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East Anglian Fen Invertebrate Survey

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Summary

1. The East Anglian Fenland Invertebrate Survey (EAFIS) was carried out between 1988 and 1990 and produced 165 standardised samples from 87 sampling stations at 43 sites containing 26,723 records of 1,676 species. 2,636 additional records were collected casually and these included a further 511 species.

2. In total, 215 nationally scarce species and 90 national red data book species were recorded confirming the national importance of East Anglian fens for invertebrate conservation. The available literature suggests that 43% of wetland invertebrate species, listed as endangered or vulnerable in Britain, have been recorded in East Anglia.

3. A variety of species new to science or new to Britain were also recorded during the study, most are from some of the lesser known families of Diptera and Hymenoptera, though a few are from groups with a wider recording base. Whilst some of these are still only known from East Anglia, others are now known to occur elsewhere.

4. Nine taxonomic groups (Auchenorrhyncha, Dolichopodidae, Sciomyzidae, Sphaeroceridae, Syrphidae, Tipuloidea and Ptychopteroidea, Carabidae and Staphylinidae, water beetles, spiders) were selected for further analysis of standardised samples. Direct comparison of species richness and beta-diversity between these groups could not be carried out, because of differences in sampling periods and the number of samples processed for each group, although trends in variation of species diversity between sites were investigated.

5. Pitfall trapping is considered to be an unsuitable method for sampling beetles in habitats with high water tables. It is suggested that hand-collecting by experienced workers is preferable for beetles and other ground-living taxa in fens and related habitats. The efficiency of water traps for Syrphidae was found to be affected by vegetation height. However, this effect was not detected for other groups investigated and water traps are recommended for flying insects in sites not managed by grazing.

6. Significant annual differences in species diversity were observed for Syrphidae and spiders. These groups contain a large number of species with good dispersal powers

and these mobile species probably represent an important component of many samples.

7. Comparison of species diversity and Species Quality Indices between Broadland, Breckland and other areas suggests that the Breckland area may have a larger regional species pool than other areas, whereas the Broads support a significantly higher proportion of more threatened species in three groups.

8. There was a clear trend for samples taken from NVC community S24 to support assemblages with a high proportion of threatened species. Pingo sites and sites succeeding to carr were also associated with assemblages of high conservation value in several groups.

9. Multivariate analysis showed that vegetation control had an important influence on species assemblage composition in six groups. Cutting was identified as having the biggest impact within the EAFIS dataset. However, despite the small number of grazed sites in the dataset, grazing was also found to affect species composition in several groups. Burning was not identified as a major influence, perhaps because of a combination of the small number of burnt sites sampled and variations in the timing of the burn at different sites.

10. Several red data book and nationally scarce species were found to be sensitive to cutting and a small-scale rotational approach to management is recommended. A mosaic of recently cut areas and areas in an advanced stage of succession will both meet invertebrate conservation objectives and diversify habitat. A single cut on unmanaged sites was found to have an impact on fewer groups than regular cutting in cycles of up to four years. It is therefore recommended that longer cutting cycles are introduced to reduce the impact of cutting on rare invertebrates.

11. Hydrology was found to have an even more comprehensive influence than vegetation control, although the poor definition of recorded environmental variables prevented the identification of clear prescriptions for water level management. Seasonal fluctuations in water level were important in several groups.

12. A methodology for monitoring the effects of site management is recommended, based on species indicator scores calculated for three or more target groups.

It is recommended that further research be carried out on the effects of flooding and ecological succession on selected invertebrate assemblages at around fifty sites ranging from marsh on mineral substrates through fen to carr.

Contents

1. Introduction

Fen is an important semi-natural habitat in Britain with distinctive communities of plants and animals. Examples of different types of fen are distributed across Britain often in small, isolated habitat patches, but the Norfolk and Suffolk Broads contain 3,000 ha of calcareous rich fen, the largest remaining continuous area of this type of fen in Britain (Fojt 1994a). East Anglia is also important for valley fens and other spring-fed systems (Wheeler & Shaw 1992). Historically, the great Fenland area of Cambridgeshire and Lincolnshire was the largest area of rich-fen in Britain, but centuries of drainage have reduced the area of fen to just 500 ha mainly concentrated in two nature reserves, Wicken Fen and Woodwalton Fen. Even in the Broads, only one third of the original area is semi-natural, the remainder having been converted to arable cultivation and improved pasture (Fuller 1986).

Apart from habitat loss, fens are also considered to be suffering a decline in quality. A recent study of fens in English SSSIs found that only 32.5% of the area surveyed was in favourable condition (Solly 2000). Fojt (1994a) identified three main causes of loss of quality in fens:

1. ecological succession to carr,
2. change in hydrological regime,
3. eutrophication.

Hydrological changes include ditching and river-straightening, which have led to dryer conditions in the Broads, while ground-water abstraction has caused problems in fens fed by springs (Fojt 1994b). Apart from the damage to botanical interest, long term dehydration of Redgrave and Lopham Fens due to groundwater abstraction also led to declines in populations of red data book invertebrates, particularly the fen raft spider, *Dolomedes plantarius,* which became confined to just one remnant pool (Harding 1993). This species is only known from one other site in Britain (Merrett & Bratton in Bratton 1991).

Fojt (1994a) listed mowing, grazing, burning, scrub management and peat cutting as management options suitable for the control of vegetation and maintenance of open fen. Essentially, they can all be viewed as anthropogenic disturbances that arrest ecological succession, although some of the recognised fen vegetation community types appear to be products of specific management systems (Fojt 1993) and it would be simplistic to consider succession as a single linear axis of change. Flooding also reverses ecological succession in wetlands (Kangas 1990), but, as with direct vegetation control, the severity and periodicity of the flooding disturbance dictates the precise successional pathway (Bravard *et al* 1992).

East Anglia is a nationally important region for threatened wetland invertebrates. 43% of endangered and vulnerable wetland species in Britain are recorded from here (see table 1). Several threatened insects are not known from any other part of country including high profile species such as the swallowtail butterfly, *Papilio machaon*, and the Norfolk hawker dragonfly, *Aeshna isosceles,* both of which are now confined to the Broads and adjacent areas. In west Norfolk, several series of pingo pools, formed in periglacial features, are of national importance for water beetles (Foster 1993).

Several important fen sites are now being returned to active management in order to conserve rare and valuable vegetation communities and birds. The East Anglian Fen Invertebrate Survey (EAFIS) was initiated in 1988 in order to investigate the effects of these reintroduced management systems on fenland assemblages of terrestrial invertebrates.

1.2 Wetland invertebrate communities

2,773 species of freshwater aquatic macroinvertebrates occur in Britain (RSPB, NRA & RSNC 1994). Most of them are arthropods and most of the rest are molluscs, but a large proportion of higher taxa within these phyla contain aquatic species. In fact, aquatic species are present in eleven of the 24 orders of insects occurring in Britain. In evolutionary history, the evolution of terrestrial invertebrate into freshwater aquatic invertebrate has occurred many times and in many different groups. Consequently, freshwater aquatic invertebrates exhibit an amazing variety of physiological and life history adaptations to their environment (Dillon 2000, Williams & Feltmate 1992) and it is no surprise that their responses to environmental variables are diverse.

Many aquatic insects undergo a terrestrial phase in their life cycle. The nature of nearby terrestrial habitats could therefore have an important influence on wetland assemblages, although very little work appears to have been done in this area. There are also a large number of specialist wetland species in groups that are traditionally regarded as purely terrestrial. Lott (2001) found more species of wetland Carabidae and Staphylinidae than water beetles during a survey of 30 ponds in Leicestershire. Eyre & Lott (1996) listed 441 terrestrial invertebrate species as characteristic of riparian habitats along British rivers and if static water biotopes, such as siltmarsh, fen and carr were taken into consideration, the species richness of terrestrial species found in wetlands would be in the same order of magnitude as that of aquatic species. Wetland terrestrial species live in the riparian zone or on emergent vegetation, and they may be just as dependent as aquatic species on wetland hydrology through requirements for high soil moisture content or through the disturbance provided by flooding. Consequently, they should be considered as an integral component of wetland invertebrate communities, even though they have generally been neglected in wetland conservation strategies.

Foster (1991) quantified the threat to aquatic insects in terms of numbers of species included in the UK red data book (Shirt 1987). As soon as other invertebrate groups are considered, together with terrestrial groups associated with wetlands, the importance of wetlands for invertebrate conservation becomes very evident. Approximately 34% of all species listed as endangered or vulnerable by Shirt (1987) and Bratton (1991) are associated with freshwater wetlands (see table 2). This amounts to 200 species, but because several groups are not covered in the red data books, the true number of threatened wetland invertebrates is higher than this.

1.2.1 The effects of site management on wetland assemblages

Compared to grassland, relatively little work has been done on wetland invertebrate assemblages, especially with regard to the effects of site management. Pollet (1992, 2001) identified light intensity at ground level, soil moisture content and litter depth as important factors affecting the species composition of reedmarsh and wet grassland dolichopodid assemblages in Belgium. Consequently, site management operations that affect vegetation cover, hydrology and turn over of litter can be expected to affect the dolichopodid fauna. Holmes, Boyce & Reed (1993) identified nutrient status, substrate saturation and grazing as important factors affecting the species composition of Welsh peatland ground beetle assemblages, so site management operations that affect water quality or water levels should have an impact on the ground beetle fauna. In a preliminary analysis of spider data from the

EAFIS dataset, Procter & Foster (1992) identified flooding and vegetation height as important determinants of species composition. As with Dolichopodidae and Carabidae, site management that impacts on hydrology will affect the spider fauna.

Table 2. Percentage of freshwater wetland species in red data book lists of endangered and vulnerable species (Bratton 1991, Shirt 1987). Figures for Lepidoptera include subspecies. Wetland species were identified from red data book species accounts supplemented by Falk (1991). 354 listed species of Diptera are not included in the analysis because they lack published species accounts.

	No species (all habitats)	**No species (freshwater wetland)**	**Percentage**
Coelenterata	1	0	0
Mollusca	17	14	82
Crustacea	3	3	100
Araneae	53	12	23
Odonata	6	6	100
Orthoptera	5	2	40
Heteroptera	20	1	5
Trichoptera	13	13	100
Lepidoptera	49	9	18
Coleoptera	226	70	31
Hymenoptera	49	4	8
Diptera	142	66	46
total	584	200	34

Foster *et al*(1990) and Painter (1999) both found big differences in aquatic invertebrate species composition between large and small fenland ditches. Ditch profile and vegetation were also important factors that both affect species composition and could be affected by management (Painter 1999). However, while the conservation value of larger ditches for water beetles was maintained by regular management, cleaning out of small ditches reduced site quality (Foster *et al*1990).

Several studies have explored the impact of reedbed management on invertebrate assemblages directly. Ditlhogo *et al* (1992) detected no long term change in the numbers of several families after the introduction of either burning or cutting to experimental plots at Hickling in the Norfolk Broads and suggested that both burning and cutting were suitable site management methods for conservation purposes. However, Foster & Procter (1995) compared a recently cut section of a reedbed at Hickling with an uncut section and found that there was a long term decrease in species quality score and a decline in numbers of all but one of the red data book species on the site. In Belgium, spider species richness was found to be similar in regularly cut reedmarsh to uncut marsh, but rare wetland species were sensitive to cutting and the spider assemblages of cut areas were characterised by assemblages with more widespread wetland species and ubiquitous species with good dispersal powers (Decleer 1990). Further details provided by Laurence *et al* (1992) on the first Hickling study makes it apparent that insect numbers in cut and burnt plots may have been distorted by vagrant species, and their conclusions cannot be accepted. Both Decleer (1990) and Foster & Procter (1995) concluded that a more cautious approach to cutting was needed in order to conserve rare fenland invertebrates and recommended leaving a mosaic of unmanaged areas of reed.

1.2.2 The effects of hydrology on wetland assemblages

Many of the studies cited above identify soil moisture and water level as factors influencing the species composition of wetland invertebrates assemblages. However, a single measurement at one point in time is probably inadequate for an understanding of the complex responses of invertebrate assemblages to fluctuations in water level. Eyre *et al* (1992) found that site-water duration was an important determinant of water beetle species composition in 77 silt-ponds in north east England. Given the range of adaptations to drying out found in aquatic invertebrates (see eg Hinton 1953), it is likely that similar responses would be found in some other aquatic invertebrate assemblages. However, Lott (2001) suggested that riparian beetles characteristic of temporary ponds were actually dependent on seasonal fluctuations in water level that exposed bare sediment suitable for breeding, rather than the impermanence of the water body.

Winter flooding has been found to reduce numbers and biomass of soil invertebrates in reedbeds (Ditlhogo *et al* 1992) and wet grassland (Ausden, Sutherland & James 2001). In a study of terrestrial and wetland ground beetle assemblages from 26 sites in floodplains in Moravia and Slovakia, Šustek (1994) detected important variations in species composition between assemblages from dry sites and damp sites subject to flooding and also between assemblages from oligotrophic sites flooded by fast-flowing water and eutrophic sites flooded by stagnant water. There were also significant differences between assemblages in sites flooded only in early spring and those in sites flooded more frequently. Similarly, in a Leicestershire river valley, more severe flooding at sites close to the main channel affects the species composition of ground beetle and rove beetle assemblages quite differently from less severe, seasonal flooding in remoter floodplain sites (Lott 1999b). Aquatic invertebrate assemblages in Rhône floodplain water bodies vary in species composition along a gradient of connectivity with the main channel (Castella *et al* 1984).

1.3 Objectives of this report

This report aims to use the EAFIS dataset as it currently stands to advise on suitable management systems for invertebrate conservation. Therefore, the following objectives have been set:

1. assessment of current dataset and selection of groups for analysis,

2. quantification of site management and relevant environmental variables and exploration of now they influence site quality, species diversity and species composition,

3. identification of management operations that may be favourable to invertebrate conservation,

4. selection of taxonomic groups suitable for monitoring the effects of site management,

5. review of sampling methods,

6. recommendations for further research.

Dolichopodidae are less comprehensive in their treatment both in terms of the number of sampling stations represented in the dataset and in the number of sampling periods processed at each station. Some non-target groups, such as Lepidoptera and Hymenoptera, appear not to have been processed in a consistent manner and these are not included in the main part of the analysis. 91 fungus gnat specimens (Diptera, Sciaroidea, Mycetophilidae), one specimen of Sphaeroceridae (Diptera) and one harvestman (Arachnida, Opiliones) could not be identified to species. In addition, it is apparent from the species list in the current dataset that specimens of Aleocharinae (Coleoptera, Staphylinidae) have not been processed, apart from those belonging to the more easily identified genera *Myllaena, Cypha, Gyrophaena* and *Drusilla*. These omissions should not compromise the results of any between-site analyses, as long as they are taxonomically consistent across different samples.

2.4 Red data book and nationally scarce species

215 nationally scarce species and 90 red data book species were recorded. Of these 177 nationally scarce species and 77 red data book species were taken in the standard sampling programme. All species are listed in appendices 6 to 8 together with the sites from where they were recorded. A high proportion of red data book and nationally scarce species records came from the Norfolk Broads, but this partly reflects the greater recording effort at sites in this area.

2.5 Species new to science or Britain

Some species previously undescribed were detected amongst material distributed to specialists. Most were fungus gnats determined by P. Chandler, Sciarid flies identified by B. Laurence, or members of the smaller parasitic Hymenoptera worked on by D. Notton. Chandler (1994) described two new fungus gnats from the genus *Rymosia* from material collected during the study, with the Holotype material for *R. fosteri* from Catfield Fens. Laurence (1994) described five new species of Sciarid fly from the survey with Holotype material of *Plastosciara taractica* collected from Thompson Common, *Corynoptera echinocordyla* and *Bradysia semantica,* two new species from the Brancaster reed beds, *Bradysia dolosa* from Catfield fens, and *Scatopsciara subdivida* from Stallode wash. Notton (1993) described two new Diapriidae (small parasitic Hymenoptera), *Trichopria striata* from Brancaster reed beds, and *Diapria luteipes* from Middle Harling Fen. Some of these taxa are already known elsewhere and may prove to be widespread, others may be scarcer and confined to wetland habitats.

A number of species were also added to the British list, some from the groups previously mentioned. For example Laurence (*loc. cit.*) also recorded six Sciarids new to Britain and Chandler (1992) reported the fungus gnat *Mycomya branderi* as the dominant fungus gnat at Old Buckenham Fen, which is otherwise only recorded from the Stumpshaw RSPB reserve, again within the current study.

Further additions to the British list were detected in other groups, for example the meniscus midge *Dixella graeca* from Walberswick (Disney, 1992), and two snail-killing flies: *Antichaeta atriseta* (Foster & Procter, 1997) and *Sciomyza testacea* (unpublished), the former only recorded from Stallode Wash, the latter widely in the Broadland sample stations but not elsewhere. Both are considered scarce in continental Europe.

4.2.2 Dolichopodidae

Syntormon tarsatus was found to have an undue influence on the ordination and was excluded from the analysis Figures 3 and 4 show the CCA ordination of species and environmental variables plotted on axes 1 to 3. Only the 37 species with the highest weighting after transformation are shown.

Axis 1 is difficult to interpret in that grazing, burning and flooding all seem to have a major influence. Axis 2, however, can be confidently linked to seasonal water level fluctuations and axis 3 can be linked to management by cutting. More than in any other group, sites where management has been recently reintroduced have a very different species composition from sites with long-established cutting regimes.

Seasonal fluctuations in water level adversely affect to varying degrees species with national conservation status that are represented in figure3, such as *Campsicnemus compeditus, Hercostomus chalybeus* and *Telmaturgus tumidulus.* In contrast to Auchenorrhyncha, several species of conservation interest, especially *Dolichopus laticola* and *Argyra elongata* appear to benefit from regular cutting.

Table 16 lists species indicator scores based on the position of each species in ordination space along two gradients based on DWATER and MANAGE2.

6. Conclusions and recommendations

6.1 Effects of management

6.1.1 Vegetation control

Only 2.4% of samples in the EAFIS dataset came from carr with a further 2.4% coming from fen-carr transitional habitats. It would be useful to study further the invertebrate assemblages of these biotopes, because sites that were transitional between open fen and carr had relatively high SQIs across several groups, suggesting that several species of high conservation value may be associated with advanced stages of ecological succession. This would appear to conflict with the generally held perception that the succession of open fen to carr diminishes its conservation value (Fojt 1994a). It may also conflict with the view that established carr is of greater conservation value than carr which has recently succeeded from open fen (Fuller 1986).

Vegetation control effectively arrests or reverses succession. A general prescription to manage fen by mowing, grazing, peat-cutting and scrub clearance (see eg Anon 1997) could therefore be damaging to invertebrate conservation. Analysis of the EAFIS dataset certainly provides plenty of evidence that cutting affects invertebrate assemblages in a number of ways. Species diversity showed significant responses in six groups, while major axes of variation in species composition could be related to cutting also in six groups. Although, only Auchenorrhyncha showed a decline in SQI at regularly cut sites, several species of conservation value in other groups appeared to be adversely sensitive to cutting, while other species appeared to benefit.

Morris (1981a) found that cutting of dry grassland in May had a weaker and less persistent impact on Auchenorrhyncha than cutting in July, because of seasonal variations in the vulnerability of different life cycle stages of the species affected. Species that occupied higher positions on vegetation in the summer were adversely affected by a summer cut. Species that overwintered in the egg stage were positively affected (Morris 1981b). It would be reasonable to assume that the timing of cutting in fens is critical in determining its impact, not only on Auchenorrhyncha, but also other groups that are vertically stratified in the vegetation, or that depend on a litter layer for hibernation. In the Broads, *Phragmites* beds are traditionally cut in the winter between December and April, while *Cladium* beds are cut in the summer between May and September. Furthermore, *Cladium* beds are traditionally cut on a four year cycle, whereas *Phragmites* beds are cut on a shorter one to two year cycle. In fact the negative response of Auchenorrhyncha SQI is confined to Phragmites beds and not observed in Cladium beds, suggesting that frequency of cutting may be more important than timing.

One of the more interesting results of the EAFIS analyses was the finding that invertebrate assemblages can be very different in sites with long-established cutting regimes from those where cutting has only recently been introduced. This calls into question the legitimacy of predictions of the impact of regular cutting, when they are based on studies using experimental plots on previously unmanaged sites (see eg Ditlhogo *et al* 1992). It also suggests that cutting carried out at longer intervals could be effective both in arresting ecological succession and reducing adverse impacts on some invertebrate groups. Long period rotational mowing and scrub clearance of small plots could benefit the conservation of invertebrates and other types of interest through:

- the retention on site of areas of relatively advanced stages of ecological succession,
- the arrest of long term succession to mature carr,
- an increase in habitat diversity.

The proportion of samples from grazed (11%) or burnt (10%) sites in the EAFIS dataset was low compared to sites managed by cutting (52%). Despite this, grazing was found to have an important influence relative to other variables on species composition in beetles, spiders and possibly Dolichopodidae. Morris (1973) suggested that grazing was a relatively benign management regime for grassland Hemiptera, because it did not involve single catastrophic events as in mowing or burning. However, all three types of management had a significantly negative effect on Auchenorrhyncha SQI in the EAFIS dataset, while grazing was also identified as having a negative impact on SQI for beetles, spiders and Dolichopodidae. Trampling by stock with repeated disturbance of a soft substrate may have a larger impact in wetlands than in terrestrial biotopes. Differences in periodicity and disturbance of the substrate between grazing and cutting could account for the fact that these two types of management had quite different influences on species composition in all but two groups (spiders and Sphaeroceridae).

The effects of fire on grasslands are known to vary considerably according to several factors including timing, severity and weather both during the fire event and afterwards (Daubenmire 1968). Variations in the season at which burning was carried out on sites represented in the EAFIS dataset could account for the lack of any clear pattern emerging from the analyses.

6.1.2 Hydrology

In general, hydrological factors were found to have an even greater effect on invertebrate assemblages than vegetation control. Unfortunately, the environmental measurements in the EAFIS dataset do not allow assemblage responses to be easily interpreted in terms that can be translated into management prescriptions. Given the importance of hydrology for invertebrates, further research into the effects of water level fluctuations should identify critical factors that can be used to set management objectives suitable for nature conservation. Even though the variable DWATER could only be estimated for part of the dataset, it, nevertheless, explained variations in the species composition of several invertebrate assemblages.

6.2 Review of sampling methods

Pitfall trapping is widely used for sampling terrestrial ground-living invertebrates and has even been found to give more representative results than sweeping for grassland Auchenorrhyncha whose species are vertically stratified in the vegetation (Payne 1982). However, the use of pitfall traps in wetlands is liable to produce sampling artefacts in three ways:

- reduced efficiency caused by damage to traps by flooding,
- reduced efficiency caused by damage to traps by grazing stock,

Table 29. Evaluation of invertebrate groups for their suitability in monitoring site management.

Group	Diversity	Ease of identification	Ease of sampling	Sensitivity to hydrology	Sensitivity to vegetation control
Auchenorrhyncha	High?	Medium	High	High	High
Dolichopodidae	High?	Low	Medium	High	High
Sciomyzidae	Medium	High	Medium	High	Low
Sphaeroceridae	Medium	Medium	Medium	High	High
Syrphidae	Too many vagrants	High	Medium	Low	Low
Tipuloidea	High	Low	Medium	High	High
Carabidae & Staphylinidae	High	High for carabids; low for staphylinids	High	High	High
Water beetles	High	High	High	High	High
Araneae	Too many vagrants	High	High	High	High

6.4 Recommendations for further research

The hydrological variables recorded in the EAFIS dataset are inadequate for an understanding of how hydrology affects invertebrate assemblages of fen. Further work is needed to provide a rationale for developing hydrological management objectives suitable for invertebrate conservation and to identify habitat factors that could be used for simple environmental monitoring programmes. A comprehensive investigation of the influence of water level fluctuations would involve consideration of periodicity, magnitude and flow during inundation. From a perspective based on physiological, behavioural and life history adaptations of wetland invertebrates, water level fluctuations can be classified into four types by their periodicity:

- predictable daily fluctuations influenced by tidal movement,
- predictable seasonal fluctuations,
- unpredictable flooding events occurring at intervals of less than one year,
- unpredictable catastrophic events occurring at intervals of more than one year.

For the investigation, it will necessary to evaluate which of these categories is important in East Anglian fens and select around 30 sites for a stratified study accordingly. At each site, some measure of severity of disturbance by flooding and magnitude of each category of flooding event should be estimated. Severity of disturbance can be deduced from substrate particle size, distribution of litter and vegetation cover. The magnitude of various types of fluctuation can be estimated from factors such as presence or absence of draw-down zone and position of site in relation to floodplain, main river channels, river catchment and tidal influences. This exercise would benefit from the participation of local site managers. For each group, the sampling, analysis and reporting could be carried out by an experienced worker in 20 days which would equate to around £5,000. For three target groups the total costs would be around £15,000.

A site known to be of high entomological value with the voluntary warden, K. Saul, providing an annual report incorporating entomological records principally for Odonata and Lepidoptera.

Sample station 1 (TG440126)

Fen meadow with each half the meadow being mown during late summer in alternate years, also occasionally grazed by cattle. Section with invertebrate traps was not cut during the sample programme, ie cut during the previous year. Relatively short sward of vegetation dominated by *Calamogrostis canescens*, *Carex panicea*, *Juncus subnodulosus*, *Cirsium dissectum* and *Hydroctyle vulgaris*. Other characteristic Broadland plants present include *Peucedanum palustre* and *Lysimachia vulgaris.*

Buxton Heath

A diverse heath and fen area forming one of the best examples of this habitat in Norfolk. The principal nature conservation interest is the valley mire which has developed along the length of a small stream.

Sample station 1 (TG175215)

Narrow band of calcareous fen alongside the stream running through the base of the mire. Vegetation dominated by *Juncus subnodulosus* and *Molinia caerulea* extensive bryophyte carpet also present. Other flowering plants recorded include *Succisa pratensis*, *Valeriana dioica*, *Caltha palustris* and *Lychnis flos-cuculi*. Large area of *Salix* carr nearby (approx. 15m away). Unmanaged.

Catfield Fens

Situated to the east of Barton Broad and on the flood plain of the River Ant this site forms part of the large Ant Valley Marshes SSSI. A complex pattern of vegetation types are present and have been studied in some detail, eg Giller (1978). Many areas of these fens are managed for the commercial harvesting of *Cladium mariscus*. Woodland, scrub and carr are also represented.

Sample station 1 (Rose Fen TG374204)

Area of fen formerly developing into scrub until being burnt during the winter of 1986/87 and again in winter of 1988/89. In summer of 1988 vegetation around invertebrate traps dominated by *Calammogrostis canescens*, with *Cladium mariscus*, *Juncus subnodulosus*, *Myrica gale* and *Peucedanum palustre* all frequent. In the two following summers the *C. canescens* was less common around the traps, though still dominant in some areas of the compartment, with the other aforementioned species becoming more frequent. Other plants species in sward include *Carex elata*, *Galium palustre*, *Lysimachis vulgaris*, *Lythrum salicariae* and *Thelypteris palustris*. Many tussocks and extensive bryophyte carpets present in this compartment, with the areas between the tussocks frequently flooded.

Sample station 2 (TG367213)

Small area of unmanaged vegetation (until 1989) forming a floating mat of bryophytes (mainly *Sphagnum* spp.) and emergents over what appears to be a former ditch. Surrounded by frequently harvested *Cladium mariscus* bed. *Phragmites australis* and *Thelypteris* dominate with *Peucedanum palustre* and *Potentilla palustris* also common. *Typha angustifolia* is a frequent emergent from the wettest areas. Extensive bryophyte carpet throughout. Vegetation was cut together with the surrounding sedge bed in the summer of 1989.

Sample station 3 (TG366212)

Cladium mariscus bed harvested every three years or so and appears to have been burnt during recent years, possibly in the winter of 1986/87. *C. mariscus* dominates the vegetation with *Phragmites australis*, *Juncus subnodulosus*, *Schoenus nigricans*, *Pedicularis palustris*, *Myrica gale* and *Molinia caerulea* among the other plant species recorded. Sedge was harvested in summer of 1989.

Sample station 4 (Catfield Great Fen TG365210)

Cladium mariscus dominated vegetation cut in 1987 prior to invertebrate sampling commencing. Small areas of the vegetation are cut each year forming a mosaic of succession within this large sedge bed. *C. mariscus* dominates the vegetation in the vicinity of the trap run with *Schoenus nigricans* fairly common also. Other plants recorded included *Pedicularis palustris*, *Myrica gale*, *Carex elata*, *C. lepidopcarpa* and *Juncus subnodulosus.* The site was flooded during many of the sample periods and some aquatic plants were present also, eg *Utricularia minor*.

Caudlesprings

This small site is sympathetically managed, single handed, by the owner for nature conservation purposes. The site comprises some recently dug ponds, spring flushes, small areas of carr and annually mown meadow. The single sample station was operated in the meadow area.

The artificially created ponds are known to be of entomological interest for their dragonfly and damselfly fauna; both *Lestes dryas* and *Sympetrum sanguineum* confirmed as breeding here.

Sample station 1 (TF941019)

Herb rich meadow with a number of *Carex* species present including *C. flacca*, *C. otrubae* and *C. hirta*, the area is annually mown during late summer. Orchids and *Lychnis flos-cuculi* are common in the sward, and *Ophioglossum* is present on the site though not in the immediate vicinity of the trap run. Spring flushes and recently created ponds are nearby. The meadow was grazed by ponies some years ago, then left unmanaged for a few years until the current owner instated an annual cutting regime.

Sutton Broad Marshes

Sample station 1 (TG373234)

Area of fairly short fen vegetation dominated by *Carex* spp., principally *C. elata* and *C. lasiocarpa*, and *Juncus subnodulosus*. The area is frequently flooded and contains extensive bryophyte carpets throughout, other plant species recorded include; *Pedicularis palustris*, *Menyanthes trifoliata*, *Potentilla palustris* and *Utricularia* spp. Formerly managed by intermittent burning, vegetation was cut in the late summer of 1989 to control scrub invasion.

Sample station 2 (TG373235)

Frequently harvested reed bed which is exceptionally species rich in tall herbs, and located between station 1 & 3 some 30 metres away from Sutton Broad. Though dominated by *Phragmites australis*, the sward contains a number nationally scarce plant species which are of frequent occurrence here, eg *Sium latifolium*, *Cicuta virosa* and *Peucedanum palustre*. Other plants common in this reed bed include *Typha angustifolia*, *Carex pseudocyperus*, *Rumex hydrolapathum*, *Oenanthe fistulosa* and some *Carex elata* tussocks. Wheeler & Shaw (1987) consider this vegetation community as *Cicuto-Phragmitetum*, distinct from *Peucedano-Phragmitetum* which is widespread in the Broadland.

Sample station 3 (TG373235)

Band of tall, dense, unmanaged vegetation adjacent to Sutton Broad. Dominated by ferns (up to 1m tall), *Typha angustifolia*, *Eupatorium cannabinum*, *Impatiens capensis* and *Epilobium hirsutum*, some *Salix* bushes present also. Dense and deep mat of litter covering an almost permanently flooded floating hover vegetation.

Sample station 4 (TG367233)

Area of fen burnt in year prior to survey commencing, with dead and charred bushes of *Rhamnus catharticus* present near to trap line. *Calammogrostis canescens* dominated the vegetation during the first year of sampling, though in the subsequent two years *Phragmites australis*, *Salix repens* and *Myrica gale* became co-dominants. The vegetation was uncut during this invertebrate survey. This sample station is located in Middle Marsh which is some distance away from stations 1,2 and 3 that are much nearer to Sutton Broad.

Swangey Fen (Attleborough Poors Fen)

A detailed botanical survey was carried during 1980 and 1981 (Wheeler, Daglish & Morris 1981), this work also provides some management recommendations. The site contains an area of species rich , spring-fed vegetation of a type, otherwise restricted mainly to the Norfolk Broadland. Little management of the vegetation has been carried out in recent years, except for some scrub clearance during 1987 (MSC team), though historically the fen was cut for peat and mown for sedge (Wheeler & Shaw, 1987).

No invertebrate records, prior to this 1988 survey, have been traced for the site.

Appendix 6 Red data book and nationally scarce species recorded from sites in the Norfolk Broads.

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Araneae											
Baryphyma gowerense (Locket)	RDB K	8								1	
Carorita paludosa Duffey	RDB 2									3	
Centromerus incultus Falconer	RDB 2						1				
Clubiona juvenis Simon	RDB 2	47			17	42		35		17	
Donacochara speciosa (Thorell)	Na	30			3	12		62	3	3	
Entelecara errata O. P.-Cambridge	Nb									1	
E. omissa O. P.-Cambridge	Na	27			33	31		2	4	36	
Hypomma fulvum (Bosenburg)	Na	87		2	58	41		77	5	60	
Marpissa radiata (Grube)	Na	2			1						
Robertus insignis O. P.-Cambridge	RDB 1				1						
Theridiosoma gemmosum (L. Koch)	Nb	1						1	1	2	
Coleoptera											
Acrotrichis lucidula Rosskothen	pRDBK	1									
A. pumila (Erichson)	pRDBK	1									
Agabus labiatus (Brahm)	Nb							3			
A. striolatus (Gyllenhal)	RDB 2	5									
A. unguicularis (Thomson)	Nb	11						2		1	
Apion minimum Herbst	pRDB 3	2									
Bembidion fumigatum (Duftschmid)	Nb	4				1		38			

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Blethisa multipunctata (L.)	Nb	1						9			
Cerapheles terminatus (Menetries)	Na	107			9	70		86		34	
Cercyon convexiusculus Stephens	Nb	35			51	14	1	32		1	
C. sternalis Sharp	Nb	4			1	3		9		1	
C. tristis (Illiger)	Nb	28				5		63		3	
Chaetarthria seminulum (Herbst)	Nb	4	2		1		1				2
Cypha discoidea (Erichson)	Nb					3					
Cyphon pubescens (F.)	Nb	7			5					1	
Demetrias imperialis (Germar)	Nb					2		4			
Donacia clavipes Fabricius	Nb				2						
Dorytomus salicinus (Gyllenhal)	Nb	1									
Dromius longiceps Dejean	Na	3				12		3		1	
Dryops anglicanus Edwards	RDB 3				6						1
D. nitidulus (Heer)	Na	1									
Enochrus coarctatus (Gredler)	Nb				8			2			
Euplectus kirbii Denny	Nb	1									
Helophorus strigifrons Thomson	Nb									2	
Hydraena palustris Erichson	RDB 2				28			5			
Hydrochus brevis (Herbst)	RDB 3	2			6			2		1	1
H. megaphallus Berge Henegouwen	pRDB 3				24						
Ilybius guttiger (Gyllenhal)	Nb	14					3	9		3	
Laccornis oblongus (Stephens)	Na	3								1	
Lathrobium rufipenne Gyllenhal	RDB 2	1									
Limnebius aluta (Bedel)	Na				81		1	69		3	

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Longitarsus parvulus (Paykull)	Na							1			
Lythraria salicariae (Paykull)	Nb	2			3						
Medon apicalis (Kraatz)	Nb	2									1
Meligethes gagathinus Erichson	Nb				1						
M. ochropus Sturm	Nb				1	4				1	
Mordellistena pseudopumila Ermisch	pRDBK						4				
Myllaena elongata (Matthews)	Nb				1						
Neobisnius procerulus (Gravenhorst)	pRDBK				1						
Ochthebius marinus (Paykull)	Nb					1					
O. viridis Peyron	Nb					1					
Odacantha melanura (L.)	Nb	9			1	1		17		3	
Oodes helopioides (F.)	Nb	101			12		41	10		10	
Oxytelus fulvipes Erichson	Na	1									
Philonthus fumarius (Gravenhorst)	Nb	5			3	1		9		1	
[P. nitidicollis (Boisduval & Lacordaire)]	Nb							2			
Phytobius waltoni Boheman	Nb	1									
Plateumaris braccata (Scopoli)	Na	3			1	1	1	8		3	
Platycis minuta (F.)	Nb										1
Platystethus nodifrons Mannerheim	Nb	4				1		2			
Pselaphaulax dresdensis (Herbst)	Nb	2				1		4		1	
Quedius balticus Korge	RDB 1	5			3	14				1	
Rhynchaenus foliorum (Mueller)	Na									2	
Rhynchites longiceps Thomson	Nb	1									
Rugilus fragilis (Gravenhorst)	Nb	9									

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Sepedophilus testaceus (F.)	Nb					1					
Silis ruficollis (F.)	Nb	131			6	71	5	106		38	
Stenus argus Gravenhorst	Nb	9								1	
S. carbonarius Gyllenhal	Nb	1									
S. europaeus Puthz	Nb									2	
S. fuscicornis Erichson	Nb	1									
S. nitens Stephens	Nb	19			62	17		15		8	
S. opticus Gravenhorst	Na						3	8			
S. palustris Erichson	Nb				12	13				2	
Stilbus atomarius (L.)	pRDBK					9					
Tapinotus sellatus (F.)	Na									1	
Telmatophilus schoenherri (Gyllenhal)	pRDBK									2	
Diptera											
Achalcus melanotrichus Mik	Nb								1		
Allodia angulata Lundstroem	pRDB 2				4	1		5		3	
A. barbata (Lundstroem)	Nb				5	2		3	4	1	
A. embla Hackman	pRDB 3	3			8			2	1	4	
Allodiopsis rufilatera (Edwards)	pRDB 2									1	
Anagnota bicolor (Meigen)	Nb							1			
Anasimyia interpuncta (Harris)	RDB 3								2		
Anatella dampfi Landrock	pRDB 3	5			8	8		6		2	
A. lenis Dziedzicki	Nb				3						
Anthomyza bifasciata Wood	Nb							7		2	
Antichaeta analis (Meigen)	pRDB 3	2			17	1		10		10	

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
A. brevipennis (Zetterstedt)	RDB 2								3	67	
Argyra elongata (Zetterstedt)	pRDB 3	1			1	4				12	
Asindulum nigrum Latreille	RDB 2	1					2				
Cephalops perspicuus (de Meijere)	RDB 2	11			9	20		12	4	10	
Cheilosia velutina Loew	Nb					1					
Colobaea bifasciella (Fallen)	Nb	111		1	5	7	1	97	13	46	
C. distincta (Meigen)	Nb					12		4	1	4	
C. pectoralis (Zetterstedt)	RDB 2									19	
Cordilura aemula Collin	pRDB 3							1	1		
Dichetophora finlandica Verbeke	pRDB 3									3	
Dixella serotina Meigen	Nb	35			36	16		209	12	24	
Dolichopus laticola Verrall	RDB 1	5			4		1				
D. nigripes Fallen	RDB 1	9									
Dorylomorpha clavifemora Coe	RDB 1					1					
Epicypta limnophila Chandler	Nb	17			24	35	2	26	8	18	
Erioptera meijerei Edwards	RDB 2				9	1	39	1		1	
E. nielseni de Meijere	Nb									15	4
Exechia cincta Winnertz	pRDB 3	1									
E. dizona Edwards	RDB 1				1						
E. exigua Lundstroem	Nb					4					
E. lucidula (Zetterstedt)	pRDB 2						2				
E. pseudofestiva	Nb	4			12	5		10	3	1	
Gimnomera tarsea (Fallen)	Nb	49			92		20			58	1
Gonomyia bifida Tonnoir	Nb							1			

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Helius pallirostris Edwards	Nb	2			3						
Hercostomus chalybeus (Wiedemann)	Nb	3			19	2		5	8	2	
Hybomitra muhlfeldi (Brauer)	pRDB 3	6					1	1		1	
Leia longiseta Barendrecht	pRDB 2	4			9	31	2	80	10	7	
Lejogaster splendida (Meigen)	Nb					2				1	
Limnophila abdominalis Staeger	Nb	2			3					1	
Limonia complicata (de Meijere)	Nb	1				1					
L. danica (Kuntze)	pRDB 3	1			2	10		12	9	2	
L. trivittata (Schummel)	Nb							1			
L. ventralis (Schummel)	Nb	2			3						
Lonchoptera nitidifrons Strobl	Nb							25		22	
L. scutellata Stein, P.	Nb	1						14	1	1	
Macrocera estonica Landrock	Nb				1			1		3	
Megalopelma nigroclavatum (Strobl)	Nb				1			1			
Molophilus bihamatus de Meijere	Nb	132									7
Mycetophila confusa Dziedzicki	pRDB 3	1			2			3	2		
M. stolida Walker	Nb				1						
Mycomya britteni Kidd	pRDB 2				2		1		1	1	
M. insignis (Winnertz)	pRDB 2							1			
Neoascia geniculata (Meigen)	Nb							9			
Nephrotoma lunulicornis (Schummel)	Nb								1		
Ochthera manicata	pRDB 3	28			6	2	4	1	1	4	
Odontomyia argentata (Fabricius)	RDB 2		1								
O. tigrina (Fabricius)	Nb				3			1			

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Orthonevra geniculata Meigen	Nb				1	1					
Parhelophilus consimilis (Malm)	RDB 2									2	
Pherbellia argyra Verbeke	RDB 2				8			12		11	
P. nana (Fallen)	Nb								2	1	
Phronia mutabilis Dziedzicki	pRDB 1	2			6			4		6	
Phthiria pulicaria	Nb					1				1	
Pilaria fuscipennis (Meigen)	Nb	12			1					2	
P. meridiana (Staeger)	Nb									1	
P. scutellata (Staeger)	Nb	1						2			
Pipizella virens (Fabricius)	Nb	1									
Platypalpus albiseta (Panzer)	Nb							1			
Psacadina verbekei Rozkonsky	Nb	9	4		5	16		6	4	18	
P. vittigera (Schiner)	RDB 2		7								
P. zernyi Mayer	RDB 2	6			11			10		23	
Pteromicra leucopeza (Meigen)	RDB 2					3		2			
Renocera striata (Meigen)	Nb				5					1	
Rhamphomyia caliginosa Collin	Nb				5	20		1			
Rymosia armata Lackschewitz	pRDB 3	2			7	2		4		4	
R. britteni Edwards	pRDB 2							3		5	
Scathophaga tinctinervis (Becker)	RDB 2					2			1		
Sceptonia costata (Wulp)	Nb								1		
Sciomyza dryomyzina Zetterstedt	RDB 2								3		
S. simplex Fallen	Nb	91			56	6		171	8	64	
Stratiomys potamida	Nb	1				1					

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
S. singularior (Harris)	Nb	1			1	5	5		2		
Suillia dumicola (Collin)	Nb					1					
Telmaturgus tumidulus (Raddatz)	pRDB 3				9		3				
Tetanocera freyi Stackelberg	RDB 3	111			105		103	105	1	71	3
T. phyllophora Melander	Nb	2									7
Thaumastoptera calceata Mik	Nb									7	
Tipula marginata Meigen	RDB 3						1				
Trichonta icenica Edwards	pRDB 3								1		
T. nigritula Edwards	RDB 1				3					3	
T. pulchra Gagne	pRDB 1							1			
Xylota abiens Meigen	Nb								1		
Hemiptera											
Adelphocoris ticinensis (Meyer-Dur)	Nb					1				1	
Aphrodes albiger (Germar)	Nb					4	3			1	
Aphrophora alpina Melichar	Nb	1			2	2				1	
Capsus wagneri Remane	Nb				1						
Chloriona dorsata Edwards	Nb							11			
C. vasconica Ribaut	Nb					1		110		9	
Cicadula flori (J.Sahlberg)	Nb	2									
Delphacodes capnodes (Scott)	Nb	2			15	15				3	
Hebrus pusillus (Fallen)	Nb				5						1
Hydrometra gracilenta Horvath	pRDB 3							1			
Macrosteles oshanini Razvyaskina	pRDBK									7	
Megamelodes lequesnei Wagner	Nb	4			3	57				12	

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Microvelia buenoi umbricola Wroblewski	RDB 3	3			1			7			
Oncodelphax pullulus (Boheman)	Nb									3	
Paradelphacodes paludosus (Flor)	Na	1			2						
Paraliburnia clypealis (J.Sahlberg)	pRDBK				22	7					
Paralimnus phragmitis (Boheman)	Nb	43			41	19		20	16	17	
Saldula opacula (Zetterstedt)	Nb							1	2		
Stroggylocephalus livens (Zetterstedt)	Nb	1							2	1	
Trioza centranthi (Vallot)	Nb						2				
Tytthus geminus (Flor)	Nb	1									
Hymenoptera											
Macropis europaea Warncke	Na	2				1					
Odynerus simillimus Morawitz F.	RDB 1					1					
Passaloecus clypealis Faester	RDB 3	2		1		3					1
Rhopalum gracile Wesmael	RDB 2				8	8					1
Sphecodes rubicundus von Hagens	Na					1					
Lepidoptera											
Acleris lorquiniana	pRDB 3	1									
Archanara dissoluta	Nb					1					
Calamatropha paludella (Hubner)	Nb									1	
Chilodes maritimus	Nb	1						2			
Earias clorana (L.)	Nb	1									
Eustrotia uncula	Nb	2				1		1			1
Macrochilo cribrumalis	Na	1								1	
Nascia cilialis	Na	1									

Species	Status	Bure Marshes	Buxton Heath	Burgh Common	Catfield Fens	Hickling Broad	Mill's Marsh	Reedham Marshes	Strumpshaw Marsh	Sutton Broad Fens	Upton Fen
Orgyia recens	RDB 2								1		
Papilio machaon	RDB 2	4				2		2	1	1	
Phlyctaenia perlucidalis (Hubner)	Na	1									
Senta flammea	RDB 3	2									
Simyra albovenosa	Na	2									
Spilosoma urticae	Nb							1		1	
Mollusca											
Vertigo moulinsiana (Dupuy)	RDB 3	1								3	
Plecoptera											
Nemoura dubitans Morton	Nb	3			1						

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Top left: Using a home-made moth trap.
Peter Wakely / English Nature 17,396
Middle left: English Nature bat warden with a whiskered bat near Holme, Devon.
Paul Glendell / English Nature 24,795
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell / English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
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