ORNIS SVECICA 11:235–252, 2001 https://doi.org/10.34080/os.v11.22849

Effects of restoration and management regime on the avifaunal composition on Swedish wet meadows

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Abstract

The present study is an attempt to evaluate the effects of restorations and management regimes on the breeding bird fauna on wet meadows in southern Sweden. A significant population change following a restoration was noted for nine of the 34 studied species and, additionally, several species showed non-significant trends. Species positively affected by restorations generally show a declining national trend. Furthermore, a species was more likely to increase if a breeding population was present before the restoration was initiated. The effects of management regimes were somewhat ambiguous, probably due to the fact that the defined management regimes were based on relatively coarse classifications (grazing, mowing or mowing combined with grazing). A subsequent test showed that associations with area and type of surrounding habitat were of equal importance for the breeding bird fauna as the choice of management regime. Information was obtained for only 15 meadow areas, and in order to attain a larger database concerning the effects of wet meadow restorations and management regimes, a simple standard protocol is suggested.

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Received 5 April 2001, Accepted 22 October 2001, Editor: A. Brodin

Introduction

The agricultural landscape is the dominating habitat in Europe, covering more than half of the land-surface of the European Union (Pain et al. 1997). Long-term reductions of bird populations in farmlands have attracted attention all over Western Europe, e.g. in Britain, Germany, Finland and Sweden (Busche 1994, Pain et al. 1997, Robertson & Berg 1992, Soikkeli & Salo 1979), and similar trends are also known from North America (Herkert 1994). For most species, the cause of the observed population declines is not known, but modernisation of farming has been viewed as the probable cause (Marchant et al. 1990, Robertson & Berg 1992, Tucker & Heath 1994, Fuller et al. 1995).

The present Swedish agricultural landscape is very different from the one a few generations ago. An increasing human population in the 19th century required larger and more efficient food-production and significant areas of wetlands were drained for the purpose of gaining arable land and cultivated pastures. This resulted in the disappearance of large areas of breeding habitat for wetland birds (Gerell 1988). In the provinces of Skåne and Mälardalen more than 90% of the total wetland area has disappeared (SNV 1998).

The modernisation of farming after World War II changed the farmland landscape to a great extent. Fewer, but considerably larger, farming units were required to increase the efficiency. This resulted in the disappearance of edge-habitats, e.g. gravel pits, stonewalls, ditches and hedges, all of which are important habitats for the bird fauna (Gerell 1988, O'Connor & Shrubb 1986). Tractors and industrial fertilisers improved the efficiency of farming significantly and the use of chemicals in agriculture increased dramatically during the same period. Pesticides like DDT, which causes sub-lethal damage in the reproduction organs of many organisms, were used extensively (Odsjö 1988).

Consequently, many of the smaller farms disappeared in the middle of the 20th century due to rationalisation (Gerell 1988). This resulted in a reduction of the total farmland area in Sweden, e.g.

large areas of pastures turned into forests. By the end of the 1960s this transformation of the landscape was proceeding at a rate of about 50,000 ha per year (Larsson 1969).

In addition, the number of dairy cattle in Sweden decreased from 1.7 million in 1900 to 0.44 million in 1999 (SDA 2000). The high-yielding dairy cattle of today have higher nutritional demands and many farmers have ceased to graze semi-natural pastures and meadows in favour of the more productive cultivated grasslands (SNV 1998). During recent decades the number of beef cattle in Sweden has increased, but the numbers are far too small to compensate for the loss of dairy cattle in semi-natural pastures and meadows (SNV 1994).

In 1870, the total area of semi-natural pastures and meadows in Sweden covered an area of 2,000,000 ha and by 1990 the area was reduced to less than 400,000 ha. A large part of this decrease was caused by the disappearance of mowed meadows, which were reduced from 1,200,000 ha to only 2,400 ha during the same period (SNV 1994).

The severe and rapid decline of wet grasslands in Sweden led to a dramatic change in the bird community composition in the agricultural landscape, and species that once were considered as characteristic of this habitat are now regionally close to extinction (Gärdenfors 2000, SNV 1998). The Swedish Red list data book includes a total number of 88 threatened bird species (Gärdenfors 2000). As many as 57 species (65%) are classified as depending on the agricultural landscape and many of these species are decreasing in numbers (Robertson & Berg 1992, Svensson 1995). Estimated population sizes and trends in Sweden for the species considered in this study are presented in Appendix 1.

During the 1990s there have been an increasing number of attempts to restore grasslands, especially in riparian habitats (see e.g. Berg & Ström 1998, Larsson & Welander in prep., Amcoff & Pettersson 1994, Amcoff 1994). Governmental subsidies have financed several restorations in order to increase the area of this important habitat (SNV 1997). Most of these restorations are considered successful and it is a common opinion that restoration projects are necessary to increase the area of suitable habitats for breeding meadow birds, especially waders (e.g. Svensson & Glimskär 1993, Svensson et al. 1992).

In recent years there has been a shortage of grazing animals in Sweden and consequently the importance of mowing as a management regime has increased (Emanuelsson et al. 2000). Major management regimes on Swedish wet meadows are at present mowing, grazing, and mowing combined with late season grazing. However, detailed evaluations of the effects of different management regimes on wet meadow birds are scarce (see, however, Cronert & Lindblad 1994, for a brief discussion).

The present study is an attempt to evaluate the effects on the avifauna of wet-meadow restorations. Specific goals are:

- Evaluate the effects of wet meadow restoration on meadow birds.
- Evaluate the effects of different management regimes on meadow birds.
- Evaluate the effects of meadow size and type of adjacent habitats on meadow birds.

This was achieved by compiling and analysing data from breeding bird surveys performed before and after wet meadow restorations. In addition, a suggestion of a suitable standard protocol for future surveys of the breeding bird fauna and management intensity on restored wet meadows is proposed.

Study area and methods

Data collection

A request for survey data on breeding birds in restored wet meadows was sent to all the 21 county administration boards (*länsstyrelser*) in Sweden. The request was also sent to all regional ornithological societies and to organisations and persons, known to be involved in wet meadow restoration programmes.

The request specifically asked for data from wet meadow areas that had been surveyed for breeding birds both before and after the restoration. Moreover, information regarding restoration measures and management regimes was collected for the different sites. If not included in the information, the area (in hectares) and the length of borders to different adjacent habitats for each site were estimated from maps.

The number of positive responses (23 objects) was much lower than expected and, furthermore, eight of these objects had to be excluded due to, e.g. lack of data concerning management, habitat descriptions or restoration measures (see Discussion below).

Study area and meadow sites

The meadow areas selected for the present study are all located in southern Sweden (see Figure 1). The northernmost (Ledskär) is situated at approximately 60°30'N 17°40'E and the southernmost (Hovby än-

gar) at 55°40'N 14°12'E. Altogether 15 meadow areas were included, but four of these (Vrenninge, Nötmyran, Hjälstaviken and Hovby ängar) were split into 16 sub-areas (see Appendix 2). Some of the areas were either adjacent to each other or situated in the same water system. We are aware of the fact that the sample is not completely independent, but their vast size, differences in management regimes, restoration time and restoration measures (and hence, large differences in habitat composition) left us with no option but to split them into sub-areas.

Each separate meadow-unit, regardless whether it is a single isolated meadow area or a sub-area in a larger meadow system, will be referred to in the present study as a 'site'. A total of 27 sites are included in the statistical analyses.

Most of the meadow areas are situated in open agricultural landscapes. All are located in the inland except for Ledskär and Bråborg which are both situated at coastal bays. Ten of the 13 inland meadow areas are located along lakeshores and three (Nötmyran, Vrenninge and Kungsängen) are situated along the rivers Svartån and Fyrisån. The size of the meadow areas varies to a great extent. The smallest (Sjötuna äng) is only about 11 ha whereas the largest (Nötmyran) covers an area of almost 340 ha.

Breeding bird surveys

Three types of breeding bird surveys have been used for the meadow areas included in this study. The most commonly used method (13 areas) was territory mapping (e.g. Svensson 1975, Bibby et al. 1992). In several meadow areas territory mapping was combined with counts of duck broods (Bibby et al. 1992, SNV 1978), since ducks are not territorial. Two meadow areas (Hjälstaviken and Sjötuna äng) have been surveyed with thorough field counts. Since both field counts and territory mapping are methods resulting in estimates of the total number of breeding pairs in the census area (and not just samples), we have chosen to treat these methods as equivalents. A few sites were excluded since these have been surveyed with different methods before and after the restoration.

Species selection

The selection of 'meadow birds' is based upon a subjective classification of habitat preferences of the species. Many bird species use the wet meadow for foraging or breeding, but few are restricted to meadow habitats only. In this study, species typical of different Swedish meadow habitats (from well-managed to overgrown) were included. Two of the extremes in this respect are Dunlin *Calidris alpina schinzii* (preferring a high grazing-pressure in open areas with no or few shrubs) and Scarlet Rosefinch *Carpodacus erythrinus* (preferring *Salix*-dominated shrubs or even deciduous forests). Altogether 34 bird species were included in the study (see Appendix 1).

Statistical analyses

To avoid effects of the large differences in site-area, the density (pairs ha^{-1}) for the different species was used in the statistical calculations. The selection of species in the surveys differed between the sites. Complete data for, e.g. Reed Bunting *Emberiza schoeniclus*, were only obtained from eight sites, and only 12 species (c. 35%) were surveyed at all 27 sites (see Appendix 1).

In order to evaluate the effects of restorations on the avifauna the breeding density, before and after the restoration, was compared and analysed with a paired t-test. For species that increased we used a G-test to investigate whether pre restoration occurrence had an effect on subsequent population densities.

A stepwise multiple regression with forward selection (SPSS 1994) was used to analyse associations between density and site management (i.e. proportions of the area managed by mowing, grazing, mowing combined with grazing, and unmanaged). All proportions were arcsine-squareroot transformed (Legendre & Legendre 1998). Species that were present in less than five sites were excluded.

Residuals of the stepwise multiple regression analyses were used as dependent variables in a second set of regression models that tested for associations between breeding bird density (when effects of management regimes were controlled for) and site characteristics. The latter included area of the site, area of the total meadow system and proportion of site-borders to different adjacent habitats (including arable field, forest, wetland and meadow).

Results

Effects of restoration

Eleven of the 34 bird species were found in too few sites (<5) to allow statistical analyses (see Appendix 1). Nine species displayed significant population changes ($p<0.05$) between the surveys (see Table 1)

Table 1. Mean ±SE density of breeding meadow birds before and after restorations and results from a paired t-test regarding population changes between surveys conducted before and after wet meadow restoration. N = number of surveyed sites for each species. Level of significance is given by ++, +, –, – –, and (–), the latter meaning close to significance.
Medeltätheter ±SE av häckande fåglar före och efter restaureringar samt reslutat från parat t-test med avseende på populationsförändringar mellan inventeringar utförda före och efter våtängsrestaurering. N = *antal inventeringsområden för varje art. Signifikansnivåerna ges med ++, +, –, – – och (–); det sista avser nära signifikant.*

Species *Art*	N	Mean ±SE densities, pairs ha^{-1} *Medel ±SE täthet, par ha^{-1}* Before restoration *Före restaurering*	After restoration *Efter restaurering*	Difference *Skillnad*	t-value *t-värde*	P-value *P-värde*	
Greylag Goose *Anser anser*	23	0.0025 ±0.002	0.0933 ±0.038	0.0908	-2.35	0.028	+
Teal *Anas crecca*	19	0.0024 ±0.002	0.0041 ±0.002	0.0017	-1.56	0.137	
Mallard *Anas platyrhynchos*	15	0.0395 ±0.012	0.2261 ±0.089	0.1866	-2.30	0.037	+
Garganey *Anas querquedula*	27	0.0037 ±0.001	0.0282 ±0.019	0.0245	-1.30	0.206	
Shoveler *Anas clypeata*	27	0.0083 ±0.002	0.0389 ±0.018	0.0306	-1.68	0.106	
Spotted Crake *Porzana porzana*	21	0.0015 ±0.001	0.0088 ±0.005	0.0073	-1.44	0.165	
Corncrake *Crex crex*	22	0.0085 ±0.005	0.0187 ±0.006	0.0102	-1.16	0.258	
Lapwing *Vanellus vanellus*	26	0.0729 ±0.024	0.2156 ±0.051	0.1427	-3.38	0.002	++
Ruff *Philomachus pugnax*	27	0.0108 ±0.005	0.0204 ±0.009	0.0096	-1.11	0.276	
Snipe *Gallinago gallinago*	13	0.1214 ±0.037	0.1125 ±0.025	-0.0089	0.44	0.670	
Black-tailed Godwit *Limosa limosa*	27	0.0141 ±0.006	0.0121 ±0.005	-0.002	0.68	0.501	
Curlew *Numenius arquata*	27	0.0141 ±0.004	0.0182 ±0.004	0.0041	-2.23	0.034	+
Redshank *Tringa totanus*	27	0.0148 ±0.006	0.0449 ±0.012	0.0301	-2.41	0.023	+
Black-headed Gull *Larus ridibundus*	22	0.6005 ±0.437	0.2302 ±0.125	-0.3703	0.98	0.340	
Skylark *Alauda arvensis*	18	0.0401 ±0.015	0.0970 ±0.018	0.0569	-3.44	0.004	++
Meadow Pipit *Anthus pratensis*	22	0.1922 ±0.044	0.2301 ±0.037	0.0379	-0.83	0.416	
Yellow Wagtail *Motacilla flava*	23	0.1936 ±0.046	0.3237 ±0.056	0.1301	-2.50	0.021	+
Whinchat *Saxicola rubetra*	22	0.2126 ±0.055	0.0924 ±0.026	-0.1202	2.85	0.010	– –
Grasshopper Warbler *Locustella naevia*	22	0.1055 ±0.018	0.0621 ±0.015	-0.0434	1.99	0.060	(–)
Sedge Warbler *Acroceph. schoenobaenus*	17	0.2180 ±0.048	0.1275 ±0.038	-0.0905	1.67	0.115	
Whitethroat *Sylvia communis*	21	0.0401 ±0.014	0.0250 ±0.008	-0.0151	1.99	0.065	(–)
Scarlet Rosefinch *Carpodacus erythrinus*	20	0.0253 ±0.008	0.0103 ±0.005	-0.015	2.36	0.029	–
Reed Bunting *Emberiza schoeniclus*	8	0.3585 ±0.084	0.1625 ±0.060	-0.196	2.24	0.060	(–)

and, additionally, three species showed non-significant population trends ($p<0.10$).

A density increase between the surveys was obtained for seven species (Greylag Goose *Anser anser*, Mallard *Anas platyrhynchos*, Lapwing *Vanellus vanellus*, Curlew *Numenius arquata*, Redshank *Tringa totanus*, Skylark *Alauda arvensis* and Yellow Wagtail *Motacilla flava*), while two species showed a significant decrease (Whinchat *Saxicola rubetra* and Scarlet Rosefinch). Additionally three species (Grasshopper Warbler *Locustella naevia*, Whitethroat *Sylvia communis* and Reed Bunting) showed a non-significant tendency to decrease between the surveys. For the remaining 11 species, no population change (or trend) occurred at all. Results are presented in Table 1.

The effect of pre-restoration occurrence was tested on the seven species with significant population increases (see Table 1). This analysis showed that a population was more probable to increase if the species was present at the site before the restoration was initiated ($G=25.2$, $df=1$, $p<0.001$). Curlew (2.8 times more likely to increase when occurring before restoration than if not occurring), Greylag Goose (2.2 times) and Skylark (1.8 times) seemed to be strongly dependent on pre-restoration presence in order to display a population increase.

Effects of management and site characteristics

Ten of the 23 analysed species showed significant associations to the four management variables (see Table 2). Two to four species showed association with each of the different management regimes, thus no single management regime seems to be preferred by a large number of species. Furthermore, the proportion of the variation in breeding bird density explained by these models was relatively low (mean

Table 2. Associations between bird species and management regimes (Beta values). Results from multiple regression models with forward selection. * = p<0.05, ** = p<0.01, *** = p<0.001
Samband mellan arter och skötselmetoder (Beta-värden). Resultat från multipla regressionsmodeller med "forward selection".

Species *Art*	Management regime *Skötselåtgärder*				r^2	*F*	*p*
	Mowing *Slåtter*	Grazing *Bete*	Mowing/grazing *Slåtter/bete*	Unmanaged *Obehandlat*			
Greylag Goose *Anser anser*		0.43*			0.15	4.7807	0.0402
Teal *Anas crecca*		-0.58**			0.30	8.7608	0.0088
Mallard *Anas platyrhynchos*							
Garganey *Anas querquedula*							
Shoveler *Anas clypeata*		0.39*			0.12	4.5615	0.0427
Spotted Crake *Porzana porzana*							
Corncrake *Crex crex*							
Lapwing *Vanellus vanellus*	-0.39*				0.12	4.3533	0.0477
Ruff *Philomachus pugnax*							
Snipe *Gallinago gallinago*	-0.64*				0.36	7.6058	0.0186
Black-tailed Godwit *Limosa limosa*			0.79***		0.60	40.186	0.0000
Curlew *Numenius arquata*			0.60***		0.34	14.294	0.0009
Redshank *Tringa totanus*							
Black-headed gull *Larus ridibundus*							
Skylark *Alauda arvensis*				0.54*	0.25	5.9614	0.0285
Meadow Pipit *Anthus pratensis*							
Yellow Wagtail *Motacilla flava*		0.42*			0.14	4.6424	0.0430
Whinchat *Saxicola rubetra*							
Grasshopper Warbler *Locustella naevia*							
Sedge Warbler *Acrocephalus schoenobaenus*							
Whitethroat *Sylvia communis*	0 .53*			0.43*	0.41	6.2649	0.0124
Scarlet Rosefinch *Carpodacus erythrinus*							
Reed Bunting *Emberiza schoeniclus*							

r^2=28%), suggesting that other factors largely influenced the density of different bird species.

Of the 23 species, 11 showed significant association with at least one of the site characteristics (Table 3). Seven species were associated with either of the two area measurements, although most of them negatively. Seven species were also associated with the type of surrounding habitat, the most important being the proportion of meadow bordering onto forest, which was associated with the density of five species.

Discussion

Data collection

There are a large number of restored wet meadows in Sweden today, but collection of data for a comparative study concerning the effects on breeding birds was difficult. Many sites, originally thought to be useful, had to be excluded because of various reasons:

- No breeding bird survey had been conducted on the restored site.
- The breeding bird survey was initiated the same year as the restoration.
- The breeding bird survey technique was changed without intersecting seasons, thus the survey results could not be compared.
- The restoration was not properly documented.
- Lack of information on type and intensity of management regime.

Finally, a couple of restored and surveyed meadow sites were not included in the study because we did not receive existing information.

In order to improve future evaluations of wet meadow restorations and management regimes we suggest that a standard protocol of breeding bird surveys,

Table 3. Associations between bird species and site characteristics (Beta values). Results from multiple regression models with forward selection. * = p<0.05, ** = p<0.01, *** = p<0.001.
Samband mellan arter och landskapets sammansättning (Beta-värden). Resultat från multipla regressionsmodeller med "forward selection".

	Area and surrounding habitat *Areal och omgivande biotop*								
Species *Art*	Site area *Areal*	Meadow area *Ängsareal*	Arable land *Åker*	Meadow *Äng*	Forest *Skog*	Wetland *Våtmark*	r^2	*F*	*p*
Greylag Goose *Anser anser*	-0.50*				-0.42*		0.32	6.1203	0.0084
Teal *Anas crecca*									
Mallard *Anas platyrhynchos*	-0.59*						0.30	6.9400	0.0206
Garganey *Anas querquedula*	-0.56**				-0.41*		0.30	6.4865	0.0056
Shoveler *Anas clypeata*									
Spotted Crake *Porzana porzana*									
Corncrake *Crex crex*									
Lapwing *Vanellus vanellus*		-0.54**					0.27	10.099	0.0041
Ruff *Philomachus pugnax*		-0.49**					0.21	8.0952	0.0087
Snipe *Gallinago gallinago*					0.81***		0.62	20.841	0.0008
Back-tailed Godwit *Limosa limosa*									
Curlew *Numenius arquata*									
Redshank *Tringa totanus*						-0.40*	0.12	4.7094	0.0397
Black-headed Gull *Larus ridibundus*									
Skylark *Alauda arvensis*						-0.69**	0.44	12.873	0.0030
Meadow Pipit *Anthus pratensis*									
Yellow Wagtail *Motacilla flava*					-0.44*		0.15	5.0190	0.0360
Whinchat *Saxicola rubetra*									
Grasshopper Warbler *Locustella naevia*		0.44*					0.16	4.9188	0.0383
Sedge Warbler *Acrocephalus schoenobaenus*									
Whitethroat *Sylvia communis*									
Scarlet Rosefinch *Carpodacus erythrinus*		0.62**			0.46*		0.35	6.2135	0.0094
Reed Bunting *Emberiza schoeniclus*									

habitat mapping and management intensity estimates should be used (see below and Appendix 3).

One confounding factor when evaluating effects of wet meadow restorations is differences in spring flooding levels between years. Berg & Ström (1998) presented population changes between years with different spring flooding levels for 12 species from Nötmyran in south-central Sweden (Site 9, Figure 1 in this study). The population changes were associated with the spring flooding levels and for six species the flooding had a positive effect on the numbers of breeding pairs (see also Jonsson 2000). For example the population size of Lapwings was positively associated with the amount of spring flooding and the population size varied between 152 and 297 pairs. For Yellow Wagtail the flooding-dependent fluctuations between years were even larger (Jonsson 2000, Berg & Ström 1998). In order to reduce the effects of this, and other temporally varying factors, it is important that studies are conducted during several years. This fact might be a problem for the present study, since data were collected from only two survey years for each site, a single year before and a single year after the restoration (except for Nötmyran, where mean values for several years were used). However, the survey data were compiled from 11 different years before restorations and nine different years after restorations (see Appendix 2), regardless of the amount of flooding, and consequently could in this respect be viewed as a random sample. Still, a breeding bird survey from a specific site and year might be biased due to low or high spring flooding levels.

Population changes in restored wet meadows

The common object for a wet meadow restoration is an area, once mowed or grazed by cattle and dominated by short-cropped grasses, but abandoned for a number of decades and today overgrown with shrubs or invaded by reeds *Phragmites communis*. The avifauna in the former habitat is often dominated by

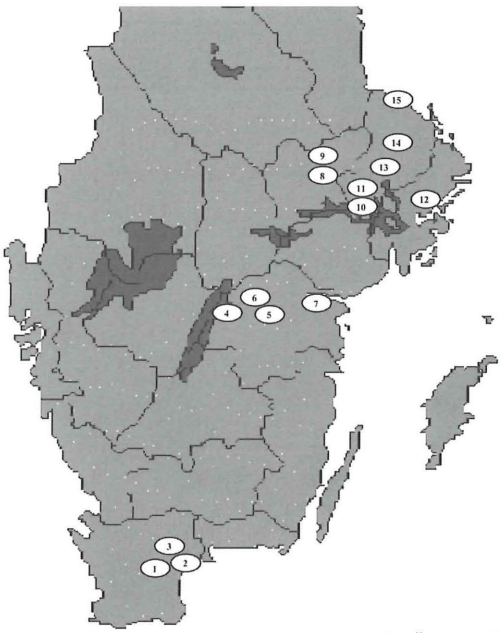

Figure 1. Meadow areas used in the present study. *Ängsområdet inkluderade i undersökningen.* 1 Hovby ängar, 2 Rinkaby ängar, 3 Håslövs ängar, 4 Sjötuna äng, 5 Härnaviken/Sättuna, 6 Kungsbro, 7 Bråborg, 8 Vrenninge, 9 Nötmyran, 10 Hjälstaviken, 11 Lårstaviken, 12 Angarnsjöängen, 13 Övre föret, 14 Vendelsjön, 15 Fladen/Ledskär

shorebirds and ducks, while the latter mainly consists of passerines (see e.g. Soikkeli & Salo 1979). This development has occurred nation-wide and has resulted in decreases of many bird populations, and the aim for wet meadow restorations is generally to change this negative trend.

In the present study, the restorations resulted in significantly higher densities for seven species and significantly lower densities for two species. Additionally, some non-significant tendencies were discernible and general trends are discussed below (see Figure 2).

Restorations had a positive effect on the densities of Greylag Goose and Mallard. For the other dabbling ducks *Anas sp.* there was a non-significant tendency to increase (see Table 1). The positive effect is probably due to a combination of factors, such as the creation of open shores when reeds are cut and the creation of a 'blue-border', i.e. areas of shallow water that flood the meadow.

Spotted Crake *Porzana porzana* and Corncrake *Crex crex* also showed non-significant increasing trends. Since these species require intermediate successions of the meadow, with grass tall enough to provide sufficient cover (Cramp et al. 1980, Green 1996), it seems reasonable that they do not respond instantly to a restoration. In addition, the Corncrakes in southern Sweden are often found on arable fields (Ahlén & Tjernberg 1996) and consequently would be less affected by wet meadow restorations.

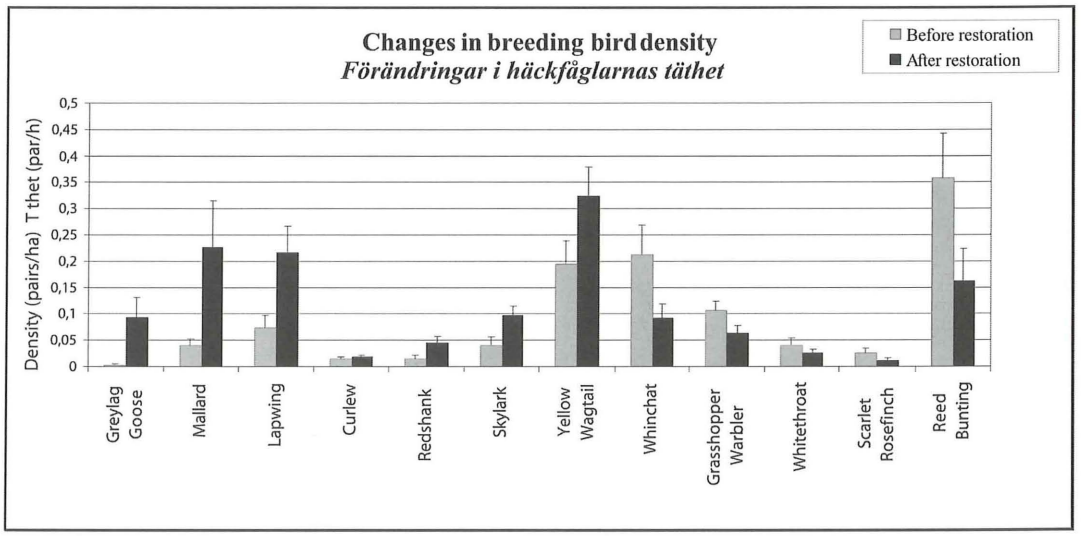

Figure 2. Breeding bird density on wet meadows before and after restoration.
Tätheter för häckande fåglar på våtängar före och efter restaurering.

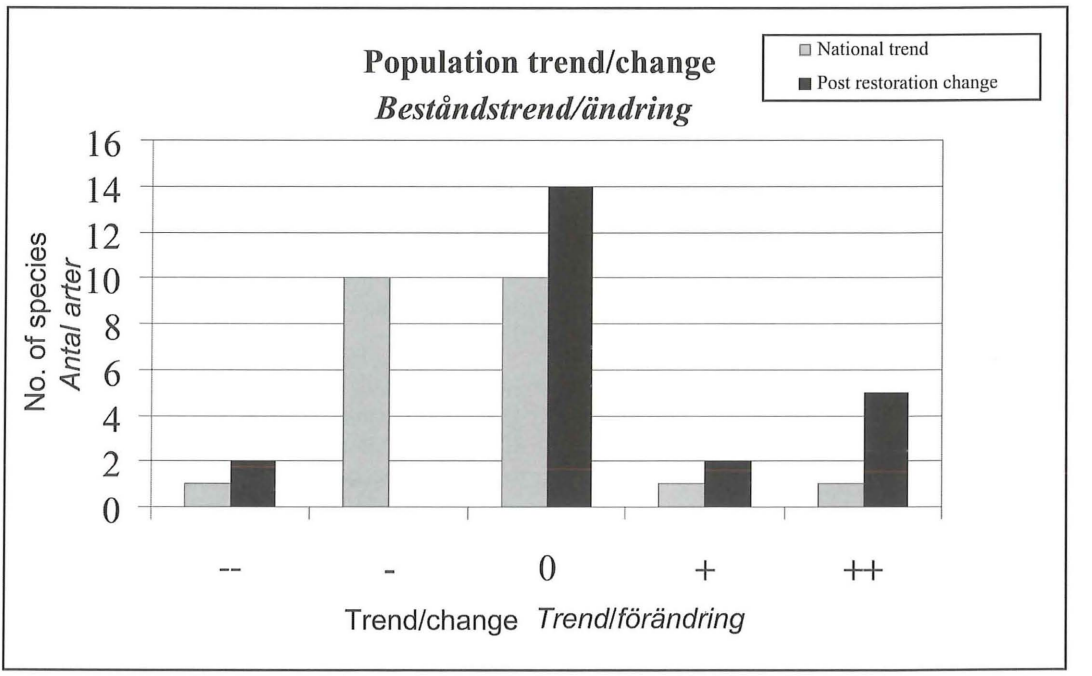

Figure 3. Population changes after wet meadow restoration (filled bars) and national trends in the 23 species presented in Table 1 (– – strong decrease, – slight decrease, 0 unchanged, + slight increase, + + strong increase). See Appendix 1 for more specific information.

Populationsförändringar efter restaurering av våtängar (fyllda staplar) samt nationella trender hos de 23 arterna i Tabell 1 (– –kraftig minskning, – svag minskning, 0 oförändrad, + svag ökning, ++ kraftig ökning). Se Appendix 1 för mer detaljerad information.

Among the shorebirds, only Lapwing, Curlew and Redshank increased significantly. However, the sample sizes for Ruff *Philomachus pugnax* and Black-tailed Godwit *Limosa limosa* were probably too small and the populations were mainly concentrated to the meadows around Lake Hammarsjön in southernmost Sweden. Restorations in some parts of this area mainly consisted of modified management regimes and the meadow sites were rather well-managed also before the restorations. With larger sample sizes density changes may have occurred also for these species.

For Black-headed Gull *Larus ridibundus* no significant change in density occurred. The colonies of gulls are often situated in the lakes, outside the boundaries of the surveyed areas, and consequently are not properly comprised by meadow surveys.

Among the passerines, Skylark and Yellow Wagtail both showed significantly higher densities after the restorations than before. This is probably due to decreased amounts of shrubs and trees, resulting in a more open habitat preferred by these species (e.g. Wilson et al. 1997). Meadow Pipit *Anthus pratensis* did not show any significant trend, which seems reasonable since this species occurs in a broad spectrum of meadow habitats (Cramp et al. 1988). Remaining passerines all tended to decrease, although this was significant only for Whinchat and Scarlet Rosefinch. For Grasshopper Warbler, Sedge warbler, Whitethroat and Reed Bunting we expected a rather strong negative population trend, but no such were found. This is probably due to the fact that a few remaining shrubs (e.g. in a ditch) might be enough to hold a territory of any of these species. Additionally, these species have broad habitat preferences and occur in residual habitats such as ditches, on set-asides and in short rotation coppice (Berg & Pärt 1994, Berg in press).

Two species, Greylag Goose and Scarlet Rosefinch, showed population changes that seem to be analogous with the nation-wide population trend, and should therefore be regarded with care. In the remaining 10 species the results differ from the national trend (see Figure 3), suggesting that population changes for these species in fact were due to the performed restorations.

In general, a species was more likely to increase at a restored site if a breeding population was present before the restoration was initiated. There are several possible explanations of this. First, the occurrence of a species before the restoration indicates that the site characteristics and the landscape composition in general are suitable for the species (e.g. long distance to forest edges for edge-avoiding species). This is a probable explanation of the different population changes in areas with and without Skylarks, since this species is abundant in most agricultural landscapes (Robertson & Berg 1992). Second, philopatric species are more likely to settle in the area where they were hatched and might increase in number when the habitat is improved (due to higher reproduction success after restoration). This is a possible explanation of the strong increase in number of Curlews in sites where the species occurred before restorations, since curlews are rare in many farmland landscapes in southern Sweden (de Jong & Berg in prep.). Third, species may judge the suitability and quality of a breeding habitat by the presence of conspecifics, i.e. conspecific attraction (Reed & Dobson 1993). In a newly created habitat, such as after a wet meadow restoration, breeding habitat availability should be high and presence of old tenacious conspecifics suggest its high suitability for a successful breeding. Thus, conspecific attraction may be a potential additional explanation of why increases in population numbers mainly were observed at sites with pre-restoration occurrence.

The breeding bird fauna in a restored meadow system is not necessarily more species-rich than the one in over-grown, abandoned meadows (Larsson 1969). On the contrary, the situation is often the reverse, since numerous passerine species prefer successional habitats with higher grasses and patches of trees and shrubs (see e.g. Soikkeli & Salo 1979). Additionally, in a newly restored wet meadow it may take several seasons for new immigrating species to establish and thereby contribute to the species-richness. However, as stated earlier, those bird species that are positively affected by restorations generally show a declining national trend (see Table 1 and Appendix 1) because of decreasing areas of managed wet meadows. Thus, changes in the breeding bird fauna following a restoration should be seen as a qualitative improvement rather than a quantitative. From a conservation point of view, restoration is a good way to create and preserve rare wetland habitats that are important to several declining bird species.

Effects of management regime and site characteristics

The results concerning the effects of management regimes are somewhat ambiguous (see Table 2). This is probably due to the fact that the defined management regimes are coarse classifications and do not include measurements of different degrees of management, i.e. grazing intensity, repeated mowing, timing of mowing etc. Detailed data of this kind were only obtained for a small number of the sites, and were consequently omitted.

Mowing is a management regime of moderate intensity that creates a homogeneous grassland habitat of intermediate height already in spring (Berg & Ström 1998). The grass is usually not cut until July, when the vegetation is rather tall and dense. This habitat is not favoured by some species, e.g. Lapwings, which prefer areas with short or no vegetation and, as a consequence, often choose to breed in nearby arable fields (Tucker et al. 1994). This fact may explain this species' negative association with mowing (see Table 2) and may also be the cause of the similar result for Snipe, which usually prefers more heterogeneous habitats with patches of bare and wet soil (Cramp et al. 1983).

In general, plant species composition could be expected to differ between sites managed by mowing and sites managed by grazing. Mowing probably favours plants that are tasty to grazing animals, early flowering species or species that are sensitive to damage early in the season (Lennartsson 1997). However, effects of plant species composition on the breeding bird fauna need further evaluation.

Grazing produces a mosaic grassland with areas of short, intermediate and tall grasses, often combined with patches of bare soil and numerous tussocks created by selective grazing and trampling of the cattle. Ground-nesting species in grazed coastal marshlands in Britain have been shown to be positively associated with complexity of the grass sward and surface topography (Milsom et al. 2000). However, vegetation structure largely depends on grazing intensity, which is an important factor to consider when suggesting management to promote a certain breeding bird composition. In some species, e.g. Yellow Wagtail, the association with grazing is probably due to the creation of tussocks providing sufficient habitat for nesting (Thorssell 1992), whilst in other species the most important factor is that the grass-height is low enough to enable foraging of insects (Pärt & Söderström 1999). Additionally, a moderate grazing pressure enhances the growth of herbage- and seed-producing plants, which are of

major importance for dabbling ducks and Greylag Goose, among others (Pehrsson 1988).

At some sites, mowing and grazing were combined, most often with late season grazing following the mowing. This seems to create a habitat favourable for shorebirds, although significant associations were found only for Black-tailed Godwit and Curlew. According to Pehrsson (1988), both overgrazing and overgrowth reduce the important seed production of *Scirpus*-species. In this respect, the combined mowing and late season grazing in a rotation scheme may be a suitable management regime when optimising the wet meadows for ducks and shorebirds.

When we started this analysis, well defined grouping of species associated to the different management regimes was expected. However, no such pattern occurred but, as mentioned earlier, the average proportion of the variation (r^2) in breeding bird density explained by meadow management type was only 0.28. Hence, roughly compared to the density analysis, it seems that the restoration itself has a large influence on breeding bird fauna, whereas the choice of main management regime (in terms of the coarse classification used here) has a smaller effect.

The breeding bird fauna in meadow habitats is, however, not only dependent on management. Therefore, the importance of other site characteristics (area and type of adjacent habitats) was analysed as well (see Table 3). Seven species were significantly associated to the two main variable groups respectively. Of the seven species showing associations with type of adjacent habitat, five were associated with the proportion of border to forest. In line with this, Pärt & Söderström (1999) found that the proportion of forest along the borders of semi-natural dry pastures is a main factor affecting the species composition in this habitat. In the present study, only Greylag Goose, Garganey and Yellow Wagtail showed negative associations with the proportion of border to forest. This is rather surprising since species with open nests often avoid forest edges (see e.g. Møller 1989), but is probably explained by the fact that many meadows were relatively large, and substantial parts of these meadows were situated far from forest edges (i.e. suitable areas for edge-avoiding species).

The ambiguous results may partly be due to the low number of well-documented wet meadow restorations in Sweden. With a simplified and more uniform way of recording and collecting data, the effects of different management regimes would be easier to analyse.

Standardised documentation of wet meadow restorations

In order to facilitate future analyses of wet meadow restorations, management regimes and breeding bird surveys, a suggestion for a standard protocol is presented in Appendix 3. A widespread use of one common survey technique would generate a large and uniform database, allowing more precise studies in the matter. The major contents of the protocol are discussed below.

Breeding bird surveys

When performing a documentation of changes in breeding bird fauna following a wet meadow restoration it is imperative that surveys are initialised one season (or preferably several) before the commencing of the restoration. This may appear as a rather obvious statement, but yet a number of sites had to be excluded from the present study due to lack of data prior to the restoration.

The choice of survey technique should be based on the fact that the essential task is to discern changes in breeding bird populations in response to restoration and management of wet meadows. Territory mapping (see e.g. Bibby et al. 1992) usually comprises the whole site, but is a very time-consuming technique and may, additionally, be very hard to conduct during years with high level of flooding.

A suitable survey technique (at least for large meadows) in this respect is point counts, which exhibit a couple of relevant advantages:

- A rather efficient technique, i.e. a relatively large number of birds are registered with a small effort. Thus, many points can be counted by the same person during a single morning.
- The method can be used in restricted parts of meadows with similar management and restoration history.

The suggested technique is similar to the one proposed by the MISTRA research programme 'Management of semi-natural grasslands – Economy and biodiversity' (Emanuelsson et al. 2001). Technical instructions for point counts are found in, e.g. Bibby et al. (1992), but in order to generate a survey technique suitable for restored wet meadows some adjustments will be proposed (for detailed instructions, see Appendix 3). In short, the point should consist of an area with a radius of 100 meters. The point should be visited three times per season, and the count should last for five minutes only. With this method a large number of points can be covered by a single observer,

and combined with a simple way of recording the management data, this will probably contribute to create a useful database within a few years.

Documentation of restorations and management regimes

A documentation of the restoration was lacking for a small number of the originally included sites in the present study. In order to create a useful database it is, however, important that all restoration measurements performed within and around the survey point are documented, at least to some extent.

Documentation of meadow management may be done in several ways, but in order to create a simple technique the standard protocol only contains measurements that can be visually estimated. Habitat mapping includes the proportion of different major habitats within, and bordering, the point. Furthermore, occurrence of linear habitats (e.g. ditches, minor roads, etc.) and other characteristic elements (e.g. trees, shrubs, barns, etc.) are noted. Documentation of management includes the proportion of the survey area managed by grazing or mowing (or combined), and vegetation height in areas with different management regimes. Finally, the amount of flooding should be estimated and recently performed restoration measures should be noted. Most of the measurements are recorded once annually, but the amount of flooding and grass height should be recorded at all three visits.

Conclusions

In conclusion, performed meadow restorations have resulted in population increases for several species depending on grazing or mowing. However, differences between broad categories of management regimes were smaller than expected. More detailed data on habitat composition and management are needed and a standard protocol for breeding bird surveys and habitat mapping is suggested in order to facilitate future analyses of meadow bird habitat preferences and effects of wet meadow restorations.

Acknowledgements

We would like to thank Martin Tjernberg, Tomas Pärt and Bo Söderström for important discussions and valuable comments on the manuscript. We would also like to thank the persons who contributed with the breeding bird survey results, management data and habitat information for the meadow areas in the study: Martin Amcoff, Mikael Molin, Svante Söderholm, Kjell Eriksson, Torsten Larsson, Björn Welander, Hans Cronert, Lars Gezelius, Dan Nilsson, Pekka Westin, Peder Hedberg Fält and Anders Eriksson. We know it took a lot of hard work to find and reconstruct the data.

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Sammanfattning

Effekter av restaurering och skötselmetod på fågelfaunans sammansättning på svenska våtängar

Den minskade arealen av hävdade våtängar i Sverige har medfört drastiska populationsminskningar av många hävdberoende fågelarter. I syfte att bryta denna negativa trend har restaureringsprojekt genomförts på många håll i landet. Denna undersökning utvärderar effekterna av restaureringar och olika skötselmetoder på fågelfaunan. Dessutom analyseras betydelsen av ängsmarkernas areal samt typ av angränsande habitat.

Vi skickade förfrågningar rörande restaureringsobjekt där häckfågelinventeringar utförts både före och efter restaureringen till samtliga länsstyrelser och regionala ornitologiska föreningar i landet samt till enskilda personer som vi visste var engagerade i sådana projekt. Antalet svar var avsevärt lägre än väntat och flera områden kunde ej användas i analyserna (se vidare under Diskussion). Totalt ingår 15 ängsområden i undersökningen (se Figur 1) men fyra av dessa delades upp i 16 delområden (se

Appendix 2). Några av dessa delområden ligger i omedelbar anslutning till varandra eller ingår i samma vattensystem. Vi är medvetna om att dessa delområden inte är oberoende av varandra, men på grund av stora variationer i areal, restaureringstidpunkter, restaureringsåtgärder och skötselmetoder var vi tvungna att göra denna uppdelning.

Fågelbestånden i våtängsområden påverkas i hög grad av vårsvämmningens omfattning. Inventeringsresultaten från ett specifikt område och år (se Appendix 2) kan därför vara missvisande för området, men inventeringarna genomfördes med stor spridning i tiden (totalt är 20 inventeringsår representerade).

Totalt inkluderades 34 fågelarter i studien (se Appendix 1, där även nationella populationsuppskattningar och trender presenteras). Inventeringsresultaten före respektive efter restaureringarna omvandlades till tätheter (par ha^{-1}) och analyserades med ett parat t-test. För arter som uppvisade en ökning undersökte vi med ett G-test om förekomst på lokalen innan restaurering hade någon effekt på populations utvecklingen.

För att utröna om olika arters förekomst påverkades av skötselmetoder (bete, slåtter, bete kombinerat med slåtter samt ohävdat) analyserades materialet med multipla regressionsmodeller. Residualerna från dessa modeller användes i en kompletterande analys där vi testade huruvida landskapets sammansättning (arealer samt andel av inventeringsområdet angränsande till åker, äng, skog och våtmark) påverkade olika arters förekomster.

Resultat

Elva av de 34 arterna fanns i för få (<5) delområden för att en statistisk analys skulle vara möjlig. Av de resterande 23 arterna uppvisade nio signifikanta ($p<0,05$) populationsförändringar mellan inventeringsåren (se Tabell 1) och ytterligare tre arter visade icke-signifikanta trender ($p<0,10$). Sju arter (grågås, gräsand, tofsvipa, storspov, rödbena, sånglärka och gulärla) ökade i täthet medan två arter (buskskvätta och rosenfink) minskade (se Tabell 1). Dessutom erhölls icke-signifikanta minskande trender för gräshoppsångare, törnsångare och sävsparv.

En ökning av tätheten för en art efter en restaurering var mer sannolik om en häckande population av arten fanns inom området redan innan restaureringen påbörjades ($G=25,2$, $df=1$, $p<0,001$). Storspov (2,8 gånger högre sannolikhet att öka om den fanns häckande före restaureringen, än om den inte fanns), grågås (2,2 gånger högre sannolikhet) och sånglärka (1,8 gånger högre sannolikhet) verkade vara relativt starkt beroende av befintliga populationer.

Tio av de 23 analyserade arterna påverkades av typ av skötselmetod (se Tabell 2). Samband erhölls för två-fyra arter med vardera skötselmetod och följaktligen verkade ingen enskild metod vara gynnsam för ett större antal arter. Elva av de 23 analyserade arterna uppvisade signifikanta samband med ängsmarkernas storlek eller typ av angränsande habitat (se Tabell 3). Den viktigaste enskilda faktorn var andelen ängsmark angränsande till skog.

Diskussion

Det finns idag ett stort antal restaurerade våtängar i Sverige, men insamlandet av data till en jämförande studie rörande effekter på häckfågelfaunan var problematisk. Åtskilliga områden som inledningsvis antogs vara användbara exkluderades p.g.a. olika orsaker:

- inga inventeringar hade utförts
- inventeringarna påbörjades samma år som restaureringen inleddes
- inventeringsmetoder skiftades utan överlappande säsonger
- restaureringen dokumenterades bristfälligt
- brist på information rörande skötselmetoder

I syfte att förenkla och förbättra framtida studier i ämnet föreslås ett standardiserat inventeringsprotokoll där skötselmetoder och habitatkartering ges betydande utrymme (se nedan samt Appendix 3).

Två arter, grågås och rosenfink, uppvisade populationsförändringar i överensstämmelse med dess utveckling i hela landet och det kan därför vara svårt att avgöra hur stor del av dessa förändringar som beror på lokala restaureringar. För övriga 10 arter skiljer sig resultaten i studien från respektive arts nationella trend, vilket tyder på att de observerade förändringarna har orsakats av restaureringarna (se Figur 3 samt Appendix 1).

Sannolikheten för att en art skulle uppvisa ökande tätheter efter en restaurering ökade generellt om en häckande population av arten fanns i området redan innan restaureringen inleddes. Det finns flera möjliga förklaringar till detta. Närvaron av en art innan en restaurering påbörjas tyder på att landskapets sammansättning är passande för arten i fråga. Detta kan vara förklaringen till de olika populationsförändringarna i områden med eller utan sånglärkor, då denna art är både talrik och väl spridd i de flesta jordbrukslandskap. Vidare är ortstrogna arter mer benägna att återvända till de områden där de ursprungligen kläcktes. Om habitatet förändras till det bättre är det troligt att dessa arter ökar i antal till följd

av förbättrad reproduktionsframgång. Då t.ex. storspoven är ovanlig i stora delar av södra Sverige kan detta vara en möjlig förklaring till den kraftiga ökningen av antalet i områden där arten förekom innan restaureringarna. Eventuellt kan vissa arter bedöma ett habitats kvalitet genom närvaron av artfränder (s.k. conspecific attraction) och detta kan vara ett snabbt och effektivt sätt att bedöma sannolikheten för en lyckad häckning.

En våtängsrestaurering medför inte nödvändigtvis en mer artrik fågelfauna än föregående igenväxta habitat. Förhållandet är ofta det motsatta då åtskilliga tättingarter föredrar senare successioner med högre gräs och bestånd av buskar och träd. De arter som gynnas av restaureringar visar emellertid ofta minskande populationer nationellt och restaureringar ger därför upphov till kvalitativa förbättringar, snarare än kvantitativa.

Resultaten från utvärderingen av skötselmetoder (se Tabell 2) är något svårtolkade, troligen till följd av den grova kategoriindelningen (bete, slåtter, bete kombinerat med slåtter samt ohävdat). Ett tydligare resultat hade troligen erhållits om hänsyn hade tagits till t.ex. betestryck, förekomst av upprepad slåtter, tidpunkter för slåtter etc., men detaljerade uppgifter likt detta fanns endast tillgängligt för ett fåtal områden. Följaktligen var förklaringsgraden relativt låg (r^2=0,28) och betydelsen av landskapets sammansättning verkar vara av jämförbar storlek med val av skötselmetod (se Tabell 3).

Standardiserad dokumentation av våtängsrestaurering

I syfte att göra framtida studier i ämnet enklare och bättre föreslår vi att ett standardiserat inventeringsprotokoll används (se Appendix 3). Med en omfattande användning av en enkel och gemensam inventeringsmetodik bör en användbar databas finnas tillgänglig inom några år.

I korta ordalag föreslår vi en punkttaxering (radie 100m) med tre besök á fem minuter per säsong. En gång per år noteras (1) fördelning av huvudhabitat inom och kring inventeringsområdet, (2) klassificering av olika skötselmetoder, (3) markanvändning på odlad mark, (4) avstånd till olika huvudhabitat, (5) förkomst av småbiotoper samt (6) eventuella restaureringsåtgärder. Vid varje besök noteras (7) vårsvämmningens omfattning samt (8) gräshöjder inom inventeringsområdet.

Appendix 1

Population sizes, recent trends and abundances before and after wet meadow restoration for the 34 bird species in the study.

Swedish population is the estimated number of pairs according to Svensson et al. (1999) and Martin Tjernberg, ArtDatabanken, SLU (pers. comm.). Trend is given as ++ (strong increase), + moderate increase, 0 no change, – moderate decrease, – – strong decrease. N = number of censused sites. With spec. = number of sites with the species before and after restoration. Proportion = proportion of sites with the species before and after restoration. Pairs = Number of pairs before and after restoration.

Populationsstorlekar, aktuella trender samt förekomster före och efter våtängsrestaurering för de 34 fågelarterna i studien.

Svenska beståndet är uppskattat antal par enligt Svensson m. fl. 1999 och Martin Tjernberg, ArtDatabanken, SLU (personlig uppgift). Trend ges med ++ (kraftig ökning), + måttlig ökning, 0 ingen förändring, – svag nedgång, – – stark nedgång. N = antal inventerade områden. Med arten = antal omnråden med arten före och efter restaurering. Andel = andel områden med arten före och efter restaurering. Par = Antal par före och efter restaurering.

Species *Art*	Swedish population *Svenska beståndet*	Trend *Trend*	N	With spec. *Med arten*	Proportion *Andel*	Pairs *Par*	Pairs/site *Par/område*
Greylag Goose *Anser anser*	6.000–10.000	++	23	3–9	0.13–0.39	8–46	0.35–2.00
Wigeon *Anas penelope*	20.000–30.000	0	27	0–1	0.00–0.04	0–1	0.00–0.04
Gadwal *A. strepera*	400–800	+	27	1–1	0.04–0.04	1–4	0.04–0.15
Teal *A. crecca*	40.000–60.000	0	19	3–6	0.16–0.32	7–11	0.37–0.58
Mallard *A. platyrhynchos*	100.000–150.000	0	15	9–13	0.60–0.87	33–78	2.20–5.20
Pintail *A. acuta*	1.000–2.000	–	27	0–0	0.00–0.00	0–0	0.00–0.00
Garganey *A. querquedula*	<400	–	27	9–12	0.33–0.44	8–19	0.30–0.70
Shoveler *A. clypeata*	1.000–1.500	–	27	11–11	0.41–0.41	22–25	0.81–0.93
Spotted Crake *Porzana porzana*	c.200	0	21	3–5	0.14–0.24	3–7	0.14–0.33
Corncrake *Crexcrex*	150–250	–	22	5–9	0.23–0.41	5–14	0.23–0.64
Oystercatcher *Haematopus ostralegus*	c.15.000	0	27	5–3	0.19–0.11	9–10	0.33–0.37
Pied Avocet *Recurvirostra avosetta*	1.000–1.200	0	24	0–0	0.00–0.00	0–0	0.00–0.00
Ringed Plover *Charadrius hiaticula*	10.000–20.000	0	24	0–0	0.00–0.00	0–0	0.00–0.00
Lapwing *Vanellus vanellus*	50.000–125.000	–	26	12–23	0.46–0.88	136–236	5.23–9.08
Dunlin *Calidris alpina*	300–400[1]	–	27	3–3	0.11–0.11	9–9	0.33–0.33
Ruff *Philomachus pugnax*	500–1.000[2]	–	27	7–9	0.26–0.33	34–40	1.26–1.48
Snipe *Gallinago gallinago*	c.150.000	—	13	11–12	0.85–0.92	68–64	5.23–4.92
Black–tailed Godwit *Limosal imosa*	<275	–	27	6–6	0.22–0.22	42–40	1.56–1.48
Curlew *Numenius arquata*	15.000–20.000	–	27	10–13	0.37–0.48	34–40	1.26–1.48
Redshank *Tringa totanus*	10.000–20.000	0	27	6–15	0.22–0.56	45–70	1.67–2.59
Wood Sandpiper *T. glareola*	50.000–100.000	0	27	2–1	0.07–0.04	1–0	0.04–0.00
Little Gull *Larus minutus*	>500	+	22	0–1	0.00–0.05	0–1	0.00–0.05
Black–headed Gull *L. ridibundus*	100.000–150.000	0	22	4–4	0.18–0.18	1607–277	73.05–12.59
Black Tern *Chlidonia sniger*	c.200	0	22	3–0	0.14–0.00	7–0	0.32–0.00
Skylark *Alaudaar vensis*	c.1.000.000	–	18	10–13	0.56–0.72	36–73	2.00–4.06
Meadow Pipit *Anthu spratensis*	500.000–1.000.000	0	22	21–19	0.95–0.86	113–174	5.14–7.91
Yellow Wagtail *Motacilla flava*	c.10.000[3]	–	23	21–22	0.91–0.96	141–313	6.13–13.61
Whinchat *Saxicola rubetra*	200.000–500.000	0	22	21–17	0.95–0.77	125–71	5.68–3.23
Grasshopper Warbler *Locustella naevia*	3.000–6.000	0	22	20–13	0.91–0.59	86–52	3.91–2.36
Marsh Warbler *Acrocephalus palustris*	15.000–20.000	0	22	1–1	0.05–0.05	1–1	0.05–0.05
Sedge Warbler *A. schoenobaenus*	50.000–200.000	0	17	15–12	0.88–0.71	169–119	9.94–7.00
Whitethroat *Sylvia communis*	500.000–1.000.000	+	21	9–8	0.43–0.38	22–14	1.05–0.67
Scarlet Rosefinch *Carpodacus erythrinus*	10.000–30.000	–	20	9–6	0.45–0.30	18–7	0.90–0.35
Reed Bunting *Emberizas choeniclus*	500.000–1.000.000	0	8	7–6	0.88–0.75	98–62	12.25–7.75

[1] *C. a .schinzii*

[2] In southern Sweden

[3] *M. f. flava*

Appendix 2.
Location of the meadow sites in this study, survey years before and after restoration, and number of years between surveys.
Geografisk placering av delområdena i studien, inventeringsår före och efter restaurering samt antal år mellan inventeringarna.

County *Landskap*	Site and water system *Lokal och vattensystem*	Survey years before *Inventeringsår före*	Survey years after *Inventeringsår efter*	Between *Mellan*
Skåne	Hovby ängar 1, Hammarsjön	1990	1993	3
Skåne	Hovby ängar 2, Hammarsjön	1990	1993	3
Skåne	Hovby ängar 3, Hammarsjön	1990	1993	3
Skåne	Rinkaby ängar, Hammarsjön	1986	1991	5
Skåne	Håslövs ängar, Hammarsjön	1986	1990	4
Östergötland	Sjötuna äng, Tåkern	1993	1998	5
Östergötland	Kungsbro N, Roxen	1981	1996	15
Östergötland	Sättuna V, Roxen	1980	1996	16
Östergötland	Härnaviken, Roxen	1980	1996	16
Östergötland	Bråborg, Svensksundsviken	1987	1998	11
Västmanland	Vrenninge S, Svartån	1989	1993	4
Västmanland	Vrenninge N, Svartån	1989	1993	4
Västmanland	Nötmyran 1, Svartån	1985, 1988	1989, 1993, 1994	
Västmanland	Nötmyran 2, Svartån	1985, 1988	1989, 1993, 1994	
Västmanland	Nötmyran 3, Svartån	1985, 1988, 1989	1993, 1994	
Västmanland	Nötmyran 4, Svartån	1985, 1988, 1989	1993, 1994	
Västmanland	Nötmyran 6, Svartån	1985, 1988, 1989	1993, 1994	
Västmanland	Nötmyran 7, Svartån	1985, 1988, 1989, 1993	1994	
Uppland	Hjälstaviken A, Mälaren	1988	1997	9
Uppland	Hjälstaviken B, Mälaren	1988	1997	9
Uppland	Hjälstaviken C, Mälaren	1988	1997	9
Uppland	Hjälstaviken D, Mälaren	1988	1997	9
Uppland	Lårstaviken, Mälaren	1993	1997	4
Uppland	Angarnsjöängen	1985	1998	13
Uppland	Övre föret, Fyrisån	1996	1998	2
Uppland	Vendelsjön	1993	1997	4
Uppland	Fladen, Ledskär	1997	2000	3
No. of years represented *Antal representerade år*		11	9	
Represented period *Representerad period*		1980-1997	1989-2000	

Appendix 3.
Standardised protocol – survey instructions

General remarks
Choosing points
A point should comprise the area of a circle with a radius of 100 meters. When choosing a point it may be wise to consider whether the point shall include an area with a single uniform management regime, or a mix of such. Preferably the chosen census area should be representative for the meadow area concerning both the habitat composition and management regime. The boundaries of a point should not be closer than 100 m from the boundaries of another point.

Counting birds
Every point should be visited three times per season. The first visit should take place between May 5-20; the second visit between May 21- June 5; and the third visit between June 6-20. To avoid that a single point is visited during the same hour at all three visits, remember to alter the sequence of the points between the censuses. Counting of birds should be conducted from sunrise to c. 10 a.m., and most importantly, every point shall be counted during exactly five minutes (use timer). The counting must be performed from the centre of the point, and make sure that the boundaries are well understood from suitable maps (take notice of ditches, fences, tracks etc.). Larger birds, such as e.g. curlews and lapwings, often leave the area when the surveyor approaches. Birds taking off from the survey area should be included as well, although the true counting has not been started. The essential task is to document breeding pairs, thus 1 male and 1 female should be noted as 1 (one), while two males should be noted as 2 (two). Make a fair estimate! Flocks of feeding or migrating birds (e.g. swallows, starlings etc.) should be excluded from the count.

Protocol instructions
1. **Point description.** Noted once per year. This measurement is performed by estimating the % of different habitats in the survey area, and by estimating the % of length to different habitats bordering the survey area.

2. **Management.** Noted once per year. The management regime(-s) used inside the point should be estimated as % (5% intervals) of the total survey area. To be able to detect late season grazing (option Grazed and Mowed), it is advisable to contact the farmer/authority responsible for the management.

3. **Land-use on arable field.** Noted once per year. This measurement is estimated as % (5% intervals) of the total *cultivated* area/border of the survey area. Thus, both columns should always summarize to 100 (or 0 if no arable field is noted in box 1).

4. **Distance to major habitat.** Noted once per year. Mark with X. Only habitats outside survey area (>100m from counting point) are included here.

5. **Additional habitat description.** Noted once per year. Mark with X. Intended to give a more complete description of the point.

6. **Restoration measures since last breeding season.** Noted once per year. Estimated as % (5% intervals) of total survey area. Documentation of restorations by means of shifted management regime does not have to be noted, since this is recorded by information in box 2 and 8.

7. **Amount of flooding.** Noted at all three visits. The amount of flooding in wet meadows is a rather difficult factor to record, but since it is one of the main sources for population fluctuations in meadow birds it is important to make rough estimates. The surveyor chooses the alternative that best describes the current situation inside the survey area.

8. **Grass height.** Noted at all three visits. Note that estimates should *not* be recorded as percentage of total *point* area, but necessarily as a % of the total area with that particular management regime! In other words, a note under the heading *Grazed* saying that 10% is <5 cm, should be read as: 10% of the total *grazed* area have a grass height of less that five cm. Thus, this gives a description of the grass height in the areas that are managed with the regimes noted as present in box no 2. Consequently, all columns will summarize to 100 (unless a specific management regime is not used in the point, which will result in blanks, hence summarizing to 0). Use 5% intervals.

Name of meadow: _____ **Point no:** _____

Date/time 1: _____ **Date/time 2:** _____ **Date/time 3:** _____

Name of surveyor: _____

1. Point description:

	% of survey area	% of bordering habitat
Meadow:	☐	☐
Arable field:	☐	☐
Shrub land:	☐	☐
Forest:	☐	☐
Wetland:	☐	☐
Other:.....	☐	☐

2. Management:

	% of survey area
Grazed:	☐
Mowed:	☐
Grazed and Mowed:	☐
Unmanaged:	☐
Other:.....	☐

3. Land-use on arable fields:

	% of arable area	% of bordering arable habitat
Spring sown:	☐	☐
Autumn sown:	☐	☐
Ley (>1 year):	☐	☐
Set aside:	☐	☐

4. Distance to major habitats (>100m):

	<250m	<500m	<1km
Forest:	☐	☐	☐
Wetland:	☐	☐	☐
Arable field:	☐	☐	☐
Farm/village:	☐	☐	☐

5. Are there any... within the survey area:

	Buildings	Trees/shrubs		Ditches	Tracks/roads	Electr. wires	Fences
Single:	☐	☐	Length 1-30 m:	☐	☐	☐	☐
Several:	☐	☐	Length >30 m:	☐	☐	☐	☐

6. Restoration since last breeding season:

	% of survey area
Cultivation:	☐
Clearing of trees/scrubs:	☐
Burning:	☐
Other:.....	☐

7. Amount of flooding within survey area:

	Visit 1	Visit 2	Visit 3
Dry:	☐	☐	☐
Damp:	☐	☐	☐
Areas of standing water:	☐	☐	☐
More or less completely flooded:	☐	☐	☐

8. Grass height:

	Grazed			Mowed			Grazed and mowed			Unmanaged		
Visit:	1	2	3	1	2	3	1	2	3	1	2	3
<5 cm:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5-15 cm:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
15-30 cm:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
>30 cm:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐