

FINAL YEAR PROJECT

THE IMPACT OF RECENT AGRICULTURAL CHANGES ON WILD BIRD SPECIES IN ESSEX

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Cover illustration: Silage cutting by Edwards (2000)

ABSTRACT

Ten farmland bird species have been showing population declines across Essex over the past few decades. Recent analyses have shown that on a European scale, there have been population declines in a vast number of farmland bird species and that these declines have been greatest in the Member States of the European Union which are bound by the Common Agricultural Policy (CAP). This finding has been attributed to the more intensive agriculture that the CAP has encouraged in these Member States. In this review paper, the exact changes in farming practice that have taken place in Essex since the introduction of CAP are considered and their potential roles in causing the decline of the ten bird species are discussed. In addition, the possible effects of the introduction of genetically modified herbicide-resistant maize on these bird species are discussed

INTRODUCTION

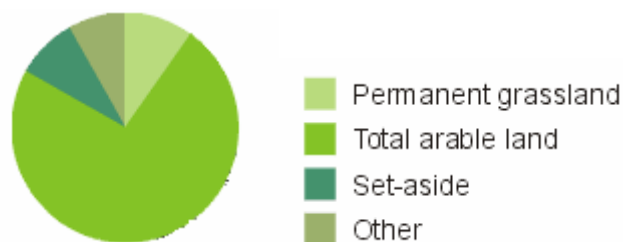
AIMS

Despite the relatively short evolutionary history of agriculture, many bird species have adapted to survive on land dedicated to food production; indeed a large proportion of species followed the spread of agriculture westwards from the Asian steppes and northwards from the semi-deserts of the Mediterranean into Europe (Donald *et al.*, 2002). Over the millennia of agricultural expansion, there have only been three or four periods in which agriculture has undergone significant change (Diamond, 1997). However, it is these changes that have dictated the survival of particular bird species and the demise of others. The aim of this project is thus to determine the effects of the most recent agricultural change, namely the introduction of the Common Agricultural Policy, on the farmland bird species of Essex.

AGRICULTURE IN ESSEX

The agricultural industry in Essex consists of both arable and livestock farming, although arable farming predominates; the land usage in Essex can be considered as similar to East Anglia as a whole (shown in Figure 1), since the topography and the climate are fairly uniform across East Anglia and it is these factors that determine the suitability of the land for different farming types.

Figure 1: Agricultural Land Use in East Anglia, 2002



Source: McMellin (2002).

East Anglia has a relatively mild climate in comparison to the rest of England and this, combined with the fact the farms are all lowland, makes the region, including Essex,

ideal for cereal cultivation. In addition, the good soils make potato farming more common here than in the other parts of England (McMellin, 2002). However, permanent grassland, used for rearing livestock, constitutes the second largest use for agricultural land in East Anglia. Land set aside from agriculture in order to reduce overall outputs and that used for other purposes constitutes the remaining proportion of agricultural land usage.

Having said this, there have been great changes in the agriculture of Essex over the previous century. In 1900, although arable farming was still predominant, over one third of the county was grassland (Wormell, 1999). During the 20th century however the livestock and grassland diminished and were replaced by more arable farming; this change was instigated because Essex with its clay soils could no longer compete with counties such as Leicestershire for grass growing (Wormell, 1999), but was ideal for cereal cultivation.

In addition, farming across the whole country changed dramatically when England joined the European Economic Community (now the European Union, EU) in 1972. The Common Agricultural Policy (CAP), under which all Member States of the EU were bound, imposed levies on imports of cheaper food and established a threshold price for European foods (intervention prices), below which the EU became the buyer, removing the surplus food from the market and storing it. As a result, farmers nationwide were guaranteed higher incomes for higher yields and this led to the intensification of the agricultural industry.

There have been great changes in the composition of the agricultural industry since the introduction of CAP, some of which were the direct result of joining the EU. As can be seen in Table 1, the production of wheat in Essex has greatly increased since 1971, whilst other crops have been less favoured. The EU introduced milk quotas to combat the surplus milk production and wastage. This in effect reduced the number of dairy cattle nationwide which in turn was the cause of the dramatic increase in oilseed rape

production (Wormell, 1999). The number of pigs has also declined, but in contrast sheep numbers have actually increased.

Table 1: Comparison of agriculture in Essex before and after CAP.

	Year	
	1971	1997
Crops (acres)		
Wheat	191,724	268,936
Barley	186,798	70,854
Oats	15,263	1,963
Potatoes	24,264	12,191
Sugar beet	21,976	10,707
Oilseed rape	112	58,329
Livestock (numbers)		
Cows in milk/calf	24,663	9,703
Bulls	500	289
Other cattle	65,197	42,168
Pigs	275,455	118,011
Sheep	49,590	76,815

Source: adapted from Wormell (1999)

FARMLAND BIRD SPECIES OF ESSEX

Lowland farmland, such as that found in Essex, provides a breeding or wintering habitat for nearly 120 bird species of European Conservation Concern (Tucker, 1997), as well as other birds which are not of conservation concern. The south-east of England is particularly rich in both bird diversity and abundance (Connor and Shrubbs, 1990). However, not all species can be considered as regular occupants of Essex farmland; those that can are listed in Table 2. The species listed in red are classed by the Royal Society for the Protection of Birds (RSPB) as ‘red list species’ – these species are either globally threatened or have suffered the most serious population declines; with the exception of the Hen Harrier, the Quail and the Twite, all the red listed species in Table 2 either suffered a population decline of at least 50% between 1974 and 1999 or their breeding range contracted by at least 50% over these 25 years (RSPB, 1999). The Essex Wildlife Trust cites ten species as showing population declines in recent years: the Blackbird, the Goldfinch, the Starling and the Swallow as showing a decline; the Dunnock as showing a significant decline; and the Reed Bunting the Skylark, the Song Thrush, the Tree Sparrow

and the Turtle Dove as suffering a dramatic decline in numbers across Essex over recent years (Essex Wildlife Trust, 1999).

Table 2: Bird Species of Essex Farmland.

Species	Category	Status	Species	Category	Status
Barn Owl	Field	Res.	Lapwing	G'n/wet	Res.,WV
Bean Goose	Ground	WV	Lesser Whitethroat	Woodland	SM
Berwick's Swan	Ground	WV	Linnet	Field	Res.,SV
Blackbird	Wd/field	Res.,WV	Little Owl	Field	Res.
Blackcap	Woodland	SM	Long-eared Owl	Field	Res.,WV
Black-headed Gull	G'n/wet	SV,WV	Long-tailed Tit	Woodland	Res.
Blue Tit	Woodland	Res.	Magpie	Field	Res.
Brambling	Wd/field	WV	Mallard	G'n/wet	Res.
Bullfinch	Woodland	Res.	Marsh Harrier	G'n/wet	SM
Canada Goose	G'n/wet	Res.	Meadow Pipit	G'n/wet	Res.,WV
Chiffchaff	Woodland	SM	Merlin	G'n/wet	SV,WV
Collard Dove	Field	Res.	Mistle Thrush	Wd/field	Res.
Common Gull	Ground	WV	Moorhen	G'n/wet	Res.
Corncrake	G'n/wet	SM	Montagu's Harrier	G'n/wet	SM
Dunlin	G'n/wet	SV	Mute Swan	G'n/wet	Res.
Chaffinch	Wd/field	Res.,WV	Oystercatcher	G'n/wet	SV
Coal Tit	Woodland	Res.	Pheasant	G'n/wet	Res.
Corn Bunting	G'n/wet	Res.	Pied Wagtail	Field	Res.
Cuckoo	Woodland	SM	Pink-Footed Goose	Ground	WV
Curlew	G'n/wet	WV	Pintail	Ground	WV
Dunnock	Woodland	Res.	Quail	G'n/wet	SM
Fieldfare	Wd/field	WV	Raven	Field	Res.
Garden Warbler	Woodland	SM	Reed Bunting	G'n/wet	Res.
Garganey	G'n/wet	SM	Red-backed Shrike	Wd/field	SM
Goldcrest	Woodland	Res.,WV	Red-legged Partridge	G'n/wet	Res.
Golden Plover	G'n/wet	SV,WV	Red Kite	Field	Res.
Goldfinch	Field	Res., SV	Redshank	G'n/wet	SV
Grasshopper Warbler	G'n/wet	SM	Red Wing	Wd/field	WV
Great Spotted Woodpecker	Woodland	Res.	Reed Warbler	G'n/wet	SM
Great Tit	Woodland	Res.	Robin	Woodland	Res.
Green Woodpecker	Wd/field	Res.	Rook	Field	Res.,WV
Grey Partridge	G'n/wet	Res.	Ring Ouzel	G'n/wet	SM
Hen Harrier	G'n/wet	SV,WV	Ruff	Ground	WV
Hobby	Woodland	SM	Sedge Warbler	G'n/wet	SM
House Sparrow	Field	Res.	Short-eared Owl	G'n/wet	SV,WV
Jackdaw	Field	Res.,WV	Shoveler	G'n/wet	SV
Jack Snipe	Ground	WV	Skylark	G'n/wet	Res.,WV
Jay	Woodland	Res.	Song Thrush	Wd/field	Res.,WV
Kestrel	Field	Res.,WV	Snipe	G'n/wet	Res.,WV

Species	Category	Status	Species	Category	Status
Sparrowhawk	Woodland	Res.	Wheatear	G'n/wet	SM
Spotted Flycatcher	Woodland	SM	Whinchat	G'n/wet	SM
Starling	Field	Res.,WV	White-Fronted goose	Ground	WV
Stockdove	Field	Res.	Whitethroat	Woodland	SM
Stone Curlew	G'n/wet	SM	Whooper Swan	Ground	WV
Stonechat	Field	Res.,SV	Wigeon	Ground	WV
Swallow	Aerial	SM	Willow Warbler	Woodland	SM
Tawny Owl	Wd/field	Res.	Woodlark	G'n/wet	Res
Teal	G'n/wet	Res.	Woodpigeon	Field	Res.
Treecreeper	Woodland	Res.	Wren	Woodland	Res.
Tree Sparrow	Field	Res.	Wryneck	Wd/field	SM
Turtle Dove	Field	SM	Yellowhammer	Field	Res.
Twite	G'n/wet	SV	Yellow Wagtail	G'n/wet	SM

G'n/wet, ground nesting or wetland birds. Ground, wintering birds only: species that feed and roost on the ground in open country, usually, but not always farmland.

Field, species that food in fields but nest in hedges or trees.

Wd/field, species that inhabit mainly woodland habitats, but in farmland, food to an important extent in fields.

Res., resident.

SV, summer visitor, taken as those birds that are summer visitors to farmland breeding sites, but mainly winter elsewhere.

SM, summer migrants, taken as those species which migrate entirely out of Britain in winter.

WV, winter visitor, includes both winter migrants and residents with populations augmented by important winter influxes.

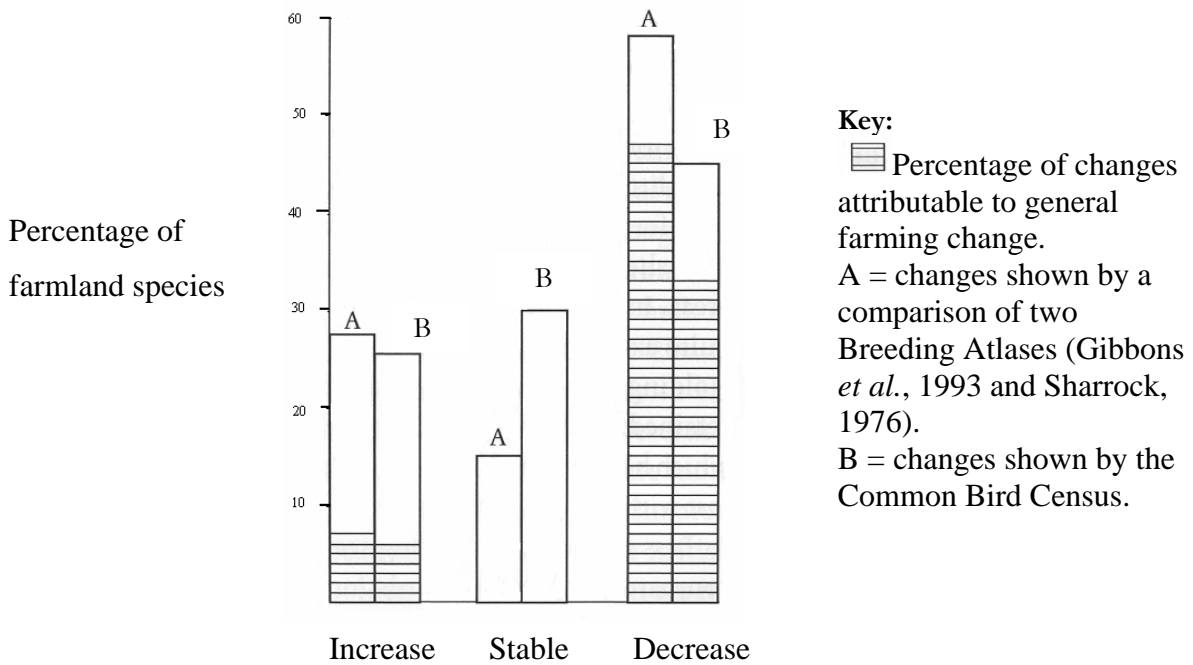
Source: adapted from Shrubbs (2003) and Essex Birdwatching Society (2003).

THE COMMON AGRICULTURAL POLICY AND BIRDS

The bird species listed in Table 2 spend a significant amount of their lives on farmland, and therefore their populations will obviously be susceptible to changes in land usage and agricultural practice. There is sufficient evidence to support the hypothesis that the aforementioned declines in farmland bird populations are due to the intensification of the agricultural industry over the last 30 years. Indeed, the declines in these populations first became apparent in the 1980s (Siriwardena *et al.*, 1998), not long after the introduction of CAP and the resulting intensification, suggesting a causal link between the two. There are several reasons given for delay between the onset of agricultural change and the onset of bird population decline. Declines in bird populations could result from reduced breeding productivity, reduced survival outside of the breeding season, or both. Since agricultural intensification was a progressive phenomenon, it is likely that its initial effects on productivity and survival were not too great. Therefore, assuming that the two factors were not affected simultaneously, density-dependent factors could have compensated for these effects (Chamberlain *et al.*, 2000); in the sparser bird population, disease would have spread less easily thus reducing disease-related deaths and in addition predator-related deaths would have also been reduced. However, as the intensification process progressed, a critical threshold would have been exceeded, such that density-dependent factors could no longer compensate for reduced production or survival (Chamberlain *et al.*, 2000). Further evidence is provided by Donald *et al.* (2001) who carried out a comparison of bird populations in EU with those in eastern European countries, where agriculture is less intensive. Although the mean farmland bird population decreased between 1970 and 1990 in most of the countries studied, the decrease was significantly greater in western European countries than in former communist countries. In addition, birds are significantly less abundant on land intensively farmed for crops than on set-aside land, which mimics low intensity farmland (Henderson *et al.*, 2000). These two observations strongly implicate agricultural intensification as a major cause of the deleterious effects on farmland bird populations. In fact, Donald *et al.* (2001) consider the threat of agricultural intensification on bird biodiversity to be comparable with that of

deforestation or global climate change. This is not surprising considering the fact that data analysed by Shrubb (2003) show that more than three-quarters of the decrease in breeding bird populations that occurred during the period from 1972 to 1997 can be attributed to changes in farming methodology and technology, as shown in Figure 2, although there is no information as to how the author came to this conclusion.

Figure 2: Changes in breeding bird populations of farmland between 1972 and 1997.



Source: Shrubb (2003).

REASONS FOR THE DECLINE IN FARMLAND BIRDS

The recent changes in farmland bird populations that have occurred in Essex can therefore be attributed mainly to the specific changes in agricultural practice that took place in the region in light of the introduction of CAP. Obviously, one of the key points to focus on when determining the exact reasons for declines in particular bird species is to look at their food source; anything that decreases the abundance of food for a particular species has the potential to adversely affect its population. The sources of food for those species which have declining populations are given in Table 3.

Table 3: The food sources and habitats of the 10 farmland bird species which are declining in Essex.

Species	Food Source	Habitat
Blackbird	Insects & worms, plus late berries from summer onwards	Gardens, woods, heaths, hedges
Dunnock	Insects & berries	Gardens, rough shrub on wasteland, hedgerows
Goldfinch	Adults on seeds, young also on caterpillars & insects	Gardens, woods, fields, hedges
Reed Bunting	Adults mainly on seeds; young fed on snails, beetles and insects	Tall vegetation around standing water & drainage ditches, also hedges bordering fields
Skylark	Mainly on grain & weed seeds, also on insects	Large open field with short vegetation, saltmarsh & wasteland
Song Thrush	Worms, insects, seeds & berries, snails when other food is scarce	Gardens, woods, heaths, fields, hedges
Starling	Invertebrates foraged from grassland, also fruit, bread & household scraps	Gardens, parks, woodland, farmland
Swallow	Insects	Open country, not too far from water
Tree Sparrow	Mainly on seeds & some grain, also insects	Old trees for breeding, stubble fields & grain stores in autumn & winter
Turtle Dove	Seeds, preferring weed seeds to cereal or grain	Hay meadows, weedy fields

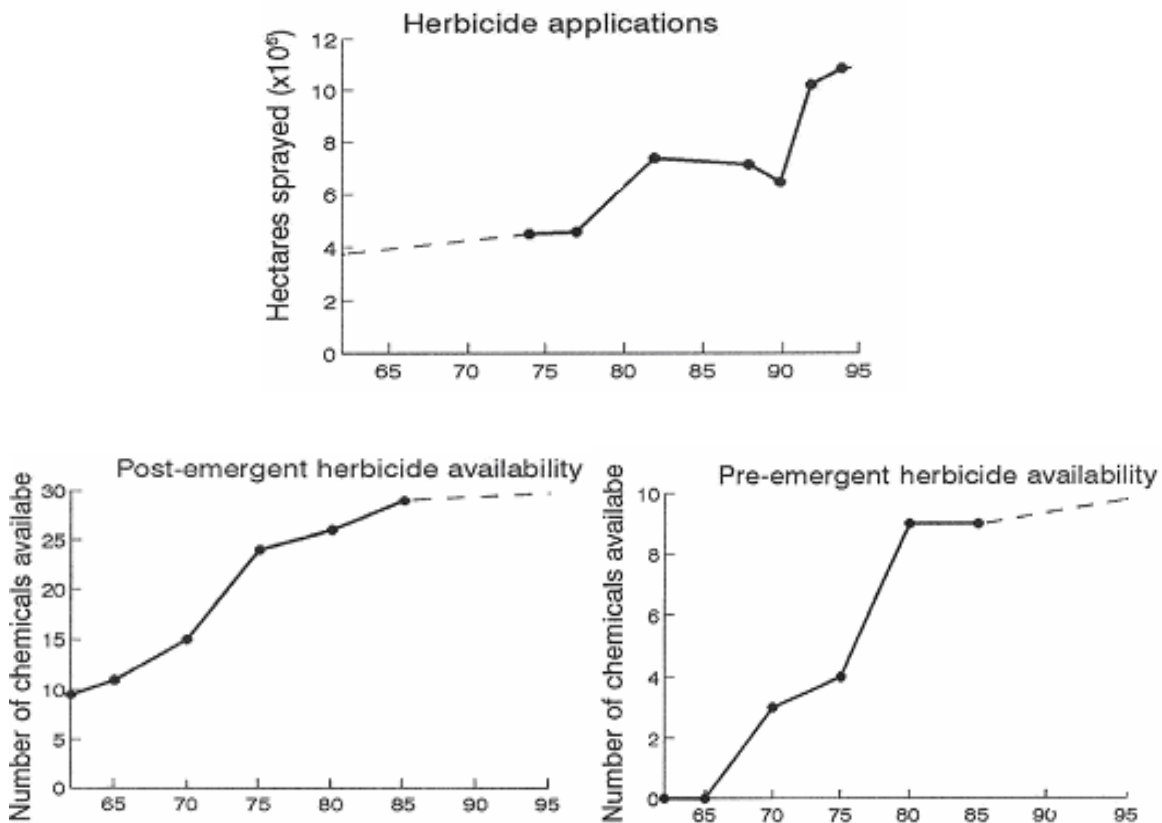
Those species in black are showing population declines, whilst those in orange are showing significant population declines and those in red are showing dramatic population declines.

Source: adapted from Essex Wildlife Trust (1999).

INCREASED PESTICIDE USE

Obviously, the use of any pesticide, be it herbicide, insecticide or molluscicide, on Essex farmland will affect the flora and fauna, resulting in decreased seed and invertebrate abundance, respectively, all of which contribute to the diets of declining farmland bird species (Table 3).

Figure 3: The pattern of herbicide usage across England and the availability of post- and pre-emergent herbicides between 1960 and 1995.



Source: Chamberlain *et al.* (2000).

Although herbicides have been used to control weeds since 1911, early herbicides were relatively ineffective at decreasing weed populations (Shrubb, 2003). As can be seen from Figure 3, in the mid-twentieth century, the herbicides sprayed on agricultural land were mainly post-emergent, acting particularly on broad-leaved weeds in cereals. The levels of usage of these post-emergent herbicides have continued to increase nationwide.

However, the introduction of pre-emergent herbicides in 1965 and the substantial increase in their use thereafter has led to dramatic reductions in seed availability (Roberts and Dawkins, 1967) since these herbicides remove competitive weeds and grasses at crop establishment (by preventing germination), thereby decreasing their ability to set seed. Indeed a review article looking at the effects of herbicide spraying on plant taxa found that herbicide application adversely affects the abundance of many species, including most importantly Polygonaceae (on Essex farmland these are represented by knotgrasses, persicarias, docks and sorrels) which have a high capacity to set seed, making them a rich source of food for birds (Wilson *et al.*, 1999). Thus, the abundance of food for birds dramatically decreased with the introduction of pre-emergent herbicides.

The pattern of herbicide usage across Essex can be assumed to be similar to that across the whole of England, but since there is a relatively high proportion of arable farming within Essex, the amount of herbicide applied to the land in this region will be greater than in other parts of the country. Such increased usage of herbicides may go some way to explain the fact that those species suffering the most pronounced population declines in Essex are those that have a substantial seed component in their diets; such species are termed “granivorous”.

The Reed Bunting is an example of a granivorous bird species which is highly dependent upon small grass and weed seeds during the winter months (Wilson *et al.*, 1996, as reported in Peach *et al.*, 1999) and provides evidence to support the indirect, deleterious effects of herbicides on birds. The species suffered a major population decline during the late 1970s and early 1980s (Marchant *et al.*, 1990), coinciding with the introduction of widespread use of herbicides; in the south-east of Britain, farmland populations declined by 4.1% per annum between 1970 and 1995, but the declines were significantly greater, 7.2% per annum, in northern Britain (Peach *et al.*, 1999). At first thought, this may seem to contradict any suggestion that populations of granivorous birds are adversely affected by herbicide spraying, since as previously mentioned, herbicide application to land is greater in Essex and other southern counties than in the north of Britain, where land use

is mainly pastoral. However, other factors must be taken into consideration; the distribution of Reed Buntings in northern Britain is patchy and typically shows low density (Marchant *et al.*, 1990), which may render the populations of the north more susceptible to local declines and extinctions (Peach *et al.*, 1999).

Figure 4: A Reed Bunting.



Source: Essex Wildlife Trust (1999)

The national population of Reed Buntings was monitored by Peach *et al.* (1999) over three decades and the population decline that occurred between 1970 and 1995 was found not to be influenced by nesting success. This is supported by a further study conducted by Siriwardena *et al.* (2001). In fact, the majority of this population decline was attributed to decreased winter survival rates (Peach *et al.*, 1999), a product of the reduction in seed availability. Although other factors influenced food availability, for example a reduction in the availability of winter stubble (as will be discussed later), the reduction in seed availability as a result of herbicide application was cited as a major factor contributing to the Reed Bunting's high winter mortality rates during this period.

However, herbicides not only affect the abundance of seeds, but also have been found in three studies to decrease the abundance of ground beetles, possibly due to the herbicides killing their host plants (Wilson *et al.*, 1999). These ground beetles may form a component of the diets of many of the declining bird species, especially the Reed

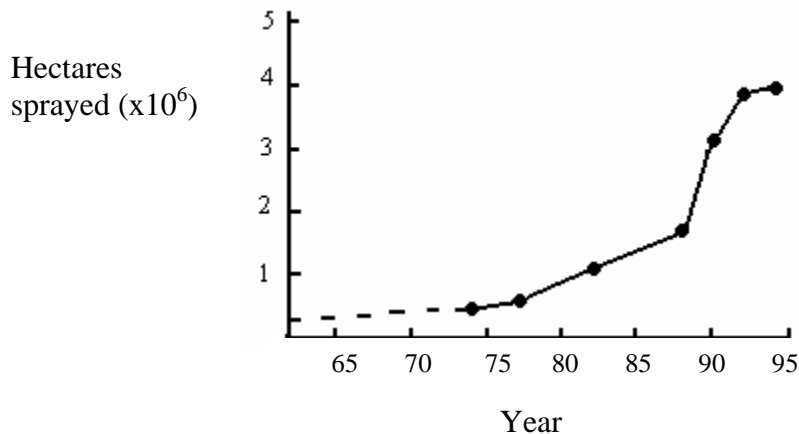
Bunting. Similarly, several studies have shown that herbicide application is detrimental to *Arachnida* (spiders), decreasing their abundance and diversity (Wilson *et al.*, 1999), thus further reducing food availability to birds. Spiders require a structurally diverse habitat in order to flourish and thus this reduction in spider populations was attributed by Baines *et al.* (1998) to be the result of a gradual loss of vertical structural complexity of the vegetation as the weeds began to collapse and rot. This reduction in spider abundance could be a contributing factor in the decline of the Skylark, which feeds its young exclusively on insects and spiders during the first week of life (RSPB,1999). In addition, spiders are an important constituent of the adults' diets between April and August (RSPB, 1999).

The detrimental effects of herbicides on broadleaved weeds also adversely affect butterfly populations. Broadleaved weeds provide two resources for butterflies, namely nectar and larval plant foods, and the reduction of these weeds has been cited as a possible cause of reduced butterfly abundance, especially in closed populations *i.e.* those species breeding in a restricted, well-defined area (Murphy, 1983). Indeed, a three year study in which large areas of cereal fields were sectioned off and had no herbicide application found that there were significantly more butterflies in these areas than in those areas that had herbicide applied to them and that this effect was universal across all species that were considered (Dover *et al.*, 1990). This is further supported by work carried out by Feber *et al.* (1996) in which spraying fields with herbicide once annually resulted in decreased butterfly abundance. In addition, a reduction in the level of herbicide spraying has been found to increase the abundance of caterpillars (Haysom *et al.*, 2000). Therefore, it is possible that the increased herbicide application to agricultural land in Essex has caused a decline in butterfly abundance and that this effect may have contributed to the decline of any of the ten bird species cited by the Essex Wildlife Trust as suffering population declines in recent years (see Table 3), in particular the Goldfinch which feeds its young on caterpillars.

Treatment of land with insecticides and molluscicides has also increased over the years (see Figure 5). No data could be found for the application levels of these substances in

Essex, but it can be assumed, that they follow the same pattern as that for England as a whole.

Figure 5: The increased application of insecticides and molluscicides to agricultural land in England between 1960 and 1995.



Source: Chamberlain *et al.* (2000)

Insecticides obviously affect the invertebrate populations which form a component of the birds' diets. Beetles for example typically suffer initial mortality rates between 60 and 90% after spraying. However, some species are able to recover their numbers within about a month (Brown *et al.*, 1988), whereas other species take far longer. As previously mentioned a reduction in the abundance of beetles could be a contributing factor to the decline in bird species, in particular the Reed Bunting. Although, the numbers of some beetle species return to normal shortly after insecticide spraying, there is still likely to be a detrimental effect on the bird populations of Essex as a result since farmers do not just apply insecticide to land once every year, but possibly many times. Even though other insect species form an alternative component to the bird diet, these will also decrease in abundance as a result of insecticide spraying; the review conducted by Wilson *et al.* (1999) found that the majority of studies had revealed that insecticides had detrimental effects on the populations of butterflies, ants and crane-flies. It is therefore expected that the increased use of insecticide on Essex farmland will have had greater effects on the populations of invertebrate feeders; these are Blackbirds, Dunnocks, Song Thrushes and

Starlings. The Swallow is an insectivore, but it is unlikely that its recent decline in Essex has been due to increased insecticide application because it is an aerial feeder, feeding on beetles, ants, leafhoppers, wasps, flies, and bees, the latter three not being adversely affected by insecticide application (Wilson *et al.*, 1999). Out of the four bird species that might suffer from reduced food supplies in the form of insects, only the Song Thrush is showing a dramatic population decline in Essex, and this might suggest that the adverse effects of insecticide application are not as great as those of herbicide application.

Figure 6: A Swallow.



Source: BTO (2003)

The use of molluscicides targets snails and slugs, which can be problematic to arable cultivation. Snails and slugs form a component of the diet of Reed Buntings and Song Thrushes. At present there have been no studies investigating the long-term trends in these populations (Wilson *et al.*, 1999). However, it is expected that their abundance on agricultural land will have decreased as a result of molluscicide application. No studies have revealed any adverse effects of molluscicides on other invertebrate species or plant species (Wilson *et al.*, 1999), suggesting that molluscicide application is rather more specific in its indirect effects on bird populations than are other forms of pesticide application. In other words, molluscicides might have been a cause of the reduced population sizes of the Song Thrush and the Reed Bunting, but not of the other eight species quoted by the Essex Wildlife Trust as showing population declines.

THE POSSIBLE INTRODUCTION OF GENETICALLY MODIFIED CROPS

Interrelated with the use of herbicides is the possible commercial production of genetically modified crops in the UK. Herbicides have not been successfully used to control all weed species for example, fat-hen, a serious pest, is difficult to control with herbicides in sugar beet cultivations since the two species are closely related (Moll, 1997) and therefore it remains a plentiful source of food for birds. This situation could change if genetically modified herbicide-tolerant sugar beet varieties were allowed to be grown, but at present this looks unlikely in the UK. However, the Environment Secretary, Margaret Beckett, has recently announced that genetically modified maize can be grown in England (BBC NEWS Online, 2004), but this was followed just a month later by an announcement from the manufacturers, Bayer CropScience, that any plans to grow GMHT maize in the UK in the near future had been abandoned (Jones, 2004). Nevertheless, the cultivation of GMHT maize in Essex at some point in the future is very possible.

Figure 7: Genetically modified maize.



Source: BBC NEWS Online (2004)

This announcement by Margaret Beckett followed an extensive four year field trial in which genetically modified herbicide-tolerant (GMHT) sugar beet, spring-sown oil seed rape, and maize were studied and the biodiversity of each cultivation compared with that of its conventional strain. The study involved dividing crop fields in two, one half being sown with conventional crop and the other half being sown with GMHT crop. The individual farmers were allowed to manage their field as they saw appropriate. At the

majority of sites, each half of the field was managed in the same way, with the exception of herbicide application. The GMHT crops were sprayed with broad-leaved herbicides to which they were resistant; the GMHT maize and rape were resistant to *Liberty* (glufosinate ammonium) and the GMHT sugar beet was resistant to *Roundup* (glyphosphate). Such broad-spectrum herbicides cannot be used on conventional crops because they will kill the crop as well as the weed (Burke, 2003).

Figure 8: Herbicide spraying.



Source: Stevens (2004)

The results showed clearly that the biodiversity of GMHT sugar beet and rape was significantly lower than that of their conventional counterparts; hence their commercial cultivation has been refused by Margaret Beckett for the time being (BBC NEWS Online, 2004). However, the report showed some potential benefits of GMHT maize to bird species, in particular granivorous ones. For example, there were more weeds in GMHT maize field than in conventional maize fields. This was attributed to the fact that persistent herbicides were applied to conventional maize early in the season, whereas with GMHT maize, *Liberty* was applied later on and was still capable of killing the weeds, even though they were large. The result of the weeds persisting for longer in GMHT fields was that the “seed rain” (the number of seeds that fell from weeds onto the seed surface) of these fields was twice that in conventional maize fields and therefore the autumn and winter availability of seeds to birds was greater (Burke, 2003). Thus if GMHT maize were to be grown in Essex over a substantial area, it might facilitate an

increase in granivorous bird species such as the Goldfinch, the Reed Bunting, the Skylark, the Tree Sparrow and the Turtle Dove.

The research also confirmed that insects and spiders were more abundant in fields where there were more weeds *i.e.* there were more insects and spiders in GMHT maize fields than in conventional maize fields. The study looked in particular at the numbers of one species of beetle, *Harpalus rufipes* in the field and found numbers to be greater in GMHT maize than in conventional maize fields (Burke, 2003). Therefore, commercial cultivation of GMHT maize in Essex could also have the effect of increasing numbers the bird species that are currently declining and which feed on invertebrates – Blackbirds, Dunnocks, Starlings and Swallows.

One argument raised against this research is the fact that the herbicide atrazine was applied to conventional maize. This is so toxic that its use is due to be banned in the EU from April 2005 (Liberal Democrats, 2004). Consequently, any conventional maize farms in Essex, and indeed the rest of the EU, will be forced to seek alternative, less potent herbicides, which would result in more weeds in the fields than are currently present in atrazine-sprayed fields. It is quite possible that there would actually be higher numbers of weeds, and hence more food for birds in terms of seeds and invertebrates, in conventional maize fields treated with less toxic herbicides than in GMHT maize fields. Therefore, from the point of view of birds, the introduction of GMHT maize cultivation may not actually be beneficial once atrazine is banned.

CHANGES IN THE TIME OF SOWING AND HARVESTING

The development of pre-emergent and grass herbicides has been very important in facilitating changes in cropping practices, particularly the widespread adoption of autumn sowing (Chamberlain *et al.*, 2000), whereas once spring sowing was more common practice. Grass weeds were previously significant pests in cereal cultivation and they were avoided by allowing the germination of grass over winter which was then ploughed in before spring sowing. However, the introduction of herbicides allowed the removal of

weeds from cereal crops, therefore permitting cereals to be sown later on in the year (Chamberlain *et al.*, 2000). This resulted in a marked change in the proportion of spring-sown crops across the whole of England. In 1962, prior to the introduction of CAP and the use of more effective herbicides, over 65% of all crops sown in East Anglia were spring-sown, but by 1982, this figure had fallen to less than 35% (O'Connor and Shrubbs, 1990).

Spring cereals provide an important nesting habitat for Skylarks, a species which prefers short vegetation (see Table 3), but winter cereals have grown too tall and dense by this time of year (Wilson *et al.*, 1997). Spring sown crops also allow the Skylark to make a greater number of breeding attempts per season because the cereal crops do not become prohibitively tall for nesting until late summer (Chamberlain and Crick, 1999). Therefore, the adoption of autumn-sowing may have led to reduced nesting success of the Skylark population in Essex, thereby contributing to the recent decline of this species. The breeding performance of another bird species that has been found to be declining in Essex, namely the Tree Sparrow, has also been shown to be adversely affected by the switch to autumn-sowing (Siriwardena *et al.*, 2001).

Figure 9: A Tree Sparrow.

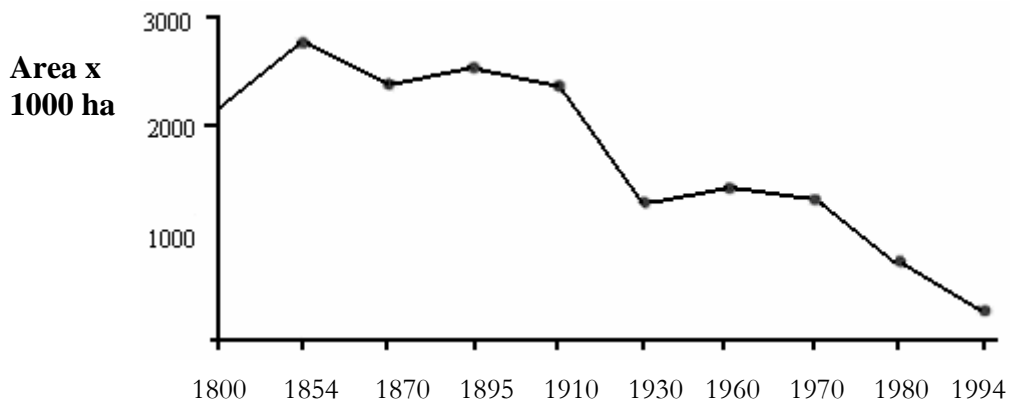


Source: Arentsen & Arentsen (2004)

However, autumn-sowing may not have manifested its detrimental effects on bird populations in Essex merely by reducing breeding success; spring-sown cereals tend to be

associated with the presence of overwinter stubbles, which provide an important winter habitat for birds (Wilson *et al.*, 1996), but the presence of such overwinter stubbles will have decreased in Essex since the introduction of autumn-sowing, following a pattern similar to that shown in Figure 10 for the UK as a whole.

Figure 10: The reduction in the availability of winter stubble in the UK between 1800 and 1994.



Source: Shrubb (2003)

It is thought that such a reduction in winter stubbles may have contributed to the decline of the Skylark (Evans, 1997) since during the winter this species is concentrated on stubble fields (Wilson *et al.*, 1995). The stubbles provide the Skylark with an abundant source of seed during a period when alternative food sources are scarce. Other granivorous species suffering population declines in Essex – the Goldfinch and the Tree Sparrow – may also have been adversely affected by the losses of winter food supplies in terms of stubbles, since stubble provides a key farmland habitat for these species (Shrubb, 2003). The Reed Bunting, although a granivorous bird, would not have been greatly affected by this change because it is more dependent upon grassland seed supplies than those in stubble during the winter months (Wilson *et al.*, 1996, as reported in Peach *et al.*, 1999). At one time, Skylarks, Goldfinches and Tree Sparrows would have had an alternative source of seed throughout the winter; grain stores were formerly threshed (beaten with a machine or flail to separate the seeds) and the resulting seeds provided food for wintering birds, but this threshing is no longer practised (O'Connor and Shrubb, 1990), thus further decreasing winter food supplies.

Essex also has a proportion of set-aside land (see Figure 1). Such land was introduced in England in the 1990s and effectively increased the abundance of winter stubble (Evans *et al.*, 1998). However, it is unlikely that the provision of set-aside could have significantly counteracted the effects of stubble depletion on arable land; it can be assumed that the proportion of arable land in Essex has remained relatively constant over the last century and so before the introduction of autumn-sowing, a large percentage of land would have provided winter stubble for birds, far more than is provided by the small proportion of set-aside at the moment. This statement is supported by the findings of Crick *et al.* (1998); they found there to be no general increase in the UK populations of granivorous birds during the period when set-aside land was at its peak. Therefore, it is possible that winter mortality rates of these granivorous species would have increased due to lack of food, thereby contributing to their population declines.

REDUCTION IN MIXED FARMING

The switch to autumn-sowing has been associated with the loss of livestock from arable areas (Evans, 1997) including Essex. In fact, the area of land used in Essex as pasture halved between 1962 and 1990 (O'Connor and Shrubbs, 1990) and the area of land utilised for cereal cultivation has increased accordingly, as can be seen clearly from Table 1. This has led to individual farms becoming increasingly specialised (Evans, 1997), cultivating a particular crop or using their land for livestock production and thus there has been a loss of habitat diversity at the farm level. Indeed, the diversity, as calculated using cereals, root crops, leys sheep and cattle, has changed significantly within East Anglia; whereas in 1875 the Shannon-Weaver diversity (an index of species diversity in which a higher value indicates greater species richness) was between 1.11 and 1.2, it had fallen to under 0.8 by 1980 (O'Connor and Shrubbs, 1990).

A reduction in habitat diversity in this way is thought to be associated with the decline of certain bird species. One such example is the Skylark, which has shown population declines in Essex over recent years. This species benefits from a mixed-farming system

because at any stage in the breeding season, one crop may be at the right height for the species' breeding requirements (Evans, 1997). Some evidence to support this statement comes from a study conducted by the British Trust for Ornithology (Evans, 1995) in which chick growth rates on organic farms were compared to those on conventional farms. Chick growth rates were higher on the organic farms, where arable/grass rotations were employed. However, it should be remembered that these higher growth rates could partly result from increased food supplies through the absence in pesticide use. Nevertheless, the importance of mixed cereals and grass was emphasised by the observation that adults foraged food for their young on grassland, even though they had nested on land used for cereal cultivation. The reduction in mixed farming systems across Essex may therefore have had some influence on the declining Skylark population.

Figure 11: A Song Thrush.



Source: Essex Wildlife Trust (1999)

The decline in Song Thrush populations in Essex might also be partly attributable to the reduction in mixed farming. It has been shown that this species made, on average, only 2.5 nesting attempts per pair in an arable area of Essex, whilst on a mixed farming/pastoral area in Sussex, each pair made an average of 4 nesting attempts (Thomson and Cotton, 2000). This led to a 33% lower productivity in Essex and in addition, the post-fledging survival rate was found to be much lower in Essex. It is very probable that such decreased survival rate was the result of the reduced habitat diversity; whereas adults would have been able to cope with a limited source of food by flying further, younger fledglings would not (Shrubb, 2003).

INCREASED FIELD SIZE AND HEDGEROW LOSS

One result of the introduction of CAP is that farmers have put a greater proportion of their land into production and improved efficiency. The modern agricultural machinery is large and powerful and most efficient when travelling in straight lines (O'Connor and Shrubbs, 1990). Therefore, larger fields have become more desirable. This in effect has reduced the extent of safe feeding areas for birds, which prefer to forage near to the hedge. (Shrubbs, 2003).

Increased field size has also led to visible signs of bird habitat loss, such as the removal of hedgerows (Gillings and Fuller, 1998). Hedgerow loss actually began before the introduction of CAP, in 1947, but the rate of removal rapidly accelerated after 1980, halting again by 1998 (Haines-Young *et al.*, 2000), with the average rate of removal over the last 50 years being 5000 km per year (Shrubbs, 2003). In 1962, Locke (as reported in O'Connor and Shrubbs, 1990) showed that Essex had a high density of hedgerows at that time compared to other counties, especially more northern ones, and so hedgerows in this region would have provided a large habitat for many bird species. Whilst no data was available on the exact rate of hedgerow removal in Essex, it is widely acknowledged that hedgerow loss has been greatest in arable areas (Barr *et al.*, 1993) because hedges serve to confine livestock, but are seen as a nuisance in cereal farming (O'Connor and Shrubbs, 1990). Since Essex is a predominantly arable area in which a large amount of cereal is grown, it is expected that the removal of hedgerows here has been greater than in other parts of the country.

Such removal of hedges could have contributed to the declines of certain bird species in Essex, especially those species which either shelter in hedgerows or use them as food sources – Blackbirds, Dunnocks, Goldfinches, Reed Buntings and Song Thrushes (see Table 3). In fact, a study carried out by Gillings and Fuller (1998) found that the population declines of 38 bird species, including the afore-mentioned, were most common on farms that had shown the severest losses of habitat in terms of hedgerow removal. However, it was also noted that such habitat loss was of secondary importance

in causing these declines; they concluded that habitat degradation, for example as a result of pesticide spraying, played the major role in causing farmland bird population declines.

This might suggest that hedgerow loss has not been a significant contributing factor to the declines of bird species in Essex, but Gillings and Fuller only took into account the complete removal of hedgerows. Therefore, their study may be misleading since the quality of hedges is also an important determinant of their use as habitats by birds. Indeed, although an estimated 700 000 km of hedge remain in England (Haines-Young *et al.*, 2000), less than 200 000 km can be considered as a good habitat for birds (Shrubb, 2003); there has been a severe deterioration in hedge quality over recent years. This is mainly the result of neglect or over-clipping of the hedges (RSPB, 1999), which has one of two outcomes. Firstly, neglect leads to continued growth of shrubs, until they eventually form tress and the hedge is re-classified as a 'line of trees' or 'gappy shrubs'. Over-clipping on the other hand creates short and thin uniform hedgerows. Both these outcomes are detrimental to birds because different bird species have different requirements. The Turtle Dove for example prefers hedges over 4m tall with lots of trees, whereas the Dunnock prefers hedges of medium height with fewer trees (RSPB, 1999).

Figure 12: A Dunnock.



Source: Bright (2004)

Therefore, the uniform hedges or lines of trees, being less diverse in their structure, support fewer bird species than the well-managed hedges that were previously available as a habitat.

Although this deterioration did not result from the introduction of CAP, the bird populations of Essex may have been better able to survive the intensification-induced hedgerow removal had the quality of hedgerows remained high – hedges are often not fully occupied, rather they serve as an overspill habitat for birds when woodland is fully occupied and so bird populations are to a certain extent resistant to hedgerow removal, as has been shown with Dunnocks (O'Connor, 1984).

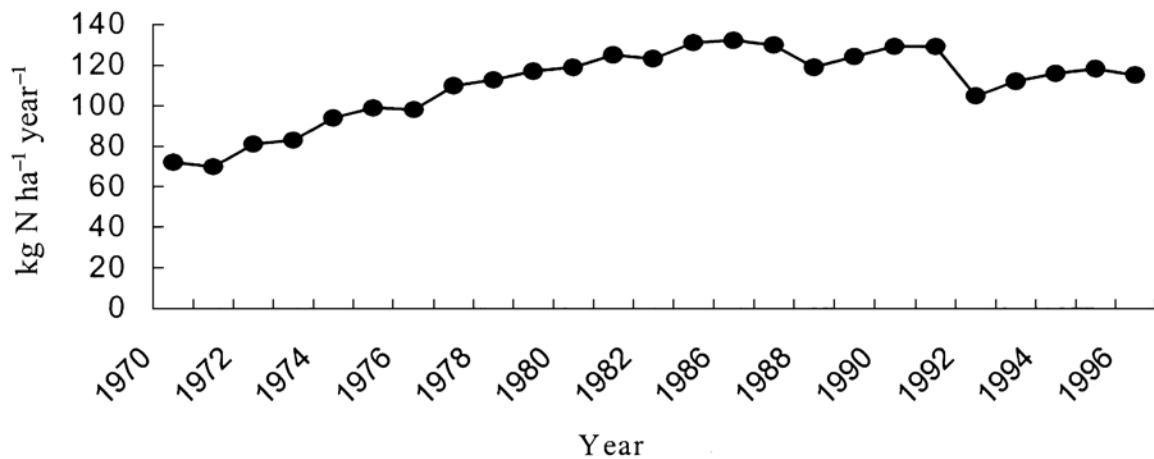
The removal of hedges may have also contributed to bird population declines through a reduction in food supplies. Hedges provide a habitat for many invertebrate species upon which birds feed and are particularly important now that invertebrates have reduced survival on fields due to pesticide spraying (Shrubb, 2003). Indeed, hedgerows provide shelter for butterfly species and more butterflies are present in fields where there is a greater degree of shelter provided by hedges (Feber *et al.*, 1996). In addition, hedges may provide an important nectar source for butterflies (Feber *et al.*, 1996) and their removal has been found to be associated with a decrease in butterfly abundance (Hill *et al.*, 1995 as reported in Wilson *et al.*, 1999). A reduction in butterflies and other invertebrates resulting from hedgerow loss may have contributed to the declines of those birds that feed on invertebrates (see Table 3). The hedge is not only a source of invertebrates, but also acts as a source of berries (Shrubb, 2003). The decline in hedgerows in Essex could therefore have adversely affected the Blackbird and the Song Thrush, both of which feed, at least partly on berries (see Table 3).

INTENSIVE GRASSLAND MANAGEMENT

To this point, only the effects of arable farming on bird species have been discussed, but as previously mentioned, a small proportion of land in Essex is used for livestock rearing (Figure 1). Livestock farming, similar to arable farming, has become more intensified since the introduction of CAP, with greater fertiliser inputs and increased stocking rates. In fact, the use of inorganic nitrogen fertiliser on grassland increased by around 100% to

an average of 132kg nitrogen per hectare per year between 1970 and 1986. The application of inorganic nitrogen fertiliser has since decreased to around 115kg/ha/year (MAFF *et al.*, 1997 as reported in Vickery *et al.* 2001), but still remains higher than pre-1970 (see Figure 13).

Figure 13: Changes in inorganic nitrogen input to grassland in the UK between 1970 and 1996.



Source: Vickery *et al.* (2001)

It can be assumed that the level of inorganic nitrogen fertiliser application in Essex reflects the UK average. In addition, inorganic potassium and phosphorus fertilisers are applied to around 67% of grassland and organic fertiliser to around 48% of grassland in the UK (Vickery *et al.*, 2001).

The aim of applying fertiliser to the land is to enrich the soil with nitrogen, potassium and phosphorus; the addition of these minerals increases grass growth. The result is a greater sward height on fertilised, compared to non-fertilised land. This is actually advantageous to bird species that prefer taller swards, such as the Snipe (Mason & Macdonald, 1976), but, as can be seen from Table 2, the Snipe is not a conservation concern in Essex.

In contrast, two of the species showing population declines in Essex, the Skylark and the Starling, tend to select open areas of low vegetation cover for foraging (Wilson *et al.*,

1997, reported in Vickery *et al.*, 2001) and thus the increased sward height that has resulted from increased fertiliser use on grassland may have contributed to their declines.

The situation is worsened further for these species since the application of inorganic fertiliser has been shown to decrease numbers and diversity of certain invertebrates, including Diptera (flies), Coleoptera (beetles), Orthoptera (crickets and grasshoppers) and Hemiptera (bugs, mainly aphids), upon which both the Skylark and the Starling sometimes feed (Vickery *et al.*, 2001). However, a review carried out by Wilson *et al.* (1999) found that there were no clear trends in the effects of fertiliser application on beetles, with some studies providing evidence of detrimental effects and others finding non-detrimental effects. Blake *et al.* (1996) actually found an increase in beetle numbers with a general increase in grassland management, which included higher levels of fertiliser application, but the size of the beetles declined. Such an effect may go some way to explain the declining populations of the Reed Bunting because the total biomass of beetle available as food will have decreased over the years as a result of more intensive grassland management. Inorganic fertilisers have also been shown in several studies to decrease the abundance of some species of moths and butterflies (Wilson *et al.*, 1999) and at high levels of application, they reduce the abundance of earthworms (Vickery *et al.*, 2000). Such a reduction in earthworms due to increased fertiliser usage may be another possible cause of the diminishing populations of Blackbirds and the Song Thrushes in Essex.

Fertiliser application not only reduces invertebrate populations, but it reduces botanical diversity as well; it encourages the growth of competitive species at the expense of slower growing ones (Kirkham *et al.*, 1996). For example, fertiliser application tends to favour meadow-grasses and Polygonaceae, but select against annual grasses (Wilson *et al.*, 1999). As previously mentioned, Polygonaceae are an important source of seed for granivorous birds and therefore fertiliser application may have helped prevent greater declines in species such as the Turtle Dove, the Tree Sparrow and the Reed Bunting that were possibly partly due to a reduction in seed availability on arable land. However, in Essex the proportion of grassland is quite small in comparison to the proportion of land

used for arable cultivation and so these beneficial effects of fertilisers would not have been great enough to prevent the declines in bird species.

Figure 14: A Turtle Dove.



Source: Essex Wildlife Trust (1999)

In addition, other factors of more intensive grassland management would have been detrimental to bird species, such as stocking rates. These are measured in livestock units (LU) per area of land with, for example, a dairy cow being equivalent to one LU; a rearing heifer being equivalent to 0.8LU; and a lowland ewe being equivalent to 0.11LU (Nix, 2003). The stocking rates of pastures nationwide have increased significantly since the introduction of the CAP; in the early 1960s, the stocking rate in Essex was between 876 and 1150 livestock units per 1000 hectares, but by 1997, this had increased to between 1151 and 1425 livestock units per 1000 hectares (Shrubb, 2003). At least part of the declines in the Reed Bunting and the Skylark might be attributed to these increases in stocking densities; these birds are ground-nesting birds (see Table 2) and therefore their nests are at risk of being lost through trampling. Obviously, the greater the stocking density, the greater the risk of nest trampling. No studies have been carried out that assess the extent of damage caused to the populations of these two particular species through nest trampling, but the phenomenon has been well-studied in the Lapwing, another ground-nesting bird species. For example, Bientema and Müskens (1987) found that nest losses of the Lapwing increased with increased stocking density and with increased

duration of grazing, as did nest losses of other ground-nesting species. In fact they attributed between 30 and 60% of nest losses, according to species, on trampling by livestock.

Another point to take into consideration is the fact that sheep in particular greatly affect soil structure by compacting it (Shrubb, 2003). Table 1 shows that the ratio of sheep to cattle has increased in the aftermath of CAP, and so the degree of soil compaction will have increased considerably, therefore influencing soil-dwelling invertebrates. Soil compaction has been shown to decrease slug populations (Ferguson *et al.*, 1988) which may form a component of the diets of the ten bird species currently showing population declines in Essex (Table 3). Although some species of earthworms can survive in highly compacted soils, others have their movement restricted (Kretzshmar, 1991) and thus their numbers are likely to have declined in recent years. This might be partly responsible for the declining numbers of Blackbirds (which feed on earthworms; Table 3) in Essex.

Figure 15: A Blackbird.



Source: Essex Wildlife Trust (1999)

Intensive grazing also tends to favour a few species of plant that can tolerate repeated defoliation, for example *Trifolium repens* (Vickery *et al.*, 2001). Although this species forms a substantial component of the diets of granivorous birds (Wilson *et al.*, 1999), similar to other plant species, it has limited ability to set seed when being grazed

intensively (Vickery *et al.*, 2001). Thus, the increased proportion of *T. repens* on intensively grazed land would not benefit granivorous bird species. Indeed the decline of such species in Essex over the last three decades could be partly attributed to the increased intensity of grazing, which results in reduced seed availability.

THE REPLACEMENT OF HAY WITH SILAGE CROPS

The increased use of pesticides and fertiliser has led to changes in the management and harvesting of grass. The use of fertiliser that allowed rapid growth of grass and the resolution of problems in making silage of consistent quality in the 1960s, combined the advent of plastic in the 1980s that could be used for wrapping baled silage, led to an almost complete switch in the method of preserving grass (Shrubb, 2003); the production of hay was replaced by the practice of ensiling grass. Whereas in 1962 only around 10% of forage grass was ensiled nationwide, this figure had risen to almost 80% by the mid 1990s (Shrubb, 2003).

With this change from hay to silage production, there was also a switch in the time of grass cutting. If silage is contaminated with soil, there can be spoilage problems due to the fermentation of carbohydrates and lactic acid to butyric acid by *Clostridium* species. (Halley and Soffe, 1988). In order to avoid such huge losses, silage fields are cut early, between May and June (O'Connor and Shrubb, 1990), whereas grass is cut for hay from late June to August because the process is dependent upon a period of dry weather. The time of cutting means that grassland is usually cut for silage prior to any flowering, whereas it is cut for hay after there has been considerable flowering (Smith and Jones, 1991). Therefore, the hay, and hence the dung from the hay fed livestock, contains considerable quantities of seeds, which provide a source of food for the granivorous birds.

One result of the switch to silage making is thus a decreased food supply in animal dung to granivorous birds and this might have been a contributing factor in the decline of the Goldfinch, the Reed Bunting, the Skylark, the Song Thrush, the Tree Sparrow and the Turtle Dove in Essex. The switch to silage making also reduced the number of hay bales in fields that were previously a rich source of seed during the winter, particularly for

finches (Shrubb, 2003); silage contains far fewer seeds and the availability to birds of those that are present is almost absent in wrapped silage bales (Figure 16). Thus, the food availability to granivorous birds has decreased significantly as a result of increasing silage production since the 1960s.

Figure 16: Tightly wrapped silage bales allow birds no access to any seeds the silage might contain.



Source: Jon (2000)

The diminishing populations of the Blackbird, Dunnock, Starling and Swallow, all invertebrate feeders, could also be, in part, attributed to the switch from hay to silage making in Essex. This is because silage making is associated with an increased frequency in mowing grassland, which adversely affects both the diversity and the abundance of invertebrate species, thereby reducing the food supply to these species. For example, studies have shown cutting for silage significantly depletes the populations of linyphiid spiders ((Vickery *et al.*, 2001). In addition, mowing at the end of June, as is common with silage production, has been found to be detrimental to butterfly populations since it removes important nectar sources at a time that coincides with maximum butterfly abundance (Feber *et al.*, 1996).

The increased frequency of grass cutting for silage might further be implicated in the decline of the ground-nesting birds of Essex (Skylarks and Reed Buntings) because

regular intensive mowing causes destruction of nests and young of these species, thereby severely reducing their breeding success (Vickery *et al.*, 2001).

Figure 17: A Skylark.



Source: Delin and Svensson (1993)

The effects of such nest destruction on Skylarks have been documented by Wilson *et al.* (1997). The Skylark is a multi-brooded species; it lays its first clutch between late April and early May and a second clutch in early June. This second clutch may follow a successful first brood or a repeat attempt after initial failure (Wilson *et al.*, 1997). The dates of both the first and the second clutch laying coincide with the times of silage cutting, leaving the clutches at risk from destruction by the machinery used for silage cutting. In fact, Guest *et al.* (1992, as reported in Shrubbs, 2003) observed that the multiple cutting of grassland for silage is timed such that Skylarks have little chance for successful nesting. As a result, the overall proportion of nests surviving on silage land from clutch initiation until at least one chick has left the nest is less than 0.3 (Wilson *et al.*, 1997). However, this is not the case with haymaking; the later cutting of grassland gives sufficient time for the first brood at least to fly the nest, and possibly also the second brood. Therefore, it is possible that the reduced breeding success as a result of the switch to ensiling grass has been a causative factor in the recent reduction of Skylark population sizes in Essex.

CONCLUSION

This review has examined evidence that the recent declines in bird populations across England are the result of the increased intensification of farming practices in light of the introduction of the Common Agricultural Policy. In Essex, a predominantly arable area, these declines have been most noticeable amongst the granivorous birds, namely Goldfinches, Reed Buntings, Skylarks, Song Thrushes, Tree Sparrows and Turtle Doves. The main reason underlying the declines in these species is the adverse effect that intensive agricultural practices have had on the availability of seeds. The increased use of pesticides, both herbicides and insecticides, has reduced seed supplies all year round and the switch from spring- to autumn-sowing has reduced the availability of stubble, an important winter source of seed for these species. In addition, the replacement of hay with silage crops has led to a reduction in seed availability at the time of harvesting. However, recent agricultural changes in Essex have not just affected the food supplies of granivorous birds, but have also reduced the availability of invertebrates which form a major part of the diet of the other species that according to Essex Wildlife Trust, are also suffering population declines in the area (Blackbirds, Dunnocks, Starlings and Swallows), as well as contributing to the diet of the granivorous birds. The reduction in invertebrates is mainly the result of increased use of insecticides, and to some extent herbicides. Hedgerow removal and the switch to silage production that have occurred in Essex have also reduced invertebrate abundance. Decreased food supplies could have contributed to the declines in any or all of the ten species.

Intensification of agriculture has not only affected bird food supplies however, but certain changes have also adversely affected nesting and breeding sites. For example, the Skylark requires short vegetation for nesting, but the switch to autumn-sowing of crops has meant that the crops are too tall by the time of the breeding season. Nesting success is further inhibited by the timing of silage cutting, whereas hay cutting previously did not disrupt nesting. The removal and deterioration of hedgerows in Essex will have also reduced the

habitat of many of the ten declining bird species. In addition, the reduction in mixed farming may have rendered many farms unsuitable habitats for birds.

Essex is a predominantly arable county and therefore it is to be expected that the changes in crop cultivation – increased pesticide use and changes in sowing time – will have had the more significant effects on reducing bird populations than those factors associated with livestock farming – intensive grassland management and increased silage production. This is not to say that the changes in livestock farming have been insignificant in the declines of bird species in Essex.

It is debatable whether the bird populations of Essex would benefit or suffer from the possible introduction of GMHT maize to the area sometime in the future. Although the main research indicates that food supplies to both granivorous and insectivorous birds would increase, a major failing in the report is that an herbicide that is soon to be banned was used on control crops. Further research would have to be carried out, comparing GM crops with crops sprayed with legalised herbicides, in order to verify any beneficial effects of GMHT maize cultivation on bird species.

In conclusion, the intensification of Essex farming practice since the introduction of CAP has probably contributed to the reduction of the ten bird species through reducing food availability and destroying their nesting and breeding sites. These effects are the result of a combination of changes that have taken place in the county over the last three decades: increased pesticide use; changes in the timing of sowing and harvesting; reduction in mixed farming; increased field size and hedgerow loss; intensive grassland management; and the replacement of hay with silage crops. Each of these changes will have affected the different bird species in different ways, depending upon the exact habitat requirements of the species concerned, but it is likely that the changes in arable production have been the most significant cause the population declines.

REFERENCES

- Arentsen, H. and Arentsen, H. (2004) The Garden Safari: Birds. <http://www.gardensafari.net/english/pages/ringmus.htm>. Accessed on 28th March 2004.
- Baines, M. Hambler, C., Johnson, P.J., Macdonald, D.W. and Smith, H. (1998) The effects of arable field margin management on the abundance and species richness of Araneae (spiders). *Ecography*, **21**, 74-86.
- BBC NEWS Online (2004) BBC News Science and Nature pages – UK’s tentative go-ahead for GMs. <http://news.bbc.co.uk/1/hi/sci/tech/3546347.stm>. Accessed on 16th March 2004.
- Barr, C.J., Bunce, R.G.H., Clarke, R.T., Fuller, R.M. Furse, M.T., Gillespie, M.K., Groom, G.B., Hallam, C.J., Hornung, M., Howard, D.C. and Ness, M.J. (1993) *Countryside survey 1990I*. Main Report. Department of the Environment. London, UK.
- Bright, A. (2004) Passerine Birds. <http://digiscopingukbirds.homestead.com/passerines1.html>. Accessed on 28th March 2004.
- Brown, R.A., White, J.S., and Everett, C.J. (1988) How does an autumn applied pyrethroid affect the terrestrial arthropod community? In: Greaves, M.P., Smith, B.D. and Greig-Smith, P.W. (Eds.), *Field Methods for the Study of the Environmental Effects of Pesticides*. British Crop Protection Council monograph 40, Thornton Heath, UK, pp.137-145.
- BTO (2003) British Trust for Ornithology page on Swallow Roost Project. <http://www.bto.org/ringing/swallowroostproject/index.htm>. Accessed on 18th March 2004.
- Burke, M. (2003) GM Crops – Effects on Farmland Wildlife. <http://www.defra.gov.uk/environment/gm/fse/results/fse-summary.pdf>. Accessed on 18th March 2004.
- Chamberlain, D.E. and Crick, H.Q.P. (1999) Population declines and reproductive performance of skylarks *Alauda Arvensis* in different regions and habitats in Great Britain. *Ibis*, **141**, 38-51.
- Chamberlain, D.E., Fuller, R.J., Bunce, R.G.H., Duckworth, J.C. and Shrubbs, M. (2000) Changes in the abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. *Journal of Applied Ecology*, **37**, 771-788.

- Crick, H.Q.P., Baillie, S.R., Balmer, D.E., Bashford, R.I., Beaven, L.P., Dudley, C., Glue, D.E., Gregory, R.D., Marchant, J.H., Peach, W.J. and Wilson, A.M. (1998) *Breeding Birds in the Wider Countryside: Their Conservation Status (1972-1996)*. BTO Research Report 198, BTO, Thetford, UK.
- Delin, H. and Svensson, L. (1993) *Photographic Guide to the Birds of Britain and Europe*. The Book People, Singapore.
- Diamond, J. (1997) *Guns, Germs and Steel*. Jonathan Cape, London.
- Donald, P.F., Green, R.E. and Heath, M.F. (2001) Agricultural intensification and the collapse of Europe's farmland bird populations. *Proceedings of the Royal Society of London*, **268**, 25-29.
- Donald, P.F., Pisano, G., Rayment, M.D., Pain, D.J. (2002) The Common Agricultural Policy, EU enlargement and the conservation of Europe's farmland birds. *Agriculture, Ecosystems and Environment*, **89**, 167-182.
- Dover, J., Sotherton, N. and Gobet, K. (1990) Reduced pesticide inputs on cereal field margins: the effects on butterfly abundance. *Ecological Entomology*, **15**, 17-24.
- Edwards, A. (2000) The role of farmyard manure in the maintenance of botanical diversity in traditionally managed hay meadows of the Pennines. <http://www.students.ncl.ac.uk/a.r.edwards/FYMresearch.htm>. Accessed on 18th March 2004.
- Evans, A.D., (1997) The importance of mixed farming for seed-eating birds in the UK. In Pain, D.J., Pienkowski, M.W. (Eds.), *Farming and Birds in Europe: The Common Agricultural Policy and its implications for bird conservation*. Academic Press, London, pp.331-357.
- Evans, A., Curtoys, J., Kew, J., Lea, A. and Rayment, M. (1998) Set-aside: Conservation by accident... and design? *Royal Society for the Protection of Birds Conservation Review*, **11**, 59-66.
- Essex Wildlife Trust (1999) Essex Wildlife Trust wildlife homepage. http://www.essexwt.org.uk/wild_home.htm Accessed on 22nd February 2004.
- Feber, R.E., Smith, H. and Maconald, D.W. (1996) The effects on butterfly abundance of the management of uncropped edges in arable fields. *Journal of Applied Ecology*, **33**, 1191-1205.
- Ferguson, C.M., Barratt, B.I.P. and Jones, P.A. (1988) Control of the grey field slug (*Deroceras reticulatum* (Müller)) by stock management prior to direct-drilled pasture establishment. *Journal of Agricultural Science*, **111**, 443-449.
- Gibbons, D.W., Reid, J.B. and Chapman, R.A. (eds.) (1993) *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991*. T.& A.D. Poyser, London, UK.

- Gillings, S. and Fuller, R.J. (1998) Changes in bird populations on sample lowland English farms in relation to loss of hedgerows and other non-crop habitats. *Oecologia*, **116**, 120-127.
- Haines-Young, R.H., Barr, C.J., Black, H.I.J., Briggs, D.J., Bunce, R.G.H., Clarke, R.T., Cooper, A., Dawson, F.H., Firbank, L.G., Fuller, R.M., Furse, M.T., Gillespie, M.K., Hill, R., Hornung, M., Howard, D.C., McCann, T., Morecroft, M.D., Petit, S., Sier, A.R.J., Smart, S.M., Smith, G.M. Stott, A.P., Stuart, R.C. and Watkins, J.W. (2000) *Accounting for Nature: Assessing Habitats in the UK Countryside*. Department of the Environment, Transport and Regions, London, UK.
- Halley, R.J. and Soffe, R.J. (1988) *Primrose McConnell's: The Agricultural Notebook, 18th edition*. Butterworths, London, UK.
- Haysom, K.A., McCracken, D.I., Robertson, D.J. and Sotherton, N.W. (2000) Grassland conservation headlands: a new approach to enhancing biodiversity on grazing land. In: Rook, A.J. and Penning, P.D. (Eds.) *Grazing Management: The Principles and Practice of Grazing for Profit and Environmental Gain Within Temperate Grassland Systems*. British Grassland Society, Reading, UK. pp. 159-160.
- Henderson, I.G., Cooper, J., Fuller, R.J. and Vickery, J. (2000) The relative abundance of birds on set-aside and neighbouring fields in summer. *Journal of Applied Ecology*, **37**, 335-347.
- Hill, D., Andrews, J., Sotherton, N., Hawkins, J. (1995) Farmland. In: Sutherland, W.J. and Hill, D.A. (eds.) *Managing Habitats for Conservation*. Cambridge University Press, Cambridge, UK, pp 230-266.
- Jon, M. (2000). Welcome to the month of June 2000 on a working farm!
<http://www.bedruleparish.btinternet.co.uk/june2.htm>. Accessed on 18th March 2004.
- Jones, G. (2004) GM maize firm pulls out of British market.
<http://www.telegraph.co.uk/news/main.jhtml>. Accessed on 22nd April, 2004.
- Kirkham, F.W., Mountford, J.O. and Wilkins, R.J. (1996) The effects of nitrogen, potassium and phosphorous addition on vegetation of a Somerset peat moor under cutting management. *Journal of Applied Ecology*, **33**, 1013-1029.
- Liberal Democrats (2004) GM Maize Go-Ahead is Unscientific.
<http://www.libdems.org.uk/index.cfm/page.homepage/section.home/article.6151>.
accessed on 18th March 2004.
- Marchant, J.H., Hudson, R., Carter, S.P. and Whittington, P. (1990) *Population Trends in British Breeding Birds*, BTO, Thetford, UK.

- Mason, C.F. and Macdonald, S.M. (1976) Aspects of the breeding biology of the snipe. *Bird Study*, **23**, 33-38.
- McMellin, G. (2002) The Environment Agency's page on agricultural land use. http://www.environment-agency.gov.uk/yourenv/eff/land/213950/agri_land/?version=1&lang=e Accessed on 22nd February 2004.
- MAFF, The Scottish Office Agriculture, Environment and Fisheries Department, Department for Northern Ireland & Welsh Office (1997) *The digest of Agricultural Census Statistics, United Kingdom*. The Stationary Office, London, UK.
- Murphy, D.D. (1983) Nectar sources as constraints on the distribution of egg masses by the checkerspot butterfly, *Euphydryas chalcedona* (Lepidoptera: Nymphalidae). *Environmental Entomology*, **12**, 463-466.
- Nix, J. (2003) *Farm Management Pocketbook, 34th Edition*. The Andersons Centre, London, UK.
- O'Connor, R.J. (1984) The importance of hedges to songbirds. In: Jenkins, D. *Agriculture and the Environment*. Cambridge, UK. pp. 117-123.
- O'Connor, R.J. and Shrubbs, M. (1990) *Farming and Birds*. Cambridge University Press, Cambridge, UK.
- Peach, W.J., Siriwardena, G.M. and Gregory, R.D. (1999) Long term changes in over-winter survival rates explain the decline of reed buntings *Emberiza schoeniculus* in Britain. *Journal of Applied Ecology*, **36**, 798-811.
- Roberts, H.A. and Dawkins, P.A. (1967) Effect of cultivation on the numbers of viable seeds in soil. *Weed Research*, **7**, 290-301.
- Royal Society for the Protection of Birds (1999) RSPB List of Birds of Conservation Concern – Red List. <http://www.rspb.org.uk/birds/guide/> Accessed on 22nd February 2004.
- Sharrock, J.T.R. (1976) *The Atlas of Breeding Birds in Britain and Ireland*. T.& A.D. Poyser, London, UK.
- Shrubbs, M. (2003) *Birds, Scythes and Combines*. Cambridge University Press, Cambridge.
- Siriwardena, G.M., Baillie, S.R., Buckland, S.T., Fewster, R.M., Marchant, J.H. and Wilson, J.D. (1998) Trends in the abundance of farmland birds: a quantitative comparison of smoothed Common Bird Census indices. *Journal of Applied Ecology*, **35**, 24-43.
- Siriwardena, G.M., Baillie, S.R., Crick, H.Q.P. and Wilson, J.D. (2001) Changes in agricultural land-use and breeding performance of some granivorous farmland passerines in Britain. *Agriculture, Ecosystems and Environment*, **84**, 191-206.

- Smith, R.S. and Jones, L. (1991) The phenology of mesotropical grassland in the Pennine Dales, northern England: historic hay cutting dates, vegetation variation and plant species phenologies. *Journal of Applied Ecology*, **28**, 42-59.
- Stevens, T. (2004) Stevens Family Farm Homepage. <http://www.stevensfarm.com/farm2.htm>. Accessed on 24th March 2004.
- The Essex Birdwatching Society (2003) The Essex Birdwatching Society's page on bird records. <http://www.essexbirdwatchesoc.co.uk/> Accessed on 22nd February 2004.
- Thomson, D.L. and Cotton, P.A. (2000) Understanding the decline of the British population of Song Thrushes *Turdus philomelos*. In: British Ornithologists Union. *Ecology and Conservation of Lowland Farmland Birds*, Tring.
- Vickery, J.A., Tallowin, J.R., Feber R.E., Asteraki, E.J., Atkinson, P.W., Fuller, R.J. and Brown, V.K. (2001) The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. *Journal of Applied Ecology*, **38**, 647-664.
- Wilson, J.D., Arroyo, B.E. and Clarke, S.C. (1996) *The diet of bird species of lowland farmland: a literature review*. Unpublished report to the Department of the Environment and English Nature. BBSRC-NERC Ecology and Behaviour group, University of Oxford, Oxford, UK
- Wilson, J.D., Evans, A.D., Poulsen, J.G. and Evans, J. (1995) Wasteland or Oasis? The use of set-aside by wintering and breeding birds. *British Wildlife*, **6**, 214-223.
- Wilson, J.D., Evans, J., Browne, S.J. and King, J.R. (1997). Territory distribution and breeding success of skylarks *Alauda arvensis* on organic and intensive farmland in southern England. *Journal of Applied Ecology*, **34**, 1462-1478.
- Wilson, J.D., Morris, A.J., Arroyo, B.E., Clarke, S.C. and Bradbury, R.B. (1999) A review of the abundance and diversity of invertebrate and plant foods of granivorous birds in northern Europe in relation to agricultural change. *Agriculture, Ecosystems and Environment*, **75**, 13-30.
- Wilson, J.D., Taylor, R. and Muirhead, L.B. (1996) Field use by farmland birds in winter: an analysis of field type preferences using resampling methods. *Bird Study*, **43**, 320-332.
- Wormell, P. (1999) *Essex Farming 1900-2000*. Abberton Books, Colchester, UK.