An assessment of the value of a newly created lowland wet grassland on ex-agricultural land for bird populations:

a comparison with surrounding habitat and of restoration techniques.

by

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Abstract

Drainage for arable production and continued agricultural intensification throughout the 20th century has lead to a dramatic reduction in the lowland wet grassland resource in the UK, an important habitat for various species of wintering birds. The residual habitat can be increased in extent, by creation and restoration programmes utilising ex-agricultural land. Little is known about the related benefits to bird populations. An observational study of wintering birds (Nov 2007 – Feb 2008) was conducted at Tubney Fen, in Cambridgeshire, previously a turf farm but converted to wet grassland in 2007. The habitat was assessed relative to the surrounding arable land and comparisons between conversion techniques were made. Both general bird populations and individual species preferences were evaluated. The grassland supported significantly higher bird densities and diversity than the adjacent arable land. The majority of species also demonstrated strong or exclusive preferences for the wet grassland, including several species of conservation concern such as the hen harrier, reed bunting and skylark. Woodpigeon, carrion crow and red-legged partridge were the only species primarily associated with the arable control area. There were no statistically significant variances in bird density between the conversion methods. The areas left as turf, did however, support proportionately the highest bird densities and diversity, followed by the naturally regenerated and seeded compartments. Both meadow pipit and skylark demonstrated strong preferences for the areas left as turf and hen harrier exclusively used the seeded grassland. Kestrel utilised each conversion type at approximately equivalent levels. Possible reasons for the findings are discussed and recommendations made for future areas of research and habitat management at the site.

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1.0 Introduction

1.1 Ecological features of wet grassland

Characterised by an abundance of lower growing grasses, sedges and rushes in addition to controlled periodic winter flooding, lowland wet grassland is a semi-natural habitat and a product of traditional pastoral management (Brown & Grice, 1993, Benstead *et al.,* 1997, Benstead *et al.*, 1999, Vickery *et al.*, 2001). It has a significant ecological value, supporting high levels of botanical, invertebrate and avian diversity, including several rare and declining species (Jefferson & Grice, 1998).

Around 500 species of vascular plants are associated with lowland wet grassland, divided into 18 communities within the National Vegetation Classification system (Rodwell, 1991, 1992, 1995). Although few red data book species are specifically restricted to the habitat, many species are present in large numbers, it therefore makes a notable contribution to botanical conservation in the UK (Benstead *et al.,* 1997). Several nationally & globally rare vascular plant species also occur, such as *Carex vulpina & Cyperus fuscus* (Jefferson & Grice, 1998). The botanical composition also allows it to support a wide range of invertebrates, including 1000 notable species, 25% of which are in the red data book. As with plants, the majority of species are not exclusive, but it provides a suitable stronghold for many, such as the Hairy Dragonfly (*Brachytron pratense*) (Benstead *et al.,* 1997).

Appropriate management, based on a traditional pastoral farming system is crucial to the preservation of wet grassland. Low input of fertilisers, control over the water table and managed grazing/cutting for hay, maintain the botanical composition and structure (Critchley *et al.*, 2004). Most importantly, accurate control over the water table is necessary to facilitate contained periodic flooding (Brown & Grice, 1993, Joyce and Wade, 1998, Vickery *et al.*, 2001).

Wet grasslands can also provide additional wider benefits that may have positive economic and/or social functions. For example, water quality improvement via natural purification process, containment of floodwaters and improved aquifer recharge (Benstead, *et al.,* 1997). It's presence in a largely agricultural landscape, may also improve the aesthetic value and provide enhanced recreational opportunities where appropriate.

1.2 Loss of Lowland Wet Grassland & Current Status

Wet grasslands in Europe have seen much loss and ecological degradation in the last 50 years. The RSPB (1994) estimate a total loss of 40% in the UK since 1930. The majority of the decline is due to the increase in land area that was drained and turned over to agricultural production since World War Two (RSPB, 1994). More recently, intensification of agricultural management practices under European Union Common Agricultural Policy (CAP), has led to a reduction in the ecological value of the remaining habitat (RSPB,1994, Joyce & Wade, 1998, Benstead *et al.*, 1999, Krebs *et al.,* 1999).

The requirement to raise productivity levels directly augmented conversion to arable cultivation rates, but also led to increased use of fertilisers and herbicides, more silage production and the re-seeding of established grasslands (Benstead *et al.,*1997). The altered management practices potentially result in a reduction in overall habitat heterogeneity both in terms of plant composition and sward structure. A corresponding increase in the likelihood of eutrophication through agricultural practice, is a further threat to the vegetation composition, as is the fragmentation of the remaining habitat (Benstead, *et al.,* 1997).

Wet grassland is now mainly concentrated on the lowland floodplains of England & Wales and to a lesser extent Scotland and Northern Ireland. It is estimated that 220,000ha remain from a historical resource of 1.2m ha (Benstead, *et al.,* 1997). Much of this residual habitat is agriculturally improved and of limited conservation value, leaving around 20,000ha of unimproved land of high ecological importance (Thomas *et al.,* 1995)

1.3 Wet grassland creation & restoration

1.3.1 Opportunities

In order to effectively conserve and enhance wet grassland in the UK, the restoration and creation of new areas of habitat is required, as well as the maintenance of existing communities. This procedure can present many challenges. None the less, the reduced pressure from the European Union for agricultural intensification has lead to increased opportunities to reinstate some of the lost habitat (Manchester *et al*., 1998). It is estimated that 1.5m ha of land in the UK has the potential to become or be restored to wet grassland (Newson, 1991). Agri-Environmental grant schemes provide payments to farmers for the conservation of existing wet grassland and creation of new habitat areas where viable. These include the Environmentally Sensitive Area and Higher Level Stewardship schemes (Benstead, *et al.,*1997, Defra, 2006). Nature reserves, run by conservation organisations such as the RSPB and Wildlife Trusts, also provide scope for wet grassland creation and restoration. Overall it is hoped that by aiming to increase the habitat area via successful reversion projects, the associated species will benefit by making their populations more sustainable

1.3.2 Targeting and site selection

Targeting areas for restoration involves evaluation of past and present habitat distribution and natural occurrence at the potential site (Mountford *et al.*, 2006). The best target areas are those which have previously supported wet grassland communities in their recent past (Joyce & Wade 1998). Ex-arable land can pose complications due to high nutrient status and impoverished seed banks (Schrautzer *et al*., 1996, Joyce & Wade 1998). Agricultural practices can also alter the physical characteristics of potential sites, for example, influences of previous fertiliser usage and cropping regimes (Manchester *et al.*, 1999). On a larger scale, the evaluation of potential success is likely to involve spatial targeting decisions, relating to the likelihood of accomplishment versus area appropriateness, i.e. has it previously suffered a pronounced loss of Wet Grassland (Mountford *et al.*, 2006).

1.3.3 Technique

The appropriate technique used for a restoration attempt is dependent on a number of physical, biological and economic factors. The degree of site isolation or distance from a potential colonisation source, time span for conversion and seed bank quality, can all effect the viability of a restoration attempt (Manchester *et al.*, 1999). The cost, reliability and technical feasibility can be restrictive, particularly for a system that must also maintain economic productivity as well as ecological benefit (Manchester *et al*., 1999). Also, the target priority in terms of botanical outcome must be designated. A restoration may be directed at single species, species groups or whole communities/habitats (Mountford *et al.,* 2006).

A number of conversion methods are available including, natural regeneration, deliberate propagule introduction using hay, sowing seed mixtures and turf transplantation. The natural colonisation of an ex-arable conversion site can be a lengthy process. It is largely dependent on seed bank quality, likely to be degraded on arable land (Manchester *et al.*, 1998). However sites which are close to existing suitable habitat to act as a source of seed and have a clean water supply (less chance of eutrophication), have the best chance of using a natural re-colonisation method (Benstead, *et al.,* 1997, Joyce & Wade, 1998, Manchester *et al.*, 1998, Mountford et al., 2006). It is not considered ideal for short term conversion.

Better results have been produced from sowing seed mixtures, which produced a more diverse sward (Manchester *et al*., 1998). This technique is commonly employed on degraded land and can be carried out using standard agricultural techniques. However the local provenance of the seed mixture must be as close to the appropriate ecotype as possible, which can be a limiting factor if native or locally sourced seed is unavailable or expensive (Manchester *et al.*, 1999).

There are also other physical and biological factors that can influence the success of restoration attempts. Soil fertility levels are directly related to the efficacy of grassland recreation. For example, ex-arable sites often have a high nutrient status that can encourage competitive arable plants to germinate and outcompete the slower growing grasses (Manchester *et al.*, 1999). However, reduction of soil nutrient status can be achieved by topsoil removal or repeated cropping. Hydrological regime must also be directed towards the specified target community, requiring good control and manipulation ability over the water levels (Manchester *et al.*, 1999). Cost can therefore be restrictive, particularly from an agronomic perspective, relating to systems that must remain agriculturally productive.

Although sward structure as a parameter and its influence on bird population dynamics are extensively researched (see, section 1.5.4), little is known about the direct effects of grassland conversion technique for ornithological value.

1.3.4 Initial subsequent management

The instatement of traditional management, such as low density grazing and good water table control, has been shown to be key to the success of a creation attempt and the maintenance of ecological diversity within the habitat (Joyce & Wade, 1998, Vickery *et al.*, 2001). Depending on the application method and the species used for a restoration, competitive ability and germination and flowering times must all be taken into account when considering subsequent management. For example, the avoidance of cutting during flowering and seeding periods for certain annual species, to ensure successful plant reproduction (Benstead, *et al.,* 1997). A cutting regime should also ensure that competitive weeds are not too persistent in the sward and that cuttings are removed from the site in order to maintain the nutrient levels (Benstead, *et al.,* 1997). The prevailing hydrological management should also be based on detailed botanical assessment (Critchley *et al.*, 2004). Ensuring species requirements are met should aid the maintenance of the vegetation composition of a site. Importantly, long term management methods can have a strong influence on avian abundance and diversity. Key considerations include fertiliser input, grazing and/or cutting regime and water table levels (Ausden and

Treweek, 1995, Benstead *et al.,* 1997, Perkins *et al.,* 2000, Ausden *et al.,* 2001, Vickery *et al.,* 2001, Ausden and Hirons, 2002)

1.4 Habitat value for bird populations

1.4.1 Breeding birds

Over 40 bird species of conservation concern are associated with lowland wet grassland in the UK (Table.1) (Benstead *et al.*, 1999). It has a high ornithological value throughout the year. As well as supporting large bird numbers during the winter, it provides breeding grounds for several declining wader species such as redshank (*Tringa totantus*), snipe (*Gallinago gallinago*) and black-tailed-godwit (*Limosa limosa*) (RSPB, 1994, Jefferson & Grice, 1998, Ausden *et al.,* 2001). Several declining passerines also breed, such as the yellow wagtail (*Motacilla flava*) and skylark (*Alauda arvensis*) (Vickery *et al.*, 2001, Bradbury and Bradter, 2004). In addition, it is also an important breeding habitat for the corncrake, a species which has recently suffered a drastic decline in the UK, and is largely restricted to grassland (Benstead *et al.,* 1997)

1.4.2 Wintering birds

Table.1 Key bird species of conservation concern associated with wet grassland, * denotes birds that breed in the habitat (adapted from: Brown & Grice, 1993; BTO, 2006)

Species	Population Status	Conservation Status
Garganey (*Anas querquedula*) *	Declining	Amber
Spotted Crake (*Porzana porzana*) *	Fluctuating	Amber
Corncrake (*Crex crex*) *	Declining	Red
Golden Plover (*Pluvialis apricaria*)	Possible Decline	Green
Lapwing (*Vanellus vanellus*) *	Declining	Amber
Ruff (*Philomachus pugnax*) *	Fluctuating	Amber
Snipe (*Gallinago gallinago*) *	Probable Decline	Amber
Black Tailed-Godwit (*Limosa limosa*) *	Declining	Red
Redshank (*Tringa totantus*) *	Moderate Decline	Amber
Barn Owl (*Tyto alba*) *	Declining	Amber
Yellow Wagtail (*Motacilla flava*) *	Rapid Decline	Amber
Whinchat (*Saxicola rubetra*) *	Declining	Green

Wet grassland is a valuable winter habitat for a range of bird species of differing feeding preferences. Insectivorous, granivorous and herbivorous species all utilise it for foraging (Wilson *et al.*, 1996, McCracken and Tallowin, 2004, Perkins *et al.*, 2000). Large numbers of waders feed and roost within wet grassland, such as lapwing (*Vanellus vanellus*) and golden plover (*Pluvialis apricaria*). Overwintering wildfowl are present during the periodic winter floods (Figure.1), many species migrating to the UK from Northern and Eastern Europe (RSPB, 1994; Benstead *et al.*, 1999). Notable species include bewick's swan (*Cygnus bewickii*), wigeon (*Anas Penelope*) and teal (*Anas crecca*) (Brown & Grice, 1993, RSPB,1994, Jefferson & Grice 1998). Some sites are nationally important due to high numbers of wildfowl they support, such as the Ouse Washes in Cambridgeshire (Benstead, *et al.,* 1997). Smaller passerines are also present on wet grassland during the winter such as starling (*Sturnus vulgaris*), skylark (*Alauda arvensis*) and linnet (*Carduelis cannabina*) (McCracken and Tallowin, 2004).

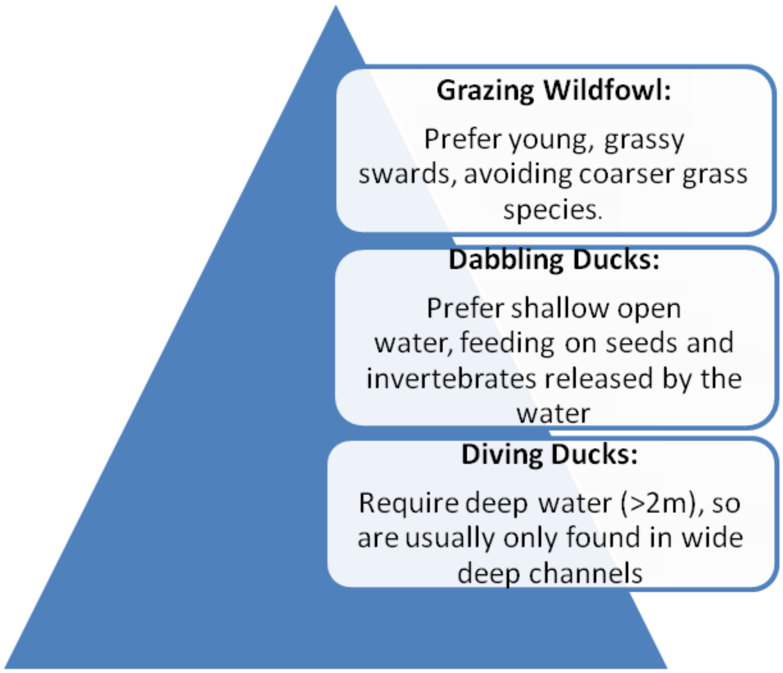

Figure.1 General feeding preferences of wintering wildfowl (adapted from Benstead *et al.* 1999)

For a site to be of good value for bird populations, certain requirements must be at least partially met. For example, appropriate feeding conditions, lack of significant disturbance and/or suitable roost sites (Benstead, *et al.,* 1997). Large areas of shallow flooding can facilitate the release of seeds and invertebrates trapped in the vegetation, providing a feeding habitat. Overwintering waders require the presence of soil dwelling invertebrates such as earthworms and cranefly larvae as a food source (Benstead, *et al.,* 1997). Avian predators also use the grassland when the prey availability is sufficient. Kestrel (*Falco tinnunculus*), barn owl (*Tyto alba*), short-eared owl (*Asio flammeus*), hen harrier (*Circus cyaneus*), merlin (*Falco columbarius*) and peregrine falcon (*Falco peregrinus*) all potentially use Wet Grassland at various times of year (Benstead *et al.,*1997). Their presence generally indicates a healthy prey population of either small birds or, in the case of the kestrel and owl species, small mammals. Some of these species, notably the hen harrier and merlin, are migratory within the UK and are persecuted in their breeding habitat, giving their conservation added importance (RSPB, 2006, RSPB, 2007b, Sim *et al.*, 2007)

1.5 Bird populations and wet grasslands: previous research

1.5.1 Population decline in farmland birds

Around 50% of land area in Europe is utilised for food production (Donald *et al.*, 2002) and a potentially high proportion of European biodiversity survives on agricultural land (Krebs *et al.*, 1999). This highlights the prevalence of a potentially valuable wildlife resource, a secondary benefit to its major purpose. However, it is the management employed on the available habitat that dictates its ecological significance. Relatively recent E.U. Common Agricultural Policy (CAP) lead to increased intensification within agriculture to raise productivity levels. Strong links between levels of intensification and farmland bird population decline have been established (Donald *et al.*, 2002). The resultant general agricultural practices, such as increases in pesticide use, removal of hedgerows and reduction in winter stubbles are all contributory factors (Donald *et al*., 2002). Specifically for wet grassland, a shift towards silage production, increased stocking levels and also fertiliser usage (Benstead, *et al.,* 1997, Donald *et al.*, 2001). On a worldwide scale potential declines may be considerable. Teyssèdre & Couvet, (2007) estimate a loss of 8 - 26% in global avifauna between 1990 and 2050 as a result of agricultural expansion.

Birds are considered a good indicator of overall farmland biodiversity, due to their prominent position in the food chain, tendency to occupy a range of habitats and the extensive population data available for analysis (Defra, 2007). The UK government use a farmland bird indicator to monitor progress towards its target to reverse the population decline in farmland birds by 2020 (figure.2). It is derived from population trend analysis of 19 key species, using data from the British Trust for Ornithology's (BTO) common bird census (CBC) and breeding bird surveys (BBS) (Defra, 2007). Farmland birds in the UK, declined by over half between the mid 1970's to the mid 1990's; (table.2 & figure.2) (Siriwardena *et al.*, 1998, Defra, 2007). The general decline has stabilised, whilst individual species trends vary. Farmland specialists have been most affected by long term decline. For example, starling numbers have continued to decrease, whilst generalist species such the kestrel have seen recent population increases (Siriwardena *et al.*, 1998, Donald *et al.*, 2002, Defra, 2007). The relative stabilization of farmland bird populations may be due to improvements made to the Agri-Environment schemes available in Europe, including the provision of options for the maintenance and creation of grassland resources (Defra, 2006).

Table.2 Population trends of farmland bird species in the UK: Changes in farmland population, 1968–1995 (%). Adapted from: (Siriwardena et al., 1998, Donald et al., 2002)

Species	Change in population (%)
Tree sparrow *Passer montanus*	−83
Grey partridge *Perdix perdix*	−74
Turtle dove *Streptopelia turtur*	−65
Corn bunting *Miliaria calandra*	−61
Skylark *Alauda arvensis*	−60
Linnet *Carduelis cannabina*	−41
Starling *Sternus vulgaris*	−40
Whitethroat *Sylvia communis*	−38
Lapwing *Vanellus vanellus*	−38
Yellowhammer *Emberiza citrinella*	−26
Goldfinch *Carduelis carduelis*	+59
Stock dove *Columba oenas*	+162

Wet grassland is a valuable habitat for bird populations within agricultural landscapes, as both a productive pastoral system or as part of a specific ecological reserve (Tucker, 1992, Wilson *et al.*, 1996, Barnett *et al.*, 2004). It is therefore of a significant conservation value, particularly when recent farmland bird population trends are considered (figure.2). Grassland loss and degradation is likely to have been a significant causal factor in these declines. Appropriate targeted management for avifauna, particularly where grassland resource is scarce, may help to reverse the observed population deteriorations (Robinson *et al.*, 2001). This should encompass benefits on local, national and global scales. Greater knowledge is therefore required as to how birds utilise a wet grassland resource in an arable habitat and methods developed for increasing its conservation value.

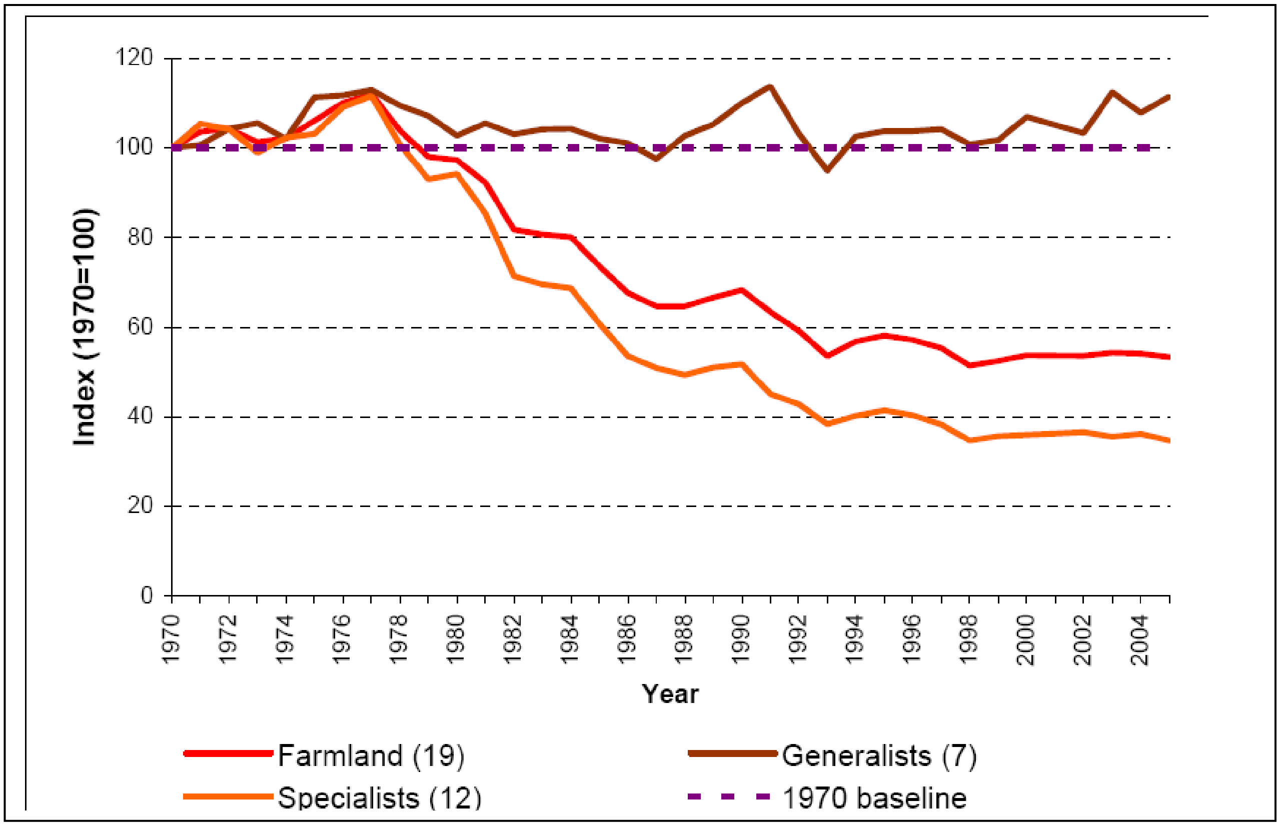

Figure.2 Population trends of farmland bird indicator species 1970 – 2005 (Defra, 2007)

1.5.2 Habitat preferences of bird populations in agricultural landscapes: General Trends

Studies of field use by wintering bird populations in agricultural landscapes, have highlighted the broad value of grassland to avifauna. Permanent grassland has been found to support high bird densities (Tucker, 1992, Wilson *et al.*, 1996, Barnett *et al.*, 2004). In particular, invertebrate feeders have shown a distinct tendency to utilise permanent grassland over other available habitats, probably due to the higher soil macro-invertebrate densities present (Tucker, 1992, Wilson *et al.*, 1996). Granivorous species may be less prevalent on improved or unimproved grassland (Barnett *et al.*, 2004). Conventional winter cereals have demonstrated limited value for wintering birds, as has bare till and oil seed rape sown fields. Bare till may however benefit smaller birds by providing better access for foraging at the soil surface and also by providing a temporary food resource directly after ploughing (Wilson *et al.*, 1996, Perkins *et al.*, 2000). Repeatedly cultivated arable land is generally thought to be of limited value due to the potential damage agricultural practices, such as ploughing and pesticide application, can have on invertebrate populations (Tucker, 1992). Spring sown cereal (winter stubbles) has been found to support moderate bird densities, generally of granivorous birds or specific species like the skylark. Winter stubbles can supply additional food via spilt grain and an increase in seeding arable weeds (Tucker, 1992, Wilson *et al.*, 1996, Robinson *et al.*, 2001).

1.5.3 Importance of heterogeneity for habitat selection

Habitat heterogeneity at field, farm and landscape scale is directly linked to biodiversity levels (Robinson *et al.*, 2001, Benton *et al.*, 2003). Within field structural variation, should provide feeding and refuge opportunities for bird's species with differing requirements. This is often also related to predator defence strategies, for example, game birds preferences for foraging in dense cover as opposed to plovers and skylarks predilection for open ground to facilitate early predator detection (Henderson *et al.,* 2001, Benton *et al.,* 2003). Increased heterogeneity at the between field scale, should ensure the provision of a mosaic of feeding, refuge and roosting areas, as well as dispersal corridors to offset the effects of fragmentation (Benton *et al.,* 2003). Although individual species requirements may vary, increased habitat heterogeneity may promote broad taxal benefits for general bird populations (Part and Soderstrom, 1999).

At a landscape scale the importance of arable habitat, particularly to granivorous species, has been tentatively quantified. Many seed-eating species such as the grey partridge (*Perdix perdix*), skylark, and yellowhammer (*Emberiza citrinella)* have been positively correlated with the amount of arable habitat available (Robinson *et al.*, 2001). The level of these preferences are resource availability dependent, generally being stronger in areas with scarce arable habitat and vice versa (Robinson *et al.*, 2001). The between habitat interactions of birds are often influenced by the surrounding resource prevalence and can be an aggregative response to resource density (Robinson *et al.*, 2004). Extrapolation of principles derived from limited scale studies must be undertaken with caution. The complex relationship between habitat use requires further clarification at all spatial scales in order to improve the performance of conservation management. However, management initiatives encompassing landscape scale factors, for example, habitat frequency in a given area, may still provide greater overall benefit via appropriate spatial targeting of objectives.

Temporal variation is also an important factor when considering habitat heterogeneity. Species requirements can change due to predictable (e.g. seasonal response) or stochastic (e.g. weather) processes, which will determine habitat choices. Habitat variability is therefore vital to ensure availability at the right time (Benton *et al.,* 2003). For example, the seedbank in arable habitat has been shown to be largely reduced by January (Robinson *et al.*, 2004). The provision of alternative habitat at the appropriate time of year may aid the sustenance of bird populations in agricultural landscapes. Avian preferences for wet grassland may therefore vary temporally, in relation to species requirements and also habitat quality at a given time period, a research area that requires more detailed investigation.

1.5.4 Habitat Structure and subsequent selection

The physical structure of agricultural and grassland swards can effect what species are likely to use a habitat, due to the implications it has for foraging. Habitat structure can determine the prey availability but also the degree of mobility and vigilance for bird species (Devereux *et al.,* 2004, Whittingham and Evans, 2004). Both lapwing and starling have been shown to be more productive in terms of foraging efficiency in shorter grassland swards (Milsom *et al.*, 1998, Devereux *et al.*, 2004). Taller swards may be preferred by meadow pipit (*Anthus pratensis*) and magpie (*Pica pica*) (Perkins *et al.,* 2000). However Barnett *et al.* (2004) found no clear relationship between bird species preferences and sward structure or density. Conclusive judgements are subsequently difficult.

Perceived, as well as actual predation risk, can also have an influence on habitat selection and foraging efficacy. The implications of this vary between species. For example, one may prefer dense cover as a predator defence strategy and another, extensive open ground (Henderson *et al*., 2001, Benton *et al.*, 2003, Whittingham and Evans, 2004). Birds can counteract amplified levels of predation risk by increasing their vigilance. The resultant behaviour usually involves increasing the frequency of head raising, potentially reducing foraging efficiency (Whittingham and Evans, 2004). The relationship between habitat choice, foraging efficiency and predator avoidance are multifaceted. They are further complicated by temporal changes in requirements and individual species differing preferences (Devereux *et al*., 2004, Whittingham and Evans, 2004). Boundary habitat and human disturbance levels can also play a part in field selection, which are hard to quantify (Milsom *et al.*, 1998). Agricultural landscapes vary greatly, both spatially and temporally and habitat choice in relation to structure may play an important role in avian population dynamics (Whittingham and Evans, 2004). Specifically, the prevailing structure of a wet grassland community can potentially have multiple influences on habitat partiality. A greater comprehension of this, in terms of new wet grassland communities within an agricultural landscape, would advance creation techniques for enhancing avian biodiversity.

1.5.5 Specific value of wet grassland

As already discussed, wet grassland is utilised as a feeding habitat by birds of various feeding preferences (Wilson *et al.*, 1996, McCracken and Tallowin, 2004, Perkins *et al.,* 2000). Insectivorous, granivorous and herbivorous species all exploit the habitat at varying degrees and on different spatial and temporal scales. For example, the greenfinch (*Carduelis chloris*) and yellowhammer both feed on the seeds of plants contained within wet grassland (Perkins *et al.,* 2000, McCracken and Tallowin, 2004). Waders and small passerines also make use of the invertebrate populations. For example, lapwing*,* snipe (*Gallinago gallinago*) and starling (McCracken and Tallowin, 2004). Grazing wildfowl are attracted to grassland particularly in winter, preferring young swards and avoiding courser species (Benstead, *et al.,* 1999).

Crucially, most research specific to wet grassland is focussed on breeding populations and established grassland communities (see: Shrubb, 1990, O'Brian & Smith, 1994, Ausden & Hirons, 2002). Many studies are also species specific and the winter feeding patterns of lapwings, a key wet grassland species, are more extensively researched. The lapwing, an amber list species, is in moderate decline in the UK, with an estimated population reduction of 49%, between 1987 & 1998 (England and Wales) (BTO, 2006, RSPB, 2007). Lapwings, along with golden plover, have also seen a shift in winter distribution to arable land in the East of Britain (Gillings *et al.*, 2006). An overall preference for established grassland as a winter feeding habitat has been noted (Milson, 1994, Tucker, 1994). Temporal behavioural patterns, relating to feeding have also been observed. Village & Westwood (1994) found a preference for recently tilled fields in early winter, then a shift to grassland in December, possibly relating to invertebrate densities. Kirkby & Fuller's (1994) study also highlighted preference changes, with grassland becoming the choice in October to November, but also during spells of cold weather. However, this contradicts findings relating to more general bird populations, where no notable temporal trends were found (Tucker, 1992).

Importantly, the methods of management employed on wet grasslands can have a strong influence over the wintering bird species found there. Fertiliser input levels, grazing and cutting regime can all influence avian populations (Perkins *et al.*, 2000, Vickery *et al.*, 2001, McCracken and Tallowin, 2004). The habitat can be sensitive to water level alterations, causing damage to the soil structure, effecting moisture content levels and subsequent invertebrate populations (Ausden and Treweek, 1995, Ausden *et al.*, 2001, Critchley *et al.*, 2004). Also the nutrient status of water has the potential to alter the botanical composition of a site and therefore the food availability for bird populations (Critchley *et al.*, 2004).

1.6 Rationale

Although extensive research is available relating to bird species requirements and selective pressures in agricultural landscapes, little is known about the specific value of newly created wet grassland to bird populations, particularly as a winter habitat. It would be beneficial to increase the understanding of how it would fit into the feeding dynamics of wintering bird species. Studying the overall habitat selection of wintering birds at a suitable site, incorporating temporal trends, should allow greater comprehension of its ornithological significance. If the restoration and creation of new wet grassland habitats is to be successful, their initial quality should be assessed. This should enable the development of more effective habitat creation techniques for future projects, facilitating the improvement of the ecological value of wet grassland, subsequently promoting the rare and declining bird species associated with the habitat.

2.0 Aims and objectives

Aim:

- To assess the initial value of a newly created wet grassland as a winter habitat for bird populations

Objectives:

- To conduct a comparative, systematic winter survey of birds using a newly created wet grassland and adjacent, intensively farmed arable land as a direct contrast
- Assess the relative value of the bird community on the wet grassland area
- To evaluate the effect of wet grassland conversion method on bird populations
- Use statistical analysis to examine the relationship between wet grassland, agricultural land and conversion technique, specifically, bird species habitat preferences and temporal trends

3.0 Study area

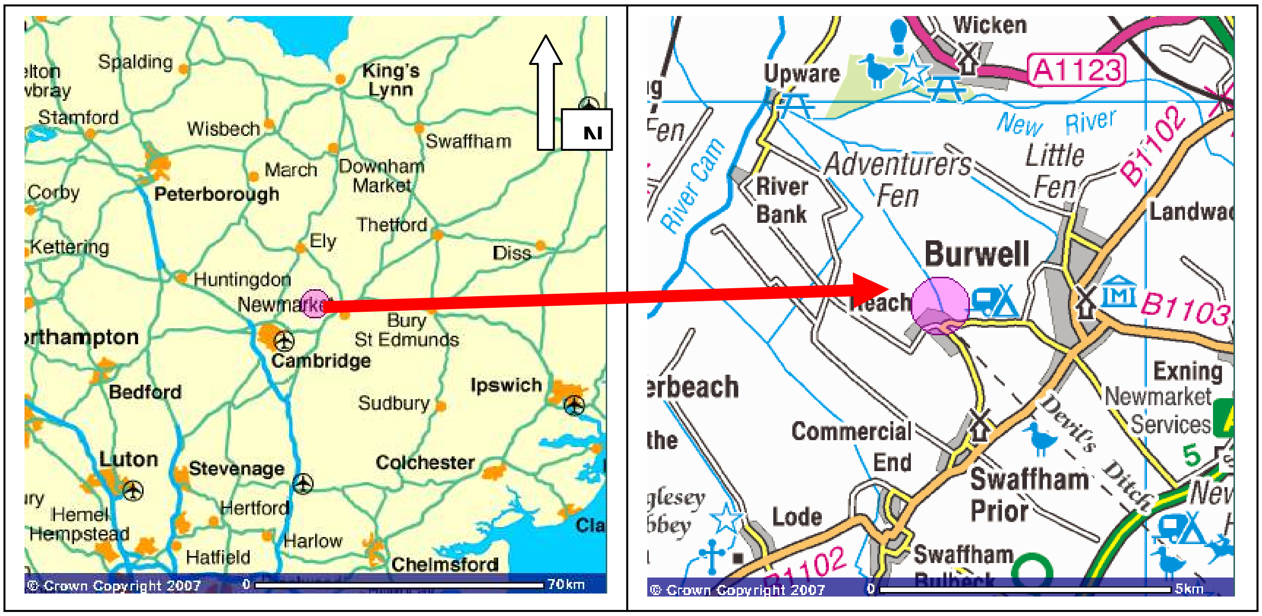

Figure.3 Location Map of Tubney Fen (Ordnance Survey, 2007)

Plate.1 Tubney Fen in October

3.1 Location

The chosen study site, Tubney Fen, is part of a National Trust expansion plan for Wicken Fen (figure.4) nature reserve. The 101ha site is positioned to the north of Reach village in Cambridgeshire, adjacent to the National Trusts recent purchase of Burwell fen (Grid squares TL 5566/TL 5567) (figure.3). The main Wicken Fen reserve is about 1km away to the North.

3.2 Site history

The Tubney Fen site is the first part of an expansion plan for Wicken Fen nature reserve on a large spatial scale. Wicken Fen is a historic site of notable ecological interest, supporting many rare species and is recognised as one of the most important wetlands in Europe (National Trust, 2007). The 'Wicken Fen Vision' is a plan by the National Trust to expand this wetland to 16 times its current size to 5,500 hectares, by converting existing agricultural land to ecologically valuable habitat, including areas of new lowland wet grassland (National Trust, 2007). The project aims to restore, create and link the existing fragmented network of wetlands in East Anglia along with the 'Great Fen Project' near Peterborough. The increase in size of the habitat should make populations of rare species more sustainable as the existing 'island of wetland' at Wicken is relatively small and isolated (National Trust, 2007). This could provide internationally valuable habitat and assist in the conservation of wetland species vulnerable to the loss of coastal habitats, due to climate change.

3.3 Current status

The land was previously used to cultivate lawn turf and was put down to wet grassland during 2007 (National Trust, 2006). The intention is to create an expanse of new wet grassland to encourage botanical and ornithological diversity. The sites recent conversion from agriculture to wet grassland and close proximity of surrounding fields still in intensive arable cultivation, make it an ideal study site to directly evaluate the two habitats (plates. 1 & 2). The size of the site provides good scope for results. Also, the close proximity of Wicken Fen and Kingfishers Bridge reserves (both sites with high bird population diversity), attracts species to the general area and should encourage the colonisation of the new habitat. The main Wicken Fen reserve, often has wintering hen harriers, short–eared owls and a diverse range of small passerines including redwing (*Turdus iliacus*), lesser redpoll (*Carduelis cabaret*) and yellowhammer (Cambridgeshire

Bird Club, 2007, Thorne, 2007). It is unknown if the land has previously supported a wet grassland community.

Plate.2 Aerial photograph of Tubney Fen before conversion to wet grassland, showing the field boundaries of the fen area and the surveyed agricultural land (Google Earth, 2007)

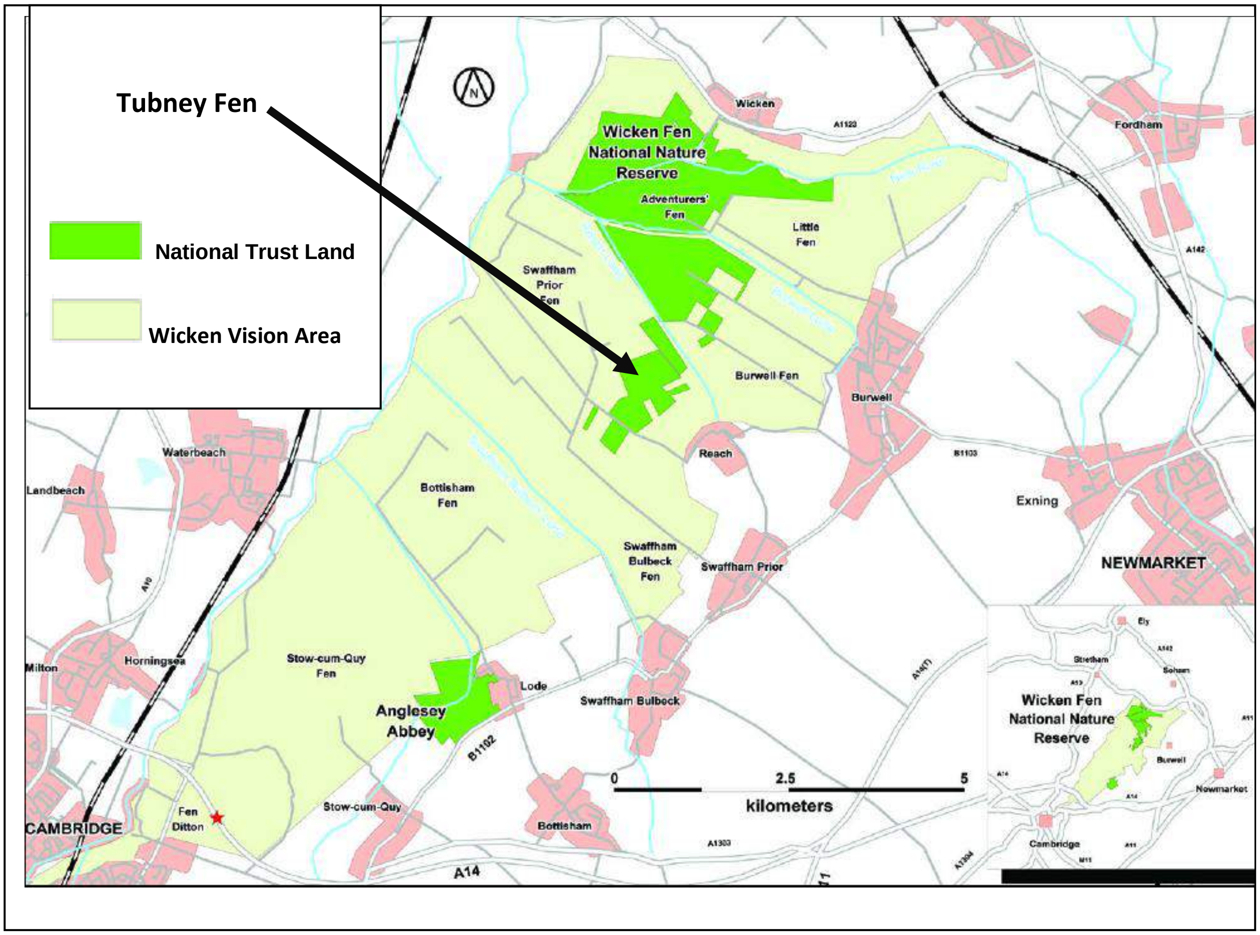

Figure.4 National Trust map highlighting Tubney Fen within the planned 'Wicken Vision' expansion plan (National Trust, 2006)

4.0 Methods

4.1 Bird counts

Systematic observational surveys of birds using both the wet grassland and the agricultural land were conducted on 11 occasions between 16/11/2007 and 08/02/2008. Individual fields were surveyed in order to define the habitats accurately. Observations were made by making a complete scan of the entire field, using 10x42 binoculars as an aid (Bushnell Trophy - model number: 231042P). All birds present were identified to species level (other than gulls which were grouped together due to limitations in identification ability) and noted on a recording sheet. This included all individuals utilising the field itself, not inclusive of birds flying over the area unless displaying obvious hunting behaviour, for example, hovering by a kestrel. Birds flushed out of a habitat were also recorded, even if they subsequently dispersed into an alternative area. It should be acknowledged that no recordings were made of species using the boundary habitats (ditches and hedgerows) or the meres present on the site, to ensure the actual habitats were accurately surveyed. Each field was designated a reference number or letter, in accordance with its habitat type (wet grassland/agricultural land) (plate.2 & table.3).

Surveys were conducted in between 09:00 and 17:00, and never within one hour of dawn or dusk, to prevent the inclusion of birds arriving or leaving roosts. Also counts were not made during periods of high wind, or heavy rain due to its implications for bird activity (Gilbert *et al.*, 1998, Bibby *et al.*, 2000).

4.2 Field information

Table.3 Field areas (m^2) for the wet grassland and agricultural study compartments

Field Reference (Wet Grassland: 1-9, Agricultural Land: A-H)	Field Area (m^2)
1	23,307
2	55,123
3	44,581
4	210,933
5	96,210
6	130,792
7	209,478
8	108,223
9	n/a
Total Wet Grassland Area	**878,647**
A	48,628
B	37,424
C	31,541
D	193,162
E	43,502
F	153,646
G	220,646
H	34,851
Total Agricultural Land Area	**763,400**
Total Surveyed Area	**1,642,047**

The area of each field surveyed was measured using a GIS software package (Google Earth Pro) and information on its present status and crop type collected by direct observation. The total wet grassland area surveyed was 878,647m^2, consisting of 8 separate fields. The ninth field was not used in the survey due to its small size and proximity to the rest of the study site (plate.2 & table.3). The total area of agricultural land was 763,400 m^2 and also consisted of 8 fields. Fields were selected based on their potential value to bird populations, immediacy to the Tubney site, access opportunities and size. The aim was to gain a range of agricultural habitats representative of the general surrounding area.

Table.4 Grassland conversion technique by field for the wet grassland study area

Field Reference	Restoration Technique
1	Left as turf
2	Un-seeded: Left as partial turf
3	Natural Regeneration (stripped of turf)
4	Seeded
5	Mostly Turf
6	Seeded
7	Mix of Seeding/Natural Regeneration
8	Natural Regeneration

Table.5 Arable field cropping regime by field for the agricultural area

Field Reference	Field use/Cultivation (during study period)
A	Sown: Crop Pre-emergent (Bare Till)
B	Winter Sown Cereal
C	Winter Sown Cereal (Sown: 28/12/2007)
D	Winter Sown Cereal
E	Leeks
F	Sown: Crop Pre-emergent (Bare Till)
G	Winter Sown Cereal
H	Winter Sown Cereal

4.3 Data analysis

All data analysis was conducted using the 'analyse-it' programme for Microsoft excel, aside from the Shannon-Wiener and Jacob's preference indices which were calculated manually using a Microsoft excel 2007 spreadsheet.

4.3.1 Bird community level preferences

Overall counts for both wet grassland and agricultural land were tabulated and the relative abundance of each species observed was noted to give an overview of the community compositions in each habitat. Overall bird population densities for the entire study period were also calculated (no. birds/ha), indicating the bird abundance levels for each habitat relative to its extent. The Mann-Whitney U test statistic (*U*) (see below for equation), was calculated to test for statistically significant differences in overall bird communities, densities and species compositions between wet grassland and agricultural land (amalgamated counts inclusive of all fields pertaining to either habitat). The paired significance tests were only conducted for the whole study period as the dataset was too small to justify analysis using this method on a temporal scale. The *U* test was used rather than the statistically more powerful t-test, because the data was not-normally distributed.

Mann-Whitney U Test (*U*), calculated as:

$$U_1 = N_1 N_2 + \frac{N_1(N_1 + 1)}{2} - R_1$$

(N= number of observations, R= Sum of the ranks. Calculated for both samples, the smaller value is the *U* statistic)

To measure abundance between both wet grassland conversion compartments and agricultural fields, bird population densities were also calculated at field level and also amalgamated by conversion technique. One-way analysis of variance (ANOVA) tests (*F*), were conducted at an overall bird community level to determine any significant variances at both a field and conversion type scale (equation not given due to the variations in protocol, see Waite, 2000, for the full procedure used).

Shannon-Weiner Diversity Index (*H'*), calculated as:

$$H' = -\sum pi \, lN \, pi$$

(pi = ni/N, where ni is the number of individuals of a species and N the total number of individuals)

In order to assess overall habitat quality for bird populations, the Shannon-Weiner index of diversity (*H')* (see above for equation) was calculated for each habitat and grassland conversion method. Its primary function is to quantify heterogeneity (Waite, 2000). This method is less sensitive to sample size other diversity indices, which considering the small scale of the study is an important factor (Waite, 2000). Also, the index is responsive to changes in the abundance of rarer species than more profuse ones, as opposed to some other diversity indices (e.g. Simpsons index of diversity), which was taken into account when interpreting results. The indices calculated for overall wet grassland and agricultural land were also assessed for statistically significant variance using the student's t-test (*t*) as outlined in Waite (2000).

4.3.2 Individual species preferences

In order to analyse individual species habitat preferences, the Jacob's preference index (D) was used (see below for equation) (Tucker, 1992). The index ranges from -1 (complete avoidance) to +1 (exclusive use), with 0 indicating usage in proportion with habitat availability (Tucker, 1992). The resultant value indicates how likely a species is to utilise a given habitat in the study area. Importantly it incorporates the proportion of habitat availability, making direct comparisons possible between samples taken from surveyed areas of differing sizes. It should be acknowledged that due to the flocking tendencies of birds during the winter, data obtained may not be fully representative of actual habitat choice (Tucker, 1992). Analysing frequency data can rectify this issue, although the scale of our results prevents this being utilised. Jacob's preference indices were calculated for all species observed on more than 5 occasions throughout the study period and in sufficient numbers relative to the species, maintaining an empirical basis for the results.

Jacobs Preference Index (JPI), calculated as:

$$D = (r - p)/(r + p - 2rp)$$

(r = proportion of occurrences in a particular habitat, p= proportion of habitat within the study area)

Species preferences between the entire wet grassland and agricultural study areas for the duration of the study period (amalgamated counts from all fields pertaining to the relevant habitat) were measured using the index (11 species - figures 5 & 6). It was also used to compare preferences between grassland conversion techniques (4 species - figure.11).

4.3.3 Temporal analysis: bird abundance and species composition

Mean bird population densities were calculated for each visit and habitat, to assess temporal changes in abundance for both wet grassland and agricultural land. The mean densities were also analysed using one-way analysis of variance (ANOVA), to test for statistically significant variations.

Sorenson's Similarity Index (SSI), calculated as:

$$2J/(A+B)$$

(A = number of species in site X, B = number of species in site Y, J = number of species common to both)

In order to assess temporal trends in species composition variance between the study areas, the Sorenson's Similarity Index was calculated for each field visit throughout the study period (see above for equation). The index evaluates the associations in species composition between two samples and is expressed on a scale between 0 and 1. 1, indicating that all species are the same for both sites and 0, indicating no similarity. However, it does not incorporate variance in the abundance levels of the species observed, just the presence or absence of relevant species.

Spearman's Rank Correlation Coefficient (*rs*), calculated as:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

(n= sample size for paired measurements, d= difference in rank between each pair of measurements)

Mean Bird densities and species compositions for the entire study period were also plotted on line graphs to visually represent any trends in abundance or species variance. Spearman's coefficients (*rs*) were also calculated to test for the significance of correlation between the trends for wet grassland and agricultural land at an overall bird community level.

The effects of temperature and wind speed on bird abundance were also assessed. Spearman's rank correlation coefficients (*rs*) were calculated for each factor (temperature and wind speed) for both habitats, to test for any significant effects. It should be acknowledged that the non-normally distributed dataset, again prevented the use of a parametric correlative test.

5.0 Results

5.1 Bird community level comparisons between the wet grassland and agricultural land

Throughout the entire study period a total of 2274 birds were observed of 27 species. Of these 1432 of 25 species were recorded within the wet grassland and 842 of 13 species on the agricultural land. The wet grassland and agricultural study areas contained statistically significant different bird communities for the overall study period (U= 542.5, $p < 0.01$). The wet grassland supported a significantly higher mean bird density (U= 534, $p < 0.01$) and mean species frequency than the agricultural land (U= 121, $p < 0.001$). The diversity indices reflected these findings, also being significantly higher on the WG than Agri land (t= 20, $p < 0.001$).

14 species (51.9%) were observed exclusively within wet grassland (see table.6). These included passerines (goldfinch *Carduelis carduelis*, linnet, meadow pipit, pied wagtail *Motacilla alba*, redpoll, reed bunting *Emberiza schoeniclus* skylark and stonechat *Saxicola torquata*), waders and wildfowl (snipe and mallard *Anas platyrhynchos*) and raptors (hen harrier, merlin and sparrowhawk *Accipiter nisus*). Only two species (7.4%) were recorded entirely on the agricultural land (gull spp and mute swan *Cygnus olor*). Carrion crow (*Corvus corone*), red-legged partridge (*Alectoris rufa*) and woodpigeon (*Columba palumbus*) were all consistently observed primarily on the agricultural land.

Table.6 summarises the percentage occurrences of individual species by habitat. On the wet grassland linnet were observed in the most abundance (27.58%), followed by woodpigeon (20.58%) and starling (19.34%). Meadow pipit, goldfinch and skylark were also observed in moderate levels (10.34%, 4.68% and 4.33% respectively). The remainder of the species were either recorded in small numbers or were birds that are usually found in small groups, pairs or singularly outside of the breeding season (kestrel, stonechat, pied wagtail). Certain species, notably raptors, are also found at low densities, with wide ranging territories such as the hen harrier and merlin. Woodpigeon was the most abundant species recorded on the agricultural land by a substantial margin (77.08%). Lapwing were seen in low numbers relative to their winter flocking tendencies (4.16%). Gulls spp, were observed in relatively moderate numbers

(6.41%), as were red-legged partridge (3.68%), starling (2.97%) and carrion crow (2.85%). All other species were recorded at insignificant levels.

Table.6 Total counts and % occurrence per species for the complete study period (* indicates exclusively observed within, or strongly preferring the specified habitat: WG= Wet Grassland, Agri= Agricultural Land)

Species	Wet Grassland Total Counts	% of Occurrence	Agricultural Land Total Counts	% of Occurrence
Carrion Crow *Corvus corone*	3	0.21	24	2.85
Chaffinch *Fringilla coelebs*	3	0.21	2	0.24
Goldfinch *Carduelis carduelis* (* WG)	67	4.68	0	0.00
Gull spp. (* Agri)	0	0.00	54	6.41
Hen Harrier *Circus cyaneus* (* WG)	8	0.56	0	0.00
Grey Heron *Ardea cinerea* (*WG)	5	0.35	0	0.00
Kestrel *Falco tinnunculus*	15	1.05	2	0.24
Lapwing *Vanellus vanellus*	1	0.07	35	4.16
Linnet *Carduelis cannabina* (* WG)	395	27.58	0	0.00
Magpie *Pica pica*	20	1.40	3	0.36
Mallard *Anas platyrhynchos* (*WG)	9	0.63	0	0.00
Meadow Pipit *Anthus pratensis* (*WG)	148	10.34	0	0.00
Merlin *Falco columbarius* (* WG)	1	0.07	0	0.00
Mute Swan *Cygnus olor* (* Agri)	0	0.00	4	0.48
Pheasant *Phasianus colchicus*	17	1.19	6	0.71
Pied Wagtail *Motacilla alba* (* WG)	2	0.14	0	0.00
Red-Legged Partridge *Alectoris rufa* (*Agri)	10	0.70	31	3.68
Lesser Redpoll *Carduelis cabaret* (* WG)	37	2.58	0	0.00
Reed Bunting *Emberiza schoeniclus* (* WG)	25	1.75	0	0.00
Rook *Corvus frugilegus*	6	0.42	1	0.12
Skylark *Alauda arvensis* (* WG)	62	4.33	0	0.00
Snipe *Gallinago gallinago* (* WG)	4	0.28	0	0.00
Sparrowhawk *Accipiter nisus* (* WG)	1	0.07	0	0.00
Starling *Sturnus vulgaris*	277	19.34	25	2.97
Stonechat *Saxicola torquata* (* WG)	9	0.63	0	0.00
Wood Pigeon *Columba palumbus*	300	20.95	649	77.08
Yellow Hammer *Emberiza citrinella*	7	0.49	2	0.24
Totals	**1432**		**842**	

Table. 7 Shannon-Weiner Index, mean bird densities and species frequency values for each study area

Habitat Type	Shannon-Weiner Index value	Mean Bird Density (per/ha)	Mean Species Frequency (per/ha)
Wet Grassland (overall)	2.07635	16.29779	0.11278
Arable Land	0.953664	11.02960	0.04644

5.2 Species habitat preferences

Several species demonstrated an exclusive use of the wet grassland and a corresponding complete avoidance of agricultural land, throughout the entire study period when analysed using the Jacobs Preference Index (JPI): meadow pipit, skylark, linnet, reed bunting and hen harrier (figures 5 & 6). Kestrel, starling and magpie all displayed a strong preference (JPI above 0.7) for wet grassland, although not an exclusive association (figures 5 & 6). Carrion crow, red-legged partridge and woodpigeon were the only species to display any preference for agricultural land, the carrion crow having the strongest preference (JPI: 0.80) and corresponding strong avoidance of wet grassland. The red-legged partridge and woodpigeons associations were weaker, although still considerable (JPI: 0.56 & 0.43 respectively) (figures 5 & 6). All other species were not observed in enough abundance to conduct JPI analysis.

Table.8 Bird species by broad foraging preference categories as outlined in Wilson *et al.* (1996). * denotes species with preferences for a particular habitat, or found exclusively within it. (WG= Wet Grassland, Agri= Agricultural Land)

Invertebrate-Feeders	Seed-Eaters
Snipe (* WG)	Red-Legged Partridge (*Agri)
Meadow Pipit (* WG)	Pheasant
Pied Wagtail (* WG)	Woodpigeon (* Agri)
Carrion Crow (* Agri)	Skylark (* WG)
Rook	Goldfinch (* WG)
Magpie (* WG)	Linnet (* WG)
Starling (* WG)	Chaffinch
	Yellowhammer
	Reed Bunting (* WG)

When evaluated relative to broad winter feeding preferences (not absolute due to spatial and temporal variations in foraging behaviour), the majority of bird species utilised the wet grassland considerably more than agricultural land regardless of foraging inclinations. Two species that demonstrated preferences for agricultural land, the woodpigeon and carrion crow, also occur within separate foraging categories (table.8).

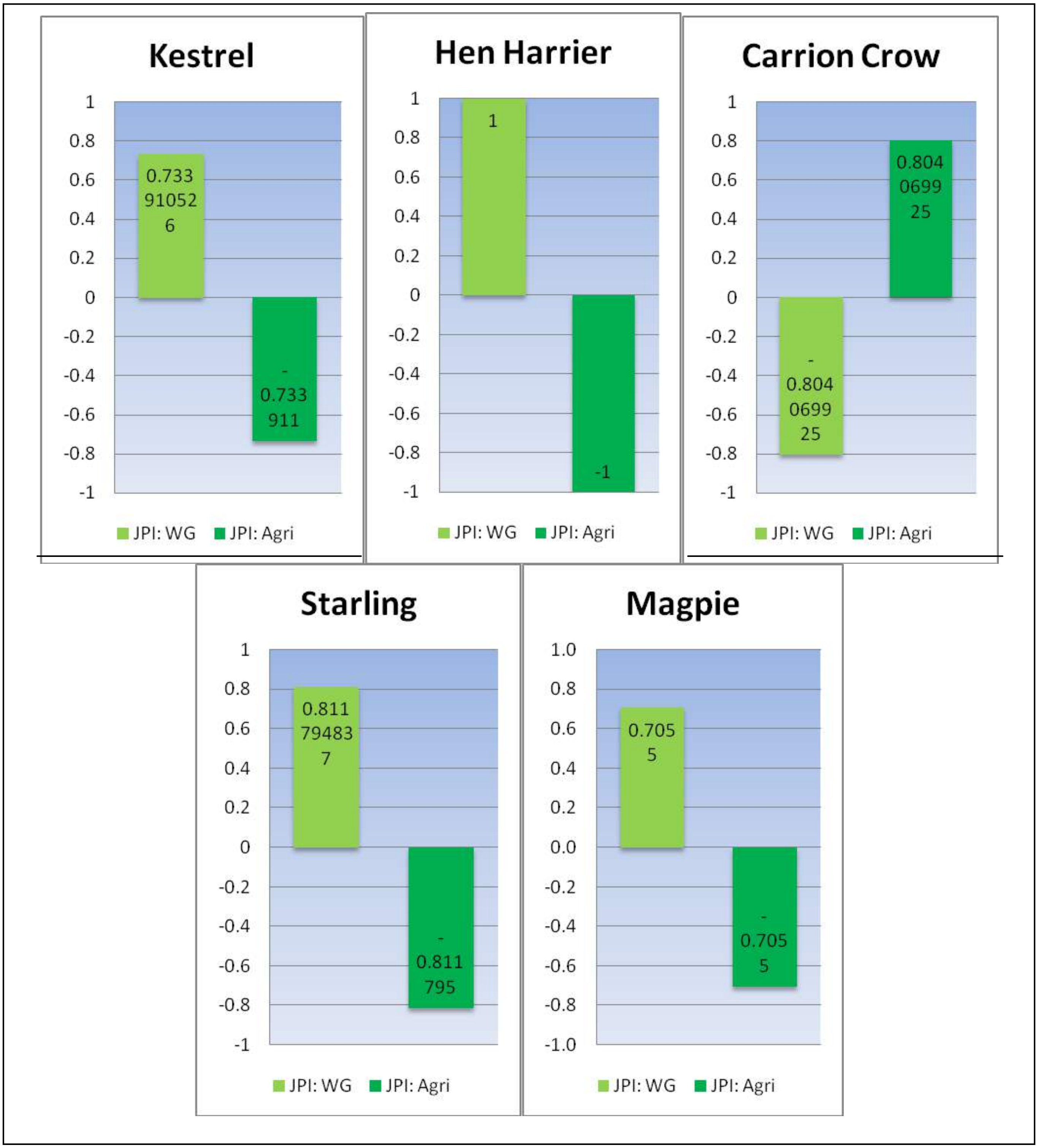

Figure.5 Jacobs preference indices (JPI) for key species. (-1 indicates complete avoidance, +1 exclusive use and 0, usage in proportion with habitat availability)

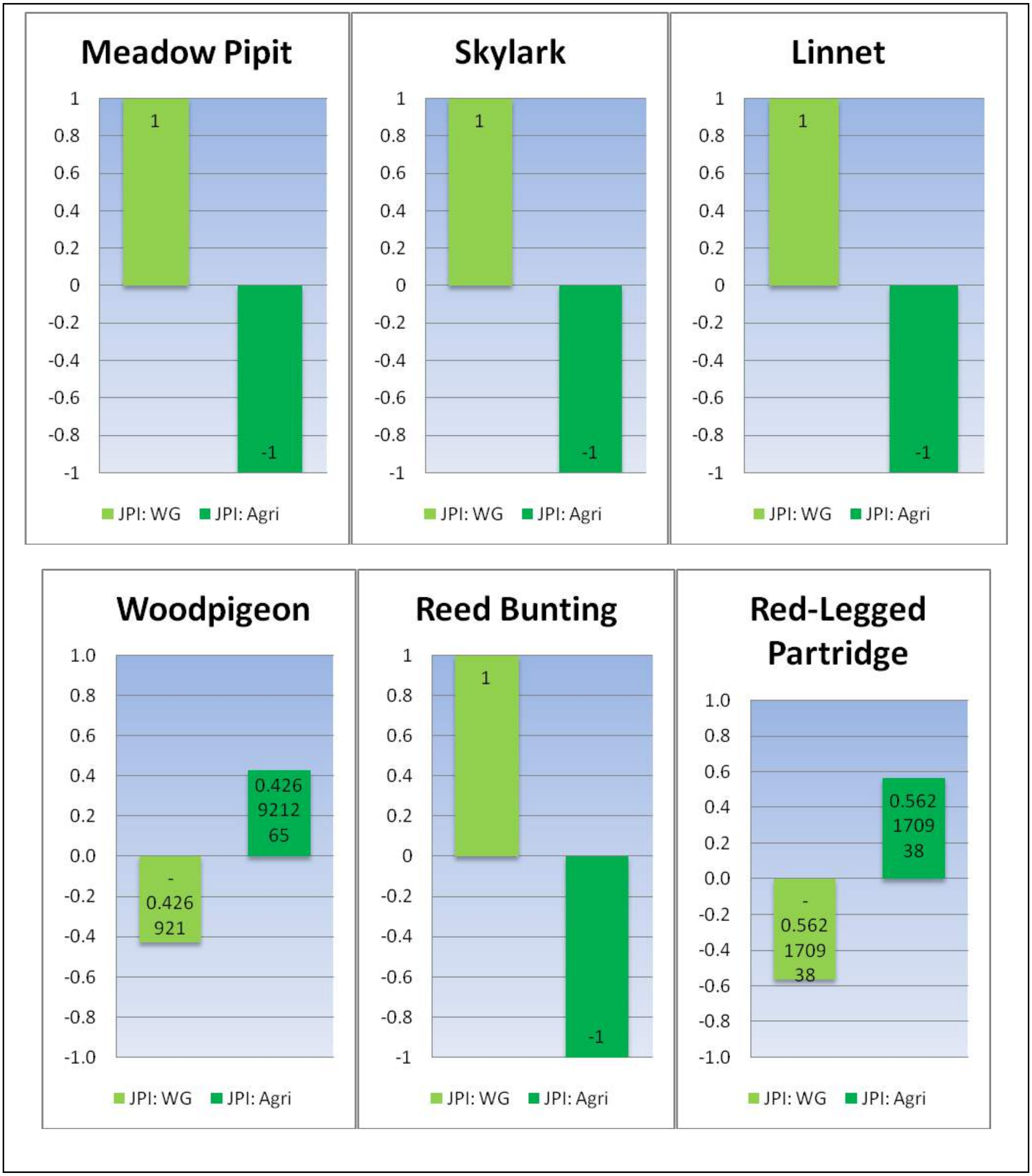

Figure.6 Jacobs preference indices for key species continued. (-1 indicates complete avoidance, +1 exclusive use and 0, usage in proportion with habitat availability)

5.3 Temporal trends in bird abundance and species composition

The temporal variance in mean bird density between visits was not found to be statistically significant for either wet grassland (Anova: $F= 1.431$, df= 10, $p < 0.17$) or agricultural land (Anova: $F= 0.7969$, df= 10, $p < 0.63$). However, mean bird densities (Inclusive of all species) for both habitats, significantly followed similar patterns for the complete duration of the study (rs: 0.59, df: 9, $p < 0.05$) (figure.7). Densities were at their highest in late November (2.87/ha), steadily dropping, until reaching low levels in mid December (0.32/ha). They continued to remain relatively constant throughout the remainder of December up until late January. The beginning of February saw an increase in bird densities similar to the levels observed during the early part of the winter, although the last field visit (8th Feb) saw them decrease to a moderate level. The respective peaks of mean density in late November for both wet grassland and agricultural land were largely due to sizable flocks of starling (WG: 23/11) and woodpigeon (Agri: 30/11) that were aggregated in one particular field for the duration of the days field work. Subsequently, there are no notable variable temporal trends in bird abundance between the two habitats. Additionally, mean bird densities were not significantly correlated with temperature or wind speed on either wet grassland or agricultural land (table.9).

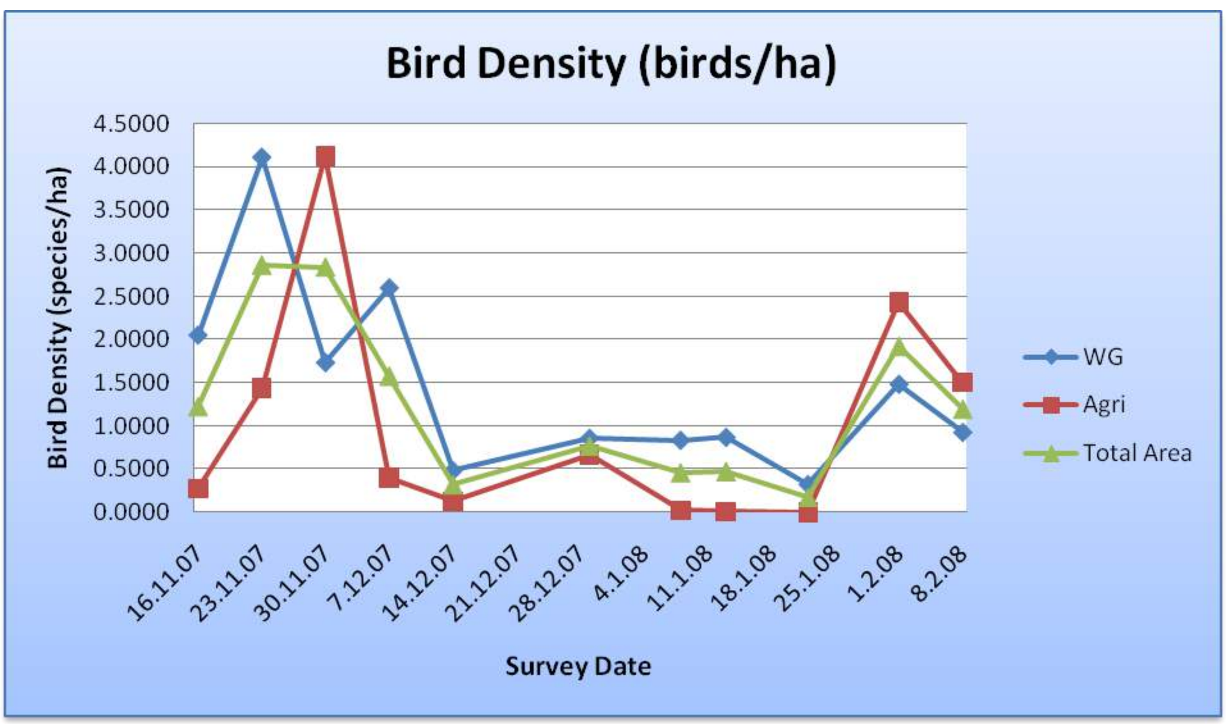

Figure.7 Total bird density (birds/ha) for the entire study period (Nov-Feb)

Table.9 Spearman's rank correlation coefficient (*rs*) calculations for: temperature (°C), wind speed (beaufort scale) and mean bird densities by surveyed area.

Relevant Factor and Study area	Spearman's rank correlation coefficient value (rs) and significance level
Temperature and wet grassland bird densities	*rs*= 0.13, df:9, p= 0.6945
Temperature and agricultural land bird densities	*rs*= 0.03, df:9, p= 0.9355
Wind Speed and wet grassland bird densities	*rs*= 0.38, df:9, p= 0.2504
Wind speed and agricultural land bird densities	*rs*= 0.42, df:9, p= 0.2037

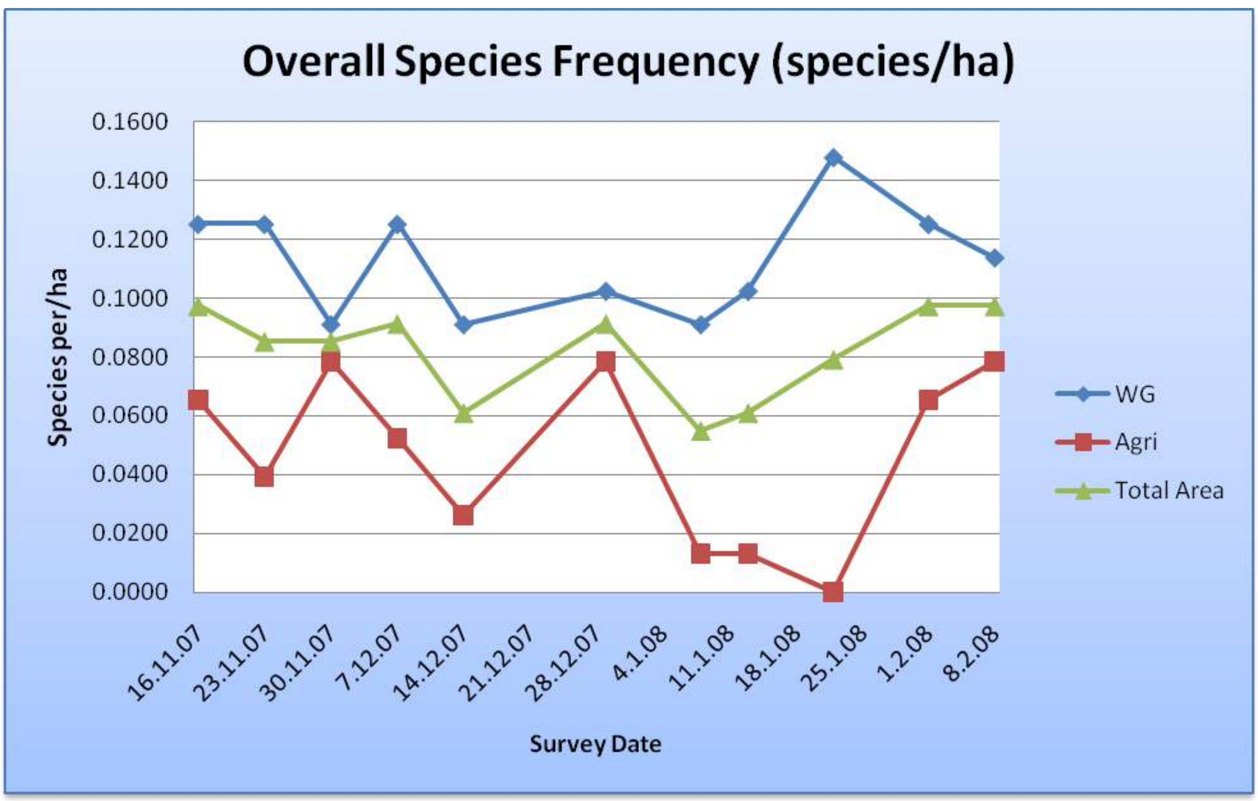

Figure. 8 Total species frequency (species/ha) for the entire study period (Nov-Feb)

The degree of species association between the wet grassland and agricultural land was variable throughout the study period (figure.8). The Sorenson's similarity index values indicate that on several visits, there was no species overlap (table.10). The species compositions did have increased association at certain points during the winter: 16th and 23rd November (SS: 0.25/0.2857), 29th December (SS: 0.26) and 1st February (SS: 0.375). On these occasions, the increased degree of similarity is predominantly due to the species consistently observed on agricultural land (carrion crow and woodpigeon), also being recorded on the wet grassland. The only species primarily associated with wet grassland also recorded the agricultural area was the kestrel, which was observed hunting over winter drilled cereals on 2 occasions.

The species frequencies observed for wet grassland were considerably higher than for agricultural land for the entire study period (figure.8). There was an exception on the 30th November, when a decrease in species frequency on the wet grassland, corresponded with an increase on the agricultural area bringing them to a similar level (figure.8). The trends for both habitats did not significantly follow the same pattern (rs= -0.14, df:9). The species frequency on the wet grassland increased considerably in late January and corresponded with a count of zero birds on the agricultural land (figure.8).

Table.10 Sorenson's similarity indices (SSI) for all survey dates

Date of field visit	Sorenson's Index
16.11.07	0.25
23.11.07	0.2857
30.11.07	0
7.12.07	0
14.12.07	0
29.12.07	0.26
8.1.08	0
13.1.08	0
22.1.08	0
1.2.08	0.375
8.2.08	0

5.4 Between field preferences: effects of conversion technique and arable land use

5.41 Bird Community Level Analysis

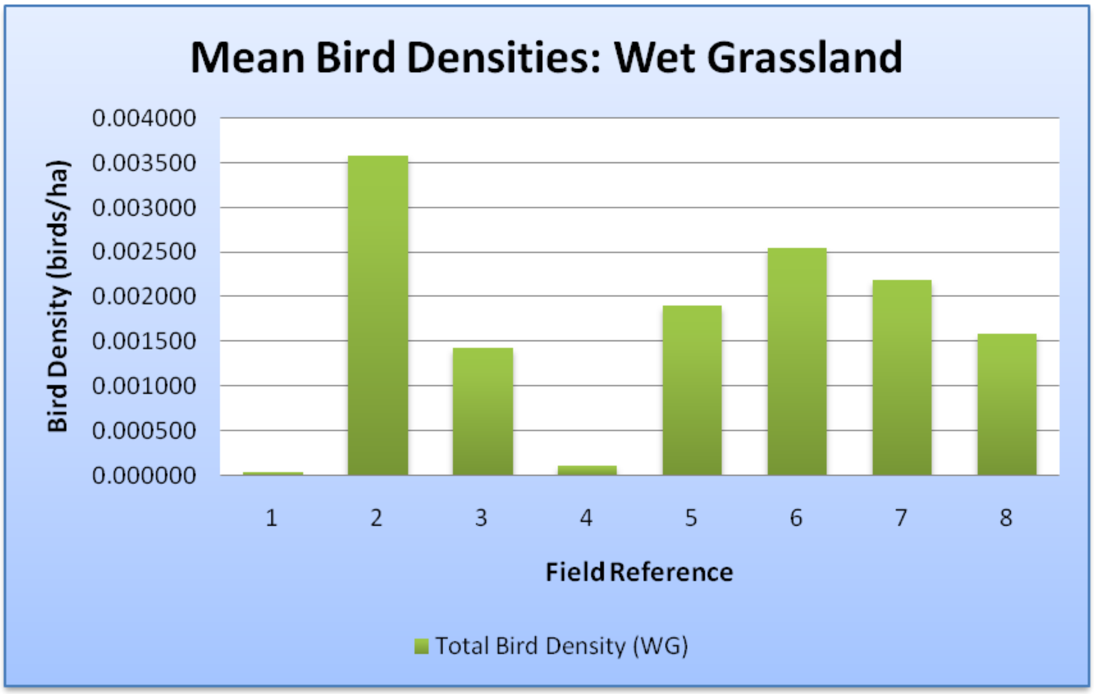

Figure.9 Mean bird densities (birds/ha) by field for wet grassland

The variance of mean bird densities per field in the wet grassland area, were not found to be statistically significant (Anova: F= 1.614, df= 7, $p < 0.14$). However, fields 1 and 4, both supported visibly lower bird densities (figure.9). For field 1 this may be explained by its relatively small size (table.3). Field 4 was one of the largest fields in the study (table.3) but had the least access of all the wet grassland areas, which is likely to have influenced the results. Field 2, an area primarily left as turf, supported the highest bird densities, reflected in the individual species preferences of both meadow pipit and skylark (figure.11). In addition, bird densities were not found to be significantly correlated with field size (rs= 0.21, df:6, $p < 0.6103$). Individual species densities by field were not analysed for either habitat due to the size of the dataset.

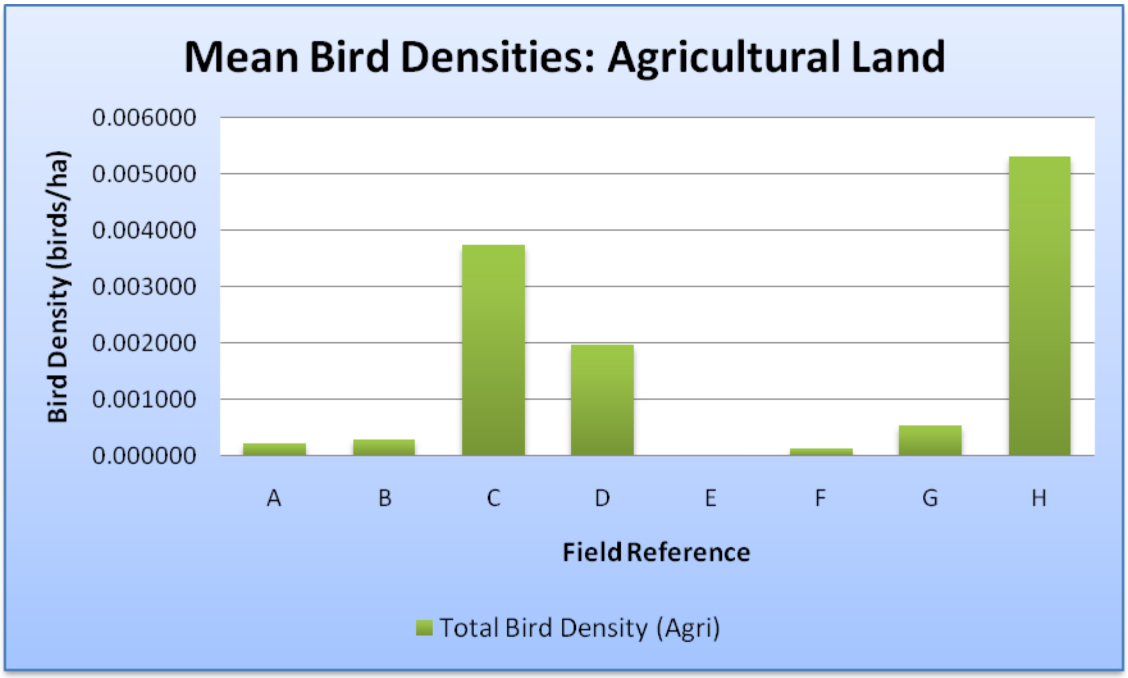

Figure.10 Mean bird densities (birds/ha) by field for agricultural land

The variance of mean densities between the agricultural fields were also not found to be statistically significant (Anova: F = 1.23, df= 7, $p < 0.3$). The fields predominantly consisted of winter sown cereals at a similar growth stage (table.5). Subsequently, preferences were not expected to have a high variance. Field H supported the highest bird densities of the agricultural fields (figure.10). This is likely to have been primarily due to a sizable flock of woodpigeon observed on a single occasion (01/02/08), further augmented by the field's relatively small size. The higher densities observed in field D were also largely influenced by the presence of large woodpigeon flocks. Field C was cultivated during the study period (28/12/2007) and supported higher bird densities after this point. As with the wet grassland, bird density and field area had no significant correlation (r_s= -0.33, df:6, $p < 0.4198$). The amount of information gained from this study regarding arable field preferences of bird populations is limited due to the interchangeable nature of agricultural land on a temporal scale and the study only covering one season.

5.42 Community and individual species habitat preferences between grassland conversion techniques

When the field counts were amalgamated in accordance with conversion method, no statistically significant variance in mean bird densities was demonstrated (Anova, F= 0.438, df:2, $p < 0.647$). Table.11 summarises the analysed data for conversion methods. The area left as turf supported the highest bird densities (21.8/ha) and had the highest diversity index value (2.05). The naturally regenerated area supported a considerable bird density (15.4/ha) and had the second highest diversity index value (1.49). The seeded area seemingly supported both the lowest species diversity (0.81) and the lowest bird densities (10.45/ha).

Table. 11 Total areas, Shannon-Weiner index values and mean bird densities by conversion type

Conversion Technique	Area (m²)	Shannon-Weiner Index value	Mean Bird Density (birds/ha)
Natural Regeneration	152,804	1.48846	15.37918
Seeded	341,725	0.81238	10.44700
Left as Turf	174,640	2.04666	21.81631

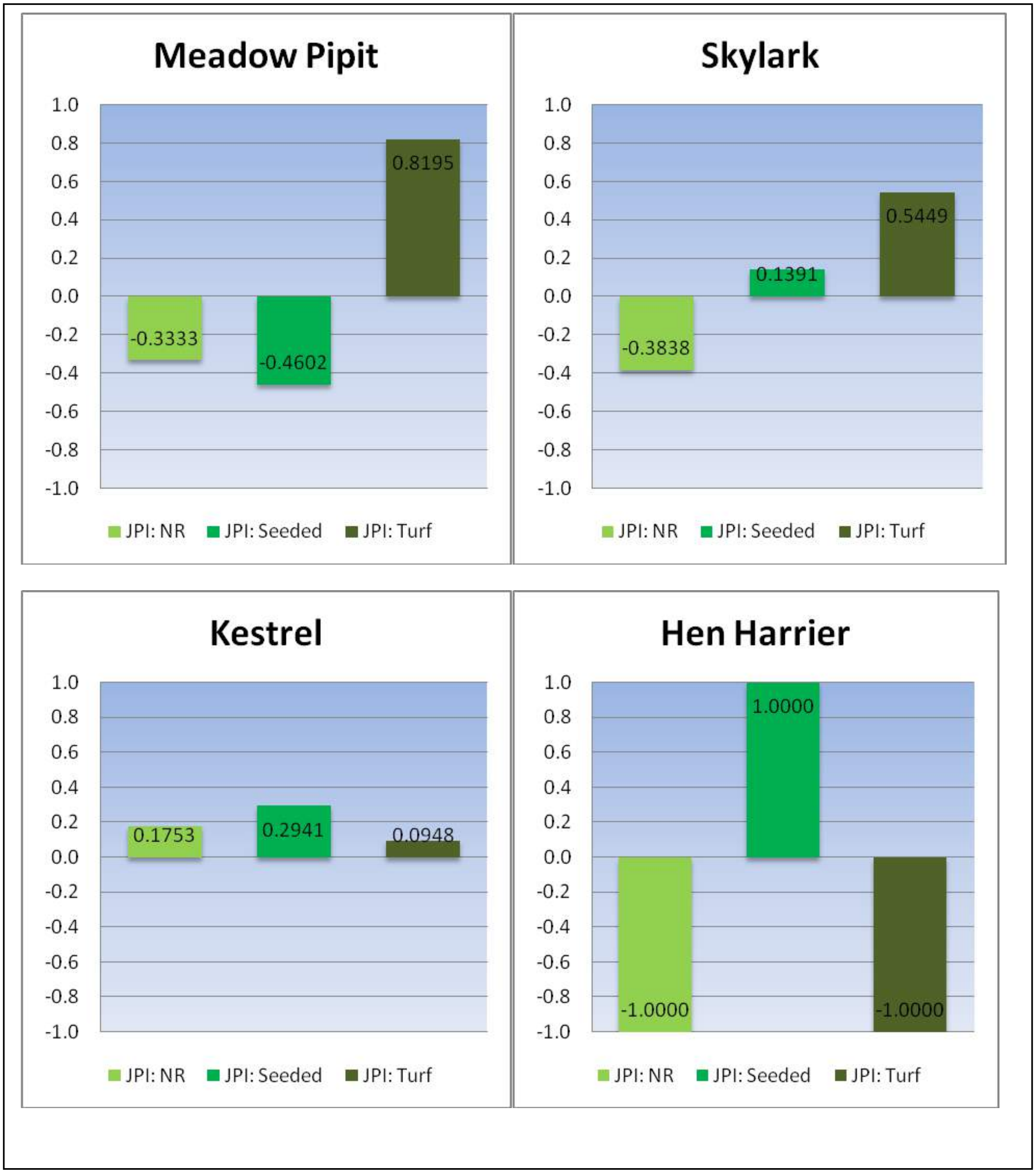

Figure.11 Jacobs preference indices (JPI) between conversion grassland type. (-1 indicates complete avoidance, +1 exclusive use and 0, usage in proportion with habitat availability)

Analysis of the preferences of individual species between grassland conversion method revealed some strong associations (figure.11). The hen harrier was exclusively associated with the seeded area (JPI= 1) and was predominantly observed hunting within the same field. Meadow pipit were strongly associated with the areas left as turf (JPI= 0.82) and avoided the naturally regenerated and seeded areas. Skylark demonstrated a moderate preference for the turf (JPI= 0.54) and utilised the seeded areas at levels only marginally above its proportional availability (JPI= 0.14), also displaying a moderate avoidance of the naturally regenerated areas. Kestrel, showed comparable preference levels for all conversion methods. It should be acknowledged that comparison of conversion methods was limited by the exclusion of a significant compartment of land within the site (field 7 – see plate.2 & table.3). The multiple grassland conversion techniques applied within the area made it unsuitable for subsequent analysis, despite 32% of birds occurring within the area.

6.0 Discussion

6.1 Wet grassland bird community

The wet grassland area at Tubney is already supporting relatively high bird abundance levels and a range of species, particularly passerines, just one year after conversion from agricultural land (table.6). Several species of conservation concern were found to be present in reasonable levels. Linnet, a red listed species and one that has observed a rapid decline in the UK (BTO, 2008) was the most abundant species at the site. A flock of around 50 were consistently observed in the same field throughout the study period. Starling and skylark were also found in good numbers, both species that are also red listed and have seen rapid UK declines according to the BTO's 'breeding birds in the wider countryside' survey (2008). Reed bunting and yellowhammer were also recorded, although in lesser numbers, both red listed species. Additionally, several amber listed species were noted at the site (meadow pipit, kestrel, snipe, stonechat, lesser-redpoll). Bird ringing carried out at specified locations at the site also confirmed the presence of linnet and yellowhammer (Thorne, *pers. Comm.*, 2008).

Conversely, wader species and wildfowl were largely absent from the site. Lapwing were recorded in very low numbers, mostly on the agricultural land and golden plover were not observed at all (table.6). Both of these species utilise grassland as a winter habitat (Milsom, 1994, Tucker, 1994, Barnett *et al.*, 2004) and large mixed flocks were observed in the surrounding areas throughout the duration of the study (personal observation). Both species, prefer short grassland swards and may actively avoid longer swards when shorter alternatives are available (Milsom *et al.*, 1998, Devereux *et al.*, 2004). Water table levels are also important for wader species (Devereux *et al.*, 2004). Recently flooded areas may contain a lower invertebrate biomass than traditionally flooded sites and a lack of water inundation can limit soil penetrability and subsequently, prey accessibility for waders (Ausden e*t al.*, 2001). The water levels at the Tubney site were sporadic but generally low with fragmented pools occurring. Swards were also relatively high and dense in certain areas. A combination of the grassland sward and water levels may have made the site unsuitable for plover species. Crucially, a lack of quantative data regarding either factor limits any clarification. Plovers are also known to use relatively few fields for winter foraging (Milsom, *et al.*, 1998) so the presence of a superior habitat nearby may have limited abundance levels. Snipe were recorded in modest numbers relative to their overall presence in the area. The prevailing flooding regime at Tubney is likely to have provided a suitable foraging habitat, given their preference for moisture retention but not excessive flooding, to maintain soil penetrability (Sutherland, 1995, Benstead *et al.,* 1997, Ausden *et al.,* 2001). Wild fowl may have also been largely absent due to the lack of widespread flooding to free up seeds from the sward (Benstead *et al.*, 1999). A mosaic of flooded and un-flooded areas including pools, may provide the best overall feeding habitat for wading species (Ausden and Treweek, 1995, Ausden *et al.*, 2001)

The presence of several raptor and owl species indicated a healthy prey population. Kestrel was the most recorded raptor (table.6). The presence of at least one female hen harrier from late November onwards was a significant observation. The hen harrier is persecuted in its moorland breeding habitat and is red listed as a result (Sim et al., 2007, BTO, 2008). The individual present may have been from the nearby Wicken Fen roost site which held around 6 individuals throughout the study period (R.Sargent, *pers. comm*. ,2008). Merlin (amber listed) and sparrowhawk were also observed in low numbers. Records from other observers (D.Elliot, *pers.comm.,* 2008- see appendix.2) confirmed the presence of both short-eared owl and barn owl at the site, as well as providing further hen harrier observations. The occurrence, particularly of the kestrel and owl species, indicates that a good small mammal population is present within the grassland. Voles are the main prey of kestrel (Valkama *et al.,* 1995) and barn owl (Love *et al.*, 2000) so are likely to occur at Tubney in significant levels. Grassland management sensitive to the ecological needs of small mammals, may help to maintain raptor populations at the site, which are seemingly high relative to the size of the area.

6.2 Habitat preferences between wet grassland and agricultural land

When taken as a whole, the newly created wet grassland site supported both considerably higher bird densities and species diversity than the immediately surrounding agricultural land. It was also utilised by a range of species that exclusively used it or demonstrated strong preferences for the habitat (table.6, figures 5 & 6). The results reflect the findings of broader scale studies of winter habitat selection in agricultural landscapes. Permanent and established grassland, although not specifically wet grassland, has been shown to sustain higher bird densities, particularly for invertebrate feeders, than other agricultural land uses. (Tucker, 1992, Wilson *et al.*, 1996). The individual species preferences will be dependent on their specific ecological requirements, notably their foraging behaviour.

Grassland supports high soil macro-invertebrate densities, where as the levels in arable cultivation are limited by constant ploughing and pesticide application (Tucker, 1992). The extra invertebrate food available in the grassland provides a food source for a number of passerines and is likely to be a significant reason for the habitat preferences displayed (McCracken and Tallowin, 2004). The wet grassland may have quickly developed a high invertebrate population, making it a suitable foraging habitat, although no invertebrate study was conducted. However, it was largely preferred by both primarily insectivorous and granivorous species. Seed-eating species have demonstrated preferences for un-grazed grassland, largely due to the prevention or limitation of seed production in grazed areas (Wilson *et al*., 1996). The land at Tubney was ungrazed for the duration of the study period, possibly allowing a substantial seed resource to establish. Skylark and starling abundance has previously been correlated with the quantity of seeding grasses in a sward (Perkins *et al.,* 2000). In addition, the linnet and skylark (table.6), are known to feed on the seeds of broad leaved plants (McCracken and Tallowin, 2004), which are likely to be largely absent from the arable land. Finches also feed on perennial grassland weeds (Robinson *et al*., 2001) and may explain the preferences of goldfinch, linnet and lesser redpoll.

The majority of the agricultural land surveyed (67.8%) consisted of winter sown cereals (not inclusive of pre-emergent crops). The strong avoidance of such areas by birds is well documented, particularly for granivorous passerines (Tucker, 1992, Wilson *et al.*, 1996). Only woodpigeon, carrion crow and red-legged partridge showed any preference for the agricultural land. Red-legged partridge are principally found in arable habitat (BTO, 2008), but carrion crow are generalists. They are known to feed on invertebrates (BTO, 2008) so are likely to have utilised the bare ground in the arable land to forage. Woodpigeon feed on the new shoots of emergent crops as well as grain and seed (Murton, *et al.*, 1964) and may explain the association with arable land, which consisted primarily of early growth stage winter crops. Wilson *et al.* (1996) found preferences for grazed grassland fields and bare till for both woodpigeon and red-legged partridge The fact that there were no between field preferences observed for the agricultural study area, is probably due to the arable usage of winter cereals across the site, with no examples of winter stubbles and only one alternative crop (table.5). Several granivorous birds species have previously demonstrated strong associations with winter stubbles, such as linnet and reed bunting (O'Conner and Shrubb, 1986, Wilson *et al.,* 1996). They have also been shown to support higher abundances of these species than winter sown cereals (Wilson, *et al.*, 1995). Seed banks can also be relatively comparable between grassland and arable crops, subsequently, field usage can be an aggregative response to resource densities for birds (Robinson *et al.*, 2004). Habitat selection may be indicative of the availability of resource rich habitat on a landscape scale (Robinson *et al.*, 2004). The lack of variation between fields may indicate a comparatively constant and poor foraging resource. The limited range of usage reflects the predominant arable farming methods utilised in the fenland areas of East Anglia, but other locations with differing farming practices may produce different results.

Habitat selection by birds is also potentially influenced by perceived and actual predation risk (Whittingham and Evans, 2004). The structure of the vegetation and the individual species predator defence mechanism can determine how a species may select a foraging habitat (Whittingham and Evans, 2004). Shorter swards often lead to an increased foraging efficiency, although the predation risk may be increased via exposure to a predator, or decreased greater visibility for earlier detection. Both skylark and starlings foraging efficiency is likely to increase in short swards and utilise the enhanced visibility as a defence strategy (Robinson and Sutherland, 1999, Devereux *et al.*, 2004, Morris, *et al.*, 2004). For these species the sward structure within the grassland may have provided a balance of beneficial foraging conditions (over the agricultural land) with enough scope for early predator detection, and could explain the preferences displayed. However, there are few empirical studies on the relative importance of predation risk as a habitat selection factor for birds.

The ecological value of both the wet grassland and agricultural land may also be strongly influenced by the relative value of the surrounding habitat. This may be apparent in terms of botanical composition, but also for bird populations. Biodiversity levels, even at a field scale may have implications for the surrounding area (McCracken, *et al.*, 2000, Weibull *et al.,* 2000). The relatively close proximity of Wicken Fen may have provided and adequate grassland seed bank for species to re-colonise the areas left to naturally regenerate and supplemented those which were seeded or left as turf. Without a long term botanical study, it is difficult to precisely determine the potential beneficial effects, or its implications for bird populations.

Granivorous species have been positively correlated with the amount of arable habitat in a grassland landscape (Robinson *et al.*, 2001). Although the study (Robinson *et al*., 2001) was conducted in areas where arable habitat was relatively scarce, the adjacent arable land at Tubney may have influenced the birds recorded on the wet grassland area. Woodpigeon and red-legged partridge, both primarily granivorous species (Morris, *et al,* 1964, BTO, 2008) were also recorded on the grassland in lesser numbers. However, several granivorous small passerines (skylark, goldfinch, linnet and reed bunting) were exclusively associated with the grassland resource and avoided the arable fields. This is likely to be due to the predominate use of winter cereals, corresponding with little cropping diversity and no winter stubbles across the study area, limiting its value to birds as discussed earlier (Gillings *et al.*, 2005, Marshall *et al.*, 2003).

In addition, the nearby Wicken Fen and Kingfishers Bridge reserves may have accelerated bird colonisation of the area and could explain the high species diversity seen at the site. Future ringing studies at the site, may determine the extent of birds utilising the area, originating from the main Wicken reserve, (table.12). Finally, the ornithological value of the agricultural area may have actually been enhanced by its immediacy to the grassland, although without broader scale comparisons this cannot be confirmed.

It should be acknowledged that the variance in habitat structure and access levels to each area may have influenced the bird counts. Birds were considerably more conspicuous in the sparse open swards of the agricultural land. The grassland areas provided effective cover for birds, notably the smaller passerines, limiting their visibility. The degree to which this affected the recording accuracy was species specific, dependent on their physical characteristics (notably, size and colouring) and their behavioural patterns. For example, if they were easily flushed and thus recorded, or stayed hidden within the grassland sward for as long as possible, reducing the likelihood of observation. However, the greater access afforded to the wet grassland due to the open access policy prevailing on National Trust land may have, conversely, increased bird visibility relative to the agricultural land and had the opposite effect. Certainly the smaller size of fields in the wet grassland area allowed closer viewing. In certain agricultural fields (particularly D & F), smaller passerines were difficult to identify from a long distance using just binoculars. In order to rectify this for future studies, permission could be secured from the land owners to walk the perimeters of the agricultural fields to improve viewing.

Tucker (1992) also highlighted the limited value of bird density as an indicator of habitat usage, due to the flocking tendencies of wintering birds having a large influence on results. Undoubtedly the large flocks of woodpigeon and starling had a considerable affect on the abundance analysis performed for the study. It is suggested that frequency of occurrence may be a better measure of abundance levels. However, analysis using this method was not possible due to the relatively small scope of the study and subsequent insufficient dataset.

6.3 Temporal trends

Analysis of temporal variations in bird abundance (density) was only performed for the bird population as a whole. The dataset was insufficient to assess individual species trends. There was no significant variation between site visits for either wet grassland or agricultural land, reflecting the findings of (Tucker, 1992). Although the study found no overall significant difference within the winter season for overall bird abundance, individual species trends have been noted for certain species such as the lapwing (Kirkby & Fuller, 1994, Village & Westwood, 1994). Wilson *et al.* (1996) noted an increased usage of bare till by birds during the initial period after sowing. Some fields were observably sown late (although no accurate data was available) and consequently may explain the observed higher bird density on the agricultural land in late November (figure.7).

The seed-bank in agricultural landscapes maybe significantly reduced by January, limiting food availability (Robinson *et al.*, 2004). However, bird densities on both the wet grassland and arable land saw increases by early February (figure.7). This might be due to comparatively less seed availability in the surrounding landscape, encouraging birds to utilise the site for foraging. Overall, bird densities followed a similar trend within both the wet grassland and agricultural land, indicating that the patterns were a consequence of general bird population fluctuations in the area as a whole. It should be acknowledged that data from just one winter season is insufficient to empirically measure temporal variations in bird abundance.

Species compositions were also analysed to assess any change in the species overlap between the wet grassland and arable land throughout the winter. On the several occasions when increased similarity between the habitats occurred (table.10), it was primarily due to the species that were associated with the agricultural land (carrion crow, red-legged partridge and woodpigeon) also utilising the grassland area. Both carrion crow and woodpigeon are generalists and are observed in a range of habitats including pastoral, also having varied diets (BTO, 2008). Although the red-legged partridge is predominantly a granivorous bird of arable land, it also uses grassland for foraging (BTO, 2008). The usage of the grassland area by these species may have been due to reduced food availability or amplified risk of predation in their preferred areas, encouraging them into alternative sections of the site.

6.4 Grassland conversion techniques

The analysis of the effect of conversion technique on birds was undermined by the exclusion of field 7, which supported 32% of the total bird abundance within the grassland study area. The defined areas of conversion method did not correspond with the area boundaries used during the recording process. Also the specific seeding mixtures used and application dates were unavailable. No significant variances were found at the bird community level either between fields or conversion methods (table.11). However, the area left as turf seemingly supported the highest bird density and species diversity, followed by the naturally regenerated land and subsequently the seeded areas, which supported the lowest densities and diversity levels.

The habitat selection factors between grasslands for general bird populations are extensive and multifaceted. Food supply, sward structure, predator avoidance and water table levels are likely to be key variables between the grassland conversion method swards at the site (Devereux *et al.*, 2004, Whittingham and Evans, 2004). This is further complicated by the potential effects of the adjacent boundary habitat and human disturbance levels (Milsom *et al.,* 1998). The scope of the study did not accommodate for the measurement of habitat selection variables so clarifying the reasons for the habitat choices displayed for general bird populations is speculative. Measurement of specific variables would facilitate more accurate assessment, notably botanical and structural sward surveys and water logging extent.

Specific species preferences are easier to assess when their relevant habitat requirements are understood. General differentiations between the swards were made observationally although not quantifiably as discussed earlier. The species preferences by conversion type were variable for those analysed (figure.11). The meadow pipit’s strong preference for the areas left as turf may be due to the longer and denser swards apparent in the turfed areas (Perkins *et al.*, 2000). Barnett *et al.* (2004) found that they were associated with the presence of seeding grasses. Their predominantly insectivorous feeding habits, indicates a sufficient invertebrate food supply in preferred areas. This can be adversely affected by a water management regime that promotes flooding (McCracken and Tallowin, 2004). Consequently, the flooding was seemingly the least extensive on the turf, and may have allowed the invertebrates population to quickly establish. The avoidance of naturally regenerated swards and seeded fields may have been due to the generally sparser grass cover and the degree of surface water was also seemingly higher in these areas. The extent of water logging was not scientifically measured, so the empirical information gained from this aspect of the study is limited

Skylark showed a preference for the seeded areas, although not as strong as the meadow pipit (figure.11) and also demonstrated a usage of the seeded areas generally in proportion with its availability. A primarily granivorous species, their association with the turfed areas potentially indicates an adequate extent of seeding grasses and broad leaved plants (McCracken and Tallowin, 2004). They have also shown tendencies for early predator detection strategies, preferring feeding in open areas and larger fields (Schon, 1999, Donald *et al.,* 2001, Benton *et al.*, 2003). However, the fields left as turf were generally smaller in area than those with other conversion method, making the findings inconsistent with other studies. A potential reason is that the extent of food supply within the naturally regenerated and seeded areas was too insufficient to justify occupation, despite the field's larger sizes and subsequent scope for early predator detection.

The raptor species showed differentiation between habitat choices. Kestrel seemed to utilise each conversion method to a similar degree, where as the hen harrier demonstrated an exclusive usage of the seeded fields (figure.11). This is probably due to the differences in feeding ecology between the two species. The kestrel's main prey consists of small mammals, notably voles (Rijnsdorp *et al.,* 1981). The extent of prey visibility and small mammal densities between the swards may have little variance, although without a mammal survey this is hard to determine. Hen harrier feed on small passerines, notably skylark and meadow pipit, but also take mammals such as voles and rabbits (Clarke, 1990, Clarke *et al.*, 1997). The preference for seeded areas, not reflected by the kestrel, may suggest a diet based on small birds. However the preferences of both skylark and meadow pipit (figure.11) do not indicate greater prey availability in these areas. It is possible that the sparser cover for potential prey species offered in the seeded fields, increased prey accessibility or vulnerability.

The preference for the areas left as turf for general bird populations may be a short term effect of sward maturity. Grassland age has been positively correlated with starling and carrion crow presence (Tucker, 1992). Naturally regenerated areas are likely to undergo slow vegetational establishment where as seeded restorations have produced more diverse and quickly established swards (Manchester *et al.,* 1999), an important consideration for birds (Benton *et al.*, 2003). The moderate preferences displayed for naturally regenerated land conflict with the trends for optimal botanical composition (Manchester *et al.,* 1999). Naturally regenerated areas may therefore be valuable for birds at the site due to enhanced access to the soil surface for foraging. The conversion method preferences are likely to vary over time and as the regenerated and seeded areas develop, they may begin to support higher bird densities and diversity. Continued monitoring would allow for the assessment of these temporal changes. In addition, it should be acknowledged that the use of established turf to recreate wet grassland is a largely unique method, only likely to be relevant to a small number of sites. Seeding and regeneration are more common and widespread methods of conversion.

The future management methods employed at the site are likely to have implications for bird populations, in particular, principally grassland species (Batáry *et al.*, 2007). Grazing is intended for the site in the future and animal choice and stocking densities can alter grassland structure and species compositions (Vickery *et al.*, 2001, Devereux *et al*., 2004). Cattle promote heterogeneity within the sward and may have a potentially positive effect on avian diversity (Perkins *et al.*, 2000, Benton *et al.*, 2003, Whittingham and Evans, 2004, Batáry *et al.*, 2007). In particular grazing with cattle may attract the plover species (lapwing & golden plover) found to be largely absent from the site (Vickery *et al.*, 2001). Mowing regime potentially effects seeding grass prevalence and species composition (McCracken and Tallowin, 2004) Additionally, water table management and its subsequent effects can also effect bird species presence (Ausden *et al.*, 2001). The results of the survey can be used to target management at the requirements of declining or desirable species such as the skylark and hen harrier.

7.0 Conclusion & Recommendations

The wet grassland area created at Tubney is already supporting a relatively diverse wintering bird population with several species of conservation concern present. The improved habitat suitability and diversity, over its previous use as a turf farm, has undoubtedly been beneficial to birds, supporting them in significantly more abundance and diversity than the surrounding arable land. This is exacerbated by the number of species exclusively or strongly associated with the grassland resource at the site. Although no comparison with a more established local recreation was possible due to a lack of data, it is now likely to be a site of at least local importance for bird populations. The use of turf as a creation method is unlikely to be applied at other sites across the country, but natural regeneration appeared to be the next best option for birds in the short term, although preferences are likely to change over time. Variance in species preferences between conversion techniques was restricted to those most abundant, due to unforeseen problems in the methodology. The results are particularly valuable for site management specific to Tubney. The birds utilising individual areas can be included in subsequent habitat management. The study has started an initial baseline for monitoring, which could produce beneficial results regarding the temporal variations in bird communities in relation to conversion method. The results only relate to short term effects and a study over a longer time period incorporating breeding birds, would facilitate greater comprehension (recommendations made in table.12).

The findings also demonstrate that creation of a wet grassland habitat on ex arable land has the potential to produce almost immediate and substantial benefits for bird populations. Subsequently, the indications of species likely to benefit from created wet grassland can be taken into account when evaluating their status and future conservation methods and targets. For example, the hen harrier has been shown to immediately use a newly created wet grassland area for foraging and may benefit quickly from a creation programme. The results are of most value to the local area, where the facilitation of the Wicken Vision, pertaining to planned wet grassland creation attempts (National Trust, 2007) may be aided by the findings. The Great Fen Project in North Cambridgeshire and Higher Level Stewardship Scheme (HLS) (Defra, 2006) which both involve similar conversions may also benefit from the study.

Effective wet grassland creation is likely to be crucial for the sustainable conservation of the associated birds when the small extent of the current resource is taken into account. It should be acknowledged that due to the scale of the study and it being restricted to one site, extrapolation to other projects in other locations should be conducted with care. It may be that the sites proximity to other areas of importance for birds dramatically accelerated the colonisation process. The variability of a range of factors, such as climatic conditions, soil type, altitude and local bird population composition may alter the effects of a creation attempt for birds.

The aims and objectives of the research were largely met, although the methodology limited the extent and subsequent wider applicability of the conversion technique comparisons. The study is a good starting point for bird population monitoring at the site, which will further enhance the understanding of the relationship between wet grassland creation and bird population dynamics. A number of recommendations relating both to specific management at Tubney and further research are outlined in table.12.

Table.12 Recommendations for further research and future habitat management at the Tubney Site.

Further Research	Habitat Management at Tubney
• Continued monitoring at the site to establish long term temporal trends in species composition and abundance relating to conversion technique. Also breeding birds surveys to incorporating species present on the site during the summer (possibly utilising future project students or the Wicken Ringing group). • Bird ringing at the site to assess the extent of birds utilising it from the main Wicken Reserve, may enhance knowledge of local bird population dynamics and colonisation rates. • Increased monitoring work at Burwell Fen (a more established section of the Wicken Vision Plan) to enable comparison. • Assessment of grassland habitat characteristics to identify the basis for the displayed bird preferences, in particular: o Botanical surveys for the areas of grassland conversion method (NVC methodology) o Small mammal surveys to determine any spatial variations in abundance o Measure and map the extent of waterlogging • Larger scale, multiple site studies of bird populations utilising a new wet grassland resource. This would provide increased scope for extrapolation. The Wicken Fen Vision project area, may be a suitable long term study site.	• Ensure that future grazing regime promotes sward heterogeneity and incorporates the specific requirements of those species found at the site, notably plovers. • Encourage managed water logging across the site to encourage wader and wildfowl colonisation. A mosaic of varying depth/extent may give the broadest benefit. • Scatter additional grass seed in the the naturally regenerated areas to enhance botanical diversity, potentially beneficial for birds. • Maintain the seeded areas at a suitable sward height for hen harrier foraging. • Ensure that any planned recreational infrastructure has a minimal impact on birds. Provision of bird hides would partially facilitate this as well as promoting recreation. A potential location is the elevated area adjacent to the mere (plate.2), which gives panoramic views over a large proportion of the site. • Create a management plan to facilitate the implementation of habitat management. It should be systematic and be reactive to any new information regarding bird populations at the site.

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Appendix.1 - Raw Data Tables

Total bird counts by field (Wet grassland: whole study period)

	1	2	3	4	5	6	7	8	Total Counts
Carrion Crow					1	1		1	**3**
Chaffinch					3				**3**
Goldfinch			9		55	2	1		**67**
Gull spp.									**0**
Hen Harrier				1			7		**8**
Heron							1	4	**5**
Kestrel		2	1	7	1		2	2	**15**
Lapwing						1			**1**
Linnet		30				290	75		**395**
Magpie	1			2	2		13	2	**20**
Mallard			9						**9**
Meadow Pipit		73	12		17	24	22		**148**
Mute Swan									
Merlin							1		**1**
Pheasant		3			1		1	12	**17**
Pied Wagtail					2				**2**
Red-Legged Partridge			10						**10**
Lesser Redpoll		20			17				**37**
Reed Bunting			11	9	2		3		**25**
Rook		4				2			**6**
Sky Lark		15	3	3	1	13	27		**62**
Snipe			3			1			**4**
Sparrowhawk					1				**1**
Starling					80		197		**277**
Stonechat			6	1			2		**9**
Wood Pigeon		47					103	150	**300**
Yellow Hammer		3					4		**7**
Area Totals	**1**	**197**	**64**	**23**	**183**	**334**	**459**	**171**	**1432**

Total bird counts by field (Agricultural land: whole study period)

	A	B	C	D	E	F	G	H	Total Counts
Carrion Crow		1		4	1	8	6	4	**24**
Chaffinch			2						**2**
Goldfinch									**0**
Gull spp.		9	41				3	1	**54**
Hen Harrier									**0**
Heron									**0**
Kestrel		1		1					**2**
Lapwing				33		2			**35**
Linnet									**0**
Magpie	1					2			**3**
Mallard									**0**
Meadow Pipit									**0**
Merlin									**0**
Mute Swan						4			**4**
Pheasant			1				5		**6**
Pied Wagtail									**0**
Red-Legged Partridge	5		12	9				5	**31**
Redpoll									**0**
Reed Bunting									**0**
Rook						1			**1**
Sky Lark									**0**
Snipe									**0**
Sparrowhawk									**0**
Starling								25	**25**
Stonechat									**0**
Wood Pigeon	5		60	333		1	100	150	**649**
Yellow Hammer			2						**2**
Area Totals	**11**	**11**	**116**	**380**	**1**	**18**	**114**	**185**	**836**

Appendix.2 Additional Observational Records (Elliot, D, 2008)

for AARON

Tubney Fen 2007

June	1	Common Sandpiper
	1	Little Egret
	1	Barn Owl
21 September	2	Marsh Harrier
	4	Kestrel
	1	Kingfisher
23 September	150	Swallow
	2	Kingfisher
1 October	1	Marsh Harrier
2 October	2	Tawny Owl
	1	Jay
	2	Magpie
	6	Meadow Pipit
3 November	1	Short eared owl
	6	Mute Swan
	2	Coot
	1	Teal
	9	Widgeon
	1	Little Grebe
	15	Yellowhammer
	5	Linnet
	1	Sparrowhawk
	25	Meadow Pipit
	100	Fieldfare
24 November		Dead Short eared owl
27 November	1	Barn Owl
	2	Mute Swan
	250	Woodpigeon
	10	Linnet
	4	Snipe
28 November	20	Linnet
17 December	1	Barn Owl
24 December	2♀	Hen Harrier
26 December	1♂	Hen Harrier

Appendix.3 Risk Assessment Form

FACULTY OF HEALTH AND HUMAN SCIENCES
SCHOOL OF LIFE SCIENCES

Initial Risk Assessment

Ref No

Date

Review

Title of activity	The value of newly created Wet Grassland, for wintering bird populations
Location of activity	Tubney Fen, near Wicken, Cambridgeshire
Brief description of activity	A systematic observational winter survey of bird populations conducted in and around the 101 hectare Tubney Fen site. This will involve 1 – 2 hours walking along tracks and paths, between November 2007 and February 2008.
Personnel involved	Aaron Grainger

List the hazards that will be encountered in the activity designated above using the information overleaf and calculate the risk classification where **RISK = Likelihood x Severity**

Hazard	Likelihood Score	Severity Score	Risk Score & Classification
Slips/Trips/Falls	2	2	4
RSI/ Eye Strain form prolonged computer usage back/neck pain.	1	2	2

Risk Score	Risk Classification	Action
1-2	Trivial	NO FURTHER ACTION REQUIRED
4-6	Tolerable	No additional controls required. Maintain current controls. Monitor.
8-16	Moderate	Reduce risk if cost effective. Implement new controls over a set period.
24-36	Substantial	DO NOT START activity. If work in progress, take urgent action.
48-64	Intolerable	Activity **MUST STOP** and not be started unless risk is reduced. Activity prohibited if no reduction in risk.

If risk classification is moderate (score of 8 and above) a full risk assessment will be required.

Types of hazard likely to be encountered in the School of Life Sciences:

Animal allergens
Biological agents
Chemical compounds
Compressed/liquefied gases
Display screen equipment
Electricity
Farm machinery
Fire
Glass
Hand tools
Ionising radiation
Laboratory/office equipment
Ladders
Manual handling
Non-ionising radiation
Pressure systems
Repetitive handling
Sharps
Slips/trips/falls
Stress
Vacuum systems
Vehicles
Workshop machinery
Others - please list

Definition of terms used:

Factor	Risk Classification	Likelihood	Severity
1	Trivial	Harm will not occur or is very unlikely to occur	No injury or disease Minor damage Group 1 organisms
2	Tolerable	Harm could occur but is unlikely to occur	Minor injury or disease Minor damage. Harmful/irritant compounds Group 2 organisms Manual handling less than guideline weights
4	Moderate	Harm possible	Moderate injury (over 3 days) Moderate damage to building/plant Corrosive/toxic/flammable compounds Group 3 organisms Manual handling at guideline weights
6	Substantial	Harm likely to occur	Serious injury or disease Serious damage to building or plant Suspect carcinogens Manual handling up to twice guideline weights
8	Intolerable	Harm will occur or is very likely to occur	Likely fatality Serious structural damage Plant damaged beyond repair Very toxic compounds Human carcinogens Group 4 organisms

Is a full risk assessment required?[1] **Yes / No**

Please print and sign your name below when the initial risk assessment is complete.

Assessor A. Given **Date** 01/10/07

Status[1] **Undergraduate / MSc student / PhD student / Staff**

Supervisor G. Greenbrown **Date** 01.11.07.

Head of Department[2] R. Southern **Date** 1/11/07

Technical Manager[2] **Date** 1/11/07

[1] Please delete
[2] Authority may be devolved to Head of Division/Departmental Safety Advisor as appropriate