuge strip. Therefore we assume for this measure in Ecopay that the timing of the mowing will follow standard mowing practice (1st cut in QM 15, 2^{nd} cut QM 21 and 3^{rd} cut QM 27).

Time of mowing refuge strips

The moving of the refuge strips itself could in principle be alternated between 2, 4 and 6 QM. In the latter case, the mowing of the strip would coïncide with the subsequent cut, which may imply cost savings (e.g. reduced labour and machine costs) for the farmer. Like the German application we assume that the refuge strips are mowed together with the subsequent main cut, and that the yield of these strips has no economic value due to the late harvest. We also assume that cutting the refuge strips 2 or to 4 is generally not done because the economic value of the 10% that is thus harvested would not cover the variable costs of the extra mowing.

As with the measure 'postponement of mowing', only variations in the timing until QM 33 (September 1) are beneficial for the meadow birds.

Early land use, conversion from cropland and fertilization

For these variables the approach is identical to that for the postponement of mowing measures.

Variables ⇒ 1*1*1*1*2*2 = 4 alternative refuge strip measures in Casper.

6.3.3 Postponement of grazing (strictly grazing)

In current Flemish legislation (see table 2):

- one uniform subsidy is provided for postponement of grazing between QM 13 and 23 (April 1 – June 15);
- compensation payment varies, depending on whether the grazing regime is preceded by conversion from cropland.

Other conditions:

- use the parcel as multiyear grassland;
- not allowed to change the grassland to cropland;
- do not execute agricultural works between QM 13 (April 1) and the first grazing;
- do not change the hydrological conditions, thus draining and dewatering are not allowed;
- neither change the soil conditions nor the (local) gradients.

Additional conditions for late grazing:

- limit the cattle density to 2 GV/ha between QM 13 and 23 (April 1 – June 15).

Annual payment (during 5 years) for late grazing without prior conversion from cropland:

- compensation for yield reduction: 369 €/ha;
- additional costs (keep cattle longer in the stable): 20 €/ha.

Additional conditions in case of prior conversion from cropland:

- convert before May 1 of the first year of the agreement the cropland to grassland;
- use the parcel thereafter as multiyear grassland;
- use a seed mixture of different grass species (the species need to come from an approved list);
- do not execute agricultural works between April 1 and the first grazing which can be done the earliest at June 15.

Annual payment (during 5 years) for late grazing after prior conversion from cropland:

- compensation for yield reduction: 379 €/ha;
- additional costs (keep cattle longer in the stable): 42 €/ha.

Flemish standard pasture practice is either a form of rotational grazing ('omweiden') or seasonal grazing ('standweiden'). In the former case cattle is rotated between parcels every two to six days. In the latter case the cattle remains in a meadow for two to six weeks, which is typically preceded or followed by a mowing regime.

In the German application of Ecopay three types of grazing measures are included.

1. all year grazing
   This measure involves extensive pasture on parcels of at least 60 ha, with an average stocking rate of 0,5 GV/ha, a lively/quiet livestock mix and zero fertilization.

   This type is not considered for application in CASPER. In Flanders it is only applied as part of conservation management within nature reserves. In terms of required area, maximum cattle density and fertilization regime we consider it too far away from standard agricultural practice to be feasible with the current types of agri-environment scheme.. For future research it might be interesting to investigate whether there are areas where these criteria could be met, for instance by 'agro conservation groups' ('agrobeheergroepen').

2. seasonal grazing
   This measure involves a more common form of extensive pasture with alternative start dates (9 alternatives, every 2 weeks between QM 13 and 29), alternative stocking rates of

1.5, 3 or 4 GV/ha, two alternative livestock types and zero fertilization. The standard grazing period starts on April 1 and ends on October 31.

This measure is included in CASPER, be it that fertilization is allowed according to standard Flemish fertilization practice (i.e. reduction only in 'vulnerable areas for water'). Two extra grazing postponement is added, up to QM 33 in stead of QM 29, because of the longer period of habitat use in Flanders (see table 4).

According to Flemish legislation a stocking rate of up to 2 GVE/ha is permitted, even during the resting period. This is higher than one of the alternative stocking rates during the German grazing season. We therefore

Stocking rate alternatives	Resting period	Grazing period
Germany	0	1,5, 3 or 4
Flanders	0 or 2	3 or 4

Flemish regulation requires for nest protection measures that youn cattle is kept from parcels with nests. For grazing no requirement with regard to type of cattle are made. In Ecopay we investigate the cost effectiveness of such requirements, by allowing two alternative stocking types: one with only quiet animals (milk cows) and one with only lively animals (young cows).

In principle, also a shorter early seasonal grazing alternative (e.g. from QM 12 until QM 15) followed by a long rest period could be considered. For practical reasons (number of measures considered) we do not include these measures yet.

3. rotational grazing
   This measure involves a more intensive form of pasture with one or two short grazing periods of not more than 1 QM. It is followed by a long rest period without grazing that allows the grass to regenerate. In that sense its ecological impact is considered similar to that of mowing. The design of this measure also corresponds to that of mowing postponement. The start dates of the subsidized measures can vary from QM 13 until QM 33. If the first grazing takes place at least 4 QM before QM 31 then it can be followed by a second grazing (5 alternative frequencies). If it occurs at least 8 QM before QM 31 then it can be followed by a third grazing rotation. In the German application fertilization alternatives may vary between reduced and no fertilization.

   This measure is included in CASPER, be it that fertilization is allowed according to standard Flemish fertilization practice (i.e. reduction only in 'vulnerable areas for water').

   As with the postponement of mowing measures, also reduction early land use (start resting period in QM 12 or 13) and prior conversion from cropland (yes or no) are variables for this measure. The number of rotational grazing alternatives thus equals that of mowing postponements: 468 + 16 = 484

6.3.4 Combination of mowing and pasture

The Flemish subsidized agro-environment schemes do not include measures that combine mowing and pasture. Several combinations are possible:

1. Mowing 1 cut + one or more grazing rotations

2. Mowing 2 cuts + one grazing rotation
3. Mowing 1 cut + seasonal grazing
4. Mowing 2 cuts + seasonal grazing

In principle, also combination with early mowing c.q. grazing, followed by a long rest period and then late grazing c.q. mowing could be considered. For practical reasons we do not include these measures yet.

The German application of Ecopay includes the combination of mowing one cut, followed by seasonal grazing with two alternative types of livestock and three alternative stocking rates.

input in excel:

copy mowing postpo design for mowing + rotational grazing; after reducing single cut measures, 400 mowing (1cut) + pasture (1 or 2 rotations) remain

for mowing + seasonal grazing, 2080 alternatives should be considered

6.3.5 Nest protection

Conditions:

- do not change the hydrological conditions, draining and dewatering are therefore not allowed;
- do not change soil conditions or local gradients;
- protect all meadow bird nests on your agricultural land (both grassland and cropland)

Annual payment:

- additional labour (consultation with expert, agricultural management being more time demanding): 40 €/nest

Nest protection is not included as a separate measure in the German application of Ecopay.

	Survival without nest protection	Survival with nest protection
Critical reproduction period	0 %	25 %
Non-critical reproduction period	50 %	75 %

assumption

- nest protection only in situatin with mowing (cf. Teunissen, p.36)

- assumption hatching success & daily survival rate

- differene protection/no protection bigger for short grass (cf. Teunissen, p.339)

- net effect is is positive but unclear, because disturbance by protection activities and increased predation reduces the effectiveness of the protection (Sanders et al, 2004:38)

- effectiveness of nest protection is reduced in cases of synthetic fertilization (Goedhart et al., powerpoint)

- include arguments in mail Peter & Karolien to exclude it here

quid inclusion in Ecopay?

wvr, 28/7: "Nest protection is one of the measures for which Flemish farmers get subsidies and they apply it quite often, as it turns out to be rather easy money for not a lot of work. It's a measure that is not included in the German list. Do you know whether it was ever considered there, or discussed by your team? There is some recent research on the effectiveness of this measure in the Netherlands, suggesting that the measure is often not very effective. One of the reasons is that the visits of the nest, as part of the monitoring, affect the breeding success in a negative way. We're still doubting whether to include the measure in the Flemish list for the Ecopay test run, but if you have any suggestions or comments, they're welcome."

mm, 3/8: "In Ecopay we consider the measure "mowing strips" which should be similar to nest protection. The mowing strips should help especially Corncrake chicks to survive when the grassland is mowed. Also nests within the mowing strips are protected. One of our practice partners sent us the attached literature (there seem to be only few numbers in literature about the success) and told us, that they implemented this measure in one part of the Federal State Brandenburg (see also attached documents). In Ecopay we assume that in grid cells with the measure mowing strips the survival probability is 25 % (in stead of 0 % at 'complete' mowing) if the timing of mowing is inside the critical reproduction period and 75 % (in stead of 50 % at 'complete' mowing) if the timing of mowing is outside the critical period but still within the total reproduction period. Experts can adapt this percentages to their knowledge."

annex: translation measures

table measures

name	**method_nr**
Mahd	3 (if 1 cut) or 2 (if 2 cuts)
Umtriebsweide	5
Saisonale_Standweide	5
Maehweide	7
Ganzjahresweide	5
Streifenmahd	3 (if 1 cut) or 2 (if 2 cuts)

table method

method_nr	**name**
1	mowing_3cut
2	mowing_2cut
3	mowing_1cut
4	weide_intensiv
5	weide_extensiv
6	maehweide_intensiv
7	maehweide_extensiv

Table 6.5. Comparison of alternative mowing regimes with timing egg deposition & habitat use of farmland birds

Date	**QM**	**Most productive timing of cut**	**Distance from 1st cut**	**Distance from 2nd cut**	**Probability of egg deposition + Reproductive period (habitat use until chicks are fully fledged)**												
					Grutto Uferschnepfe Back-tailed godwit	Wulp Großer Brachvogel Curlew	Tureluur Rotschenkel Redshank	Kievit Kiebitz Lapwing	Scholekster Austernfischer Eurasian Oystercatcher	Zomertaling Knäkente Garganey	Slobeend Löffelente Northern shoveler	Graspieper Wiesenpieper Meadow pipit	Veldleeuwerik Feldlerche Skylark	Gele kwikstaart Schafstelze Yellow wagtail	Grauwe gors Grauammer Corn bunting	Geelgors Goldammer Yellowhammer	Patrijs Rebhuhn Partridge
1/jan	1																
8/jan	2																
15/jan	3																
22/jan	4																
1/feb	5																
8/feb	6																
15/feb	7																
22/feb	8																
1/mrt	9							0,05									
8/mrt	10							0,05									
15/mrt	11							0,05									
22/mrt	12				0,05			0,1				0,05					
1/apr	13				0,15	0,05		0,1				0,05	0,05			0,05	
8/apr	14				0,2	0,15	0,05	0,15			0,05	0,15	0,05			0,1	0,05
15/apr	15	1	0		0,15	0,2	0,1	0,15			0,15	0,1	0,1			0,1	0,05
22/apr	16				0,15	0,4	0,2	0,1		0,05	0,2	0,05	0,15	0,1		0,1	0,1
1/mei	17		2		0,1	0,15	0,2	0,05		0,05	0,2	0,05	0,1	0,15		0,1	0,1
8/mei	18				0,1	0,05	0,2	0,05		0,05	0,15	0,1	0,05	0,25		0,05	0,3
15/mei	19		4		0,05		0,2	0,05		0,2	0,1	0,15	0,05	0,2		0,05	0,3
22/mei	20				0,05		0,05	0,05		0,2	0,05	0,05	0,15	0,1		0,1	0,1
1/jun	21	2	optimal = 6	0				0,05		0,2	0,05	0,05	0,1	0,1		0,1	
8/jun	22									0,15	0,05	0,05	0,05	0,05		0,1	
15/jun	23		8							0,05		0,05	0,05	0,05		0,05	
22/jun	24									0,05		0,05	0,05			0,05	
1/jul	25		10	0								0,05	0,05			0,05	
8/jul	26																
15/jul	27	3	12	6													
22/jul	28																
1/aug	29		14	8													
8/aug	30																
15/aug	31		16	10													
22/aug	32																
1/sep	33		18	12													

standard/economicall optimal QM for 1st, 2nd and 3rd cut
period for which, from Dutch research, the % of yield loss is known
period of egg deposition in which Flemish agri-environment schemes still allow land management
critical reproductive period
reproductive period per species, based on Flemish ecological parameters

6.4 Measures for species protection: cropland bird management

In Flemish legislation the following measures for species protection – cropland bird management are subsidized (Decision Flemish Government of April 30, 2010, art.8,chapter3):

Table 6.6 Subsidised measures for cropland bird management in Flanders

	Annual subsidy
Mixed grass strips	1570 €/ha
Ploughed mixed grass strips	1600 €/ha
Lark squares	15 €/square
Fauna borders	500 €/ha
Winter stubs	50 €/ha
Grain borders	1500 €/ha
Bird feed crops	1490 €/ha

6.4.1 Mixed grass strips

Conditions:

- The parcel is cropland but temporary grassland is possible.
- The strip is 6 – 12 meter wide, sowing is done within the first 4 months of the first year of the agreement with perennial tussock grass species.
- For 'closed landscape species': the strip will be placed along a wooded small landscape element.
- For 'open landscape species': the strip will be placed a minimal 100 meter distance from vertical elements like trees, buildings, etc…
- During the first year of the agreement the strip can be mowed three times; the four subsequent years the strip can be mowed for only 50 % from July 15; the remaining 50 % will be mowed the year after.
- No use of pesticides, except for controlling thistles.
- No manure, including grazing or liming.
- Clippings need to be removed within 15 days.
- The strip cannot be used for transit or for storage depot.

Annual payment:

- 1570 €/ha/year or 0,157 €/m²/year, based on an estimated yield loss of 1290 €/ha/year and 280 €/ha/year additional costs for buying grass seeds and maintenance.

6.4.2 Ploughed mixed grass strips

Conditions:

- The grass strip is not placed at the border of the parcel and is above ground level of the parcel.
- No driving allowed.
- The parcel is cropland but temporary grassland is possible.
- The strip is 6 – 12 meter wide; sowing is done within the first 4 months of the first year of the agreement with perennial tussock grass species.
- For 'closed landscape species': the strip will be placed along a wooded small landscape element.

- For 'open landscape species': the strip will be placed at minimal 100 meter from vertical elements like trees, buildings, etcetera.
- During the first year of the agreement the strip can be mowed three times, the four subsequent years the strip can only be mowed for 50 % from July 15. The remaining 50 % will be mowed the year after.
- No pesticides, except for controlling thistles.
- No manure, including grazing or liming.
- Clippings need to be removed within 15 days.
- The strip cannot be used for transit or as storage depot.

Annual payment:

- 1600 €/ha/year or 0,16 €/m²/year, based on an estimated yield loss of 1290 €/ha/year and 310 €/ha/year additional costs for buying grass seeds and maintenance.

6.4.3 Lark squares

Conditions:

- The parcel is cereal cropland (no corn) of minimal 0,5 ha.
- The squares that remain unsown are minimal 16 m² and are scattered across the parcel.
- The squares are placed at least 100 meter from vertical elements such as trees, hedgerows etcetera, and from busy roads; at least 250 meter from forests of at least 5 ha; and at least 20 meter from the parcel border.
- The squares can be rotated annually within the parcel, but their number needs to remain constant.
- No tracks of farming machines should pass alongside or across the square.
- 2 squares/ha and minimal 2 per parcel.

Annual payment:

- 15 €/square with maximum of 30 €/square.

6.4.4 Fauna borders

Conditions:

- The parcel is cereal cropland (no corn).
- A cereal border of 6 – 12 meter.
- The cereal border is not fertilized or limed.
- No pesticides from March 15 until the harvest, except for controlling thistles.
- The cereal borders can be rotated annually at the farm level.
- The cereal borders can be harvested and can be used as headland.

Annual payment:

- 500 €/ha/year or 0,05 €/ha/year, based on the estimated yield loss.

6.4.5 Winter stubs

Conditions:

- The parcel is a cereal cropland (no corn), flax, peas or beans.
- Maximum 5 ha/farmer.

- The stubs can be rotated annually at the farm level.
- The stubs are kept until March 15 of the following year.
- After the harvest the parcel is not fertilized or worked on.
- Just before the harvest and until March 15 of the following year the use of pesticides is forbidden, except for controlling thistles.

Annual payment:

- 50 €/ha/year.

6.4.6 Grain borders

Conditions:

- The parcel is cropland.
- A cereal border (no corn) of 6 – 12 meter is created or left after the harvest.
- The border is not located along buildings or along water courses.
- The border is not harvested and is kept at least until March 15 of the following year.
- Normal fertilizing like the main crop.
- The borders can be rotated annually at the farm level.
- The use of pesticides will be included in the agreement.
- For 'closed landscape species' the border is preferably placed along wooded small landscape elements.

Annual payment:

- 1500 €/ha/year or 0,15 €/m²/year, based on an estimated yield loss of 1290 €/ha/year and 210 €/ha/year to compensate the additional costs (e.g. extra labour and cereal seeds).

6.4.7 Bird feed crops

Conditions:

- Growing of a specific seed-generating crop (mixture) which is included in the agreement.
- In agreement with the expert a crop rotation scheme is developed.
- The crop is kept for the whole winter, and at least until March 15 of the following year.
- Pesticide and fertilizer use is agreed in the contract, based on the crop rotation scheme.
- The border is at least 6 m wide and the area is not more than 0,5 ha/farm.

Annual payment:

- depending on the chosen crops (fixed rate of 1490 €/ha/year) based on an estimated yield loss of 1290 €/ha/year and additional costs (seed mix) of 200 €/ha/year.

6.4.8 Grass corners

Conditions:

- The parcel is grassland.
- A part of the parcel is set aside (min. 0,1 ha, max. 0,5 ha).
- Pesticides are not allowed, besides for controlling thistles.

- No manure (including lime)
- For 'closed landscape species': the strip will be placed along a wooded small landscape element.
- For 'open landscape species': the strip will be created at least 100 meter from vertical elements such as trees, hedgerows etcetera, and from busy roads; at least 250 meter from forests of at least 5 ha; and at least 20 meter from the parcel border.
- After July 15 the parcel is mowed for 50 %; the remaining 50 % will be mowed the year after.
- Clippings need to be removed within 15 days.

Yearly payment:

- 950 €/ha/year or 0,95 €/m²/year, based on an estimated yield loss of 950 €/m²/year and additional costs (mowing, removing clippings) of 90 €/ha/year.

7 Optimization

A. Sturm, M. Mewes

This chapter describes how the simulation and the optimization is carried out in the CASPER-tool. Simulation is used for the analysis of the effectiveness of measures and their costs and optimization for the cost-effectiveness analysis.

7.1 Simulation in the ECOPAY-tool

The user can simulate the effectiveness of agri-environmental schemes and estimate the total budget required for these schemes as well as assess the costs of individual measures and their impact on selected bird species.

Effectiveness-analysis of agri-environmental schemes

An important feature of the ECOPAY-tool is the simulation of the impact of existing or potential agri-environmental schemes on selected species and the determination of the resulting total budget for the schemes. The impact of land use measures on species is estimated in the CASPER-tool by determining the effective habitat area. The ecological model identifies for each species *j* the effective habitat area A_j^{eff} depending on the species requirements and the land use measures required by the agri-environmental schemes.

Several user-defined variables determine a specific agri-environmental scheme. These variables can be divided into two input groups:

1. The first input refers to the selection of one or more land use measures m, the corresponding payment(s) pm and maximal area(s) $A_m^{\max}$ on which a selected measure m is to be implemented within a study area. The input of a maximum area for each selected land use is necessary to ensure that the software cannot assign all pixels to the same land use measure. The maximum area along with the payments pm for the implementation of a land use measure m enables the user indirectly to specify a maximum budget for this measure.
2. The second input includes the selection of one or more target species j and its (their) specific minimum local habitat quality $q_j^{\min}$. The user has to set a minimum threshold value for this quality for each species. As described in Chapter 6, the ecological model assesses the local habitat quality $q_j^{l,m}$ resulting from a land use measure m for each pixel l. For each target species, this quality adds up to a value between 0 (habitat not suitable for the species) and 1 (habitat very suitable for the species). Whether the local habitat quality generated by a specific land use on a pixel yields an area which is added to the effective habitat area of a species depends on two factors: first the habitat quality for a species j calculated by the ecological model has to be greater than or equal to the local minimum habitat quality, i.e. $q_j^{l,m} \geq q_j^{\min}$, and second the pixel under consideration has to be within a certain dispersal distance to at least one pixel in which the species does already exist. The second consideration is especially important for species with a limited dispersal capability, like butterflies. However, for birds it is assumed in general that their dispersal capability enables them to reach every appropriate pixel. If either condition is not fulfilled for species j, the area of the pixel will not contribute to the effective habitat area A_j^{eff}.

In summary, in the ECOPAY-tool an agri-environmental scheme is characterized by selected land use measures m included in the scheme, together with their respective payments pm and maximum areas A_m^{max} as well as the selected target species and their required local minimum habitat quality q_j^{min} .

After the user has selected the land use measures, the target species and the associated parameters pm, A_m^{max} and q_j^{min} the software determines the resulting land use pattern for the study area by the following procedure:

1. For each selected measure m, the software identifies all pixels for which the difference between payment and costs is greater than or equal to 0 and where the required local minimum habitat quality has been reached for at least one species. These pixels are contained in measure lists Lm (e.g., for five measures lists L1 through L5 are generated) and ordered according to the difference between payment and costs for each measure with the pixel with the largest difference in the first place. If for a land use measure the difference between payments and costs is lower than 0, the CASPER-tool assumes that this land use measure is not applied and no list is generated for it.

2. In the next steps the CASPER-tool considers only pixels with a difference between payment and costs greater than or equal to 0 for at least one selected measure m. The final allocation of the measures on single pixels happens as follows: each first element (i.e., the pixel with the highest difference between payment and costs for each measure) of each measure list Lm is compared to each other. The first element with the largest difference between payment and costs is permanently allocated to the corresponding pixel. This pixel is marked as chosen. In the list from which the measure was taken (e.g. L1), the next element is considered for the next step, while from the other lists (in this example L2 to L5) the first elements are still taken into account. Once again, the differences between payment and costs are compared, and again the element with the largest difference, e.g. from measure list L_2, is selected. Now two situations may arise:

   (1) The corresponding pixel has already been assigned to another land use measure (in this example in the first query to L1) and has been marked as chosen. Nothing happens in this case, but it is continued with the next element in the corresponding list L2.

   (2) The pixel has not been assigned yet. Then the measure will be allocated permanently to the pixel, the pixel is saved as assigned and it is continued with the next element in the corresponding list L2 .

This process continues until either (i) all the pixels that meet the required local minimum quality and that have a positive difference between payment and costs have been assigned to a measure (i.e. all pixels in the lists Lm have been assigned to a measure) or (ii) all maximum areas A_m^{max} have been reached, or (iii) the total budget is depleted. All pixels which have not been assigned to a measure (either because its maximum area has been reached or because the costs exceed the payment for all possible measures) are assumed to be cultivated according to the reference measures (i.e. standard farming practice).

The procedure described is based on the idea that in reality, the farmers have the strongest interest to participate in those measures for which the difference between payment and costs is highest. This holds as long as a measure is still available, i.e. A_m^{max} has not yet been reached. After that, farmers will endeavor to take part in the measure which is second most attractive for them, etc. With this method, the farmers get (if possible) the measure which profits them most.

The budget required at case study level (In database: case study is named country) results from the sum of the payments pm for respective measures m multiplied by the number of pixels lm on which the measures are carried out (Eq. (1-1)):

Eq. (1-1)

$$B = \sum_m p_m l_m$$

Overall, this effectiveness-analysis provides (I) the regional land use pattern resulting from the payment specifications and the measures and species selection, (II) the arising benefits for the protected species in form of the local habitat quality summed up for all selected species, (III) the measure that is carried out on the particular pixel, (IV) the effective habitat areas (considering regional habitat quality), and (V) the total budget spent.

<u>Simulation of costs and effectiveness of measures</u>

In the simulation of the costs and effectiveness of the land use measures, each measure is considered individually. This means that costs of the selected measures and the ecological benefit based on the local habitat qualities $q_j^{l,m}$ of the selected targeted species j for land use measure m will be estimated for each pixel.

7.2 Optimization and determination of cost-effectiveness of agri-environmental schemes

For the optimization to determine cost-effective agri-environmental schemes and resulting regional land use patterns, it needs to be taken into account that a budget is required at the federal state level to finance the payments for farmers. Bearing in mind that the available budget is limited, the user can basically choose between two options for determining the cost effectiveness of programs:

<u>Option 1: Given budget</u>

The user defines a certain budget and the following target function is maximized under the constraint that the given budget may not be exceeded (Eq. (1-2)):

$$A = \sum_j w_j A_j^{eff} \rightarrow \max$$ under the constraint $B \leq B_0$ (Eq. 1.2)

The quantity A is the weighted sum of all effective habitat areas A_j^{eff} of all species j that the user has selected as target species. The user can determine the relative importance of these species through the weighting factor wj. If – for example – w1 is twice as large as w2, the species or rather the habitat area of the species 1 is taken into account in the optimization with twice the weight of species 2. The weighting factors wj can take on values between 1 and 100 reflecting the importance of the species protection from the decision maker’s point of view. A value of 1 represents an unimportant species and a value of 100 a very important species.

Based on this input the CASPER-tool now calculates for a given budget B0 the land use pattern that maximizes the target function (Eq. (1-2)). This means that the software estimates the agri-environmental scheme including the payments necessary to implement this land use pattern in the study area.

Option 2: Given conservation goal

The user defines the conservation goal to be achieved with the agri-environmental scheme, and the necessary budget to achieve this goal is minimized. The conservation goal is formulated in terms of the minimum size for the effective habitat area $A_j^{\min}$ for all species j classified as target species by the user (Eq. (1-3)):

$B \rightarrow \min$ under the constraint that $A_j \geq A_j^{\min}$ is valid for all j Eq. (1-3)

An explicit weighting of species is not necessary as an implicit weighting takes place by the user's definition of the minimum size of the effective habitat area $A_j^{\min}$ for each species j.

Additional optimization requirements

The user now still has to decide whether the determination of cost-effective agri-environmental schemes should (1) be limited to a sample of selected land use measures or (2) consider all measures contained in the CASPER-tool. Attention! Optimization is a time consuming process. Depending on the size of the input, the computation time of the program may take up to several days before the result is available. For (1), the user should select the relevant land use measures and the software then determines the cost-effective land use pattern and related compensation payments. Such an approach is appropriate when a preliminary selection of possible measures has been taken place, for instance based on the simulation of measures' effectiveness and costs. For (2) the optimization process takes into account all land use measures contained in the CASPER-tool when determining the most cost-effective land use pattern and the respective compensation payments.

Optimization process

The cost-effectiveness of both options is processed through 'simulated annealing', a numerical optimization procedure. In principle, it repeats the algorithm described for the effectiveness analysis (chapter 1.1) again and again for different payments for each measure. The overall budgets and environmental benefits resulting from the effectiveness analysis are then compared and evaluated. A detailed description of the procedure can be found in Chapter 2.2.

7.3 Technical details

7.3.1 Technical principles of implementation

The software is written in C++ and based on the Microsoft MFC classes. The development environment is Visual C++. MySQL by Oracle is used as database, in particular the freely available version 'MySQL Community Server release 5.1' with the also free C++ connector of ORACLE (version 1.0.5) (see http://www.mysql.com/). The interface between the database and the CASPER-tool is deposited in the database object (datenbank.cpp and datenbak.h). If MySQL should be replaced by a different database, the functions of the new database must be adapted in this database object.

7.3.2 Optimization algorithm

The optimization is based on the 'simulated annealing' algorithm. Simulated annealing is a heuristic optimization procedure that we use because the complexity of the optimization in the CASPER-tool does not allow the precise calculation of an optimum. The basic idea of simulated annealing stems from a method from physics and depicts a cooling process. When a heated metal cools down so slowly that its atoms have sufficient time to arrange themselves to form stable crystals, an energetic state close to the optimum is reached.

This method was implemented as an optimization procedure in 1983 by Kirkpatrick *et al.* (1983) in order to find a global maximum (minimum) for functions that have multiple local maxima (minima) (see figure 7.1). In each iteration a solution for the optimization is generated randomly. This solution is compared with the previous best solution. If the new solution is better than the former in terms of the desired optimum, the new solution is stored as the best solution and in the next iteration a new random solution is produced. If the generated solution is worse than the best so far, it is randomly decided whether it will be saved as the best solution. That means, the process allows poorer intermediate results on the way to the optimum to reduce the likelihood of sticking to a local maximum (minimum).

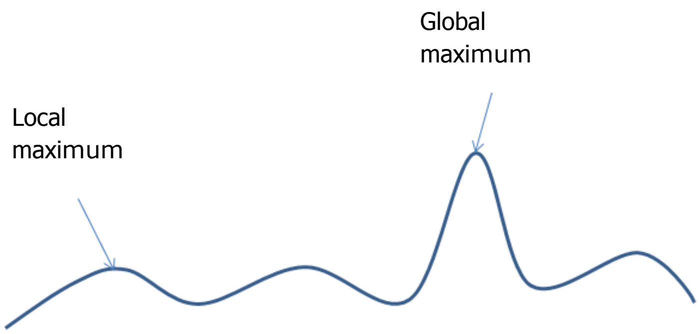


Figure 7.1 Illustration of a function with local and global maximum

7.3.3 Technical details of the database

We chose the freely available (i.e. open source) MySQL database by Oracle (see: http://www.mysql.com/why-mysql/). The database is built in a way that the respective data for the information folders, the agri-economic cost assessment, the GIS-data and output data are saved. The database has one main interface regulating the access to it. This means, that functions of this interface realise the data import and export. A C++-Connector (again from Sun Microsystems) connects the database with the CASPER-tool user interface.

7.3.4 Data base structure of ECOPAY-tool

In the following, the data base structure of the CASPER-tool is explained by describing for each table which entries in which units and which connections between different tables exist. Screenshot 2-1 represents the home page of the CASPER-tool data base and gives on the left side an overview of all its tables. The tables are arranged in alphabetical order. You can find detailed information to the use of a MySQL-data base under http://www.mysql.com/why-mysql/.

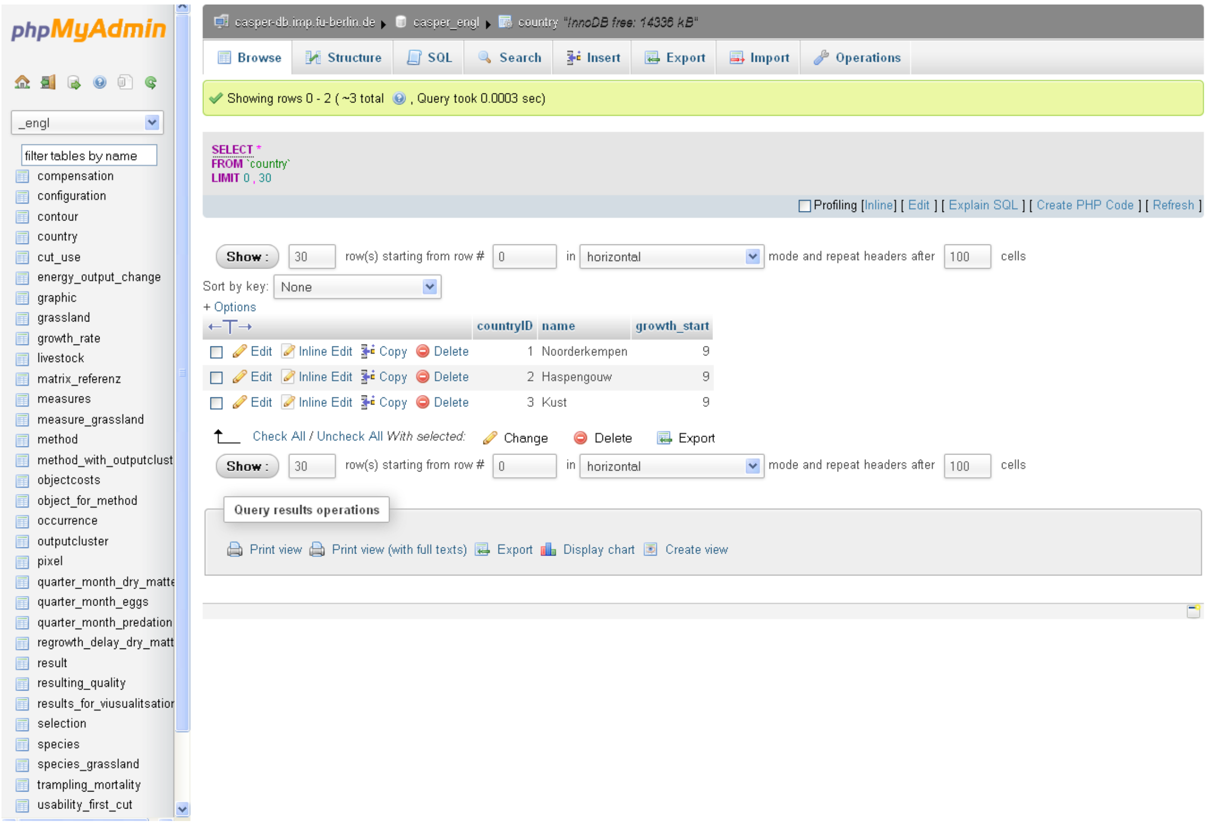
Some tables are connected to each other, i.e. they are based on each other or they access each other. Each dataset gets a distinct identification number (ID). One dataset is a complete (row-)entry in one table. For example a table named "country" exists for the selection of the study area (see screenshot 2-1). The dataset consists of the "countryID", the name of the study area, and the start date (week or 'quarter month') of the vegetation period (grass growth) for this study area. The CASPER-tool contains the three study areas Noorderkempen, Haspengouw and Kust. Therefore, three datasets exist:

countryID = 1; name = Noorderkempen; growth_start = 9

countryID = 2; name = Haspengouw; growth_start = 9

countryID = 3; name = Kust; growth_start = 9

The table country, for example, is logically linked to the table pixel, because each pixel belongs to just one study area. Therefore, the table pixel comprises a column for the "countryID", thus each pixel is assigned to just one study area.



8 Results

A. Sturm, P. Van Gossum, J. Aertsens, M. Mewes, W. Van Reeth

8.1 Simulation of effectiveness and costs of land use measures

The ECOPAY software tool is able to identify single or – most likely – sets of land use measures to protect multiple bird species cost-effectively.

Several test runs have been done to simulate the effectiveness and costs of all land use measures. Thus, each measure is considered individually. To make the files more readable we did not consider the early_land_use measures in the test runs. At the moment the early land use has no input on either the ecological or the economical model, so it just doubles the measures without providing new results. Therefore, the simulation have been done with early_land_use = 0. The first test runs were used to adjust some of the specifications of the species as well as to correct some of the database entries for the agri-economic cost assessment. After these corrections all simulation test runs were recomputed. The test runs presented in this chapter have been done after the adaption of the database.

First test run: minimal habitat quality 0,01, mowing measures

Table 8.1 shows the example for the bird Grutto for the mowing measures with a minimal local habitat of 0,01. The first column gives the measureID of the measure in the database, the second column the speciesID. SpeciesID 1 represents the Grutto (the speciesID is defined in table "species" in the data base). The name of the species is also given in the extra column "species_name". The column m_name states the name of the measure, so that the user has not to look up each measure in the data base according to the measuresID. The following three columns (qual_min, qual_max and qual_medium) show the results of the ecological model in form of the ecological benefit based on the local habitat qualities of the target species. The minimal, maximal and medium local habitat quality is given.

The next columnes present the costs of the measures with minimal costs for the measures (cost_min), maximal costs (cost_max) and medium costs (cost_medium). The last columnes show the effective area, which corresponds to the sum of all local habitat qualities of pixels, where for the measure the minimum local habitat quality is exceeded, multiplied with the size of the pixels (0,81 ha), and the number of these pixels.

Second test run: minimal habitat quality 0,12, mowing measures

Table 8.2 shows the example for the second test run for the bird Grutto with a minimal local habitat of 0,12 for the mowing measures. It can be seen that a lot of measures are not able to generate the defined minimal local habitat quality (table 8.2, m_name= "Massnahme…" and all data entries in these rows are 0).

Third test run: minimal habitat quality 0,01, combination of mowing and seasonal grazing

The results for the measures with a combination of mowing and seasonal grazing are separated according to the different livestock types (quiet, lively: influence on trampling mortality). So the results are better to read and to compare. Tables 8.3-4 show the example for the grotto - a bird which is sensitive to trampling mortality – for livestock 1 (= lively, table 8.3) and 2 (= quiet, table 8.4).

Fourth test run: minimal habitat quality 0,12, combination of mowing and seasonal grazing

Table 8.5 and 8.6 shows the results for the grotto - a bird which is sensitive to trampling mortality – for livestock 1 (= lively, table 8.5) and 2 (= quiet, table 8.6) with a minimal habitat quality of 0,12.

Fifth test run: minimal habitat quality 0,12, seasonal grazing

As an example for the results for the seasonal grazing measures tables 8.7 shows the example for the zomertaling - a bird which had previously no trampling mortality and has now a very low trampling mortality. This means the ecological values mostly depend on the abiotic properties of the pixel for the bird and the grass height. Therefore, nearly all grassland pixels qualify themselves (see table 8.7, if some do not, this is because the bird does not like short grass very much (value of 0,5). If the other values for the bird's requirements are also small, multiplying them with 0,5 can make the difference if a pixel qualifies itself or not.

Column „m_name": four times the „same" measure name means:

First and second measure of the four which belong together: both measures do not allow grazing in the resting period, the first measure for a lively livestock, and the second measure for quiet livestock.

Third and fourth measure: both measures allow grazing also in the resting period, the third measure for a lively livestock, and the fourth measure for quiet livestock.

If a measure allows too many livestock on a field in comparison to the maximal possible yield (reference value), it cannot be applied.

Sixth test run: minimal habitat quality 0,12, rotational grazing

As an example for the results for the seasonal grazing measures tables 8.8 shows the example for the zomertaling. Like described for the fifth test run if a measure allows too many livestock on a field in comparison to the maximal possible yield (reference value), it cannot be applied.

Table 8.1 Results of the first simulation of effectiveness and costs for the Grutto with minimal habitat quality of 0,01 for mowing measures

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
10	1	mowing_postpo, 15/0/0/0,1 (D)	Grutto	0,010686	0,263922	0,062406	-118,292	1750,47	880,042	80,5249	1593
12	1	mowing_postpo, 15/16/6/0,1 (D)	Grutto	0,010686	0,263703	0,062409	164,689	1917,24	1101,29	80,5278	1593
14	1	mowing_postpo, 16/0/0/0,1 (D)	Grutto	0,010138	0,177625	0,042485	-147,673	1564,39	767,817	54,0971	1572
16	1	mowing_postpo, 17/14/6/0,1 (D)	Grutto	0,01033	0,131305	0,032006	89,2623	1439,54	814,46	39,8463	1537
18	1	mowing_postpo, 17/4/10/6,1 (D)	Grutto	0,010034	0,013453	0,011699	138,345	459,304	313,753	0,255852	27
20	1	mowing_postpo, 17/4/4/6,1 (D)	Grutto	0,010378	0,013563	0,011789	68,2341	226,537	145,826	0,248279	26
22	1	mowing_postpo, 17/4/6/6,1 (D)	Grutto	0,010294	0,013453	0,011756	33,9041	112,562	77,1653	0,247574	26
24	1	mowing_postpo, 17/4/8/6,1 (D)	Grutto	0,010075	0,013398	0,011699	56,7077	188,269	126,483	0,255865	27
26	1	mowing_postpo, 17/4/10/6,1 (D)	Grutto	0,010075	0,013453	0,011719	138,345	459,304	309,039	0,256289	27
28	1	mowing_postpo, 17/6/8/6,1 (D)	Grutto	0,010069	0,039211	0,013255	15,5802	109,138	65,645	6,47392	603
30	1	mowing_postpo, 17/6/6/6,1 (D)	Grutto	0,010069	0,03932	0,013255	0,621932	134,692	77,9548	6,47393	603
32	1	mowing_postpo, 17/8/4/6,1 (D)	Grutto	0,010019	0,067539	0,017903	39,9535	379,801	230,183	18,7794	1295
34	1	mowing_postpo, 17/8/6/6,1 (D)	Grutto	0,010003	0,06743	0,017904	31,5931	306,909	185,921	18,7801	1295
36	1	mowing_postpo, 17/10/6/0,1 (D)	Grutto	0,010007	0,116047	0,028426	25,8415	1037,87	571,242	34,8828	1515
38	1	mowing_postpo, 17/10/4/6,1 (D)	Grutto	0,010036	0,115828	0,028426	137,363	888,102	538,852	34,8832	1515
40	1	mowing_postpo, 17/12/6/0,1 (D)	Grutto	0,010321	0,132234	0,032011	74,806	1347,98	758,912	39,8529	1537
42	1	mowing_postpo, 18/13/6/0,1 (D)	Grutto	0,010073	0,111016	0,027321	44,2264	1154,31	641,954	33,4821	1513
44	1	mowing_postpo, 18/4/8/6,1 (D)	Grutto	0,010133	0,05157	0,014924	26,1474	165,6	101,752	12,5477	1038
46	1	mowing_postpo, 18/4/4/6,1 (D)	Grutto	0,010003	0,051734	0,01492	26,9671	197,667	120,301	12,5566	1039
48	1	mowing_postpo, 18/4/6/6,1 (D)	Grutto	0,010003	0,051789	0,01492	6,59089	70,9376	26,9266	12,5562	1039
50	1	mowing_postpo, 18/4/8/6,1 (D)	Grutto	0,010034	0,051734	0,014918	26,1474	165,6	101,742	12,5544	1039
52	1	mowing_postpo, 18/6/0/0,1 (D)	Grutto	0,010072	0,064641	0,017278	-166,287	586,766	244,92	17,8855	1278
54	1	mowing_postpo, 18/6/4/6,1 (D)	Grutto	0,010072	0,064477	0,017276	11,7559	119,956	72,4878	17,8836	1278
56	1	mowing_postpo, 18/6/6/6,1 (D)	Grutto	0,010081	0,064367	0,016921	0	0	0	16,8582	1230
58	1	mowing_postpo, 18/6/8/0,1 (D)	Grutto	0,010081	0,064531	0,017276	-85,7108	276,304	111,815	17,8836	1278
60	1	mowing_postpo, 18/8/8/0,1 (D)	Grutto	0,010027	0,078914	0,020137	-71,9673	431,828	205,158	22,8357	1400
62	1	mowing_postpo, 18/8/6/6,1 (D)	Grutto	0,010027	0,078531	0,020136	20,2356	212,432	128,16	22,8343	1400
64	1	mowing_postpo, 18/10/6/0,1 (D)	Grutto	0,010063	0,110852	0,027321	-11,9062	798,802	426,11	33,483	1513
66	1	mowing_postpo, 18/12/6/0,1 (D)	Grutto	0,010068	0,111617	0,027321	31,5982	1074,33	593,395	33,4824	1513
68	1	mowing_postpo, 19/12/6/0,1 (D)	Grutto	0,010081	0,129281	0,031394	20,352	1003,1	549,675	39,0846	1537
70	1	mowing_postpo, 19/4/8/6,1 (D)	Grutto	0,010002	0,101227	0,024818	26,9163	172,945	104,922	30,0537	1495
72	1	mowing_postpo, 19/4/4/6,1 (D)	Grutto	0,010019	0,100078	0,024861	23,7675	150,528	91,6623	30,025	1491
74	1	mowing_postpo, 19/4/6/6,1 (D)	Grutto	0,010008	0,100242	0,024857	8,8715	56,1862	34,4045	30,02	1491

76	1	mowing_postpo, 19/4/0/0,1 (D)	Grutto	0,010002	0,10057	0,024848	-129,959	816,843	380,34	30,0294	1492
78	1	mowing_postpo, 19/6/6/6,1 (D)	Grutto	0,010222	0,113258	0,027805	10,6279	67,3097	40,8996	34,0752	1513
80	1	mowing_postpo, 19/6/4/6,1 (D)	Grutto	0,010242	0,112984	0,027807	21,0347	181,929	109,542	34,0782	1513
82	1	mowing_postpo, 19/8/4/6,1 (D)	Grutto	0,010272	0,114023	0,027937	35,9691	285,666	172,354	34,2373	1513
84	1	mowing_postpo, 19/8/0/0,1 (D)	Grutto	0,010297	0,114625	0,027929	-151,479	680,547	297,909	34,2272	1513
86	1	mowing_postpo, 19/10/6/0,1 (D)	Grutto	0,010119	0,129445	0,031396	-35,5234	649,227	334,975	39,0873	1537
88	1	mowing_postpo, 19/10/6/6,1 (D)	Grutto	0,010098	0,128953	0,031395	80,5932	639,913	385,844	39,0861	1537
90	1	mowing_postpo, 20/11/6/0,1 (D)	Grutto	0,01077	0,152305	0,036719	-2,70032	857,106	460,301	46,2488	1555
92	1	mowing_postpo, 20/4/8/0,1 (D)	Grutto	0,010735	0,152961	0,036719	-46,335	535,936	266,526	46,2498	1555
94	1	mowing_postpo, 20/4/4/6,1 (D)	Grutto	0,010743	0,152687	0,036724	54,3993	351,912	213,085	46,2557	1555
96	1	mowing_postpo, 20/4/6/6,1 (D)	Grutto	0,0107	0,151867	0,036725	36,6638	232,204	140,778	46,2572	1555
98	1	mowing_postpo, 20/6/0/0,1 (D)	Grutto	0,010743	0,152141	0,036719	-121,681	869,266	411,086	46,2488	1555
100	1	mowing_postpo, 20/6/4/6,1 (D)	Grutto	0,010715	0,152523	0,036723	50,3145	347,682	210,127	46,2546	1555
102	1	mowing_postpo, 20/6/8/0,1 (D)	Grutto	0,010735	0,152523	0,036718	-54,2097	493,443	240,645	46,2476	1555
104	1	mowing_postpo, 20/8/0/0,1 (D)	Grutto	0,010793	0,152414	0,036719	-137,096	771,64	351,936	46,2491	1555
106	1	mowing_postpo, 20/8/6/0,1 (D)	Grutto	0,010762	0,153344	0,036718	-60,0952	523,452	257,598	46,2485	1555
108	1	mowing_postpo, 20/10/6/0,1 (D)	Grutto	0,010785	0,152523	0,036719	-32,5766	667,89	345,657	46,2487	1555
110	1	mowing_postpo, 21/10/6/0,1 (D)	Grutto	0,010076	0,235812	0,055798	28,4736	1054,54	579,125	71,908	1591
112	1	mowing_postpo, 21/4/0/0,1 (D)	Grutto	0,010066	0,236359	0,055802	-85,3147	1099,59	549,71	71,912	1591
114	1	mowing_postpo, 21/4/4/6,1 (D)	Grutto	0,010078	0,235813	0,055796	87,5461	572,682	346,266	71,9053	1591
116	1	mowing_postpo, 21/4/6/6,1 (D)	Grutto	0,010066	0,236031	0,055799	68,9471	504,282	303,968	71,9082	1591
118	1	mowing_postpo, 21/4/8/0,1 (D)	Grutto	0,010076	0,235102	0,055798	-18,9852	753,969	397,212	71,9073	1591
120	1	mowing_postpo, 21/6/0/0,1 (D)	Grutto	0,010066	0,236031	0,055805	-117,536	895,519	426,203	71,9161	1591
122	1	mowing_postpo, 21/6/4/6,1 (D)	Grutto	0,01009	0,236414	0,055798	75,4373	495,909	299,803	71,9069	1591
124	1	mowing_postpo, 21/6/6/0,1 (D)	Grutto	0,010078	0,236031	0,055795	-39,4032	624,655	318,949	71,904	1591
126	1	mowing_postpo, 21/8/6/0,1 (D)	Grutto	0,010052	0,235484	0,055804	-21,3758	738,829	388,049	71,9146	1591
128	1	mowing_postpo, 21/12/0/0,1 (D)	Grutto	0,010078	0,236195	0,055803	-21,985	1500,68	792,457	71,914	1591
130	1	mowing_postpo, 22/9/6/0,1 (D)	Grutto	0,011827	0,319266	0,075517	33,0648	1083,62	596,918	97,5032	1594
132	1	mowing_postpo, 22/4/6/0,1 (D)	Grutto	0,011836	0,318828	0,075508	7,47442	921,546	498,803	97,4913	1594
134	1	mowing_postpo, 22/4/4/6,1 (D)	Grutto	0,01189	0,31932	0,075515	124,628	815,038	492,936	97,5	1594
136	1	mowing_postpo, 22/4/8/0,1 (D)	Grutto	0,01186	0,320906	0,075522	16,3969	978,056	533,012	97,5091	1594
138	1	mowing_postpo, 22/6/8/0,1 (D)	Grutto	0,011872	0,319266	0,07551	0,785041	879,18	473,156	97,4945	1594
140	1	mowing_postpo, 22/8/6/0,1 (D)	Grutto	0,011833	0,319266	0,075514	11,2061	945,181	513,11	97,4994	1594
142	1	mowing_postpo, 23/8/6/0,1 (D)	Grutto	0,011028	0,386969	0,090721	38,9181	1120,69	619,158	118,382	1611
144	1	mowing_postpo, 23/4/6/6,1 (D)	Grutto	0,011028	0,387734	0,090717	132,519	939,244	566,63	118,378	1611
146	1	mowing_postpo, 23/4/4/6,1 (D)	Grutto	0,011028	0,386422	0,09072	148,552	983,709	594,569	118,381	1611
148	1	mowing_postpo, 23/6/6/0,1 (D)	Grutto	0,011019	0,387406	0,090719	26,2403	1040,4	570,565	118,379	1611

150	1	mowing_postpo, 23/8/6/0,1 (D)	Grutto	0,011019	0,387625	0,090716	38,9181	1120,69	619,158	118,376	1611
152	1	mowing_postpo, 24/7/6/0,1 (D)	Grutto	0,010936	0,443734	0,103532	75,32	1351,24	758,827	135,184	1612
154	1	mowing_postpo, 24/4/6/0,1 (D)	Grutto	0,010928	0,44275	0,103534	73,6191	1340,46	752,307	135,187	1612
156	1	mowing_postpo, 24/6/6/0,1 (D)	Grutto	0,010963	0,44275	0,103533	64,2	1280,81	716,198	135,186	1612
158	1	mowing_postpo, 24/9/0/0,1 (D)	Grutto	0,010907	0,441766	0,103522	181,307	2194,34	1266,06	135,17	1612
160	1	mowing_postpo, 25/6/6/0,1 (D)	Grutto	0,011984	0,483219	0,113204	74,8049	1347,97	756,853	147,813	1612
162	1	mowing_postpo, 25/4/6/0,1 (D)	Grutto	0,011973	0,484203	0,113217	79,6938	1378,94	775,594	147,83	1612
164	1	mowing_postpo, 25/8/0/0,1 (D)	Grutto	0,011938	0,483984	0,113219	168,845	2115,41	1218,29	147,832	1612
166	1	mowing_postpo, 26/5/6/0,1 (D)	Grutto	0,010317	0,512641	0,119514	84,8649	1411,69	795,384	156,632	1618
168	1	mowing_postpo, 26/4/6/0,1 (D)	Grutto	0,010319	0,511766	0,119523	95,0323	1476,08	834,359	156,645	1618
170	1	mowing_postpo, 26/8/0/0,1 (D)	Grutto	0,01033	0,512203	0,119515	4,68862	1669,61	894,826	156,634	1618
172	1	mowing_postpo, 27/4/6/0,1 (D)	Grutto	0,01064	0,528172	0,123037	104,436	1535,64	870,408	161,25	1618
174	1	mowing_postpo, 27/6/6/0,1 (D)	Grutto	0,010622	0,527625	0,123033	101,523	1517,19	859,24	161,245	1618
176	1	mowing_postpo, 28/6/0/0,1 (D)	Grutto	0,010907	0,542609	0,126331	21,5111	1776,15	959,313	165,567	1618
178	1	mowing_postpo, 29/6/0/0,1 (D)	Grutto	0,010918	0,540969	0,126338	8,24272	1692,12	908,45	165,576	1618
180	1	mowing_postpo, 29/6/0/0,1 (D)	Grutto	0,01092	0,540859	0,126335	8,24272	1692,12	908,45	165,572	1618
182	1	mowing_postpo, 30/6/0/0,1 (D)	Grutto	0,010918	0,541406	0,126335	10,1466	1704,18	915,748	165,572	1618
184	1	mowing_postpo, 31/6/0/0,1 (D)	Grutto	0,010925	0,541297	0,126329	21,1194	1773,67	957,811	165,564	1618
186	1	mowing_postpo, 33/6/0/0,1 (D)	Grutto	0,010916	0,541625	0,126336	29,4048	1826,15	989,572	165,573	1618
187	1	refuge strips, 18/6/6/6,1 (D)	Grutto	0,010988	0,192719	0,046111	30,417	214,724	129,601	58,7134	1572

Table 8.2 Results of the simulation of effectiveness and costs for the Grutto with minimal habitat quality of 0,12 for mowing measures with measureID10-88.

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
10	1	mowing_postpo, 15/0/0/0,1 (D)	Grutto	0,1203	0,263703	0,179377	-102,423	1472,53	893,467	11,4783	79
12	1	mowing_postpo, 15/16/6/0,1 (D)	Grutto	0,12015	0,26425	0,180086	180,558	1656,74	1111,37	11,3778	78
14	1	mowing_postpo, 16/0/0/0,1 (D)	Grutto	0,121725	0,178391	0,148867	80,2193	1309,96	743,291	4,09979	34
16	1	mowing_postpo, 17/14/6/0,1 (D)	Grutto	0,12	0,131852	0,126117	588,853	1239,38	903,803	1,02154	10
18	1	Massnahme, mowing_postpo, 17/4	Grutto	0	0	0	0	0	0	0	0
20	1	Massnahme, mowing_postpo, 17/4	Grutto	0	0	0	0	0	0	0	0
22	1	Massnahme, mowing_postpo, 17/4	Grutto	0	0	0	0	0	0	0	0
24	1	Massnahme, mowing_postpo, 17/4	Grutto	0	0	0	0	0	0	0	0
26	1	Massnahme, mowing_postpo, 17/4	Grutto	0	0	0	0	0	0	0	0
28	1	Massnahme, mowing_postpo, 17/6	Grutto	0	0	0	0	0	0	0	0
30	1	Massnahme, mowing_postpo, 17/6	Grutto	0	0	0	0	0	0	0	0
32	1	Massnahme, mowing_postpo, 17/8	Grutto	0	0	0	0	0	0	0	0
34	1	Massnahme, mowing_postpo, 17/8	Grutto	0	0	0	0	0	0	0	0
36	1	Massnahme, mowing_postpo, 17/10	Grutto	0	0	0	0	0	0	0	0
38	1	Massnahme, mowing_postpo, 17/10	Grutto	0	0	0	0	0	0	0	0
40	1	mowing_postpo, 17/12/6/0,1 (D)	Grutto	0,1202	0,131578	0,126103	546,448	1159,38	831,138	1,02144	10
42	1	Massnahme, mowing_postpo, 18/13	Grutto	0	0	0	0	0	0	0	0
44	1	Massnahme, mowing_postpo, 18/4	Grutto	0	0	0	0	0	0	0	0
46	1	Massnahme, mowing_postpo, 18/4	Grutto	0	0	0	0	0	0	0	0
48	1	Massnahme, mowing_postpo, 18/4	Grutto	0	0	0	0	0	0	0	0
50	1	Massnahme, mowing_postpo, 18/4	Grutto	0	0	0	0	0	0	0	0
52	1	Massnahme, mowing_postpo, 18/6	Grutto	0	0	0	0	0	0	0	0
54	1	Massnahme, mowing_postpo, 18/6	Grutto	0	0	0	0	0	0	0	0
56	1	Massnahme, mowing_postpo, 18/6	Grutto	0	0	0	0	0	0	0	0
58	1	Massnahme, mowing_postpo, 18/6	Grutto	0	0	0	0	0	0	0	0
60	1	Massnahme, mowing_postpo, 18/8	Grutto	0	0	0	0	0	0	0	0
62	1	Massnahme, mowing_postpo, 18/8	Grutto	0	0	0	0	0	0	0	0
64	1	Massnahme, mowing_postpo, 18/10	Grutto	0	0	0	0	0	0	0	0
66	1	Massnahme, mowing_postpo, 18/12	Grutto	0	0	0	0	0	0	0	0
68	1	mowing_postpo, 19/12/6/0,1 (D)	Grutto	0,121481	0,128734	0,125573	386,716	858,072	610,668	0,712	7
70	1	Massnahme, mowing_postpo, 19/4	Grutto	0	0	0	0	0	0	0	0
72	1	Massnahme, mowing_postpo, 19/4	Grutto	0	0	0	0	0	0	0	0
74	1	Massnahme, mowing_postpo, 19/4	Grutto	0	0	0	0	0	0	0	0
76	1	Massnahme, mowing_postpo, 19/4	Grutto	0	0	0	0	0	0	0	0

78	1	Massnahme, mowing_postpo, 19/6	Grutto	0	0	0	0	0	0	0	0
80	1	Massnahme, mowing_postpo, 19/6	Grutto	0	0	0	0	0	0	0	0
82	1	Massnahme, mowing_postpo, 19/8	Grutto	0	0	0	0	0	0	0	0
84	1	Massnahme, mowing_postpo, 19/8	Grutto	0	0	0	0	0	0	0	0
86	1	mowing_postpo, 19/10/6/0,1 (D)	Grutto	0,121584	0,1295	0,126044	222,815	548,894	371,734	0,714669	7
88	1	mowing_postpo, 19/10/6/6,1 (D)	Grutto	0,120402	0,129719	0,125305	296,381	559,082	409,962	0,811974	8
…	…	…	…	…	…	…	…	…	…	…	…

Table 8.3 Some results of the simulation of effectiveness and costs for the Grutto with a minimal habitat quality of 0.01 for measures with a combination of mowing and seasonal grazing with livestock 1 (= lively)

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
880	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
882	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
884	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
886	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
896	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
898	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
900	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
902	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
912	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,010011	0,171762	0,029225	104,975	1163,41	701,801	258,999	9847
914	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,010048	0,162148	0,0281	64,8645	909,376	546,36	246,776	9758
916	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,010001	0,16145	0,028024	53,4043	836,795	501,922	246,519	9774
918	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,010036	0,160649	0,027729	13,2936	582,761	346,409	243,323	9750
928	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,010002	0,249217	0,041777	122,165	1272,28	766,824	381,141	10137
930	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,010023	0,254612	0,043104	70,5946	945,667	567,046	396,081	10210
932	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,010031	0,234442	0,038995	76,3247	981,957	589,74	353,519	10073
934	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,010002	0,255419	0,042937	24,7538	655,342	389,839	394,466	10208
944	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,010042	0,269388	0,044535	139,356	1381,15	832,985	409,27	10211
946	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,010019	0,283904	0,047925	76,3247	981,957	589,111	441,2	10229
948	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,010009	0,239844	0,041116	99,245	1127,12	678,259	374,262	10114
950	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,010006	0,287183	0,047935	36,214	727,923	434,035	441,253	10228
960	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
962	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
964	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0

966	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
976	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
978	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
980	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
982	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
992	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,010041	0,137202	0,024152	84,189	1031,76	622,014	206,845	9516
994	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,010004	0,131175	0,022898	44,0784	777,731	466,515	194,812	9453
996	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,010002	0,140274	0,023178	35,4832	723,295	433,05	197,38	9462
998	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,010002	0,127553	0,022	74,0938	469,261	289,602	178,537	9017
1008	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,010059	0,187243	0,031864	101,379	1140,64	687,379	284,736	9929
1010	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,010083	0,192679	0,032964	49,8085	814,021	487,544	294,839	9938
1012	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,010007	0,178831	0,029699	58,4036	868,457	521,064	263,812	9870
1014	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,010001	0,192533	0,032781	6,83275	541,842	321,054	293,167	9937
1024	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,010001	0,179411	0,030582	118,57	1249,51	754,125	272,733	9909
1026	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,01002	0,196493	0,033195	55,5386	850,312	509,745	296,996	9941
1028	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,010004	0,166234	0,02814	81,324	1013,62	610,076	247,563	9775
1030	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,010009	0,200219	0,033203	18,2929	614,423	365,465	297,124	9943
…	…	…	…	…	…	…	…	…	…	…	…

Table 8.4 Some results of the simulation of effectiveness and costs for the Grutto with a minimal habitat quality of 0.01 for measures with a combination of mowing and seasonal grazing with livestock 2 (= quiet)

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
888	1	mowing1_grazing_seas, 15/4/0/0,3 (GV), 1 (D)	Grutto	0,01002	0,037061	0,017713	70,5946	826,214	508,282	9,37356	588
890	1	mowing1_grazing_seas, 15/4/0/0,3 (GV), 1 (D)	Grutto	0,010006	0,0294	0,01549	53,4043	731,094	440,589	6,85914	492
892	1	mowing1_grazing_seas, 15/4/0/0,4 (GV), 1 (D)	Grutto	0,010029	0,017228	0,011255	7,56352	477,442	250,696	1,67134	165
894	1	mowing1_grazing_seas, 15/4/0/0,4 (GV), 1 (D)	Grutto	0,010278	0,012648	0,011463	179,646	290,197	234,921	0,020633	2
904	1	mowing1_grazing_seas, 15/6/0/0,3 (GV), 1 (D)	Grutto	0,010001	0,076582	0,015333	87,7848	1054,54	641,469	92,6941	6717
906	1	mowing1_grazing_seas, 15/6/0/0,3 (GV), 1 (D)	Grutto	0,010004	0,061945	0,013805	59,1344	873,085	527,383	58,3588	4697
908	1	mowing1_grazing_seas, 15/6/0/0,4 (GV), 1 (D)	Grutto	0,01001	0,046184	0,020582	30,4839	604,268	359,184	13,0962	707
910	1	mowing1_grazing_seas, 15/6/0/0,4 (GV), 1 (D)	Grutto	0,010003	0,034915	0,017257	1,83343	445,736	248,31	8,66636	558
920	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,010012	0,208205	0,035166	104,975	1163,41	700,908	318,079	10050
922	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,010013	0,192706	0,032962	64,8645	909,376	545,868	294,844	9939
924	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,010016	0,18451	0,031828	53,4043	836,795	501,587	284,392	9928
926	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,010034	0,178785	0,030587	13,2936	582,761	346,146	272,498	9899
936	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,010021	0,259232	0,043282	122,165	1272,28	766,515	397,717	10210
938	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,010251	0,263061	0,04451	70,5946	945,667	567,083	409,041	10211
940	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,010044	0,241482	0,040121	76,3247	981,957	589,706	364,448	10093

942	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,010084	0,260801	0,043825	24,7538	655,342	389,816	402,747	10211
952	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,010042	0,269388	0,044535	139,356	1381,15	832,985	409,27	10211
954	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,010019	0,283904	0,047925	76,3247	981,957	589,111	441,2	10229
956	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,010009	0,239844	0,041116	99,245	1127,12	678,259	374,262	10114
958	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,010006	0,287183	0,047935	36,214	727,923	434,035	441,253	10228
968	1	mowing1_grazing_seas, 16/4/0/0,3 (GV), 1 (D)	Grutto	0,010014	0,025792	0,014414	49,8085	711,198	422,539	5,34452	412
970	1	mowing1_grazing_seas, 16/4/0/0,3 (GV), 1 (D)	Grutto	0,010038	0,021072	0,01273	32,6182	616,078	353,147	3,52869	308
972	1	mowing1_grazing_seas, 16/4/0/0,4 (GV), 1 (D)	Grutto	0,01237	0,01237	0,01237	287,128	287,128	287,128	0,011133	1
974	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
984	1	mowing1_grazing_seas, 16/6/0/0,3 (GV), 1 (D)	Grutto	0,010002	0,053376	0,013458	66,9987	922,893	555,469	39,4124	3254
986	1	mowing1_grazing_seas, 16/6/0/0,3 (GV), 1 (D)	Grutto	0,010008	0,04318	0,019804	38,3483	647,785	388,509	12,0847	678
988	1	mowing1_grazing_seas, 16/6/0/0,4 (GV), 1 (D)	Grutto	0,010019	0,033641	0,016758	12,5628	505,105	288,897	8,05394	534
990	1	mowing1_grazing_seas, 16/6/0/0,4 (GV), 1 (D)	Grutto	0,010012	0,024772	0,014001	62,6336	346,573	249,276	3,67958	292
1000	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,010007	0,157028	0,027268	84,189	1031,76	621,346	238,961	9737
1002	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,010001	0,147232	0,025412	44,0784	777,731	465,969	221,501	9685
1004	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,010005	0,152995	0,025191	35,4832	723,295	432,713	218,196	9624
1006	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,010002	0,137487	0,023553	74,0938	469,261	289,256	193,533	9130
1016	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,010059	0,187243	0,031864	101,379	1140,64	687,379	284,736	9929
1018	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,010083	0,192679	0,032964	49,8085	814,021	487,544	294,839	9938
1020	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,010007	0,178831	0,029699	58,4036	868,457	521,064	263,812	9870
1022	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,010001	0,192533	0,032781	6,83275	541,842	321,054	293,167	9937
1032	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,010001	0,179411	0,030582	118,57	1249,51	754,125	272,733	9909
1034	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,01002	0,196493	0,033195	55,5386	850,312	509,745	296,996	9941
1036	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,010004	0,166234	0,02814	81,324	1013,62	610,076	247,563	9775
1038	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,010009	0,200219	0,033203	18,2929	614,423	365,465	297,124	9943
…	…	…	…	…	…	…	…	…	…	…	…

Table 8.5 Some results of the simulation of effectiveness and costs for the Grutto with a minimal habitat quality of 0.12 for measures with a combination of mowing and seasonal grazing with livestock 1 (= lively)

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
880	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
882	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
884	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
886	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
896	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0

898	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
900	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
902	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
912	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,120089	0,183166	0,127691	132,528	1168,2	694,723	8,89499	86
914	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,120038	0,177895	0,126262	92,4169	946,251	547,748	5,01133	49
916	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,120436	0,175363	0,129835	80,9567	882,838	449,738	2,73432	26
918	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,120022	0,171825	0,126777	40,8461	660,892	375,863	3,49144	34
928	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,120596	0,276181	0,160799	149,718	1263,32	801,152	44,6748	343
930	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,120202	0,289641	0,164214	98,147	977,957	599,447	49,4809	372
932	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,120056	0,258608	0,152982	103,877	1009,66	626,441	37,2986	301
934	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,12013	0,283315	0,163845	52,3063	724,305	424,574	48,839	368
944	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,120113	0,297265	0,169207	166,908	1358,44	864,498	54,1379	395
946	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,120091	0,32586	0,177737	103,877	1009,66	621,688	62,3378	433
948	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,120187	0,289008	0,160472	126,797	1136,49	713,41	44,584	343
950	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,12015	0,327696	0,177589	63,7664	787,718	472,506	62,2859	433
960	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
962	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
964	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
966	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
976	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
978	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
980	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
982	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
992	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,122817	0,145884	0,137065	111,741	801,349	465,653	0,444091	4
994	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,129078	0,141259	0,134936	71,6308	632,884	327,915	0,327895	3
996	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,127939	0,135324	0,132477	63,0357	596,784	300,793	0,321919	3
998	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,12553	0,139666	0,133887	22,925	428,32	174,221	0,325346	3
1008	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,12032	0,208353	0,136973	128,932	1148,3	696,209	18,3064	165
1010	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,120039	0,213435	0,138685	77,3609	862,941	515,537	23,0286	205
1012	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,120291	0,193369	0,131247	85,9561	910,501	526,307	12,1194	114
1014	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,120217	0,213671	0,138477	34,3852	625,142	349,7	22,3211	199
1024	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,120046	0,193461	0,134638	146,122	1243,42	766,948	15,9223	146
1026	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,120034	0,224363	0,140129	83,091	894,648	534,251	24,4034	215
1028	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,120063	0,188911	0,127552	108,876	1037,33	588,849	9,40183	91
1030	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,120149	0,219419	0,13999	45,8454	688,555	395,121	24,2658	214
…	…	…	…	…	…	…	…	…	…	…	…

Table 8.6 Some results of the simulation of effectiveness and costs for the Grutto with a minimal habitat quality of 0.12 for measures with a combination of mowing and seasonal grazing with livestock 2 (= quiet)

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
888	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
890	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
892	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
894	1	Massnahme, mowing1_grazing_seas, 15/4	Grutto	0	0	0	0	0	0	0	0
904	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
906	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
908	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
910	1	Massnahme, mowing1_grazing_seas, 15/6	Grutto	0	0	0	0	0	0	0	0
920	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,120293	0,220929	0,141541	132,528	1168,2	727,771	25,3373	221
922	1	mowing1_grazing_seas, 15/8/0/0,3 (GV), 1 (D)	Grutto	0,120099	0,208502	0,136789	92,4169	946,251	569,707	19,9439	180
924	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,120067	0,189517	0,133389	80,9567	882,838	517,771	14,37	133
926	1	mowing1_grazing_seas, 15/8/0/0,4 (GV), 1 (D)	Grutto	0,120216	0,189367	0,131762	40,8461	660,892	359,633	12,4871	117
936	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,120094	0,295406	0,164625	149,718	1263,32	796,575	49,3381	370
938	1	mowing1_grazing_seas, 15/10/0/0,3 (GV), 1 (D)	Grutto	0,120158	0,297556	0,167904	98,147	977,957	603,097	52,9047	389
940	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,120138	0,264128	0,155127	103,877	1009,66	621,218	40,2088	320
942	1	mowing1_grazing_seas, 15/10/0/0,4 (GV), 1 (D)	Grutto	0,120221	0,295441	0,16613	52,3063	724,305	425,239	51,1348	380
952	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,120383	0,302301	0,169425	166,908	1358,44	863,988	54,0702	394
954	1	mowing1_grazing_seas, 15/12/0/0,3 (GV), 1 (D)	Grutto	0,120542	0,326854	0,177602	103,877	1009,66	624,338	62,4342	434
956	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,120302	0,277475	0,160611	126,797	1136,49	710,166	44,7527	344
958	1	mowing1_grazing_seas, 15/12/0/0,4 (GV), 1 (D)	Grutto	0,120025	0,324924	0,177948	63,7664	787,718	472,049	62,1234	431
968	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
970	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
972	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
974	1	Massnahme, mowing1_grazing_seas, 16/4	Grutto	0	0	0	0	0	0	0	0
984	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
986	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
988	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
990	1	Massnahme, mowing1_grazing_seas, 16/6	Grutto	0	0	0	0	0	0	0	0
1000	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,120017	0,167154	0,133354	111,741	826,532	526,552	1,40422	13
1002	1	mowing1_grazing_seas, 16/8/0/0,3 (GV), 1 (D)	Grutto	0,123918	0,15928	0,13918	71,6308	652,719	385,093	0,676415	6
1004	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,121276	0,159325	0,135485	63,0357	615,473	355,487	0,658458	6
1006	1	mowing1_grazing_seas, 16/8/0/0,4 (GV), 1 (D)	Grutto	0,124411	0,149504	0,14073	22,925	428,32	197,723	0,455964	4

1016	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,120379	0,207151	0,136516	128,932	1148,3	701,974	18,7982	170
1018	1	mowing1_grazing_seas, 16/10/0/0,3 (GV), 1 (D)	Grutto	0,120098	0,215602	0,139064	77,3609	862,941	516,444	22,7537	202
1020	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,12017	0,190119	0,13159	85,9561	910,501	524,305	12,3642	116
1022	1	mowing1_grazing_seas, 16/10/0/0,4 (GV), 1 (D)	Grutto	0,120317	0,214786	0,138545	34,3852	625,142	352,221	22,2198	198
1032	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,12044	0,19895	0,13489	146,122	1243,42	764,508	16,1706	148
1034	1	mowing1_grazing_seas, 16/12/0/0,3 (GV), 1 (D)	Grutto	0,120008	0,220343	0,139914	83,091	894,648	542,917	24,3661	215
1036	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,120311	0,18323	0,128473	108,876	1037,33	609,895	8,63721	83
1038	1	mowing1_grazing_seas, 16/12/0/0,4 (GV), 1 (D)	Grutto	0,120197	0,220725	0,13987	45,8454	688,555	397,762	24,4716	216
…	…	…	…	…	…	…	…	…	…	…	…

Table 8.7 Some results of the simulation of effectiveness and costs for the Zomertaling with a minimal habitat quality of 0.12 for seasonal grazing measures

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
393	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,582143	0,083413	3,34643	500,037	295,741	301,339	4014
394	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,582143	0,083413	3,34643	500,037	295,741	301,339	4014
395	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,51834	0,081691	73,223	463,746	284,09	284,531	3870
396	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,518107	0,081691	73,223	463,746	284,09	284,531	3870
397	3	grazing_seas_postpo, 15/0/0/0,4 (GV), 1 (D)	Zomertaling	0,0105	0,46725	0,073869	4,46191	28,2588	17,3112	256,489	3858
398	3	grazing_seas_postpo, 15/0/0/0,4 (GV), 1 (D)	Zomertaling	0,0105	0,46725	0,073869	4,46191	28,2588	17,3112	256,489	3858
399	3	Massnahme, grazing_seas_postpo, 15/0	Zomertaling	0	0	0	0	0	0	0	0
400	3	Massnahme, grazing_seas_postpo, 15/0	Zomertaling	0	0	0	0	0	0	0	0
401	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,582143	0,083413	3,34643	500,037	295,741	301,339	4014
402	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,582143	0,083413	3,34643	500,037	295,741	301,339	4014
403	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,518107	0,081691	73,223	463,746	284,09	284,531	3870
404	3	grazing_seas_postpo, 15/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010291	0,518107	0,081691	73,223	463,746	284,09	284,53	3870
405	3	grazing_seas_postpo, 15/0/0/0,4 (GV), 1 (D)	Zomertaling	0,0105	0,46725	0,073869	4,46191	28,2588	17,3112	256,489	3858
406	3	grazing_seas_postpo, 15/0/0/0,4 (GV), 1 (D)	Zomertaling	0,0105	0,46725	0,073869	4,46191	28,2588	17,3112	256,489	3858
407	3	Massnahme, grazing_seas_postpo, 15/0	Zomertaling	0	0	0	0	0	0	0	0
408	3	Massnahme, grazing_seas_postpo, 15/0	Zomertaling	0	0	0	0	0	0	0	0
409	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010349	0,587007	0,084036	20,5367	608,908	362,14	303,587	4014
410	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010358	0,586223	0,084035	20,5367	608,908	362,14	303,585	4014
411	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,01031	0,583214	0,08357	3,34643	500,037	295,741	301,904	4014
412	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,01031	0,583214	0,08357	3,34643	500,037	295,741	301,905	4014
413	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010574	0,47056	0,074517	27,3823	173,421	106,237	258,736	3858
414	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,01058	0,470824	0,074519	27,3823	173,421	106,237	258,744	3858
415	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010543	0,469157	0,074174	10,192	64,5494	39,5426	257,548	3858
416	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010543	0,469157	0,074174	10,192	64,5494	39,5426	257,547	3858
417	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010363	0,587268	0,084036	20,5367	608,908	362,14	303,589	4014
418	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010377	0,587007	0,084036	20,5367	608,908	362,14	303,587	4014
419	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,01031	0,583214	0,08357	3,34643	500,037	295,741	301,905	4014
420	3	grazing_seas_postpo, 17/0/0/0,3 (GV), 1 (D)	Zomertaling	0,01031	0,583214	0,08357	3,34643	500,037	295,741	301,904	4014
421	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,01058	0,471881	0,074518	27,3823	173,421	106,237	258,741	3858
422	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010574	0,472145	0,074518	27,3823	173,421	106,237	258,742	3858
423	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010543	0,469421	0,074174	10,192	64,5494	39,5426	257,547	3858
424	3	grazing_seas_postpo, 17/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010543	0,469157	0,074174	10,192	64,5494	39,5426	257,547	3858
425	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010599	0,599297	0,086058	37,727	717,78	428,539	310,894	4014

426	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010603	0,600603	0,086058	37,727	717,78	428,539	310,891	4014
427	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010373	0,587047	0,084082	9,07653	536,327	317,874	303,753	4014
428	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010373	0,586786	0,084081	9,07653	536,327	317,874	303,752	4014
429	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010004	0,484647	0,07654	50,3027	318,584	195,158	266,244	3865
430	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010004	0,485704	0,076522	50,3027	318,584	195,189	266,251	3866
431	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010686	0,475514	0,075179	21,6522	137,131	84,0054	261,038	3858
432	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010686	0,475514	0,075179	21,6522	137,131	84,0054	261,036	3858
433	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010599	0,601647	0,086063	37,727	717,78	428,539	310,911	4014
434	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010613	0,60008	0,086052	37,727	717,78	428,539	310,869	4014
435	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010373	0,586786	0,084081	9,07653	536,327	317,874	303,752	4014
436	3	grazing_seas_postpo, 19/0/0/0,3 (GV), 1 (D)	Zomertaling	0,010373	0,586786	0,084082	9,07653	536,327	317,874	303,754	4014
437	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010004	0,48359	0,076529	50,3027	318,584	195,176	266,273	3866
438	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010004	0,484911	0,076523	50,3027	318,584	195,197	266,255	3866
439	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010686	0,475514	0,075179	21,6522	137,131	84,0054	261,035	3858
440	3	grazing_seas_postpo, 19/0/0/0,4 (GV), 1 (D)	Zomertaling	0,010686	0,475514	0,075179	21,6522	137,131	84,0054	261,037	3858
…	…	…	…	…	…	…	…	…	…	…	…

Table 8.8 Some results of the simulation of effectiveness and costs for the Zomertaling with a minimal habitat quality of 0.12 for rotational grazing measures

measureID	speciesID	m_name	species_name	qual_min	qual_max	qual_medium	cost_min	cost_max	cost_medium	eff_area	nr_pixel
198	3	grazing_rot_postpo, 15/0/0/0,1 (D)	Zomertaling	0,120047	0,92125	0,18472	342,116	2295,46	1436,26	313,709	1887
200	3	grazing_rot_postpo, 15/16/6/0,1 (D)	Zomertaling	0,120033	0,89125	0,183705	311,146	2099,31	1316,97	290,823	1759
202	3	grazing_rot_postpo, 16/0/0/0,1 (D)	Zomertaling	0,122168	0,8375	0,195832	312,735	1976,15	1336,84	218,372	1239
204	3	grazing_rot_postpo, 17/14/6/0,1 (D)	Zomertaling	0,120389	0,72375	0,183733	248,835	1507,3	1073,55	164,698	996
206	3	grazing_rot_postpo, 17/4/10/6,1 (D)	Zomertaling	0,123561	0,158594	0,137579	147,314	935,585	458,916	0,495284	4
208	3	Massnahme, grazing_rot_postpo, 17/4	Zomertaling	0	0	0	0	0	0	0	0
210	3	Massnahme, grazing_rot_postpo, 17/4	Zomertaling	0	0	0	0	0	0	0	0
212	3	Massnahme, grazing_rot_postpo, 17/4	Zomertaling	0	0	0	0	0	0	0	0
214	3	grazing_rot_postpo, 17/4/10/6,1 (D)	Zomertaling	0,123931	0,157969	0,137307	147,314	935,585	458,916	0,494304	4
216	3	Massnahme, grazing_rot_postpo, 17/6	Zomertaling	0	0	0	0	0	0	0	0
218	3	Massnahme, grazing_rot_postpo, 17/6	Zomertaling	0	0	0	0	0	0	0	0
220	3	grazing_rot_postpo, 17/8/4/6,1 (D)	Zomertaling	0,120562	0,199531	0,137933	122,079	784,389	533,361	4,59317	37
222	3	grazing_rot_postpo, 17/8/6/6,1 (D)	Zomertaling	0,121125	0,197813	0,137697	112,133	717,84	488,3	4,58532	37
224	3	grazing_rot_postpo, 17/10/6/0,1 (D)	Zomertaling	0,120047	0,401719	0,188557	202,136	1230,95	831,609	34,6191	204
226	3	grazing_rot_postpo, 17/10/4/6,1 (D)	Zomertaling	0,120186	0,403906	0,188662	186,392	1151,82	775,426	34,6384	204
228	3	grazing_rot_postpo, 17/12/6/0,1 (D)	Zomertaling	0,1225	0,620469	0,175684	242,201	1470,14	1033,86	111,472	705
230	3	grazing_rot_postpo, 18/13/6/0,1 (D)	Zomertaling	0,120442	0,634219	0,173836	210,358	1291,82	915,364	126,883	811

232	3	Massnahme, grazing_rot_postpo, 18/4	Zomertaling	0	0	0	0	0	0	0	0
234	3	Massnahme, grazing_rot_postpo, 18/4	Zomertaling	0	0	0	0	0	0	0	0
236	3	Massnahme, grazing_rot_postpo, 18/4	Zomertaling	0	0	0	0	0	0	0	0
238	3	Massnahme, grazing_rot_postpo, 18/4	Zomertaling	0	0	0	0	0	0	0	0
240	3	Massnahme, grazing_rot_postpo, 18/6	Zomertaling	0	0	0	0	0	0	0	0
242	3	Massnahme, grazing_rot_postpo, 18/6	Zomertaling	0	0	0	0	0	0	0	0
244	3	Massnahme, grazing_rot_postpo, 18/6	Zomertaling	0	0	0	0	0	0	0	0
246	3	Massnahme, grazing_rot_postpo, 18/6	Zomertaling	0	0	0	0	0	0	0	0
248	3	grazing_rot_postpo, 18/8/8/0,1 (D)	Zomertaling	0,12035	0,230937	0,147794	118,025	761,478	523,961	7,58181	57
250	3	grazing_rot_postpo, 18/8/6/6,1 (D)	Zomertaling	0,120758	0,228437	0,147747	85,6434	581,835	400,564	7,57941	57
252	3	grazing_rot_postpo, 18/10/6/0,1 (D)	Zomertaling	0,121416	0,448906	0,201713	168,519	1044,94	708,162	41,2099	227
254	3	grazing_rot_postpo, 18/12/6/0,1 (D)	Zomertaling	0,121156	0,608594	0,174121	205,723	1265,87	889,373	110,48	705
256	3	grazing_rot_postpo, 19/12/6/0,1 (D)	Zomertaling	0,1204	0,469375	0,207567	193,042	1180,63	801,615	43,7136	234
258	3	Massnahme, grazing_rot_postpo, 19/4	Zomertaling	0	0	0	0	0	0	0	0
260	3	Massnahme, grazing_rot_postpo, 19/4	Zomertaling	0	0	0	0	0	0	0	0
262	3	Massnahme, grazing_rot_postpo, 19/4	Zomertaling	0	0	0	0	0	0	0	0
264	3	Massnahme, grazing_rot_postpo, 19/4	Zomertaling	0	0	0	0	0	0	0	0
266	3	Massnahme, grazing_rot_postpo, 19/6	Zomertaling	0	0	0	0	0	0	0	0
268	3	Massnahme, grazing_rot_postpo, 19/6	Zomertaling	0	0	0	0	0	0	0	0
270	3	grazing_rot_postpo, 19/8/4/6,1 (D)	Zomertaling	0,120352	0,185938	0,132395	89,8427	622,068	417,07	3,09804	26
272	3	grazing_rot_postpo, 19/8/0/0,1 (D)	Zomertaling	0,120758	0,182969	0,132501	151,424	950,34	639,681	2,98128	25
274	3	grazing_rot_postpo, 19/10/6/0,1 (D)	Zomertaling	0,120269	0,377813	0,181651	155,985	975,579	657,226	30,4085	186
276	3	grazing_rot_postpo, 19/10/6/6,1 (D)	Zomertaling	0,12	0,378594	0,182268	139,603	939,984	625,673	30,1835	184
…	…	…	…	…	…	…	…	…	…	…	…

8.2 Meadow bird management: optimisation

The ECOPAY software tool can be used to compare the output of current measures of the existing agri-environment scheme concerning time of mowing, grazing and the amount of fertilizer with modifications of these measures (e.g. postponement of mowing, grazing dates).

The results for possible adjustments (cp. table 8.9) on meadow bird management are given in table 8.10. The effect was investigated on a combination of a wader (godwit), a duck (northern shoveler) and a songbird (medow pipit). The three bird species get an equal importance. Based on the results it is possible to conclude that the cost effectiveness of the meadow bird policy can be increased by following improvements:

For seasonal grazing:

- Not allowing cattle during the resting period (both measures reach the target, but the cost of adjusted small-1 is lower than the cost of current small-1)
- Not allowing young cattle, because they are more wild than the adult cattle (wild cows do not reach the target of graspieper and slobeend)
- The combination of both measures is even the most cost-effective one (small-3b, adjusted). Reducing the cattle during the grazing period from 4 to 3 does not improve the cost-effectiveness.

For rotational grazing and mowing:

- A second delay from 6 to 8 weeks after the first mowing delay

Table 8.9 Adjustments of current policy

	Current	**Adjusted**
Small-1	2 GV during resting period	0 GV during resting period
Small-2a	Up to 4 GV during grazing period	Reducing to max. 3 GV
Small-2b	GV: 4+2	GV: 3+0
Small-3a	Wild can be possible	Only calm
Small-3b	Wild can be possible	Only calm + 0 GV during resting period
Small-3c	Wild can be possible	Only calm + 0 GV resting + 3GV grazing period
Small-4a	Only delay first cut	Delay first and second cut (8 QM’s)
Small-4b	Only delay first cut	Delay first and second cut (9 QM’s)
Small-5	Resting period from 1 April	Resting period from 22 March (future: effect of EMT-fertilisation need to be added)

Table 8.10 Result of small adjustments

		Delived			% target	Cost	Total required area (ha)
		meadow pipit	godwit	Northern shoveler			
Small-1	current	145	113	99	100	100	100
	Adjusted	154	120	100	100	84	100
Small-2a	current	151	132	100	100	96	104
	adjusted	147	120	99	100	103	99
Small-2b	current	151	132	100	100	96	104
	adjusted	111	102	99	100	90	88
Small-3a	current	90	132	78	89	87	82
	adjusted	144	110	99	100	99	99
Small-3b	current	90	132	78	89	87	82
	adjusted	126	99	110	100	66	87
Small-3c	current	90	132	78	89	87	82
	adjusted	108	100	107	100	92	91
Small-4a	current	100	194	116	100	100	100
	adjusted	104	166	99	100	79	85
Small-4b	current	100	194	116	100	100	100
	adjusted	105	167	100	100	96	86

8.3 Analysis of (cost) effectiveness of agri-environmental measures by wader species

In this subchapter, it was decided to do an analysis of the effectiveness and the cost effectiveness of a selection of agri-environmental measures for the wader species, i.e. lapwing, oystercatcher, curlew, godwit and redshank. The analysis is done with a fixed target area and follows the logic of a grant system with a fixed amount.

8.3.1 Selection of agri-environmental measures

The ECOPAY dataset includes besides the current measures 3.512 alternative measures. This dataset was reduced to 745 measures after the initiatial test runs. The ECOPAY dataset includes also measures with an early start of the resting period (March 21), with a postphonement of the third cut and with two cattle types (young and adult). An early start of the resting period has currently no additional ecological effect because the effect of fertilizer application on meadow birds is not yet included in the model. A postphonement of the third cut has mostly no effect on the meadow bird egg and chicken survival because the third cut is usually done after the critical breeding period of the last batch of wader chicks. In economic sense the third cut is also less important because the grass growth is already in decline. Cattle type was of no influence by mowing and mowing + rotational grazing. These grass use systems are characterized by a high cattle density during a short period. This high cattle density creates already a high trampling pressure on meadow eggs and chicks. Cattle type does not create an additional effect in those grass use systems.

The 745 alternative measures consists of 47 mowing measures, 84 seasonal grazing measures, 424 mowing + seasonal grazing measures, 100 rotational grazing measures and

90 mowing + rotational grazing measures. This is still a lot of measures and therefore it was checked if a further reduction of measures was possible.

For the grass use systems mowing, rotational grazing and mowing + rotational grazing a further reduction was possible because there was no influence of the postphonement of the second cut on the ecological result (figure 8.1 – 8.3), while the economic cost differ between them. The cost was higher when the in-between period was higher than the economical optimum, i.e. 4 or 6 quartermonths depending on the time of the first cut. The agri-environmental measure with the lowest cost was selected. In addition, agri-environmental measures without an ecological result, i.e. variants with first cut at May 21 by mowing ,were also removed from the selected measures. After this reduction 17 mowing measures, 18 rotational grazing measures and 16 mowing + rotational grazing measures were left.

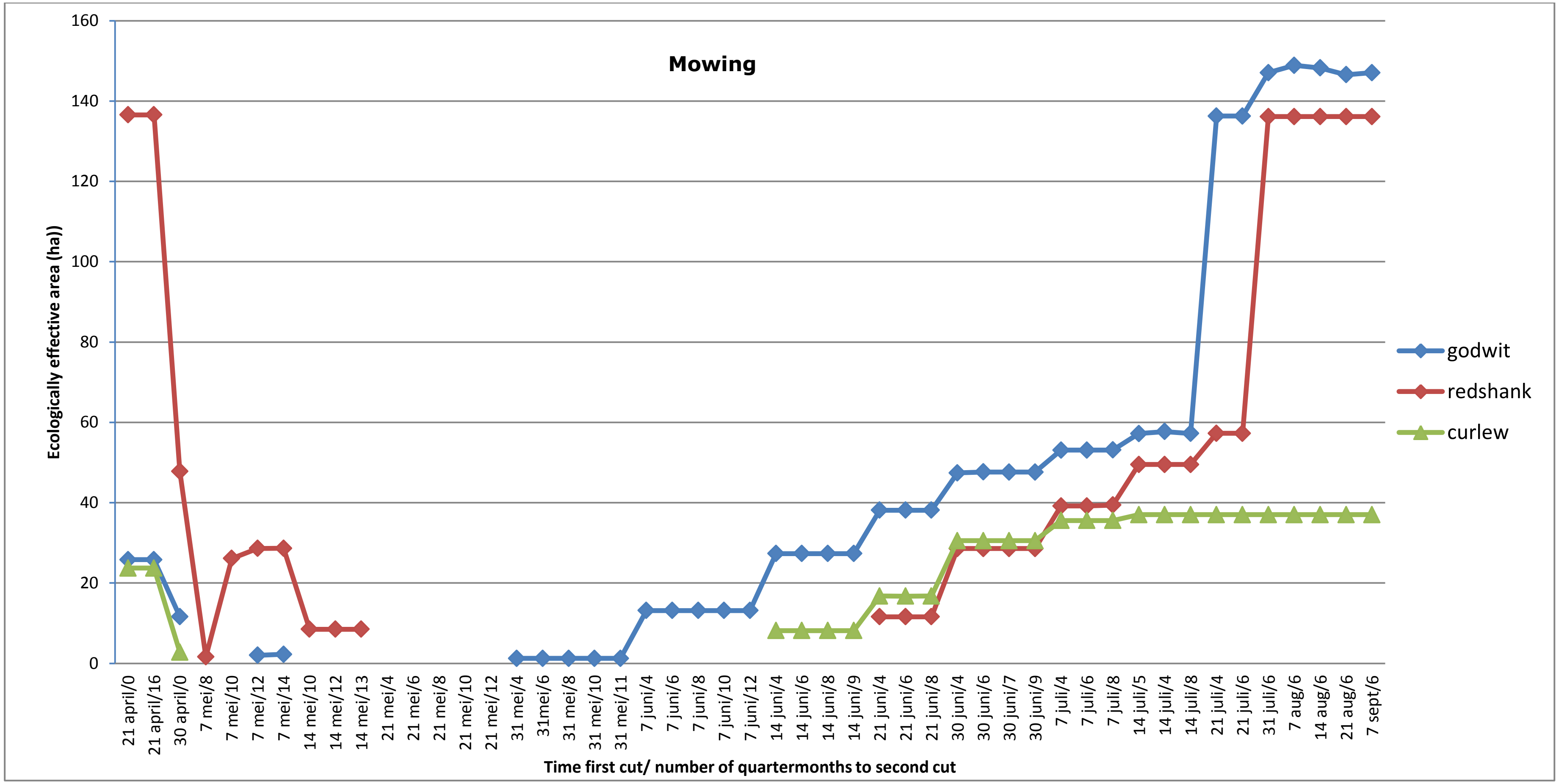


Figure 8.1 No influence of postphonement of second cut on the ecologically effective area by grass use system mowing

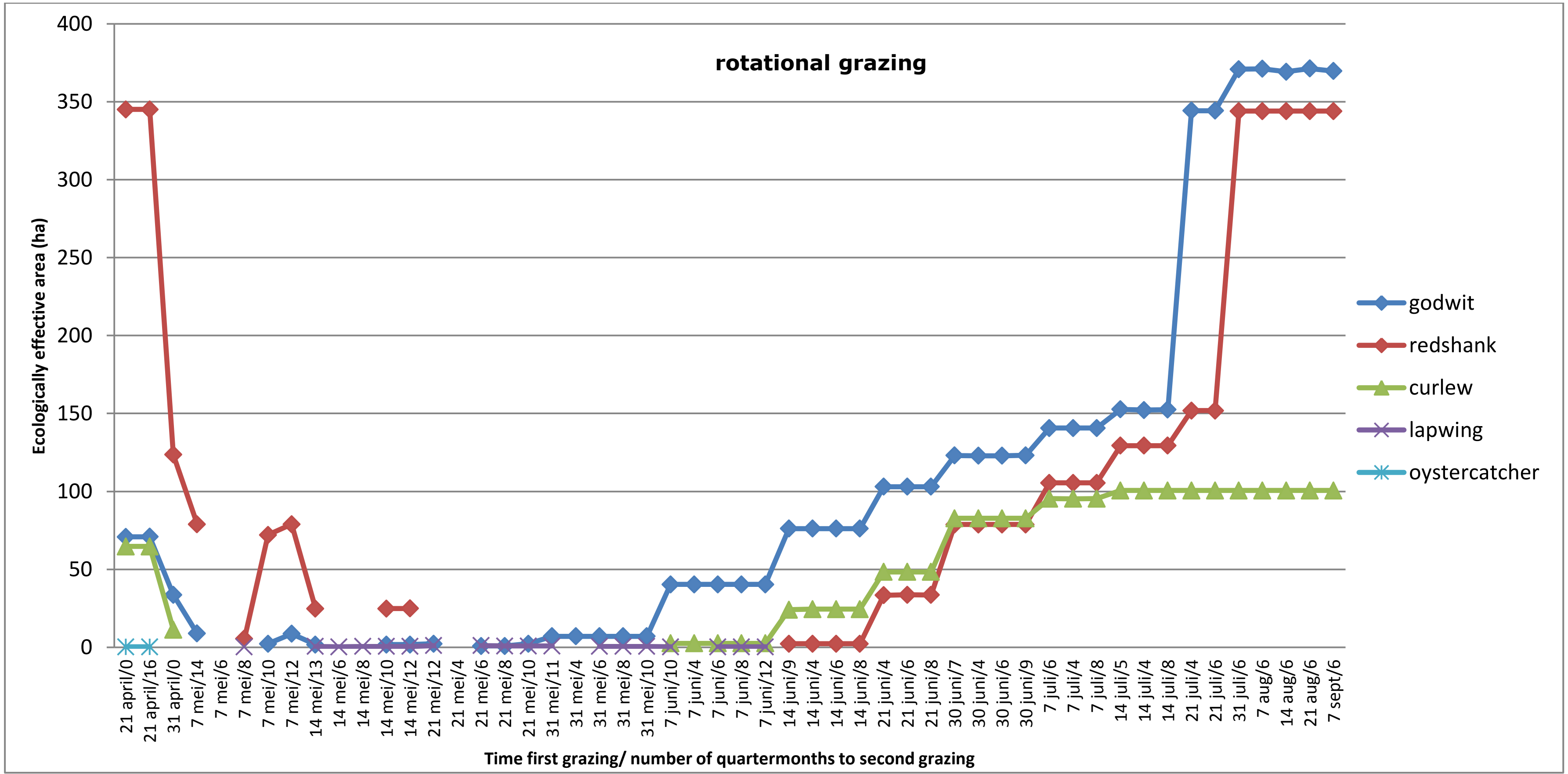


Figure 8.2 No influence of postphonement of second cut on the ecologically effective area by grass use system rotational grazing

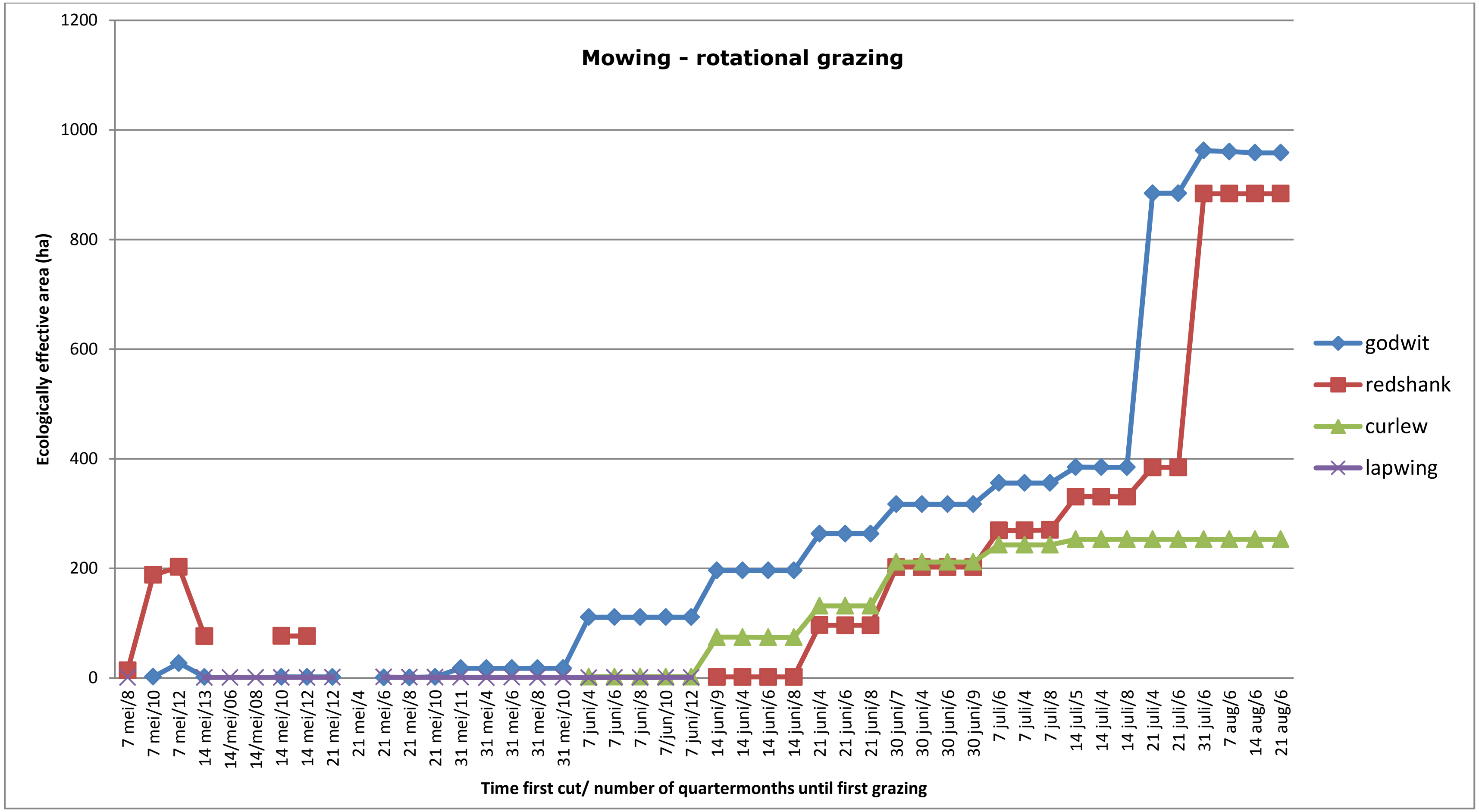


Figure 8.3 Maximal possible ecologically effective area of the different agri-environmental measures in scenario without predation and by grass use system mowing - rotational grazing

For seasional grazing a further reduction was also possible, because the agri-environmental measures which allows two cows during the resting period does not result in an ecologically effective area for godwit, redshank, curlew and oystercatcher and in a really small one by lapwing (<1,14 ha) (figure 8.4). Thus, those measures can be neglected in ecological sense. In addition, it was decided to keep only the measures with adult cows (figure 8.5). Adult cows result in higher ecological results than young cows for the measures with resting period until July 7 or 21 depending on the bird species, while the economic cost of both is the same. For longer resting periods, there is no difference between young and adult cows. Only 22 seasonal grazing measures were kept.

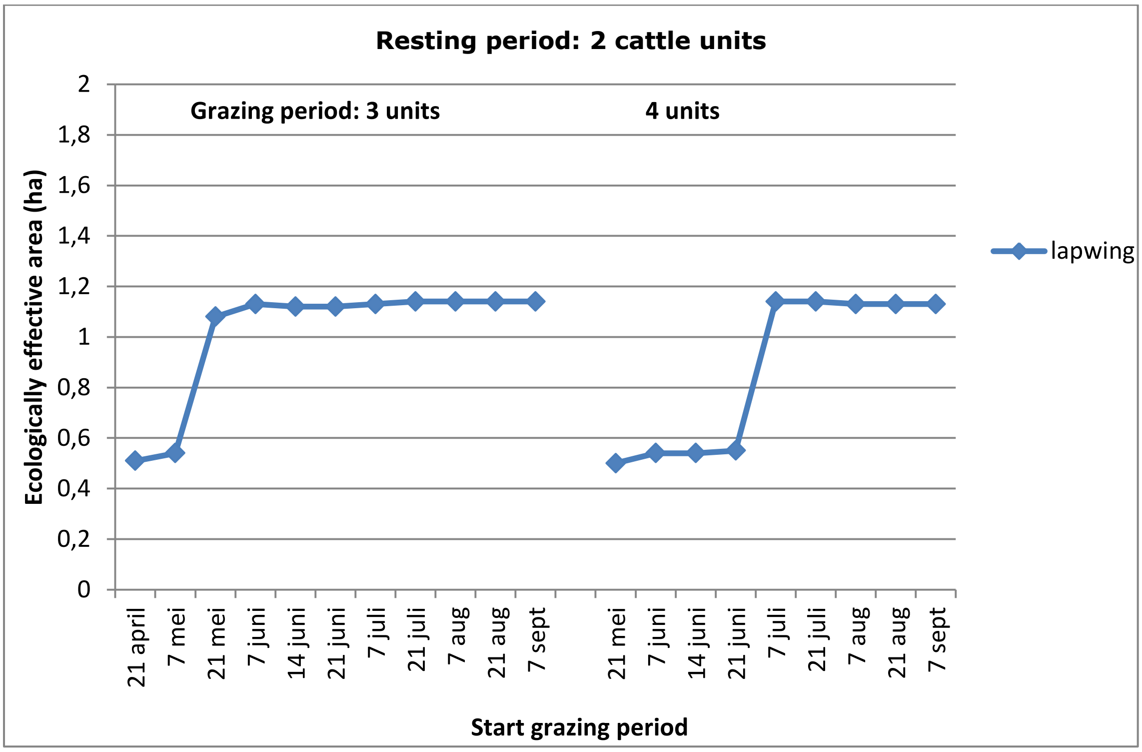
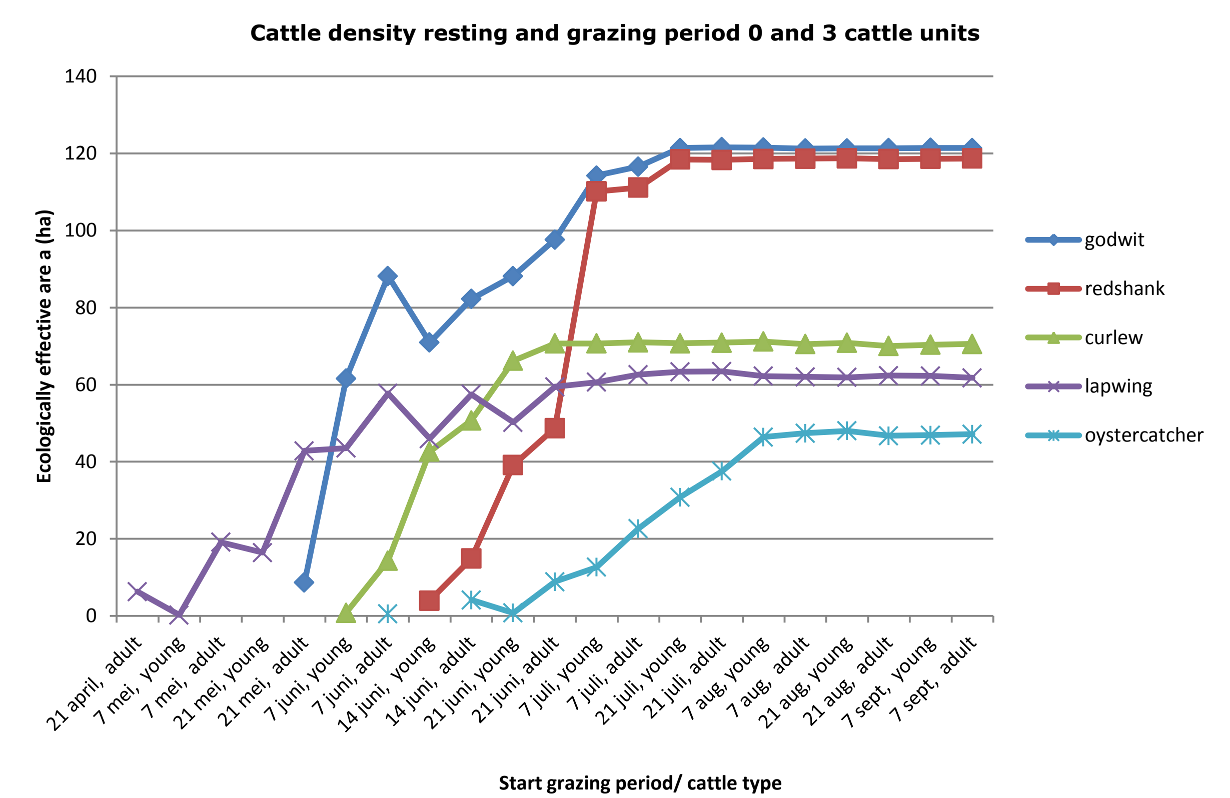


Figure 8.4 The ecological result of agri-environmental measures by seasonal grazing when the cattle density is 2 cattle units during resting period (no effective area for godwit, redshank, curlew and oystercatcher)



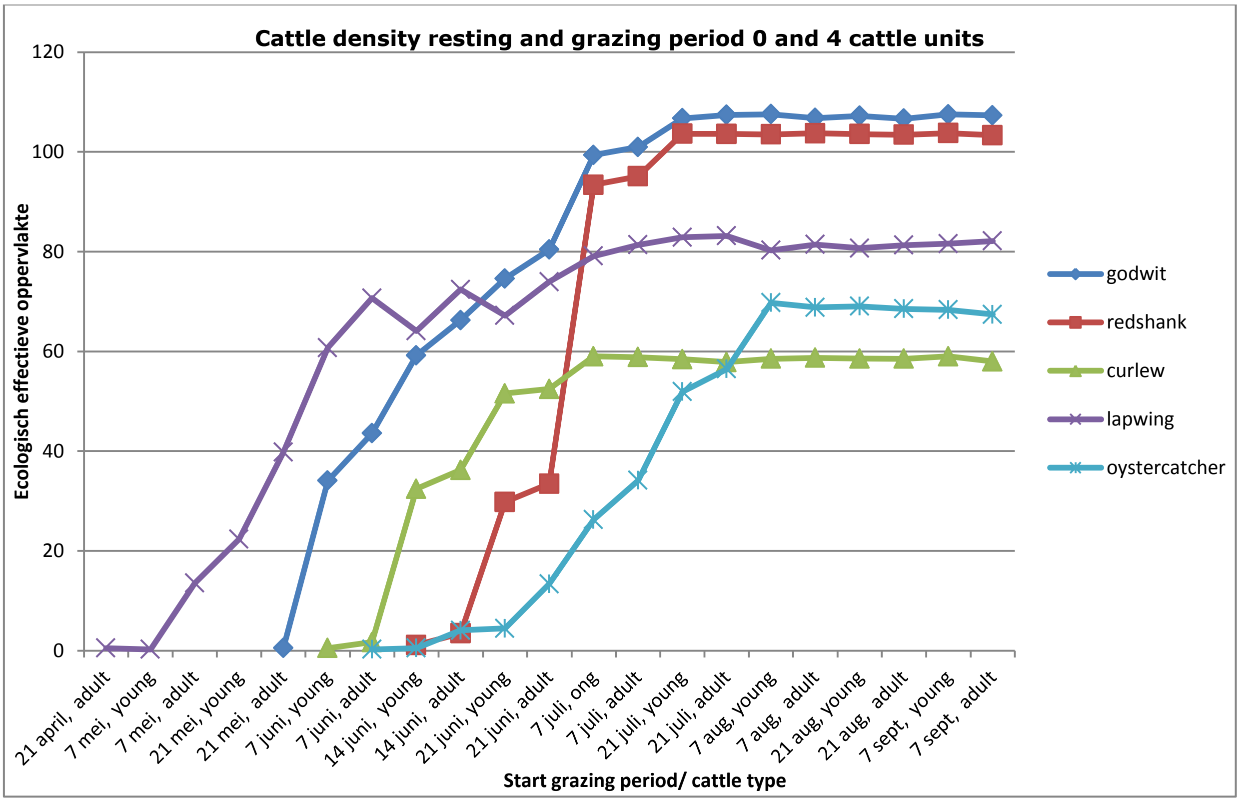


Figure 8.5 The influence of cattle type on the ecological result of agri-environmental measures by seasonal grazing when the cattle density is 0 cattle units during resting period

For mowing + seasonal grazing a further reduction was also possible. It was possible to distinguish two variants:

- variant with an early or normal first cut (April 21 to May 31) (figure 8.6)
- variant with a late first cut (June 7 to August 7) (figure 8.7)

The following conclusions can be drawn from figure 8.6 and 8.7:

- The 2/3-variant (resp. 2 and 3 cattle units during resting and grazing period) results in the same ecological result than the 2/4 variant. The 2/3 variant has a higer compensation cost than the 2/4 variant and therefore the 2/3 variant was not kept as a possible agr-environmental measure.
- Cattle type has only an influence by the variant with an early or normal first cut and when the resting period is short (intercutperiod less than 8 quartermonths). For the agri-environmental measures with a short intercut period, adult cows result in a higher ecological result than young cows. Therefore? It was decided to keep only the agri-environmental measures with adult cows.
- Delay of second cut has no influence by the variant with a late first cut. The variant with the lowest economic cost was kept in the selected agri-environmental measures.

After this reduction only 66 mowing + seasonal grazing measures were kept.

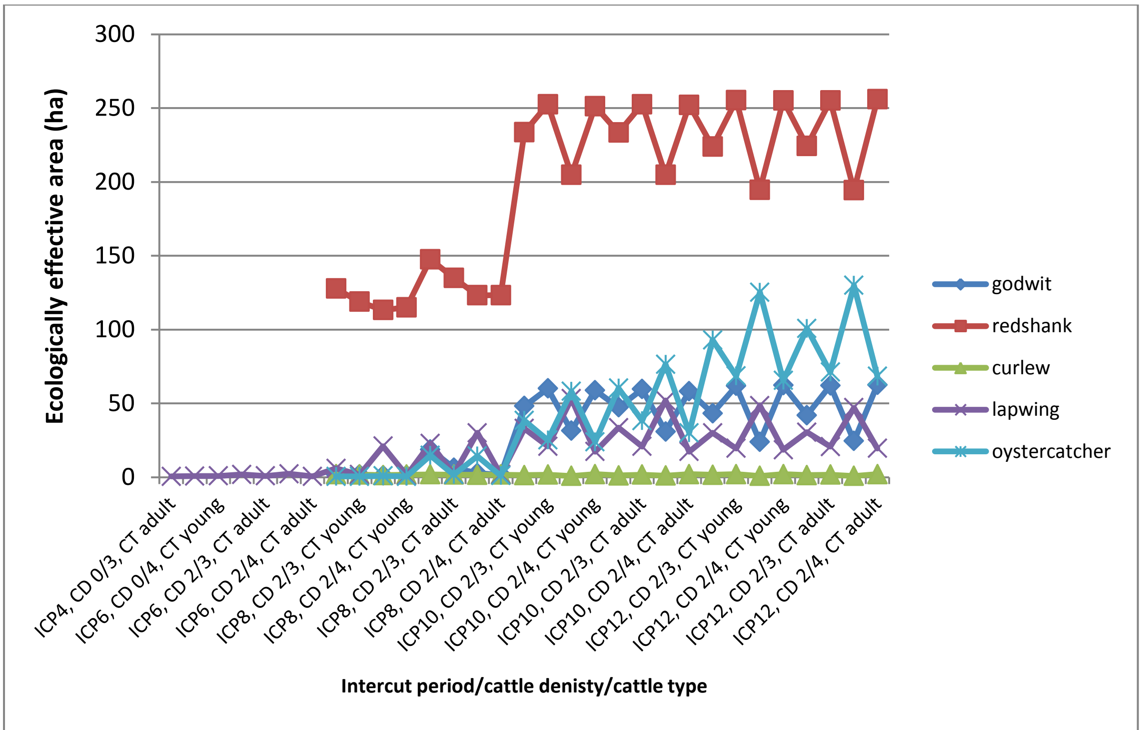


Figure 8.6 Agri-environmental measures: ecologically effective area by all measures with the first cut on April 30 (similar for the variants with a first cut between April 21 and May 30)

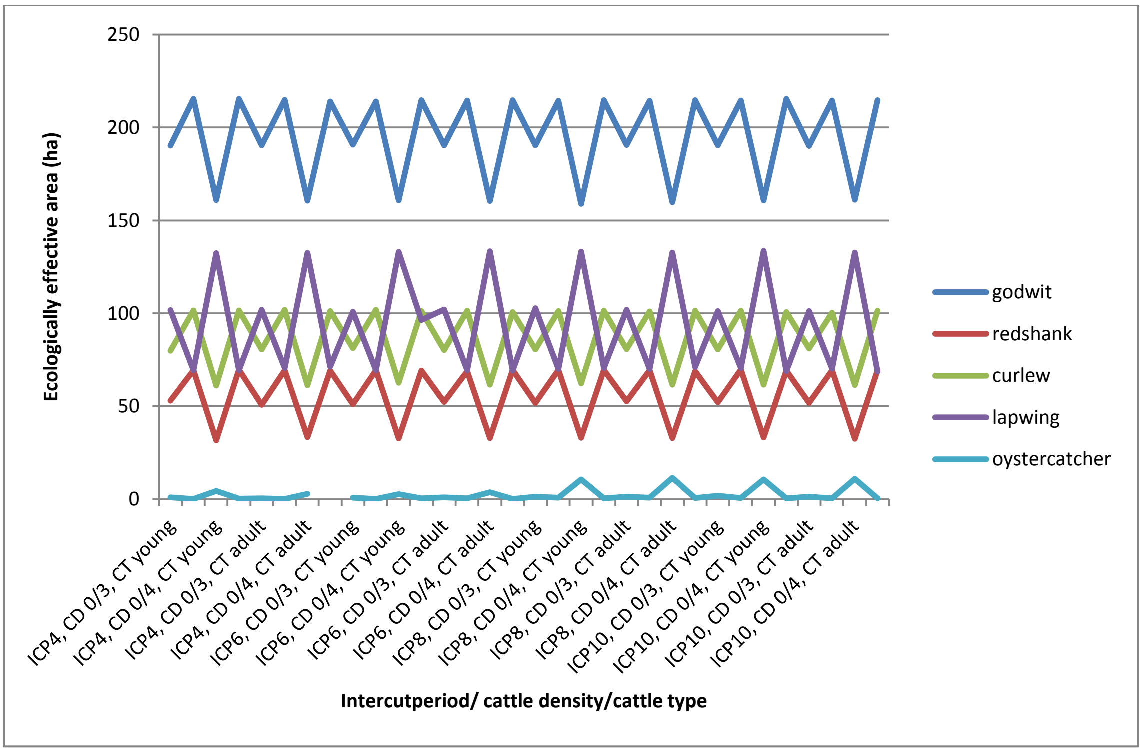


Figure 8.7 Agri-environmental measures: ecologically effective area by all measures with the first cut on June 21 (similar for the variants with a first cut between June 7 and August 7)

Target area

This is the minimum ecological effective area which is targeted by policy-makers. In policy documents this target area is not mentioned. Therefore, it was decided to calculate a target area based on the official indicated meadow bird areas (5114 ha) and on the grassland nature reserves in the Northern Campine region (724 ha). A realisation rate of 20% by the meadow bird areas seems us feasible. In addition the grassland nature reserves do not have always meadow bird as objective, botanical management is at least of the same importance. Therefore, it was decided that only 50% of the nature reserves have meadow birds as objective. Thus the target area is 1384, 8 ha (=0,2*5114 ha + 0,5 * 362 ha) and the target ecological effective area is 203,6 ha (=0,147 * 1384,8). Thus when the grassland use distribution is taken into account, this means 20,36 for mowing, 25,44 for rotational and seaqsonal grazing and 66,16 for the mixed systems.

Logic of grant system

The optimisation module in ECOPAY follows the logic of an auction (a farmer gets a compensation which equals his/her economic loss), while in the Flemish policy practice the logic of grants (all farmers gets the same amount regardless of their specific economic loss) prevails. The difference between both systems is illustrated in figure 8.8. A grant system will give some farmers a higher compensation than their economic loss, while an auction take this specific loss into account. An auction seems on the first hand cheaper than a grant system. However, an auction has a higer public transaction cost and therefore it is not in all situations a cheaper option.

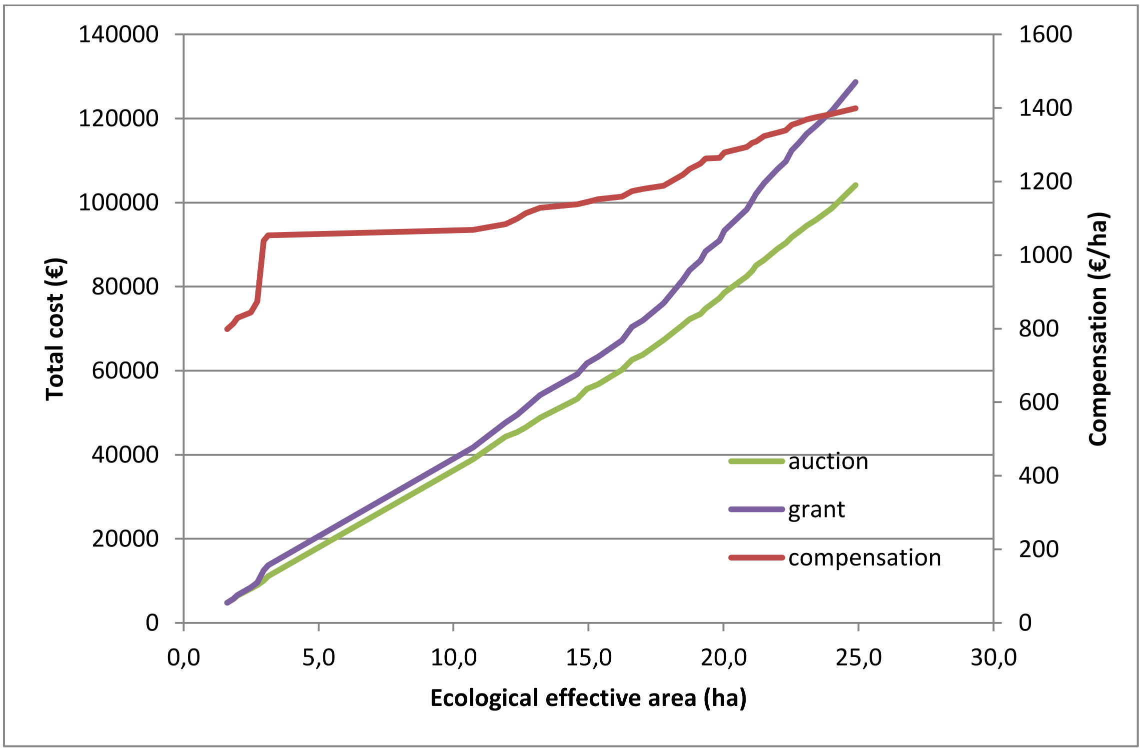


Figure 8.8 The difference between grants and auctions when the potential grass growth of a pixel varies for the case mowing with first cut at June 30 and second cut at August 15.

To apply the logic of a grant system, it was decided to use the simulation module of an agri-environmental scheme in ECOPAY. This module was used in an iterative way to find the necassary compensation which is high enough to convince enough farmers to reach the target ecological effective area of the considered grassland use system.

8.3.2 How effective are the current policy and the policy alternatives?

For the five selected wader species, it was examined which of the current measures (delay of grazing and mowing to 14 June) could result in the target area. This was done with and without time dependent predation. If the current measures could nor reach the target area, it was checked if this target could be reach by one of the alternative measures(preference for measure which was most close to the current policy and could reach the target). This result is show in tables 8.10 - 8.11 and figures 8.9 - 8.18.

The results suggest that the agri-envoronmental measures, including the variants with a longer or shorter delay of mowing or grazing, are only partially effective. More specifically, the following conclusions can be made:

- In the scenario with predation the current meausures are unsuitable for all wader species. This is also the case for all alternative measures when curlew, lapwing or oystercatcher is the target species. In addition, there are no suitable alternative measures when godwit or redshank is the target species and when the grass use system is seasonal grazing or mowing.
- In the scenario without predation the current measures are suitable for godwit for all grass use systems.
- Redshank and curlew are species which have a preference for late mowing or grazing (mowing from 31 July, other measures from 21 July)
- For lapwing and oystercatcher it is not possible to design agri-environmental measures ‘delayed mowing’ or ‘delayed grazing’ for the grass use systems ‘mowing’, rotational

grazing or a combination of both. This is because both species have a preference for short grass (<15 cm) and prefer more a continuous grazing.

- By seasonal grazing it is important that no cattle graze during the resting period, otherwise the benefit for meadow birds of delayed grazing get small. This is also the case for lapwing and oystercatcher when mowing is followed by seasonal grazing.
- Cattle type is not important, when the first mowing or grazing cut is 14 June or later.

Table 8.11 Current or alternative meadow bird measures to reach the target ecological effective area in the scenario without predation

Without predation	Seaonal grazing	Rotational grazing	mowing	mowing + rotational grazing	Mowing + seasonal grazing
Godwit	14 June; no cows in resting period	14 June	14 June	14 June	14 June; 2 cattle units in resting period
Redshank	*21 June;* no cows in resting period	*21 June*	*30 June*	*21 June*	*21 June;* 2 cattle units in resting period
Curlew	14 June; no cows in resting period	*21 June*	*30 June*	*21 June*	*21 June;* 2 cattle units in resting period
Lapwing	14 June; no cows in resting period				14 June; no cows in resting period
Oyster-catcher	*7 July;* no cows in resting period				*14 July;* no cows in resting period

(red: target is not reached with current and alternative measures; orange: target is not reached with current meaures, but it is possible with alternative measures, in italic the alternative measure which reach the target and with the smallest difference with the current measure is given; green: target is reached by one of the current measures)

Table 8.12 Current or alternative meadow bird measures to reach the target ecological effective area in the scenario withpredation

With predation	Seasonal grazing	Rotational grazing	Mowing	Mowing + rotational grazing	Mowing + seasonal grazing
Godwit		*30 June*		21 *June*	*7 July;* 2 cattle units in resting period
Redshank		*14 July*		*7 July*	*14 July;* 2 cattle units in resting period
Curlew					
Lapwing					
Oyster-catcher					

(red: target is not reached with current and alternative measures; orange: target is not reached with current meaures, but it is possible with alternative measures, in italic the alternative measure which reach the target and with the smallest difference with the current measure is given; green: target is reached by one of the current measures)

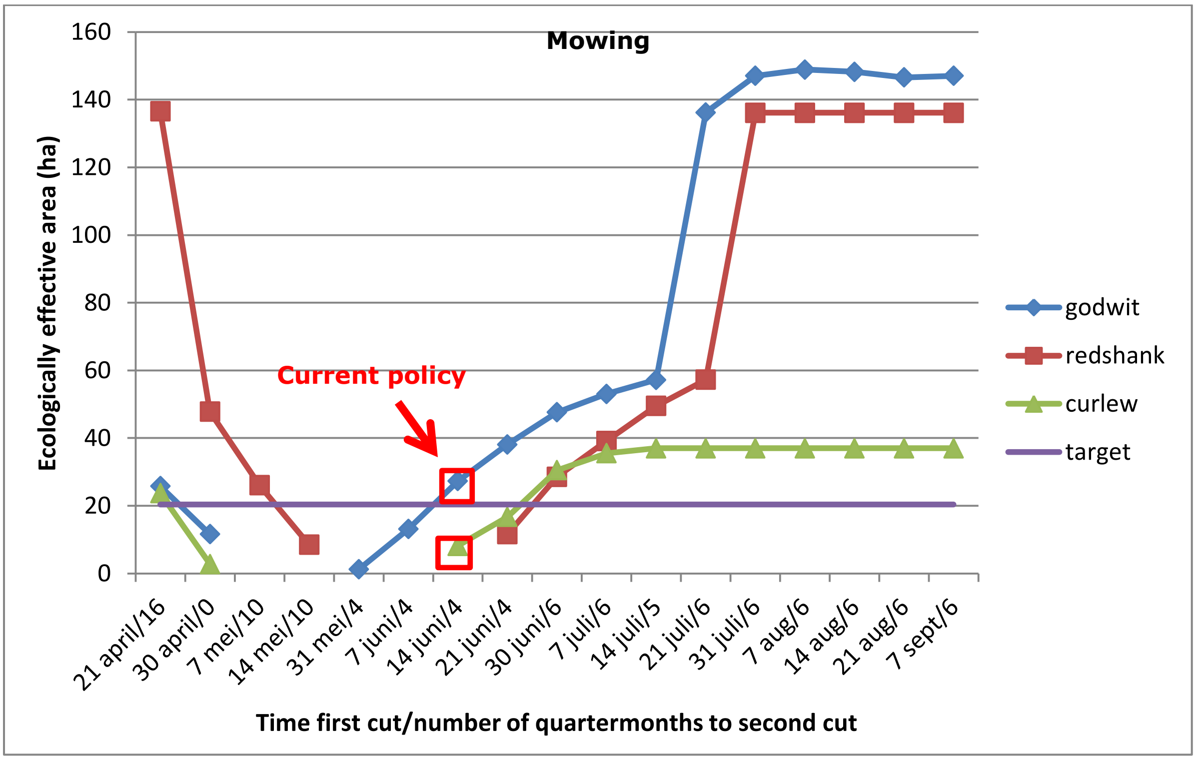


Figure 8.9 Maximal possible ecologically effective area of the different agri-environmental measures in scenario without predation and by grass use system mowing

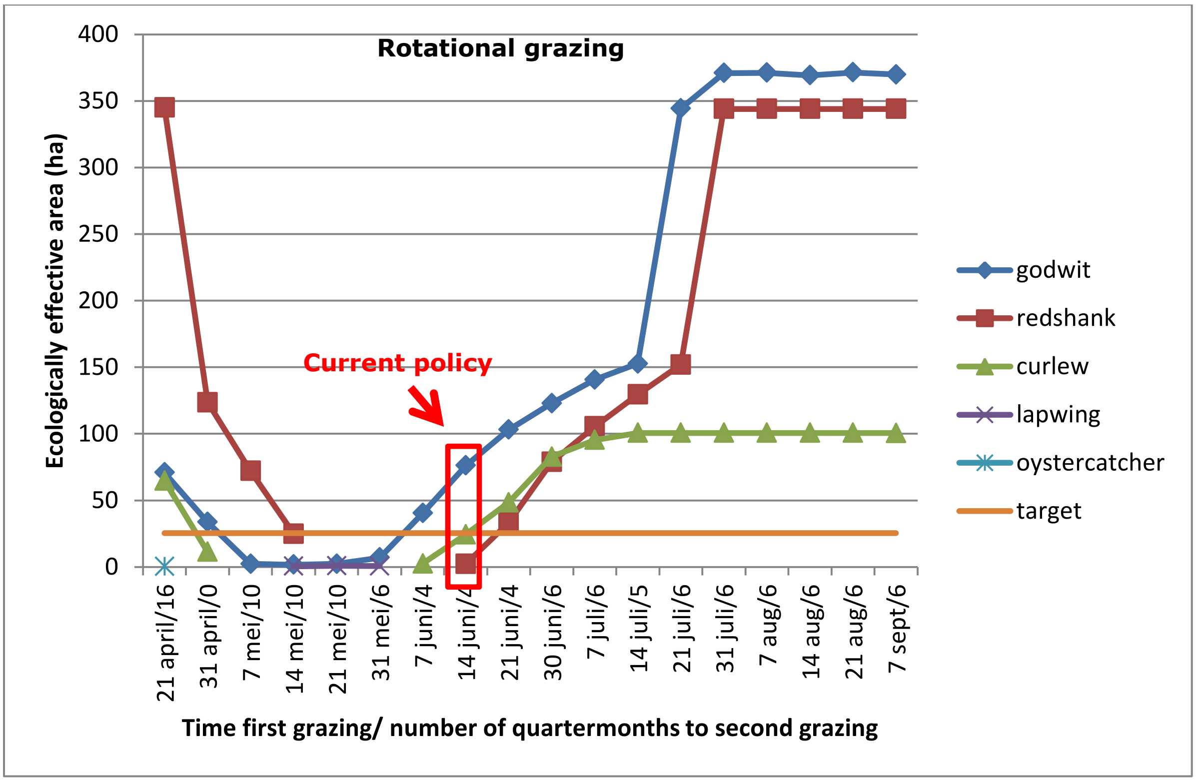


Figure 8.10 Maximal possible ecologically effective area of the different agri-environmental measures in scenario without predation and by grass use system rotational grazing

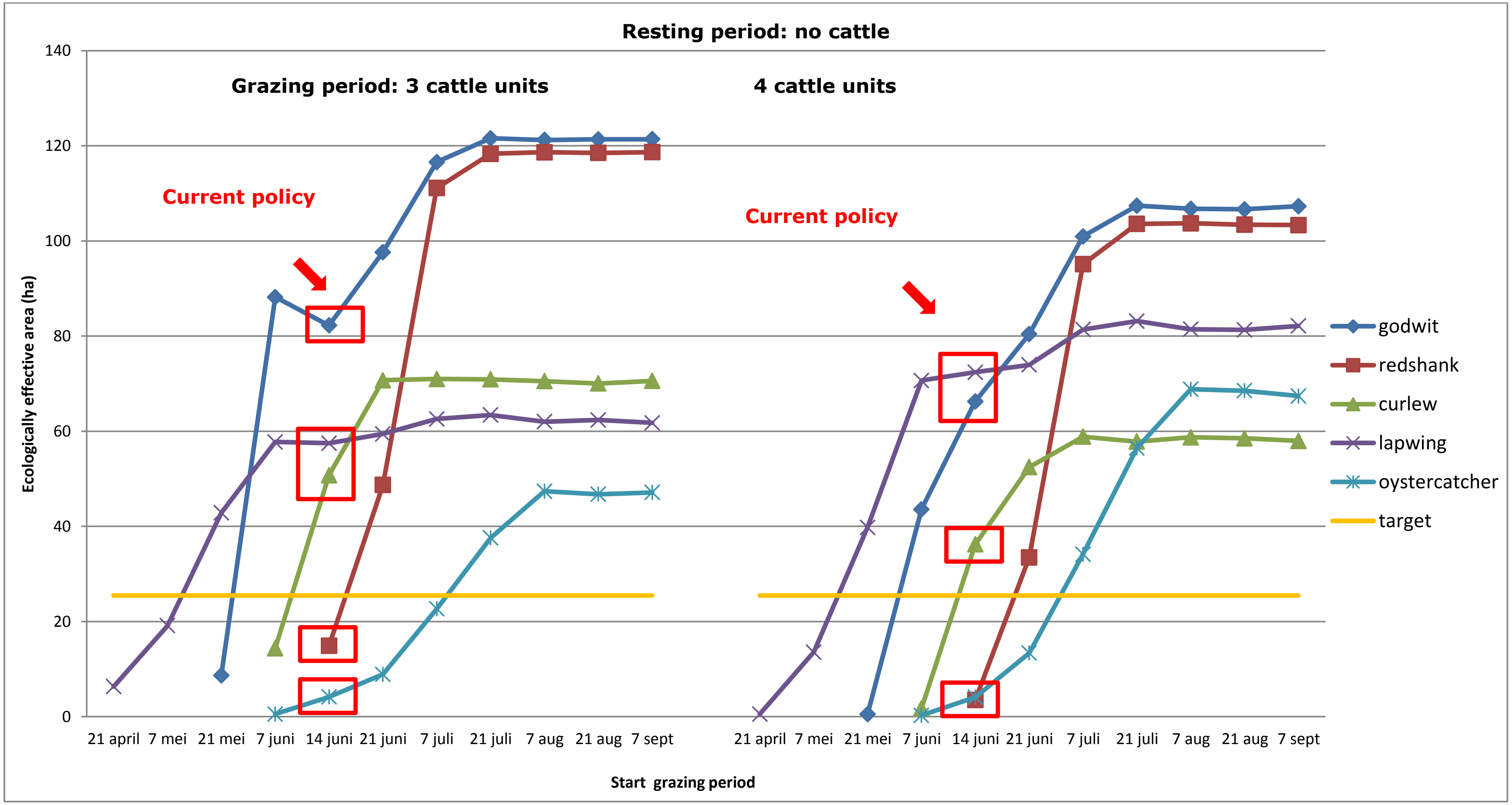


Figure 8.11 Maximal possible ecologically effective area of the different agri-environmental measures in scenario without predation and by grass use system seasonal grazing

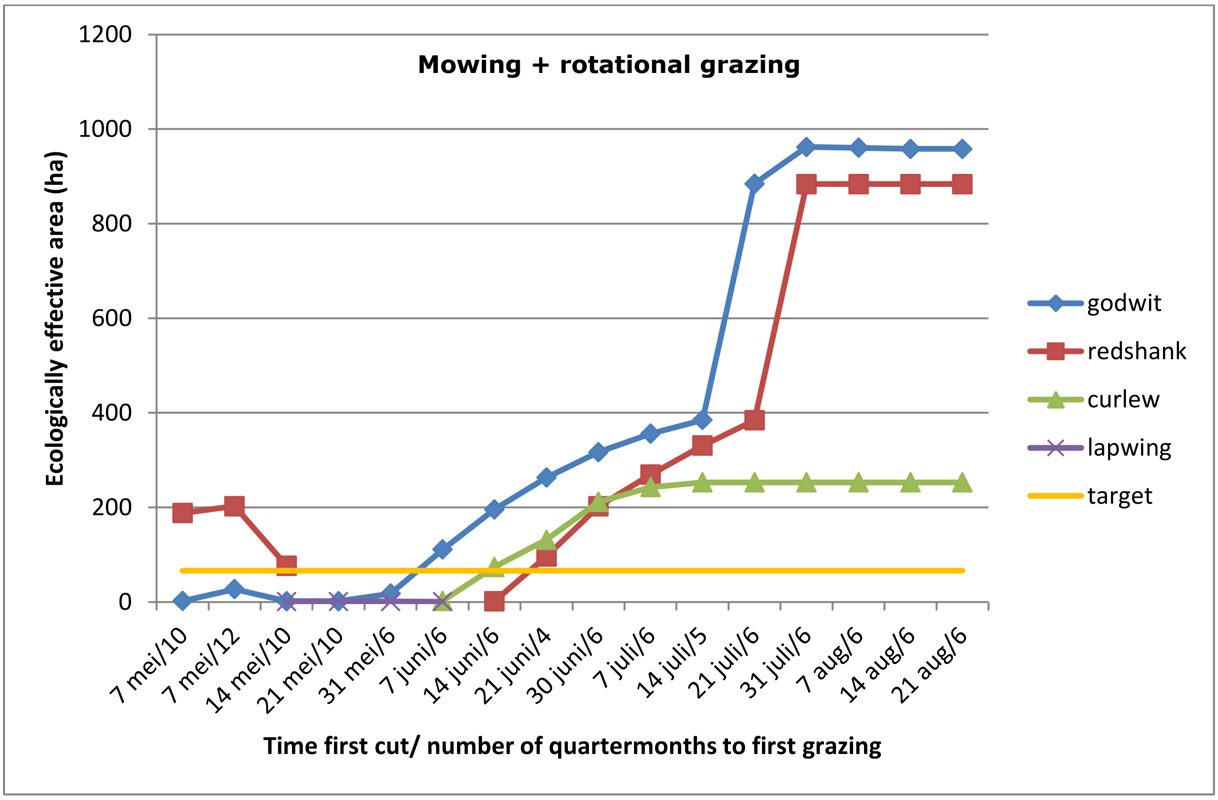


Figure 8.12 Maximal possible ecologically effective area of the different agri-environmental measures in scenario without predation and by grass use system mowing - rotational grazing

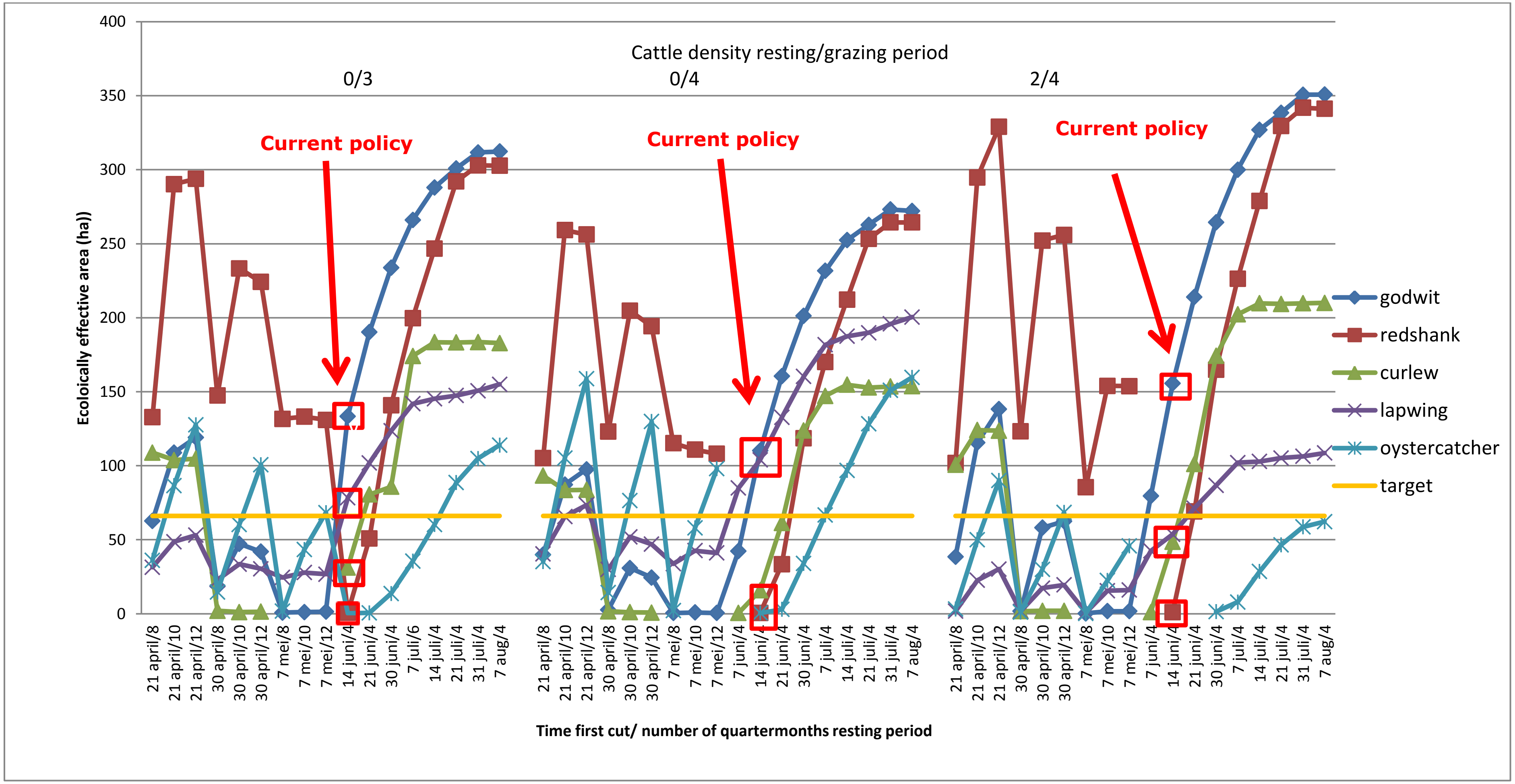


Figure 8.13 Maximal possible ecologically effective area of the different agri-environmental measures in scenario without predation and by grass use system mowing + seasonal grazing

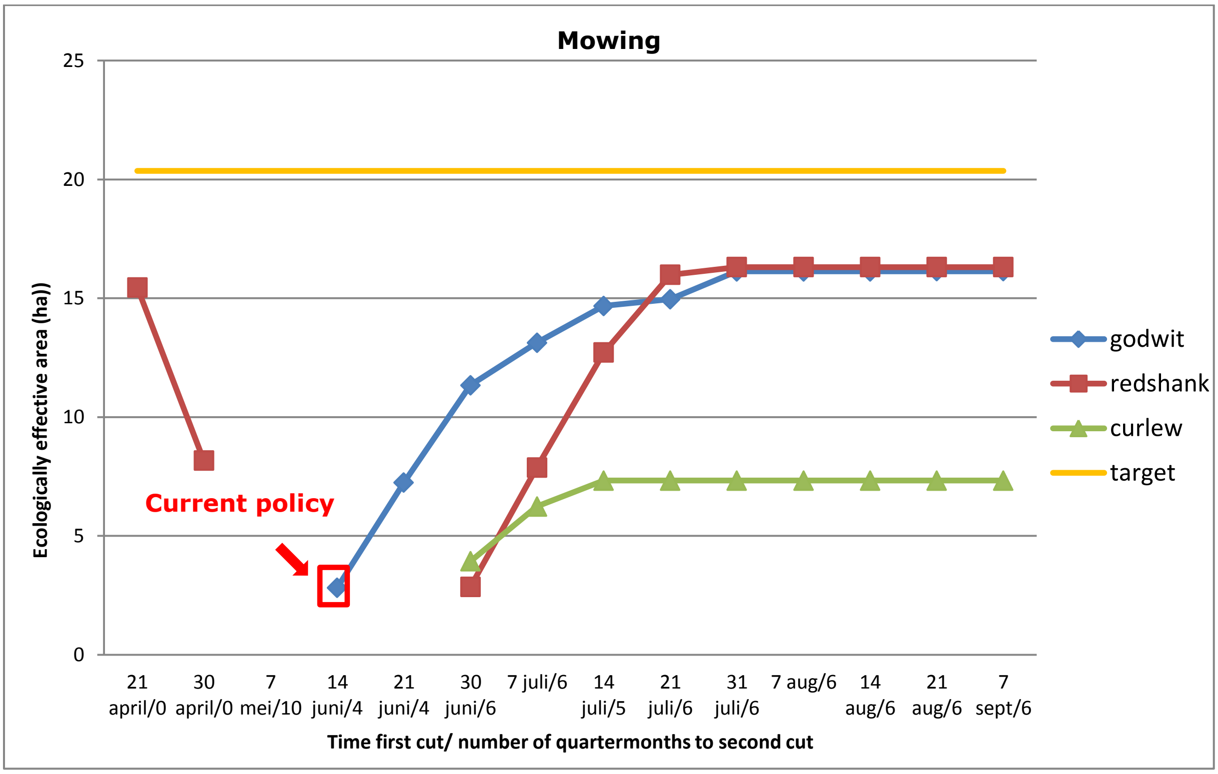


Figure 8.14 Maximal possible ecologically effective area of the different agri-environmental measures in scenario with predation and by grass use system mowing

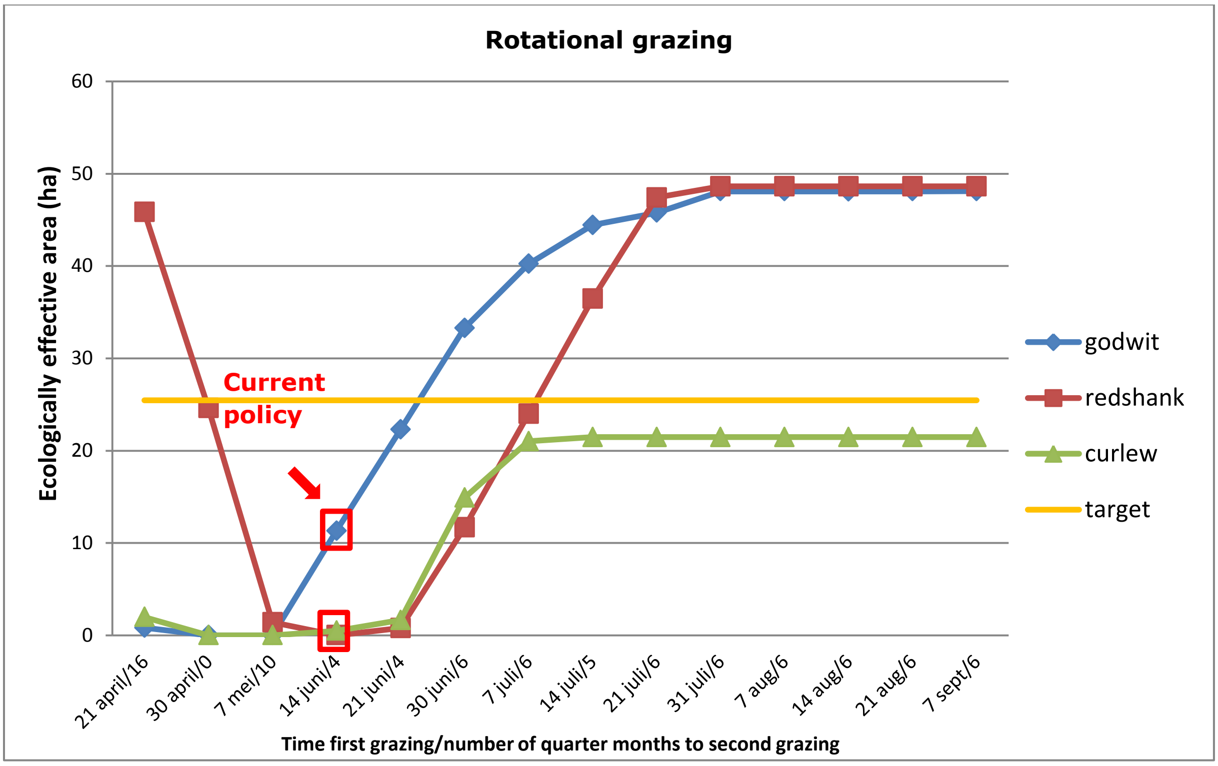


Figure 8.15 Maximal possible ecologically effective area of the different agri-environmental measures in scenario with predation and by grass use system rotational grazing

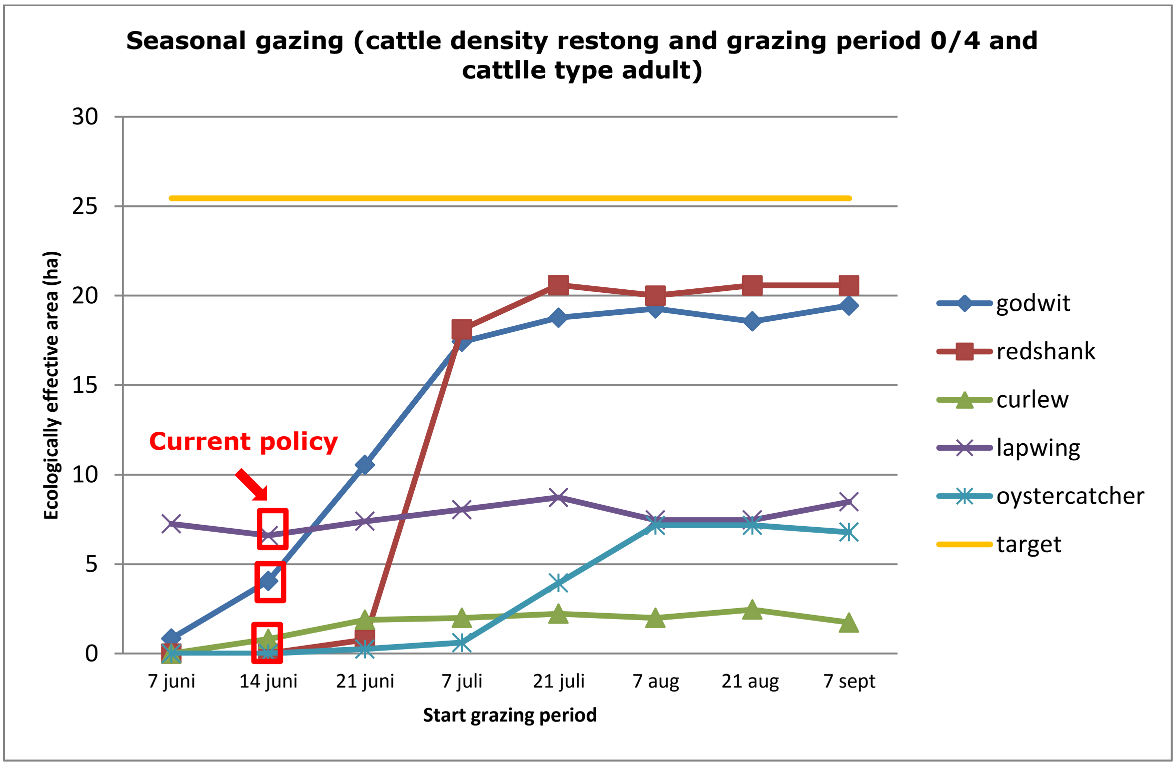


Figure 8.16 Maximal possible ecologically effective area of the different agri-environmental measures in scenario with predation and by grass use system seasonal grazing

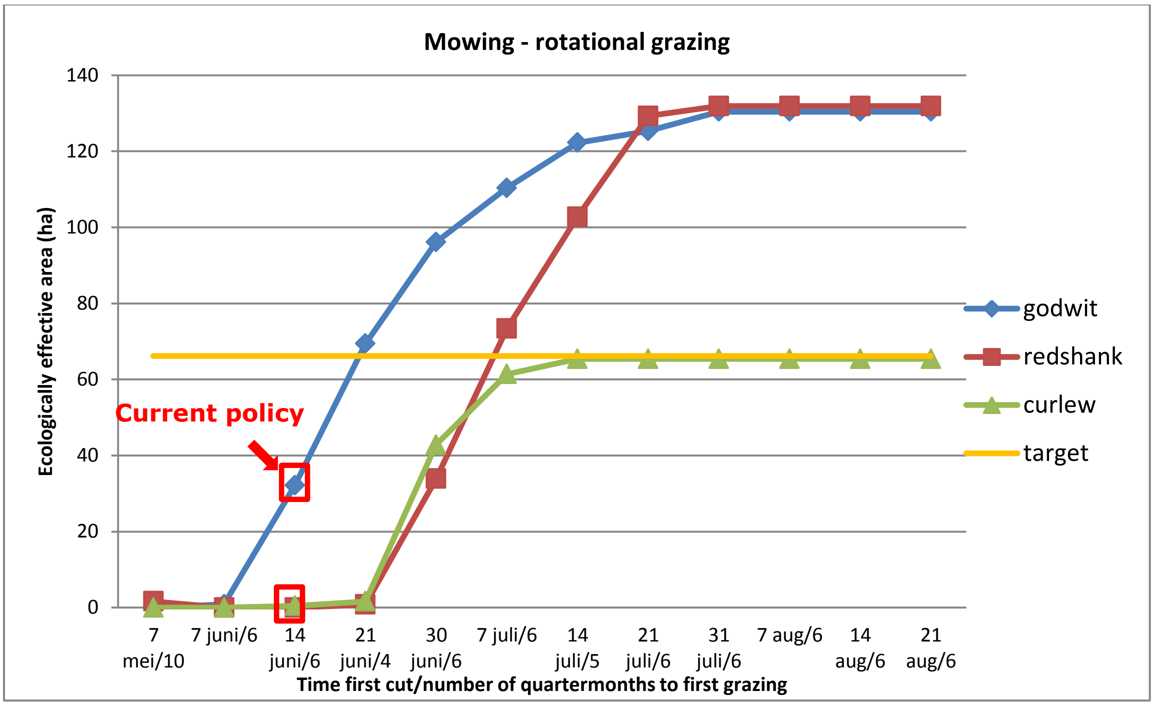


Figure 8.17 Maximal possible ecologically effective area of the different agri-environmental measures in scenario with predation and by grass use system mowing + rotational grazing

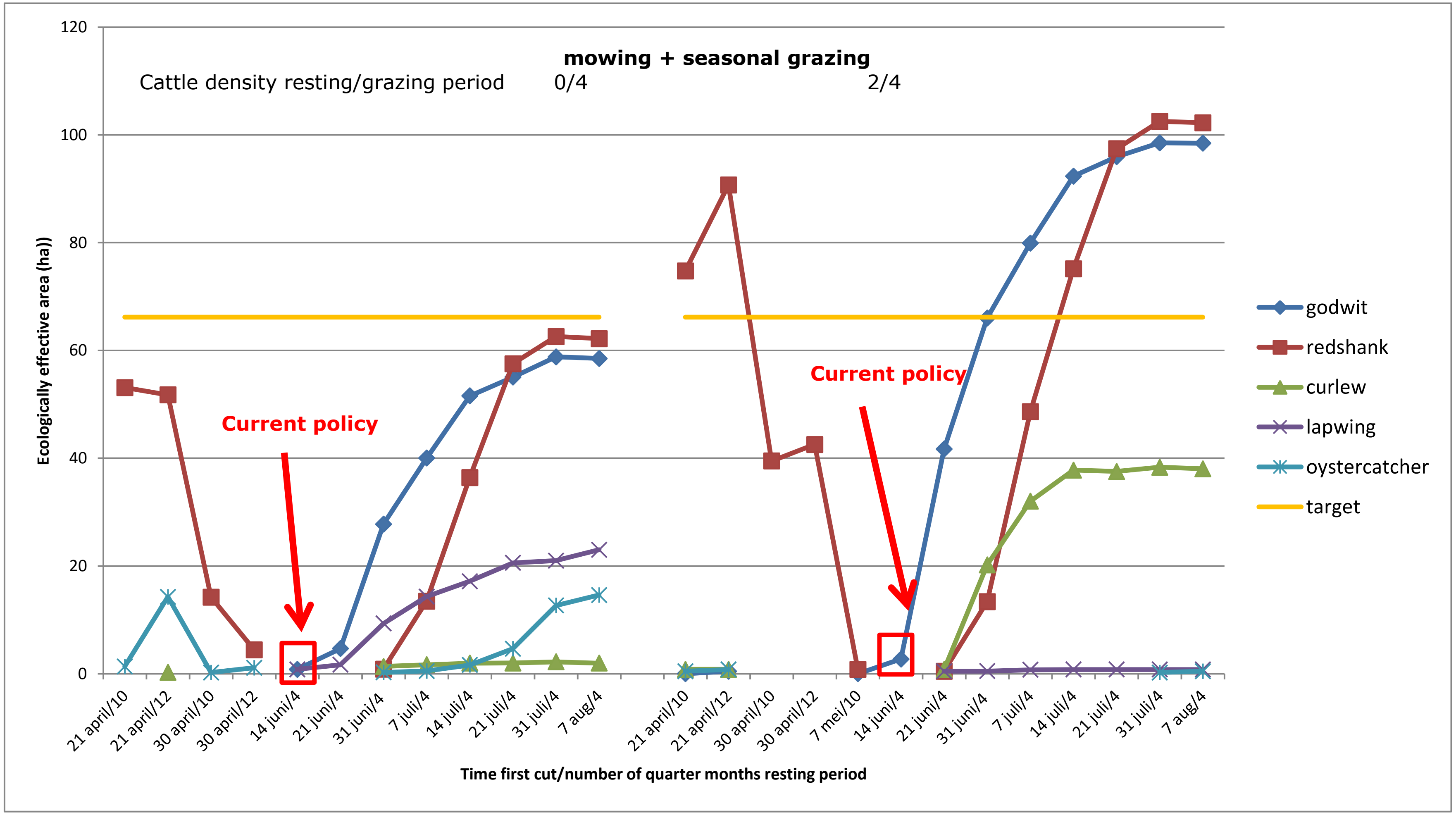


Figure 8.18 Maximal possible ecologically effective area of the different agri-environmental measures in scenario with predation and by grass use system mowing + seasonal grazing

8.3.3 Increase of cost effectiveness

Table 8.12 and figures 8.19 – 8.23 the current measures are compared with alternative measures. It is decided that the current measure equals 1 for godwit, because it is the only wader species for which the current measures are effective in all grass use systems (table 8.10). a value higher than 1 means that the alterntive measure is more effective than the current measure for godwit. Thus that the same budget delivers a higher ecological result. The following conclusions can be made:

- The cost more to reach the same ecological result by curlew and oystercatcher than godwit (the values by oystercatcher and curlew are always less than 1);
- The cost effectiveness of godwit management can be increased by prolonging the resting period from 14 June to 21 June by mowing, 7 jUly by seasonal grazing and 14 July by rotational grazing and the mixed systems. The cost-effectiveness can be improved with 15% by seasonal grazing, 25% by mowing and the mixed systems and 41% by rotational grazing.
- Redshank is a species for which either a late first cut (July 7 or 21) or an early first cut (April 21 – May 7) is the most cost effective. The early first cut is followed by a long period without agricultural activities (around 3 months) ;
- Curlew is a species for which a late first cut (June 21 – July 14) is the most cost-effectieve;
- Lapwing is a species for which seasonal grazing with a resting period until May 21 or June 7 is the most cost effective one.
- Oystercatcher is a species for which seasonal grazing with a resting period until July 21 is the most cost effective one. In the mixed system mowing + seasonal grazing an early cut (April 21-30) is the most cost effective one. The early first cut is followed by a long period without agricultural activities (around 3 months)

Table 8.13 The agri-environmental measure with the highest cost effectiveness

	mowing	Rotational grazing	Seasonal grazing	Mowing + rotational grazing	Mowing + seasonal grazing
Godwit	June 21 (1,25)	July 14 (1,41)	July 7 (1,15)	July 14 (1,24)	July 14 (1,24)
Redshank	July 21 (1,01)	July 21 (1,37)	July 21 (1,10)	July 21 (1,29)	April 21 + 3 month resting period (1,87)
Curlew	July 14 (0,88)	July 7(0,90)	June 21 (0,87)	July 7 (0,94)	April 21 + 10 months resting period (0,91)
Lapwing	-	-	June 7 (1,14)	-	June 21 (0,71)
oystercatcher	-	-	July 21 (0,66)	-	April + 3 months resting period (0,67)

(between brackets the value is given relative to godwit management with resting period until 14 June; >1: the ecological result is higher than this godwit management with the same budget)

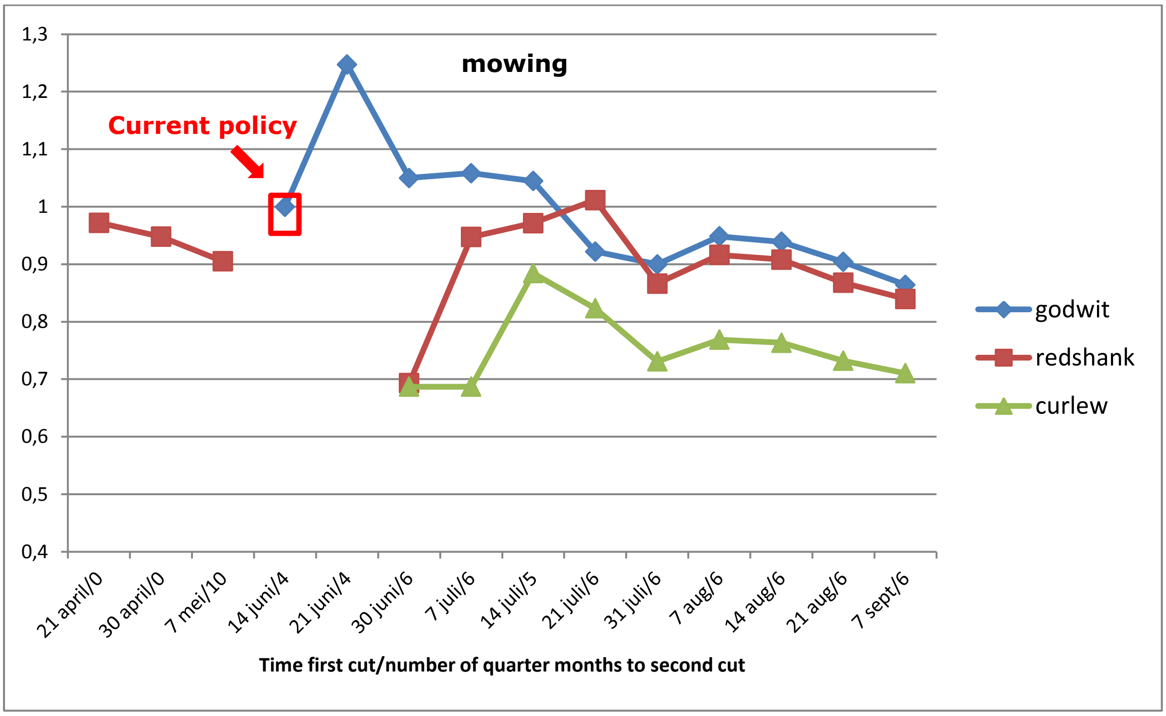


Figure 8.19 Cost effectiveness of mowing agri-environmental measures (godwit management June 14 is the reference, the other meaures and the other species are relatively compared with this reference)

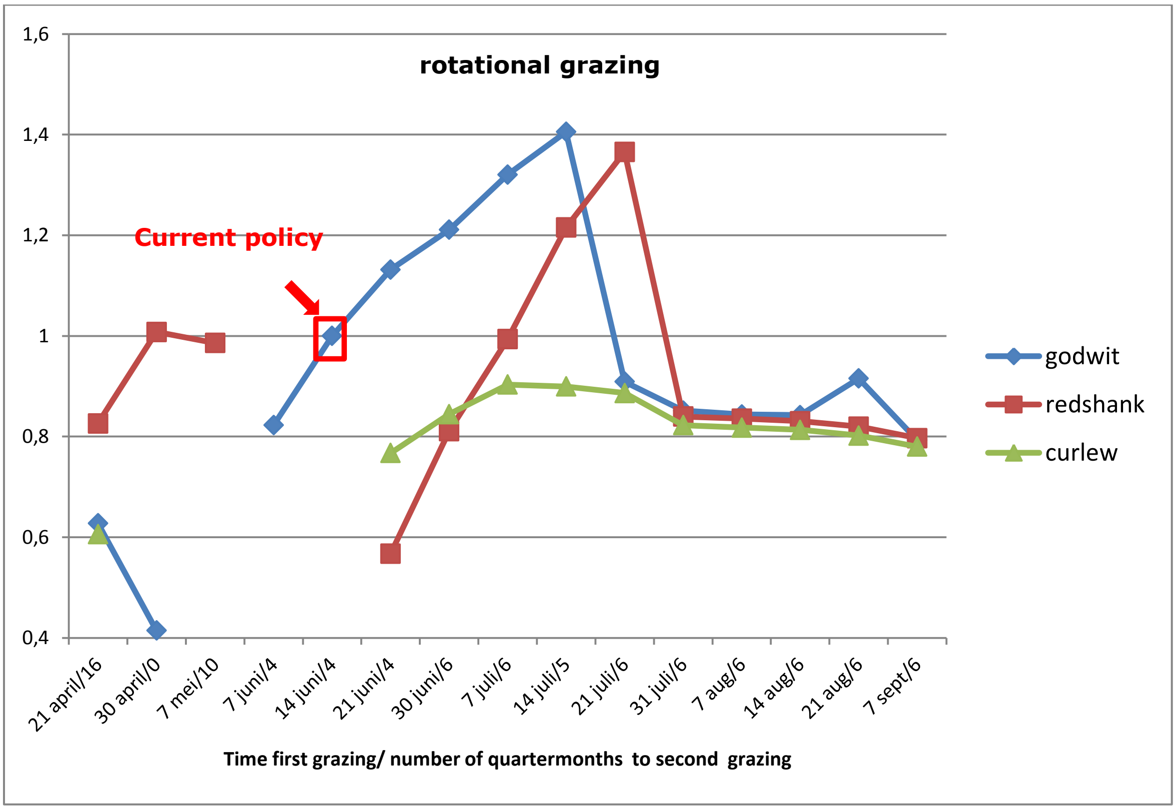


Figure 8.20 Cost effectiveness of rotational grazing agri-environmental measures (godwit management June 14 is the reference, the other meaures and the other species are relatively compared with this reference)

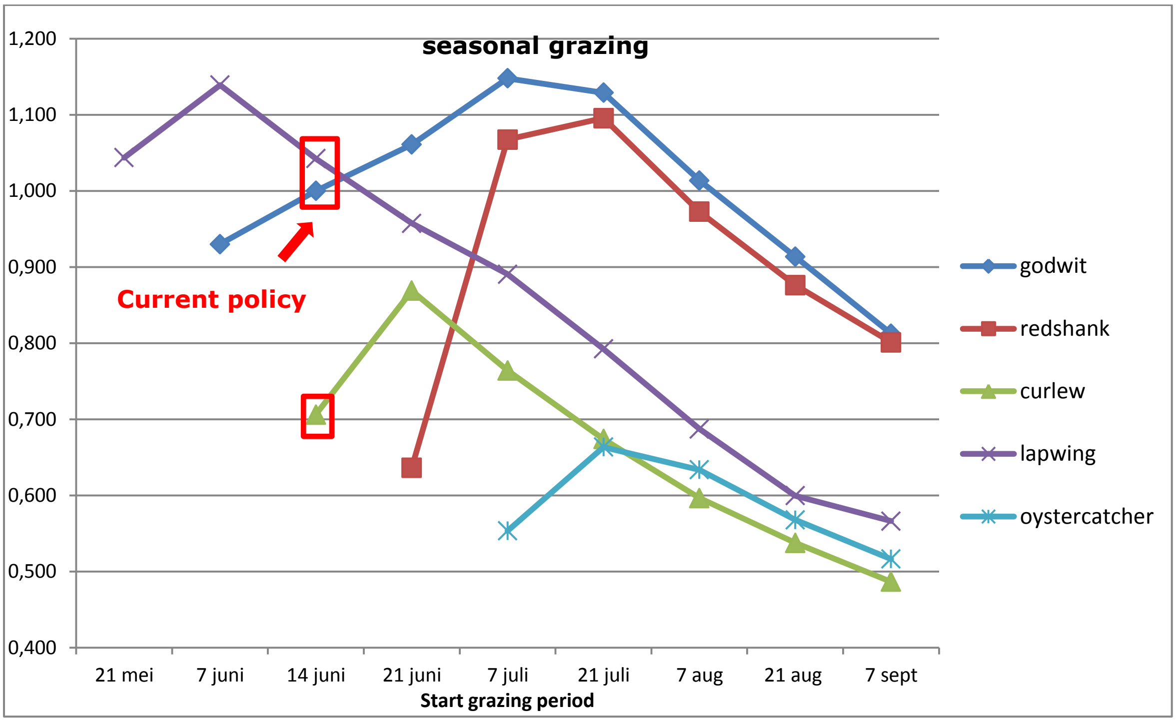


Figure 8.21 Cost effectiveness of seasonal grazing agri-environmental measures (godwit management June 14 is the reference, the other meaures and the other species are relatively compared with this reference)

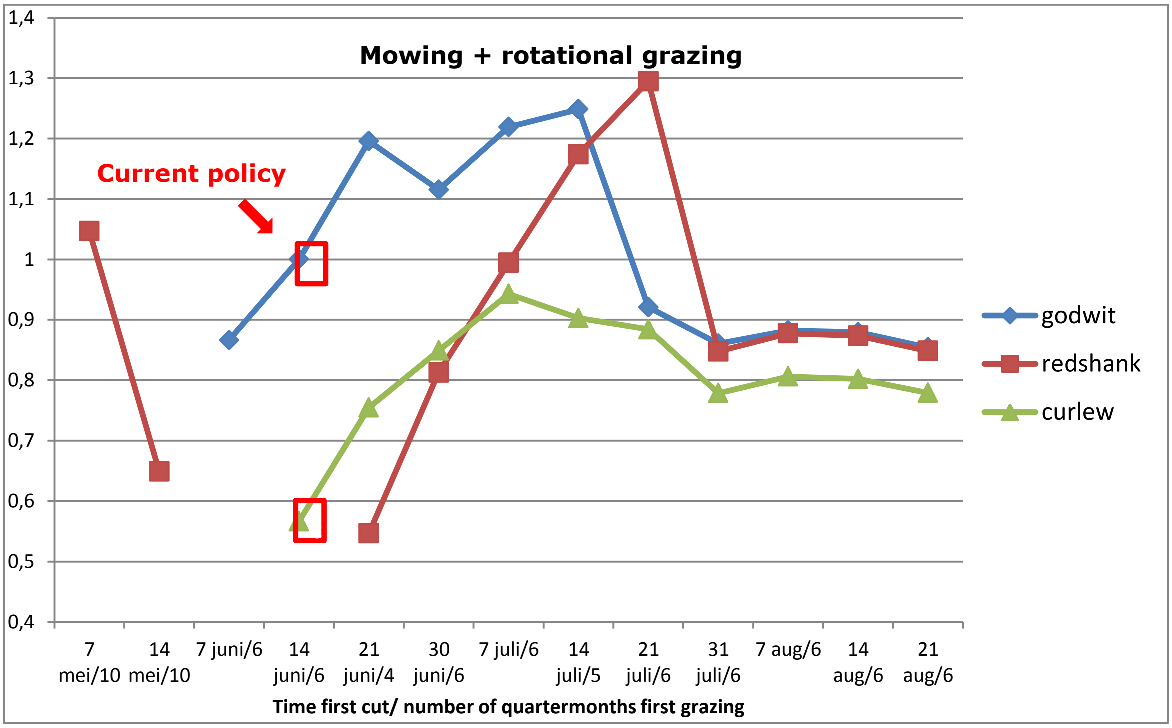


Figure 8.22 Cost effectiveness of mowing + rotational grazing agri-environmental measures (godwit management June 14 is the reference, the other meaures and the other species are relatively compared with this reference)

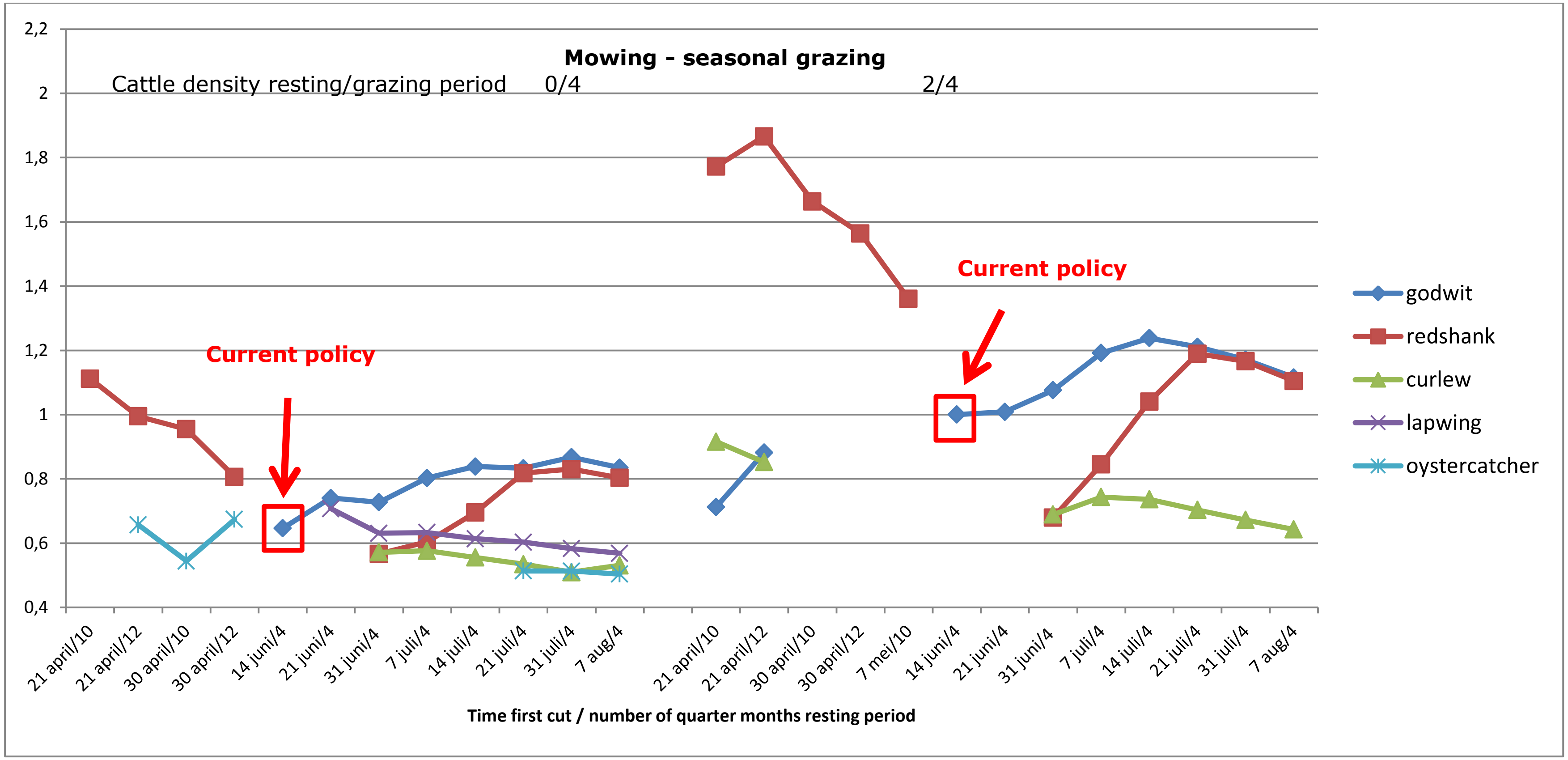


Figure 8.23 Cost effectiveness of mowing + seasonal grazing agri-environmental measures (godwit management June 14 is the reference, the other meaures and the other species are relatively compared with this reference)

9 Agri-environment measures and ecosystem services

M. Mewes, W. Van Reeth, J. Aertsens

The ecological model of the CASPER tool (based on the SOKO Bio tool) estimates the effects of land use measures (mowing, grazing, and mixture of both) on the species-specific local habitat quality (local level) and the overall effective habitat area (regional level) available for breeding. These variables are comparable among species and can therefore be used as measure for the local and regional species-specific ecological benefit. Biodiversity effects can be shown by simulating and ranking effective habitat areas of all considered species. Furthermore, alternative measures or sets of measures can be simulated and the results be compared. Distribution maps of the local ecological benefits for a given species visualise the spatial distribution of this benefit as a function of a measure or mix of measures for this species. By combining the ecological model with an economic model the CASPER software tool is also able to identify single or – most likely – sets of biodiversity-enhancing land use measures to protect multiple bird species cost-effectively.

The impact of these cost-effective sets of measures for multiple species protection generated by the CASPER tool will probably also have an effect on other ecosystem services than the habitat function.

In the following, the links between agri-environmental measures (= land use measures) and ecosystem services are introduced. Section 9.2 deals in particular with measures for bird protection and the possibility for a qualitative assessment of their impacts on ecosystem services (trade-offs and synergies).

9.1 Agri-environmental measures and ecosystem service provision

Agri-environmental measures and schemes are currently mainly designed to benefit biodiversity, but are not explicitly linked with ecosystem services (Whittingham 2011). However often agri-environmental measures can not only improve biodiversity but also deliver further ecosystem services (Whittingham 2011, Bradburry *et al*. 2010). Ecosystem services are differentiated by the UN Millennium Ecosystems Assessment in (i) provisioning (e.g. timber), (ii) regulating (e.g. water quality and quantity), (iii) supporting (e.g. pollination) and (iv) cultural services (e.g. recreation and ecotourism) (MA 2005). Examples show that agri-environmental measures and schemes can improve ecosystem service provision, **such as pollination services, biological control and carbon storage** (Whittingham 2011). Also biodiversity can in itself provide a range of ecosystem services (see Box). According to Whittingham (2011) agri-environmental schemes located in **heterogeneous landscapes** and in areas supporting **high levels of biodiversity** are likely to yield greater benefits than those in more homogeneous landscapes.

Different land use and agri-environmental measures lead to various ecosystem services besides biodiversity whereas trade-offs and synergies can occur (compare e.g. Anderson *et al*. 2009, Bennett *et al*. 2009, Chan *et al*. 2006).

Biodiversity delivering ecosystem services itself

Whelan *et al.* (2008) give a review about ecosystem services provided by birds which contribute to all four types of services – provisioning, regulating, cultural, and supporting services (according to the UN Millennium Ecosystem Assessment). The authors discuss the manifold roles of birds in ecosystems e.g. predators, pollinators, scavengers, seed dispersers, seed predators, and ecosystem engineers. They classify ecosystem services that arise via behaviour (like consumption of agricultural pests) and those that arise via bird products (like nests and guano). In a special profile in the Journal of Applied Ecology three examples of ecosystem services delivered by enhanced biodiversity on farmland are given (Whittingham 2011, p. 511): First, enhancing plant diversity by flowerrich swards maintained through appropriate grazing or mowing can also enhance plant biodiversity (see Fritch *et al.* 2011). Also organic management can lead to higher plant density and diversity (Power & Stout 2011) which is a key to enhancing the abundance of pollinating species.

Second, enhanced biodiversity can provide biological control services instead of artificial pesticides (e.g. for organic farms in heterogeneous landscapes Winqvist *et al.* 2011). Eitzinger & Traugott (2011) demonstrate the importance of predatory beetle larvae in the food chain. They suggest that by providing suitable conditions for these cold-adapted beetle larvae (e.g. by providing mulch, compost or plant cover in the winter on arable fields), then their ability to reduce agricultural pest populations (i.e. acting as a biological control) could be substantially enhanced. Third enhanced biodiversity under proper management conditions can yield increased carbon and nitrogen storage and improved soil structure according to De Deyn *et al.* (2011).

Chan *et al*. (2006) explored the trade-offs and opportunities for aligning conservation goals for biodiversity with **six ecosystem services by using a spatial explicit conservation planning** framework. They define the six ecosystem services as follows (p. 2139):

1. carbon storage (*not sequestration*): "carbon locked up in above- and below-ground biomass of primary producers. When natural vegetation cover is converted to agriculture or urban land, carbon is released to the atmosphere as carbon dioxide",
2. flood control: mitigation of flood risk by land cover and buffer areas,
3. forage production for grazing livestock (not mentioned by the authors but equals on crop land the crop production),
4. outdoor recreation: "provision of recreation opportunities by natural and semi-natural landscapes",
5. crop pollination by natural pollinators. "Many insect species including the widely cultivated European honeybee contribute importantly to numerous crops", and
6. and water provision: "supply of fresh water to meet the demand of the agricultural, industrial, and residential sectors" includes water quality from agriculture and urban development and active purification of water in wetlands and other habitats.

The authors evaluated the spatial correspondence of biodiversity and the provision of services by testing service correlation and network overlap. The seven benefit functions - for biodiversity and the other six ecosystem services - showed distinctly different spatial distributions, "although some areas are of high value to multiple services and other areas are of low value to many" (p. 2144). Chan *et al.* (2006, p. 2138) found weak positive and some weak negative associations between the priority areas for biodiversity conservation and the flows of the six ecosystem services. Excluding crop pollination and forage production (introduced as the two agriculture-focused services) from this analysis eliminated all negative correlations (=trade-offs). Another result of the study was that biodiversity conservation also protects multiple collateral ecosystem services. For further details see Chan *et al.* (2006).

In the following the potential of synergies and trade-offs by linking land use measures and ecosystem services is assessed in more detail for bird conservation measures.

9.2 Agri-environmental measures for bird conservation and ecosystem service provision

9.2.1 Evidence from UK

Bradbury *et al*. (2010) analyse in particular how farmland bird conservation can also provide a range of other ecosystem services (ES) like cultural ES (e.g. recreational bird watching, hunting, spiritual refreshment and/or aesthetic appeal) and regulating ES (like carbon sequestration, water regulation and quality). The authors discuss the potential for synergies and trade-offs between farmland bird conservation and regulating ES, at a range of locations and spatial scales. Table 9.1 shows the influence of management options (mostly being also biodiversity-enhancing land use measures) which enhance regulating services on farmland according to Bradbury *et al.* 2010, p. 988).

Table 9.1. A selection of management options on lowland farmland that can influence regulating ES (taken from Bradbury *et al.* 2010, p. 988)

Final service	Benefit	Land management objectives	Management options
Carbon sequestration; Green-house gas emission reduction	Climate change mitigation	Reduce soil carbon oxidation Reduce energy consumption Increase soil carbon sequestration Reduce nitrous oxide emissions Reduce methane emissions	Convert arable land to permanent grassland, in particular on organic soils Reduce cultivation intensity Grow woody vegetation: hedgerows, woodland, biomass crops Improve crop nitrogen (N) use, manure N use, tailor nutrient supplied in feed to livestock nutrient requirement Provide high quality feed, reduce stocking levels, digest manures anaerobically
Water regulation; Erosion regulation	Usable water; Flood risk management; Hazard control;	Improve soil infiltration Reduce surface run-off	Ameliorate soil structural damage and compaction Create/restore semi-natural habitats including scrub, plant trees Maintain/create flow barriers: hedgerows, earth banks, buffer strips, beetle-banks Restore vegetation cover on bare soils, under-sow arable crops such as maize Implement minimal cultivation or no-till techniques on arable land
Water purification	Clean water	Reduce fertiliser leaching and pesticides	Tailor N, P and K inputs to crop requirements Use plants with improved N use efficiency Use manure N efficiently Create low input grassland and conservation heathlands Avoid application in inappropriate (e.g. wet/frozen) conditions Prevent pollutant surface run-off, create physical buffer zones Provide reed beds/wetlands to filter water before entry to water courses Reduce/prevent soil erosion

In their next step the authors examined management options available within the English Entry Level Environmental Stewardship Scheme and made a preliminary assessment of the potential for consistency between bird conservation and service provision for different Scheme options, focusing specifically on six regulating services (see table 9.2). Table 9.2 gives a shortened measure-impact assessment example of Bradbury *et al.* (2010).

Table 9.2 Shortened measure-impact assessment matrix

	Regulating ecosystem services						
Measure (according to ELS option)	Climate	Waterre-gulation	Ero-sion	Water quality	Pest control	Polli-nation	**Total ES score**
Permanent grassland with very low inputs	2	1	1	2		1	7
Cereals for whole crop silage followed by over-wintered stubbles		-1	-1	-1			-3
6 m uncropped cultivated margins (in arable)		-1	-1	1/-1	1	1	0
Permanent grassland with low inputs	1	1	1	1		1	5
Over-wintered stubbles		1	1	1	1/-1		3
6 m buffer strips on cultivated land	1	1	1	1	1	1	6
Under sown spring cereals	1	1	2	1	-1		4
Hedgerow management (on both sides of hedge)					1	1	2
Hedgerow management (on one side of hedge)					1	1	2
Skylark plots					-1	1	0

The matrix is based on Bradbury *et al*. (2010), table 2, page 989. The mentioned agri-environmental measures can have a positive effect on farmbird populations and belong to the Entry Level Environmental Stewardship Scheme (http://www.naturalengland.gov.uk/ourwork/farming/funding/es/els/default.aspx). For each measure the estimated effect on ecosystem services climate, water reulation, erosion prevention, water quality, pest control and pollinination is given. The scores reflect the net impact of each option on each service, compared to the most typical business as usual practice in the absence of that agri-environment option (2, considerably better provision by the option, per unit area; 1, slightly better provision by the option; 0, no difference; −1, slightly worse provision by the option; −2, considerably worse provision by the option).

A similar table could be developed for the Flanders measures whereas their impact on the Ecosystem Services still has to be assumed e.g. based on the approach of Bradbury *et al.* (2010). For ES the approach of Bradbury et al. (2010) is based on Land Use Consultants & GHK Consulting Ltd (2009), who scored for each Entry Level Environmental Stewardship Scheme option, the likely gross provision of each service identified in the Millennium Ecosystem Assessment on a scale of -2 (high negative impact) to 2 (high positive impact). Bradbury *et al.* (2010) "varied this approach by using our own knowledge and consultation with a wide literature to estimate the net impact of each option on each service, compared to the most typical business as usual practice in the absence of that agri-environment option. The authors first allocated scores independently. The authors are aware of that this approach would benefit from systematic scoring by a number of experts in each of the services and the results should be considered indicative.

Results of the study of Bradbury *et al.* (2010) are that measures for species do not necessarily enhance other services (they can even have a negative impact) but the authors could identify some potential synergies with enhancement of regulating services provided by permanent grassland, very low inputs on either arable or grassland, and field corner management. So assessing the relevance of agri-environmental measures not only for birds but also for other ES helps to find the complementarities to be optimized and the negative trade-offs to be minimised.

By comparing the assessments of the measure-impact assessment matrix of table 2 with the Flanders region some scores may be the same as in table 2 but others may need to be adapted due to the underlying assumptions like local conditions, typical business as usual land use management, etc.

9.2.2 Flemish preliminary result

In Flanders, possible contributions of management agreements to the restoration of ecosystem services from agriculture are only preliminary explored (eg erosion prevention, natural pest control, natural pollination, water purification ...) (D'Haene 2010; Danckaert 2009; Jacobs et al 2010b). Table 6 shows via a measure impact assessment matrix, the possible relevance of meadow bird management measures for 11 ecosystem services, and the quality of meadow bird habitat. The ecosystem services are based on the CICES classification.

Table 9.3 Impact assessment matrix: relation between meadow bird measures and ecosystem services

		Provisioning services				Regulating services				Cultural services		
Meadow bird agr-environmental measures	Habitat quality for meadow birds	Nutrition	Drinking water	Materials	Energy	Water quality	Erosion prevention	Climate regulation	Natural pest control and pollination	Recreation	Experience related services	Intelectual services
Delayed mowing	0/+	-	0/+	-	?	+	0	0/+	0	0/+	0/+	0/+
Delayed grazing	0/+	-	0/+	-	?	+	0	0/+	0	0/+	0/+	0/+
Conversion cropland to meadows	0/+	-	0/+	-	?	+	0/+	0/+	?	0/+	0/+	0/+
Nest protection	?	0	0	-	0	0	0	0	0	0/+	0/+	0/+
Refuge strips	0/+	-	0	-	0	0	0/+	0/+	?	0/+	0/+	0/+
Reduced cattle density	0/+	-	0/+		?	+	0	0	0	0/+	0/+	0/+
Increased groundwater level (*)	0/+	-	0/+	-	?	+	?	+	?	0/+	0/+	0/+
Prohibition synthetic fertiliser (*)	0/+	-	0/+	-	?	+	0	?	?	0/+	0/+	0/+

(*) These measures are currently not applied as agri-environmental measures. Nevertheless, there are used in a nature reserve context.

For most meadow bird measures the literature suggest a positive impact on the ecological quality of meadow bird habitat. However the impact on the meadow bird offspring survival is strongly depending on the implementation modalities (eg timing and density of the measures) and can vary between large (high density, no agricultural management during critical breeding period) or negligible. Therefore, the score '0 / + ' is assigned. In addition, for nest protection it is not clear whether the effect is positive (due to the better protection against agricultural operations) or negative (due to disturbance of the monitoring activities which also result in a higher predation risk because the monitoring makes the predators attentive where the meadow bird offspring are).

The meadow bird measures will have a negative effect on the grass yield (quantity and quality) and therefore the impact on the producing ecosystem services 'materials' (feed) and 'food' (development of grazing cows) are negative. Some of the measures (delayed mowing, delayed grazing, reduced cattle density) leads also to reduced application of fertilizers. This may be a limited positive impact on the service-producing "water" if the plots are located in sensitive areas for water extraction. The impact on the service-producing "energy" is unclear.

The reduced fertilization leads also to reduced eutrophication of soil, surface water and groundwater. Given the magnitude of this effect is not clear in all circumastances and/or is depending on local environmental conditions (eg soil type, contact with water), the score '0 / + 'was assigned. The measure conversion cropland to grassland can result in an increased erosion prevention. Nevertheless, this impact also depends on local conditions (eg slope, soil type, content of organic matter in the soil, land cover, ...). In addition it can also lead to increased carbon storage in the soil (climate control). This effect also occurs when the measure increased ground water level is applied; This measure is only applied in the context of reserve management. For most other regulatory services the effects of meadow bird measures are negligible or too uncertain for a score to be awarded.

For cultural services, a neutral to positive effect is expected due to the increased attractiveness of areas with rather rare bird species. This landscape is attractive for holidaymakers (Liekens et al 2012). In addition, such a landscape has also a social and cultural value to local residents (eg pleasant environment to live, strengthening regional identity, social interaction), for mental development (eg therapeutic value of natural landscapes), for artistic inspiration and knowledge and cognitive development (eg interaction of children with nature). However, based on the available information it is difficult to address this aspect of 'meadow birds' to separate from the broader landscape context

9.3 How to value the ecosystem services?

Table 9.3 helps to identify andvisualize some ecosystem services of meadow bird areas. To compare costs and benefits in the context of an economic appraisal those services should be translated in physical and monetary units. For producing services there are often market prices available to value the volume of the deliverd ecosystem service (eg ton feed of a certain quality, m³ wood of a certain dimension). However, to know the net welfare effect it is also needed that other cost and benefits are valuated. For regulating services, alternative valuation methods are available (Hutson et al 2007; Liekens et al 2009). In recent years researchers of VITO and Antwerp University, commissioned by the Department of Environment, Nature and Energy, have developed the ‘nature value Explorer '(www.rma.vito.be / nature explorer). This online calculation tool allows for a limited number of ecosystem services to calculate the volumes in physical quantities and then translate these quantities into euros. The removal of nutrients through ecosystems is valued on the basis of marginal abatement costs needed to achieve European water quality targets. In Flanders, this abatment cost is 74 euro/ton for nitrogen and 800 euro/ton for phosphorus (Liekens et al 2009:135-136). The valuation of ecosystem services 'climate control' is also based on the cost reduction method, a value of 50 € / tCO2-eq or 183 € / ton C is used (Liekens et al, 2009:137). Others come via an alternative valuation based on avoided damage costs to a value of 15-326 € / ton C (Aertsens *et al.* 2012; Lettens *et al*. 2010). Also the valuation of erosion prevention are presented is based on avoided damage costs. Which are, however, highly dependent on the local context (Jacobs et al 2010a), as also indicated above.

Producing services can usually be contained in a tangible, physical output (eg tons, liters, ...). Also regulating services are mostly due to known biophysical processes, but there are still important knowledge gaps (eg climate regulation). Cultural services are often relate to intangible outputs. Which can be interpreted in qualitative categories, but is difficult to quantify. For that reason, often, instead of cultural services itself, characteristics of the ecosystems or areas are used as an indicator for the size or the quality of the service (eg green surface area, average distance green space for residential, ...). An alternative is to look at the number of customers of a cultural service (eg number of holidaymakers, the frequency of visits) to get an idea of the importance or the trend of a cultural service. The economic value of that cultural services can be looked at the behavior of users of that service (eg distance as input for the travel costs method) or users may be asked about their preferences (eg contingent valuation, choice experiments) (Hutson et al 2007). Based on the latter method citizens can also be asked about the value that people attach to a particular area, landscape or natural type. This applies not only to the value people assign to a specific area as a resident or visitor (amenity value). Also, the value of the specific area is called up, even though, it has been not actively used (existence value) or the value one assigns to it for the next generation (transmission value).

VITO has used a choice experiment to gauge the amenity and transfer value of the arrangement of fields and meadows with small landscape elements (KLE) (eg hollow roads, ponds, orchards, hedges, ...) in some scenarios, combined with more biodiversity in the landscape. A survey was sent to 8,734 persons, of which 878 completely filled out the survey (Liekens et al 2012). The valuation study shows a positive willingness to pay for the restoration of small landscape elements in agricultural areas. The exact value varies depending on the type of small landscape element, the accessibility of the landscape, the presence or absence of endangered species and the surface of the area. In addition, characteristics of the respondent also affects the assigned value, eg, age, household income, membership association of nature and distance from the site to the residence. The willingness to pay increases by 39 € / household if the introduction of small landscape elements in the agricultural landscape leads to greater biodiversity and a greater presence of endangered species. Households who are members of a natural association (8% in Flanders) are even willing to pay 62 € / household. With 2.6 million Flemish households (in 2009) the increased species richness can only for the cultural services be estimated at an economic value in the order of 100 million € / year.

The results of this study can not directly be used to estimate the amenity and transfer value of meadow bird measures in euros, because the scope of the survey (enrichment of the agricultural landscape and biodiversity in general) is much broader than meadow birds. Nevetheless, the established valuation function does point to a higher economic value of the agricultural landscape when rare species occur. Agri-environmental measures that lead to a better protection of species (eg meadow bird, bird management field, hamster protection) or a higher botanical diversity achieve therefore also a real economic value at the landscape level.

There is also not always a clear link between the classification of ecosystem services (CICES classification) and the categories of economic valuation which are be used, for example in the cultural services. To avoid this, a closer interdisciplinary collaboration between economists, social scientist and ecologist will be needed. In addition, it is also important to place the economic values in their social context (Cowling *et al.* 2008). This context determines which stakeholders attach importance to certain services, who delivers, who benefits abnd who bears the costs. Embedding environmental and economic assessments in a social context requires a participatory approach that involved the stakeholders (Daily et al 2009).

9.4 How the ecosystem services and benefits can be cashed?

On the one hand, the agricultural sector is being criticized because the intensification creates external cost (eg environmental pollution) for the society, now and/or in the future. On the other hand, the above analysis shows also that agri-environmental measures for meadow birds can provide external benefits. Both the cost and the benefits stays currently outside the economic market. Costs are not included in the price of agricultural products, while benefits are not paid by neither the consumers nor the agri-environmental payments. These payments are only based on the loss of agricultural income and the implementation cost of the measure. However, this choice is also understandable because the above analysis shows that our current knowledge is too low the value the societal gains precisely in euros. Nevertheless, for a number of services the current knowledge can indicate a policy relevant magnitude.

It is important to emphasize that politics need to decide if the value of the 'ecosystem gains' (a) can be entirely collected by the land user who supplies the services, (b) may be included in the prices of real estate, (c) must be given to the levels of government and institutions with the open space preservation, or (d) can be considered as a value to society. Considering the agri-environmental measures the European policy position is that only the implementation cost, the lost income and a small transaction cost can be reimbursed.

Political debate on this is helpful to further research that attempts to assess the magnitude and distribution of the ecosystem gains more visible and arguably making, for example, in debates about the management and future of the open space in Flanders. Gretchen Daily wrote 15 years ago: "Just as it would be absurd to calculate the full value of a human being on the basis of his or her wage-earning power, or the economic value of his or her constituent materials, there exists no absolute value of ecosystem services waiting to be discovered and revealed to the world by a member of the intellectual community. (...) Nonetheless, as imperfect Measures their fiduciary value, if Understood as Such, are better than simply ignoring ecosystem services altogether, as is gene rally done in decision making today. "(Daily 1997). The new EU biodiversity strategy tries abolish it and asks the Member States to 2020 the economic value of ecosystem services in their territory to determine and include them in systems for accounting and reporting (target 2, action 5) (EC, 2011). The preparations for the new RDP III (2014-2020) offer an excellent opportunity to further steps here to bet.

10 Conclusions

P. Van Gossum, W. Van Reeth, J. Aertsens, S. Broekx, T. Van Daele

ECOPAY Flanders can currently be used as a decision support system in the instrument design stage of agri-environmental measures for meadow birds. Thus, it will help the Flemish government by selecting the portifolo of agri-environmental measures which the government will be use to realise the policy targets on meadow birds.

At this moment, ECOPAY-Flanders can not be used to develop a meadow bird plan for a specific meadow bird area. A meadow bird plan can support the farm planning agents (‘bedrijfsplanner’) by giving them the most fruitful locations and the most fruitful measures on that location to realise a cost effective meadow bird management. To answer such questions a downscaling of the model will be needed. The downscaling will requires additional data (e.g. breeding locations of meadow birds, line-shaped landscape elements) and more fine-scaling data on ecological grassland types, grass growth and the economical potential of the grassland. In addition, it will requires an adaptation of the ecological model to include:

- line-shaped agri-environmental measures (including removal of tree rows as predation mitigating measure),
- multi pixel agri-environmental measures (e.g. changing soil moisture to a more optimal soil moisture for the targeted meadow birds, mosaic grassland management).

Furthermore, it will be also important to include the different manure types (inorganic and organic) and more seasonal grazing periods in the economical model. A lower use of inorganic manure in the agri-environmental situation than in the reference situation will lead to saved costs, while a lower use of organic manure will increase the cost. More seasonal grazing periods are needed to take into account the seasonal grass growth variability and thus the different livestock densities a farmer will be use during a season.

Another possible extension is to include cropland birds. This extension will requires new economical models for all crops where agri-environmental measures can be fruitful for cropland birds. In addition, it will require a new ecological model for winter survival and an adaptation of the current ecological model for summer survival.

References

Anderson, B.J., P.R. Armsworth, F. Eigenbrod, C.D. Thomas, S. Gillings, A. Heinemeyer, D.B. Roy, K.J. Gaston (2009): Spatial covariance between biodiversity and other ecosystem service priorities. Journal of Applied Ecology 46(4): 888-896.

ASG, (2010). Handboek Melkveehouderij; Animal Sciences Group (van Wageningen UR) -2010; 512 p. http://www.verantwoordeveehouderij.nl/index.asp?pzprojecten/projectkaart.asp?IDProject=233

Beintema A., Moedt O. en van Zadelhoff F. (1995). Ecologische atlas van de Nederlandse weidevogels. Schuyt & co., Haarlem, 352 pp.

Bennett, E.M., G.D. Peterson, L.J. Gordon (2009): Understanding relationships among multiple ecosystem services. Ecology Letters 12(12): 1394-1404.

Bernaerts, E.; Demuynck, E. (2011). Hoofdstuk 4: Grondgebonden veeteelt; In: Platteau,J Van Bogaert,T.; Van Gijseghem, D; (2011). Landbouwrapport 2010; pp. 87-119. http://lv.vlaanderen.be/nlapps/data/docattachments/LARA_Sectoren_H4_Grondgebonden_veeteelt.pdf

Bradbury, R.B., C. Stoate, J.R.B. Tallowin (2010): FORUM: Lowland farmland bird conservation in the context of wider ecosystem service delivery. Journal of Applied Ecology 47(5): 986-993.

Chan, K.M.A., M.R. Shaw, D.R. Cameron, E.C. Underwood, G.C. Daily (2006): Conservation Planning for Ecosystem Services. PLoS Biol 4(11): e379.

De Deyn G.B., R.S. Shiel, N.J. Ostle, N.P. McNamara, S. Oakley, I. Young, C. Freeman, N. Fenner, H. Quirk, R.D. Bardgett (2011): Additional carbon sequestration benefits of grassland diversity restoration. Journal of Applied Ecology 48: 600-608.

Dijkstra H. (1991). Natuur- en landschapsbeheer door landbouwbedrijven. Coal-publikatie n°60, 1991, 109 p.

Eitzinger, B. & Traugott, M. (2011): Which prey sustains cold-adapted invertebrate generalist predators in arable land? Examining prey choices by molecular gut analysis. Journal of Applied Ecology 48: 591–599.

Fritch, R.A., Sheridan, H., Finn, J.A., Kirwan, L. & hUllacháin, D.Ó. (2011): Methods of enhancing botanical diversity within field margins of intensively managed grassland: a 7-year field experiment. Journal of Applied Ecology 48: 551–560.

Geypens M. (S.D); Notities bij de cursus graasland en voederteelt. Deel 1 Graasland; 181 p.

Jacobs G., Van Huylenbroeck G., Martens, L. (1998). Analyse van de inpasbaarheid van natuur- en milieuvoorwaarden op melkveebedrijven met behulp van een simulatiemodel; In: Van Huylenbroeck, G. en Jacobs, G. (1998). Naar een duurzame grasland- en groenvoederuitbating: onderzoek naar de integratie van landbouwkundige en ecologische doelstellingen bij grasland- en groenvoederwinning; pp. 165-198.

Land Use Consultants & GHK Consulting Ltd. (2009): Provision of ecosystem services through the environmental stewardship scheme. Final report for Defra project NR0121. http://www.hedgelaying.ie/images/1253357089.pdf.

MA (Millennium Ecosystem Assessment) (2005): Ecosystems and Human Well-being: Current State and Trends. Island Press, WashingtonDC.

Nevens, F; en Reheul, D; (1998a). Opbrengst en voederkwaliteit van graslanden met huidige of toekomstige natuurwaarde; In: Van Huylenbroeck, G. en Jacobs, G. (1998). Naar een duurzame grasland- en groenvoederuitbating: onderzoek naar de integratie van landbouwkundige en ecologische doelstellingen bij grasland- en groenvoederwinning; pp. 141-163.

Nevens, F; en Reheul, D; (1998b). Gebruik van toegediende stikstof door grasland en groenvoedergewassen – Fytotechnische mogelijkheden tot optimaal N-gebruik; In: Van Huylenbroeck, G. en Jacobs, G. (1998). Naar een duurzame grasland- en groenvoederuitbating: onderzoek naar de integratie van landbouwkundige en ecologische doelstellingen bij grasland- en groenvoederwinning; pp. 85-108.

Platteau,J Van Bogaert,T.; Van Gijseghem, D; (2011). Landbouwrapport 2010. 294p; http://lv.vlaanderen.be/nlapps/docs/default.asp?id=1987

Power, E.F. & Stout, J.C. (2011): Organic dairy farming: impacts on insect-flower interactions and pollination. Journal of Applied Ecology 48: 561–569.

PR (Proefstation voor de rundveehouderij, schapenhouderij en paardenhouderij). (1986). De graslandkalender – toelichitn op het gebruik, adviezen graslandexploitatie, verwerken en boeoordelen resultaten; 44 p. http://library.wur.nl/way/bestanden/clc/244283.pdf

Sprangers J.; Van Rabenswaay C., Reyrink L., Smeets P. (1990). Relaties tussen graslandgebruik, vegetatie en weidevogels bij aangepaste landbouw. CABO-verslag/COAL-publicatie 56, december 1990, 71 pp.

Steurbaut P., Vanlierop F. & Herremans M. (2005). Begeleiding van de vrijwillige weidevogelbescherming in Vlaanderen in uitvoering van de Europese Verordening 2078/92. Eindverslag. Studie in opdracht van AMINAL afdeling Natuur. Natuurpunt Studie, Mechelen

Strubbe D., Verschelde P., Hens M. Wils C., Bauwens D., Dermout M. en De Bruyn L., 2010. Impact van PDPO II maatregelen op de biodiversiteit. Studie uitgevoerd door het Instituut voor Natuur- en Bosonderzoek (INBO) in opdracht van het Departement Landbouw en Visserij, afdeling Monitoring en Studie, Brussel. 100 blz + bijlagen.

Ternier, K.; Bronchart, F; Reheul, D;; Mahieu, J.; Nevens, F.; (2001). Beheersgrasland: opbrengst - rantsoenen - bedrijfseconomie. Proclam vzw: Beitem-Rumbeke : Belgium ; Gent : Belgium. ISBN 90-806516-1-3. 40 pp.

Van Broekhoven E., Somers L. & Tacquenier B. (2011). Overzicht van de boekhoudkundige resultaten van 766 land- en tuinbouwbedrijven: Boekjaar 2009; Landbouwmonitoringsnetwerk, Beleidsdomein Landbouw en Visserij, afdeling Monitoring en Studie, Brussel.

Van der Straeten, B; Buysse, J; Nolte, S; Lauwers, L; Marchand, F; Claeys, D; Van Huylenbroeck, G; (2010). "A multi-agent simulation model for spatial optimisation of manure allocation"; JOURNAL OF ENVIRONMENTAL PLANNING AND MANAGEMENT

Van der Straeten, B; Buysse, Jeroen; Lauwers, Ludwig; Nolte, Stephan; Marchand, F; Claeys, D; Van Huylenbroeck, Guido. (2009). "A MAS model for optimizing the spatial aspects of livestock production and manure abatement"; PhD Symposium Agricultural and Natural Resource Economics, 11th, Proceedings (2009). https://biblio.ugent.be/input/download?func=downloadFile&fileOId=734820&recordOId=734702

Van der Straeten, Bart; Buysse, Jeroen; Marchand, Fleur; Lauwers, Ludwig; Van Huylenbroeck, Guido; (2008). "Fertilization : trade-offs between manure abatement and plant productivity conference" EAAE Congress, 12th, Proceedings (2008); . https://biblio.ugent.be/input/download?func=downloadFile&fileOId=494750&recordOId=494680

Van Huylenbroeck, G.; Jacobs, G. (1998). Naar een duurzame grasland- en groenvoederuitbating: onderzoek naar de integratie van landbouwkundige en ecologische doelstellingen bij grasland- en groenvoederwinning. Ministerie van Middenstand en Landbouw, Centum voor Grasland- en Groenvoederonderzoek: Brussel. ISBN 90-76528-01-2. vi, 221 pp

Van Huylenbroeck, G; Jacobs, G; Vanrolleghem, P. (2000). A simulation model to evaluate the impact of environmental programmes on dairy farms. International Transactions in Operational Research; Volume 7, Issue 2, pages 171–183, March 2000

Van Impe J. (2003). Voortplantingssucces van Kievit Vanellus vanellus, Grutto Limosa limosa en Tureluur Tringa totanus te Antwerpen-Linkeroever. Natuur.oriolus 69: 45-59.

Verboven, A.; Reheul, D. (2000). Beheersovereenkomsten op grasland: invloed op de opbrengsten en de kwaliteit: inpasbaarheid op bedrijfsniveau: eindrapport [pdf]. Universiteit Gent (RUG), Faculteit van de Landbouwkundige en Toegepaste Biologische Wetenschappen, Vakgroep Plantaardige Productie: Gent : Belgium. 95 pp.,

Vermeersch G., Anselin A., Devos K., Herremans M., Stevens J., Gabriëls J. & Van Der Krieken B. (2004). Atlas van de Vlaamse broedvogels 2000-2002. Mededelingen van het Instituut voor Natuurbehoud 23. Instituut voor Natuurbehoud, Brussel.

Vermeersch, G., Onkelinx, T., 2011. Algemene broedvogels Vlaanderen. Trends na de eerste cyclus in een Europees perspectief. Vogelnieuws, 17, 4-7.

Wätzold F., Drechsler M., Armstrong C.W., Baumgartner S., Grimm V., Huth A., Perrings C., Possingham H.P., Shogren J.F., Skonhoft A., Verboom-Vasiljev J., & Wissel C. (2006). Ecological-economic modeling for biodiversity management: Potential, pitfalls, and prospects. Conservation Biology 20(4): 1034-1041.

Whelan, C. J., D.G. Wenny, R.J. Marquis (2008): Ecosystem Services Provided by Birds. Annals of the New York Academy of Sciences 1134(1): 25-60.

Whittingham, M. J. (2011): The future of agri-environment schemes: biodiversity gains and ecosystem service delivery? Journal of Applied Ecology 48(3): 509-513.

Winqvist, C., Bengtsson, J., Aavik, T., Berendse, F., Clement, L.W., Eggers, S., Fischer, C., Flohre, A., Geiger, F., Liira, J., Part, T., Thies, C., Tscharntke, T., Weisser, W.W. & Bommarco, R. (2011): Mixed effects of organic farming and landscape complexity on farmland biodiversity and biological control potential across Europe. Journal of Applied Ecology 48: 570–579.