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# Winter Ecology of Golden Plovers and Lapwings: A Review and Consideration of Extensive Survey Methods

**Authors**

**S. Gillings & R.J. Fuller**

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## 1. EXECUTIVE SUMMARY

Britain supports internationally important numbers of Golden Plovers and Lapwings in winter. The majority of these birds spend the winter on lowland farmland where they are missed by existing monitoring schemes. This report is in two main parts: the first is a literature review and the second is a discussion of survey methods. We start by summarising current knowledge of the population size, trends, distribution and movements of plovers wintering in Britain. Patterns of habitat use and how they are affected by season, region and lunar phase are discussed, particularly with respect to plovers on farmland. We discuss components of agricultural change that may have affected plovers and highlight the need for further research, particularly extensive surveys.

We describe several sources of data on plover numbers and distribution from previous surveys that are available to researchers planning extensive and intensive surveys. We then describe work undertaken by ourselves and BTO volunteers during winters 1996/97 and 1997/98 using different counting techniques to identify suitable methods for an extensive volunteer based survey of wintering plovers. Problems identified include the highly clumped distribution of plover flocks, the high frequency of movements of entire flocks at a local level, and the changing composition of flocks in terms of individuals. The main implication of this work is that surveys of randomly selected grid squares are unlikely to produce meaningful population estimates for Golden Plovers and Lapwings. Suggestions of alternative methods for surveying plovers are made.

## 2. INTRODUCTION

Long-term monitoring of British breeding birds by the British Trust for Ornithology (BTO) has revealed dramatic declines in populations of many species of bird associated with lowland farmland (Fuller *et al.* 1995). Over the last 25 years a number of species have decreased in number by up to 80% and disappeared from some areas so that their British breeding ranges are now much smaller than during the 1960s and 1970s. For some of these species, changes in the agricultural landscape, primarily through intensification, have caused declines in productivity (e.g. Grey Partridge *Perdix perdix* (Potts 1986)). In others, changes have led to problems in winter when food may be scarce (e.g. Corn Bunting *Miliaria calandra* Donald & Aebischer 1996). For some species, a combination of factors acting in both the summer and winter period may be causing the observed declines.

Relatively little work has considered those species that are primarily present during the winter period of which Golden Plovers *Pluvialis apricaria* and Lapwings *Vanellus vanellus* are two of the main examples in Britain. An estimated 22,600 pairs of Golden Plovers breed on the uplands of the United Kingdom (Stone *et al.* 1997) and then move to lowland farmland in winter where their numbers are swelled by northern European and Icelandic breeders. In the United Kingdom approximately 200,000 to 250,000 pairs of Lapwings (Stone *et al.* 1997) breed on a variety of habitats but in winter the population increases 10-fold and birds primarily occupy lowland agricultural land (Lack 1986). Breeding Lapwings have been adversely affected by agricultural intensification in the lowlands (see Hudson *et al.* 1994) and localised declines in breeding Golden Plover populations have been reported in the uplands (e.g. Hancock & Avery 1998). The effects of land use change on these wintering plovers are poorly understood.

During winter, Britain holds internationally important populations of both of these species. Britain has an international obligation under the Convention on Wetlands of International Importance especially as Waterfowl Habitats (the Ramsar Convention) to conserve those inhabiting wetlands. We also have an obligation to conserve all populations of migratory birds under the 1979 Birds Directive (79/409/EEC) and the 1992 Habitats Directive (92/43/EEC). These directives include an obligation to monitor populations. The Wetland Bird Survey (WeBS) Steering Group has identified that Golden Plovers and Lapwings are not adequately monitored by core WeBS counts and that a survey, or monitoring programme, is required (Cranswick *et al.* unpubl.). Additionally a survey of wintering Golden Plovers and Lapwings would help us to understand further how birds use agricultural habitats. The latter would be invaluable if monitoring suggested that plover conservation was an important issue.

A unique strength of the BTO is the ability to organise large numbers of volunteers to participate in extensive surveys of bird populations. Sometimes surveys can follow standard methods. Occasionally, repeat surveys are made following methodology used for a previous survey of a particular species (e.g. BTO Breeding Lapwing Survey, (Browne 1998). For some species existing survey techniques do not seem wholly appropriate and wintering Golden Plovers and Lapwings are examples. These two species typically form large flocks that are difficult to find. Flocks are often aggregated so that large expanses of farmland hold no birds. Furthermore, there is great potential for double counting due to the flock's high mobility. These problems are considered further in Sections 8 and 9.

The purpose of this report is to review current knowledge of the status and ecology of wintering Golden Plovers and Lapwings. We go on to consider how changes in farm management might have affected plovers and to discuss the need for future research and, in particular, the need for surveys of wintering plovers. The questions that a survey of Golden Plovers and Lapwings might aim to answer are discussed, followed by a description of the archive information sources that are at our disposal and the pilot work and intensive study undertaken over recent winters. The report then describes current BTO thinking on techniques for surveying wintering Golden Plovers and Lapwings.

Hereafter, 'plovers' is taken to mean both Golden Plovers and Lapwings, a tetrad is a 2 km × 2 km square, a 5 km is a 5 km × 5 km square and a 10 km is a 10 km × 10 km square.

3. LITERATURE REVIEW

## 3.1 Previous Surveys of Wintering Golden Plovers and Lapwings

During this century, non-breeding Golden Plovers and Lapwings in Britain have been the subject of one and two extensive surveys respectively. Both species were also surveyed by the BTO's *Atlas of Wintering Birds in Britain and Ireland* (Lack 1986). The 1937 Lapwing Habitat Enquiry collated information from a sample of counties, predominantly those in the Thames valley and north-east/central England. This survey described general patterns of habitat use throughout the year (Nicholson 1938). The 1960/61 Lapwing Habitat Enquiry was designed to supplement the previous one and to determine whether there had been any changes in habitat preference (Lister 1964). Due to the design of the studies and the nature of the observers' returns, both surveys were highly qualitative rather than quantitative.

During the winters of 1976/77 and 1977/78 the BTO organised a national survey of Golden Plovers aimed at identifying areas important for the species and at examining patterns of habitat use (Fuller & Lloyd 1981). The *Winter Atlas* was the most recent survey that included Golden Plovers and Lapwings. Survey work was undertaken during three consecutive winters (1981/82, 1982/83 and 1983/84) to map the distribution of wintering birds throughout the British Isles and provide winter population estimates (Lack 1986). There has been no systematic monitoring of the complete wintering population of either species. The small proportion that winter in intertidal areas has been surveyed since 1969, initially as the Birds of Estuaries Enquiry (BoEE), and then since 1992 by the Wetland Bird Survey (WeBS) under a partnership between BTO, the Royal Society for the Protection of Birds (RSPB), the Wildfowl and Wetlands Trust (WWT) and the Joint Nature Conservation Committee (JNCC). Since the establishment of WeBS waders have been counted on inland wetlands though some observers only provide presence/absence data (pre-1992 counts of waders on inland wetlands were sporadic). In summary, the coverage of even the small proportion of the British wintering plover populations that inhabit wetlands is incomplete and the large numbers inhabiting lowland farmland are completely ignored for monitoring purposes. In the Republic of Ireland plovers on inland and coastal wetlands are counted through the Irish Wetland Bird Survey (I-WeBS) which has been in operation since winter 1994/95. A further source of information on wintering Golden Plovers and Lapwings in Britain is found in county and local bird reports. However, these counts are not systematic and the level of recording varies from county to county and from year to year. Also a small number of counties have organised their own one-off Golden Plover and/or Lapwing surveys (e.g. Kent, Hodge 1996). These surveys are usually run in single winters and are rarely coordinated between adjacent counties so that it is impossible to determine whether population estimates are 'typical' for the county or whether they reflect an immigration or emigration event. Detection of trends at the county level is therefore very difficult.

## 3.2 Population Size and Trends

Cayford and Waters (1996) calculated the most recent estimates of the size of the wintering population of Golden Plovers and Lapwings in Great Britain as 250,000 and 1,500,000 respectively. These estimates were based on WeBS data and *Winter Atlas* data and form our best guess of the wintering population across all habitats in Britain. However, the estimates date back to the early-1980s when the *Winter Atlas* was conducted. Cayford and Waters (1996) estimated that 73% of Golden Plovers and 85% of Lapwings wintered inland away from WeBS sites and were therefore unmonitored. While these percentage estimates are likely to vary between winters due to the effects of cold weather movements, they give an impression of the scale of the unmonitored proportions of these populations.

The most recent population totals for wetland sites monitored by WeBS are presented by Cranswick *et al.* (1997) for winter 1995/96. Table 3.2.1 gives the maximum count recorded between October 1995 and March 1996 (the 'peak count') for Great Britain, Northern Ireland and the Republic of Ireland for estuarine/coastal sites and inland wetlands. Peak counts occur in November in Great Britain then in December and January in Northern Ireland and the Republic of Ireland as birds spread west during mid winter. Here we present the 'Britain and Ireland total' which is the combined number of birds in Great Britain, Northern Ireland and the Republic of Ireland. Using this definition rather than individual country totals is more meaningful because it recognises that plovers in the Republic of Ireland are not independent of those in Britain or Northern Ireland. The Britain and Ireland total for Golden Plovers and Lapwings wintering in wetland habitats is based on November counts. Totalling peak counts will overestimate the size of the Britain and Ireland population because some birds counted in November in Great Britain almost certainly move west (Kirby & Lack 1993) and are counted again in December or January in Northern Ireland or the Republic of Ireland. For both species the number of individuals recorded on WeBS sites throughout Britain and Ireland between October 1995 and March 1996 peaked in November (Table 3.2.2). This is probably because most European birds have arrived in Britain and Ireland by November whilst few birds have departed to Iberia or North Africa. The timing of the Britain and Ireland peak count may vary slightly between years due to weather conditions.

Table 3.2.3 gives critical thresholds for notification of sites of international and national importance. A site is designated as being of international importance if it regularly holds in excess of 1% of the international population of a species. Based on the most recent population estimates (Cayford & Waters 1996) sites are defined as being of national importance if they regularly hold more than 1% of the Great Britain, or all-Ireland population. The term 'regularly hold' is quantified as the 'winter (five-year) peak mean' which is a mean of the peak count from each of the five most recent winters. Cranswick *et al.* (1997) list the wetland sites that qualified for international and national importance in 1995/96 in Great Britain and Northern Ireland. Delany (1997) listed equivalent sites in the Republic of Ireland based on data collected by the first two years of I-WeBS. Few sites meet the qualifying level of 20,000 Lapwings for national significance so Cranswick *et al.* (1996) chose a threshold of 5,000 for the purposes of listing 'important sites' in their report, and this is applied here. All-Ireland importance is confusing because two different thresholds are used, one for Northern Ireland (WeBS) and another for the Republic of Ireland (I-WeBS) (Cranswick *et al*. 1997; Delany 1997; Table 3.2.3). Figures 3.2.1 and 3.2.2 shows the distribution of sites of international, national and all-Ireland importance (both methods) in 1995/96. It is important to remember that these maps are based solely on data from WeBS and I-WeBS. They therefore plot the distribution of important coastal and inland wetland sites but no important inland terrestrial sites. Since I-WeBS only started in winter 1994/95 it is not yet possible to produce a five-year peak mean. The figures show sites that exceeded the I-WeBS interim all-Ireland threshold in 1995/96. Thirteen of the 35 sites of all-Ireland importance for Golden Plovers and 12 of the 30 sites for Lapwings failed to qualify in 1994/95. Moreover, eight sites for Golden Plovers and seven sites for Lapwings qualified in 1994/95 but not in 1995/96. For species such as these that show such large annual variations in population size and distribution, five-year peak means will recognise sites that are always important but may fail to register sites that are of great importance in certain years. Such sites might be important refuges in years of severe weather in Britain for example.

The only data from which trends can be calculated is the WeBS database that contains counts every year since 1970/71. Trends are routinely calculated from WeBS count data for other species of wader. The main reason why trends have not been calculated for Golden Plovers and Lapwings is that only a fraction of the British populations occur on WeBS sites (Prys-Jones *et al.* 1994) and consequently trends could be misinterpreted. Furthermore, calculation and interpretation of trends is complicated by the dramatic immigration and emigration movements that plovers make in response to changes in weather patterns. However, calculation of trends might provide insights into the patterns of use of estuarine and coastal habitats, and may suggest further research.

## 3.3 Distribution and Movements

In Britain in winter plovers are widely distributed and this is apparent from the percentage of 10 km squares inhabited during the Winter Atlas: 57% and 79% for Golden Plovers and Lapwings respectively (Lack 1986). However, describing occupancy in this way may give a false impression of the species' true ranges because three winter periods are combined whereas in any single winter, range may be smaller. In winter, Lapwings avoid areas of high ground in the north and west of Britain and are concentrated in the lowlands of south and central England and west of the Pennines. Wintering Golden Plovers similarly avoid land over 200 m and their distribution centre is approximately 150 km north of the Lapwing core (Kirby & Lack 1993). In Ireland, a large number of Golden Plovers also winter in the NE, along the S coast and on the Shannon lowlands. This difference in the core wintering areas of the two species may be due to differences in the location of the breeding range from which each originates (Kirby & Lack 1993). British breeders of both species remain to winter in varying numbers every year but they are swelled by birds from elsewhere. Lapwings breeding in Scandinavia, The Netherlands, Denmark and N Germany all winter in Britain, whereas Golden Plovers wintering in Ireland and western Britain breed predominantly in Iceland (Fuller in Lack 1986). The smaller numbers of Golden Plovers in eastern Britain originate from Scandinavia and continental Europe. Alternatively, differences in distribution centres may be caused by regional variation in the availability of preferred habitats (Kirby & Lack 1993). Golden Plovers appear to have a stronger affinity for grasslands whilst Lapwings will utilise a wider range of habitats (see below). Consequently, Golden Plovers may find more suitable habitat in Ireland and in the north of England whereas Lapwings can make relatively more use of cultivated areas in the milder south.

Lapwings arrive gradually throughout the late summer, autumn and winter. The breeding population of the lowlands is supplemented by a modest immigration in June and July, perhaps marking the return of failed breeders from Hungary, Czechoslovakia, Switzerland and southern Germany (Imboden 1974). Between November and January a second, larger, arrival occurs during which the peak numbers are attained. Numbers remain relatively high until a sharp drop off marking northwards spring migration in March (Crooks & Moxey 1966; R.J. Fuller unpubl.). Precise information on Golden Plover movements is lacking but the total Britain and Ireland population also peaks in November (Section 3.2).

Plovers are renowned for their cold weather movements (Elkins 1983). During ‘normal' winter weather, Golden Plovers and Lapwings are aggregated but at the onset of cold weather, especially if accompanied by frost or snow, flocks disperse more widely (Kirby 1995; S. Gillings & R.J. Fuller unpubl.). If conditions persist for more than three days mass movements ensue, usually in a south or south-westerly direction, or towards the coast (Kirby & Lack 1993). Few birds actually leave the country though the number that do so increases with the severity of the winter. Ringing recoveries suggest that some birds reach France and Spain whilst records exist from as far afield as Morocco, the Canaries and Madeira (Elkins 1983). Kirby and Lack (1993) report that during the winters most birds move to the shorelines of south-eastern and eastern England whereas Fuller (1988) concluded that plovers only move as far as is necessary to escape the cold weather. The number of birds inhabiting a Buckinghamshire site in January 1988 increased 12-fold when the region immediately north suffered a heavy snowfall. Such movements are probably associated with appreciable mortality. Analysis of ringing data for the period 1961 to 1969 demonstrated that 69% of the variation in adult Lapwing survival could be explained by mean winter soil temperature and total winter rainfall (Peach *et al.* 1994), two climatic variables which clearly relate to the severity of the winter. Also Yalden and Pearce-Higgins (1997) demonstrated that the growth rate of a breeding population studied over 24 years was partly determined by mean monthly air temperature during the winter. Catchpole *et al.* (in press) demonstrated that adult Lapwing survival was negatively related to winter weather severity.

In the winters of both 1981/82 and 1984/85 plover populations in Buckinghamshire crashed to zero during a cold snap, presumably as plovers moved to ‘refuge areas’ less affected by the severe weather. When normal conditions returned there was a rapid recovery but not to pre-movement levels (R.J. Fuller unpubl.). Apparently some individuals remain in the refuge areas and do not leave them until the breeding season. Kirby and Lack (1993) demonstrated that Golden Plovers were less likely to return to vacated areas than Lapwings whereas Fuller and Youngman (1979) found the opposite. These complex patterns of occupancy and movement vary both between and within winters and between regions though Kirby and Lack (1993) suggest that the distance of the refuge, the ease of movement and the suitability of the refuge may be contributory factors. How birds know when to return is unknown, though if, as Fuller (1988) suggested, birds only move as far as necessary to escape cold weather, they may simply track the receding edge of the cold zone.

## 3.4 Habitat Usage: Regional and Seasonal Differences

Both Golden Plovers and Lapwings are said to use traditional ‘home ranges' in winter (Fuller & Youngman 1979) which have been considered stable through time (but for an exception see Gregory 1987 and Section 8.1). Golden Plovers and Lapwings can be found on winter cereals, bare till and on a variety of grassland types, including pastures and airfields. Much research has been generated due to their use of the latter because of the high incidence of bird strikes (e.g. Milsom *et al.* 1985). Most studies of habitat use report a strong preference for feeding on grassland, particularly permanent pastures (Lister 1964; Fuller & Youngman 1979; Fuller & Lloyd 1981; Milsom *et al.* 1985; Fuller 1988; Tucker 1992). For example, Milsom *et al.* (1985) found that between July and March the airfield in their study site contained between 62% and 98% of the local Lapwing population despite the airfield only accounting for 19% of the study area. This apparent preference for grassland could explain the rather low Lapwing densities which are apparent in the largely arable landscape of East Anglia in mid-winter.

The abundance and availability of potential prey items present in different habitats is likely to be an important factor shaping the distribution of plovers between fields. Both plover species consume invertebrates found in field vegetation and just below the soil surface (notably earthworms, beetles, and dipteran larvae). Prey availability is probably higher in vegetated fields than in bare till because the vegetation insulates the soil surface and creates a suitable microclimate for soil invertebrates which would otherwise be buried deeper (Parr 1992). This is reflected by the general avoidance of bare till by a variety of birds in winter (Tucker 1992). Earthworms (Annelida) are a common dietary component (Barnard & Thompson 1985) whose abundance can be estimated. Permanent pastures are richest in earthworms, with less in winter cereals and the least in row crops (Edwards & Lofty 1977; Barnard & Thompson 1985). In grassland, worm biomass increases as a function of the time since last ploughing, hence permanent pastures attain a higher biomass of earthworms than temporary grasslands. Plover distribution is positively correlated both with the biomass of earthworms and with field age. Furthermore, both species have higher net rates of energy intake in old compared to recent pastures (Barnard & Thompson 1985). Interestingly, Golden Plovers may use the presence of Lapwings as a visual cue to identify suitable feeding areas (Barnard & Thompson 1985). However, the presence of Lapwings does not appear to be the sole factor since Golden Plovers will fly over four or more flocks before alighting. The flocks they eventually join tend to be the largest ones and those inhabiting fields with a higher biomass of worms (Barnard & Thompson 1985). These patterns of use may generally be true on grassland where the dominant prey are undoubtedly earthworms, but in arable fields, where earthworms are less abundant, processes may differ.

Sward structure may also play an important role in determining winter distribution between fields through effects on invertebrate abundance and availability. For example, in the Lower Derwent Valley, North Yorkshire, Lapwings generally preferred short swards but avoided swards more than 10 cm tall (Gregory 1987). Milsom *et al.* (1998) also demonstrated that both Golden Plovers and Lapwings preferred to feed in fields that had been mown twice, rather than fields that had been mown only once, and unmown fields were virtually avoided. The optimum sward height appeared to be around 7 cm tall. However, heavy grazing can decrease the diversity and abundance of spiders, surface-active beetles and productivity of emergent flies (Keiller *et al.* 1995). Conversely, grazing may benefit foraging plovers through dunging. Not only does dung harbour its own invertebrate fauna but soil productivity may be increased as grazing animals convert unavailable nutrients into simpler nutrients which soil invertebrates can readily assimilate (Keiller *et al.* 1995). Grazing may also affect plover prey populations through trampling by stock. Hence, there may be an optimal grazing intensity that maximises invertebrate availability for foraging plovers. There has been little detailed research on relationships between grazing and habitat quality for wintering Golden Plovers and Lapwings. One exception is the work of Tucker (1992) in Buckinghamshire who found that both species tended to select fields used by cattle but avoid fields used by sheep. Tucker speculated that this may have been a consequence of variation in sward height (lower with sheep) affecting prey availability through modification of microclimate.

Despite associations with grassland at certain times, plovers forage on cultivated land and will even desert grassland for this purpose. Milsom *et al.* (1985) found that Lapwings foraged on an airfield during July since at that time it contained the only available short vegetation. However, in August and September, following the cereal harvest, Lapwings moved onto cultivated land where they foraged more intensely and became more nomadic, searching out fields of recent plough. They suggested that food availability decreased in late summer reflecting the decreased surface activity of potential prey items. In Buckinghamshire (R.J. Fuller unpubl.) and in Norfolk (S. Gillings unpubl.) Lapwings quickly exploited freshly ploughed fields in autumn but these fields retained their attractiveness to the birds for just a few days following the ploughing. Cultivated land is also used widely by both species for roosting though the extent to which cultivated land is used over grassland varies geographically (Fuller & Lloyd 1981; Barnard & Thompson 1985).

After feeding on cultivated land during the early part of the winter, in many areas flocks switch to feed on grassland during late to mid-winter, probably in response to cold weather (R.J. Fuller unpubl.; Milsom *et al.* 1985; Shrubb 1988). Soil protected by a dense layer of insulating vegetation may remain unfrozen during periods of ground frost and thus render soil invertebrates relatively more surface-active and relatively more available to plovers foraging on grassland than those foraging on cultivated land. The timing of the switch varies between studies and this probably reflects differences in the weather between winters and study sites. The switch to grassland does not occur in all areas. In Norfolk, where grassland occurs at low density, Golden Plovers and Lapwings did not switch to grassland even during cold weather. They persisted feeding on sugar beet stubbles, short autumn cereals, and bare till throughout the winter until departing for breeding grounds in March (S. Gillings unpubl.).

Most studies report a preference for grassland in mid-winter but there are exceptions, e.g. preference for cereals (Gregory 1987) and for ploughland (Crooks & Moxey 1966), possibly suggesting that regional differences in habitat selection exist. Many studies also report the importance of mixed farming systems that contain a mosaic of grassland and cultivated arable fields. Shrubb (1988) found such a situation in West Sussex where, although the land was managed intensively, the mosaic and rotation of crops and leys allowed Lapwings to be present in all but the most severe weather. Shrubb (1988) highlighted the importance of rotations and demonstrated that field use by plovers depended not only on the current crop but also the crop history of the field. Fields cropped as cereals for three or more consecutive years were virtually avoided whilst those that followed break-crops of leys or oil-seed rape were highly used. Soil invertebrates are benefited by high organic content (e.g. earthworms, Edwards & Lofty 1977) and undisturbed soils. Hence soil fauna is increased by break-crops since the organic content of the soil peaks and cultivation may cease for at least one year allowing invertebrate populations to recover (Shrubb 1988). Another potentially important feature of rotational farm management is that the timing of crop-specific agricultural operations varies between crops. Therefore suitable ploughed feeding areas are continually produced throughout the winter period as different crops reach maturity and are harvested. In this way, preferred feeding habitat may become available sequentially rather than simultaneously and can be fully exploited. In such landscapes plovers may be opportunistic, taking advantage of sudden localised prey concentrations as fields are ploughed or sugar beet fields are harvested.

Structural features of the landscape are also important. Milsom *et al.* (1985) found that Lapwings were commoner on fields that lacked, or had only short, boundary features (hedge, fences, etc). Crooks and Moxey (1966) also found a preference for large fields though, contrastingly, Milsom *et al.* (1985) found that small fields were weakly preferred.

Since plovers feed on soil invertebrates it is not surprising that relationships have also been found between bird distribution and soil factors. Lister (1964) demonstrated a preference for well-drained subsoils such as chalk, sands and gravels. Soil saturation is fatal for soil fauna and hence regularly flooded fields are unsuitable feeding areas although occasionally flooded fields may be used since they yield high densities of drowned earthworms (Kirby 1995). Indeed, Crooks and Moxey (1966) report that Lapwings commonly feed on damp fields. The general preference for dry soils does not explain why these species are so uncommon in Breckland. One possibility is that sandy soils such as those of the Brecks support few soil invertebrates (e.g. earthworms) due to the low organic matter content of the soil. Alternatively, the sparse vegetation typical of sandy soils may be an inadequate buffer against cold temperatures. Under such conditions, soil invertebrates such as earthworms move down the soil profile and are then less available to foraging plovers. Lister (1964) also drew attention to the possible relationship between earthworm diversity and abundance and soil pH. Earthworms may constitute a significant component of plover diet and changes in soil pH may consequently affect plover distribution.

## 3.5 Diurnal Behaviour and Moon Phase

Spencer (1953) first drew attention to the relationship between the lunar cycle and Lapwing behaviour. The classic pattern is that Lapwings feed predominantly during daylight hours except for a few days around the full moon when they feed nocturnally and remain virtually inactive during the day. This is an over simplification because nocturnal feeding can occur at other times of the lunar cycle. The pattern is strongest during the winter months though the effects of weather may modify it. For instance, Lapwings do not feed at night if thick cloud cover obscures the moon or if there is snow or heavy frost on the ground. This suggests that the behaviour is an opportunistic response rather being part of an endogenous circa lunar rhythm (Milsom *et al.* 1990).

A number of hypotheses have been advanced to explain these observations. One holds that plovers feed at night to escape kleptoparasitism by gulls (*Larus* spp.). Although feeding at night may be less efficient for a visual predator such as a Lapwing, this is compensated by the absence of gulls that normally steal prey and increase prey handling times (Barnard & Thompson 1985). This explains why birds do not feed when cloud cover is high but does not explain why some individuals continue to feed during the day. Alternatively, plovers may switch to night feeding because soil invertebrates are more surface-active during mild, damp, nights (e.g. earthworms; Edwards & Lofty 1977). If this were the reason, plovers should feed during all full moon periods rather than just winter ones. The fact that this behaviour only occurs during winter suggests that birds are responding to an energy deficiency, possibly arising as a result of the low ambient temperatures or short day length, perhaps combined with the effects of kleptoparasitism. Theoretical models predicting the need for supplementary feeding during November to February (Milsom *et al.* 1990) support this hypothesis. A parallel can be drawn between plovers and Oystercatcher (*Haematopus ostralegus*), in which a similar energy deficiency during winter drives some individuals to change their normal feeding behaviour and supplement their energy intake by feeding on coastal fields at high tide (Heppleston 1971). Like plovers, field-feeding Oystercatcher preferred grassland and when this was not available (e.g. when the ground was frozen) they followed the plough.

## 4. EFFECTS OF AGRICULTURAL CHANGE

The equilibrium population size of any population is a balance of productivity, mortality, immigration and emigration (Begon *et al.* 1996). Agricultural intensification in both lowland and upland areas has brought about a number of changes in habitat extent and quality with the potential to affect productivity and mortality of plovers.

Lapwing breed on both lowland and upland farmland. In lowland farmland, farm specialisation has replaced mixed farmland mosaics with large expanses of grassland or arable crops. In combination with loss of old pastures and the switch from spring-sown to autumn-sown cereals, the quantity and quality of existing breeding habitat for Lapwings has been drastically reduced (Galbraith 1988; Hudson *et al.* 1994). Similarly, for Lapwings breeding in upland areas, the preferred habitat is old grassland that is being lost through grassland improvement (Baines 1989). Peach *et al.* (1994) found that only eight out of 24 Lapwing populations for which productivity data were available produced sufficient offspring to balance winter mortality.

In Britain breeding Golden Plovers are restricted to upland area but even these areas have been subject to changes in land use (Boobyer 1992; Byrkedal & Thompson 1998). Prime Golden Plover nesting habitat has been destroyed due to conversion to agricultural land and forestry plantation. Furthermore, there has been a decrease in the area of old pasture adjacent to breeding habitat where off-duty birds often feed (Byrkedal & Thompson 1998). It is likely that such changes have caused localised population declines noted in Scotland (e.g. Hancock & Avery 1988; possibly Parr 1992). Crick (1992) analysed data from the 669 Golden Plover Nest Record Cards of the BTO's Nest Record Scheme. Nest failure rates remained constant on heather moorland and bog but increased significantly on grass moors in NW England and Wales. Crick attributed these increases to a recent rise in sheep stocking. NW England and Wales have seen amongst the largest increases in sheep stocking rates anywhere in Britain (Fuller 1996). Shrubb *et al.* (1997), however, thought that predation by crows was more likely. Crow numbers have increased in these areas though this could be an indirect effect of increased sheep stocking levels.

Thus agricultural intensification has caused a reduction in breeding productivity. Similar environmental changes could potentially depress over-winter survival and compound declines and localised extinctions caused during the breeding season.

Amongst possible deleterious changes affecting wintering plovers, the most important is probably the loss of old grasslands through conversion to arable land. Old grasslands have higher densities of lumbricid worms and adult coleoptera than new grasslands and arable farmland (Barnard & Thompson 1985). The area of rough grazing has been declining steeply since the early-1960s with the biggest losses in Wales and the south-west with smaller losses in northern England (Chamberlain & Fuller 1998). These areas are not particularly important for wintering plovers based on the *Winter Atlas* distribution (Lack 1986). Permanent grass (over five years old) has declined slowly since a peak in 1965 and temporary grass has tended to decrease also. Losses of permanent and temporary grassland have been most prevalent in a band running through north-eastern England to the Wash then through central England to the River Severn (Chamberlain & Fuller 1998). This area is particularly important for plovers wintering on farmland (Lack 1986). Smaller losses of grassland could still have a major effect in areas where grassland is already scarce. In East Anglia, for example, small amounts of grassland may be the only refuges for plovers through periods of severe weather - loss of even a small area of grassland could therefore have a marked effect on plover distribution.

Changes in grassland management have undoubtedly brought about changes that could affect wintering plovers. Changes include pasture improvement and changes in grazing regimes, all of which may reduce the carrying capacity of grass fields (i.e. fewer birds can be sustained per unit field area per unit time). Large areas of old pasture have been improved by drainage, fertiliser application and reseeding (Fuller & Lloyd 1981). Drainage and reseeding effectively reduce the age of the grassland by changing soil conditions, sward structure and sward composition with likely deleterious consequences for soil invertebrate populations. Application of nitrogen fertilisers to grasslands has almost certainly increased in line with increased application to tilled land (D.C. Chamberlain pers. comm.). Tucker (1992) highlighted the cessation of the use of manure and slurry and replacement by chemical fertilisers as a potentially important factor. Organic products introduce organic matter into the soil and benefit populations of soil invertebrates (e.g. earthworms; Edwards & Lofty 1977) on which plovers feed. However, slurry is extremely acidic and may actually kill earthworms (F. Mawby pers. comm.). Molluscicides and carbamate fungicides are used with increasing frequency on intensive farms and are toxic to these same invertebrates (Tucker 1992). Changes to livestock stocking densities have also occurred over the last 30 years. Since the mid-1970s the number of sheep in Britain has increased dramatically (Fuller 1996). This phenomenon has affected both upland and lowland areas and may have changed foraging conditions for plovers.

Loss, or degradation, of these habitats will mean that plover flocks may deplete the available food to such an extent that they cannot stay in one area all winter. Consequently plover flocks may be forced to shift to other areas of unexploited grassland (if any exist), or to other habitats (arable farmland or intertidal areas). These areas may not be

the richest feeding areas and will have a lower carrying capacity. Alternatively, flocks may be forced to break up and disperse through the wider countryside, existing in smaller groups. These changes may also mean that essential cold weather refuges may no longer exist (Parr 1992) and birds will increasingly be forced to undertake energetically costly cold weather movements that were previously unnecessary or infrequent.

Parallel changes have occurred in arable farm management. For example, organic fertilisers are now rarely spread on fields so there is little organic input for soil fauna. Cereal stubbles are usually ploughed very soon after harvest and fields are rarely left fallow so soil invertebrate populations do not have time to recover between periods of soil disturbance. Increased application of synthetic chemicals to arable farmland has decreased the populations of several invertebrate groups, either through the direct effect of toxicity, or through indirect effects such as the loss of food plants (Donald 1998). Simplified crop rotations may have reduced the diversity of crops present within a flock's range with the consequence that ideal feeding conditions (e.g. recently turned soil) come in a small number of seasonally restricted pulses rather than continuously through the winter. Some effects of farm intensification may have benefited plovers. Removal of hedgerows and amalgamation of small fields into larger fields may have provided the range of field sizes preferred by plovers but such benefits are likely to be small and no compensation for reductions in food supplies. Very little work has quantified how these changes in arable farm management have affected wintering plover populations.

Thus, the intensification of both grassland and arable management have caused loss of foraging habitat and a deterioration in the quality of the remaining habitat. Consequently there may have been a general reduction in the carrying capacity of lowland farmland habitats for wintering plovers over the last 30 years. It should be emphasised, however, that there is no evidence of a recent decline in Lapwing survival rates to support this (Peach *et al.* 1994; Catchpole *et al.* 1999) and there are no published statistics for Golden Plover survival rates.

## 5. FUTURE RESEARCH

A key part of any future research should be an attempt to quantify the size and distribution of the current winter populations of Golden Plovers and Lapwings and to determine whether any long-term trends are evident over and above short-term weather-induced fluctuations. Whilst comparison with previous survey results might be difficult or even impossible, the establishment of a base population estimate is the foundation for future monitoring. An extensive survey, carried out annually or periodically, and supplemented by WeBS could provide such a baseline. Ideally, surveys should be linked to similar work in the European winter ranges of the two species. There are two reasons for this. First, it will be difficult to produce a valid population estimate or trend statistic when the proportion of the flyway population wintering in Britain can vary from year to year. For example, cold continental weather in early winter can cause an influx, or cold British weather can cause an emigration. Second, should an increase or decrease in numbers be noted in Britain, co-ordinated counts would be especially valuable in determining whether the trend represents population change or a change in migration route and wintering range. Rapid changes in migration routes have been noted for a passerine, the Blackcap *Sylvia atricapilla* (Berthold *et al.* 1992), and might occur elsewhere with sufficient selection pressure.

Further research on the habitat preferences of wintering plovers is highly desirable. Preferences may differ regionally, possibly depending upon the local availability of different habitat/crop types. While grassland may be the preferred feeding habitat in the Midlands, areas of East Anglia have so little grassland that flocks there may specialise on arable crops instead. Some extremely large flocks, especially of Golden Plovers, utilise some of these eastern arable areas throughout the winter, weather permitting. There are interesting questions to be asked about how such numbers can persist in these extremely intensively managed agricultural landscapes. In areas where grass is not used exclusively there exists the potential for seasonal variation in preferences with habitat switching as the range of crops and habitats changes temporally. For example, in early autumn stubbles may dominate a flock's range but later they are replaced by plough then by the next year's crop. The importance of sugar beet to arable plovers has not been investigated but potentially it may provide large areas of suitable feeding habitat when harvested in midwinter. Habitat choice is also affected by the severity of winter weather. The buffering of microclimate by vegetation on some fields may cause short-term habitat switching to take advantage of small differences in prey availability. During cold weather birds form smaller flocks and spread over a larger number of fields, possibly using sub-optimal habitats. The singular effects of region, season, weather and other factors (such as lunar phase) on habitat choice are poorly understood. Moreover these factors may interact in as yet unknown and unpredicted ways.

The decades since the last extensive surveys (Fuller & Lloyd 1981; Lack 1986) have seen the loss of much old grassland habitat and the inception of agri-environment packages such as set-aside, environmentally sensitive areas (ESAs) and an increase in the number of organic farms. The habitats created under these schemes have the potential to substitute for habitat lost through grassland improvement and arable conversion. For example, farmers are required to cut all set-aside during late summer to a height of 10 cm or less. Such a policy could provide large quantities of suitable, short cropped, pasture-like land which could be used by early returning Lapwings (see Milsom *et al.* 1998 for an example of how mowing can attract waders). Whilst much research has focussed on the usage by

breeding birds of habitats provided by these schemes, little or none has taken place in winter. It is not known to what extent these habitats are utilised by wintering plover or what management regimes could make them more attractive. Similarly, current literature does not adequately cover the precise effects of grassland management regimes on plovers or the invertebrates on which they feed. Some studies have hinted at the importance of stocking densities, species of grazing animal and the addition of fertiliser and manure but none have given this issue a comprehensive coverage. The main reason is that little is known about the diet of plovers during winter. Barnard and Thompson (1985) base much of their modelling on the assumption that plovers feed predominantly on earthworms, though the generality of this statement is unknown. Indeed it is unlikely to be true of plovers feeding in arable farmland because earthworms occur at low densities in continually ploughed and cultivated fields (Edwards & Lofty 1977). Therefore future research should quantify the diet of both species, preferably at intervals throughout the winter and separately for flocks feeding in different habitats.

Intensive work at a small number of study sites, comprising pastoral, arable and mixed farm systems, could consider further the switch between different farm habitats by feeding flocks. It would be interesting to evaluate how significant for plovers is the lack of grassland refuges in the arable landscape during cold weather. Hence the effects of specialisation towards arable farming on one hand, or pastoralism on the other, could be assessed. As stated earlier, some birds remain in cold weather refuge areas and do not return north until the beginning of the breeding season. Future research could examine refuge sites to determine the basis for their selection and to examine the benefits of remaining in the refuge (which might be unfamiliar) relative to returning to the traditional wintering flock range.

6. EXISTING DATASETS

Several datasets exist that contain information that may be of use when designing and setting up surveys of Golden Plovers and Lapwings.

## 6.1 BTO Golden Plover Survey (1976/77 & 1977/78)

A full survey of Golden Plovers was conducted in the winters of 1976/77 and 1977/78. Synchronised counts were made during specified count periods (one in 1976/77 and three in 1977/78). Volunteers visited sites that were known to hold Golden Plovers (based on prior knowledge, regional bird reports and a pilot season). For full details see Fuller & Lloyd (1981). We have a record of the locations of all flock ranges counted for this survey (hardcopy). It may be worth resurveying areas that held plovers in the 1970s survey as a means of assessing changes in distribution and numbers. Care must be taken however to ensure that the birds have not merely moved slightly from their 1970s location giving the appearance of an 'extinct' flock range. A problem in interpreting the results of the 1970s surveys is that there is no measure of coverage, i.e. it is impossible to be sure exactly how many birds were present within a defined area. Fuller and Lloyd (1981) discuss this problem at some length and conclude that minimum numbers would have been recorded within many wintering areas.

## 6.2 BTO *Winter Atlas* Data

The *Winter Atlas* fieldwork was conducted in the winters of 1981/82, 1982/83 and 1983/84. Volunteers visited most 10 km squares in Britain and Ireland and recorded the number of Golden Plovers and Lapwings seen on each visit. Visits on which no individuals of one or both species were recorded are entered as zero counts. From this information it is possible to distinguish between areas where birds were truly absent rather than simply not visited by the fieldworker. The dataset consists of corrected counts of each species in each 10 km square on individual dates using the six-hour day correction (see Lack 1986). This data may be useful as a means of selecting grid squares or stratification for extensive surveys. The *Winter Atlas* maps also enable broad geographical patterns of abundance to be discerned.

## 6.3 ITE Environmental Datasets

Three computerised datasets from the Institute of Terrestrial Ecology (ITE) exist:

- The *ITE Land Cover Map of Great Britain* (Fuller & Parsell 1990) is a remotely-sensed dataset compiled in 1990 that gives the proportion of each 1 km square of the Ordnance Survey national grid covered by each of 25 'landcover' types. The dataset is currently being updated. Examples of landcover types include the area of sea, saltmarsh, urban areas, woodland. The *Land Cover Map* is useful for square selection procedures for extensive surveys and for subsequent distribution modelling.

- The *ITE Land Classification of Great Britain* (Bunce *et al.* 1996) is a categorisation of every 1 km square as one of 32 'land classes'. These land classes combine elements of landform and land use and can be combined into four ITE 'Landscape Types': Arable, Pastural, Marginal upland and Upland. The *Land Classification* is useful for square selection and modelling.
- The *ITE Land Characteristics Data Bank for Great Britain* (Ball *et al.* 1983) describes physical attributes of each 10 km square of the national grid. Attributes measured include altitude and aspect for example. The *Land Characteristics* are useful for square selection and modelling.

## 6.4 Flock Range Register

Since winter 1996 we have been compiling a list of sites that have held significant numbers of either, or both, Golden Plovers and Lapwings during the last decade. A request for information was put out to all BTO regional representatives and area/county bird recorders. Regional representatives and recorders were initially asked whether a threshold of 200 birds would serve to identify the main flocks in their region. This was an attempt to take account of regional variation in flock sizes and their reporting rates. In areas where Golden Plovers were common only large flocks tended to be reported. Elsewhere, where plovers were uncommon, even flocks numbering as few as 10 birds were reported. If the '>200' threshold was unsuitable, a new region threshold was agreed and all sites satisfying the criteria were included in the register. The register does not include sites currently counted by WeBS. The register lists approximately 1,100 sites but is currently (July 1998) incomplete and may ultimately attain a size of 1,500 sites. The register should act as a source of sites for site-based survey approaches.

## 6.5 BTO/JNCC Wintering Skylark Survey - Additional Species Data

The BTO/JNCC Wintering Skylark Survey involved volunteer coverage of up to *c* 1,500 1 km squares selected using a stratified random approach. In addition to counting Skylarks, volunteers were asked to note nine additional species and record how many of each were recorded in their square. Golden Plovers and Lapwings were two of these nine additional species. Consequently the survey has produced simple population size, density, distribution and habitat preference data for both species. There may be small biases involved because the squares were selected based on past wintering Skylark distribution but the distribution of plovers largely coincides (Lack 1986). The data were collected between November 1997 and February 1998 inclusive.

## 7. THE KEY AIMS OF AN EXTENSIVE SURVEY

To summarise from Section 5, there are four key questions that might be addressed by a survey:

What is the current British wintering population of Golden Plovers and Lapwings?
Are any long-term trends in population size evident?
What is the distribution of wintering plovers?
What are the habitat preferences of plovers in winter?

Information collected for these four aims can be analysed to investigate more detailed questions including the effects of region, season, weather, lunar phase and survey strata on population size, distribution, trends and habitat preferences. A perfect survey would provide data to answer all these questions while remaining enjoyable and satisfying for participating volunteers. From personal experience of extensive surveys, and of counting plovers generally, we identified several aspects of wintering plover ecology and behaviour that we thought might make designing an extensive survey difficult. For this reason we opted to undertake two winters of pilot work to evaluate survey methods and to get a feel for some of the problems of surveying wintering Golden Plovers and Lapwings. This work is described in the next Section.

8. WORK UNDERTAKEN TO DATE TO ASSESS SURVEY METHODS

Work on wintering plovers began in autumn 1996 with a request for information for the Flock Range Register. At the same time we identified a study area in south-east Norfolk where we might begin intensive work on a population of wintering plovers. Following on from these, and further thoughts on survey design, a small pilot survey of wintering Golden Plovers and Lapwings was set up to run in January 1997. Also, as a desk exercise, we calculated Golden Plover and Lapwing population estimates from additional species data collected as part of the Wintering Skylark Survey.

## 8.1 Intensive Work

An area of approximately 75 km² was identified to the north of Diss, Norfolk, where unknown numbers of both Golden Plovers and Lapwings had been present in previous winters. Initially three road transects were defined to be covered at weekly-fortnightly intervals. The aim was to map and count all flocks of plovers in fields visible from the road transects and to record cropping so that patterns of habitat association might be investigated. Simultaneously, we made frequent visits to surrounding farmland to keep track of plovers when they were not on the transect fields. The peak count for winter 1996/97 was approximately 4,000 Golden Plovers and 2,000 Lapwings. Mostly these birds were present within the initially defined study area but we had to extend the transects to include an adjacent disused airfield that was frequented by large plover flocks in mid winter.

The situation was somewhat different in winter 1997/98 with a peak population of *c* 8,000 Golden Plovers and *c* 4,000 Lapwings throughout November and December. The main difference was that flocks completely abandoned the transect areas in mid December. This did not coincide with any severe weather and it seemed highly unlikely that the birds had emigrated. After a search of seven 10 km squares, the birds were rediscovered in two new locations, each less than 5 km from the edge of the existing study area (Figure 8.1.1). Despite the relatively small movements involved it took some time to track the flocks down. We can be certain that the flocks consisted of the same individuals because the total number of birds was almost identical and because we had naturally marked individuals. Before the movement occurred, a Grey Plover *Pluvialis squatarola* was recorded with Golden Plovers on Transect 1. Grey Plovers are very scarce inland in Norfolk, and are usually only found at inland wetlands (Taylor *et al*. in press). This bird was subsequently recorded at both of the new flock centres. Also two Golden Plovers with distinctive aberrant plumage were recorded at both of the new flock centres, and back on the transects when flocks returned there in early 1998. Over two to three weeks, observations of these 'marked birds' confirmed that flocks, or at least some individual birds, were regularly making movements between sets of fields up to 10 km to 12 km apart. Smaller movements were suspected prior to the appearance of the marked birds. On 15 November 1997 approximately 2,000 Golden Plovers and 2,000 Lapwings were seen to depart from a large daytime roost on Transect 3 and fly directly to the airfield some 6 km away. Local movements appear to be common and flock composition in terms of individuals is probably highly variable with much interchange. It is not known to what extent these movements are typical of other farm systems, such as pastural or mixed systems.

While this work has shown that the same plovers use areas some distance apart and readily move, it also reveals that utilised fields tend to form several well separated clusters rather than being scattered uniformly across the flock's range. Consequently, the proportion of fields used is very small. To illustrate this point Figure 8.1.1 shows the distribution of fields used by Golden Plovers between October 1997 and March 1998. During this period only 40 of the 162 transect fields were used (25%). However, only 14 were used five or more times in the whole winter and these frequently used fields tended to be close together (Figure 8.1.2). These statistics ignore hundreds of fields that were never used in the immediate surroundings of the transect fields. This pattern of field use is, however, weather-dependent because in frosty conditions birds disperse over wide areas and occur at low density in a larger number of fields. Though the presence of birds is easier to confirm at such times, it is more difficult to be sure that all the birds have been counted.

Three conclusions can be drawn from the intensive work. First, flocks can be extremely mobile within winters. This was identified as a problem from the start but the frequency and scale of the movements was not anticipated. A typical pattern in many farmland areas seems to be that birds may use one or two particular areas of farmland for several weeks and then move to another area, which may be several km away. This is not obviously weather-dependent nor does it obviously relate to farming activities. Additionally, over a 10-year period in Buckinghamshire birds not only shifted locations within winters but also used different groups of fields in different winters (Fuller 1988). One cannot determine numbers simply by visiting fields where the species has been recorded in the past; indeed the whole notion of 'traditional sites' needs to be treated with extreme caution.

Second, on much farmland the birds are extremely localised. The birds are often concentrated into an extremely

small proportion of available farmland. Large areas of apparently suitable habitat are typically unused within any winter. This means that it is very difficult to identify a site containing suitable habitat. The main implication is that it is extremely easy to reach the conclusion that birds are not present within an area that may, in fact, support a large number of birds.

Third, surveys of randomly selected transects or gird squares will not produce meaningful population estimates due to the unpredictable movements and extreme patchiness. Selected sampling locations will simply miss the major concentrations of birds. We always anticipated that the clumped distributions would be the main problem in surveying these birds but it appears to be even more severe than expected.

Intensive work will continue to monitor how plovers use a range of feeding areas and how and why movements occur. With better understanding of these movements we should be better placed to design and interpret extensive surveys in the future. Furthermore, we will know whether, and how, to draw comparisons with earlier surveys.

## 8.2 Pilot Surveys

During January 1997 10 volunteers were asked to help survey Golden Plovers and Lapwings as part of a small scale pilot survey aimed at evaluating survey and recording methods. Experience from intensive work at the time suggested that one way to overcome some problems of plover aggregation was to use a larger grid square. Rather then using 1 km squares or tetrads, we opted for 5 km squares. The reasoning behind this was that a larger square was more likely to encounter a flock than a smaller square. Also, due to the greater detectability of plovers compared to smaller bird species, such as Skylarks *Alauda arvensis*, a large square would not take too long to survey, at least when the birds were highly clumped. Since the pilot was aimed primarily at assessing counting and recording methods, volunteers were permitted to select their own square based on known occupancy by plovers. Using a simple set of instructions and forms (Appendix I) the volunteers were asked to record the position and composition of all plover flocks encountered.

Four of the 10 volunteers completed and returned their pilot survey forms. The mean time taken for coverage of the 5 km was 3.6 hours (range three to six hours). The volunteers had no difficulty covering the square but since they were asked to select areas with plovers there were no disappointingly empty squares. This may have biased the results towards areas that were good for seeing plovers, i.e. flat open land with few hedges. Covering a 5 km square in rolling land with many hedges may be a far more tedious prospect, and potentially impossible in the time required. This was the general impression given by fieldworkers in Devon who responded to a request for comments. The conclusions of the pilot survey were that while a 5 km square may be coverable in some parts of Britain this is not true everywhere. So while larger squares are needed to increase the likelihood of recording target species, smaller squares are needed to make searching practical. Furthermore, the investment of time and effort required to cover a 5 km is acceptable to volunteers if they see target species but not if the square is unoccupied.

The only problems encountered with the fieldwork methods were crop identification and confusion when differentiating between loafing and roosting plovers.

## 8.3 Population Estimates Derived from the Wintering Skylark Survey

One possible method of surveying Golden Plovers and Lapwings might be to use randomly selected 1 km squares. We do not believe that random squares will be very successful in detecting birds that are present and a large proportion of squares are likely to yield no birds. Consequently population estimates will be both ambiguous and likely to have wide confidence limits. As an exercise to see what might be achievable with random 1 km squares, we analysed counts of plovers from Wintering Skylark Survey data.

At the time of writing the dataset contains counts from 304 1 km squares, of which 26 (8.6%) were occupied by Golden Plovers and 66 (21.7%) were occupied by Lapwings. When outstanding Wintering Skylark Survey forms have been received from volunteers it is likely that the dataset should contain counts from at least 700 1 km squares. Counts were made on three visits in each square and for this simple analysis the maximum count of each species in each square was selected. Originally the squares were selected by a stratified random approach that picked squares from within the winter range of Skylarks based on *Winter Atlas* data. This does not bias the distribution for the purposes of this desk study because the winter distributions of Golden Plovers, Lapwings and Skylarks coincide, being largely on lowland farmland and coasts. Using this data, the existing square stratification and the number of 1 km squares in Britain in each stratum, we calculated wintering Golden Plovers and Lapwings population estimates with bootstrapped confidence limits (Table 8.3.1). The population estimates are both approximately double those presented by Cayford and Waters (1996) and have very wide confidence limits corresponding to 55 to 72% of the

Golden Plover population estimate and 45 to 59% of the Lapwing population estimate.

It is clear that a survey employing randomly selected 1 km squares will not provide statistically acceptable population estimates. Furthermore, the estimates may be difficult or impossible to interpret given the problems identified in Section 8.1.

9. SURVEY METHODS

Based on the results of the literature review, results of pilot surveys and experiences from intensive work on wintering Golden Plovers and Lapwings we can make some suggestions regarding survey design.

## 9.1 Grid Squares or Survey Sites

Extensive surveys can be either square-based or site-based, or a combination of the two. Recent examples of square-based surveys include the Breeding Bird Survey[a] (Gregory *et al.* 1996) and the Farmland Bunting Survey[b] (Donald & Evans 1994). Site-based surveys include the survey of breeding waders of wet meadows[c] (Smith 1983), 1997 Woodlark Survey[d] (Wotton & Gillings submitted) and the ongoing Wetland Bird Survey[e] (Cranswick *et al.* 1997). A survey of lowland breeding waders in Scotland[f] used a combination approach (O'Brien 1996) (for affiliations of these surveys see footnote[1]). In all cases volunteers can undertake the fieldwork.

To reiterate from Section 8, intensive work, pilot work and data from the Wintering Skylark Survey have shown that grid squares are likely to be an ineffective means of surveying Golden Plovers and Lapwings in winter. One reason for this is that plovers are aggregated to the extent that very few randomly positioned grid squares will be occupied and population estimates derived from such samples will have wide confidence limits. Furthermore, we anticipate that large concentrations of plovers will be missed so population estimates may be difficult to interpret and possibly meaningless. Neither can squares be revisited for estimating trends in numbers because local movements may either bring birds into an empty square or move birds out of an occupied square, registering a false increase or decrease. This may not occur at random, being more likely in certain regions, under certain weather conditions or at certain times of the year.

Site-based surveys can either aim to cover all suitable sites, or to identify all suitable sites and survey a random selection. For species like Woodlark *Lullula arborea* that have narrow habitat requirements it is relatively straight forward to identify suitable sites (Wotton & Gillings submitted). For species like plovers we have insufficient understanding of habitat selection to derive a list of suitable sites based on habitat characters. Indeed on current knowledge, large numbers of apparently suitable 'sites' exist that are never occupied. We could define a list of suitable sites based on known occupancy but this method suffers from bias and may miss unknown concentrations of birds. Also, defining the boundary of a site is necessary because population estimate calculations require the area surveyed (or alternatively the number of 'sites' in Britain). This is an easy exercise for species like Woodlark because their preferred habitat (heathland and forestry plantations) occurs in discrete patches. Plovers prefer certain sets of fields within the farmland matrix and defining a boundary for an amorphous farmland site is virtually impossible. Furthermore, intensive work has highlighted that a fixed boundary is likely to be ineffective when keeping track of local plover movements. Therefore, it will be extremely difficult to survey a selection of sites (random or otherwise) and then extrapolate to a population estimate. One way to survey plovers to produce a valid population estimate may be to use a modified atlas approach whereby large areas are searched, preferably in a synchronised manner. This method would aim to survey all known sites and to locate and count birds in the wider countryside. A problem with this approach is that it would require a huge manpower effort.

A site-based survey may be useful for looking at detailed habitat preferences, local dynamics and long-term population trends. Such surveys may also be indispensable in obtaining more realistic population estimates if sufficient can be undertaken, and the data combined with extensive results from the *Winter Atlas* and the proposed BTO/JNCC surveys of wintering farmland birds planned for winters between 1999 and 2002. To be effective, volunteers would need to make regular visits to their site and ensure that they covered surrounding areas so that birds could be relocated if short-distance movements took birds out of the initially-defined study area. Care must be taken however so that the range of sites covered is not biased towards certain regions or habitats otherwise preferences and trends detected may also be biased. However, these sites do hold a major proportion of the British populations of Golden Plovers and Lapwings so the information collected, though non-random, may be doubly important. Also, there is scope for answering detailed questions about habitat preferences by surveying sites in arable, pastural and mixed farming areas (Figure 9.1.1), or sites with and without sugar beet (Figure 9.1.2), for example. This information would be extremely valuable in helping to understand recent and possible future impacts of agricultural change on

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[1] **These surveys were organised and supported by the following organisation: [a] BTO/RSPB/JNCC, [b] BTO/JNCC, [c] BTO/RSPB/Nature Conservancy Council, [d] BTO/RSPB/English Nature, [e] BTO/RSPB/WWT/JNCC, [f] RSPB.**

the birds.

## 9.2 Field Methods

Counts must be activity-specific so that crops and habitats used exclusively for feeding or roosting can be differentiated. The counting and recording methods must take account of the potential for movements within a site. It is quite likely that during the course of a visit small numbers of birds will move between flocks, and whole flocks will switch fields. It is essential that the range of fields and habitats used is measured but without giving a false impression of the total number of birds present due to double counting. A modification of notation used in territory mapping for differentiating between simultaneous registrations of different birds and separate registrations of the same bird might be useful. Individuals or flocks seen only in flight should be noted because they may constitute disturbed birds moving to more distant feeding or roosting areas. It may pay to follow such movements, or search in the direction they were heading, since this can help locate otherwise undetected areas where plovers may be found if the study area appears unoccupied.

Differences in detectability between habitats and between activities can be a problem. Plovers feeding on young cereal fields are very obvious compared to plovers roosting in cereal stubbles or plough. Approaching fields closer, or spending longer scanning can make inconspicuous birds more detectable in problem habitats. In this way variation in detectability is minimised because the extra proximity or time spent in open, easily viewed, habitats (e.g. young cereals) does not yield any further individuals.

### 9.3 Work in Winter 1998/99

We plan to collect more information on detailed usage of farmland, both through volunteers and by continuing our studies in south Norfolk. We propose that these volunteer based surveys of wintering Golden Plovers and Lapwings be integrated with the large scale surveys of wintering farmland birds to be conducted in the three winters 1999/2000, 2000/2001 and 2001/2002 for which planning and pilot work is proceeding this winter.

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We would like to thank all the volunteers who, over many years have spent countless, often cold hours, participating in the numerous surveys discussed here. We wish to thank the farmers and landowners that have allowed access to private farmland in our south Norfolk study site. Peter Lack gave advice on *Winter Atlas* data and Graham Austin, Andy Musgrove and Ray Waters gave advice on the Wetland Bird Survey. Comments from Juliet Vickery and Mark Rehfisch improved an earlier draft of this report. Thanks also to Nicola Read for formatting the report. This work, and the Wintering Skylark Survey, was funded by the Joint Nature Conservation Committee, on behalf of English Nature, Countryside Council for Wales, Scottish Natural Heritage and the Environment and Heritage Service in Northern Ireland.

## References


Baines, D. (1989) The effects of improvement of upland, marginal grasslands on the breeding success of lapwings *vanellus-vanellus* and other waders. *Ibis,* **131,** 497-506.

Ball, D.F., Radford, G.L., Williams, W.M. (1983) *A land characteristic data bank for Great Britain*. ITE, Bangor.

Barnard, C.J. & Thompson, D.B.A. (1985) *Gulls and plovers: the ecology and behaviour of mixed species feeding groups.* Croom Helm Ltd, London.

Begon, M., Mortimer, M. & Thompson, D.J. (1996) *Population ecology: a unified study of animals and plants*. Blackwell Sciences Ltd, Oxford.

Berthold, P., Helbig, A.J., Mohr, G. & Querner, U. (1992) Rapid microevolution of migratory behaviour in a wild bird species. *Nature*, **360,** 668-670.

Boobyer, G. (1992) *Population trends of the Golden Plover* Pluvialis apricaria *in Britain.* JNCC, Peterborough.

Browne, S. (1998) The 1998 and 1999 breeding Lapwing survey. *BTO News,* number **214**, pp 18.

Bunce, R.G.H., Barr, C.J., Clarke, R.T., Howard, D.C. & Lane, A.M.J. (1996) ITE Merlewood Land Classification of Great Britain. *International Journal of Biogeography*, **23**, 625-634.

Byrkjedal, I. & Thompson, D.B.A. (1998) *Tundra plovers: the Eurasian, Pacific and American Golden Plovers and Grey Plover*. T. & A.D. Poyser, London.

Catchpole, E.A., Morgan, B.J.T., Freeman, S.N. & Peach, W.J. (in press) Modelling the survival of British Lapwings *Vanellus vanellus* using ring-recovery data and weather covariates. *Bird Study*.

Cayford, J.T. & Waters, R.J. (1996) Population estimates for waders Charadrii wintering in Great Britain, 1987/88-1991/92. *Biological Conservation*,**77,** 7-17.

Chamberlain, D.E. & Fuller, R.J. (1998) *The effects of agricultural management on populations and distributions of farmland birds.* BTO Research Report 209**,** British Trust for Ornithology. Thetford.

Cranswick, P.A., Rehfisch, M.M., Pettifor, R., Stroud, D.A., Craddock, D., Waters, R.J. & Norris, K. *The Wetland Bird Survey (WeBS): forward strategy 1996-97 to 2000-01*. [Unpublished, 1998].

Cranswick, P.A., Waters, R.J., Musgrove, A.J. & Pollitt, M.S. (1997) *The Wetland Bird Survey 1996-96: wildfowl and wader counts.* BTO/WWT/RSPB/JNCC, Slimbridge.

Crick, H.Q.P. (1992) *Trends in the breeding performance of golden plover in Britain.* JNCC Report 23**,** JNCC, Peterborough.

Crooks, S.E. & Moxey, P.A. (1966) Study of a wintering lapwing population in North West Middlesex. *The London Bird Report (for 1965)* (ed. F.H. Jones).

DAFS (1988) *Agricultural and Horticultural Census 1st June 1988*. Department of Agriculture and Fisheries for Scotland, Edinburgh.

Delany, S. (1997) *I-WeBS Report 1995-96: Results of the second winter of the Irish Wetland Bird Survey,* **2,** BirdWatch Ireland.

Donald, P.F. (1998) Changes in the abundance of invertebrates and plants on British farmland. *British Wildlife*, **9**, 279-289.

Donald P.F. & Aebischer N.J., (eds) (1996) *The ecology and conservation of corn buntings* Miliaria calandra. JNCC, Peterborough.

**Donald, P.F. & Evans, A.D. (1994) Habitat selection by Corn Buntings *Miliaria calandra* in winter. *Bird Study*, 41, 199-210.**

**Edwards, C.A. & Lofty, J.R. (1977) *Biology of earthworms*. 2nd Chapman and Hall, London.**

**Elkins, N. (1983) *Weather and bird behaviour*. T. & A.D. Poyser, Calton.**

**Fuller, R.J. (1988) Wintering golden plovers in central Buckinghamshire: annual variation in numbers and distribution. *Buckinghamshire Bird Report 1988*, 4-8.**

**Fuller, R.J. (1996) *Relationships between grazing and birds with particular reference to sheep in the British uplands*. BTO Research Report 164. BTO, Thetford.**

**Fuller, R.J., Gregory, R.D., Gibbons, D.W., Marchant, J.H., Wilson, J.D., Baillie, S.R. & Carter, N. (1995) Population declines and range contractions among lowland farmland birds in Britain. *Conservation Biology*, 9, 1425-1441.**

**Fuller, R.J. & Lloyd, D. (1981) The distribution of wintering Golden Plovers in Britain, 1977-78. *Bird Study*, 28, 169-185.**

**Fuller, R.J. & Youngman, R.E. (1979) The utilisation of farmland by Golden Plovers wintering in southern England. *Bird Study*, 26, 37-46.**

**Fuller, R.M. & Parsell, R.J. (1990) Classification of TM imagery in the study of land use in lowland Britain, practical considerations for operational use. *International Journal of Remote Sensing*, 10, 1901-1919.**

**Galbraith, H. (1988) Effects of agriculture on the breeding ecology of Lapwings *Vanellus vanellus*. *Journal of Applied Ecology*, 25, 487-503.**

**Gregory, R.D. (1987) Comparative winter feeding ecology of Lapwings *Vanellus vanellus* and Golden Plovers *Pluvialis apricaria* on cereals and grassland in the Lower Derwent Valley. *Bird Study*, 34, 244-250.**

**Gregory, R.D., Bashford, R.I., Balmer, D.E., Marchant, J.H., Wilson, A.M. & Baillie, S.R. (1996) *The Breeding Bird Survey 1994-1995.* British Trust for Ornithology. Thetford.**

**Hancock, M. & Avery, M.I. (1998) Changes in breeding bird populations in peatlands and young forestry in north east Sutherland and Caithness between 1988 and 1995. *Scottish Birds*, 19, 195-205.**

**Heppleston, P.B. (1971) The feeding ecology of Oystercatchers (*Haematopus ostralegus* L.) in winter in Northern Scotland. *Journal of Animal Ecology*, 40, 651-669.**

**Hodge, T. (1996) K.O.S. Golden Plover Survey, January 1996. *Kent Ornithological Society Newsletter.***

**Hudson, R., Tucker, G.M. & Fuller, R.J. (1994) Lapwing *Vanellus vanellus* populations in relation to agricultural changes: a review. In: *The ecology and conservation of lapwings***

**Vanellus vanellus (eds. G.M. Tucker, S.M. Davies & R.J. Fuller) pp. 1-26. JNCC, Peterborough.**

**Imboden, C. (1974) Zug, Fremdansieldlung und Brutperiode des Kiebitz *Vanellus vanellus* in Europa. *Ornithologische Beobachter*, 71, 5-134.**

**Keiller, S.W., Buse, A. & Cherrett, J.M. (1995) *Effects of sheep grazing on upland arthropods in Snowdonia and mid-Wales*, 6, ITE, Bangor.**

**Kirby, J. (1995) *Distribution and dynamics of wintering waders in Britain with particular reference to weather*. Unpublished PhD Thesis.**

**Kirby, J.S. & Lack, P.C. (1993) Spatial dynamics of wintering Lapwings and Golden Plovers in Britain and Ireland, 1981/82 to 1983/84. *Bird Study*, 40, 38-50.**

**Lack, P.C. (1986) *The atlas of wintering birds in Britain and Ireland.* T. &. A.D. Poyser, Calton.**

**Lister, M.D. (1964) The Lapwing habitat enquiry, 1960-61. *Bird Study*, 11, 128-147.**

**MAFF (1988) *Agricultural and Horticultural Census 1st June, 1988.* Ministry of Agriculture, Fisheries and Food, Guildford.**

**Milsom, T.P., Ennis, D.C., Haskell, D.J., Langton, S.D. & McKay, H.V. (1998) Design of grassland feeding areas for waders during winter: the relative importance of sward, landscape factors and human disturbance. *Biological Conservation*, 84, 119-129.**

**Milsom, T.P., Holditch, R.S. & Rochard, J.B.A. (1985) Diurnal use of an airfield and adjacent agricultural habitats by Lapwings *Vanellus vanellus. Journal of Applied Ecology*, 22, 313-326.**

**Milsom, T.P., Rochard, J.B.A. & Poole, S.J. (1990) Activity patterns of Lapwings *Vanellus vanellus* in relation to the lunar cycle. *Ornis Scandinavica*, 21, 147-156.**

**Nicholson, E.M. (1938) Report on the Lapwing Habitat Enquiry, 1937. *British Birds*, 32, 170-191.**

**O'Brien, M. (1996) The numbers of breeding waders in lowland Scotland. *Scottish Birds*, 18, 231-241.**

**Parr, R. (1992) The decline to extinction of a population of Golden Plover in north-east Scotland. *Ornis Scandinavica*, 23, 152-158.**

**Peach, W.J., Thompson, P.S. & Coulson, J.C. (1994) Annual and long-term variations in the survival rates of British Lapwings *Vanellus vanellus. Journal of Animal Ecology*, 63, 60-70.**

**Potts, G.R. (1986) *The partridge: pesticides, predation and conservation.* Collins, London.**

**Prys-Jones, R.P., Underhill, L.G. & Waters, R.J. (1994) Index numbers for waterbird populations II. Coastal wintering waders in the United Kingdom, 1970/71-1990/91. *Journal***

*of Applied Ecology*, 31, 481-492.

**Shrubb, M. (1988) The influence of crop rotations and field size on a wintering Lapwing *Vanellus vanellus* in a mixed farmland in West Sussex. *Bird Study*, 35, 123-131.**

**Shrubb, M., Williams, I.T. & Lovegrove, R.R. (1997) The impact of changes in farming and other land uses on bird populations in Wales. *Welsh Birds*, 5, 4-26.**

**Smith, K.W. (1983) The status and distribution of waders breeding on wet lowland grasslands in England and Wales. *Bird Study*, 30, 177-192.**

**Spencer, K.G. (1953) *The lapwing in Britain.* Brown, Hull.**

**Stone, B.H., Sears, J., Cranswick, P.A., Gregory, R.D., Gibbons, D.W., Rehfisch, M.M., Aebischer, N.J. & Reid, J.B. (1997) Population estimates of birds in Britain and in the United Kingdom. *British Birds*, 90, 1-22.**

**Taylor, M., Seago, M., Allard, P. & Dorling, D. (in press) *The Birds of Norfolk*. Pica Press, Robertsbridge.**

**Tucker, G.M. (1992) Effects of agricultural practices on field use by invertebrate-feeding birds in winter. *Journal of Applied Ecology*, 29, 779-790.**

**Way, L.S., Grice, P., Mackay, A., Galbraith, C.A., Stroud, D.A. & Pienkowski, M.W. (1993) Ireland's internationally important bird sites: a review of sites for the EC Special Protection Area network. JNCC, Peterborough.**

**Wotton, S. & Gillings, S. (1998) Numbers and distribution of Woodlarks *Lullula arborea* in Britain in 1997. *Bird Study*, submitted.**

**Yalden, D.W. & Pearce-Higgins, J.W. (1997) Density-dependence and winter weather as factors affecting the size of a population of Golden Plovers *Pluvialis apricaria*. *Bird Study*, 44, 227-234.**

| Region/habitat | Golden Plover Count | Golden Plover Month | Lapwing Count | Lapwing Month |
|---|---|---|---|---|
| Great Britain estuarine/coastal peak | 104,421 | Nov | 249,804 | Nov |
| Great Britain inland wetland peak | 43,487 | Nov | 156,734 | Nov |
| N. Ireland estuarine/coastal peak | 12,730 [11,414 | Dec Nov][a] | 24,944 | Nov |
| N. Ireland inland wetland peak | 5,615 [4,945 | Dec Nov][a] | 9,522 [8,088 | Dec Nov][a] |
| Republic of Ireland estuarine/coastal/inland wetland peak | 83,994 [52,800 | Jan Nov][a] | 121,813 [56,726 | Jan Nov][a] |
| Britain and Ireland estuarine/coastal/inland wetland total[b] | 217,067 | Nov | 496,296 | Nov |

[a] November counts are given where the peak count did not occur in November. These counts are totalled to give the Britain and Ireland total.

[b] The Britain and Ireland total does not include any terrestrial Golden Plovers or Lapwings.

**Table 3.2.1** Winter populations of Golden Plovers and Lapwings as determined by WeBS and I-WeBS surveys in winter 1995/96. For each country or region the peak count (and the month recorded) is given for estuarine/coastal and inland WeBS and I-WeBS sites. Counts were extracted from Cranswick *et al.* (1997).

**(a)**

| Region | Type | October | November | December | January | February | March |
|---|---|---|---|---|---|---|---|
| Great Britain | Estuarine/Coastal | 71,491 | 104,421 | 77,918 | 71,799 | 28,210 | 34,907 |
| | Inland wetland | 10,354 | 43,487 | 18,327 | 20,021 | 10,511 | 12,133 |
| Northern Ireland | Estuarine/Coastal | 13,920 | 11,414 | 12,730 | 9,572 | 6,506 | 8,542 |
| | Inland wetland | 1,187 | 4,945 | 5,615 | 3,538 | 3,325 | 2,720 |
| Republic of Ireland | Estuarine/Coastal/ Inland wetland | 33,143 | 52,800 | 66,337 | 83,994 | 48,617 | 44,061 |
| Britain & Ireland | Estuarine/Coastal/ Inland wetland | 130,095 | 217,067 | 180,927 | 188,924 | 97,169 | 102,363 |

**(b)**

| Region | Type | October | November | December | January | February | March |
|---|---|---|---|---|---|---|---|
| Great Britain | Estuarine/Coastal | 110,035 | 249,804 | 197,504 | 161,392 | 39,400 | 63,674 |
| | Inland wetland | 61,796 | 156,734 | 83,722 | 100,359 | 69,708 | 70,750 |
| Northern Ireland | Estuarine/Coastal | 3,348 | 24,944 | 24,254 | 13,679 | 9,157 | 1,655 |
| | Inland wetland | 1,533 | 8,088 | 9,522 | 5,354 | 4,702 | 849 |
| Republic of Ireland | Estuarine/Coastal/ Inland wetland | 7,363 | 56,726 | 79,730 | 121,813 | 81,740 | 11,713 |
| Britain & Ireland | Estuarine/Coastal/ Inland wetland | 184,075 | 496,296 | 394,732 | 402,597 | 204,707 | 148,641 |

**Table 3.2.2 Monthly totals from WeBS sites in Great Britain, Northern Ireland and I-WeBS sites in the Republic of Ireland in winter 1995/96. (a) Golden Plovers; (b) Lapwings. Type is the type of WeBS/I-WeBS site to which the count refers. Counts were extracted from Cranswick *et al*. 1997.**

| Threshold | Golden Plover | Lapwing |
|---|---|---|
| International importance | 18,000 | 20,000[a] |
| GB national importance | 2,500 | 20,000[a] |
| All-Ireland importance (for Northern Ireland)[b] | 2,000 | 2,500 |
| All-Ireland importance (for Republic of Ireland)[c] | 1,500 | 2,000 |

[a] The 1% threshold is set at a conservative level of 20,000 because of the uncertainty about the size of the wintering population (Cayford & Waters 1996). A threshold of 5,000 Lapwings is used to list important sites by Cranswick *et al.* (1997).

[b] Produced by Way *et al*. 1993 for Northern Ireland

[c] Interim thresholds set for scientific reporting by agreement between I-WeBS and the WeBS partners. Previously set thresholds for Northern Ireland will remain in use for statutory designation of sites (Delany 1997).

**Table 3.2.3 Thresholds for designation of sites of international and national importance for Golden Plovers and Lapwings (Cranswick *et al.* 1997).**

| Species | Median | 95% Confidence Limits | |
|---|---|---|---|
| | | Lower | Upper |
| Lapwing[b] | 2,939,303 | 1,602,240 | 4,667,663 |
| Golden Plover[c] | 434,936 | 194,240 | 747,527 |

[a] These figures are provisional, being based on counts from only 304 1 km squares. We expect to be able to produce estimates using data from over 700 squares when outstanding forms have been returned by volunteers.

[b] For comparison, Lapwing population estimate from Cayford & Waters (1996) = 1,500,000

[c] For comparison, Golden Plover population estimate from Cayford & Waters (1996) = 250,000

**Table 8.3.1** Population estimates[a] for wintering Golden Plovers and Lapwings calculated by resampling from the Wintering Skylark Survey's additional species data. For methods see Section 8.3.

**Figure 3.2.1 Distribution of WeBS and I-WeBS sites of national and international importance of Golden Plovers, based on Cranswick *et al.* (1997) and Delany (1997). Note that no inland terrestrial sites are included - only coastal and inland wetlands.**

**Figure 3.2.2 Distribution of WeBS and I-WeBS sites of national and international importance of Lapwing, based on Cranswick *et al.* (1997) and Delany (1997). Note that no inland terrestrial sites are included - only coastal and inland wetlands. Note also that we have followed Cranswick *et al.* (1997) in listing sites with more than 5,000 birds for national importance though 20,000 is the true threshold based on 1% criteria.**

**Figure 8.1.1 The distribution of fields used by Golden Plovers in winter 1997/98 in our study site in south Norfolk. Dots represent increasing frequency of usage defined as the number of survey visits on which birds were recorded in a field (small to large, increasing use). Irregular black areas are villages, lines are selected roads. Movements of marked bird were noted between all the main centres of distribution (see Section 8.1).**

**Figure 8.1.2 Bar chart showing the frequency with which fields were used at varying intensity, using the same usage categories as in Figure 8.1.1. Note that this figure shows only the usage of the fields immediately surrounding the transects. Surrounding fields that were surveyed less regularly, but that never held birds, are not included in the 'Never' bar of the chart.**

**Figure 9.1.1 A classification of all 10 km squares of the British national grid by farming type. Predominantly arable (solid symbol), pastoral (open symbol), or mixed farm systems (split symbol) have been defined using the area of arable and pastoral land (data for England and Wales from MAFF 1988; data for Scotland from DAFS 1988).**

**Figure 9.1.2 Area of Sugar Beet grown in England and Wales (Data for England and Wales from MAFF 1988). Dots indicate increasing acreage of Sugar Beet per 10 km square (small dots to large dots).**

# APPENDIX I

**Appendix 1 Instructions and supporting material provided to volunteers for a pilot survey of wintering Golden Plovers and Lapwings (see Section 8.2).**