ENVIRONMENTALLY SENSITIVE AREAS SCHEME

The Effectiveness of Ditch Management for Wildlife in the Broads and Somerset Levels & Moors ESAs

PREPARED BY

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EXECUTIVE SUMMARY

Grazing marsh ditches are characteristic of a number of lowland ESAs. Agreement holders in these ESAs are expected to manage their ditches to maintain and enhance their value for wildlife. Following the publication, in 1997, of English Nature's report on the deterioration in the botanical quality of grazing marsh ditches in the Broads ESA, MAFF contracted ADAS to identify and report on ditch management issues of relevance to ESAs.

During the first half of 1999, consultations were held with English Nature, MAFF and FRCA staff in the Broads, Somerset Levels & Moors and North Kent Marshes ESAs. A pilot study was carried out in the summer of 1999 and a method for assessing the effectiveness of ditch management in relation to their value for wildlife was developed. Following the pilot study, MAFF contracted ADAS to implement extensive surveys of ditch management in the Broads and Somerset Levels & Moors ESAs in winter 1999. This report outlines the field survey methods used and consultations carried out, discusses and evaluates the results and identifies a number of recommendations.

The field survey method for assessing the effectiveness of ditch management was based on the need to be able to identify the presence, abundance and distribution of a variety of structural features required by the characteristic plants and animals within management units. These structural features included the width and depth of water, presence and abundance of aquatic and bankside vegetation, steepness of bank slopes and presence of boggy or poached areas along the margins. The structural features found and their potential suitability for communities and species characteristic of these ESAs is presented.

Across a management unit, ditch management can be described as effective for preserving or retaining the wildlife value, if it results in the creation of a variety of the required structural features with a spatial distribution compatible with the dispersal and re-colonisation abilities of key characteristic species.

Without prior knowledge of the scale of spatial variation of ditch structural features it was difficult to devise an appropriate sampling strategy. So, the survey concentrated on the scale of 'management areas', using IDB sub-areas. This brought compatibility with previous surveys, as these were the units surveyed during English Nature's 1997 survey of the Broads ESA. In the Somerset Levels & Moors ESA, where IDB sub-areas do not exist, similar sized areas were chosen subjectively from within randomly selected larger IDB areas. This allowed the survey to be conducted at a similar spatial scale to that in the Broads ESA.

The bulk of the survey work was done during October and November 1999. This was not an ideal time of year for this type of field survey, but it was thought that the structural information recorded was representative of what would have been recorded during the summer season. In all, 995 ditches were surveyed in the Broads ESA in seven IDB sub-area and a further 521 ditches in the Somerset Levels & Moors in five areas. All the ditches in these twelve case study sites were surveyed to enable the spatial distribution of their features to be displayed within a Geographical Information System (GIS).

Once the data for all the ditches had been collated, statistics for each structural feature were calculated to establish the range of variation of these within and between sites. The ditches were also classified into 14 ditch classes defined on the basis of the presence of differing combinations of features relating to ESA management (e.g. grazing of the bankside, depth of water and extent of vegetation cover).

In both ESAs, the majority of ditches surveyed were between 1 and 3 m wide and between 0.2 and 1.5 m deep. The G1 (grazed/deep/open water) and A1 (arable/ungrazed/deep/open water) ditch classes had the largest numbers of ditches, suggesting that shallow, well vegetated/overgrown ditches are relatively uncommon. The characteristics of each sample site varied. Some sites had more ditch classes present than expected, given the numbers of ditches present, suggesting a reasonable degree of structural diversity, and others had fewer.

As might be expected, ditches on agreement land tended to comprise the 'grazed' classes (G1–G6) whereas non-agreement ditches tended to comprise the 'arable/ungrazed' classes (A1–A6). There was a high proportion of agreement land within the case study sites making true comparisons between the characteristics of agreement and non-agreement ditches difficult to establish.

The GIS was used to display the spatial relationship of each ditch feature across the sample sites. A variety of example plots are presented which provide indications of the spatial heterogeneity of ditch features at each site. At some sites there was a good mixture of features/classes, whereas other sites are dominated by large clusters of similar ditches. The interpretation of this information is the key to assessing the effectiveness of ditch management. For any site, management can be deemed to be effective if it results in the provision of the range of structural attributes or features required by the characteristic plants and animals. For both the Broads and Somerset Levels & Moors ESAs, aquatic and marginal plants and invertebrates (including internationally important and Biodiversity Action Plan species) are regarded as being of prime importance within grazing marsh ditches so their requirements should be at the forefront of ditch management advice.

Of the sites surveyed in the Broads ESA, two (Smallburgh and Lower Yare 5) exhibited a relatively even distribution of the ditch classes potentially providing features required by aquatic and marginal plants and invertebrates. These two sites are regarded as being managed effectively for these communities. In the Somerset Levels & Moors ESA, three sites (Curry Moor, North Moor and Wet Moor) appeared to be being managed effectively for aquatic and marginal communities. For the range of wildlife characteristic of grazing marsh ditches, less effective management appeared to be occurring at sites where there were large geographic clusters of ditches within the same class, potentially reducing the opportunities for a greater variety of plant and animal communities. Three of the sample sites had these characteristics, two in the Broads and one in the Somerset Levels.

In addition to the field surveys, information about ditch management was collected both from the land holders at each case study site and also from a general postal questionnaire sent out to about 1000 land holders with land in each ESA. The postal questionnaire was designed to gather ditch management information from a more extensive sample of land holders and to help with the interpretation of information gathered from the case study sites. The management data relating to the sample site ditches was very variable and many land holders were only able to impart rough estimates about the dates of management practices. There was no obvious relationship between agreement status and frequency of management. When the management information was compared with the survey data for each ditch, no obvious relationships were found. This suggests that management dates alone are not useful for predicting differences in the structural features of ditches. These need to be assessed through periodic field surveys, as described in this report.

Responses to the postal questionnaire were received from about a fifth of land holders in both the Broads and Somerset Levels & Moors ESAs. This is an acceptable response rate for indicative surveys such as this. Although there were similarities in the lengths and structure of grazing marsh ditches on holdings within each ESA, there were major differences in their management frequency. The ditches in the Broads ESA are, on average, managed on a 4–10 year rotation, whereas those in the Somerset Levels & Moors tend to be managed on a 1–3 year rotation. Groups of ditches tend to be managed at the same time, particularly in the Somerset Levels & Moors where more than 50% of the ditches on a holding can be managed at a time. However, because of the fragmented ownership in this ESA this high proportion of annual management is not likely to have the same impact on wildlife as that in management units where large blocks of ditches are managed at the same time. Most management is carried out during September to February, as would be expected. A large proportion of respondents from the Broads ESA indicated that they leave sections of vegetation uncleared in ditches, whereas those in the Somerset Levels & Moors are more rigorous at cleaning out the vegetation completely. Reprofiling and restoration of ditches has been carried out by numerous agreement holders, particularly in the Broads ESA, where there has been a marked increase in the number of ditch-related conservation plans in the last four years.

Differences in the ditch characteristics, land ownership patterns and management practices within each ESA and, to some extent the case study sites within them, highlight the need to interpret the results of this survey at a local level rather than taking too broad-brushed an approach, i.e. it may not be appropriate to extrapolate the results to the ESA level.

Valuable advice on ditch management is provided mainly by the FRCA Project Officers in each ESA, although some advice, particularly on SSSIs is provided by English Nature staff. IDBs are responsible for the management of the larger ditches and main drains within each ESA. In the Broads, in particular, the IDBs are conscientiously incorporating environmental guidance into their standard management procedures.

Concerns about the lack of management highlighted in English Nature's dyke survey report of 1997 may have triggered more advice and sensitive ditch management in the Broads ESA. Certainly, the field survey results suggest that there are more 'Open' ditches, particularly on agreement land, than those choked with vegetation. In both ESAs, the pattern of ditch management varies within management units, some achieving the desired distribution and variety of features for characteristic grazing marsh ditch communities, others not.

The following recommendations are made:

- alter the ESA management prescriptions such that only a proportion (e.g. 20%) of an agreement holder's ditches are managed at any one time.
- identify the key land management priorities (agriculture, flood defence and wildlife conservation) for blocks of land, such as IDB sub-areas or their equivalent. This should enable future ditch management advice and practice to be targeted to meet the objectives for each area.
- provide site-specific explanatory literature to land managers within sites where specific ditch structures are required to meet biodiversity objectives.
- carry out further studies on the scale of spatial diversity in ditch structure required by key species within each ESA.

INTRODUCTION

BACKGROUND TO THIS PROJECT

1.1. Ditches[1] are man-made structures which are important and characteristic features of the coastal and floodplain grazing marsh Biodiversity Action Plan (BAP) priority habitat. This is the principal BAP habitat in many lowland ESAs, including the Broads, Somerset Levels & Moors, North Kent Marshes, Essex Coast, Suffolk River Valleys, Test and Avon Valleys and Upper Thames Tributaries. Requirements for ditch maintenance and/or management are included within the prescriptions and farmer guidelines for these ESAs (Appendix I). The guidelines for each tier of agreement highlight the need to manage ditches to maintain the required water levels and protect their value for wildlife. Since a proportion of the agreement payment for farmers is related to ditch maintenance/management, it is important for MAFF to know whether management carried out under ESA agreement is effective in maintaining and enhancing the ditches' wildlife value.

1.2. A limited amount of monitoring of grazing marsh ditches in ESAs has been carried out by ADAS, under contract with MAFF. This has involved detailed botanical monitoring of small samples of ditches in the Broads, Somerset Levels & Moors and North Kent Marshes, all of which has since been discontinued. In these and other ESAs an assessment of the landscape quality of ditches has also been carried out but these assessments have not allowed for objective monitoring of ditch management condition.

1.3. Grazing marsh ditches are subject to great variation in their constituent vegetation, which is influenced by water quality, management regimes, adjacent land management and soil type. In 1997, English Nature carried out a survey of 2,684 Broads grazing marsh dykes, which are of national and international importance in terms of their freshwater plant and animal communities. The previous large-scale English Nature survey of Broads dykes was in 1988/89. The 1997 survey (Harris *et al.*, 1997) found that there had been a continued loss in species-rich, freshwater plant communities in dykes throughout the Broads since 1989. The report suggested that *'sub-optimal dyke management was a contributory factor in the deterioration of the dyke flora, and was apparent throughout the Broads area..'*. A significant proportion of dykes was found to be overgrown with emergent vegetation with little or no open water. This was thought to be primarily due to a widespread and general lack of rotational 'slubbing out'. Also, in several areas a lack of grazing management, due to using the marshes for hay or silage, or the use of fencing to prevent sheep access, had resulted in the dykes becoming overgrown.

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[1] Known in different regions as dykes, drains, rhynes, fleets, etc.

1.4. In early 1999, ADAS was asked by MAFF to carry out a scoping study to identify ditch management issues relevant to ESAs and to gain an understanding of what is meant by effective ditch management, particularly in relation to their value for wildlife. Three ESAs (Broads, Somerset Levels & Moors and North Kent Marshes) were visited and informal consultations held with local English Nature conservation officers, FRCA Project Officers and others involved with ditch management in each area.

1.5. ADAS was then commissioned to carry out a more extensive project on ditch management. The overall aim was to assess whether ditch management within the ESAs is effective in terms of providing a good range of wildlife habitats and is maintaining the right balance between ditches at different stages within the cycle of ecological succession, from open water through to fully vegetated. The objectives of this project were as follows:

- develop a method for assessing the effectiveness of ditch management in maintaining a range of vegetation types and other important environmental features (e.g. poached banksides) within grazing marsh ditches;

- develop a Geographical Information System (GIS) to portray the relationship between different ditch categories, management data and ESA agreement status across the holdings within the sample IDB sub-areas;

- assess the effectiveness of ditch management (on agreement and non-agreement land) within the Broads and Somerset Levels & Moors ESAs;

- evaluate this information and report findings for each ESA surveyed;

- develop a GIS extension to aid interpretation and analysis of ditch management data by the Customer and its statutory consultees.

WILDLIFE INTEREST AND MANAGEMENT OF GRAZING MARSH DITCHES

1.6. Grazing marsh ditches provide refuges for a wide range of aquatic plants and animals, many of which are nationally scarce. For instance, in the Broads there are over 108 species of aquatic plant (including several nationally scarce species, such as water soldier) and about 180 nationally rare or scarce species of invertebrate (such as the Norfolk hawker dragonfly and the shining ram's-horn snail), 27 of which are confined to this habitat (Doarks and Madgwick, 1996). In the Somerset Levels & Moors there are at least 9 nationally scarce aquatic plant species and 8 Red Data Book (RDB) aquatic invertebrate species associated with ditches (English Nature, 1997). In both these areas and other ESAs, ditches are also associated with a variety of breeding birds (including reed bunting and garganey), amphibians, otters and water voles (both BAP priority species).

1.7. To retain their value for wildlife, ditches need management and good quality water. In general, ditch management involves two processes: slubbing out and vegetation cutting. Slubbing out removes the sediment and vegetation from the bottom and sides of the ditches and starts a new cycle of plant growth. Slubbing out can be combined with re-profiling which involves scraping the ditch banks to change their angle of slope. Vegetation cutting simply involves removing vegetation from the watercourse. This arrests plant growth for that season but does not normally initiate a new growth cycle. The frequency of management required to maintain ditches is usually related to the rate at which vegetation re-establishes which in turn can be related to its state before clearance. For instance, ditches that have dried out are likely to take longer to recolonise with aquatic plants than those which are regularly slubbed out (Painter, 1998).

1.8. The responsibility for ditch management within grazing marshes is divided between the Internal Drainage Boards (IDBs) and the Environment Agency (EA) for main arterial drains, and farmers and other land owners (such as conservation organisations) for secondary drains. Each type of land owner will have their own particular interests and will manage the ditches accordingly, albeit within the relevant restrictions imposed if the land is under ESA agreement. In general, livestock farmers will tend to manage ditches to retain their usefulness and safety as wet fences and as a source of drinking water for their stock. Arable farmers and IDB engineers, on the other hand, are likely to regard efficient drainage as a priority. Changes in the agricultural economy, such as those brought about by BSE, resulting in a lack of grazing, and likely problems with climate change and sea level rise are also thought to affect the health of grazing marsh ditches, both directly and indirectly, through changes in ditch management practices.

1.9. The features required by the wildlife (both plants and animals) associated with grazing marsh ditches are presented in Table 1.1. This list of features was compiled during a meeting with English Nature Conservation Officers early in 1999. The presence and spatial distribution of these features within ditch management units (e.g. IDB sub-areas) is likely to be an important factor in determining the effectiveness of ditch management for maintaining or enhancing their wildlife value.

1.10. Within the ESAs, land holders are encouraged, through the management prescriptions and by conservation advisors, to ensure that their grazing marsh ditches contain water all year round (both as a source of water for livestock and to protect aquatic wildlife), are periodically cleaned out by digging or vegetation cutting and have their banks grazed by livestock. Although these *methods* of management are important, the *pattern* in which management is done is also likely to affect the wildlife value of grazing marsh ditches. For instance, some land owners may request that a contractor cleans out all the ditches on a marsh at the same time. If the marsh is large and managed by one or two land owners this could result in large numbers of ditches all, initially at any rate, in the same stage of hydroseral succession. This could have a serious impact on individual species or communities, particularly if they are not very mobile. What is more desirable is management that results in a mosaic of features across management units, the scale of which should suit the most important species or communities for that area.

1.11. Across a management unit, such as a farm, nature reserve or Internal Drainage Board sub-area, ditch management could, therefore, be described as effective (in terms of retaining or enhancing the wildlife value) if it results in:

- *the creation of a variety of the required features (Table 1.1) with a spatial distribution compatible with species' dispersal and recolonisation abilities.*

1.12. This report describes the methods used to assess the presence, variety and distribution of features characteristic of grazing marsh ditches within sample areas, and the management to which these and other ditches within the Broads and Somerset Levels & Moors ESAs are subjected. The results for the extensive field surveys and consultations carried out in the Broads and Somerset Levels & Moors ESAs are presented. These results are then discussed and evaluated by investigating the relationship between the features found and their distribution within each sample area and their potential suitability for communities and species characteristic of these ESAs. Recommendations for improving the current ESA prescriptions for ditch management are made, together with suggestions for further studies that could be carried out.

METHODS

2.1. The ability to record the presence, abundance and distribution of both required and detrimental features for grazing marsh ditch communities was the starting point for developing a field survey method for assessing the effectiveness of ditch management in ESAs. In conjunction with this it was also necessary to ascertain what management was actually being carried out on the ditches in each ESA being surveyed. This involved consultation with farmers, other landholders and contractors within the ESAs, as well as those providing them with advice.

FIELD SURVEY

2.2. The field survey method was developed in liaison with English Nature conservation officers. Its development involved several iterations during which the practicalities of recording the presence and abundance of each 'required' and 'detrimental' feature were discussed and reviewed. During the pilot study, the method was tested on a sample of about 30 ditches in each of the Broads, Somerset Levels and North Kent Marshes ESAs to ensure that comparable information could be collected from a wide variety of ditches in different geographical locations.

2.3. The following paragraphs briefly describe the resultant method adopted for the extensive field survey of ditches in the Broads and Somerset Levels & Moors ESAs in winter 1999. The information recorded provides an objective assessment of the range and structure of features available to the plants and animals that may live within each ditch and its immediate margins. The detailed methodology is presented in Appendix II.

2.4. Following a period of training, each surveyor should be supplied with field survey maps for the sites and contact names and telephone numbers for the land holders. Each ditch at the site should be given a unique number, which is clearly marked on the map (an example is provided in Appendix III). This number together with the site reference code provide a unique, geo-referenced, identifier for each ditch.

Figure 1.1 Cattle and ditch with a good 'berm'

Table 1.1 Features required by plants and animals associated with grazing marsh ditches

Community type	Required features	Detrimental features
Plants		Over-deepened channels. Over-hanging dense vegetation. Ochre on peaty soils. Extensive scrub, particularly on south-facing banks.
Aquatic plants (submerged and floating-leaved)	Permanent presence of deep, open water.	
Emergent plants	Shallow water and/or ditch wet throughout the year.	
Marginal plants (growing on berm or within 'drawdown' zone on banks)	High winter water level/water table. Poaching/disturbance (at moderate levels). Continuity of habitat i.e. reservoirs left for recolonisation. **Berm** at water level in e.g. Broads and Somerset Levels (where summer water can be maintained). Bank covered by water in winter and spring followed by gradual drawdown in summer in e.g. North Kent Marshes and Essex Coast.	Steep slopes and large freeboard. Nettles and thistles. Fencing and cattle watering holes.
Invertebrates		
Aquatic invertebrates	Shallow water with not too much shade from overhanging or dense emergent vegetation.	Overhanging dense vegetation.
Marginal invertebrates	Broad 'drawdown' zone with light poaching and small patches of bare mud. A gappy fringe of emergent vegetation. Nearer bank tops need small scale tussocky vegetation grazed by cattle not sheep. Good structural diversity within 2m of bank top. Isolated scrub bushes.	Fencing and cattle watering holes. Steep slopes.
Birds		
Passerines (Warblers, etc.)	Persistent stands of reeds and tall emergents.	
Wildfowl (Ducks, coots, etc.)	Lack of disturbance and good cover. Good width of watercourse.	
Waders	Broad berm or drawdown zone	
Mammals		
Water voles	Large area of cover. Steep bank on one side, shallow on other. Bank above water level. Moderately deep (2') permanent water.	
Otters	Good bankside cover and fish. Lack of disturbance.	
Fish	Permanent water, open water, good depth.	
Amphibians	Same as for invertebrates plus tussocky banks. Scrub/wood or dense vegetation for winter hibernation.	

2.5. Once permission for access has been given by the land owner/holder and the ditches for which he/she is responsible for managing have been identified, the surveyor should walk to the mid-point (approximately) of every ditch[2]. It is important that all ditches within each sample site are surveyed to enable the variety and spatial distribution of the features to be established and mapped. The presence and abundance of features making up the structure of the 10 m of ditch on each side of the surveyor should be recorded (abundance is recorded to the nearest 5%, for simplicity).

- width and depth of water
- % cover of open water, aquatic vegetation, algae and/or duckweed (these should sum to 100%)
- % cover of submerged vegetation (below water surface), tall emergent vegetation (above water surface) and bankside vegetation overhanging the water surface
- presence of ochre (iron hydroxide)

2.6. The adjacent land use should be identified and, if the land is grassland, evidence of livestock grazing the land must be recorded. If a boundary feature, such as a fence, that prevents livestock grazing the ditch banks is present, this should also be recorded. The slope of the bank on each side of the ditch should be estimated and the presence of a berm (platform or shelf at the base of the bank) recorded.

2.7. Finally the presence and abundance of features present on the 2 m field edge and bank slopes on each side of the ditch should be recorded. These features include:

- Recent ditch spoil (i.e. suggesting recent digging out of silt)
- Poaching/muddy conditions (i.e. suggesting evidence of livestock trampling)
- Short vegetation less than 15 cm (e.g. which has been grazed or mown)
- Medium vegetation on average 15 cm to 1m tall
- Tall vegetation more than 1 m tall (e.g. reeds)
- Weeds such as nettles, docks and thistles
- Woody scrub less than 5 m tall (e.g. brambles, thorn and sallow)
- Trees more than 5 m tall (including pollarded willows)

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[2] A ditch is defined as a section of watercourse between two other intersecting ditches and must be >20m long, and usually forming a field boundary i.e. not within-field grips. Long ditches with an obvious bend, or sinuous ditches, can be subdivided and each section clearly numbered on the field survey map.

2.8. The data relating to the features can be recorded using either an electronic data logger (such as Psion Walkabout data loggers equipped with Questor software (Paradigm Technology Ltd)) or on paper proformas (Appendix IV). The structure of the questionnaire compiled in purpose-built software such as Questor can follow that of the paper proforma and can incorporate validation checks such that, for example, it is impossible to record more than 100% cover for any one feature. The speed of recording on the data loggers is similar to recording on paper, but they have the following advantages

- reasonably waterproof (purpose made covers)
- can incorporate automatic validation
- enable downloading of the data straight onto a PC (saves about 5 minutes of data inputting time per ditch and avoids mistakes during manual data inputting).

SITE SELECTION FOR THE BROADS AND SOMERSET LEVELS & MOORS

2.9. At the start of the project it was agreed with MAFF that the extensive survey should involve about 1,500 ditches in the Broads and Somerset Levels & Moors in total (see Annex J of MAFF's ESA Monitoring Schedule for 2000/2001). In order to establish the number of ditches that should be surveyed in each of the ESAs, the following procedure was used:

- The landscape types for which ditches are characteristic features were identified from the ESA landscape monitoring reports (ADAS 1996a and ADAS 1996b). For the Broads these are: *Open Valleys, Enclosed Valleys, Enclosed Broads* and *Open Marshes*. For the Somerset Levels & Moors the relevant landscape types are: *Open Moor, Semi-open Moor* and *Domesticated Moor*.
- The area of each landscape type (as present in 1996) was established (again from the monitoring reports) and the total area of land within which ditches are characteristic features was calculated for each ESA. The results were 31,950 ha for the Broads and 25,991 ha for the Somerset Levels & Moors.
- For the two ESAs, therefore, a total of 57,941 ha is characterised by the presence of grazing marsh ditches. Of this total area, 55% is in the Broads ESA and 45% in the Somerset Levels & Moors ESA. The number of ditches to be surveyed in each ESA was, therefore, calculated as 825 in the Broads and 675 in the Somerset Levels & Moors.

2.10. English Nature's 1997 survey of ditches in the Broads ESA (Harris *et al.*, 1997) used IDB sub-areas[3] as the survey units. These sub-areas comprise identifiable

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[3] In the Broads ESA the IDB sub-areas are those identified in Harris *et al.* (1997) and relate to areas of different rateable value. In the Somerset Levels & Moors ESA the 'sub-areas' simply represent blocks

blocks of grazing marsh within the same hydrological regime and at a scale, which is manageable from a field survey viewpoint. A similar approach of sampling within case-study areas was adopted for both the Broads and Somerset Levels & Moors ESA. In each ESA, stratified random sampling was used to select the case study sites for the field survey. For the Broads ESA, IDB sub-areas were the logical survey unit for this study. Random numbers were used to select IDB sub-areas as case study sites from within each of the IDB areas in the chosen landscape types until a sufficient number of ditches had been reached. In the Somerset Levels & Moors, where IDB sub-areas do not exist, areas of a similar size to the Broads IDB sub-areas were selected from within the chosen landscape types in randomly selected IDB areas. The 12 selected sites and the expected number of ditches (estimated from maps and, for the Broads, from the report by Harris *et al.,* 1997) in each site are presented in Tables 2.1 and 2.2.

2.11. It should be stressed that the survey of ditches within case study sites does not result in information which is representative of all variation in ditch structure across the ESAs. To do this would have involved a survey of individual ditches randomly distributed across each ESA. The sampling approach adopted aimed to provide information about the range and distribution of variability within management units where ditches were interconnecting but yet were being managed by a range of land holders. IDB sub-areas (or areas of equivalent size) were chosen as the sampling unit since these had been used by English Nature during their 1997 survey and they provide information about ditches on a scale greater than that for individual farms so that management practices within adjacent blocks of land can be assessed.

Table 2.1 Sample sites selected for the Broads ESA

Site name	Site code	Landscape type	Approximate area (ha.)	Expected number of ditches
Smallburgh 9	S9	*Enclosed Broads*	100	38
Happisburgh to Winterton 1	HW1	*Open Broads*	350	48
Lower Bure and Halvergate 2	LBH2	*Open Grazing Marsh*	175	136
Lower Bure and Halvergate 11	LBH11	*Open Grazing Marsh*	300	140
Langley, Chedgrave and Toft Monks 3	LCT3	*Open Grazing Marsh*	200	220
Lower Yare 5	LY5	*Open Valleys*	175	74
Lower Waveney 2	LW2	*Open Valleys*	200	192
			Total	**848**

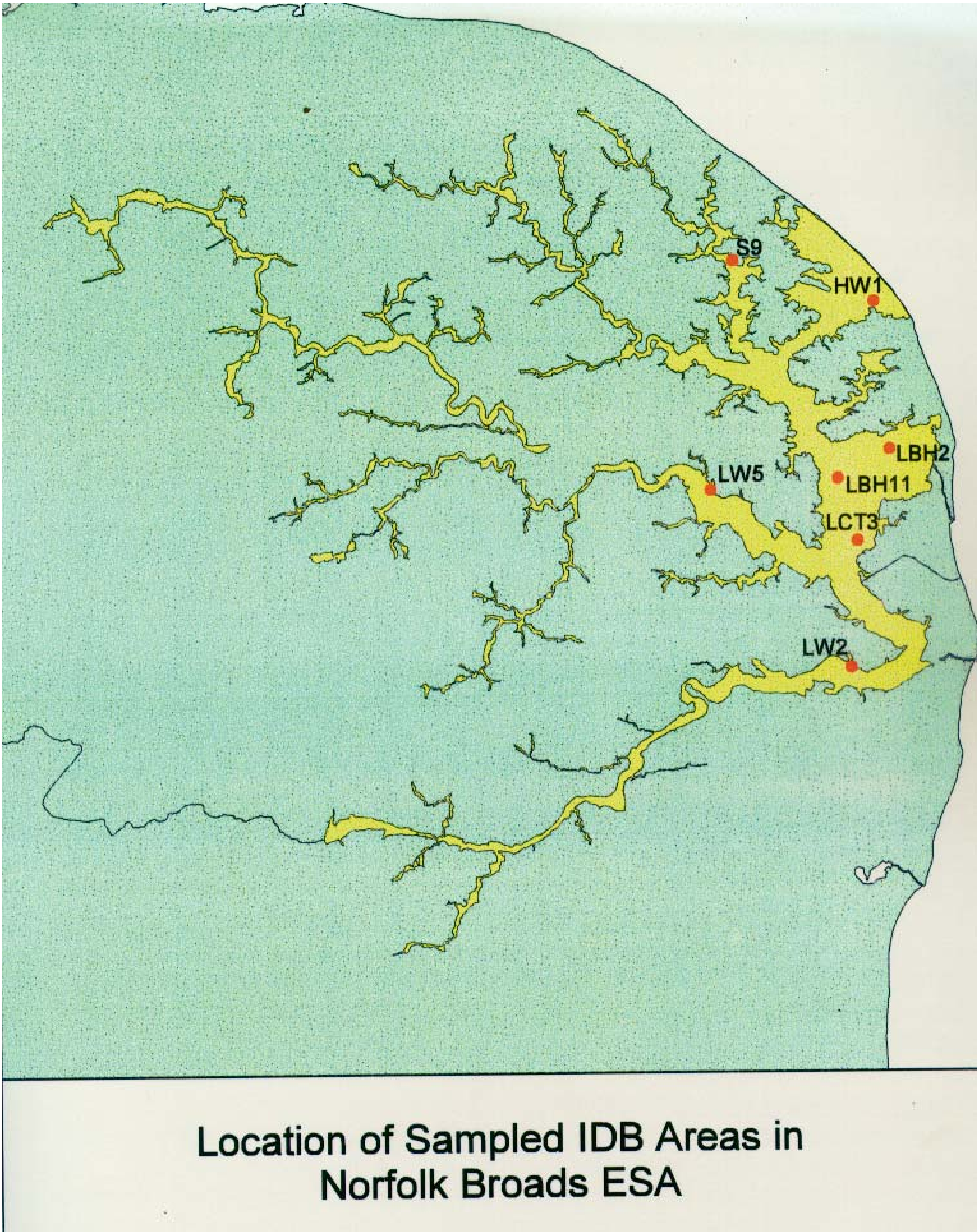
of land with obvious boundaries, such as roads or main drains, in which there appeared to be at least 100 ditches.

Table 2.2 Sample sites selected for the Somerset Levels & Moors ESA

Site name	Site code	Landscape type	Approximate area (ha.)	Expected number of ditches
Stoke Moor	SM	*Semi-open Moor*	150	142
North Moor	NM	*Open Moor*	175	171
Curry Moor	CM	*Open Moor*	100	157
West Sedge Moor	WSM	*Open Moor*	250	140
Wet Moor	WM	*Open Moor*	175	150
			Total	**760**

2.12. The distribution of these sites across each ESA are shown in Figures 2.1 and 2.2. The area of each site ranges from about 100 ha to 350 ha in the Broads, and from about 100 ha to 250 ha in the Somerset Levels & Moors. Most sites included both agreement and non-agreement land and ditches managed either by private landowners or by IDBs. At two sites (LY5 in the Broads and West Sedge Moor in the Somerset Levels & Moors) the majority of the land was owned and managed by the RSPB.

2.13. The ditches adjacent to agricultural land (grassland or arable) at each site were surveyed during October to the beginning of December 1999. This was not an ideal time of year for the survey work to take place and one or two problems with fluctuating water levels, following periods of high rainfall, were encountered. However, the presence of all physical features could be assessed and it is thought that the majority of vegetation that would have been present in the ditches during the summer months was still visible during the survey period, except where recent management had taken place. The records obtained during the field survey were, therefore, thought to provide a reasonable representation of the variety of features associated with the normal growing/breeding season.



Location of Sampled IDB Areas in Norfolk Broads ESA

Produced by Environment Modelling and GIS Group / Spatial Data Team, ADAS Wolverhampton
ESA boundary data supplied by FRCA.

Figure 2.2 - Distribution of monitoring sites in the Somerset Levels & Moors ESA

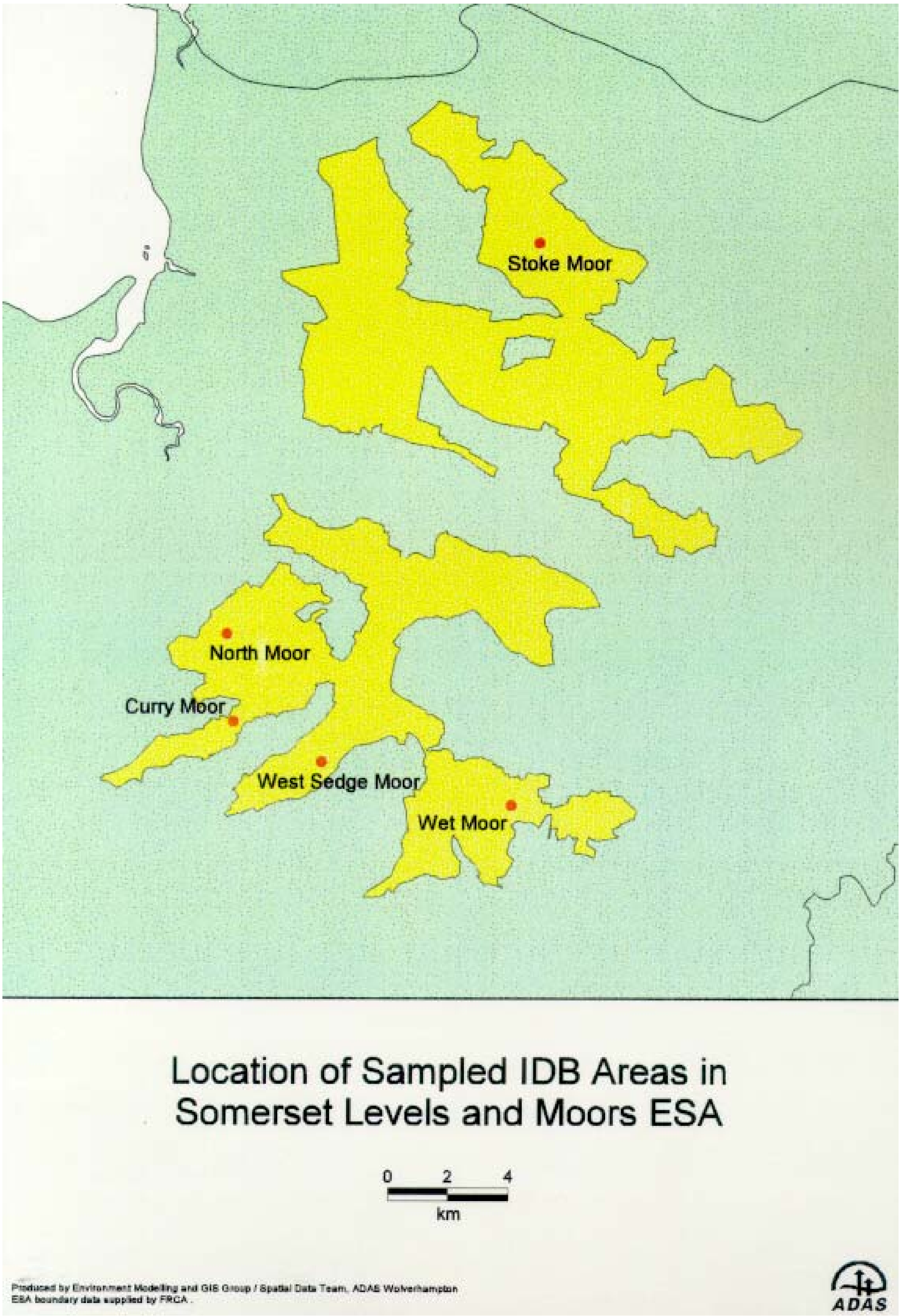


Figure 2.2 - Distribution of monitoring sites in the Somerset Levels & Moors ESA

DATA HANDLING

2.14. For those data that were recorded on paper proformas, the following procedures were carried out:

- completeness check by each field surveyor at the end of each day
- proformas photocopied and the originals sent to the data input point (e.g. secretary at ADAS Oxford)
- data input to an Excel database and validated against the paper proformas
- data Emailed to analysis point (e.g. R & D at ADAS Wolverhampton) for collation and analysis

2.15. Data recorded on the Psion data loggers were automatically downloaded onto each surveyor's PC, set up with Questor (Paradigm Technology) software. The data were then electronically transmitted, via Email, to the data analysis point at ADAS Wolverhampton where they were collated within an Access database prior to analysis. Data collection within the data loggers was self-validating which ensured that appropriate scores were given for each entry field.

ANALYSIS AND DITCH CLASSIFICATION

2.16. Once the data were collated, statistics for each feature (e.g. water width and depth) were calculated for each site to establish the range of variation within and between sites. In addition, the ditches were allocated to different classes according to combinations of features so that the variety of ditch classes within and between sites could be assessed. For the purposes of this project, the ditches were classified on the basis of features relating to ESA management (e.g. evidence of grazing and depth of water) and the stage of hydroseral succession (i.e. extent of vegetation cover). The classification involved the following process:

1 The ditches were sub-divided into 'Grazed' and 'Arable/Ungrazed' according to whether their banks were or had recently been grazed (evidence of livestock, shallow slope on at least one side and/or presence of berm on at least one side) or not (adjacent land cultivated or no evidence of livestock and/or banks fenced or bank slopes very steep).

2 The ditches in the above sub-divisions were further divided according to their water depth. The cut-off of 60 cm was used because this is the minimum depth of water permitted in Tier 2 of the Broads ESA. This cut-off has been used for ditches in both ESAs to enable comparisons to be made and to differentiate between relatively deep and relatively shallow ditches at the time of the survey. However, it is understood that ditches in the Somerset Levels & Moors tend to be shallower, on average, than those in the Broads so, for future studies, it may be more appropriate to use a different water depth as the cut-off

value. Ditches with less than 10 cm of water were regarded as being dry and were not further sub-divided.

3 The final sub-division relates to the amount of vegetation in the watercourse, which provides some indication of their stage in the hydroseral succession. 'Open' ditches are those with lots of open water (>50% cover) and little emergent vegetation (<50% cover); 'Mixed' ditches have both open water and emergent vegetation (<50% cover of each); and 'Emergent' ditches are dominated by emergent vegetation (>50% cover), such as common reed, reedmace or branched bur-reed.

2.17. The classification described above resulted in 14 ditch classes, which are summarised in Table 2.3. Photographs showing examples of ditches in some of these classes are presented in Appendix V.

Table 2.3 Classification of grazing marsh ditches

GRAZED BANKS (this season's evidence of livestock on at least one field edge, at least one bank has shallow slope i.e. < 45° angle and/or berm on at least one side)							
Water depth > 60 cm				**Water depth < 60 cm**			**Water depth < 10 cm**
Watercourse vegetation	Open	Mixed	Emergent	Open	Mixed	Emergent	Dry
Ditch Class	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	**GD**

ARABLE/UNGRAZED BANKS (or, if grass, neither bank grazed, and/or fenced, and/or bank slopes very steep i.e. > 45° angle)							
Water depth > 60 cm				**Water depth < 60 cm**			**Water depth < 10 cm**
Watercourse vegetation	Open	Mixed	Emergent	Open	Mixed	Emergent	Dry
Ditch Class	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**AD**

2.18. The number of ditch classes within each case study site provides an initial indication of structural variation across the ditches. However, the sites have different numbers of ditches and those with more ditches are more likely to have more ditch classes (up to the maximum 14) than those with fewer ditches. It is not possible, therefore, to calculate a standard diversity index. Instead, for a site with n ditches, the expected number of ditch classes (ED) can be calculated using the formula

$$ED = n \times P$$

where $$P = \frac{GT_N}{GT_n}$$

and GT_N is the sum of all the ditch classes actually present across all case study sites and GT_n is the sum of all the ditches present at all case study sites. This method assumes a linear relationship between the number of ditches and the number of ditch classes. If N (the actual number of ditch classes present) is greater than ED then the site is likely to be more diverse (i.e. have more ditch classes) than would be expected if the number of ditch classes was in proportion to the number of ditches present. The results can not be tested for statistical significance because the sample ditches are not independent from each other (the ditches are physically linked and managed by the same land holders).

2.19. As well as knowing whether there are more or less ditch classes present than would be expected, the distribution of the total number of ditches amongst classes will provide an indication of the 'even-ness of spread' of ditches within ditch classes at each site. For instance, a fairly even spread of ditches would be indicated by more or less equal numbers of ditches at a site in each class. Conversely, a relatively uneven spread of ditches would be indicated if the majority of ditches at a site were in just one or two classes.

2.20. An index for 'even-ness of spread' (S_n) can be calculated for each case study site as follows:

$$S_n = \Sigma \, |d - E_d|$$

where d is the number of ditches within each class and E_d is the expected number of ditches in each class. A high value for S_n indicates an uneven spread of ditches i.e. where the number of ditches in each class is very different from that which would be expected. A low value for S_n indicates a more even spread of ditches amongst the classes present at a site.

2.21. The geo-referencing of each ditch at each site also enabled the spatial distribution of individual features and ditch classes to be mapped within a GIS. This enabled the spatial patterning of ditch classes within each site to be viewed and assessed in the context of the 'even-ness of spread' values obtained. An even spread of ditches between ditch classes may occur without any spatial contiguity between similar ditches (e.g. if there are 5 ditches in each class, the 5 could be distributed separately within the management unit or together in one block). The GIS also enables the distribution of other features e.g. water depth, % cover of emergent vegetation, etc. to be viewed in the context of factors, such as ESA agreement status and management operations. As explained in paragraphs 1.9 to 1.11, the pattern of distribution of the individual structural features, and ditch classes could, in conjunction with the management information, allow an assessment of the suitability and effectiveness of ditch management for the characteristic wildlife at each site. For instance, at any site it might be desirable to have a balance between ditch physical characteristics, represented by equal proportions of open, mixed and emergent ditch classes.

2.22. It is likely that some similarity will be seen between adjacent ditches due to the nature of management practices. The ideal situation for nature conservation is likely to be somewhere between the two extremes of highly heterogeneous and homogeneous ditch conditions. Defining the degree of heterogeneity necessary for conservation of plant and animal species and communities is very difficult. No guidelines have been published on this matter, and part of the problem is that different species will have different requirements. For the purposes of this work, two threshold sizes of homogeneous areas were set, against which spatial variation in ditch characteristics could be evaluated. Where mobile species of animals are of paramount importance, it was hypothesised that a homogeneous area of 100 ha. or greater would be acceptable. However, for groups with more limited mobility and dispersal characteristics, such as snails, plants, etc., a homogeneous area of 25 ha. or more could cause problems with, for instance, species dispersal and survival if the ditches within that area became unsuitable for the species.

2.23. Of interest for management of ditches for conservation is not only whether ditches are surrounded by similar ditches but also over what distance this similarity occurs. In other words, how big is a 'patch' of similar ditch condition. Similarity in ditch condition can be described in terms of neighbouring ditches – e.g. similarity between a ditch and those surrounding it but dissimilarity thereafter. Similarity in ditch condition can also be described using actual distance apart – e.g. ditches on average up to 1 km apart tend to be similar in their physical characteristics and likely provision of habitats, but those more than 1 km apart are on average typical of different conditions. Use of actual distance between ditches will give more reliable results because of problems with different densities of ditch networks. Depending on the species involved and their dispersal mechanism (e.g. aquatic plants dispersing via floating seeds), a more realistic measure of the distance over which similarity in ditch characteristics occurs may be determined by taking into account the downstream connectivity between ditches to give the actual distance (by water) between similar ditch characteristics within a sub-area. This was outside the scope of this study but could be investigated in the future, using the data collected during this survey.

2.24. Within the GIS it will be possible to determine the range of distances within a site a particular species may need to travel or disperse to arrive at the nearest similar habitat. The maximum distance to travel can then be related to the known biology of the species. This is a useful tool for determining the sustainability of a particular network of ditches for a species under threat. For the purposes of this project, two sets of case study plots are presented for the Broads ESA:

- suitability of ditches for the shining ram's-horn snail
- suitability of ditches for damselflies and dragonflies (Odonata)

CONSULTATION

Site owners/managers

2.25. For each of the field survey sites it was necessary to contact the land holder/manager, first to seek permission for access to the land and second to determine the date when each surveyed ditch had last been slubbed out. The information was either recorded on the survey proforma or within the data logger (if collected on the same day as the field survey) or, as was more often the case, it was recorded on a separate form. The management data was subsequently entered into an Excel spreadsheet containing the survey data.

Ditch management postal questionnaire

2.26. In addition to gathering information about the management of individual ditches as part of the field survey, general information about ditch management across the Broads and Somerset Levels & Moors ESAs was gathered using a postal questionnaire (Appendix VI). The questionnaire was designed to gather information that would help interpret the field survey information and put it into the context of ESA wide ditch management practices. The questionnaire with an accompanying letter was sent to approximately 1,000 land holders (both agreement and non-agreement) in each ESA.

2.27. Land holders were required to indicate how much of their land was under ESA agreement and what types of stock had access to their grazing marsh ditches. They were asked to provide a description of their ditches in terms of approximate lengths adjacent to grazing marsh and arable land, those with steep sided and those with shallow sided bank slopes and those dominated by particular types of vegetation. There were questions about the frequency and type of management and who carries out the management. The reasons for management being carried out were investigated along with sources of advice.

Others involved in ditch management

2.28. Informal face to face and telephone consultations were held with a variety of other people involved with ditch management in the ESAs. These included the FRCA Project Officers, conservation advisors, including FWAG and English Nature, the Broads Authority and the ditch contractors themselves. The questions put to each are presented in Appendices VII, VIII and IX. The aim was to gather additional information about management methods and attitudes to ditch management and the ESA scheme.

RESULTS

3.1. The field survey and management data relating to the ditches at each sample site within each ESA have been analysed to enable comparisons between sites within ESAs to be made. ESA-wide similarities and differences in the characteristics of grazing marsh ditches have also been established. Information collected from the management questionnaire and during the consultations has also been collated to 'add value' to the field survey information and to help interpret the results.

FIELD SURVEY

Number of ditches surveyed

3.2. When the maps for each sample site were produced and the ditches on them numbered, it was found that there was some variation from the expected number of ditches (Tables 2.1 and 2.2 in Methods). In addition, during the field survey, some ditches shown on the map were no longer present on the ground or were adjacent to non-agricultural land (e.g. reedbed, carr woodland, etc.), and in other situations new (as yet unmapped) ditches were encountered. In all, information on 1516 ditches was collected (995 in the Broads and 521 in the Somerset Levels & Moors). A detailed breakdown of the number of ditches, and their agreement status, surveyed in each sample site within each ESA is presented in Tables 3.1 and 3.2.

3.3. The majority (86%) of ditches surveyed in the Broads ESA were under agreement. There was considerable variation in the agreement status of ditches between sites. Site LCT3 was unusual in having only ditches under Tier 2 agreement. Sites LY5 and LW2 had very few non-agreement ditches and a large proportion under the high water level tiers (Tiers 2 and/or 3) whereas, at HW1, 69% of the ditches were non-agreement land and the remainder under Tier 1 agreement.

3.4. As with the Broads ESA, 86% of the ditches surveyed in the Somerset Levels & Moors ESA were under agreement. However, the agreement status of ditches within these sites was more complex than that of the Broads. This is due to the fragmented nature of land ownership resulting in land on each side of ditches occasionally coming under different tiers of agreement (e.g. Tier 1/3 indicates land in Tier 1 on one side and in Tier 3 on the other side of the ditch). The assumption has to be made that the prescriptions for these ditches would need to meet the requirements of the land in the higher tiers. In the Tables 3.1 and 3.2, therefore, ditches adjacent to both Tier 1 and Tier 2 land have been allocated to Tier 2, those adjacent to Tier 2 and Tier 3 have been allocated to Tier 3, etc.

Table 3.1. Numbers of ditches surveyed in the Broads ESA.

Site name	Site code	Tier 1	Tier 2	Tier 3	Non Agreement	Total ditches surveyed
Smallburgh 9	S9	0	19	8	12	39
Happisburgh to Winterton 1	HW1	41	0	0	93	134
Lower Bure and Halvergate 2	LBH2	61	59	0	21	141
Lower Bure and Halvergate 11	LBH11	93	60	0	8	161
Langley, Chedgrave and Toft Monks 3	LCT3	0	158	0	0	158
Lower Yare 5	LY5	20	28	59	1	108
Lower Waveney 2	LW2	169	84	0	1	254
	Total	384	408	67	136	995

(Key to Tiers: 1 = Permanent Grassland, 2 = Extensive Grassland, 3 = Wet Grassland)

Table 3.2. Numbers of ditches surveyed in the Somerset Levels & Moors ESA.

IDB sub-area	Site code	Tier 1 or 1A	Tier 1/2	Tier 1/3	Tier 2	Tier 2/3	Tier 3	Non Agreement	Total ditches surveyed
Stoke Moor	SM	79	2	0	6	0	0	12	99
North Moor	NM	58	5	0	20	0	0	45	128
Curry Moor	CM	54	2	0	10	0	0	14	80
West Sedge Moor	WSM	15	2	6	15	7	46	3	94
Wet Moor	WM	5	0	1	39	0	75	0	120
	Total	211	11	7	90	7	121	74	521

(Key to Tiers: 1 = Permanent Grassland, 1A =Extensive Permanent Grassland, 2 = Wet Permanent Grassland, 3 = Permanent Grassland Raised Water Level Areas)

Ditch width and water depth

3.5. The numbers of ditches in each ditch width class for each site are presented in Appendix X. The majority of ditches surveyed in the Broads ESA were within the 1–3 m width class and, for this and the 3–5 m width classes, there was little difference in width, between ditches with differing agreement status (Table 3.3). It is interesting to note, however, that the greatest proportion of narrow ditches (<1 m) were on non-agreement land. The greatest proportion of very wide ditches (>5 m) were under Tier 1.

Table 3.3 Proportions of ditches in each width class by agreement status for the Broads ESA

Ditch width class	Tier 1	Tier 2	Tier 3	Non Agreement	All ditches
			% of ditches		
< 1 m	7	2	3	16	6
1–3 m	59	60	85	63	62
3–5 m	26	31	12	18	26
> 5 m	8	7	0	3	6

3.6. The ditch widths at the majority of sites in the Broads fitted the general pattern for this ESA (Appendix X). However, at sites LBH11 and S9 there were almost equal proportions of ditches in the 1−3 m and 3−5 m classes. The site with the largest proportion of very narrow ditches (<1 m) was HW1. Sites S9, LBH11 and LW2 had the highest proportion of very wide ditches (>5 m), including main drains and soke dykes (adjacent to rivers).

3.7. There is no obvious relationship, in the Somerset Levels & Moors ESA, between the ditch width classes and their agreement status (Table 3.4). It is noted that none of the Tier 3 ditches were in the narrowest ditch width class, whereas a relatively high proportion were in the two widest ditch classes.

Table 3.4: Proportions of ditches in each width class by agreement status for the Somerset Levels & Moors ESA

Ditch width class	Tier 1	Tier 2	Tier 3	Non Agreement	All ditches
			% of ditches		
< 1 m	17	4	0	9	9
1–3 m	73	81	66	82	74
3–5 m	6	12	27	7	13
> 5 m	4	3	7	2	4

3.8. Stoke Moor had a much higher proportion of very narrow ditches (< 1 m) than the other sites, whereas Wet Moor and West Sedge Moor had larger proportions of the 3−5 m wide ditches (Appendix X).

3.9. The water in the majority of ditches in both the Broads and the Somerset Levels & Moors ESAs was, during the survey period, more than 60 cm deep (Tables 3.5 and 3.6). However, it should be noted that water levels tended to fluctuate and some very high water depths were recorded following a period of heavy rainfall during mid-October.

Table 3.5. Proportions of ditches in water depth classes by agreement status in the Broads ESA.

	% of ditches				
Water depths	**Tier 1**	**Tier 2**	**Tier 3**	**Non Agreement**	**All ditches**
0–0.1 m	2	3	2	10	4
0.2–0.6 m	31	17	29	49	28
0.7–1.5 m	65	79	68	41	67
>1.5 m	2	1	1	0	1

3.10. In the Broads, the higher tiers tended to have larger proportions of ditches with relatively deep water and, as might be expected, there was a high proportion of non-agreement ditches which were relatively shallow (<0.6 m deep).

3.11. Site HW1 had the highest proportions of shallow and dry ditches (53% and 12% respectively) (Appendix XI). In contrast, more than 85% of the ditches at sites LBH11 and LCT3 had relatively deep water (0.7 m deep or more).

3.12. The ditches in the Somerset Levels & Moors are generally more shallow than those of the Broads (R. Bradford pers. comm.) and it is notable that the proportion of ditches with shallower water (>0.1–0.6 m) was larger in the Somerset Levels & Moors than in the Broads ESA. As with the Broads, the higher tiers tended to have higher proportions of relatively deep ditches, although in the Somerset Levels & Moors ESA there was also a high proportion of non-agreement ditches with relatively deep water.

Table 3.6. Proportions of ditches in water depth classes by agreement status in the Somerset Levels & Moors ESA.

	% of ditches				
Water depths	**Tier 1**	**Tier 2**	**Tier 3**	**Non Agreement**	**All ditches**
0–0.1 m	7	0	0	0	3
0.2–0.6 m	57	46	31	46	46
0.7–1.5 m	35	53	63	50	48
>1.5 m	1	2	6	4	3

3.13. At Stoke Moor, the ditches are traditionally emptied each winter, prior to allowing them to refill naturally during the spring. This might explain the relatively high proportion of shallow water at this site (Appendix XI). Very few ditches at the sites in either ESA were dry (i.e. <0.1 m of water).

Ditch classes

3.14. The number of ditches in each ditch class (see paragraph 2.16) in the Broads ESA sample sites are presented in Appendix XII. It is important to note that it was not possible to classify all the ditches because not all the data (e.g. water depth) was available for all the ditches. Table 3.7 presents the ditch classes by their agreement status with the figures in brackets showing the percentage of ditch classes within each tier.

3.15. Over 70% of the ditches under ESA agreement are within the G (Grazed) classes as might be expected for areas where grazing with livestock is encouraged. By far the highest proportion of these are within the G1 class (Grazed/deep/open water). Conversely 89% of the non-agreement ditches are within the A (Arable/Ungrazed) classes.

3.16. Only 5% of all the ditches in the Broads ESA case study sites were within classes G6 or A6, which suggests that shallow, well vegetated/overgrown ditches are relatively uncommon at these sites.

3.17. In the Somerset Levels & Moors ESA, the proportions of G (Grazed) and A (Arable/Ungrazed) ditches within Tier 1 and the non-agreement land were similar (Table 3.8). Tiers 2 and 3, on the other hand, had much higher proportions of G ditches. As with the Broads ESA, there were relatively few shallow, well vegetated/overgrown ditches at the case study sites.

Table 3.7 Number and percentage of ditches in each ditch class by agreement status in the Broads ESA

Ditch class	Tier 1 (%)	Tier 2 (%)	Tier 3 (%)	Non Agreement (%)	Total (%)
G1	167 (44)	189 (47)	26 (39)	3 (2)	385 (39)
G2	39 (10)	36 (9)	8 (12)	4 (3)	87 (9)
G3	26 (7)	29 (7)	7 (11)	3 (2)	65 (7)
G4	20 (5)	6 (1)	5 (8)	2 (2)	33 (3)
G5	10 (3)	2 (<1)	1 (2)	0 (0)	13 (1)
G6	18 (5)	25 (6)	6 (9)	3 (2)	52 (5)
GD	1 (<1)	2 (<1)	1 (2)	0 (0)	4 (<1)
A1	60 (16)	71 (18)	8 (12)	39 (31)	178 (18)
A2	7 (2)	7 (2)	3 (5)	9 (7)	26 (3)
A3	4 (1)	20 (5)	1 (2)	4 (3)	29 (3)
A4	11 (3)	6 (1)	0 (0)	19 (15)	36 (4)
A5	3 (1)	2 (<1)	0 (0)	6 (5)	11 (1)
A6	12 (3)	6 (1)	0 (0)	32 (25)	50 (5)
AD	1 (<1)	2 (<1)	0 (0)	4 (3)	7 (1)
Total	379 (100)	403 (100)	66 (100)	128 (100)	976 (100)

Table 3.8 Number and percentage of ditches in each ditch class by agreement status in the Somerset Levels & Moors ESA

Ditch class	Tier 1 (%)	Tier 2 (%)	Tier 3 (%)	Non Agreement (%)	Total (%)
G1	37 (18)	27 (26)	80 (59)	5 (7)	149 (29)
G2	12 (6)	10 (10)	15 (11)	6 (8)	43 (8)
G3	8 (4)	6 (6)	9 (7)	9 (12)	32 (6)
G4	20 (10)	14 (14)	6 (4)	5 (7)	45 (9)
G5	10 (5)	3 (3)	1 (1)	0 (0)	14 (3)
G6	16 (8)	6 (6)	4 (3)	5 (7)	31 (6)
GD	1 (<1)	0 (0)	0 (0)	0 (0)	1 (<1)
A1	34 (15)	11 (11)	9 (7)	20 (27)	74 (14)
A2	14 (7)	15 (15)	5 (4)	10 (14)	44 (8)
A3	1 (<1)	4 (4)	3 (2)	0 (0)	8 (2)
A4	35 (17)	2 (2)	1 (1)	10 (14)	48 (9)
A5	16 (8)	3 (3)	2 (1)	0 (0)	21 (4)
A6	5 (2)	0 (0)	0 (0)	4 (4)	9 (2)
AD	1 (<1)	0 (0)	0 (0)	0 (0)	1 (<1)
Total	210 (100)	101 (100)	135 (100)	74 (100)	520 (100)

3.18. Looking at the number of classes present at each case study site (Figures 3.1 and 3.2), it is evident that most sites have most of the available classes. However, one would expect the sites with the most ditches to have the most classes and this is not always the case (Appendix XII). In particular, site S9 in the Broads has far more ditch classes represented than would be expected, whereas site LBH11 has fewer ditch classes than expected. Sites LW2 and LY5 had ditches representing all the possible classes. In the Somerset Levels & Moors ESA, Curry Moor has slightly more ditch classes than would be expected and both Stoke Moor and Wet Moor slightly fewer than expected.

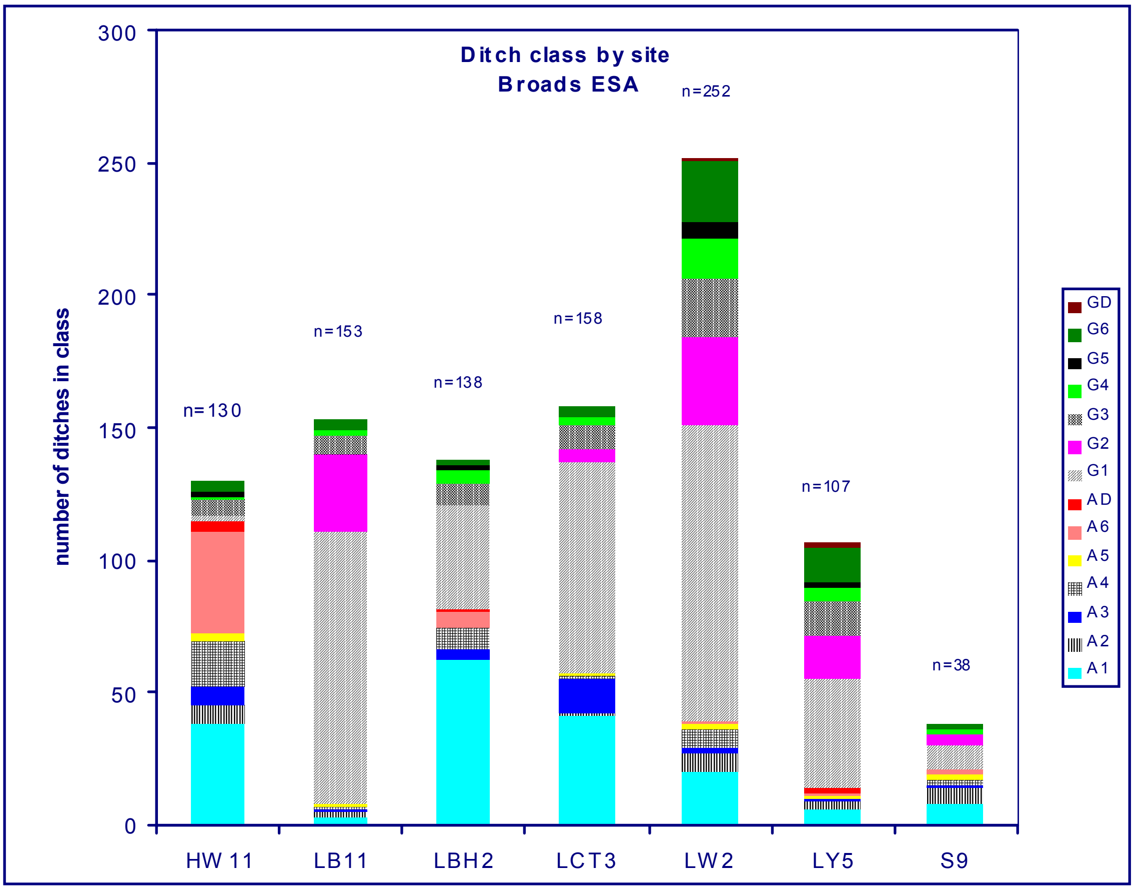


Figure 3.1. Ditch classes in each case study site in the Broads ESA.

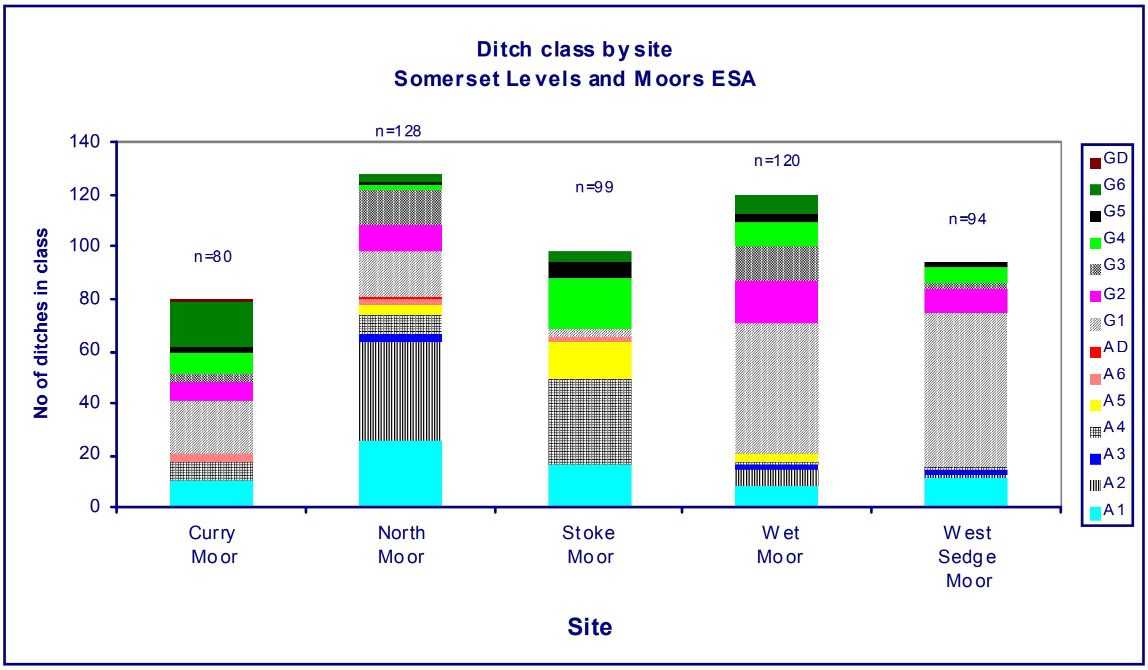


Figure 3.2. Ditch classes in each case study site in the Somerset Levels & Moors.

3.19. The number of ditches within each ditch class at each site provides an indication of the 'even-ness' of spread (S_n) across classes (see paragraph 2.19 and 2.20). Sites with an even spread of classes will have similar numbers of ditches in each class and a low score for S_n. Those with an uneven spread will have very different numbers of ditches within each class and a high score for S_n (Appendix XII). In the Broads ESA, site S9 has a fairly even distribution of ditches within the classes present. In contrast, sites LBH11 and LW2 have a very uneven distribution of ditches within the classes, with a predominance of the class G1. In the Somerset Levels & Moors ESA, Curry Moor and Stoke Moor had the most even distribution of ditches amongst the classes. West Sedge Moor had the most uneven distribution of ditches amongst classes, heavily dominated by ditches in the G1 class.

Successional stages

3.20. One of the factors that might be important for planning ditch management at individual sites is the proportion of ditches in different stages of hydroseral succession, from open water through to domination by emergent vegetation. In both ESAs, the majority of sample sites are dominated by ditches in the 'Open' classes (Figure 3.3 and 3.5).

3.21. In the Broads ESA, none of the sites show an even distribution in the proportions of successional stages (Figure 3.3). Only site HW1 shows a more even distribution between 'Open' and 'Emergent' classes Site S9 has the highest proportion of 'Mixed' classes and sites LW2 and LY5 have relatively high proportions of both 'Mixed' and 'Emergent' ditch classes.

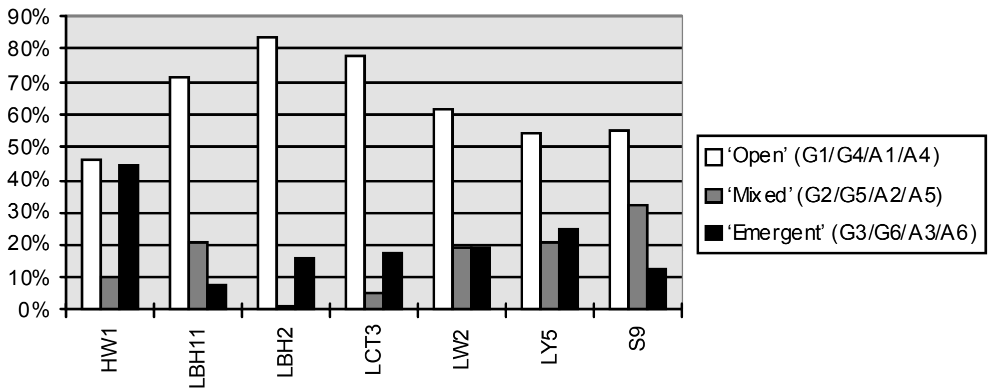


Figure 3.3 Proportions of 'Open', 'Mixed' and 'Emergent' ditch classes in the Broads ESA sample sites.

3.22. Within the Broads ESA, the greatest proportion of 'Emergent' (fully vegetated) ditches occurs within ditches on non-agreement land (Figure 3.4). The agreement land all has a high proportion of 'Open' ditches with similar, small proportions of 'Mixed' and 'Emergent' ditches.

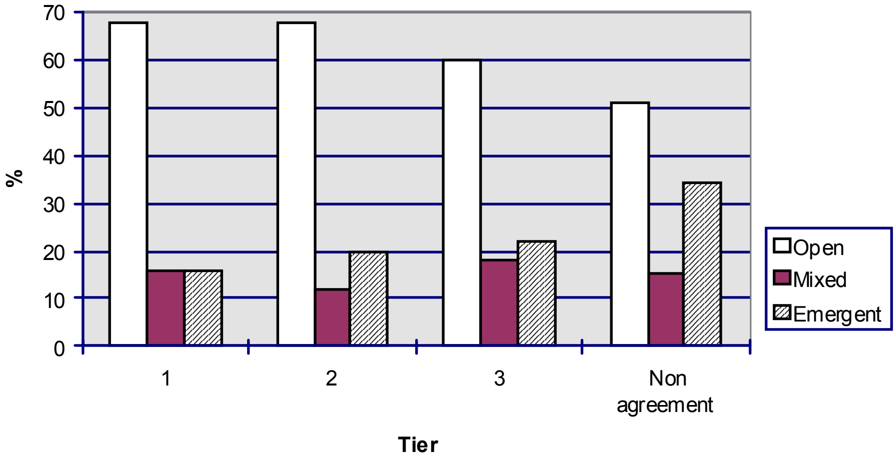


Figure 3.4. Proportions of 'Open', 'Mixed' and 'Emergent' ditch classes by agreement status in the Broads ESA.

3.23. The Somerset Levels & Moors ESA sites are also dominated by ditches in the 'Open' classes. West Sedge Moor and Stoke Moor, in particular, had very few ditches in either of the other two types of class (Figure 3.5). At Stoke Moor many of the ditches were found, during the survey, to have recently been slubbed out. Curry Moor, has a reasonable proportion of 'Emergent' ditch classes and North Moor has the most even spread between the proportions of 'Open' and 'Mixed' ditch classes.

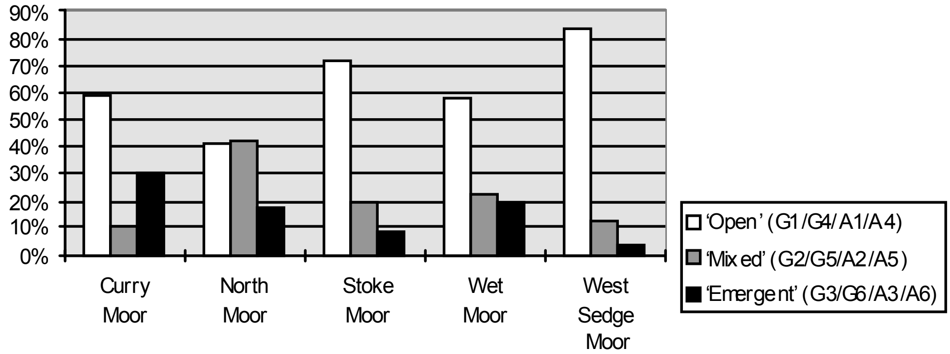


Figure 3.5. Proportions of 'Open', 'Mixed' and 'Emergent' ditch classes in the Somerset Levels & Moors ESA sample sites.

3.24. As with the Broads ESA, the highest proportion of 'Emergent' ditches occurs on non-agreement land (Figure 3.6). On the agreement land, again the highest proportions of ditches are within the 'Open' classes, although in this ESA there were relatively high proportions of ditches within the 'Mixed' classes.

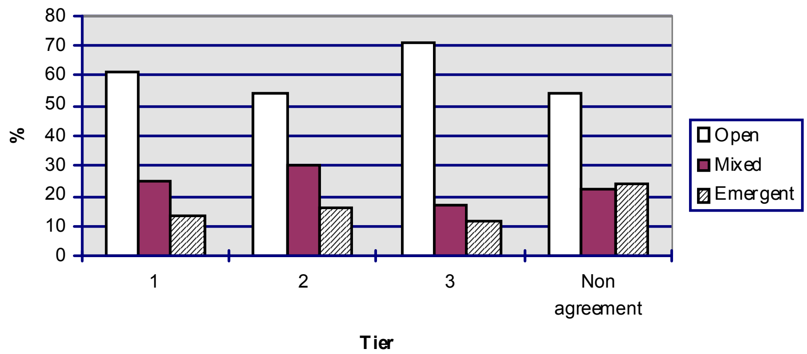


Figure 3.6. Proportions of 'Open', 'Mixed' and 'Emergent' ditch classes by agreement status in the Somerset Levels & Moors ESA.

Spatial distribution of ditch features

3.25. The GIS can be used to display the spatial relationship of each ditch feature across each sample site. Quantification of the size of homogeneous areas of ditch characteristics can be made using the tools in the GIS. Estimates of the size of homogeneous areas may be conservative, as information is not available within this study on the extent that a homogeneous patch of ditch characteristics continues into IDB sub-areas surrounding each sample site. A number of example plots (Figures 3.7 to 3.14) are presented which provide evidence of both medium (>25 ha.) and large (>100 ha.) scale spatial homogeneity in ditch characteristics. The GIS extension provided as part of this project provides the tools for further analysis.

3.26. Figures 3.7 and 3.8 show the distribution of ditch water depths across sites LBH11 and LY5. More spatial homogeneity may be expected for a characteristic such as water depth, which is likely to be related to large-scale features of the landscape (e.g. geomorphological processes) as well as the more anthropogenic effects of ditch management. The ditches at LBH11 are mostly fairly deep (i.e. at least 60 cm of water) and the whole area of the site (about 300 ha.) is fairly homogeneous. The ditches within LY5 do show some variation in ditch depths, which include a mixture of deep and shallow water, particularly at the northern and southern extremities of the site. In between the classified ditches is a large area of non-agricultural land (reedbed and carr woodland, etc.). For both sites, where there are variations in ditch depths, some similarity is seen between connected ditches, as would be expected.

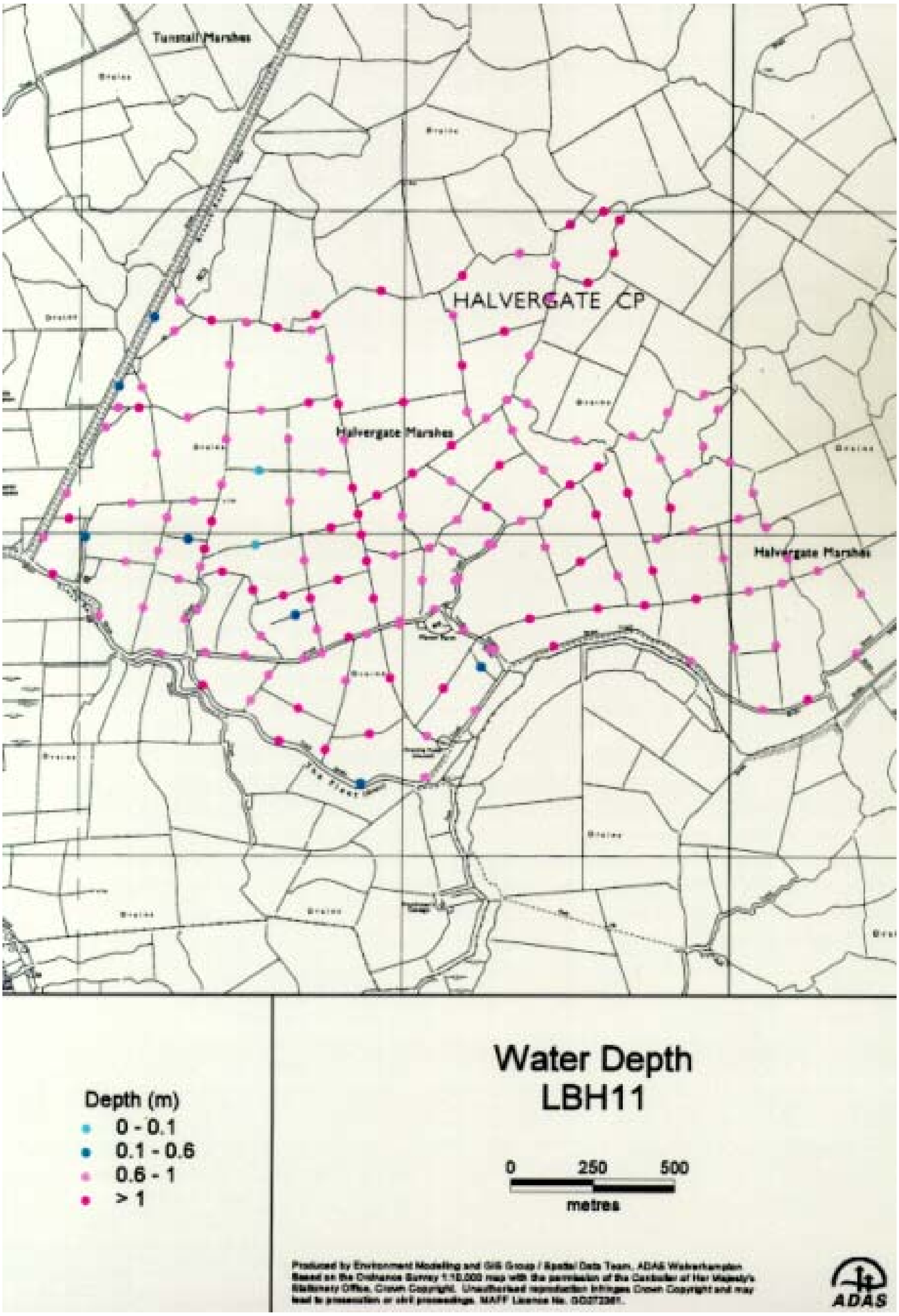


Figure 3.7 - Distribution of ditch water depths across LBH11

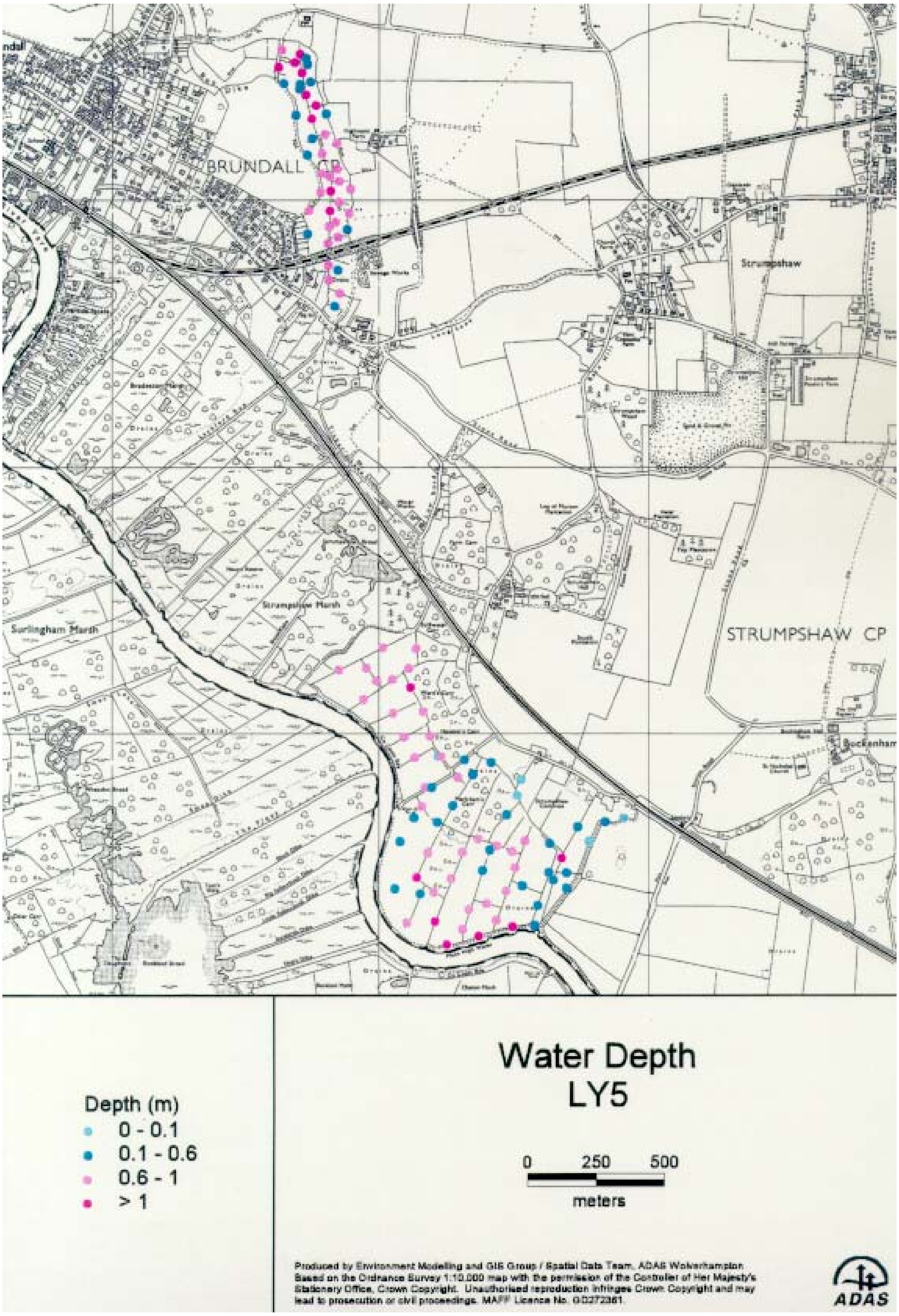


Figure 3.8 - Distribution of ditch water depths across LY5

3.27. Figures 3.9 and 3.10 show the distribution of ditches with different proportions of aquatic vegetation across sites HW1 and LBH2. Both these sites show evidence of large-scale (>100 ha.) patches of similar ditch characteristics. Within HW1, there is a large area (about 200 ha.) of relatively homogeneous ditches, to the east of Horsey Road, with low cover scores for aquatic vegetation, and corresponding high cover scores for open water. To the west of Horsey Road, aquatic vegetation is moderately abundant. The plot for LBH2 indicates very low proportions of aquatic vegetation. This may be due to the brackish nature of the ditches in this area (Harris *et al.*, 1997) or recent management operations. Within this site, there is some patchiness in the spatial distribution of the aquatic vegetation. There is a large area (>100 ha.) with little aquatic vegetation, high cover scores for open water, and some variability in the presence of emergent vegetation (possibly related to different rates of succession within the area). Within LBH2, there are also relatively homogeneous areas of medium size (>25 ha.) where the cover scores of aquatic vegetation are of moderate size.

3.28. Figures 3.11 and 3.12 show the distribution of ditches with different proportions of submerged vegetation across sites LW2 and HW1. At LW2 there appears to be a reasonable distribution of ditches with submerged vegetation across the site. At HW1, on the other hand, where the majority of ditches are very shallow, there is little or no submerged vegetation.

Figures 3.13 and 3.14 show the distribution of ditches in different ditch classes across sites LY5 and LBH11. At LY5 there appears to be a reasonable mosaic at each end of the site with different classes within close proximity to each other. The patches of different ditch classes are small, being less than 25 ha. in size. As many of these small patches are on the edge of LY5, more information on whether they develop into larger areas in neighbouring IDB sub-areas would be necessary before making a judgement on the favourability of the current distribution of ditch classes for biodiversity or conservation of particular species or communities. At LBH11 the pattern of ditch classes appears to be more homogenous with large areas of class G1, in particular, that dominate the entire site.

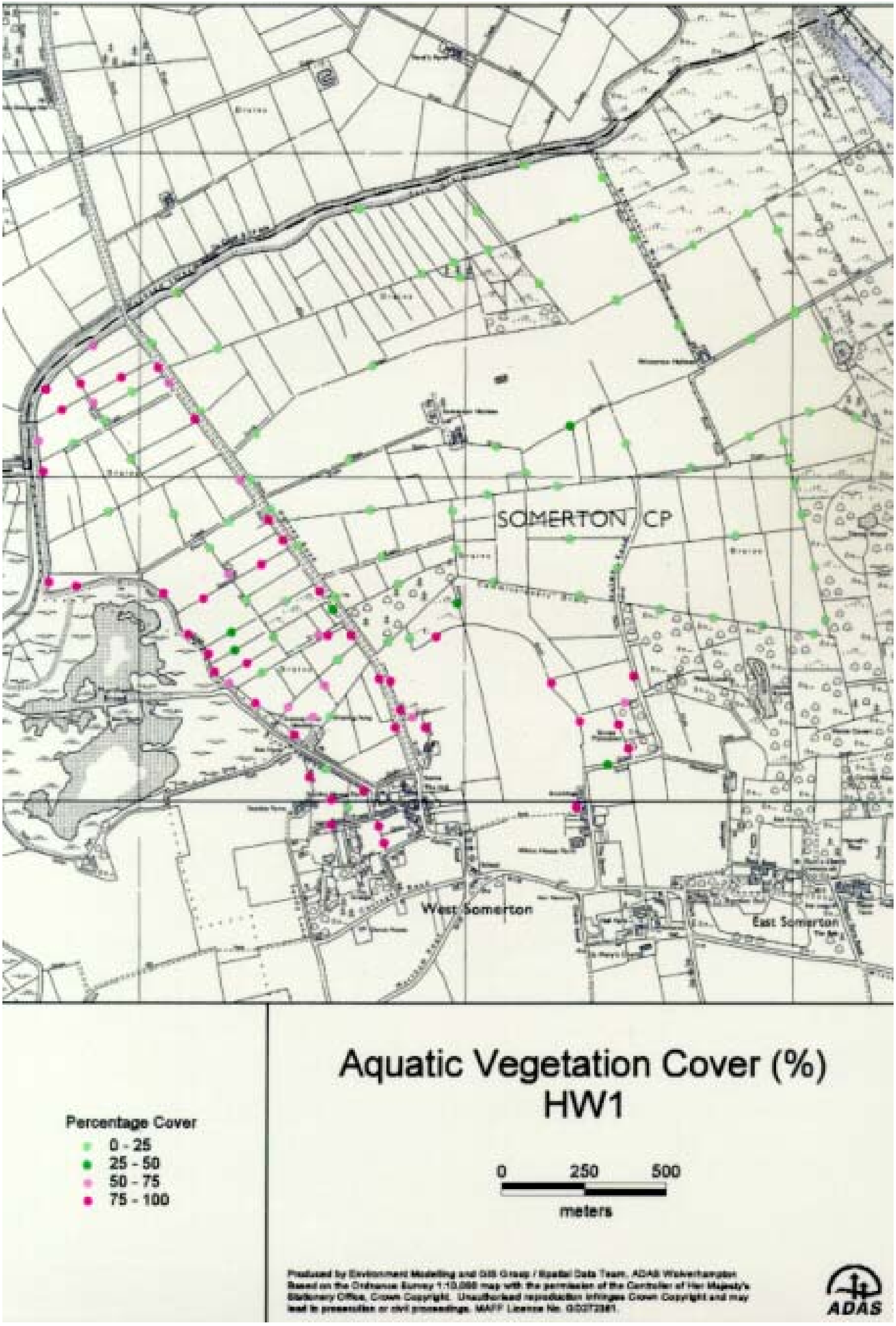


Figure 3.9 - Distribution of emergent vegetation abundance across HW1

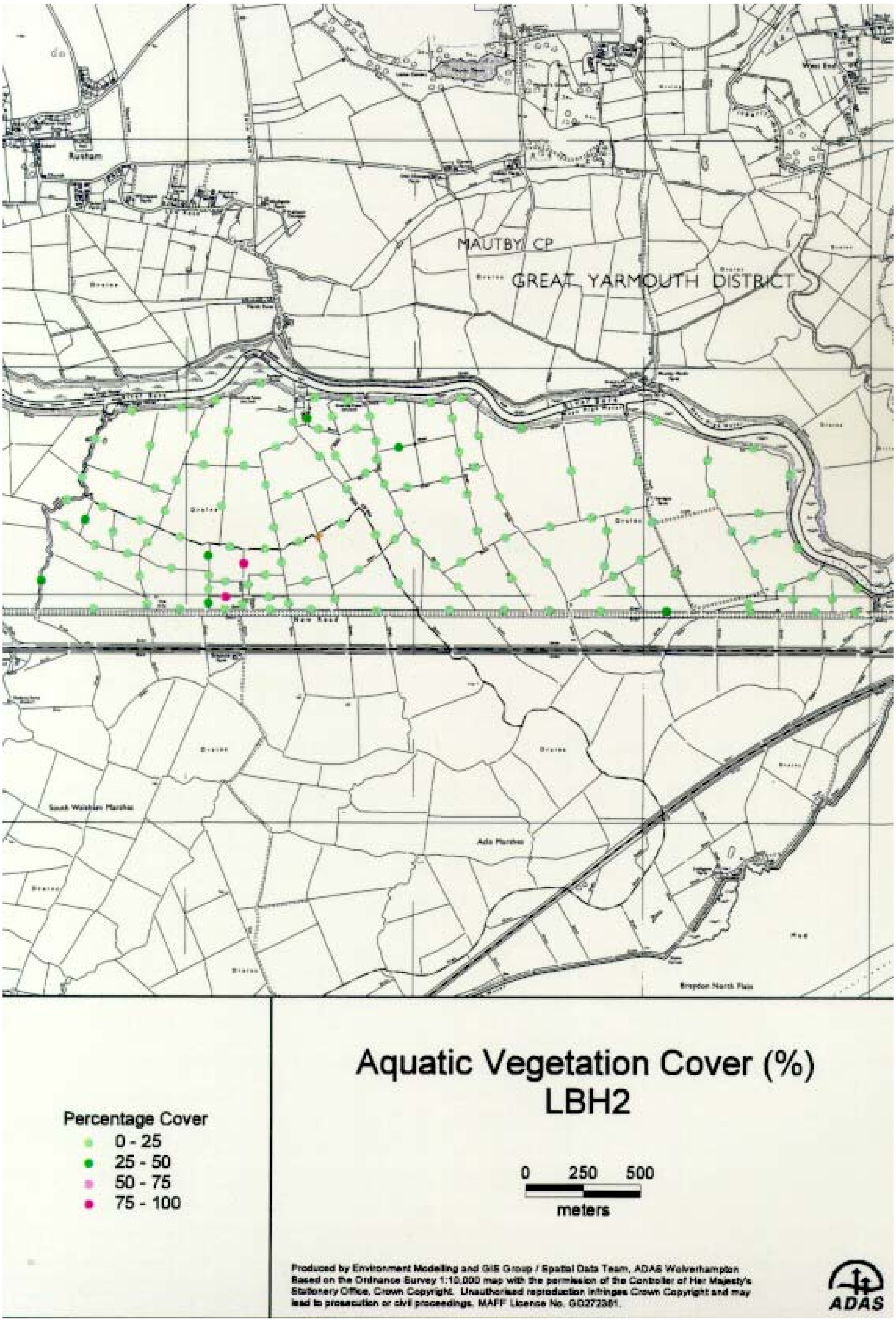


Figure 3.10 - Distribution of aquatic vegetation abundance across LBH2

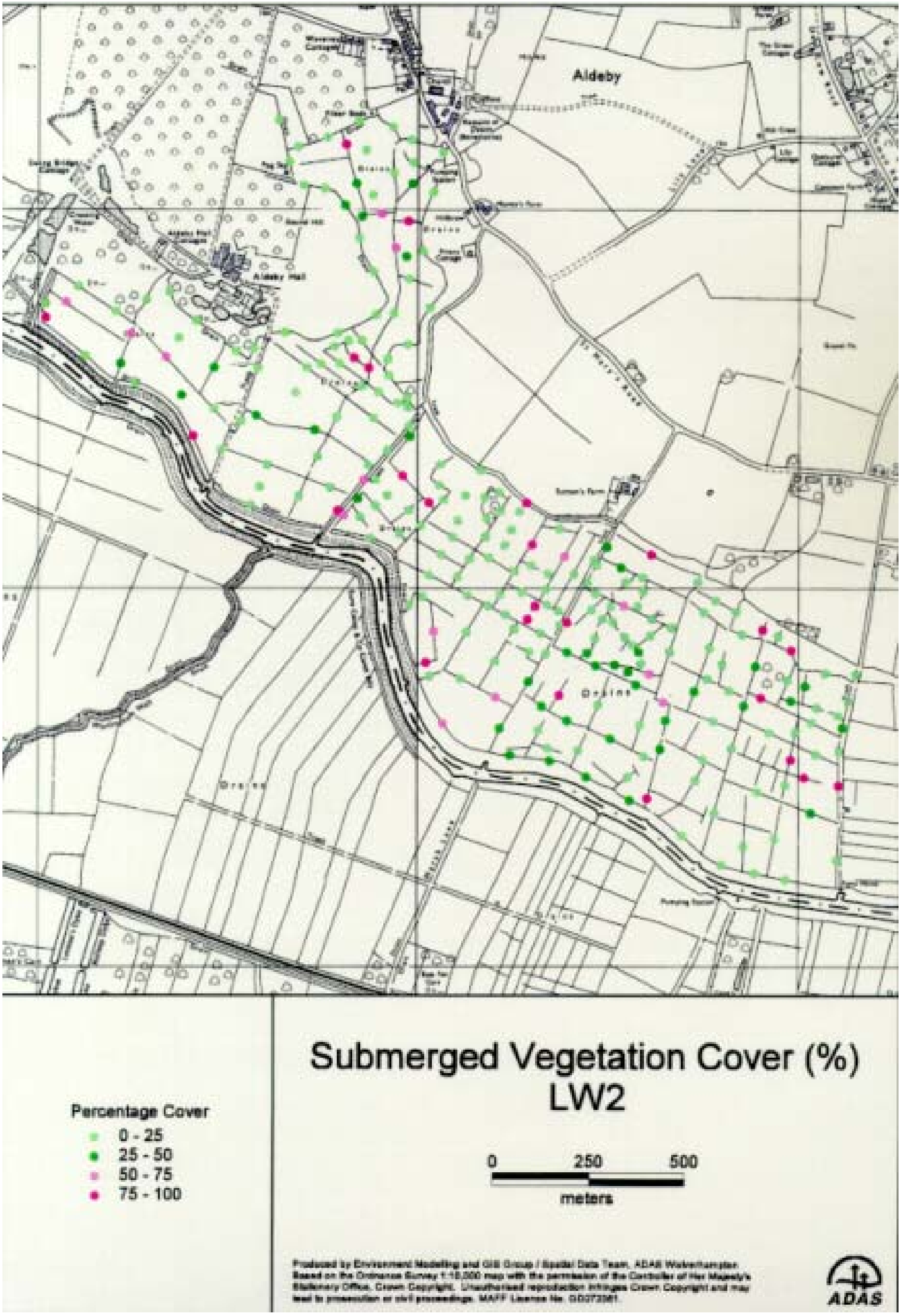


Figure 3.11 - Distribution of submerged vegetation abundance across LW2

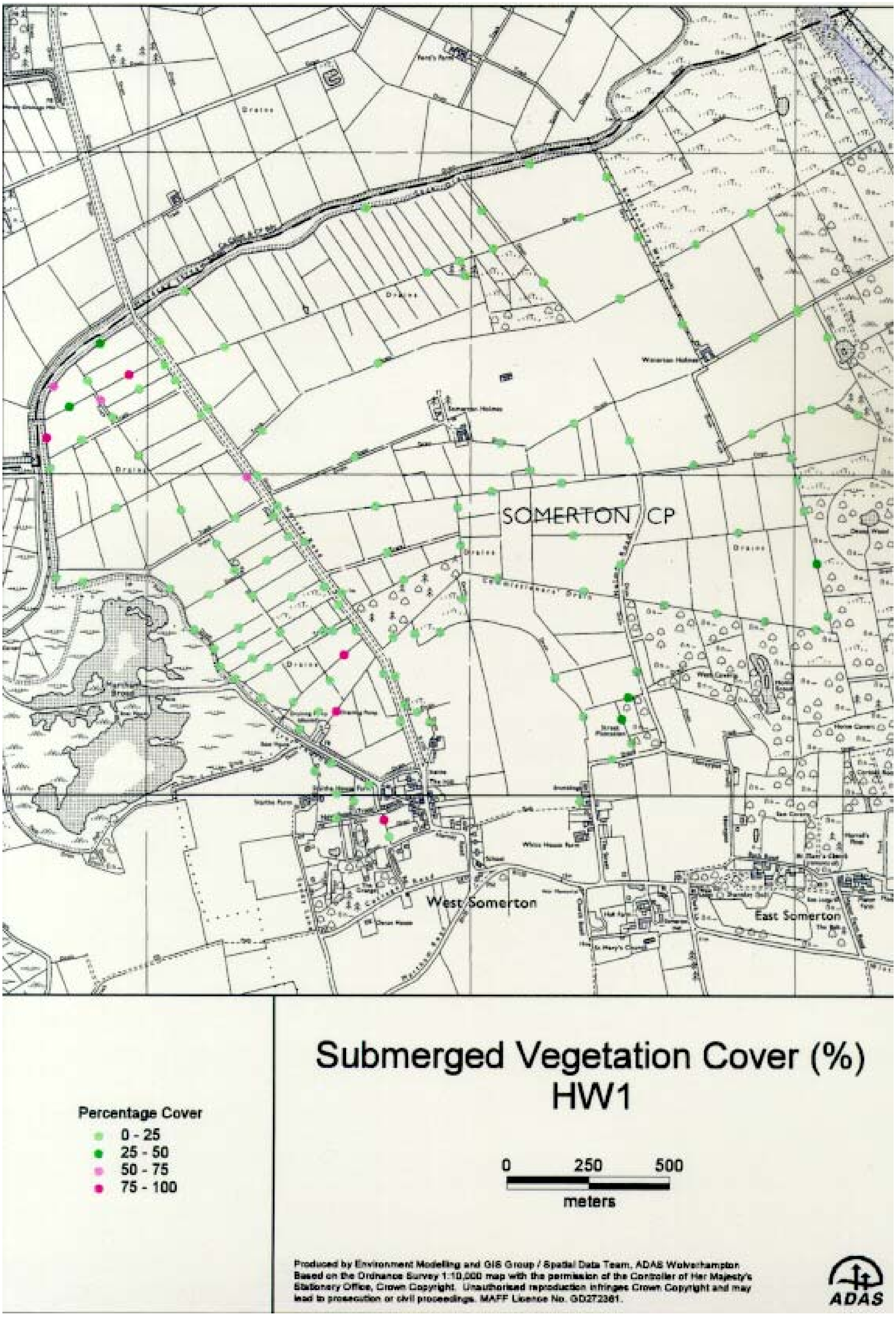


Figure 3.12 - Distribution of submerged vegetation abundance across HW1

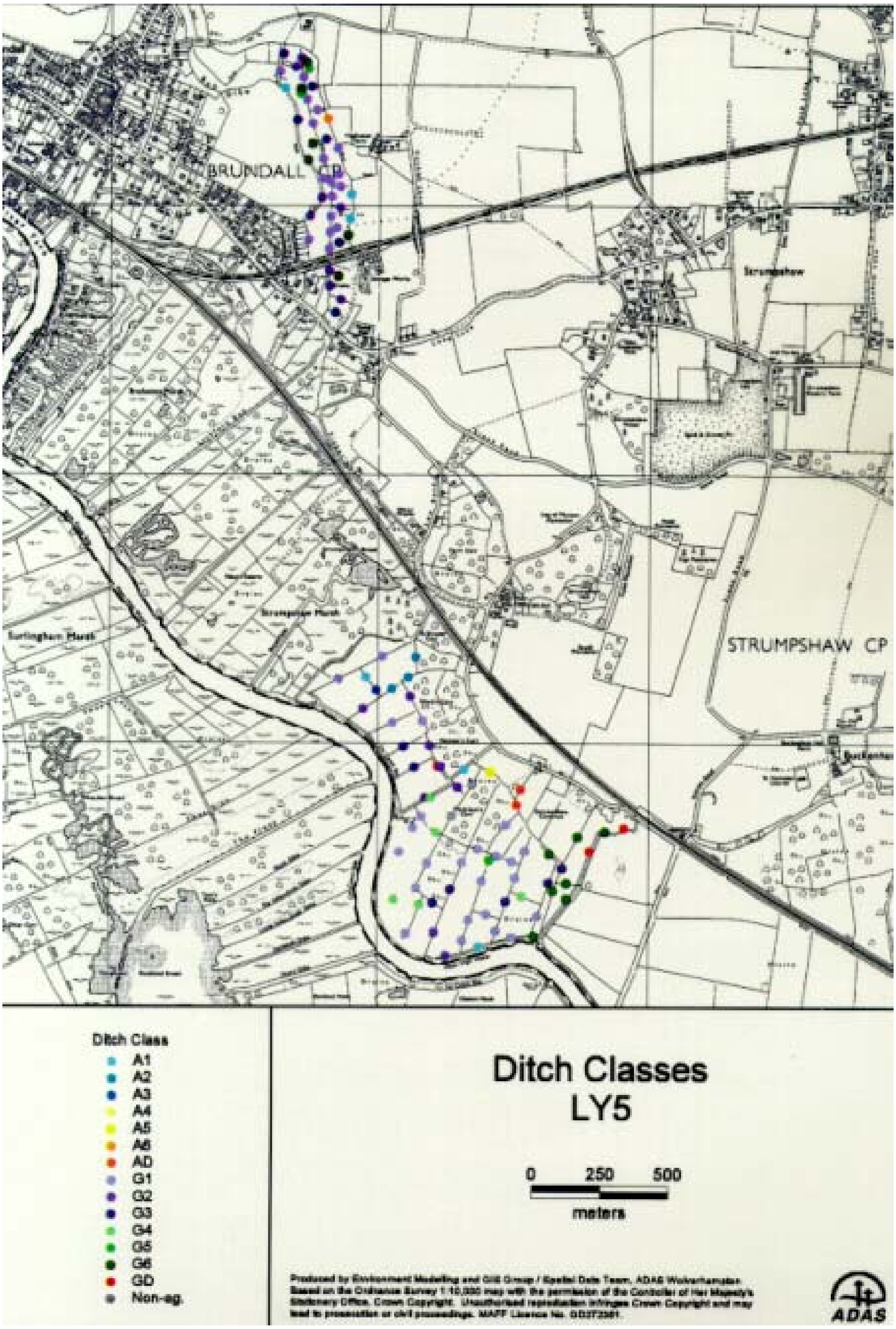


Figure 3.13 - Distribution of ditch classes across LY5

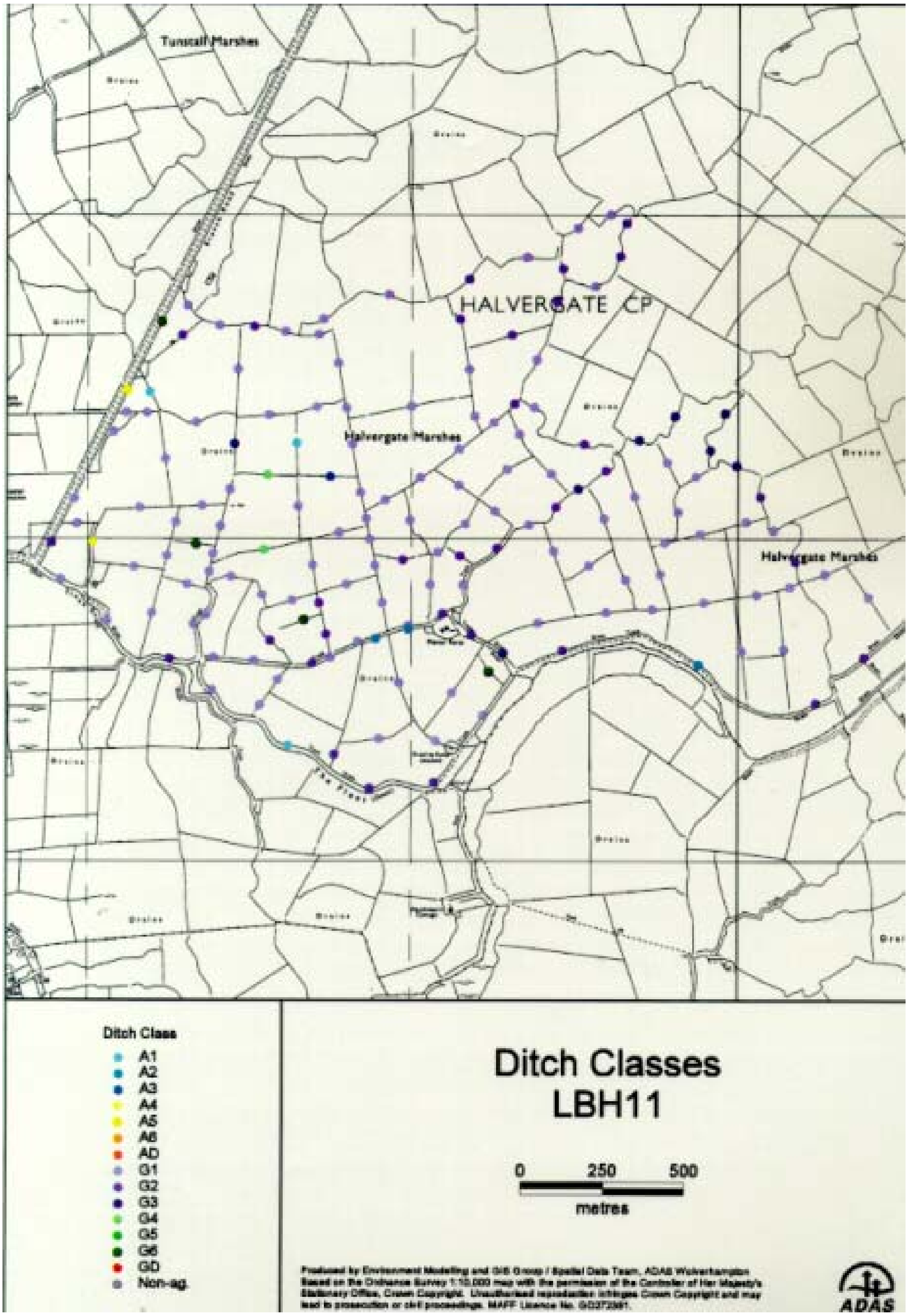


Figure 3.14 - Distribution of ditch classes across LBH11

Site suitability for wildlife communities

3.29. In order to determine which sites are likely to be suitable for certain communities, it is necessary to examine the relationship between the ditch classes and the features required by particular communities (refer back to Table 1.1). Although, for simplicity, the ditch classes, defined for the purposes of this report, do not include all the required features e.g. the presence of a particular bankside vegetation structure, the fact that this structure has been recorded as part of the field survey means that its presence and distribution within a site can be assessed using the GIS (see case studies in the next section). The ditch classes most closely associated with the majority of the required features are presented in Table 3.9, which shows that some classes, such as G1 and G2, potentially provide more of the features required by communities/species than others.

3.30. Each case study site within each ESA has different combinations of ditch classes, with some more abundant than others. Using Table 3.9, it is possible to provide a simple assessment of the potential suitability of sites for each of the above community types. Tables 3.10 and 3.11 show the results of this assessment for the sites within each ESA. Ditch classes were only included in the assessment if they comprised at least 10% of all ditches present at the case study site. This was an arbitrary cut-off level and does not take account of the length or density of ditch class involved and, as such, may not be appropriate for e.g. the less mobile species, which may require a high density of the appropriate ditch class(es).

3.31. Within the Broads ESA, all the sites would appear to have the features required by aquatic plants, aquatic invertebrates, fish and, if the bankside cover and other factors are suitable, otters and amphibians (Table 3.10). Most sites have structural features required by emergent plants, marginal plants, marginal invertebrates and water voles (if the bankside cover and other factors are suitable). Passerines and wildfowl using ditches for breeding sites require stands of reeds and other tall emergents for cover. The ditch classes fulfilling these requirements only occurred at, or above, the 10% cut-off level at two sites, HW1 and LY5. In fact site LY5 was the only site to be potentially suitable for all the key ditch communities/species.

3.32. Within the Somerset Levels & Moors ESA, all the sites had the features required by aquatic plants, aquatic invertebrates, marginal invertebrates, fish and if the other factors are present, otters and amphibians (Table 3.11). At most sites there were features required by emergent and marginal plants, passerines, waders and water voles (if the other factors are suitable). The requirements for wildfowl appeared to only be met at Curry Moor (CM), although even at this site there were relatively few (<10%) ditches >3m wide.

Table 3.9 Relationship between features required by different communities and the ditch classes

Required features	Ditch classes	Community type
		PLANTS
Permanent presence of deep, open water.	G1, G2, A1, A2	Aquatic plants (submerged and floating-leaved)
Shallow water and/or ditch wet throughout the year.	**G2, G3, G4, G5, G6, A2, A3, A4, A5, A6**	Emergent plants
High winter water level/water table. Poaching/disturbance (at moderate levels). Continuity of habitat i.e. reservoirs left for recolonisation. **Berm** at water level in e.g. Broads and Somerset Levels (where summer water can be maintained).	**G1, G2**	Marginal plants (growing on berm or within 'drawdown' zone on banks)
		INVERTEBRATES
Deep or shallow water plus shallow margins with not too much shade from overhanging or dense emergent vegetation.	**G1, G2, G4, G5, A1, A2, A4, A5**	Aquatic invertebrates
Broad 'drawdown' zone with light poaching and small patches of bare mud. A gappy fringe of emergent vegetation. Nearer bank tops need small scale tussocky vegetation grazed by cattle not sheep. Good structural diversity within 2m of bank top. Isolated scrub bushes.	**G1, G2, G3, G4**	Marginal invertebrates
		BIRDS
Persistent stands of reeds and tall emergents.	**G3, G6, A3, A6**	Passerines (Warblers, etc.)
Lack of disturbance and good cover. Good width of watercourse.	**G6, A6 + e.g. >3m wide**	Wildfowl (Ducks, coots, etc.)
Broad berm or drawdown zone	**G1, G2 most likely**	Waders
Large area of cover. Steep bank on one side, shallow on other. Bank above water level. Moderately deep (2') permanent water.	**G1, G2, G3, A1, A2, A3 + additional feature combinations**	**MAMMALS** Water voles
Good bankside cover and fish. Lack of disturbance.	**G1, G2, A1, A2 + bankside cover, + fish**	Otters
Permanent water, open water, good depth.	**G1, G2, A1, A2**	**FISH**
Same as for invertebrates plus tussocky banks. Scrub/wood or dense vegetation for winter hibernation.	**G1, G2, G4, G5, A2, A4, A5 + bankside vegetation**	**AMPHIBIANS**

Table 3.10 Potential suitability of the Broads ESA case study sites for key ditch communities/species

		Sites potentially suitable for these communities/species											
Site code	**Most abundant ditch classes (i.e. containing >10% of ditches at the site)**	Aquatic plants	Emergent plants	Marginal plants	Aquatic invertebrates	Marginal invertebrates	Passerines	Wildfowl (if suitable bankside cover, etc)	Waders	Water vole (if suitable bankside cover, etc)	Otter (if suitable bankside cover, etc)	Fish	Amphibians (if suitable bankside cover, etc)
HW1	A1, A4, A6	✓	✓		✓		✓	✓			✓	✓	✓
LBH11	G1, G2,	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
LBH2	G1, A1,	✓		✓	✓	✓			✓		✓	✓	✓
LCT3	G1, A1,	✓		✓	✓	✓			✓		✓	✓	✓
LW2	G1, G2,	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
LY5	G1, G2, G3, G6,	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S9	G1, G2, A1, A2,	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓

Table 3.11 Potential suitability of the Somerset Levels & Moors ESA case study sites for key ditch communities/species

		Sites potentially suitable for these communities/species											
Site code	**Most abundant ditch classes (i.e. containing >10% of ditches at the site)**	Aquatic plants	Emergent plants	Marginal plants	Aquatic invertebr ates	Marginal invertebr ates	Passerine s	Wildfowl (if suitable bankside cover, etc)	Waders	Water vole (if suitable bankside cover, etc)	Otter (if suitable bankside cover, etc)	Fish	Amphibi ans (if suitable bankside cover, etc)
CM	G1, G6, A1	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
NM	G1, G3, A1, A2,	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
SM	G4, A1, A4, A5	✓	✓		✓	✓	✓				✓	✓	✓
WM	G1, G2, G3,	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
WSM	G1, A1	✓		✓	✓	✓			✓	✓	✓	✓	✓

3.33. To assess a site's potential suitability for a particular species for which the required features are known, it is possible to select for these features within the GIS and then map their distribution within sites. To illustrate this, two case studies were carried out using the requirements of Odonata (damselflies and dragonflies), which are relatively mobile, and the shining ram's-horn snail (a BAP species characteristic of parts of the Broads ESA) which is relatively immobile.

Case studies

3.34. The GIS was used to plot the presence and distribution of ditches with the required characteristics for Odonata and the shining ram's-horn snail. The criteria used were as follows:

- Odonata - >50% open water cover + < 20% emergent vegetation cover + >5% submerged vegetation cover + >5% aquatic vegetation cover. Aquatic and submerged vegetation are required during the larval stages and for egg laying. Light emergent cover is required for emerging larvae and perching adults. Plenty of open water provides suitable hunting territory, although individual species may have specific requirements (Painter, 1998).

- Shining ram's-horn snail - water depth <90 cm + >50% bank poaching cover + >60% emergent vegetation cover. In a survey of the Waveney Valley (Norfolk) these snails were typically found in relatively shallow ditches with extensive emergent vegetation and extensive bankside trampling by cattle (Jackson, 1999).

3.35. The maps relating to these criteria for Odonata and shining ram's-horn snail have been produced for site LW2 (Figures 3.15 and 3.16). As might be expected, given the different criteria used, there is no correspondence between the ditches suitable for Odonata and those suitable for the shining ram's-horn snail. Although there appear to be more ditches matching the criteria for Odonata, these are generally clustered in the middle of this site. There appear to be only three suitable ditches for the shining ram's-horn snail. The implications of these results are discussed in Chapter 4

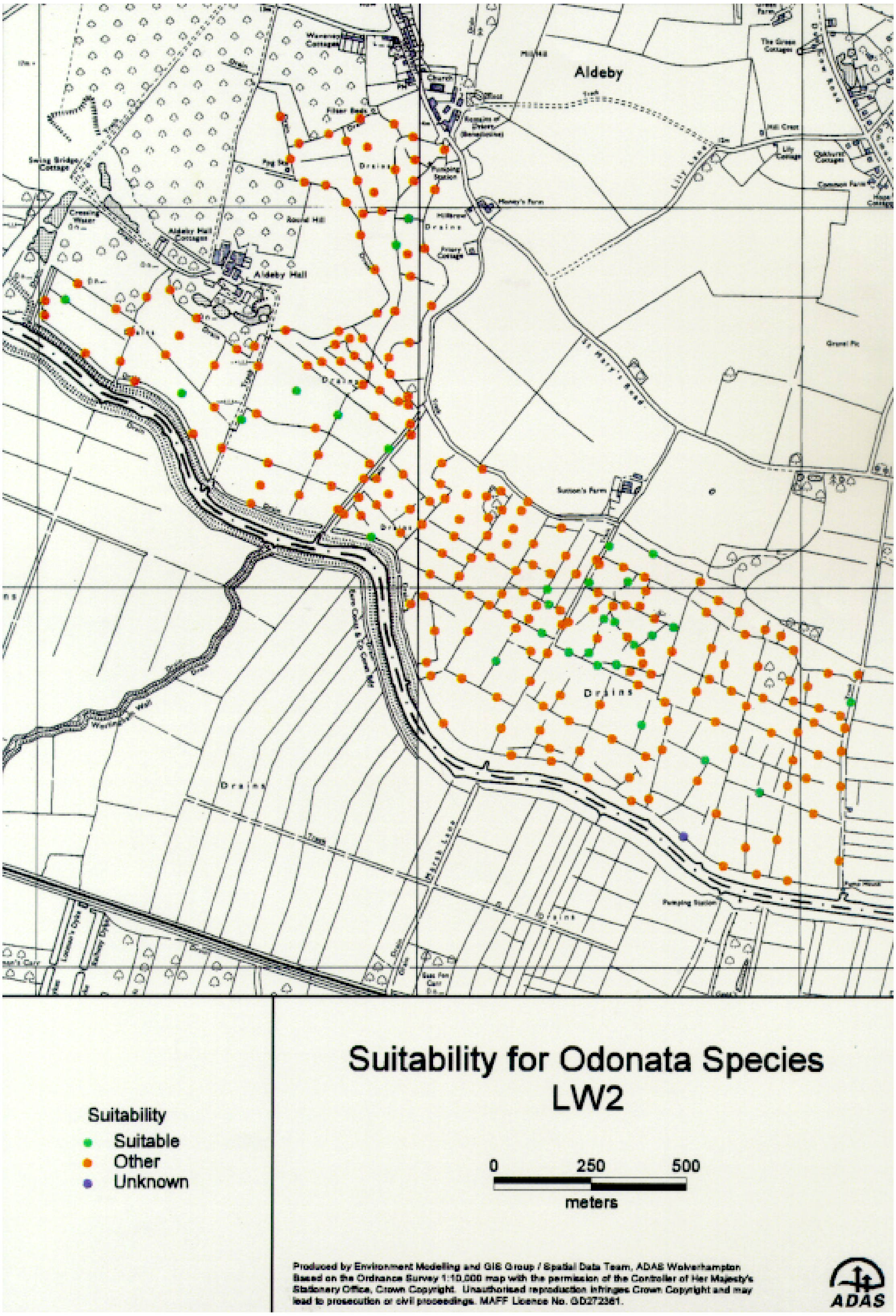


Figure 3.15 - Distribution of ditches suitable for Odonata at LW2

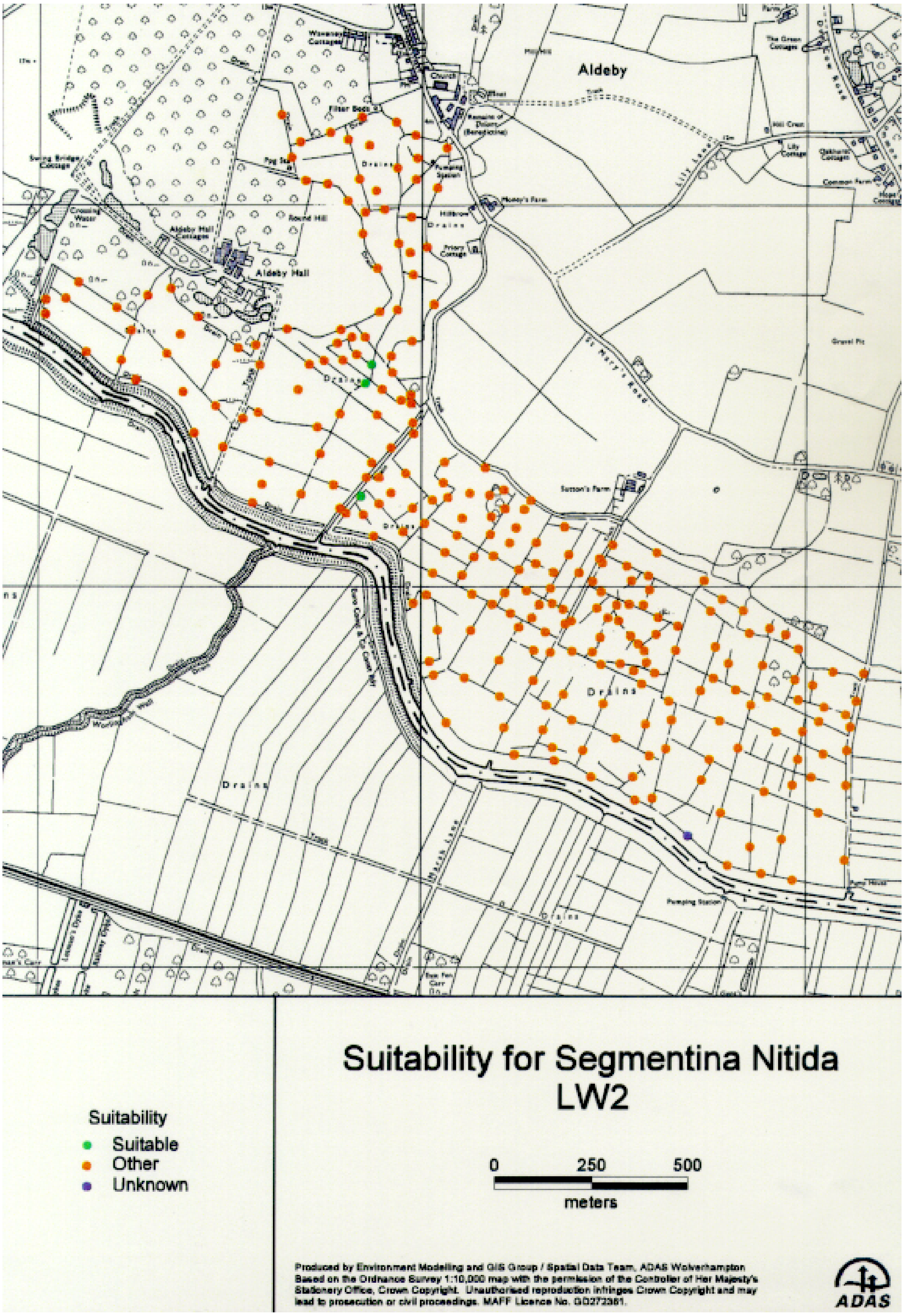


Figure 3.16 - Distribution of ditches suitable for shining ram's horn snail (Segmentina nitida) at LW2

Site management information

3.36. The data relating to the slubbing out of individual ditches at each site was very variable and information relating to the 'year of last management' was not available for half (52%) of the Broads ESA sample ditches and about a quarter (28%) of the Somerset Levels & Moors ESA sample ditches. Many land holders were able to say roughly over what period their ditches were slubbed out e.g. 'once every 10 years or so' but relatively few could give precise dates i.e. month and year of last management (Appendix XIII).

3.37. For those ditches where year of last management data were available, it was evident that a far higher proportion of ditches had been managed in the last three years (1996–1999) in the Somerset Levels & Moors ESA than in the Broads ESA (Figures 3.17 and 3.18). In the Broads ESA over 20% of the ditches had not been managed since 1990, whereas almost 90% of the ditches in the Somerset Levels & Moors (for which management data were obtained) had been managed in the last three years (61% in 1999 alone).

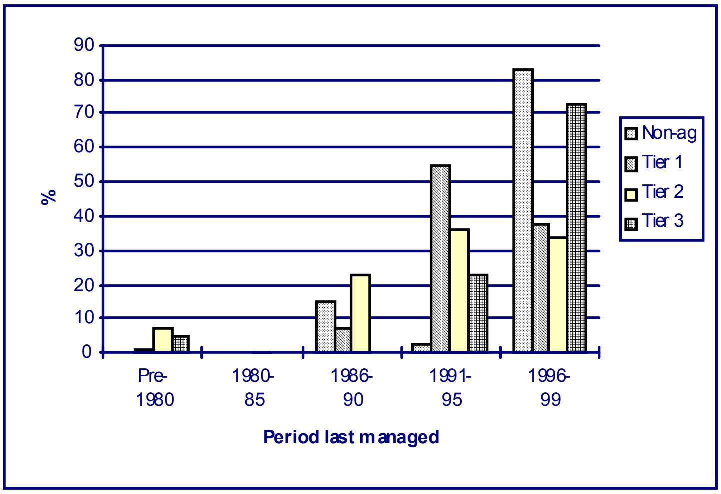


Figure 3.17: Recency of ditch management according to agreement status in the Broads ESA

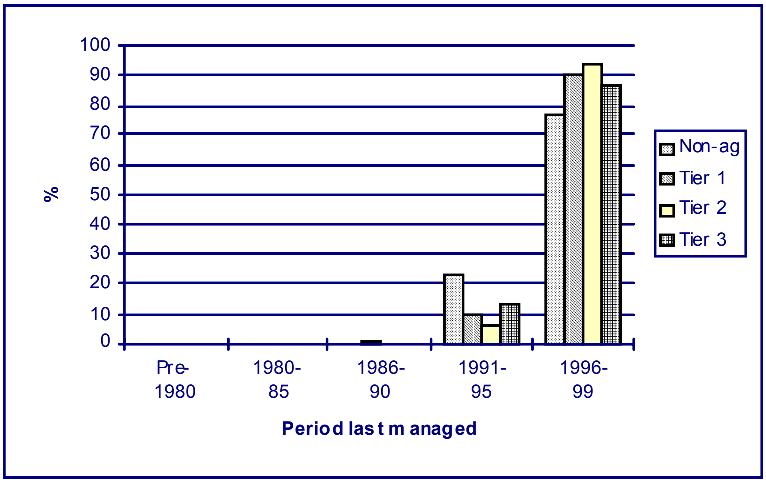


Figure 3.18: Recency of ditch management according to agreement status in the Somerset Levels and Moors ESA

3.38. For the Broads ESA, there is no obvious relationship between agreement status and the period when the ditches were last managed. It is interesting to note that the majority of Tier 3 ditches had been managed in the last 3 years, as had the majority of non-agreement ditches. Ditches under Tiers 1 and 2 were more evenly spread between periods of last management. A greater proportion of ditches under Tiers 2 and 3 had not been managed since before 1980 than those in Tier 1 or non-agreement.

3.39. In the Somerset Levels & Moors ESA there were almost equal proportions of ditches within different tiers, which had been managed during the last three years. There is a slight indication that more of the non-agreement ditches had not been managed since the 1991–95 period than those under ESA agreement.

3.40. The relationship between the recency of ditch management and the features present in the ditches was investigated by plotting the ditch management date against e.g. water depth, % cover aquatic vegetation, % cover emergent vegetation, ditch classes, etc.. No relationships were found between the ditch characteristics and the management information relating to the Broads ESA.

Spatial distribution of ditch management dates

3.41. The distribution of ditch management dates is shown for sites LBH11 and LCT3 in Figures 3.19 and 3.20. There is a large proportion of ditches for which no 'year of last management' data are available. Where the data are available, distinct clusters of ditches all managed in the same year are evident. This suggests that, at these sites, land owners tend to have their ditches managed in blocks of several ditches at a time rather than managing them individually in rotation.

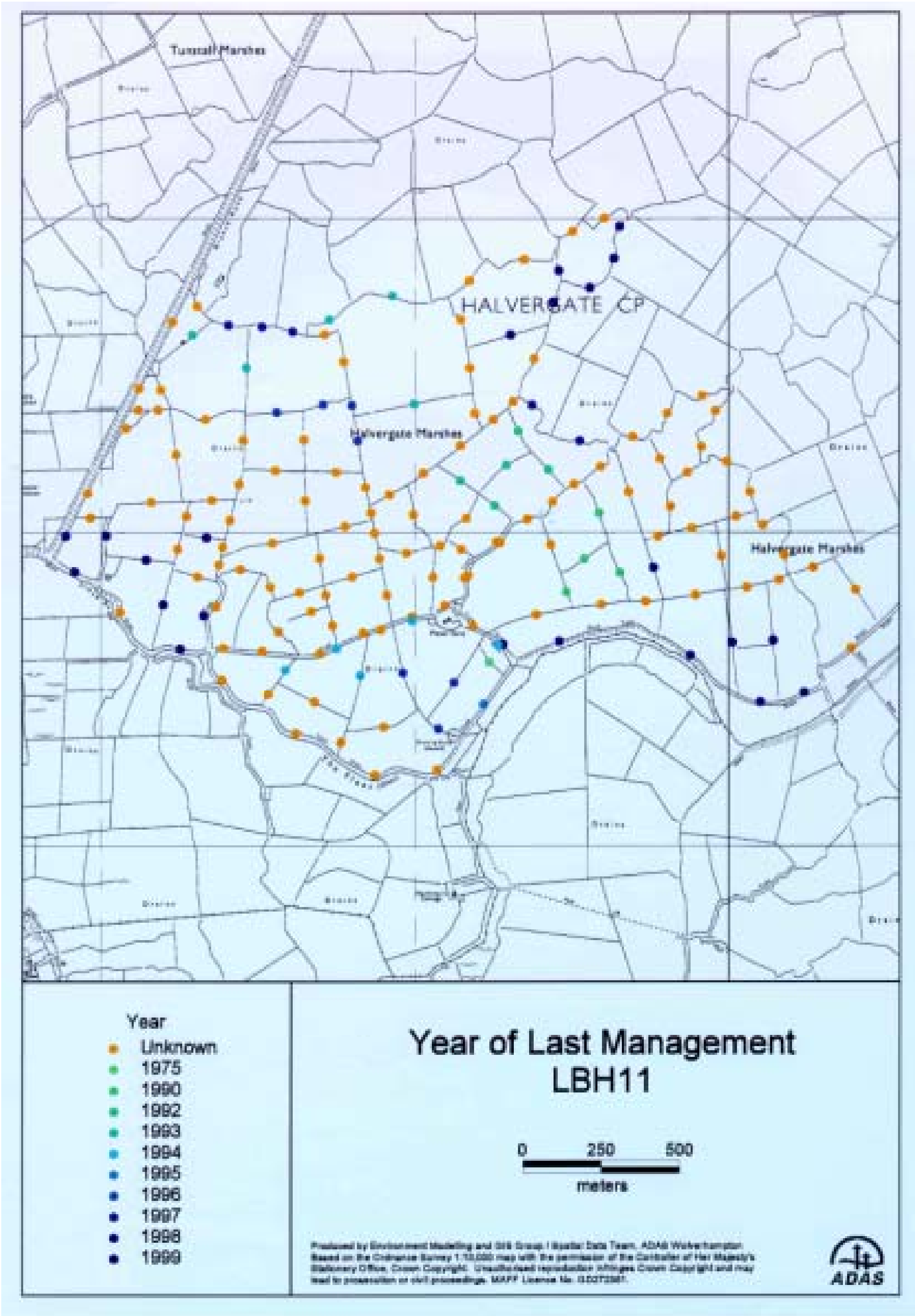


Figure 3.19 - Distribution of ditch management dates at LBH11

Figure 3.20 - Distribution of ditch management dates at LCT3

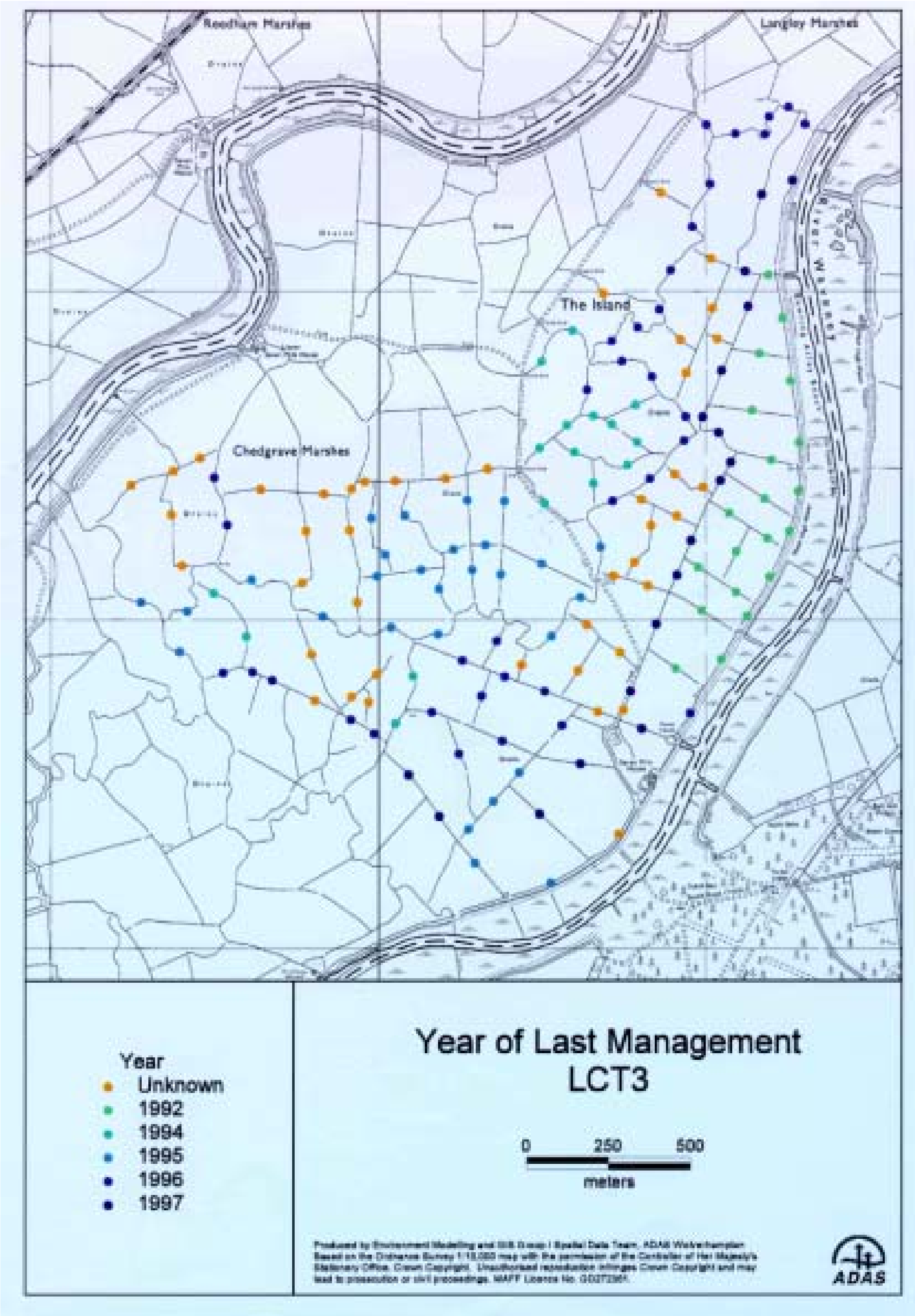


Figure 3.20 - Distribution of ditch management dates at LCT3

CONSULTATION

Postal management questionnaire

3.42. Responses to the ditch management questionnaire were received from 224 land holders in the Broads ESA and 176 land holders in the Somerset Levels & Moors ESA, a response rate of 22% and 18% respectively. Tables of results received for each question are presented in Appendix XIV.

3.43. Although the majority of respondents were ESA agreement holders (93% in the Broads and 97% in the Somerset Levels & Moors), a large proportion (36% in the Broads and 33% in the Somerset Levels & Moors) also managed non-agreement land within the ESA boundaries. Beef cattle are the principal livestock type having access to grazing marsh ditches, with dairy cattle and sheep also well represented. In addition, horses have access to grazing marsh ditches, particularly within the Broads ESA.

3.44. The average total length of ditch bordering each grazing marsh holding under ESA agreement in the Broads is 2,328 m. For the Somerset Levels & Moors ESA the figure is 1,907 m suggesting that, on average, farmers in these ESAs have a similar commitment to ditch management. However, the range of ditch lengths for which individual land owners are responsible varies considerably. In the Broads ESA the minimum ditch length was 8 m and the maximum 70,000 m. In the Somerset Levels & Moors ESA the minimum was 4 m and the maximum 54,100 m. More of the ditches in the Somerset Levels & Moors ESA form part of the farm boundary than those of the Broads, which is expected given the fragmented nature of land ownership in the Somerset Levels & Moors ESA. Both ESAs have similar lengths of ditch, on agreement land, that are fenced to prevent access by livestock.

3.45. In addition to the ditches on land under ESA agreement, many farmers are also responsible for the management of non-agreement ditches, a greater length of which borders arable land.

3.46. In both ESAs there were greater lengths of steep-sided ditches, with bank slopes of 45° or more, than shallow-sided ditches. Both ESAs also appear to have similar proportions of vegetation of various types on agreement and non-agreement ditch banks. In the Somerset Levels & Moors ESA, a greater proportion of ditch bank was thought to be dominated by weeds, such as thistles and nettles, than in the Broads ESA. The respondents for both ESAs thought that the greatest proportion of their agreement ditch watercourses comprised a mixture of open water with emergent, submerged and aquatic vegetation. There was a higher proportion of agreement and non-agreement ditches in the Somerset Levels & Moors ESA with the water surface covered with algae or duckweed.

3.47. Of the respondents providing information about ditch management in the Broads, about half (46%) carry out 'slubbing' (digging out the silt) every 4–6 years on agreement land, with a further third (32%) slubbing out on a longer rotation (6–10 yearly). On non-agreement land the figures were 31% and 37% respectively possibly indicating slightly less frequent slubbing out on non-agreement land. Although vegetation cutting within the watercourse was carried out on occasions, about half

(47%) of the respondents in the Broads, said that this was never done on their land. There was a similar response about watercourse management on non-agreement land in the Broads. However, bank cutting was much more common on non-agreement land than agreement land, presumably because of the need to cut vegetation growing in ditches alongside arable fields.

3.48. When slubbing out their ditches, two-thirds (69%) of the respondents in the Broads tend to slub out up to a quarter (24%) of their agreement ditches in any one year with a further fifth (19%) suggesting that they slub out up to half (49%) in a year. The same pattern was reported for non-agreement ditches. It is interesting to note, however, that although agreement ditches are frequently managed in blocks (adjacent ditches managed at the same time), a higher proportion of respondents (56%) indicated that they managed individual ditches across the farm. The same pattern was true of non-agreement ditches in the Broads.

3.49. In the Somerset Levels & Moors ESA the respondents suggested that both slubbing out and vegetation cutting were done on a more frequent basis than in the Broads ESA. More than 60% of the respondents slubbed out their agreement ditches on a 3, 2 or 1-yearly rotation and over two-thirds (70%) carried out vegetation cutting over these rotation periods. On non-agreement land, there was a similar pattern. Bank cutting tends to be done more frequently on non-agreement land than on agreement land.

3.50. In the Somerset Levels & Moors ESA, slubbing out appears to involve larger proportions of ditches than in the Broads ESA. For instance, over a third (38%) of the respondents suggested that they slub out between 50% and 100% of their agreement ditches in a year. In the Broads ESA, only 12% of the respondents reported slubbing out more than 50% of their ditches at a time. For non-agreement ditches in the Somerset Levels & Moors ESA, 45% suggested that they slub out more than 50% at a time (14% for the Broads non-agreement ditches). However, as for the Broads ESA, more respondents suggested that they managed ditches as individuals across the farm rather than in blocks at the same time. This may be because of the fragmented land ownership in the Somerset Levels & Moors ESA.

3.51. In both the Broads and Somerset Levels & Moors ESAs, the majority of the respondents carry out ditch management during the autumn and winter months (September to February) on both agreement and non-agreement land. The reasons for ditch management varied within the ESAs, although there appeared to be similar responses from both sets of respondents. For land under ESA agreement, most of the respondents (88% in the Broads and 74% in the Somerset Levels & Moors) suggested that ditches with either a lot of emergent vegetation and/or a thick layer of silt on the ditch bottom were those in need of management. However, 34% of the respondents in the Broads and 41% in the Somerset Levels & Moors suggested that ditches with a mixture of open water, emergent and submerged aquatic vegetation require management. It is interesting to note that over 10% of the respondents in each ESA suggested that ditches with open water and few aquatic plants would require management.

3.52. The majority of respondents for the Broads ESA suggested that, following management, their ditches had lengths where the vegetation had been left untouched on purpose. In contrast, the majority for the Somerset Levels & Moors ESA cleared all vegetation from their watercourses.

3.53. In the Broads ESA vegetation cleared from the watercourse and the banks tends to be disposed of either along the ditch banks or along the edge of the adjacent field. The slubbings, on the other hand, are usually spread on the edge of the adjacent field. In the Somerset Levels & Moors disposal of bank and watercourse vegetation along the ditch banks is the most common practice, particularly for agreement land. Slubbings tend to be spread either on the banks or on the field edge. There is a similar response for both agreement and non-agreement land.

3.54. Small proportions of respondents in each ESA (23% in the Broads and 10% in the Somerset Levels & Moors) had used bunds or sluices to raise ditch water levels. The majority of this work is likely to have been done with capital grants from ESA conservation plans in order to achieve water depths appropriate for the high water levels required by Tiers 2 and 3.

3.55. A large proportion of the respondents from both ESAs (63% in the Broads and 76% in the Somerset Levels & Moors), indicated that they had carried out restoration or re-profiling of their ditches within the last 5 years. Information from MAFF for the Broads ESA confirms that the number of agreement holders with conservation plans involving ditch re-profiling has increased from 8 in 1996 to 26 in 1999. Each time these conservation plans involve several ditches and, in the last financial year, several very large schemes were involved (P. Phillips, MAFF, pers. comm.). The statistics for conservation plans are not available for the Somerset Levels & Moors ESA, but it was thought that only a small number relate to ditch profiling/restoration (D. Charman, FRCA, pers. comm.). It is possible that there has been a misunderstanding in terms of the meaning of the question generating these responses.

3.56. In response to the question on which factors were important in determining the way ditches are managed, the respondents in both the Broads and Somerset Levels & Moors ESAs suggested that provision of drainage and ESA prescriptions were the two most important/very important factors. The respondents in each ESA also suggested that the provision of wildlife and wildfowl habitats, prevention of livestock casualties and provision of water for livestock were the next most important/very important factors in determining ditch management. The cost of maintenance was thought to be important/very important by a higher proportion of respondents in the Broads than in the Somerset Levels & Moors.

3.57. The respondents for both ESAs suggest that advice from the ESA Project Officers is the most important factor in making decisions on ditch management. MAFF compliance monitoring is the second most important influence with advice from conservation advisers third.

Others involved in ditch management

3.58. Discussions relating to ditch management were held with the Project Officers for both ESAs, during which examples of advisory literature were also obtained. In the Broads ESA, all agreement holders have been provided with the ditch management leaflet designed by FRCA and English Nature (Appendix XV). This is backed up by periodic articles in the ESA Newsletter. Similar material has been produced by English Nature for land holders in the Somerset Levels & Moors ESA.

3.59. In the Broads ESA, all agreement holders are visited at least once every 5 years for general discussions relating to their agreement land. Since 1997 about 5% of agreement holders have been selected randomly each year for these 'Care and Maintenance' visits, during which all aspects of their agreement are discussed, including issues relating to ditch management. The advice relating to ditch management is based on the Tier 2 prescriptions (even if the agreement holder only has land under Tier 1). The 'Care and Maintenance' visits are followed up with letters, which for those in Tier 2, usually suggests continuing with their existing ditch management plan (given to Tier 2 agreement holders during 1992–1997). In the last two to three years there has been much more emphasis on ditch management in the Broads ESA. In particular, many ditches have been re-profiled under ESA conservation plans.

3.60. In the Broads ESA a fifth (20%) of the agreement holders are subject to compliance monitoring by MAFF each year. However, the management of ditches is lower on the list of priorities, during compliance monitoring, than general land management issues and there is no systematic method for assessing the state of ditch management on a holding (J. Crohill, MAFF, pers.comm.). No agreement holders have ever been penalised in the Broads ESA for failing to carry out ditch management (Q. Hill, FRCA, pers. comm.).

3.61. Tier 3 (Raised Water Levels) agreement holders in the Somerset Levels & Moors ESA tend to get more advice than those in either Tier 1 or Tier 2. The main objectives of the advice given are to keep the water flowing through them, as well as maintaining their wildlife, landscape and historical interest. The compliance monitoring carried out by MAFF within the Somerset Levels & Moors ESA is relatively strict (in comparison with that for the Broads). During their visits, MAFF score ditches against a 5-point scale (Appendix XVI). Ditches that have 'excessive growth' of vegetation, which restricts the flow of water, are 'failed' and the agreement holder has to ensure they are cleaned out within a given timescale to avoid forfeiting his or her payments. Farmers are often asked to contact the Project Officers to confirm that 'failed' ditches have been cleaned out.

3.62. English Nature are actively involved in providing advice on ditch management in both ESAs, particularly within SSSIs. There is a good relationship between the EN and FRCA staff and, as stated earlier, they have collaborated to produce the advisory literature. There is general support for the ESA prescriptions but concern was expressed at the lack of a ditch condition related performance indicator for the Somerset Levels & Moors ESA.

3.63. The Broads Authority only occasionally provides advice on ditch management. In the past they provided advice on a more regular basis but since there are now more ESA Project Officers there is little need for additional advice (S. Tolhurst, pers. comm.). Any advice that is provided would follow the EN/FRCA guidelines (Appendix XV). The Broads Authority are concerned that problems with water flow due to blocked internal ditches may be resulting in excessive pumping due to concerns about water lying on the land. It was suggested that further emphasis should be placed on ensuring the free flow of water by regular checks for blockages.

The additional funding for re-profiling ditches under ESA Conservation Plans was welcomed.

3.64. FWAG and local wildlife trusts are less involved with advice within the ESA boundaries than outside. The FRCA Project Officers are regarded as the specialists within ESA areas and there is general confidence in their conservation related advice.

3.65. The IDBs are responsible for managing the main drains and 'viewed' rhynes within the Broads and Somerset Levels & Moors. They employ a mixture of their own staff and commercial contractors to carry out slubbing out and vegetation cutting. In the Broads ESA, by far the greatest proportion of IDB drains are under the responsibility of the Kings Lynn Consortium of Internal Drainage Boards KLCIDB). A Conservation Officer (ex English Nature) was recruited last year and has helped produce the IDB's Standard Maintenance Operations, which set environmental standards for their work and help to focus their obligations towards conservation. These specify that drains should not all be managed at the same time and that they should be cleaned out in rotation with a 3–5 year, or longer, return period. Where de-silting is required only the centre section of the channel will be cleaned in wide drains. On narrower drains (2m wide or less) just one side of the watercourse will be cleaned. This ensures that there should always be areas of vegetation left untouched, even within recently managed ditches.

3.66. Some of the IDBs in the Somerset Levels & Moors are in liaison with the KLCIDB and considering the development of similar Standard Maintenance Operations. However, each IDB area in the Somerset Levels & Moors has different characteristics and it is thought that guidance on ditch management will need to be suitably flexible (D. Alsop, Parrett Consortium of IDBs, pers. comm.).

3.67. Those carrying out ditch management in the ESAs include contractors working for individual land owners and IDBs. All the contractors spoken to have a thorough understanding of the drainage and wildlife value of the ditches they are managing. However, although they were aware of the broad principles behind the ESA scheme they were, generally, not familiar with the requirements of the management prescriptions.

DISCUSSION

4.1. The networks of grazing marsh ditches are characteristic features of several lowland ESAs, enabling the adjacent land to be managed for agriculture whilst providing important habitats for wildlife. Periodic management of the vegetation and sediment within ditches is essential for maintaining their drainage function. However, if ditch management is also to be effective at maintaining their wildlife value it needs to result in the creation, or retention, of the range of features required by the characteristic plants and animals.

4.2. Water is an obvious requirement, but the quality, depth and permanence within ditches vary within and between ESAs. Water levels in grazing marshes are, in part, managed by the IDBs and are controlled by a series of secondary structures, such as pumps, floodbanks, sluices and bunds. Digging out removes silt and vegetation from the bottom of ditches, freeing the flow of water through the ditch network, and initiates a new cycle of plant growth. This is beneficial when done sensitively but over-severe and/or frequent silt removal can drastically deplete plant and animal communities and change the structure of ditches. Vegetation cutting simply removes vegetation from the watercourse without disturbing the bottom silt. This arrests plant growth but, unlike digging out, does not normally initiate a completely new growth cycle. Bankside grazing, especially by cattle, helps to prevent excess growth of bankside and emergent plants, which could overshadow the watercourse, and can provide muddy conditions suited to certain marginal invertebrates and plants.

4.3. Different combinations of features within ditches are required by different species. The shining ram's horn snail (a BAP priority species), for instance, requires shallow water with extensive emergent vegetation, heavily poached banks and often occurs in algae-covered ditches (Jackson and Howlett, 1999). Grass-wrack pondweed, another BAP priority species found in the Broads, requires deep, open water with little or no algae. The Norfolk hawker dragonfly requires well-vegetated ditches with good water quality and often appears to be associated with ditches containing water soldier (C. Doarks, English Nature, pers. comm.). It is essential therefore for ditch management, in association with certain water quality requirements outwith the scope of this project, to contribute to ensuring that, within management units, there are enough ditches in different stages of succession to provide the variety of ditch features suited to the key species.

4.4. In both ESAs, the majority of ditches within this project's case study sites were adjacent to land under ESA agreement, reflecting the high uptake of ESA agreements throughout both ESAs (76% agreement land in the Broads ESA, 60% in the Somerset Levels & Moors ESA). In the Somerset Levels & Moors ESA the fragmented land ownership has resulted in a complex mosaic of different tiers of agreement on each side of many ditches, whereas in the Broads ESA there tend to be larger blocks of land under the same ownership and within the same tiers. This has implications for ditch management since, in the Broads ESA, it is more likely that large numbers of interconnecting ditches will be managed at the same time, potentially reducing the variety of ditch features present in any one year.

4.5. The ditches at the sample sites for both the Broads and Somerset Levels & Moors ESA had certain similarities in terms of their structure. The majority were between 1 and 3 m wide and had water between 60 cm and 1.5 m deep. However, in the Broads ESA, there was a greater proportion of wide, deep ditches mostly under Tier 1 agreement. Most of the very narrow and relatively shallow ditches were on non-agreement land. Shallow ditches with water less than 60 cm in depth were more abundant in the Somerset Levels & Moors. Ditches with deeper water tended to be under the higher tiers of agreement (Tiers 2 and 3), although there was also a high proportion of non-agreement ditches, often IDB-managed, with deep water.

4.6. The fact that these grazing marsh ditches are part of a pumped drainage system means, of course, that water depth can fluctuate on a regular (sometimes daily) basis. For instance, during the field survey, problems were encountered as a result of deep flooding that occurred within the space of a day following a period of high rainfall.

4.7. The timescale and degree of water level fluctuation (i.e. the drawdown period and zone) within the ditches in each ESA is an important factor in determining the suitability of ditches to certain aquatic organisms, such as marginal invertebrates. This project has only been able to assess water levels at one point in time and has, therefore, not gathered any information about water level fluctuations. It is known, for instance, that at Stoke Moor in the Somerset Levels & Moors ESA the ditches are traditionally pumped almost dry each winter. They, therefore, undergo major seasonal fluctuations in water level and may not provide suitable conditions for communities, such as aquatic plants and fish, or species requiring more stable conditions.

4.8. Most of the agreement ditches within the Broads ESA were within ditch classes that represented ditches with grazed banks. This was to be expected in an area where livestock grazing is encouraged. The similar proportions of 'grazed' and 'ungrazed' ditches within Tier 1 and non-agreement land in the Somerset Levels & Moors ESA, suggests that many of the Tier 1 ditches are steep sided and are not easily grazed by cattle (or other livestock). There would, therefore, appear to be a slightly greater contrast between the structure of ditches in different tiers in the Somerset Levels & Moors ESA than that for the Broads ESA.

4.9. When the numbers of ditches within individual classes were calculated it was found that the highest proportions were in the G1 (grazed banks/deep/open water) and A1 (arable/ungrazed/deep/open water) classes. This was true of both the Broads and the Somerset Levels & Moors sample sites. Following their dyke survey in the Broads in 1997, Harris *et al*, (1997) suggested that one of the reasons for the observed deterioration in the botanical quality of the ditches might have been sub-optimal dyke management, leading to them becoming overgrown with vegetation. This survey suggests that overgrown, neglected ditches are rather uncommon at the sample sites in the Broads. The abundance of open ditches in the Broads ESA, may be as a result of more enthusiastic ditch management initiated, in part by publicity about the 1997 survey results and also because of an increase in pro-active advice from the ESA Project Officers, combined with additional funding for ditch restoration and re-profiling under ESA conservation plans. In the Somerset Levels & Moors the traditional frequency of ditch management (1–3 yearly), combined with rigorous compliance monitoring is likely to explain the large proportion of open ditches.

4.10. Despite differences in the numbers of ditches at each site, the majority of sites contained the majority of classes. The even-ness of spread of ditch numbers in each class, combined with maps showing the spatial distribution of ditch classes, provides a useful indication of the homogeneity of ditch structure at each site. In the Broads ESA, the site at Smallburgh (S9) had an even distribution of different classes, whereas the Lower Bure 2 (LBH2) and Lower Waveney (LW2) sites had large clusters of the G1 ditch class. These ditch class distributions are to be expected given the pattern of land ownership and method of ditch management in these areas. In S9 the land ownership is relatively small scale and only small amounts of ditch management are carried out at different times. In LBH2, on the other hand, agreement holders engage the IDB digger driver to manage large numbers of interconnecting ditches during the same season. In the Somerset Levels & Moors ESA, Curry Moor and Stoke Moor provided examples of sites with an even distribution of classes, whereas West Sedge Moor (managed by the RSPB) was dominated by the G1 class. It is interesting that North Moor, managed almost entirely by one IDB contractor, had the most even spread between proportions of 'Open' and 'Mixed' ditch classes.

4.11. The frequency of management tends to be much higher in the Somerset Levels & Moors ESA than in the Broads. In the Somerset Levels & Moors, ditches are traditionally managed on a 1–3 yearly rotation, whereas those in the Broads are generally managed once every 4–10 years because of the different topography, soil types and land drainage regime. There was no obvious relationship between agreement status and frequency of management although it should be remembered that a large proportion of land owners were not able to specify when their ditches had last been managed. The responses from the postal questionnaire tended, however, to agree with the information gathered from the case study sites. As with the case study sites for the Somerset Levels & Moors ESA, there was a slight indication that non-agreement ditches are managed over a wider range of rotation periods (some very frequently, others very infrequently) than agreement ditches.

4.12. The ESA prescriptions for the Somerset Levels & Moors ESA do not specify a management frequency, whereas those for the Broads ESA clearly state that ditches and dykes should be slubbed out once every 5–8 years. Under the current prescriptions, there is no requirement to limit the number of ditches that are managed during any one year so it is possible (as was witnessed during this project) that all the ditches on a holding could be managed in the same season. Where large blocks of land are concerned, this could have a major detrimental impact on the wildlife characteristic of ditches, particularly less mobile species. This problem could be avoided if, as well as Project Officers providing appropriate advice, additional wording in the ESA prescriptions limited the proportion of ditches within management units which could be managed in any one year. Manipulation in the pattern and frequency of management to safeguard the conservation interests of ditches is likely to be more difficult to achieve, however, if it results in a difference from what is traditional in that area.

4.13. The fact that no relationship was found between ditch characteristics and the date of last management must be interpreted with some caution. First, it is highly likely that there is considerable inaccuracy in the management information provided by agreement holders. Land managers are not required to keep records of ditch management and, given the large numbers of ditches maintained by individuals at some sites, it is possible that generalisations about 'year of last management' were made. This has caused a certain amount of 'noise' in the data that may be masking any real relationships between ditch characteristics and management date. Second, it is thought that individual ditches within a locality may respond differently to management, particularly with regard to the rate of change of ditch characteristics from a management event such as slubbing out. For instance, ditches in peaty areas or where there is a high nutrient load in the water and/or where management has been very 'gentle' will tend to revegetate very rapidly (C. Doarks, English Nature, pers. comm.). If this is the case, it will be difficult to identify general relationships between ditch characteristics and time since last management for an area as large and heterogeneous as the Broads ESA.

4.14. In the Somerset Levels & Moors ESA a large proportion (90%) of ditches had been managed in the last few years. There is, therefore, very little information relating to ditches that have not been managed for a long time, because there simply are not that many that are managed on a long rotation. For the data that was available, it would appear that there is a larger cover of open water in recently managed ditches. However, it would be unwise to use open water cover as a predictor of management recency.

4.15. Despite the lack of a clear relationship between the recency of ditch management and the ditch classes present at a site, ditch management obviously has an impact on the successional stages and wildlife present and is required to maintain the flow of water. What this project is suggesting is that it is not possible to use ditch management dates alone to predict the variation and distribution of ditch structures present. Other projects (e.g. Janse, 1998) have also found that revegetation of ditches is not simply correlated with time since the last management operation and that other factors are also important. The actual variation and distribution of ditch structures, therefore, need to be assessed through periodic surveys using the method described in this report, or modelled using a range of field-measured physical variables. However, ditch management can be used as a strategic tool to achieve the right balance between ditch classes at each site to help contribute to the achievement of their wildlife objectives. Other factors influencing the achievement of wildlife objectives will include water quality, pumping regime, salinity problems, etc.

4.16. The frequency of surveys to establish the presence of the features within ditches will depend on the speed of hydroseral succession. This will differ from site to site as succession is influenced by ditch width, depth, water quality, soil type, etc. If the rate of successional change is not known, it may be necessary to initially carry out surveys on an annual basis. This would also allow changes in the distribution of features in response to ditch management to be assessed.

4.17. Decisions about whether or not ditch management is effective need to be made at a local level at regular periods (e.g. on a 3–5 year cycle) with knowledge about all the conservation, agricultural and other interests. Some ditch classes have been found to potentially provide more of the required features than others. For instance, the deep water and grazed classes (G1–G3) potentially provide more of the required features than the shallow water ungrazed classes (A4–A6). The classes, which generally appear to provide the features required by aquatic plants, include G1, G2, A1 and A2. Marginal plants are best catered for by G1 and G2 because of the likely presence of a berm and potentially valuable drawdown zone. The features required by aquatic invertebrates are likely to be provided by G1, G2, G4, G5, A1, A2, A4 and A5 and those required by marginal invertebrates by G1, G2, G3 and G4. Since much of the wildlife interest within grazing marsh ditches within the two ESAs centres around aquatic and marginal plants and invertebrates, sites with an even distribution of the above ditch classes could be deemed to be being managed more effectively than those with large clusters of a single or only a couple of ditch classes.

4.18. If the objectives for site management are geared more towards species that have different requirements, such as an extensive cover of emergent vegetation, an even distribution of classes such as G3, G6, A3 or A6 would indicate effective management. Conversely, for species that require larger, continuous areas of good quality habitat, such as water voles or otters, effective management may require the presence of larger clusters of similar habitats. For such species the effectiveness of management may need to be assessed at a more regional scale, reflecting their dispersal distances and the territory requirements of functional (persistent) populations.

4.19. With this in mind, the sites managed most effectively for aquatic and marginal plants and invertebrates in the Broads ESA would include S9 (Smallburgh) and LY5 (Lower Yare 5). These sites both had a reasonably even distribution of ditch classes including those most suitable for aquatic and marginal wildlife. Other sites with classes suitable for aquatic and marginal wildlife included LBH11 (Lower Bure and Halvergate 11), LBH2 (Lower Bure and Halvergate 2), LCT3 (Langley, Chedgrave and Toft Monks 3) and LW2 (Lower Waveney 2). However, these sites tended to be dominated by just one or two classes in large geographic clusters less likely to suit as great a variety of aquatic/marginal communities as those sites with a more even distribution of classes.

4.20. Only two sites in the Broads ESA appear to be providing conditions potentially suitable for communities requiring shallow, overgrown ditches (G5, G6, A5 or A6) including HW1 (Happisburgh to Winterton 1) and LY5. The case study relating to the shining ram's-horn snail indicated that there were only three ditches with the required features at site LW2. This is viewed with some concern since parts of the Lower Waveney Valley are known to provide a stronghold for this species. If the distribution of this species is to be increased, agreement holders will need to be actively encouraged to only clean out one side of a ditch at a time (i.e. following EN/FRCA guidelines) to maintain appropriate cover all year round. In addition, the proportion of ditches allowed to run through to a late stage of succession should be agreed in discussion with conservation interests and agreement holders and, if necessary, increased at the sites where this species is most important.

4.21. In the Somerset Levels & Moors ESA, sites providing potentially suitable conditions for aquatic and marginal plants and invertebrates include CM (Curry Moor), NM (North Moor) and WM (Wet Moor). These sites all have the required ditch classes with a relatively even distribution, suggesting effective management for these aquatic and marginal communities. At site WSM (West Sedge Moor) the appropriate classes are present but there is a heavy domination by classes G1 and A1 which is likely to restrict the variety of plants and animals found. At site SM (Stoke Moor) the relatively steep banks and the predominance of shallow water reduced the numbers of ditches potentially suited to marginal plants.

4.22. Sites in the Somerset Levels & Moors ESA which were potentially suitable for communities requiring shallow, overgrown ditches included CM and SM. Overall, the number and even-ness of distribution of ditch classes at CM suggests that this is the site within the Somerset Levels & Moors ESA which is being managed most effectively in terms of providing features suited to the greatest variety of plant and animal communities.

4.23. The large proportion of agreement land within the case study sites makes it difficult to objectively relate the ditch classes to agreement status. However, there was a general trend for land under agreement to have ditches within the 'grazed' classes (G1–G6 and GD) which are overall considered to be more valuable for the characteristic communities than the 'ungrazed classes' (A1–A6 and AD). The 'ungrazed classes' were more common within the non-agreement land, particularly in the Broads ESA. The A6 class was relatively common on non-agreement land in the Broads ESA and may be contributing to the requirements of passerines and other communities characteristic of overgrown, shallow ditches.

4.24. Agreement holders in both ESAs have access to Project Officers, English Nature conservation officers and other advisors. The advice provided is valued and would appear to have resulted in a broad understanding of the value of grazing marsh ditches to wildlife.

4.25. The most important requirement at present is for each management unit, such as IDB sub-areas (or equivalent), within each ESA to be reviewed in terms of their agricultural, flood defence and conservation objectives so that priorities for management can be identified (perhaps in a format similar to Water Level Management Plans for IDB areas). This would enable Project Officers to provide targeted advice on ditch management that would balance and integrate the requirements to meet these objectives within each area. In some areas the over-riding priority might be flood defence, whereas in other areas the priority might be to increase the suitability of ditch habitat for aquatic plants and invertebrates. As long as the objectives for each area as a whole are understood by all those involved in ditch management (land owners, Project Officers, advisors and ditch contractors), there is more likely to be some success in collaborating to achieve them. This is particularly the case in areas where there is a high proportion of agreement land, which can be heavily influenced by appropriate ESA prescriptions.

CONCLUSIONS AND RECOMMENDATIONS

5.1. This project has resulted in the development of a method for assessing the presence and distribution of structural features required by wildlife characteristic of grazing marsh ditches, and has investigated their relationship with ditch management practices. The variety and distribution of ditches, classified according to the features present, provides an indication of the effectiveness of management, in combination with water quality, flow and other factors, in creating the conditions required by different communities or species.

5.2. Of the sites studied in the Broads ESA, those at Smallburgh (S9) and in the Lower Yare (LY5) had a relatively even distribution of ditches with the features required by aquatic and marginal plants and invertebrates. Their management was therefore deemed to be effective in potentially providing the features required by these communities. The site in the Lower Yare was also effectively providing the ditch features required by communities favouring shallow, overgrown ditches.

5.3. In the Somerset Levels & Moors ESA, Curry Moor (CM), North Moor (NM) and Wet Moor (WM) were effectively providing the features potentially required by aquatic and marginal plant and invertebrate communities. Curry Moor also had many shallow, overgrown ditches and was, overall, thought to be being managed effectively for a large variety of ditch communities characteristic of the ESA.

5.4. Sites thought to be being managed less effectively were those where there was a heavy dominance of one or two ditch classes in large clusters within the site. This was often the result in areas where large blocks of land were owned by the same land owner and where ditch management was carried out on large numbers of interconnecting ditches during the space of one or two seasons.

5.5. Ditches on agreement land potentially provide the features required by the characteristic aquatic and marginal plant and invertebrate communities. Non-agreement ditches are potentially less suitable for marginal plants and invertebrates but, particularly in the Broads ESA, may be contributing the stands of reeds and other tall vegetation required by passerines and other communities characteristic of overgrown ditches.

5.6. Judgements about the effectiveness of ditch management are best made with knowledge about the land management priorities applicable to individual management units. These priorities need to be clearly identified for each management unit across each ESA. Where ditch management is not thought to be helping to achieve the conservation objectives for management units, advice should be provided to agreement holders such that a more appropriate balance between ditch classes is obtained.

5.7. One means of achieving this could be by adding a clause in the ESA prescriptions which limits the proportion of ditches that can be managed by agreement holders in any season e.g. 'Slub out ditches and dykes once every 5–8 years, ensuring that no more than 20% are cleaned in any one year.' This may still be cost effective for farmers who are responsible for managing large numbers of interconnecting ditches but may not be appropriate for the land owners with relatively few ditches. In either situation the cost implications of carrying out ditch management on a smaller proportion of ditches on a regular basis would need to be reflected in ESA payments.

5.8. A more strategic method for achieving the desired balance between ditch classes would be through integrating ditch management within larger blocks of land e.g. at the scale of IDB sub-areas (or equivalent) i.e. blocks of 100–300 ha of land with interconnecting ditches. Agreement holders would need to subscribe to a ditch management plan that would relate to the entire block of land, only managing their ditches when it was deemed appropriate within the plan. This would cater for both large and small land holders.

5.9. With both these recommendations, ESA payments to agreement holders would need to reflect any resulting cost implications.

5.10. To further help in the achievement of appropriate ditch management, 'Farmer friendly' site specific literature should be prepared for sites with particular species requirements.

SUGGESTIONS FOR FURTHER STUDIES

5.11. The results for the survey sites suggest that large proportions of the ditches are dominated by open water, with very little aquatic or emergent vegetation. This finding was not expected for the Broads ESA, given the relatively low management frequency and the results of English Nature's 1997 survey.

- It is suggested that a proportion of ditches, for which reliable management information has been obtained, are resurveyed during the summer months (July to September) to establish the rate of change in features following management. Records of soil type and nutrient status should also be gathered to help with interpretation about rates of succession. This could help determine the required frequency of future survey work.

5.12. There is a need to validate the information about structural features with concurrent surveys of plants, invertebrates and other communities. This would enable the associations between ditch structure and ditch communities to be assessed during the same season and would avoid the problems associated with trying to link 'old' data with structural features that may have changed as a result of recent ditch management.

- Concurrent surveys of ditch structure and other communities (e.g. aquatic plants and aquatic invertebrates) should be carried out in sample areas in each ESA.

5.13. Relatively little is known about the mobility and ease with which colonisation takes place for species characteristic of grazing marsh ditches.

- Further studies should be carried out to relate species mobility to the scale of ditch feature spatial distribution required.

5.14. Since this project started, English Nature have recommended the use of grazing marsh ditches in East Anglia as 'biodiversity indicators' because they are a habitat whose well-being or decline is heavily influenced by socio-economic activities (English Nature, 1999). Procedures for monitoring changes in the extent and quality of ditches as biodiversity indicators have yet to be established (J. Ward, EN, pers. comm.).

- A scoping study should be carried out to investigate the requirements for monitoring grazing marsh ditches as biodiversity indicators.

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