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Targeting areas for the restoration and re-creation of coastal and floodplain grazing marsh

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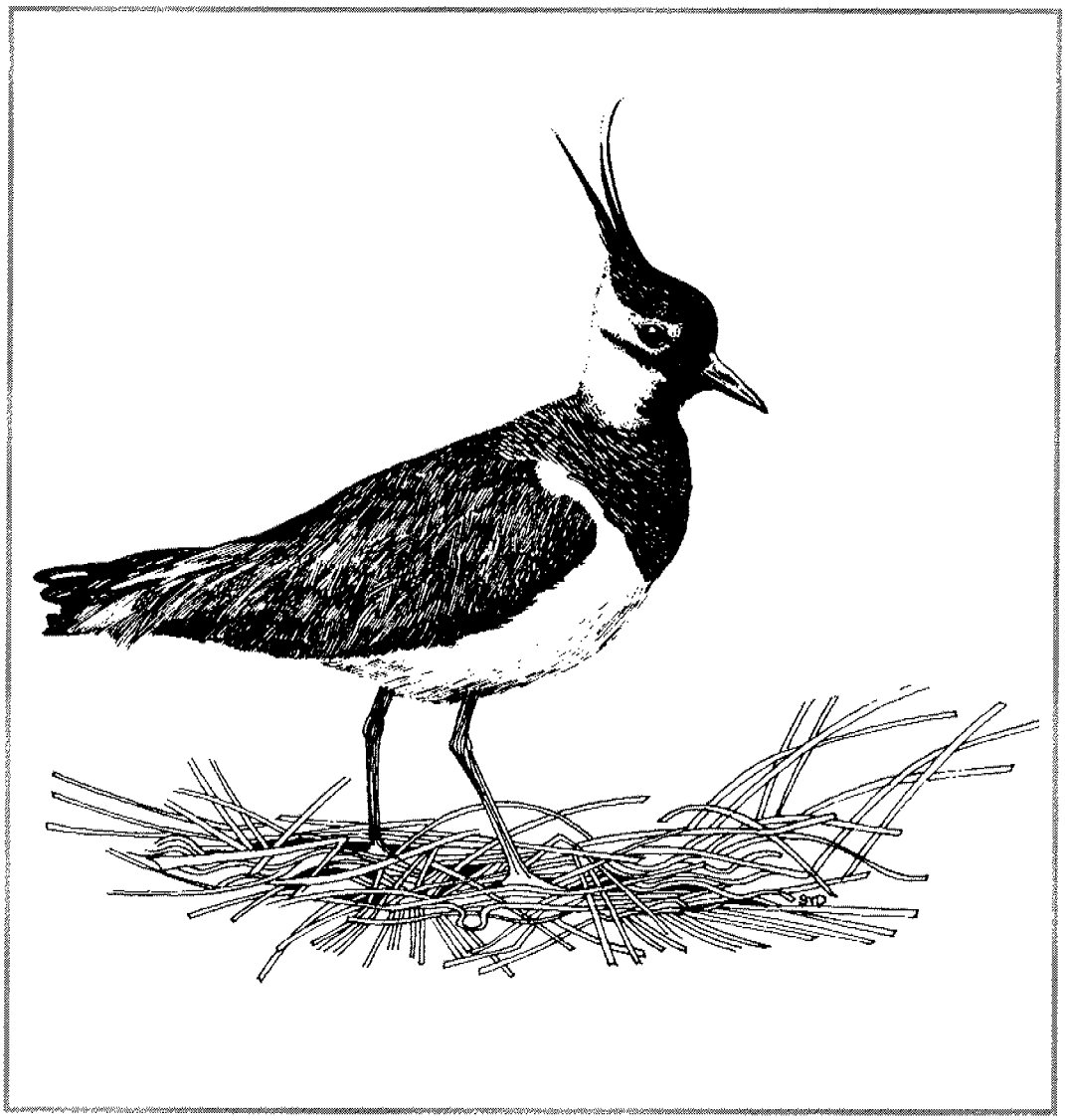

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Targeting areas for the restoration and re-creation of coastal and floodplain grazing marsh

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Acknowledgements

Construction of the *Grazing Marsh GIS* required access to a wide variety of data-sets. The authors want to acknowledge the great help provided by Dr Martin Drake and Rob Cameron of English Nature for acting as the conduit for these data, and ensuring that they arrived with the ITE in a usable form. We would also like to thank Dr Andy Swash, David Askew and Andrew Cooke of FRCA for arranging access to Countryside Stewardship Project Officers, and providing a summary of take-up data for England. Within the Environment Agency, Alastair Duncan, Graham Storey and Neil Veitch provided a data-set on arable land liable to flood from rivers. Phillipa Swanton of FRCA provided a 5m contour data-set as a means of identifying coastal arable land liable to flood.

A major part of the current project was a survey of current and planned restoration schemes. The success of the survey depended on the response and active co-operation of local and national officers of English Nature, FRCA, the RSPB, the Wildlife Trusts, BASC, FWAG, the Environment Agency *etc.* These individuals are listed in Appendix 2B, and the ITE very much appreciates the help they provided.

The authors are grateful to the following colleagues who participated in a workshop at Monks Wood to discuss the targeting and evaluation of restoration schemes. From ITE: D.R. Barratt, P.D. Carey, M.O. Hill, S.J. Manchester, R.F. Pywell, J. Sheail and C.C. Stuckey; and from English Nature: M. Drake and J. Trueman. Particular thanks go to Richard Pywell who led discussion, as well as introducing the theme of measuring success, and to Martin Drake and Peter Carey who respectively explained the background to the research and the principles behind coining objectives for habitat restoration. Sarah Manchester recorded the proceedings of the workshop and an edited version of her very full account is included as Appendix 4.

The authors are very grateful to Martin Drake and Rob Cameron for their constructive criticism of the first draft of this report, which we hope has led to a more useful account of the research.

Executive summary

1. This report describes research undertaken by the NERC Institute of Terrestrial Ecology, and is accompanied by a confidential Annexe and the *Grazing Marsh GIS*. It was prepared in response to the Steering Group of the Habitat Action Plan for coastal and floodplain grazing marshes.

2. The purpose of the research was to assess the conservation value of the extant grazing marsh resource and its geographical variation. Secondly, the project sought to develop a strategy for targeting restoration of grazing marsh both where losses had been most pronounced and where implementation of restoration schemes was likely to be most successful.

3. The research followed creation of a *Grazing Marsh GIS* incorporating both the sites mapped by Dargie (1993, 1995) and botanical data from the Biological Records Centre at ITE Monks Wood. These data were used to derive quality assessments for all the individual grazing marsh sites in England [Chapter 3].

4. Within the present project, zoological data (birds and insects), data on designated areas and EN Natural Areas, and take-up of agri-environment schemes were added to the *Grazing Marsh GIS* [Chapter 4].

5. The grazing marsh resource was re-evaluated on the basis of zoological and botanical criteria, and six attributes (3 ornithological, 1 entomological and 2 botanical) were used to rank both the Natural Areas and all individual sites. Evaluation was conducted on each attribute individually, and then the results combined to provide an overall ranking of Natural Areas on the basis of grazing marsh quality [Chapter 5].

6. The Natural Areas were also ranked on the basis of the total area of grazing marsh they contained. The qualitative and quantitative rankings were then compared. Ten Natural areas with extensive high quality grazing marsh were chosen as providing sites where habitat restoration was most likely to be successful. A further 13 Natural Areas were selected where there was large areas of degraded marsh, or ditched arable land, and where restoration might achieve the greatest net gain in biodiversity [Chapter 5].

7. A survey was conducted of extant and planned restoration activity and the results tabulated as an Annexe, a summary of whose contents were linked to the *Grazing Marsh GIS*. Schemes were classified on the basis of whether they met re-creation, rehabilitation or enhancement goals, and on whether they were ongoing, likely to occur, or represented highly speculative long-term planning. The total areas of schemes (ha) in each category were summarised both by Natural Area and by Environmentally Sensitive Area [Chapter 6].

8. Partly through a workshop at ITE Monks Wood, methods were reviewed for the identification of targets for habitat restoration and evaluation of the success of restoration schemes [Chapter 7 and Appendix 4].

9. The ranking of Natural Areas based upon biological and size criteria was compared with a further assessment based upon the liability of the land to flood, its altitude and

the land-cover present in 25m cells derived from the *ITE Land Cover Map*. The initial and secondary rankings were closely related, and supported the original selection of 23 Natural Areas. [Chapter 7]

10. Methods for determining targets for re-creation and rehabilitation of grazing marsh were assessed under a number of scenarios based on differing restoration approaches. The degree to which targets might be met by ongoing and planned schemes was estimated. Final restoration targets were set for those Natural Areas selected on biological criteria and the proportion allocated on the basis of the amount of suitable land-cover *i.e.* tilled for re-creation and grassland for rehabilitation. These Natural Area targets were expressed as a percentage of the likely English national targets for re-creation and rehabilitation [Chapter 7].

11. The report acknowledges that two clear approaches to targeting exist, focusing either on areas of high quality marsh where success is likely, or on degraded marsh and ditched arable where relative gain in biodiversity may be greater. The report is accompanied by a confidential annexe of schemes, a compact disc containing the *ITE Grazing Marsh GIS* and a diskette with those GIS files which contain confidential information.

1. Background

Coastal and floodplain grazing marsh has been recognised as a key habitat in the UK (UK Biodiversity Steering Group, 1995), and represented one of the first habitats to have a costed Habitat Action Plan prepared. The plan sought not only to maintain some 300,000 ha of extant marshes in the UK, but also to rehabilitate 10,000 ha and create a further 2,500 ha on ditched arable land by the year 2000. Overall responsibility for meeting these objectives lay with a Steering Group chaired by English Nature, but with representatives from the Environment Agency (EA), the Royal Society for the Protection of Birds (RSPB), Countryside Council for Wales (CCW), Scottish Natural Heritage (SNH), the Ministry of Agriculture Fisheries and Food (MAFF), the Farming and Rural Conservation Agency (FRCA), the National Farmers' Union (NFU), the Association of Drainage Authorities (ADA), the Wildlife Trusts, British Association for Shooting and Conservation (BASC) and the Broads Authority. English Nature sponsored a research programme to help meet targets set by the Habitat Action Plan. The present report details research conducted during the third phase of this programme.

The grazing marsh habitat represents a characteristic landscape, made up of lowland wet grassland, and other features such as surface drainage channels. This landscape was created by the early stages of agricultural reclamation of floodplain and coastal wetlands (Mountford and Sheail, 1989), but a substantial proportion of the original area has since been subject to further drainage and converted to intensive arable land (Mountford, 1994). The nature conservation value of grazing marsh lies not only in its important populations of wetland birds, but also in invertebrates and plants, especially those associated with the channels. The continued survival of this diverse wildlife requires integrated management of water-levels, grazing, and grass-cutting (Benstead *et al.*, 1997). Grazing marsh continues to be vulnerable to agricultural intensification, neglect and inappropriate management of water and vegetation. In addition, there are direct losses to industrial and urban expansion, pollution and mineral extraction, particularly of river gravels and peat (Mountford, 1994).

Five fundamental objectives for successful habitat conservation and ecological restoration may be recognised, applicable to all key habitats:

I. Estimate the past distribution of the resource.
II. Assess the present distribution of the habitat and its geographical variation.
III. Review current management practices.
IV. Assess the scope for ecological restoration (rehabilitation and re-creation).
V. Target restoration effort where
    a. losses have been most pronounced; and
    b. implementation of schemes is most likely to be successful.

The need for inventory alluded to in objective II was largely met by Dargie (1993, 1995), whose definition of "lowland wet grassland" corresponds closely to "grazing marsh" in the sense used in this report. Some indication of the variation in grazing marsh vegetation (including geographical) can be gained through the National Vegetation Classification (*NVC:* Rodwell, 1991, 1992, 1995). Unfortunately, the *NVC* account of aquatic and swamp vegetation pays rather little attention to drainage channels, and its usefulness in grazing marshes is thus reduced.

The current research programme was initiated when English Nature commissioned a Geographical Information System that incorporated the maps prepared by Dargie (1993). These maps sought to depict the entire lowland wet grassland (grazing marsh) resource for England extant in the early 1990s. It is useful to compare the Dargie maps with those produced by ADA and Marshall *et al.* (1978), which show those areas of England and Wales drained by land drainage channels. Such maps may be taken to indicate the potential distribution of grazing marsh. Further estimations of the maximum extent of grazing marsh may be gained from maps of a) soils derived from river and marine alluvium, b) areas protected by flood banks, or known to be liable to flood; and c) areas below 5m AOD. Taken together with historical land-use information (tithe returns, OS maps, land-use maps *etc.*), an appraisal may be made which partly meets objective I.

The NERC Institute of Terrestrial Ecology developed a general strategy for addressing objectives I, II and V, which used wet grassland as its example (Mountford *et al.*, 1997). This research was commissioned by MAFF, but was also presented to the steering group of the grazing marsh Habitat Action Plan. Following this presentation and report, the ITE were commissioned by the Environment Agency and RSPB to develop the approach for grazing marshes, through adding botanical data to the basic GIS. The approach followed by this second phase of the research programme (completed in June 1998) is outlined in Chapter 3. The present project further builds on this methodology, adding a much greater range of data-sets to the *Grazing Marsh GIS*, and attempts to meet objective V.

Note: The indiscriminate use of the terms "restoration", "rehabilitation", "enhancement" and "re-creation" has caused much confusion amongst scientists, conservationists, policy-makers and land-managers. Bradshaw (in press) has discussed in detail the meaning of these words, and the practices/purposes that each implies. Whilst not claiming that the present report is absolutely free of such inconsistencies in their usage, an attempt was made to strictly follow the definitions advanced by Bradshaw, and set out here on page 5 of Appendix 4, which describes a workshop held at Monks Wood.

2. Objectives of study

1. To set restoration and re-creation targets for each of English Nature's Natural Areas.

2. To establish criteria for the identification and evaluation of projects which may be taken forward to meet targets identified in the Biodiversity Action Plan.

3. To identify parcels of land which collectively meet the national target for restoration and re-creation.

3. Introduction

3.1 Creation of the national grazing marsh GIS

The first requirement for successful implementation of the Habitat Action Plan for coastal and floodplain grazing marsh was detailed knowledge of the extent and condition of the resource. As discussed above, this had been largely achieved by Dargie (1993, 1995), though there were some problems and omissions (Jefferson and Grice, 1998). Most significantly, the estimated total of *ca.* 230,000 ha for the extent of "lowland wet grassland" excluded Lincolnshire and blocks whose extent was <10 ha. However, as a baseline for defining the distribution of grazing marsh, these paper maps were clearly invaluable. Therefore, as the first stage in the present programme of research, English Nature commissioned a Geographical Information System (GIS) which incorporated all the blocks of lowland wet grassland identified by Dargie. This GIS, hereafter referred to as the *Grazing Marsh GIS*, was augmented in later studies and forms the basis of the present work.

3.2 Augmentation and use of the Grazing Marsh GIS

3.2.1 Botanical data-sets

The first stage in the building up of the *Grazing Marsh GIS* was to add a wide range of botanical data-sets held in the Biological Records Centre at ITE Monks Wood (Roy *et al.*, 1998). Biological indicator values derived from survey and experimentation are increasingly used to assess the quality of habitats and communities, and also to monitor change (Ellenberg, 1988; Londo, 1988; Mountford and Chapman, 1993; Mountford *et al.*, 1997). At the outset of the present programme of research, Mountford and Newbold devised a provisional system for ranking the indicator value of individual plant species for grazing marsh (included as an Appendix in Mountford *et al.*, 1998c). This system was reviewed by experts within English Nature, and following revision used in the project commissioned by the Environment Agency and the Royal Society for the Protection of Birds. The use of indicator values allowed the evaluation of sites both on the basis of their botanical complement and their quality (see 3.2.2/3). The botanical data assembled during this project were associated in the *Grazing Marsh GIS* with this refined indicator ranking.

A large botanical data-base was created that could be spatially referenced to the grazing marsh sites identified by Dargie (1993, 1995) and held within the *GIS*. This data-base was itself derived from six other major data-bases which were (or continue to be) built up during the preparation of major works on plant distribution:

1. the main BRC botanical data-base (built up since 1960);

2. *Atlas of the British Flora* (Perring and Walters, 1962; second edition 1982);

3. *Scarce Plants in Britain* (Stewart, Pearman and Preston, 1994);

4. *Pondweeds of Great Britain and Ireland* (Preston, 1995);

5. *Aquatic Plants in Britain and Ireland* (Preston and Croft, 1997); and

6. *Atlas 2000* project (rapidly expanding - 1995 onward).

The potential distribution of grazing marsh was assessed by a co-occurrence approach (Mountford *et al.*, 1997). Individual distributions of all grazing marsh indicator species were overlain within the *GIS* to produce potential species richness maps of grazing marsh vegetation. These maps used all available records and identified regions where:

a. grazing marsh species have been recorded together; and

b. Average quality was high (using the ranking of grazing marsh plants).

Changes over time in the recorded distribution of nationally rare and nationally scarce grazing marsh plants could also be presented, allowing areas where significant losses had been incurred to be identified. Such areas of marked decline might be the targets for any campaign of grazing marsh rehabilitation or re-creation.

3.2.2 Actual and potential flora of grazing marsh polygons

All records held by the Biological Records Centre (and hence all those incorporated within the *Grazing Marsh GIS*) have national grid references attached, though the spatial resolution varies considerably (from 0.1-10km). Those 0.1km, 1km, 2km and 10km BRC records which overlapped with areas of grazing marsh (as identified in the *GIS*) were identified. It was possible to confidently assign records with 0.1km or 1km resolution grid reference to a grazing marsh site. However, 2km and 10km records could only be defined as "potentially" occurring within the site. Thus, "actual" and "potential" species lists were derived for each grazing marsh area mapped by Dargie, and held in the *GIS*. Precision in BRC records tended to be linked to the rarity of the species: **a**) few records for common grazing marsh species were localised to 0.1km or 1km; whilst **b**) most records of nationally rare or scarce species could be localised to 0.1km. Finally, the species lists for each grazing marsh site could be used subsequently to provide a measure of "actual" and "potential" quality, based on the revised ranking system.

3.2.3 Evaluating the quality of grazing marsh areas

In many instances the GIS polygons (*i.e.* Dargie sites) were not exactly contained within the mapping squares of the National Grid, and hence a number of methods had to be used to assess site quality. This was particularly the case in large polygons *e.g.* the Ouse Washes or the Axe/Brue Levels and Moors in Somerset, where a grazing marsh site might intersect several 10km square. In this way the "potential" species pool of the grazing marsh site could be seriously inflated. To overcome this weakness in the approach, a method of weighting site-quality was derived for each species. The weighting was based upon the proportion of the 10km squares within which the species occurred among those which the particular grazing marsh site intersected. For example, if a given grazing marsh polygon intersects four 10 km squares, and species **x** occurs in all four 10km squares, it is given a weight of 1. However, if species **y** only occurs in two of the four 10 km squares, it is given a weight of 0.5. Measures of quality were provided for each of the grazing marsh areas identified by Dargie (listed in Appendix 1 of the present report). As submitted to the Environment Agency and the RSPB, the *Grazing Marsh GIS* contained both distribution information on species and the various quality measures, both data-sets being available for visualisation and interrogation.

3.2.4 Recommendations for further development of the approach

The final report of the project commissioned by EA/RSPB made several recommendations for refining the targeting of grazing marsh restoration and for using the framework of the GIS to integrate a greater range of spatial data-sets (Roy *et al.*, 1998). These recommendations form part of the basis of the present research:

- Add data-sets on a wider range of species groups, including vertebrate and invertebrate animals.

- Relate the blocks of lowland wet grassland (*i.e.* grazing marsh) to English Nature Natural Areas (Anon, 1996), counties, river networks (including Local Area Action Plans), soils and climate.

- Identify those sites where the actual number of species recorded is much less than would be predicted through this approach - such sites may be especially appropriate for restoration.

4. Development of the *grazing marsh GIS*

4.1 Introduction

The following account details those data-sets which have been incorporated into the *Grazing Marsh GIS* since the submission of the final ITE report to the Environment Agency (Roy *et al.*, 1998). The derivation of a further data-set from a survey of existing and planned restoration schemes is outlined in Chapter 6, and the process whereby this material was incorporated into the GIS is described in section 6.3. Similarly the development of a further data-set comprising information on land-cover, altitude and liability to flood is described in section 7.2. A summary of all the material now held within the *GIS* is given in Appendix 1, which represents a prJcis of this chapter and Roy *et al.* (1988). In the following description, the term "Dargie polygons" is used to indicate the individual blocks of lowland wet grassland mapped by Dargie (1993), and subsequently digitised as the basis of the *Grazing Marsh GIS*. The polygons used in the current report differ in one respect from those employed in previous phases of the work. Following consultation with English Nature local staff, the single large block of the Axe and Brue valleys in the Somerset Levels and Moors was divided into four on the basis of the soil types:

a. Coastal alluvial soils ("levels)
b. Riverine alluvium and peat of the Axe valley
c. Riverine alluvium and peat of the Brue Valley
d. Riverine alluvium west of the Wedmore island connecting Axe and Brue valleys.

Similarly the moors south of Langport (Wet Moor, West Moor *etc*) were separated from those of King's Sedgemoor.

As submitted with this report, the GIS includes a range of data-sets:

- grazing marsh distribution – the Dargie polygons;
- inventory of unimproved grassland;
- boundaries of Environmentally Sensitive and Natural Areas (ESA and NA);
- locations and boundaries of SSSI;
- spatial data on bird numbers (*WeBS*, breeding wader surveys);
- invertebrate distribution data (Site Register and BRC);
- BRC botanical data-sets *e.g.* Aquatic Plants; *Atlas 2000*; Scarce Plants; Pondweeds; *Atlas of the British Flora*; main BRC data-set (see Chapter 3 and Roy *et al.*, 1998);
- survey of extant/planned grazing marsh restoration projects, including information on take-up of Countryside Stewardship schemes; and
- Potential wet grassland areas: combining Institute of Hydrology liable to flood data, areas below 5m AOD (FRCA data), and data derived from ITE Land Cover Map.

A summary of Key species have been distinguished within the GIS *i.e* those listed in the short or middle list of the UK Biodiversity Action Plan, as well as nationally rare or scarce species for which grazing marshes are a major habitat. The list of typical grazing marsh plants follows that given in Mountford *et al.* (1998c).

4.2 Associating zoological and management data to GIS polygons (both Dargie and Natural Area)

The methods used to add botanical data to the original GIS of "Dargie polygons" are described fully by Roy *et al.* (1998) and in summary form in Chapter 3 of the present report. A similar approach was employed to incorporate new data-sets as they became available, and then to assess the comparative nature conservation value of all English Nature Natural Areas and the individual Dargie polygons they contained. Four major data-sets were received by the ITE between August and December 1998: **a)** invertebrates (comprising selected insect groups); **b)** breeding waders of wet meadows; **c)** wetland bird survey (WeBS); and **d)** take-up of management schemes and total area. All these data-sets comprised point-data and were associated with Dargie or Natural Area polygons on the basis of their proximity. Information on the liability of land to flood and altitude was collated by the FRCA and NERC Institute of Hydrology in early 1999, and combined with land-cover data derived from the ITE *Land Cover Map*. Most outputs from subsequent analyses were used to provide attributes which could also be associated to the polygons, hence allowing them to be mapped. Finally, some summary data were generated which could not be readily associated with polygons.

4.2.1. Invertebrates

Records of seven insect groups were provided by English Nature entomologists (Dr M. Drake and colleagues): 1) *Noctuidae*, 2) non-Noctuid moths, 3) *Odonata*, 4) *Carabidae*, 5) *Orthoptera*, 6) *Syrphidae* and 7) non-Syrphid *Diptera*. These groups and their component species were selected on the basis that they were associated with wetland habitats (including grazing marsh) and that national mapping schemes had provided adequate distribution information. These data were then spatially referenced as outlined below.

Variable resolution of National Grid co-ordinates

All grid references were set to 8 characters (*e.g.* SZ023887), thus locating a record to the south-west corner of a 100m square of the National Grid. Not all records within the data-set had such resolution, and it was necessary to deal with less precise data in one of two ways:

1. **Records with 4-character grid references** (*i.e.* which identified a 10km square) were located at the SW corner of the central 1km square (*e.g.* TM01 became TM050150).

2. **Records with 6-character references** (*i.e.* which identified a 1km square) were located in the SW corner of the central 100m square (*e.g.* SZ0288 became SZ025885).

Any records within the data-set which lacked grid reference information were omitted from any subsequent analyses.

Outline of methods

Following discussion with entomologists within ITE and English Nature, the GIS approach followed five basic stages, providing four types of spatially-referenced measure:

1. A 1km buffer was placed around each Dargie polygon.

2. For each of the seven insect groups, the **group species-richness** within each buffered polygon was calculated individually.

3. This absolute group species-richness figure was then divided by the area (km^2) of the buffered polygon to provide an estimate of the **relative density of species**.

4. The **total insect species-richness** was calculated as the sum of species-counts from all seven groups.

5. As in stage 3, **total species density** was calculated by dividing the total species richness by the area of the buffered polygon.

Output: derived attributes associated with Dargie polygons

A final insect data-set was derived which incorporated each of these measures of species-richness and density, and was held within a "shape-file" (***inverts.shp***) within the *Grazing Marsh GIS*. Shape files constitute the standard format within which spatial data are held by *ArcView* – the GIS package employed in the present research. Table 4.1 lists the insect attributes that are associated with each of the Dargie polygons in the GIS:

Table 4.1 Insect attributes held within *Grazing Marsh GIS*

Attribute			Description
Unique_val			Unique Dargie identifier
Area			Description
Buff_area			Area of 1km buffered Dargie (km^2)
Moth_rich *Orth_rich* *Fly_rich*	*Noct_rich* *Drag_rich*	*Syrp_rich* *Cara_rich*	Species richness of each insect group in each 1km buffered Dargie polygon.
Moth_dens *Orth_dens* *Fly_dens*	*Noct_dens* *Drag_dens*	*Syrp_dens* *Cara_dens*	Density of species in 1km buffered polygon (number km^{-2})
Total_rich			Total number of species across all groups in 1km polygon
Total_dens			Density of number of species across all groups in 1km buffered polygon

4.2.2 Breeding Waders of Wet Meadows

Breeding wader data was supplied for five species for two dates (1982 and 1987- the latter reported in 1989): lapwing (*Vanellus vanellus)*, snipe (*Gallinago gallinago*), curlew (*Numenius arquata*), redshank (*Tringa totanus*) and oyster-catcher (*Haematopus ostralegus*). The 1987 data were less extensive, covering only 196 distinct sites, in contrast to the 1136 included within the 1982 data. The 1987 survey covered a sub-sample of the 1982 sites which included all areas expected to have significant numbers of waders.

Outline of methods

The stages followed in incorporating the breeding wader data differ somewhat from those described for invertebrates, due to the greater mobility of birds and in order to accommodate the two survey years:

1. A 5km buffer was placed around each Dargie polygon.

2. For each year, **bird counts** were summed by species for sites falling within each polygon.

3. For **each species** and in each polygon, the **1982 and 1987 counts were combined** using the following logical approach:

   if (1987 is null) and (1982 is not null) then pairs = 1982
   if (1987 is not null) and (1982 is null) then pairs = 1987
   if (1987 is not null) and (1982 is not null) then pairs = (1987 + 1982) / 2
   else pairs = null

   This approach may introduce a bias whereby genuine zero counts are discounted *i.e.* a site with breeding waders in 1982 but none recorded in 1987. It is not apparent from the data-set whether such an observation means that no birds were present or that the site was not visited.

4. **Total wader count** in each polygon was calculated as the sum of the values for each species.

5. **Density** was calculated for each wader species by dividing the species counts by the area (km^2) of the 5km buffered polygon.

6. The **percentage of the UK breeding population** occurring in the buffered polygon was calculated for each species individually and the total count of all waders present. Figures for the size of the UK population were taken from the Breeding Atlas for 1988-91 (Gibbons *et al.*, 1993) – see Table 4.2:

Table 4.2 Standardised values for population size of wading birds in the UK – derived as mid-point of estimated range of population size

Species	Mid-point (pairs)	Atlas range (pairs)
Lapwing	211500	185-238000
Snipe	30000	30000
Curlew	35000	33-38000
Redshank	32100	30600-33600
Oystercatcher	38000	33-43000

Output: derived attributes associated with Dargie polygons

As with the insect data, the final data-set incorporating breeding wader information is held in a shape-file (***bwwm.shp***), and the attributes included are listed above in Table 4.3.

Table 4.3 Breeding wader attributes held within the *Grazing Marsh GIS*

Attribute	Description
Unique_val	Unique Dargie identifier
Buff_area	Area of 5km buffered Dargie polygon (km^2)
Lap *Sni* *Cur* *Red* *Oys* *Total_pair*	Number of pairs of each wader species and total pairs in each 5km buffered Dargie polygon.
Lap_dens *Sni_dens* *Cur_dens* *Red_dens* *Oys_dens* *Total_dens*	Density of each wader species and total in 5km buffered polygon (pairs km^{-2})
Lap_uk *Sni_uk* *Cur_uk* *Red_uk* *Oys_uk* *Total_uk*	Percentage of UK population in each 5km buffered polygon.

4.2.3 Wetland bird survey (WeBS)

Wetland bird counts were provided by English Nature for 698 sites, containing information on 69 distinct species. As supplied, the data comprised ASCII files where each row associated **a)** a site-species pair and **b)** a count value. These sites were spatially located via a "look-up table" containing latitude/longitude co-ordinates. Individual bird species were identified by two letter codes, and two further attributes were coded as:

WILD = total wildfowl count at site
ZZ = total wader count at site

Therefore:

WILD + *ZZ* = total birds at site

Outline of methods

1. *WeBS* count data from within 1km of each Dargie polygon were associated with that polygon.

2. At each *WeBS* site, each species was scored according to whether the population count was of regional (1), national (2) or international (3) importance (highest score only used).

3. The sum of all species scores within each Dargie polygon was calculated.

4. A national rank was assigned to each Dargie polygon based upon these summed scores.

5. A single value was then calculated for each Natural Area by summing the ranks of the Dargie polygons within each Natural Area.

6. Where Dargie polygons straddled Natural Area boundaries, the Dargie rank was scaled by the proportion of the polygon in the Natural Area.

Output: derived attributes associated with Dargie polygons

The *WeBS* attributes associated with each Dargie polygon are listed in Table 4.4, and these data held within a shape-file ***webs.shp.***

Table 4.4 Wetland bird survey attributes held in the *Grazing Marsh GIS*

Attribute	Description
Unique_val	Unique Dargie identifier
Buff_area	Area of 5km buffered Dargie polygon (km^2)
Num_spp	Number of distinct species recorded in 5km buffered polygon
All_count	Total bird count (all species) of 5km buffered polygon
Wild_count	Wildfowl (all species) count in 5km buffered polygon
Wade_count	Wader (all species) count in 5km buffered polygon
Spp_dens	Number of species per km^2 of 5km buffered polygon
Total_dens	Total number of birds (all species) per km^2 of 5km buffered polygon
Wild_dens	Number of wildfowl (all species) per km^2 of 5km buffered polygon
Wade_dens	Number of waders (all species) per km^2 of 5km buffered polygon
Webs_impo (Importance)	Sum of all species scored on regional, national or international importance for Webs sites within 1km of polygon.

4.2.4 Take-up of management schemes by Natural Area

The FRCA provided an *ArcView* shape-file (***frcacs97***) which summarised the take-up by farmers/landowners of those Countryside Stewardship management schemes relevant to grazing marsh. Appendix 3 tabulates the data for each Natural Area, together with a summary

by FRCA region (Part 2). Individual schemes for the period 1991-7 were associated by the FRCA to the central point of the agreement area, though for present purposes, definition of scheme boundaries would have been preferable. Those management categories (agri-environment scheme options) selected were: **a)** field boundaries hedges; **b)** field boundaries ditches; **c)** field boundaries mixed; **d)** old meadows and pasture; and **e)** waterside land. The take up for each Natural Area, expressed as a proportion of the national figure, was calculated individually for these schemes and all schemes combined (see also Section 6.3.2).

Output: take-up within Natural Areas

The results of this exercise are linked to the *Grazing Marsh GIS* in an Excel 97 file (***takeup.xlw***). The attributes calculated for each Natural Area are presented in Table 4.5:

Table 4.5 CSS take-up attributes held in the *Grazing Marsh GIS*

Attribute	Description
Natural Area	Name.
Area	NA area (ha)
Marsh area	Area of marsh in NA (ha)
1. Field boundaries ditches	Proportion of national take-up within NA for the specified management scheme (1-5).
2. Field boundaries hedges	
3. Field boundaries mixed	
4. Old meadows and Pastures	
5. Waterside land	
All schemes combined	Proportion of national take-up within NA for all schemes (1-5) combined.

4.3 Natural Area quality scores

The principles behind calculating quality scores were outlined in section 3.2 for botanical data, and the results of adding other attributes (both biological and non-biological) are discussed in Chapter 5. The following outline identifies those modifications to the basic approach (Roy *et al*, 1998) which were required to meet the objectives of the present project.

4.3.1 The use of area weighted means

In order to provide an overview of the quality of Natural Areas with respect to grazing marsh wetlands, quality scores were generated based upon those selected biological attributes previously calculated for Dargie polygons. For each attribute, the **area weighted mean** and **area weighted mean national rank** were calculated across Dargie polygons in each Natural Area. An exception was the *WeBS* importance scores, which were calculated as outlined in 4.2.3. Any polygons without data for an attribute were excluded from the exercise. This need for area weighted means arose from the fact that certain Dargie polygons straddle the boundaries between Natural Area polygons, therefore preventing their exclusive allocation to a single Natural Area.

4.3.2 Selected attributes

Six biological attributes of the Dargie polygons were selected for calculating Natural Area quality scores. The selection of attributes was based upon the breadth of taxonomic groups covered (ornithological, entomological and botanical), and the amount of information held within each attribute *i.e.* the attributes were all derived from data-sets with good national coverage, and including several (usually many) individual species. These attributes were:

1.	webs_impo:	sum of nationally ranked importance scores (*WeBS counts*)
2.	num_spp_mn_webs:	absolute numbers of species (*WeBS counts*)
3.	bwwb_tot_dens_mn:	density of 5 breeding waders (*Breeding waders, wet meadows*)
4.	actual_rare_spp_mn:	actual number of rare/scarce plant species
5.	pwgtqual_mn:	Potential average quality (weighted) of all plant species
6.	invert_tot_rich_mn:	absolute number of invertebrate species recorded.

The quality score for each attribute is associated to its Natural Area in a further shape file (*na_atts.shp*) held within the *Grazing Marsh GIS*.

As mentioned above, two further major data-sets, including a) extant and planned restoration schemes and b) land use, flood liability and altitude, were incorporated into the *Grazing Marsh GIS*. The development and content of these data-sets, and how they were integrated with the biological attributes is described in chapters 6 and 7.