

# **Broads Fen Invertebrate Survey**

**Project 1: Assemblage responses to local factors**

**Project 4: Evaluation of invertebrate assemblages**

**Final Report**

**D A LOTT, C M DRAKE & P LEE**

**January 25<sup>th</sup> 2010**

***ARACHNE***

**Invertebrate Information Services**

**Oakdene, The Heath, Tattingsstone, Ipswich IP9 2LX  
Tel / Fax: 01473 327835  
e-mail: paulatarachne@aol.com**



## Contents

SUMMARY .....	2
INTRODUCTION .....	3
METHODS .....	4
<i>Sampling of invertebrates</i> .....	4
<i>Recording of environmental variables</i> .....	5
<i>Analysis</i> .....	6
RESULTS .....	8
<i>Species recorded</i> .....	8
<i>Species richness</i> .....	9
<i>Canonical Correspondence Analysis (CCA)</i> .....	12
<i>Analysis using ISIS</i> .....	8
CONCLUSIONS .....	11
<i>Responses to hydrological variables</i> .....	11
<i>Responses to vegetation management</i> .....	13
<i>Responses to diversity in vegetation structure</i> .....	14
<i>Future monitoring programmes</i> .....	14
ACKNOWLEDGMENTS .....	15
APPENDIX 1: LIST OF ALL SAMPLE SITES AND THEIR RECORDED ENVIRONMENTAL VARIABLES .....	16
APPENDIX 2: LIST OF SPECIES RECORDED 2007 TO 2009 .....	20
APPENDIX 3: SCORES FOR ISIS WETLAND BROAD ASSEMBLAGE TYPES BY COMPARTMENT .....	38
APPENDIX 4: RECORDED SPECIES NUMBERS FOR ISIS SPECIFIC ASSEMBLAGE TYPES BY COMPARTMENT .....	39

## **Summary**

1. A three year fieldwork project sampled a range of invertebrate groups at 120 sampling sites in 40 fen management compartments across the Ant, Bure, Thurne and Yare river catchments in the Norfolk Broads. 843 species were recorded including 40 of Red Data Book status or equivalent. Environmental variables relating to hydrology, vegetation management and vegetation structure were also recorded at each sampling site.
2. The results were analysed by exploring the relationship between the recorded environmental variables and species richness. Multivariate analysis was used to explore the response of assemblage species composition to environmental variables. ISIS, a computer application being developed by Natural England for assessing invertebrate assemblages, proved particularly useful in identifying environmental variables that affect conservation interest.
3. Two main invertebrate communities were identified. True fen invertebrates are not associated with open water. They are found in mires, where free water is retained in moss, tussocks and the peat surface and they occupy the interior of the management compartments including abandoned ditches clogged with peat. The true fen community is dominated by the ISIS permanent wet mire assemblage type. Aquatic, open water species constitute a separate ecological group and are associated with boundary ditches. Both communities have value for conservation.
4. Hydrology has the largest influence on the conservation value of the true fen invertebrate community. Permanent wet mire assemblages and, especially, rare permanent mire species are sensitive to water level fluctuations. In habitats where much of the surface dries out, the proportion of permanent wet mire species is reduced in favour of damp grassland and mineral marsh species.
5. Vegetation management has a lesser impact on invertebrate assemblages. In particular, commercial sedge- and reed-cutting has minimal influence restricted to a slight lowering of species richness, possibly because it is currently carried out on such a small scale.
6. Diversity of vegetation structure and density of individual vegetation features tend to increase species richness by attracting a wider mix of assemblage types not necessarily associated with true fen. Consequently, this increase in species diversity is not usually associated with an increase in conservation value associated with true fen assemblages. However, the presence of shrubs and tussocks does favour the ISIS “moss and tussock” assemblage type, which has intrinsic conservation value.
7. Conservation management by grazing or long rotation cutting is mainly carried out in habitats that are too dry to be optimal habitats for true fen invertebrates. It is probably not feasible to manage optimal habitats by grazing, so long rotation cutting designed to create a patchwork of cut and uncut areas with tussocks and isolated shrubs should serve as a model management plan objective when invertebrate conservation is the aim. The species composition of some groups is affected by grazing and long term cutting and it is possible that individual species of conservation interest may be affected by changes in site management.
8. It is recommended that the ISIS representation and rarity scores be used in future monitoring of the conservation value of true fen invertebrate assemblages in the Broads. It is also recommended that the open water community of boundary ditches be monitored separately using the same methodology.

## **Introduction**

The high conservation value of the wetland invertebrate fauna of many sites in the Broads National Park is well documented (Lott *et al*, 2002). A number of threatened species, from the relatively obscure such as the money spider *Centromerus semiater* and the solitary wasp *Rhopalum gracile* to the high profile such as the Swallowtail *Papilio machaon* and the Norfolk Hawker *Aeshna isosceles*, are apparently restricted to Broadland fens in the UK. However, the area is also important for many other groups of wildlife and organisations such as the Norfolk Wildlife Trust and RSPB have initiated management programmes to conserve rare species and communities. Commercial reed and sedge continues to be harvested from the Broads fens, providing a sustainable form of small-scale management.

Several methods have been advocated for managing fens including burning, cutting, frosting, grazing, herbicide application and scrub removal (Hawke and José, 1996). Whilst some of these approaches are controversial and none have proved completely satisfactory for conservation aims, there has been a more recent change of emphasis from intensive cutting to grazing regimes. Although grazing does not prevent succession, it is often stated to be good for the structural diversity of the habitat and particularly for invertebrate assemblages (e.g. Kirby, 1992). However, there is a paucity of scientific evidence that would either lend support to, or discourage, any of these techniques as management for invertebrates in fen habitats.

At a meeting in February 2007, representatives of the Broads Authority, Natural England and RSPB agreed on the need for the research reported here. The initial aim of the work was to enable management decisions in the Broads to be taken on the basis of scientific evidence rather than assumptions. Clearly, in order to achieve this aim, it was necessary to ascertain the impacts of grazing and other fen management regimes on invertebrate assemblages but it was recognised also that the responses of the assemblages to changes in hydrology and salinity could be used to investigate the impacts of climate change. Therefore the research was designed to allow long term monitoring of invertebrate assemblages with the initial results providing the baseline data.

In order to achieve the aims of the research, four objectives were identified and a project was designed to meet each of them. These objectives were:

1. to assess fen invertebrate assemblage responses to local environmental factors;
2. to assess fen invertebrate assemblage responses to changes in salinity;
3. to develop a programme to monitor fen invertebrate assemblage responses to climate change;
4. to identify and quantify the conservation value of fen invertebrate assemblages for use in the monitoring and surveillance of operations to protect, restore and create habitats.

Work on the projects began in 2007 and continued until 2009. This report covers progress made towards objectives one and four. It presents and interprets the results obtained over the three year duration of the project. Progress made towards objectives two and three is covered in separate supplementary reports.

In line with the original aim of the research, project one was designed to assess the responses of fen invertebrate assemblages to different vegetation management techniques including grazing and a variety of cutting regimes. Alongside this management variable, invertebrate assemblage responses to a series of hydrological variables including fluctuations in water level and connectivity to the main river channel were investigated. Responses to diversity in vegetation structure were also assessed. It was considered best that the effects of these local factors were assessed in a single, integrated project rather than as separate gradient analyses, because the factors often interact in the way that they influence assemblages.

Site quality evaluation, or more precisely, assemblage quality evaluation, is not only of value for selecting sites for conservation action, but also for monitoring their protection, restoration and creation. Species rarity has traditionally been an important parameter for evaluating conservation quality. An alternative approach is to evaluate an assemblage according to how typical it is of an intrinsically interesting assemblage type or habitat. Project four used the data gathered during project one to evaluate the type and conservation value of the invertebrate assemblages sampled.

## **Methods**

### **Sampling of invertebrates**

A total of 120 samples of each of the target groups from 40 compartments were taken over the three years of the project, but the distribution of samples between the three years of operation varies from target group to target group. This was a result of the need for remedial sampling for Auchenorrhyncha, spiders and Diptera in 2008 due to bad weather in 2007. Consequently, annual variations are not easily compared between groups. However, all target groups were collected at 30 sampling sites in 10 management compartments in 2009. The invertebrate groups targeted are listed in tables 1 and 2.

**Table 1. Schedule of invertebrate groups sampled in 2009**

<i>Group</i>	<i>Sampling method</i>	<i>Time of visits</i>	<i>No. samples</i>
aquatic insects (water beetles & water bugs)	pond-netting	May	30
Araneae (spiders)	suction-sampling	June & September	30
Auchenorrhyncha (hoppers)	suction-sampling	June & August	30
Carabidae & Staphylinidae (ground beetles & rove beetles)	ground-searching	June	30
Diptera (two-winged flies)	sweep-netting & suction-sampling	June	30

Time-standardised methods of ground-searching, pond-netting, sweep-netting and suction sampling were used for sampling assemblages of each of the target groups (for details of techniques see Drake *et al.*, 2007). Adoption of these fieldwork methods yielded the comparable samples required for statistical analysis and also

fulfilled the requirements of baseline data for further monitoring. The use of these methods in 2009 is summarised in table 1. The timing of visits was similar in 2007 and 2008 but, due to the poor weather, all of the Diptera samples and some of the Auchenorrhyncha and spider samples from 2007 were discarded.

**Table 2. Target Diptera families**

Anthomyzidae	Dolichopodidae	Opomyzidae	Stratiomyidae
Aulacigastridae	Empididae	Psilidae	Syrphidae
Chamaemyiidae	Ephydriidae	Ptychopteridae	Tabanidae
Chaoboridae	Hybotidae	Rhagionidae	Tephritidae
Culicidae	Limoniidae	Scathophagidae	Tipulidae
Diastatidae	Lonchopteridae	Sciomyzidae	Ulidiidae
Dixidae	Micropezidae	Sepsidae	Therevidae

### Recording of environmental variables

A series of environmental variables were identified in the scoping report as potentially useful for interpreting the results of species sampling and these were measured at each sampling site throughout the project. A résumé of the environmental variables recorded is given in table 3. The values recorded are listed in appendix 1.

**Table 3. Descriptions of recorded environmental variables**

<i>Variable</i>	<i>Scale (between / within compartments)</i>	<i>Properties and values</i>	<i>Scoring system</i>
BAREGRD	within	Continuous integers (0–10)	no. times a thrown ping-pong ball hits soil
CONNECT	within	Categorical (1-3)	middle of compartment = 1 abandoned ditch = 2 edge of compartment = 3
CUT1	between	Nominal (0,1)	reed bed cut annually or biennially = 1
CUT4	between	Nominal (0,1)	sedge-bed cut every four years = 1
CUT7	between	Nominal (0,1)	fen cut irregularly for conservation = 1
DWATER	between	Nominal (0,1)	surface permanently wet = 0 most of surface dry in summer = 1
GRAZED	between	Nominal (0,1)	periodically grazed = 1
SCRUB	within	Continuous integers (0–10)	no. of bushes in sampling area
TUSSOCK	within	Continuous integers (0–10)	no. of tussocks in sampling area
UNMANAGD	between	Nominal (0,1)	unmanaged for last twelve years = 1
VEGDIV	within	Continuous integers (1-7)	no. vegetation surfaces in sampling area as defined by NE CSM methodology

The utility of each variable was continuously monitored throughout the project. Right at the beginning of the project, it was realised that the site management variables had to be refined to reflect the variety of different cutting regimes operating in Broads fenland. Thus a single nominal variable, CUT, indicating whether the compartment was managed by cutting or not, has been replaced by three nominal variables, CUT1, CUT4 and CUT7, related to cutting of red beds, sedge beds and conservation areas respectively. The within compartment variable, TCUT, was defined as the length of

time since a fen was last cut. In the absence of written records for most of the sites visited, it was found to be impossible to estimate values for this variable. Consequently its measurement was abandoned.

Changes to hydrological variables were also required. CONNECT1, a measure of connectivity to main rivers was originally conceived as an indicator of nutrient enrichment. Once in the field, it was also observed to represent tidal range depending on the river catchment and to overlap with DWATER, a measure of water level fluctuations. Consequently, it was abandoned as a consistent indicator of anything. The variable CONNECT is a measure of the location of a sample site in relation to ditches. It was originally labelled CONNECT2 and was used in the selection of sample sites in each compartment. Ideally one sample was to be taken from the middle of the compartment, one from an abandoned ditch and one from the edge of a boundary ditch. However, it was not possible to locate abandoned ditches in every compartment.

DWATER scores are based on assessments of surface wetness made in the driest month of the year that they were sampled. The driest month in 2007 was September, while in 2008 it was July and in 2009 it was August. A more precise DWATER2 variable was investigated in 2008 but proved to be no more useful in characterising species assemblage responses to water level fluctuations. Consequently DWATER2 measurements were not repeated in 2009.

A shortlist of management compartments that were easily accessible and could be linked to existing environmental data on hydrology and management was drawn up for selecting the compartments for sampling in 2007. In 2008 and 2009 the strategy for selecting compartments for sampling relied purely on management class.

## Analysis

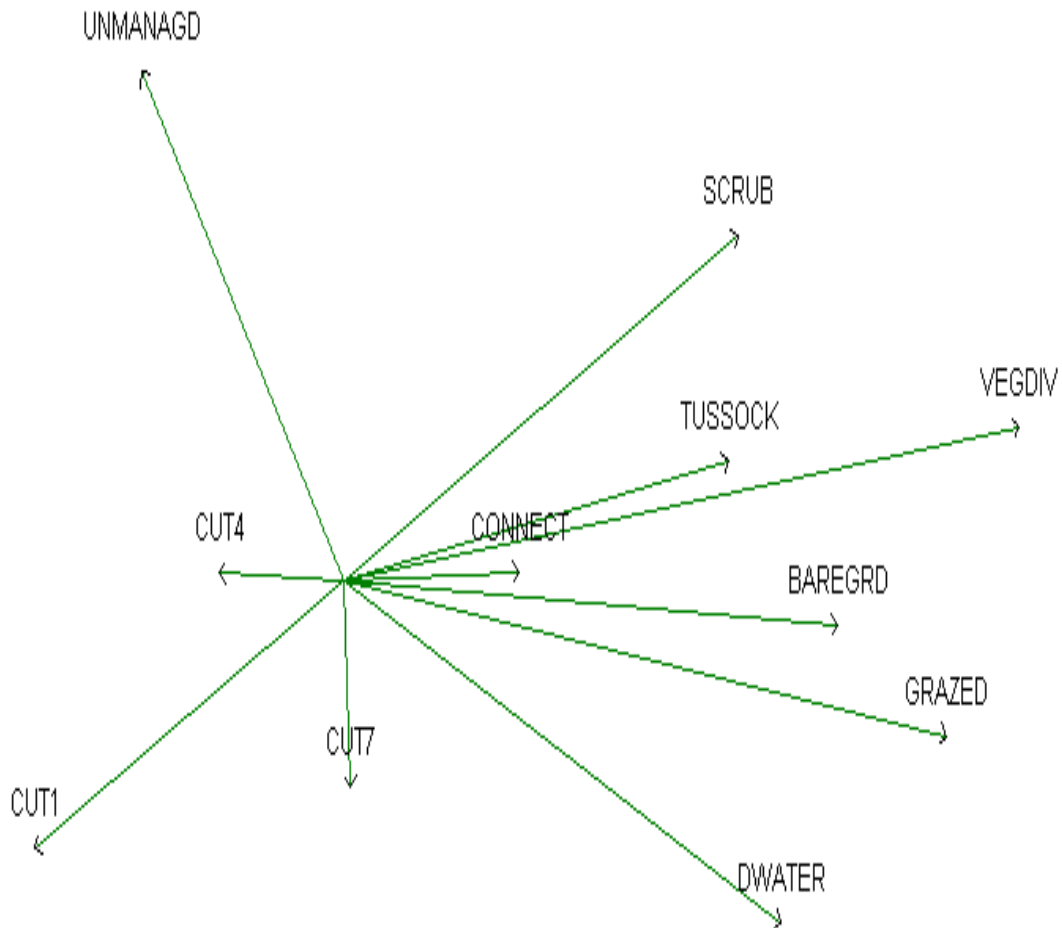
A Principal Components Analysis (PCA) was carried out on the recorded values from 2007-9 (see Fig. 1) in order to explore relationships between the environmental variables. High diversity of vegetation structure, density of scrub and tussocks and extent of bare ground were most associated with grazed sites and least associated with more highly managed sites in management categories CUT1 and CUT4. Sites subject to water level fluctuations (scoring 1 for DWATER) were more likely to be grazed or irregularly cut for conservation objectives. In other words, conservation activities appear to be more likely to be pursued on sites that are drier in the summer rather than permanently wet fen.

Three types of analysis were carried out on the species lists generated.

For each of the 120 samples, a series of **species richness** values were counted as the total number of species recorded in each target group. Relationships with environmental variables were explored with non-parametric methods using “Analyse-it” software. Spearman’s Rank Correlation was used for continuous variables and the Kruskal-Wallis test was used for categorical and nominal variables.

Species richness is notoriously sensitive to inequalities in sampling effort, but this factor has been minimised in this project by the adoption of standardised sampling protocols. Species richness is a simple, but effective species diversity measure. It can

be a powerful tool for interpreting how invertebrate assemblages respond to environmental factors, but it should be recognised that it is not a straightforward measure of conservation value. An assemblage may contain a large number of widespread species that do not necessarily represent conservation priorities.



**Figure 1: Principal Components Analysis (PCA) plot of recorded environmental variables.** (each variable is represented by a vector; alignment of vectors indicates covariance in the data set)

In order to focus on species that are particularly sensitive to environmental change, it is necessary to take account of the species composition of invertebrate assemblages. Variations in species composition and their relationship to the measured environmental variables were investigated using **Canonical Correspondence Analysis (CCA or CANOCO)**. This is a type of multivariate analysis whose results are best presented as a series of Cartesian graphs that ordinate species and environmental variables together, showing their relationships through spatial alignment on the graph. CCA is a powerful interpretative tool. It can:

- measure the relative magnitudes of the influences of different environmental variables on species composition,
- detect whether two environmental variables are influencing species composition in a similar, opposite or independent fashion,

- identify which species are most sensitive to a particular combination of environmental variables.

For each taxonomic group, CCA was performed on complete data sets using untransformed raw abundances. Analyses were performed using Pisces software. Because of the low species numbers recorded for Sciomyzidae and Auchenorrhyncha, their samples were pooled for each compartment before analysis, effectively reducing the number of samples from 120 to 40.

CCA gauges the influence of environmental variables on assemblages but makes no assessment of their conservation value. For assessing conservation value, scores are usually assigned to individual species within an assemblage and aggregated in some way to produce a score for the whole assemblage. ISIS (Invertebrate Species-habitat Information System) is a computer application developed by Natural England for assessing invertebrate assemblages in this way. It interprets species lists by recognising assemblage types and scoring each assemblage type according to its conservation value. ISIS assemblage types are defined by species composition but labelled according to their favoured habitat in terms that are meaningful to non-specialists. Two hierarchical levels of assemblage type are recognised.

Broad Assemblage Types (BATs) are characterised by more widespread species. They can be expressed in lists from a wide range of sites. Their classification reflects environmental factors such as hydrology and disturbance-succession cycles that have an important effect on invertebrate assemblages. ISIS summarises the relative representation of each BAT within the sampled assemblage and evaluates the conservation value of each BAT using a rarity score calculated according to individual rarity values of its constituent species.

The most narrowly defined level, Specific Assemblage Types (SATs), are characterised by species found within a narrower range of habitats and are considered to have intrinsic conservation value. In general, they are only well expressed in lists from sites with conservation value.

ISIS analyses were carried out on three pooled samples within each compartment using data for all target groups together. The version used was ISIS 2009.

## **Results**

### **Species recorded**

The species recorded over the three years of the project are listed in appendix 2. 843 species from target groups were recorded in standardised samples. This figure excludes species recorded exclusively from discarded samples taken in adverse weather conditions in 2007 and also non-target species recorded casually. It is interesting to note that the list of target species includes 40 species with a rarity score equivalent to Red Data Book or nationally scarce grade A status. It is also worth noting that several species have restricted distributions within Britain (see tables 9 & 10). Although the recording of rare species is not a specific objective of the project, the presence of species of conservation concern in the analysis should make the results more relevant to an assessment of the suitability of different management regimes for conservation.

A separate document has been provided to the Broads Authority ecologists giving full details of all species records from the three years of the project. This includes records from discarded samples and also non-target species recorded casually.

### Species richness

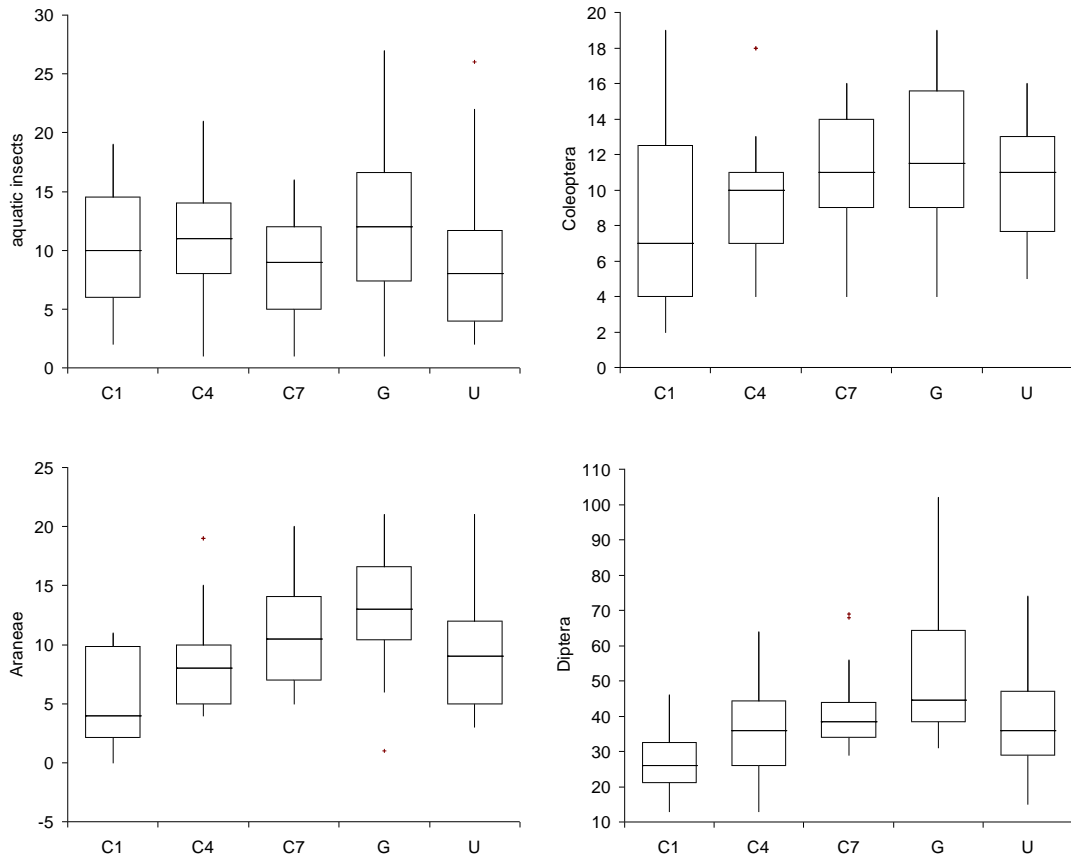
Summary statistics for numbers of species recorded are given below. The average number of Auchenorrhyncha species recorded in each sample was very low and this will have compromised the suitability of the results for some of the analyses carried out. By contrast, some individual families or family groups of Diptera were recorded in sufficient numbers to enable their responses to be individually analysed.

**Table 4. Species richness statistics for whole data set of 120 samples**

<i>Target group</i>	<i>total S (<math>\gamma</math>-diversity)</i>	<i>mean sample S (<math>\alpha</math>-diversity)</i>	<i>between sample <math>\beta</math>-diversity</i>
Aquatic beetles & bugs	124	10.2	12.2
Araneae (spiders)	103	9.8	10.5
Auchenorrhyncha (hoppers)	58	3.1	19.0
Carabidae & Staphylinidae	140	10.4	13.4
Diptera	418	39.8	10.5
Craneflies	64	5.5	11.7
Dolichopodidae	87	8.9	9.8
Ephydriidae	57	8.9	6.4
Sciomyzidae	41	3.6	11.5

The sensitivity of species richness to management variables varies from group to group but, except for aquatic insects, samples from grazed areas tended to have a greater number of species than samples from regularly cut areas of reed or sedge (see figure 2).

The statistical significance of these variations of species richness can be assessed using the Kruskal-Wallis Test. This is a non-parametric test that compares the rankings of values of species richness between classes of samples defined by the management regime operating at each sampling site. The test generates a test statistic and a figure for the probability that the observed difference in rankings could be generated by chance. The observed differences in responses to management by spiders (Araneae) and Diptera are highly significant (Kruskal-Wallis statistics = 24.7 and 26.6 respectively,  $p < 0.001$  in both cases). The observed differences in beetle (Coleoptera) species richness is much less significant (Kruskal-Wallis statistic = 9.6,  $p < 0.05$ ), while aquatic insects show no significant response (Kruskal-Wallis statistic = 8.1)



**Figure 2: Box plots for numbers of species in samples of various target groups according to management regime (C1 = reeds cut annually or biennially, C4 = sedge cut every four years, C7 = fen cut irregularly for conservation, G = grazed, U – unmanaged; in box plots the central line represents the median value; the box contains the two middle 25% quartiles representing half of all the values recorded; the whiskers represent the spread of extreme values up to 1.5 times the spread beyond the ends of the box)**

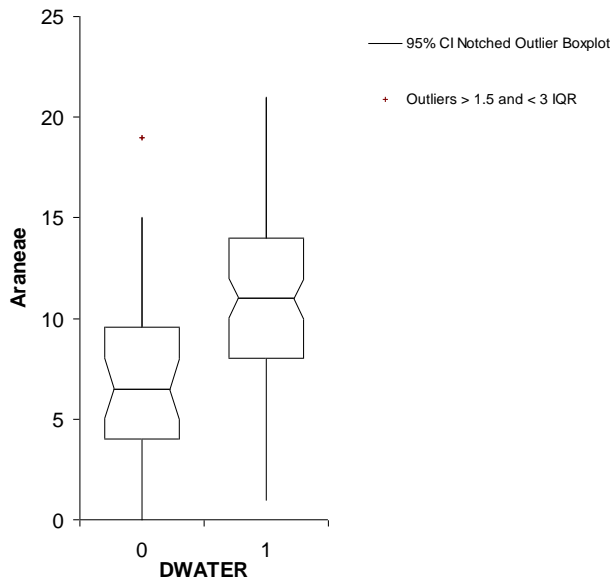
Many groups exhibited a positive response of species richness to diversity of structure (see table 5). The exceptions were the aquatic insects and ground-living beetles. For other groups, diversity of vegetation structure can be supposed to attract a wider range of ecological groups, each linked to a particular height of vegetation or combination of different vegetation heights. For example, some species of Auchenorrhyncha are known to climb tall vegetation in the summer, while others remain at ground level. A structurally diverse fen will tend to attract both groups and be more species rich. In general, grazing promotes structural diversity and this is probably the main reason why grazed sites tended to yield samples with higher species richness than commercially cut sedge- and reed-beds, which have swards of an even height over large areas.

The responses to individual vegetation features varied between taxonomic groups, including different families of Diptera. Groups whose species richness responded positively to the density of tussocks could contain species that rely on them for hibernation or survival during floods.

**Table 5. Values of Spearman’s rho for rank correlation of species richness against diversity of vegetation structure** (probabilities of such values being generated by chance are represented by asterisks where \*\*\* =  $p < 0.001$ ; \*\* =  $p < 0.01$ ; \* =  $p < 0.05$ ; values in italics represent no significant relationship)

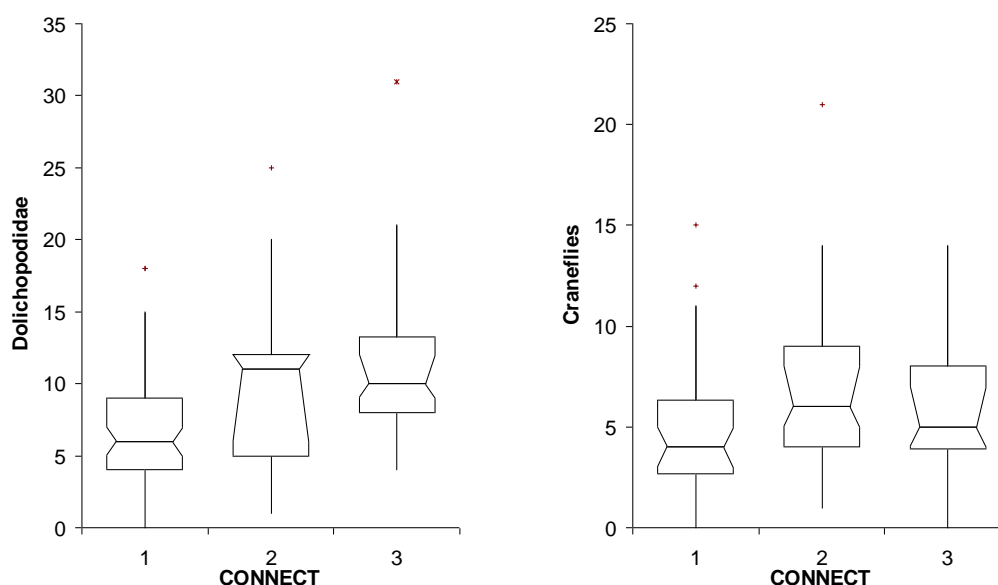
<i>Target group</i>	<i>VEGDIV</i>	<i>BAREGRD</i>	<i>SCRUB</i>	<i>TUSSOCK</i>
Aquatic insects	+0.10	+0.03	+0.11	-0.03
Araneae	<b>+0.22</b> *	+0.13	+0.17	<b>+0.33</b> ***
Auchenorrhyncha	<b>+0.36</b> ***	<b>+0.23</b> *	<b>+0.23</b> *	<b>+0.42</b> ***
Coleoptera (terrestrial)	+0.01	+0.13	+0.07	+0.17
Diptera	<b>+0.59</b> ***	<b>+0.37</b> ***	<b>+0.42</b> ***	<b>+0.24</b> **
Craneflies	<b>+0.34</b> ***	+0.18	<b>+0.29</b> *	+0.13
Dolichopodidae	<b>+0.44</b> ***	<b>+0.35</b> ***	<b>+0.26</b> **	+0.13
Ephydriidae	<b>+0.23</b> *	<b>+0.29</b> **	+0.11	+0.04
Sciomyzidae	<b>+0.43</b> ***	+0.14	<b>+0.30</b> ***	<b>+0.32</b> ***

In general, hydrological variables were found to have less influence on species richness than management variables. However, spider species richness was found to be significantly lower in permanently wet sites than those that dried out in the summer (environmental variable DWATER) (Kruskal-Wallis statistic = 22.4,  $p < 0.001$ ) (see figure 3), while Diptera species richness was significantly lower in samples taken away from ditches than those taken from the edges of well-maintained boundary ditches (environmental variable CONNECT). It is interesting to note that the response



**Figure 3: Notched box plots for numbers of species in samples of spiders according to water level fluctuations** (in box plots the central line represents the median value; the box contains the two middle 25% quartiles representing half of all the values recorded; the whiskers represent the spread of extreme values up to 1.5 times the spread beyond the ends of the box; in notched box plots the notches on the side of the box indicate the 95% confidence interval for the value of the mean)

of species richness of Diptera to CONNECT varied considerably between different families. The response of Dolichopodidae was much more significant (Kruskal-Wallis statistic = 20.1,  $p < 0.001$ ) than for other groups such as craneflies, whose response was not significant (Kruskal-Wallis statistic = 4.2) (see figure 4).



**Figure 4: Notched box plots for numbers of species in samples of Diptera according to sample site location in relation to ditches (CONNECT scores: 1 = sample site located away from ditches; 2 = abandoned ditch covered by skin of vegetated peat; 3 = well-maintained boundary ditch; see Fig. 3 for explanation of notched box plots)**

### Canonical Correspondence Analysis (CCA)

Table 6 shows the proportion of the total variance explained by individual recorded variables for selected groups. It is immediately evident that different taxonomic groups responded to different variables. In addition, the response to the recorded variables in some groups, such as aquatic insects and craneflies, was much stronger than in others. However, some general trends can be observed. With some notable exceptions, the large scale variables, DWATER and the management variables, tended to explain a greater proportion of the variance in species composition than the small scale variables connected to vegetation structure. The extent of bare ground (BAREGRD) was unusual among the small scale variables in having a relatively large influence on the species composition of several groups. Within the large scale variables, CUT1 and CUT4, the nominal variables representing regular, commercial cutting regimes generally explained a lower proportion of the variance in species composition than the other management variables. In other words, there were few species that were confined to, or preferred, or even avoided this type of management regime.

CCA biplots for selected taxa are shown in figures 5 to 9. The plots indicate how species responded to the environmental variables selected for analysis. The proportion of variance explained by measured variables was insufficient to obtain interpretable results for spiders, Dolichopodidae and Sciomyzidae.

**Table 6. Variance in species composition of samples explained by individual environmental variables**

<i>Aquatic Insects</i>			<i>Beetles (Carabidae &amp; Staphylinidae)</i>		
<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>	<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>
CONNECT	0.38	3.48	UNMANAGD	0.17	1.53
DWATER	0.22	2.03	VEGDIV	0.15	1.41
UNMANAGD	0.17	1.51	DWATER	0.15	1.38
VEGDIV	0.16	1.44	BAREGRD	0.14	1.31
SCRUB	0.16	1.42	CUT7	0.13	1.20
CUT4	0.14	1.24	GRAZED	0.13	1.20
GRAZED	0.13	1.20	CONNECT	0.12	1.08
BAREGRD	0.13	1.18	SCRUB	0.11	1.05
CUT1	0.13	1.14	CUT1	0.10	0.92
TUSSOCK	0.12	1.11	CUT4	0.09	0.80
CUT7	0.09	0.80	TUSSOCK	0.08	0.70

<i>Spiders</i>			<i>Diptera</i>		
<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>	<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>
CUT1	0.13	1.90	BAREGRD	0.29	3.54
SCRUB	0.10	1.50	DWATER	0.19	2.25
DWATER	0.10	1.46	GRAZED	0.18	2.21
GRAZED	0.10	1.46	VEGDIV	0.17	2.03
UNMANAGD	0.09	1.33	CONNECT	0.16	1.92
BAREGRD	0.09	1.30	CUT7	0.15	1.83
CONNECT	0.09	1.28	UNMANAGD	0.10	1.17
VEGDIV	0.08	1.24	TUSSOCK	0.10	1.17
CUT4	0.08	1.16	CUT4	0.09	1.13
CUT7	0.07	1.09	SCRUB	0.08	0.94
TUSSOCK	0.06	0.95	CUT1	0.07	0.88

<i>Diptera - craneflies</i>			<i>Diptera - Dolichopodidae</i>		
<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>	<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>
CUT7	0.30	3.31	GRAZED	0.15	2.14
BAREGRD	0.30	3.31	UNMANAGD	0.14	1.97
GRAZED	0.29	3.22	TUSSOCK	0.13	1.88
DWATER	0.26	2.92	CUT1	0.11	1.62
VEGDIV	0.24	2.64	CONNECT	0.11	1.51
CUT1	0.22	2.41	BAREGRD	0.09	1.34
SCRUB	0.18	2.01	VEGDIV	0.09	1.22
UNMANAGD	0.15	1.70	DWATER	0.08	1.14
CONNECT	0.14	1.56	CUT7	0.08	1.10
CUT4	0.13	1.43	CUT4	0.06	0.85
TUSSOCK	0.09	1.03	SCRUB	0.06	0.79

**Table 6 (continued). Variance in species composition of samples explained by individual environmental variables**

<i>Diptera - Ephydridae</i>					
<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>			
BAREGRD	0.32	9.18			
VEGDIV	0.15	4.23			
GRAZED	0.14	4.11			
DWATER	0.10	2.99			
CONNECT	0.10	2.77			
CUT4	0.06	1.80			
SCRUB	0.06	1.69			
TUSSOCK	0.05	1.56			
UNMANAGD	0.04	1.17			
CUT7	0.04	1.16			
CUT1	0.04	1.14			

<i>Diptera - Sciomyzidae</i>			<i>Auchenorrhyncha</i>		
<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>	<i>Variable</i>	<i>Eigenvalue</i>	<i>% of variance</i>
GRAZED	0.14	4.11	CUT1	0.53	8.14
CUT7	0.14	3.93	GRAZED	0.44	6.72
DWATER	0.14	3.91	DWATER	0.35	5.33
CUT1	0.12	3.41	UNMANAGD	0.33	5.00
UNMANAGD	0.09	2.62	CUT7	0.21	3.27
CUT4	0.06	1.72	CUT4	0.15	2.30

**Aquatic insects (figure 5)**

Axis 1 representing the largest spread of variation was dominated by a split between, on the one hand open water species associated with boundary ditches scoring high for CONNECT, and on the other hand true fen species occupying internal sites within the compartments that scored low for CONNECT. A high proportion of the aquatic bugs (Heteroptera), such as *Ilyocoris cimicoides*, *Sigara semistriata* and *Plea minutissima*, fell into the open water group. This group also included beetles such as *Gyrinus marinus*, *Hyphydrus ovatus* and *Agabus sturmii*. The true fen species were separated on axis 2 according to their sensitivity to water level fluctuations (DWATER). *Hydraena palustris*, *Agabus striolatus* and *Suphrodytes dorsalis* were more frequent in samples from internal sampling points within the compartment that are permanently wet and *Helophorus strigifrons*, *Hydroporus neglectus* and *H. umbrosus* were more frequent in samples from internal sampling points within compartments whose surface tends to dry out during the summer. Fen management variables had little influence on aquatic insect species composition.

**Terrestrial beetles (Carabidae and Staphylinidae) (figure 6)**

The recorded variables explained a relatively small proportion of the variance in species composition of terrestrial beetles but it is still possible to interpret the results in the light of the known ecologies of the species concerned. The degree to which water levels fluctuated had a relatively important influence. *Paradromius longiceps*, *Demetrias imperialis*, *Stenus latifrons* and *Stenus palustris* are species characteristic of wet mires that were frequent in samples from permanently wet habitats, while *Quedius fuliginosus*, *Acupalpus parvulus*, *Oxytelus fulvipes* and *Carpelimus*

*impressus* were frequent in samples from sites whose surface tends to dry out during the summer. As for management variables, the largest differences in species composition were observed between unmanaged sites on the one hand and sites managed by either grazing or irregular, long rotation cutting (CUT7) on the other hand. *Oxytelus fulvipes*, *Thinodromus arcuatus* and *Carpelimus impressus* were associated with unmanaged sites. *Badister dilatatus*, *Loricera pilicornis*, *Carpelimus elongatulus* and *Hygronoma dimidiata* were associated with managed sites. It is interesting to note that a species of high conservation value, *Quedius balticus*, was also associated with this latter group.

### **Craneflies (figure 7)**

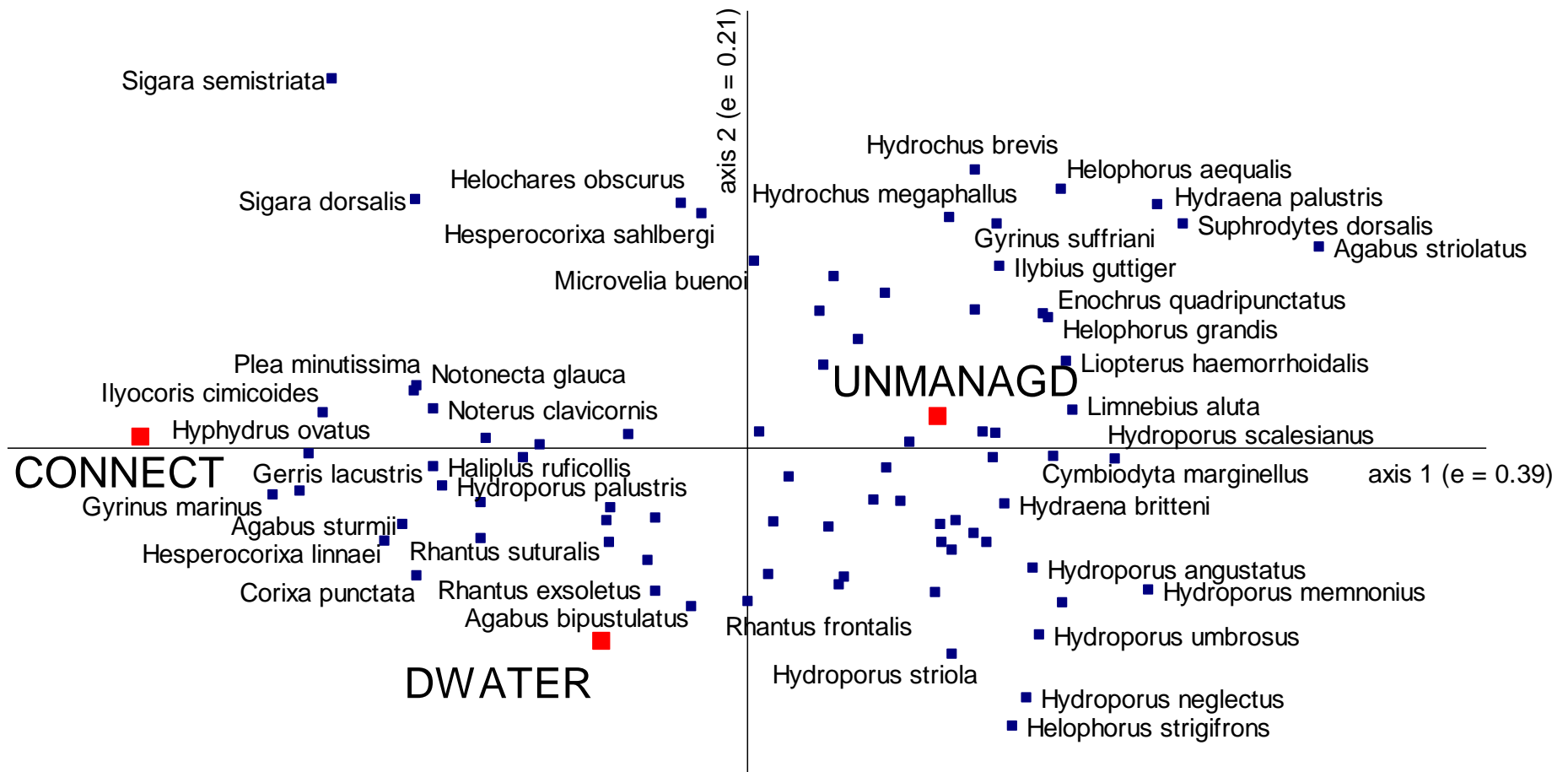
DWATER also had a large influence on crane fly species composition, while the largest gradient of variance in species composition was related to a split between grazed sites and sites cut on a long term rotation. Unmanaged sites did not support a distinctive assemblage. *Neolimnomyia batava*, *Paradelphomyia czezikiana* and *Thaumastoptera calceata* were associated with permanently wet sites that are cut irregularly for conservation objectives. *Prionocera turcica*, *Helius pallirostris*, *Dicranomyia autumnalis*, *D. lucida* and an unidentified species of *Pilara* were also associated with permanently wet sites but less influenced by management regime. Species associated with sites that dry out in the summer included *Cheilotrichia imbuta*, *Molophilus bihamatus* and *Erioptera lutea* as well as several species that were associated with grazed sites including *Erioptera flavata*, *Molophilus pleuralis* and *Symplecta stictica*.

### **Ephydriidae (figure 8)**

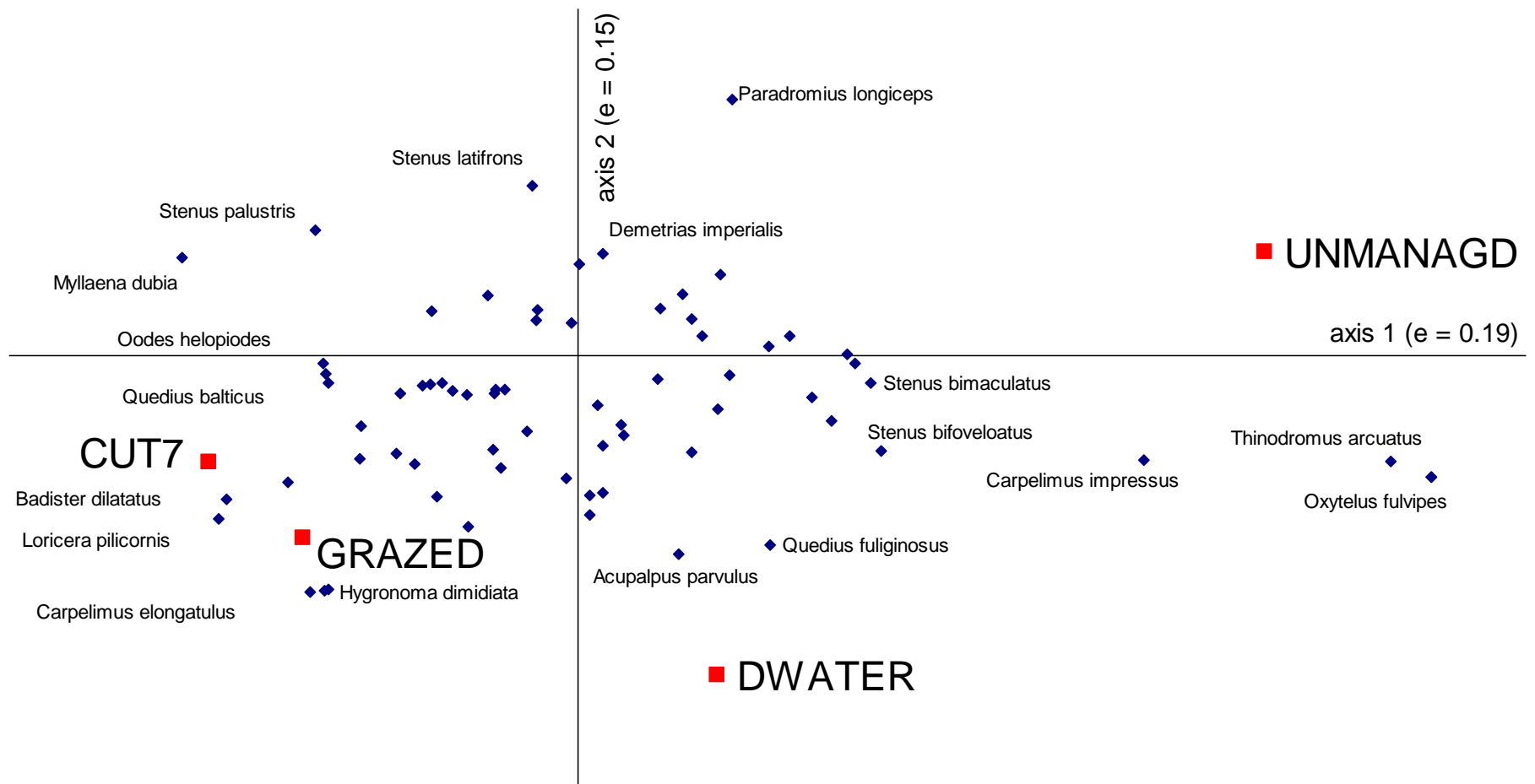
The extent of bare ground dominated the identifiable environmental influence on variance in the species composition of Ephydriidae. *Parydra coarctata*, *P. hecate*, *Scatella stagnalis* and *Hyadina guttata* were all associated with high scores for BAREGRD. The larvae of *Parydra* and *Scatella* species feed on microbes in the water film on the surface of wet mud or peat, while the larvae of *Hyadina* species feed on blue-green algae in a similar environment, so it is no surprise that the abundance of adults in samples is linked to the extent of bare ground. By contrast, the larvae of *Notiphila* species are aquatic detritus feeders that tap into emergent plants for their oxygen supply. The adults sit on vegetation. Consequently, their abundances in samples are probably independent of the extent of bare ground.

### **Auchenorrhyncha (figure 9)**

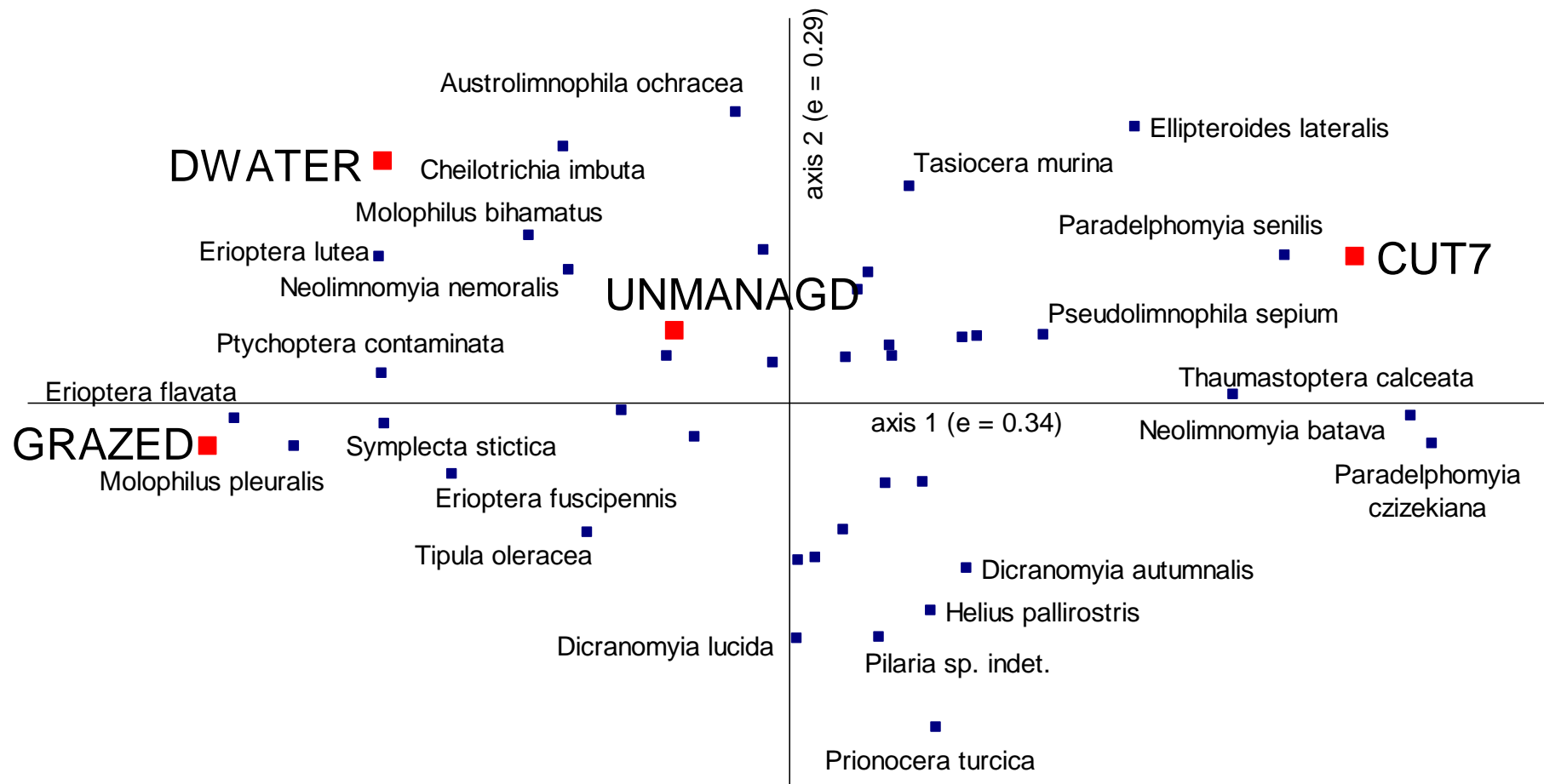
Axis 1 of the biplot for Auchenorrhyncha separated a small group of *Chloriona* species, whose foodplant is *Phragmites*. They appeared to prefer their *Phragmites* to be cut on a regular one or two year rotation. Axis 2 separated species associated with grazed sites from species associated with unmanaged sites. *Mocuellus metrius*, *Calligypona reyi*, *Cicadula flori* and *Conosanus obsoletus* favoured unmanaged sites, while *Conomelus anceps*, *Cicadella viridis* and *Aphrodes albiger* favoured grazed sites.



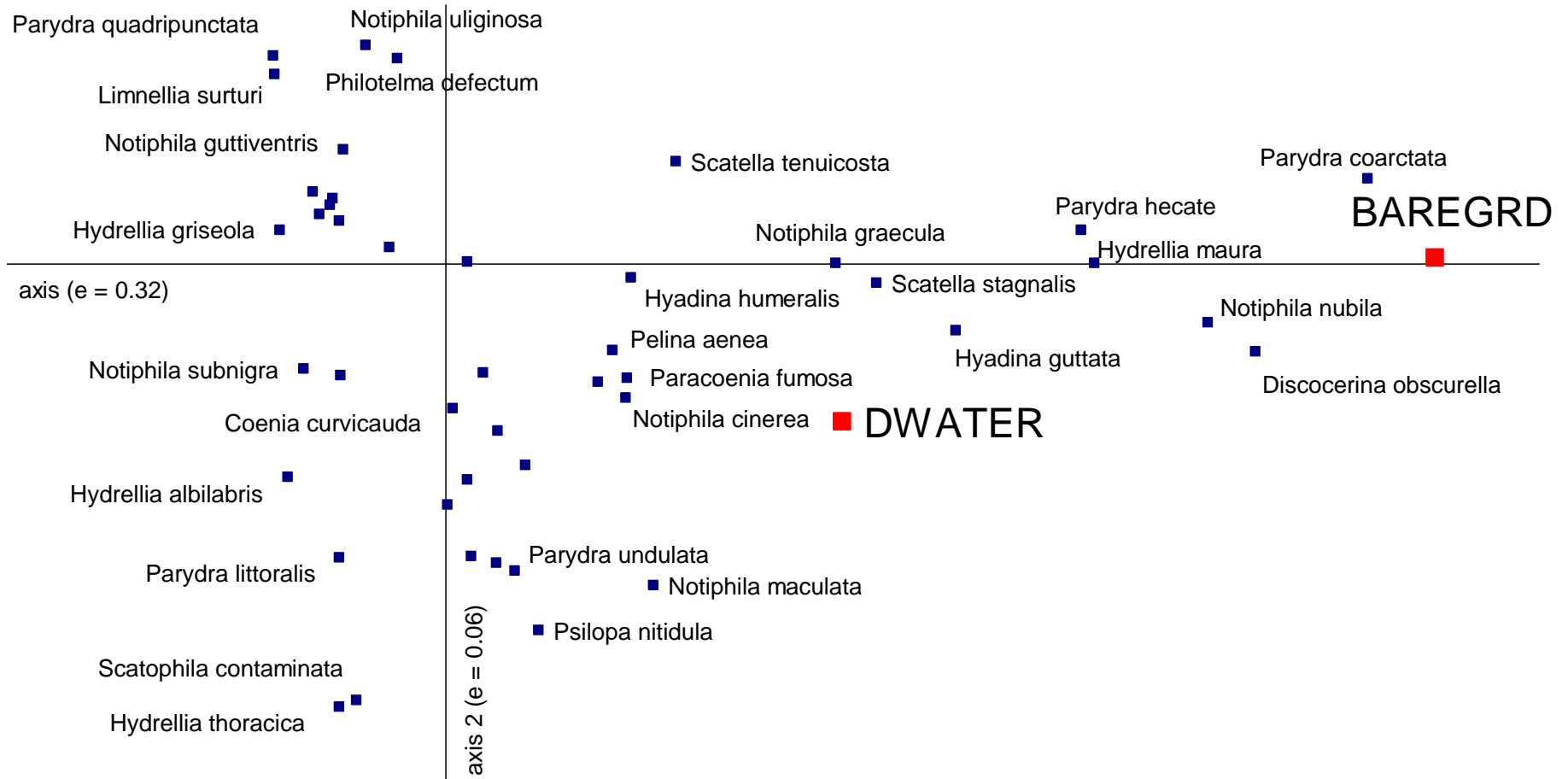
**Figure 5: CCA biplot of species and environmental variables from samples of aquatic insect** Only species recorded from three or more samples are shown; only species showing relatively large responses to variables are labelled; species close to or opposite environmental variables (red points) exhibit a positive or negative response respectively.



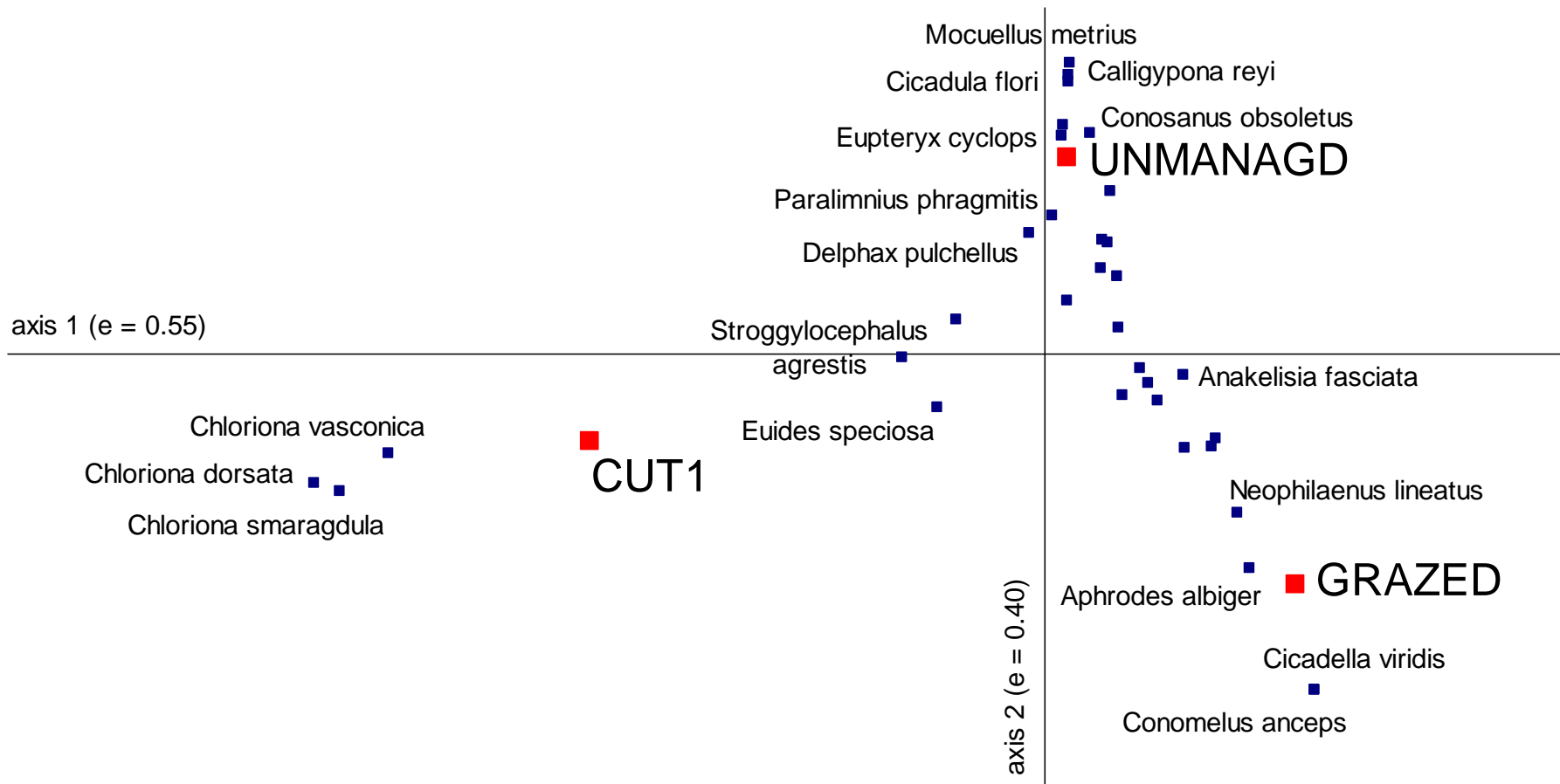
**Figure 6: CCA biplot of species and environmental variables from samples of terrestrial beetles in the Carabidae and Staphylinidae.** Only species recorded from three or more samples are shown; only species showing relatively large responses to variables are labelled; species close to or opposite environmental variables (red points) exhibit a positive or negative response respectively.



**Figure 7: CCA biplot of species and environmental variables from samples of crane-flies.** Only species recorded from three or more samples are shown; only species showing relatively large responses to variables are labelled; species close to or opposite environmental variables (red points) exhibit a positive or negative response respectively.



**Figure 8: CCA biplot of species and environmental variables from samples of Ephydriidae.** Only species recorded from three or more samples are shown; only species showing relatively large responses to variables are labelled; species close to or opposite environmental variables (red points) exhibit a positive or negative response respectively.

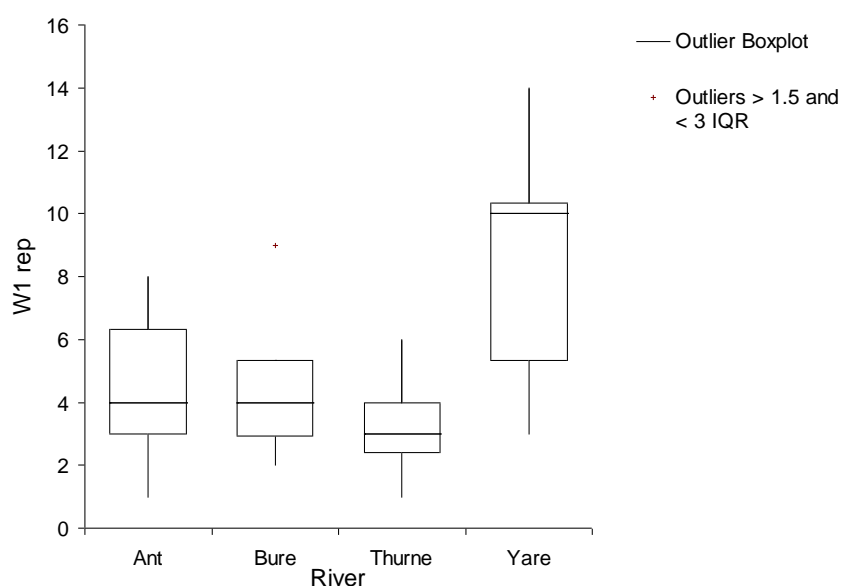


**Figure 9: CCA biplot of species and environmental variables from samples of Auchenorrhyncha.** Only species recorded from three or more samples are shown; only species showing relatively large responses to variables are labelled; species close to or opposite environmental variables (red points) exhibit a positive or negative response respectively.

## Analysis using ISIS

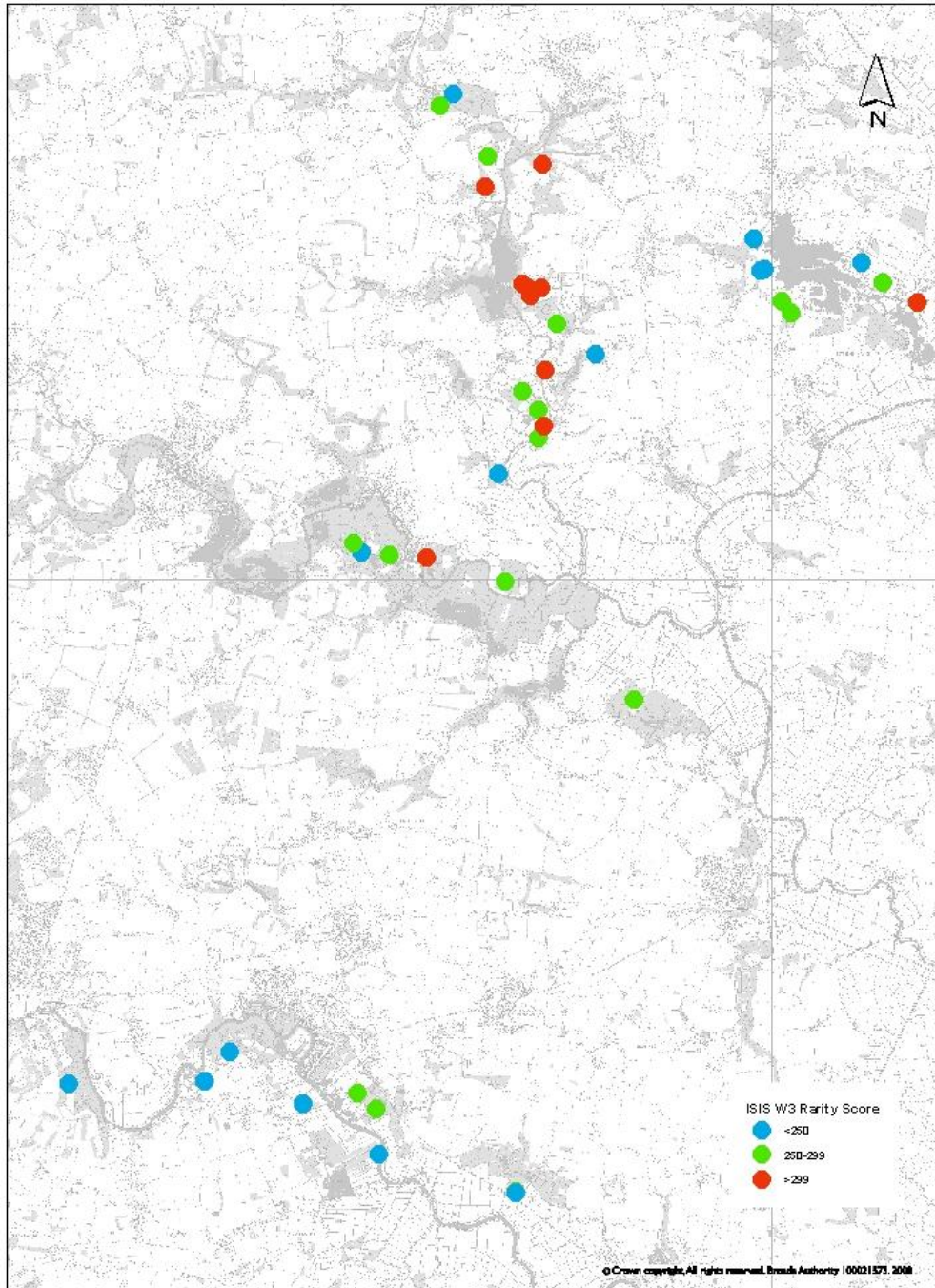
### Broad assemblage types (BATs)

The scores relating to wetland BATs for each compartment are listed in appendix 3. As should be expected, the W3 assemblage type (permanent wet mires) dominated all the compartment assemblages according to their representation scores. This assemblage type should be counted as the priority assemblage type in fens. In all cases, the W2 assemblage type (mineral marsh and open water) was the second most important component of compartment assemblages. A surprising number of W1 (flowing water) species of Diptera were recorded in the survey. They were mainly found in samples taken from boundary ditches (Kruskal-Wallis statistic = 13.72;  $p < 0.001$ ). Figure 10 shows that they were also not evenly distributed between river systems and that sites on the Yare had higher representation scores for the W1 assemblage type. The Yare has by far the greatest tidal range of the rivers in the Broads. These differences are particularly apparent in ditch systems connected to the Yare which can dry out and refill with each tide and generate a considerable flow of water. It is possible that the greater frequency of W1 Diptera in samples from the Yare is connected with this tidal range.



**Figure 10: Box plots for compartmental W1 representation scores within each river system** (the central line represents the median value; the box contains the two middle 25% quartiles representing half of all the values recorded; the whiskers represent the spread of extreme values up to 1.5 times the spread beyond the ends of the box).

The W3 rarity score indicates the conservation value of the permanent wet mire component of Broadland invertebrate assemblages. Fig. 11 shows that the highest scores are concentrated in the Ant catchment.



**Figure 11: Map of sampled compartments graded by W3 rarity score**

Relationships between ISIS scores and environmental variables were explored using individual sample lists. Hydrological variables had a large influence on scores for the W3 (permanent wet mire) BAT (see table 7). Assemblages in compartments that dried out in the summer contained a smaller proportion of specialist permanent wet mire species and the respective rarity scores show that there were fewer rare specialist species in these assemblages. Boundary ditch edges (CONNECT) also tended to have a lower proportion of specialist permanent wet mire species, but at these sites the rarity scores were not quite so depressed. Abandoned ditches did not display the same

variations as well-maintained boundary ditches. Their assemblages were much more similar to the true fen assemblages within the compartment.

**Table 7. Values of Kruskal-Wallis test statistic for variations of ISIS scores between different hydrological classes** (This test is used to compare the rankings of samples belonging to different classes; probabilities of test statistic values being generated by chance are represented by asterisks where \*\*\* =  $p < 0.001$ ; \*\* =  $p < 0.01$ ; values in italics are not significant)

	<i>DWATER</i>	<i>CONNECT</i>	<i>CONNECT</i> ( <i>boundary ditch v other classes</i> )	<i>CONNECT</i> ( <i>abandoned ditch v internal</i> )
W3 representation score	<b>-20.4***</b>	<b>28.1***</b>	<b>-27.2***</b>	-0.9
W3 rarity score	<b>-22.3***</b>	<b>12.2**</b>	<b>-9.4**</b>	+2.7

Management variables had a much lesser impact on ISIS scores. The only apparent influence detected was on W3 rarity scores. While sedge-cutting on a four year rotation was associated with depressed species richness (see Fig. 2), it was also associated with assemblages containing a higher proportion of rare specialist permanent wet mire species (Kruskal-Wallis statistic = 7.19;  $p < 0.01$ ). On the other hand, grazed sites supported a lower proportion of rare specialist permanent wet mire species (Kruskal-Wallis statistic = 17.74;  $p < 0.001$ ). However, significant relationships do not always represent causal relationships, nor relationships that are relevant to an understanding of conservation issues. The depression of ISIS scores on grazed sites is connected to the higher species-richness of assemblages on those sites (see Fig. 2), which is caused by the influx of widespread, eurytopic species, while the higher ISIS scores on cut sedge beds is connected with the opposite situation. In addition, the covariance of these variables with DWATER detected in Fig. 1 throws some doubt on a causal relationship between management variables and ISIS scores. They could be at least partly a by-product of the hydrological influence.

Vegetation structure had mixed impact on ISIS scores. Higher values for VEGDIV and BAREGRD both depressed the W3 representation score (see table 8). In addition higher values for BAREGRD depressed the W3 rarity score. It seems that while increasing the diversity of vegetation structure promotes greater species diversity, it is of little value for true fen invertebrate assemblages, because it encourages the immigration of other assemblage types. This is especially the case for creating patches of bare ground, which actually appears to deter rarer true fen species.

**Table 8. Values of Spearman's rank coefficient for correlations of ISIS scores with vegetation structure variables** (\*\* =  $p < 0.01$ ; values in italics are not significant)

	<i>BAREGRD</i>	<i>SCRUB</i>	<i>TUSSOCK</i>	<i>VEGDIV</i>
W3 representation score	<b>-0.28**</b>	<i>-0.10</i>	<i>0.00</i>	<b>-0.27**</b>
W3 rarity score	<b>-0.28**</b>	<i>+0.02</i>	<i>-0.09</i>	<i>-0.12</i>

### **Specific assemblage types (SATs)**

The important SATs recorded for each compartment are listed in appendix 4. The most widely recorded SATs were W314 (reed fen and pools) and W313 (moss and tussock fen). SATs recorded at much lower levels of representation included W312 (Sphagnum bog), W221 (undisturbed fluctuating marsh), W211 (open water on disturbed sediment) and W126 (seepage).

The SAT scores are simple species richness values covering a small range of integers. In addition, there is still some imprecision in the definition of W314 and W313 assemblage types especially as expressed in the coding of Diptera species. It is perhaps not surprising that they gave less clear responses to the recorded environmental variables. Only the W313 (moss and tussock fen) assemblage type exhibited a significant response by correlating positively to density of tussocks (Spearman's rank coefficient = 0.19;  $p < 0.05$ ) and even more positively to the sum of SCRUB + TUSSOCK (Spearman's rank coefficient = 0.24;  $p < 0.01$ ). The W221 (undisturbed fluctuating marsh) SAT was slightly better represented at sites which dried out at the surface in summer (DWATER = 1). However, better examples of this assemblage type are found away from fens on mineral sediments in river floodplains. The W211 (open water on disturbed sediment) SAT was confined to boundary ditches, but again better examples of this assemblage type are found away from fens in coastal marshes and secondary habitats such as gravel pits.

### **Conclusions**

Two invertebrate communities can be identified as conservation priorities in Broadland fen. The most important is the true fen community associated with the interior of the fen compartments. This community is dominated by species characteristic of the ISIS permanent wet mire assemblage type; species that are not particularly associated with open water. They are found in mires where free water is retained in shallow puddles, moss, tussocks and the peat surface. This community contains a large number of Red Data Book species and several species with restricted distributions within Britain (see table 9).

The second community consists of aquatic species living in the open water of the boundary ditches. It contains a lower proportion of species characteristic of the ISIS permanent wet mire assemblage type but several species of conservation concern are more or less confined to this community including several with restricted distributions within Britain (see table 10). Despite the fact that many species belong to just one of these communities, at least during the adult stage, it should be recognised that the two communities overlap considerably in species composition. In addition, many Diptera species develop in the margins of the ditch and wander as adults into the fen.

### **Responses to hydrological variables**

Hydrology is the most important factor affecting the conservation value of the true fen invertebrate community in the Broads. Most true fen species, especially the rare ones, are associated with permanently wet sites where the peat surface does not dry out in the summer. In compartments where most of the surface dries out in the summer a larger proportion of the species recorded are characteristic of fluctuating marsh or damp grassland and many of the rarer, true fen species are absent. It is sometimes argued by invertebrate conservationists that water beetles belonging to this

community require temporary pools but this statement should be qualified by the need to avoid too much desiccation. Their requirements are probably better defined as shallow pools or free water held in mossy or tussocky vegetation and the surface layers of the peat.

**Table 9. Broadland true fen species with restricted distributions in Britain**

<i>Group</i>	<i>Species</i>
Water beetles	<i>Agabus striolatus</i>
Rove beetles	<i>Lathrobium rufipenne</i> <i>Quedius balticus</i>
Spiders	<i>Baryphyma gowerense</i> <i>Centromerus semiater</i> <i>Carorita paludosa</i>
Hoppers	<i>Metalimnus formosus</i>
Diptera	<i>Stenomicroa delicata</i> <i>Dolichopus laticola</i> <i>Dolichopus nigripes</i> <i>Thrypticus smaragdinus</i> <i>Notiphila subnigra</i> <i>Notiphila umbrosa</i> <i>Ochthera manicata</i> <i>Parydra undulate</i>

**Table 10. Broadland open water species with restricted distributions in Britain**

<i>Group</i>	<i>Species</i>
Dragonflies	<i>Aeshna isosceles</i>
Water beetles	<i>Dytiscus duimidiatus</i> <i>Graphoderus cinereus</i> <i>Helochares obscurus</i> <i>Hydrophilus piceus</i>
Water bugs	<i>Hydrometra gracilentia</i> <i>Microvelia buenoi</i>

The important influence of water level fluctuations identified by the current study underlines the value of the permanent mire habitats in the Broads for true fen invertebrate conservation in Britain. Many other lowland river valley fens in Britain such as the Somerset levels and the remnants of the Cambridgeshire fens are predominantly represented by habitats that dry out in the summer. Much of the permanently wet fen habitat is concentrated in more upland areas or is spring-fed and somewhat different in character. The Broads therefore contains the largest area of British lowland river valley fen that is in good hydrological condition for invertebrates.

Although tidal range was not originally factored into the project design as an environmental variable, it is apparent from the results that it does have an influence on the boundary ditch open water community. The tidal flow in the Yare catchment

supports several species, mainly Diptera, that are elsewhere associated with seepages and riverbanks.

## **Responses to vegetation management**

Management of fen vegetation by cutting or grazing has a much lesser influence than hydrology on the conservation value of the true fen invertebrate community in the Broads. In particular, there are very few species dependent on or even sensitive to regular commercial sedge- and reed-cutting. The only exceptions among the target groups selected for study were a small group of widespread species of hoppers that responded positively to regular cutting of their *Phragmites* foodplant.

It is, however, necessary to introduce a caveat to these conclusions. The low response detected to regular short-rotation cutting is no doubt due to the current small scale of commercial operations. The commercial sedge and reed beds studied in the present project were all surrounded by much larger areas of fen that was either cut on a much longer period of rotation or recently unmanaged. These less intensively managed areas could obviously provide a large pool of potential colonists and there is ample opportunity for rapid recolonisation by invertebrates after any local extinction brought about by mowing operations. If commercial cutting were to become more extensive, the general depression in species richness observed in the current project could become more severe and permanent.

On many nature reserves cutting is carried out purely for conservation objectives. According to management plans these operations are programmed for a four to five year rotation but in practice they are carried out on an irregular basis; when it is judged that “it needs doing”. This equates to a six or seven year rotation. On some compartments light grazing is used to manage vegetation and, in some cases, both cutting and grazing have been used. It is likely that even the compartments classified as unmanaged in the current project have been cut or grazed at some time within the last twenty or thirty years. As pointed out by one of the reserve wardens, truly unmanaged fen is actually rare. Although no responses of conservation value of invertebrate assemblages to vegetation management were detected using ISIS, the species composition of some groups is affected by grazing and long term cutting and it is possible that populations of individual species of conservation interest may be affected by changes in site management. This should be borne in mind when considering changes to the management of a site that is known to support a species of conservation interest that is also rare in the Broads itself.

Judging from the compartments selected for sampling in the current study, it may be that vegetation management for conservation is mainly taking place on compartments that dry out in the summer, i.e. fen habitat that is less valuable for the true fen invertebrate community. Of course, there are practical difficulties in grazing permanently wet sites using most of the available domestic species. Invertebrate conservationists often favour non-intensive grazing as a management regime, but it is not feasible on the permanently wet compartments that are most valuable for fen invertebrates. Long term irregular cutting to create a patchwork of cut areas and less managed areas containing isolated shrubs and tussocks would seem to represent a more realistic way of preventing succession to carr on the best habitats.

## **Responses to diversity in vegetation structure**

Diversity of vegetation structure and density of individual vegetation features tend to increase species richness by attracting a wider mix of assemblage types not necessarily associated with true fen. Consequently, this increase in species diversity is not usually associated with an increase in conservation value of the true fen community.

One ISIS specific assemblage type (“moss and tussock fen” assemblage type) was found to respond positively to the density of tussocks and shrubs. This assemblage type is considered to be of intrinsic conservation value, so the promotion of habitat containing shrubs and tussocks would be a useful conservation objective to incorporate into management plans, whenever appropriate.

## **Future monitoring programmes**

In the current project ISIS has furnished clear results giving a comprehensible overview of how different variables interact with conservation interest. The ISIS representation score for the W3 permanent wet mire assemblage type can be used to monitor how the balance between different assemblage types is responding to changes in hydrology. The rarity score for the W3 permanent wet mire assemblage type can be used to monitor conservation interest associated with the true fen community. It is recommended that these scores be used in any future monitoring programme dealing with the conservation interest of true fen invertebrates in the Broads.

The results of the current project can be used as a baseline for any future monitoring programme, but only by following the same sampling protocol and using the same target taxa. It may be possible to cut costs by streamlining the target taxa. Some groups such as spiders appear to contribute very little to the overall response to environmental variables. By contrast, hoppers appear to be a very useful group, despite the fact that the sampling protocol was insufficient to generate enough data to carry out analyses of individual samples and it might be desirable to increase the time allocated to their sampling. However, there is no guarantee that ISIS would work as well on a reduced set of target taxa and any changes to sampling methods would invalidate the results of the current project as a baseline.

It is recommended that the open water community of the boundary ditches be monitored separately as they are responding to a different set of environmental factors and subject to separate management regimes. The same methods using the ISIS W3 representation and rarity scores can be used.

The results for ISIS specific assemblage types were more difficult to link to environmental factors. The two most relevant assemblage types (W313 “moss and tussock fen” and W314 “reed-fen and pools”) are not yet finally defined, either in terms of their ecological requirements or in terms of their characteristic species. It was originally intended to use data from the current project to revise the ISIS classification of permanent wet mire SATs and, in particular, Diptera species codings. There is an obvious danger of entering into a circular argument, by using the resulting classification and codings to analyse data from the same data set. In the event, data from the current project has only been used to corroborate conclusions reached from analyses of other data sets and the revision of Diptera species codes remains to be undertaken, because it requires data from a wider range of habitats than are

represented in the Broads study area. The usefulness of ISIS specific assemblage types is therefore dependent on further development work.

## **Acknowledgments**

Sandie Tolhurst, Sue Stephenson and Sally Lucas (Broads Authority) acted as project officers and, with Rick Southwood (Natural England), selected the compartments to be surveyed and provided landowner contact details and environmental information. Jon Webb (NE) assisted with a preliminary review of ISIS assemblage types.

Aquatic insects were sampled and identified by Derek Lott and Adrian Chalkley. Terrestrial beetles were sampled and identified by Derek Lott and Paul Lee. Diptera were sampled and identified by Martin Drake. Auchenorrhyncha and spiders were sampled and identified by Paul Lee. Rob Andrews (BA), John Blackburn (NWT), Peter Boardman, James Colman, Mandy Gluth (BC), Hannah Gray (BA), Ian Robinson (RSPB), John Royal, Rick Southwood (NE), Tim Strudwick (RSPB) and George Taylor (NWT) gave permission for access and provided information on site management and hydrology. John Blackburn made a boat available for access to sites along Meadow Dyke. Andy Hewitt, Joe Cullum, Gary Elliott and staff at Hickling Broad Nature Reserve assisted with access and provided information on site management.

## **References**

Drake, C.M., Lott, D.A., Alexander, K.N.A. and Webb, J. 2007. *Surveying terrestrial and freshwater invertebrates for conservation evaluation*. Natural England Research Report NERR005. Natural England, Peterborough.

Hawke, C.J. and José, P.V. 1996. *Reedbed Management for Commercial and Wildlife Interests*. RSPB, Sandy.

Kirby, P. 1992. *Habitat Management for Invertebrates: A practical handbook*. RSPB, Sandy.

Lott, D.A., Procter, D.A. and Foster, A.P. 2002. *East Anglian Fen Invertebrate Survey*. *English Nature Research Reports Number 477*. English Nature, Peterborough.

## **Appendix 1: List of all sample sites and their recorded environmental variables**

C1 = reed cut on an annual rotation, C4 = sedge cut on a four year rotation, C7 = fen cut on an irregular longer term rotation for conservation objectives, G = grazed, U = unmanaged for at least ten years.

<i>Compartment</i>	<i>Grid reference</i>	<i>Management</i>	<i>DWATER</i>
Barton Fen 1	TG359236	C4	0
Barton Fen 3	TG358230	C1	1
Catfield Fen (BC) 1	TG366212	C4	0
Catfield Fen (BC) 2	TG368212	U	0
Catfield Fen 3	TG372205	C4	1
Catfield Great Fen 1	TG365213	U	0
Catfield Great Fen 2	TG365211	C4	0
Common Fen	TG351244	C7	1
Ebb and Flow	TG362159	C4	0
Hassingham Fen 1	TG363050	U	0
Hassingham Fen 2	TG364050	C1	0
Hickling Broad (Bygraves Marsh)	TG429213	C1	0
Hickling Broad 1	TG413208	C4	0
Hickling Broad 2 (Skoyles Marsh)	TG425217	G	1
Hickling Broad 3 (Lings Mill)	TG407215	G	1
Hickling Broad 4 (Lings Mill)	TG413211	G	1
Hickling Broad 5 (Lings Mill)	TG408215	C4	1
Hickling Broad 6 (The Smea)	TG407221	U	1
Horning Marsh Farm	TG350164	C7	1
How Hill (opposite bank)	TG369190	C1	1
Hulver Ground	TG361179	C7	1
Kirby Marsh	TG286069	U	1
Little Reedham	TG368185	C7	0
Meadow Dyke	TG436210	U	0
Reedham Marsh	TG365193	C4	1
Rockland Island	TG339057	U	1
Sharp Street	TG369197	C1	1
Snipe Marsh	TG378200	G	1
Stalham Fen	TG352247	G	1
Strumpshaw Fen 1	TG338065	C7	0
Strumpshaw Fen 2	TG335067	C7	1
Surlingham Broad	TG312075	U	1
Surlingham Church Marsh	TG308070	G	1
Surlingham Marsh	TG326066	G	1
Sutton Fen	TG368234	U	0
Turf Fen	TG368188	U	0
Upton Fen	TG385138	C7	1
Woodbastwick Fen 1	TG338165	G	1
Woodbastwick Fen 2	TG341164	U	0
Woodbastwick Fen 3	TG335167	C4	1

<i>Sample</i>	<i>CONNECT</i>	<i>BAREGRD</i>	<i>SCRUB</i>	<i>TUSSOCK</i>	<i>VEGDIV</i>	<i>Notes</i>
BartF11	1	0	0	0	1	
BartF12	1	0	0	0	2	
BartF13	3	0	0	5	3	
BartF31	1	0	0	0	2	
BartF32	2	0	0	0	4	
BartF33	3	0	5	0	4	
CatfF11	1	0	1	0	2	
CatfF12	2	0	10	0	4	cut path part of sample site
CatfF13	3	0	2	0	4	
CatfF21	1	0	2	3	3	
CatfF22	2	0	0	0	2	
CatfF23	1	0	4	0	3	
CatfF31	1	0	0	0	3	
CatfF32	1	0	0	0	3	
CatfF33	3	0	0	4	3	
CatfG11	1	0	10	10	4	
CatfG12	1	0	10	0	4	
CatfG13	3	1	10	0	4	
CatfG21	1	0	0	0	2	
CatfG22	2	0	0	0	3	
CatfG23	1	0	1	4	3	
CommF11	1	0	6	10	5	
CommF12	1	0	0	10	3	
CommF13	1	0	0	10	2	
Ebb&F11	1	0	1	3	5	
Ebb&F12	2	5	1	3	5	
Ebb&F13	3	0	1	0	3	
Hassi11	1	0	0	0	1	
Hassi12	2	0	1	0	3	
Hassi13	1	0	0	0	1	
Hassi21	1	0	0	0	1	
Hassi22	1	0	0	0	1	
Hassi23	1	0	0	0	1	
HicBM11	1	0	0	0	3	
HicBM12	2	0	0	0	3	
HicBM13	3	0	0	0	3	
Hickl11	1	0	0	0	2	
Hickl12	2	0	0	0	2	
Hickl13	3	0	0	0	3	
Hickl21	1	0	0	0	3	
Hickl22	2	0	0	0	4	
Hickl23	3	0	0	0	3	
Hickl31	1	3	0	2	4	
Hickl32	1	1	0	3	3	
Hickl33	3	0	0	0	3	
Hickl41	1	2	3	10	5	
Hickl42	2	0	0	2	4	
Hickl43	3	6	3	4	6	

Hickl51	1	0	0	0	2	
Hickl52	1	0	0	0	2	
Hickl53	3	0	0	0	3	
Hickl61	1	0	0	10	2	
Hickl62	2	0	1	0	3	
Hickl63	3	1	4	0	4	
HornM11	1	1	3	0	3	
HornM12	2	0	0	0	3	
HornM13	3	0	0	0	2	
HowH11	1	0	0	0	2	
HowH12	1	0	0	0	1	
HowH13	3	0	0	0	3	
HulvG11	1	0	0	0	2	
HulvG12	1	4	0	0	4	
HulvG13	3	1	0	0	2	
Kirby11	1	0	0	0	3	
Kirby12	2	0	5	2	6	
Kirby13	3	1	4	0	5	
LReed11	1	1	6	5	5	
LReed12	2	0	1	0	6	
LReed13	3	0	0	0	3	
MeadD11	1	0	0	0	3	
MeadD12	2	0	0	0	3	
MeadD13	3	0	2	5	5	
Reedh11	1	0	5	10	3	area not cut regularly
Reedh12	1	2	0	0	3	
Reedh13	3	0	0	2	3	
Rock11	1	0	1	0	2	
Rock12	2	0	0	0	1	
Rock13	3	0	0	0	2	very tidal
Sharp11	1	0	0	0	2	
Sharp12	1	0	0	0	1	
Sharp13	3	0	0	0	3	
Snipe11	2	0	4	0	2	
Snipe12	1	0	1	1	3	
Snipe13	3	2	0	3	4	
StalF11	1	0	8	3	4	
StalF12	2	0	1	0	3	
StalF13	3	1	3	0	6	
Strum11	1	0	0	3	2	
Strum12	3	0	0	0	2	
Strum13	1	0	0	0	2	wet area with thin skin
Strum21	1	0	0	0	1	
Strum22	2	0	0	0	2	
Strum23	3	0	0	0	2	
SurIB11	1	0	1	2	4	
SurIB12	2	0	4	1	4	
SurIB13	3	1	0	0	4	very tidal
SurCM11	1	1	3	10	4	
SurCM12	2	2	5	2	6	
SurCM13	3	1	0	2	5	
SurIM11	1	0	0	0	3	
SurIM12	1	1	0	6	3	
SurIM13	3	0	0	3	3	very tidal

Sutto11	1	0	1	3	2	
Sutto12	2	0	0	0	3	
Sutto13	3	0	0	0	3	Cut path on bank by ditch
TurfF11	1	0	0	0	1	
TurfF12	1	0	0	0	2	
TurfF13	3	0	0	0	2	
Upton11	1	0	0	0	2	
Upton12	2	0	4	1	3	
Upton13	1	0	0	0	4	
Woodb11	1	0	10	10	4	
Woodb12	2	0	10	0	4	
Woodb13	3	0	0	0	4	Cut path by ditch
Woodb21	1	0	3	10	2	
Woodb22	1	0	4	0	2	
Woodb23	3	0	0	2	3	
Woodb31	1	0	0	10	4	
Woodb32	2	0	0	10	4	
Woodb33	3	0	3	3	6	

## Appendix 2: List of species recorded 2007 to 2009

ISIS BAT codes: 0 = unclassified, A1 = Arboreal canopy, A2 = wood decay, F1 = unshaded early successional mosaic, F2 = grassland & scrub matrix, F3 = shaded field & ground layer, M3 = saltmarsh, estuary & mudflat, W1 = flowing water, W2 = mineral marsh & open water, W3 = permanent wet mire, #N/A = not in ISIS database.

ISIS SAT codes: W211 = open water on disturbed sediments, W221 = undisturbed fluctuating marsh, W312 = Sphagnum bog, W313 = moss and tussock fen, W314 = reed fen and pools.

ISIS rarity scores for target groups are based on recently recorded range size in Britain, where these are accessible. Scores of 8 or 16 are more or less equivalent, as far as they can be, to national red data book status or a nationally scarce grade A designation; a score of 4 is roughly equivalent to a nationally scarce grade B designation.

Group	Species	No. samples	No. specimens	ISIS BAT code	ISIS SAT code	ISIS Rarity Score
Carabidae	<i>Acupalpus dubius</i>	16	33	W3		1
	<i>Acupalpus parvulus</i>	3	3	W3		2
	<i>Agonum emarginatum</i>	2	2	W2		2
	<i>Agonum fuliginosum</i>	15	22	W2		1
	<i>Agonum gracile</i>	6	11	W3		2
	<i>Agonum thoreyi</i>	89	299	W3		1
	<i>Agonum viduum</i>	5	5	W2		2
	<i>Amara communis</i>	3	3	F2		2
	<i>Amara ovata</i>	1	1	F1		1
	<i>Amara plebeja</i>	1	1	F2		1
	<i>Amara similata</i>	2	2	F1		1
	<i>Anchomenus dorsalis</i>	1	1	F1		1
	<i>Badister dilatatus</i>	3	5	W2	W221	4
	<i>Badister sodalis</i>	2	3	F2		4
	<i>Bembidion assimile</i>	12	13	W2		2
	<i>Bembidion bruxellense</i>	2	2	W1		2
	<i>Bembidion fumigatum</i>	5	5	W2		4
	<i>Bembidion guttula</i>	1	1	W2		1
	<i>Bembidion mannerheimii</i>	1	1	F2		2
	<i>Blethisa multipunctata</i>	2	2	W2		4
	<i>Clivina fossor</i>	2	2	F2		1
	<i>Demetrias imperialis</i>	18	23	W3	W314	4
	<i>Demetrias monostigma</i>	1	1	W3		4
	<i>Elaphrus cupreus</i>	4	6	W2		1
	<i>Leistus terminatus</i>	1	1	F2		1
	<i>Loricera pilicornis</i>	4	5	0		1
	<i>Odacantha melanura</i>	48	78	W3	W314	4
	<i>Oodes helopioides</i>	13	21	W3	W314	4
	<i>Paradromius linearis</i>	2	2	F2		1
	<i>Paradromius longiceps</i>	4	4	W3	W314	4
	<i>Philorhizus melanocephalus</i>	1	2	F1		1
	<i>Pterostichus diligens</i>	29	50	W3		1
	<i>Pterostichus gracilis</i>	1	1	W2	W221	4
	<i>Pterostichus minor</i>	25	40	W3		1
<i>Pterostichus nigrita</i>	9	10	W2		1	
Carabidae (cont'd)	<i>Pterostichus rhaeticus</i>	1	1	F2		1

<i>Pterostichus strenuus</i>	2	2	F2	1
<i>Pterostichus vernalis</i>	2	2	F2	2
<i>Stenolophus mixtus</i>	1	1	W2	1
<i>Stenolophus skrimshiranus</i>	1	1	W3	4
<i>Stenolophus teutonus</i>	1	1	W2	4
<i>Stomis pumicatus</i>	1	1	F2	2

Group	Species	No. samples	No. specimens	/SIS BAT code	/SIS SAT code	/SIS Rarity Score
Staphylinidae	<i>Acrotona pygmaea</i>	1	1	0		2
	<i>Aloconota gregaria</i>	1	1	0		1
	<i>Aloconota insecta</i>	1	1	W1		2
	<i>Anotylus rugosus</i>	4	5	W2		1
	<i>Atheta graminicola</i>	16	34	W2		1
	<i>Brachygluta fossulata</i>	2	2	F2		1
	<i>Bryaxis bulbifer</i>	4	6	W2		1
	<i>Carpelimus corticinus</i>	1	2	W2		1
	<i>Carpelimus elongatulus</i>	4	6	W2		1
	<i>Carpelimus impressus</i>	6	12	W2	W221	2
	<i>Carpelimus rivularis</i>	1	1	W2		1
	<i>Coprophilus striatulus</i>	1	1	0		1
	<i>Cypha discoidea</i>	2	2	W2		4
	<i>Cypha longicornis</i>	1	1	F3		1
	<i>Dacrila fallax</i>	20	27	W3	W313	4
	<i>Dilacra luteipes</i>	2	2	W2		2
	<i>Dochmonota clancula</i>	3	3	W2	W221	2
	<i>Erichsonius cinerascens</i>	50	154	W3		2
	<i>Euaesthetus ruficapillus</i>	5	7	W3	W313	2
	<i>Fagniezia impressa</i>	19	29	W3	W313	4
	<i>Gabrius breviventer</i>	11	14	W2		1
	<i>Geostiba circellaris</i>	1	1	F2		1
	<i>Gymnusa brevicollis</i>	2	2	W3	W312	2
	<i>Hygronoma dimidiata</i>	6	7	W3		2
	<i>Ilyobates bennetti</i>	1	1	0		2
	<i>Lathrobium brunnipes</i>	13	18	0		1
	<i>Lathrobium elongatum</i>	11	13	W3		2
	<i>Lathrobium fovulum</i>	3	3	W2	W221	2
	<i>Lathrobium impressum</i>	1	1	W2	W221	2
	<i>Lathrobium rufipenne</i>	1	2	W3	W313	16
	<i>Lathrobium terminatum</i>	20	25	W3		1
	<i>Lesteva longoelytrata</i>	11	18	W1		1
	<i>Lesteva sicula</i>	45	130	W2		1
	<i>Mocyta fungi</i>	7	7	0		1
	<i>Myllaena brevicornis</i>	2	2	W1		1
	<i>Myllaena dubia</i>	8	16	W3		1
	<i>Myllaena infuscata</i>	5	5	W2	W221	2
	<i>Myllaena intermedia</i>	13	18	W2		1
	<i>Myllaena minuta</i>	8	9	W3		2
	<i>Ochtheophilum fracticorne</i>	1	1	W3		2
	<i>Ocyusa maura</i>	34	101	W2		2
	<i>Ocyusa picina</i>	64	230	W3	W314	2
	<i>Olophrum fuscum</i>	2	2	W3	W312	4
	<i>Omalium rivulare</i>	2	2	F2		1
	<i>Oxypoda elongatula</i>	20	27	W3		1
	<i>Oxytelus fulvipes</i>	3	5	W2	W221	4
	<i>Pachnida nigella</i>	18	21	W3	W314	2
	<i>Paederus riparius</i>	57	95	W3	W314	2
	<i>Philhygra malleus</i>	6	6	W2		1
	<i>Philonthus corvinus</i>	2	2	W3	W312	4
<i>Philonthus fumarius</i>	32	55	W3	W313	4	
<i>Philonthus micans</i>	2	2	W2		2	
<i>Philonthus nigrita</i>	2	2	W3	W312	2	

## Staphylinidae (cont.)

<i>Philonthus quisquiliarius</i>	8	12	W2		1
<i>Philonthus succicola</i>	1	1	F2		2
<i>Philonthus tenuicornis</i>	1	1	F2		2
<i>Philonthus umbratilis</i>	1	3	W2		2
<i>Philonthus varians</i>	1	1	0		1
<i>Pselaphaulax dresdensis</i>	1	1	W3	W313	4
<i>Pseudomedon obsoletus</i>	1	1	W2		8
<i>Quedius balticus</i>	4	4	W3	W314	16
<i>Quedius boopoides</i>	2	2	W3	W313	2
<i>Quedius fuliginosus</i>	4	5	W2		1
<i>Quedius maurorufus</i>	7	8	W1		1
<i>Quedius schatzmayri</i>	1	1	F2		2
<i>Reichenbachia juncorum</i>	1	2	W3		2
<i>Rugilus erichsoni</i>	2	2	W3		2
<i>Rugilus rufipes</i>	1	1	F2		1
<i>Rybaxis longicornis</i>	11	20	W2		1
<i>Schistoglossa viduata</i>	1	1	W3	W313	4
<i>Sepedophilus marshami</i>	1	1	F2		1
<i>Sepedophilus nigripennis</i>	1	1	F2		1
<i>Staphylinus erythropterus</i>	1	1	F2		2
<i>Stenus argus</i>	2	2	W2	W221	4
<i>Stenus bifoveolatus</i>	5	5	W3		1
<i>Stenus bimaculatus</i>	14	22	W2		1
<i>Stenus binotatus</i>	1	1	W2		1
<i>Stenus boops</i>	9	11	W2		1
<i>Stenus butrintensis</i>	2	2	W3	W314	4
<i>Stenus carbonarius</i>	25	34	W3	W314	4
<i>Stenus cicindeloides</i>	3	5	W2		1
<i>Stenus incrassatus</i>	1	1	W2		2
<i>Stenus junco</i>	63	143	W2		1
<i>Stenus latifrons</i>	49	110	W3		1
<i>Stenus lustrator</i>	8	16	W3		4
<i>Stenus nitens</i>	57	151	W3		2
<i>Stenus nitidiusculus</i>	11	16	W3		1
<i>Stenus ossium</i>	1	3	F2		1
<i>Stenus palustris</i>	16	40	W3	W313	4
<i>Stenus providus</i>	4	5	W2		1
<i>Stenus solutus</i>	13	20	W3	W314	2
<i>Tachyporus hypnorum</i>	1	1	F2		1
<i>Tachyporus obtusus</i>	1	1	F2		1
<i>Tachyporus pallidus</i>	3	3	W2		2
<i>Tachyporus transversalis</i>	1	1	W3		2
<i>Thinodromus arcuatus</i>	8	29	W1		2
<i>Thinonoma atra</i>	2	2	W2		2
<i>Zyras collaris</i>	1	1	W2		4

Group	Species	No. samples	No. specimens	ISIS BAT code	ISIS SAT code	ISIS Rarity Score
Water beetles	<i>Agabus bipustulatus</i>	12	22	W2		1
	<i>Agabus striolatus</i>	3	3	W3	W313	8
	<i>Agabus sturmii</i>	15	49	W2		1
	<i>Agabus uliginosus</i>	1	1	W3		4
	<i>Agabus unguicularis</i>	10	17	W3	W313	2
	<i>Anacaena globulus</i>	18	39	W2		1
	<i>Anacaena limbata</i>	86	351	W2		1
	<i>Anacaena lutescens</i>	22	32	W3		1
	<i>Cercyon convexiusculus</i>	17	23	W2		2
	<i>Cercyon granarius</i>	1	1	W3	W313	8
	<i>Cercyon marinus</i>	8	15	W2		2
	<i>Cercyon sternalis</i>	12	14	W3		2
	<i>Cercyon tristis</i>	7	10	W2		2
	<i>Cercyon ustulatus</i>	2	2	W2		2
	<i>Chaetarthria seminulum</i>	1	1	W3		2
	<i>Coelambus impressopunctatus</i>	2	2	W3		1
	<i>Coelostoma orbiculare</i>	29	57	W3		2
	<i>Colymbetes fuscus</i>	8	12	W2		1
	<i>Cymbiodyta marginellus</i>	33	103	W3		2
	<i>Donacia semicuprea</i>	1	4	W3		2
	<i>Dryops anglicanus</i>	23	127	W3	W313	8
	<i>Dryops luridus</i>	1	1	W2		1
	<i>Dytiscus marginalis</i>	2	3	W2		1
	<i>Enochrus bicolor</i>	1	2	M3	M311	4
	<i>Enochrus coarctatus</i>	39	130	W3		2
	<i>Enochrus melanocephalus</i>	2	2	W2	W211	2
	<i>Enochrus quadripunctatus</i>	5	8	W3	W313	4
	<i>Enochrus testaceus</i>	25	52	W2		2
	<i>Graphoderus cinereus</i>	1	1	W3	W314	8
	<i>Graptodytes granularis</i>	9	28	W3	W313	2
	<i>Graptodytes pictus</i>	2	4	W2		2
	<i>Gyrinus marinus</i>	3	10	W2		2
	<i>Gyrinus paykulli</i>	2	2	W3	W314	4
	<i>Gyrinus substriatus</i>	1	2	W2		1
	<i>Gyrinus suffriani</i>	4	5	W3	W314	8
	<i>Haliplus confinis</i>	1	3	W2		2
	<i>Haliplus lineatocollis</i>	2	2	W1		1
	<i>Haliplus ruficollis</i>	20	71	W2		1
	<i>Haliplus variegatus</i>	2	3	W3	W314	8
	<i>Helochares lividus</i>	3	4	W2	W211	2
	<i>Helochares obscurus</i>	6	20	W3	W314	8
	<i>Helophorus aequalis</i>	3	4	W2		1
	<i>Helophorus brevipalpis</i>	1	1	W2		1
	<i>Helophorus flavipes</i>	2	2	W3		1
	<i>Helophorus grandis</i>	3	3	W2		1
	<i>Helophorus griseus</i>	1	1	W2		2
	<i>Helophorus minutus</i>	8	9	W2		1
	<i>Helophorus obscurus</i>	1	1	W2		1
	<i>Helophorus strigifrons</i>	3	5	W2		4
	<i>Hydaticus seminiger</i>	18	25	W3	W313	2
	<i>Hydaticus transversalis</i>	2	2	W3	W314	4
	<i>Hydraena britteni</i>	11	26	W3		2
	<i>Hydraena palustris</i>	7	14	W3	W313	16
	<i>Hydraena riparia</i>	4	7	W2		2

Water beetles (cont.)	<i>Hydraena testacea</i>	1	1	W2		4
	<i>Hydrobius fuscipes</i>	39	83	W2		1
	<i>Hydrochus brevis</i>	3	3	W3	W313	4
	<i>Hydrochus ignicollis</i>	1	1	W3	W314	8
	<i>Hydrochus megaphallus</i>	4	11	W3	W313	16
	<i>Hydroglyphus geminus</i>	1	1	W2	W211	2
	<i>Hydrophilus piceus</i>	2	2	W3	W314	4
	<i>Hydroporus angustatus</i>	37	129	W2		1
	<i>Hydroporus erythrocephalus</i>	6	7	W2		1
	<i>Hydroporus gyllenhali</i>	1	1	W3		1
	<i>Hydroporus incognitus</i>	6	8	W2		1
	<i>Hydroporus melanarius</i>	2	4	W3		2
	<i>Hydroporus memnonius</i>	7	18	W3		1
	<i>Hydroporus neglectus</i>	4	11	W3		4
	<i>Hydroporus palustris</i>	14	47	W2		1
	<i>Hydroporus planus</i>	13	13	W2		1
	<i>Hydroporus pubescens</i>	9	14	W3		1
	<i>Hydroporus scalesianus</i>	10	12	W3	W313	8
	<i>Hydroporus striola</i>	8	12	W3		1
	<i>Hydroporus umbrosus</i>	6	11	W3		2
	<i>Hydrovatus cuspidatus</i>	1	1	0		0
	<i>Hygrobia hermanni</i>	2	8	W2		2
	<i>Hygrotus decoratus</i>	19	45	W3	W313	4
	<i>Hygrotus impressopunctatus</i>	8	12	W3		1
	<i>Hygrotus inaequalis</i>	29	125	W2		1
	<i>Hygrotus versicolor</i>	1	2	W2	W211	2
	<i>Hyphydrus ovatus</i>	30	176	W2		1
	<i>Ilybius ater</i>	13	23	W2		1
	<i>Ilybius chalconatus</i>	1	1	W1		2
	<i>Ilybius fuliginosus</i>	1	2	W2		1
	<i>Ilybius guttiger</i>	11	20	W3	W313	2
	<i>Ilybius quadriguttatus</i>	17	29	W3		2
	<i>Laccobius bipunctatus</i>	18	47	W2		1
	<i>Laccobius striatulus</i>	1	1	W1		2
	<i>Laccophilus minutus</i>	1	1	W2		1
	<i>Laccornis oblongus</i>	10	17	W3	W313	4
	<i>Limnebius aluta</i>	6	11	W3	W313	8
	<i>Limnebius nitidus</i>	2	9	W2		4
	<i>Limnebius truncatellus</i>	1	1	W1		1
	<i>Liopterus haemorrhoidalis</i>	40	118	W3		2
	<i>Noterus clavicornis</i>	31	106	W2		1
	<i>Noterus crassicornis</i>	21	75	W3	W314	2
	<i>Ochthebius minimus</i>	16	20	W2		1
	<i>Peltodytes caesus</i>	2	3	W2	W211	2
	<i>Porhydrus lineatus</i>	1	1	W2		2
	<i>Rhantus exsoletus</i>	6	11	W3		2
	<i>Rhantus frontalis</i>	12	31	W3		4
	<i>Rhantus grapii</i>	11	17	W3	W313	2
	<i>Rhantus suturalis</i>	13	31	W2	W211	2
	<i>Suphrodytes dorsalis</i>	5	7	W3		2

Group	Species	No. samples	No. specimens	ISIS BAT code	ISIS SAT code	ISIS Rarity Score
Water bugs	<i>Corixa panzeri</i>	2	2	W2	W211	2
	<i>Corixa punctata</i>	6	10	W2	0	1
	<i>Gerris lacustris</i>	4	7	W2	0	1
	<i>Gerris odontogaster</i>	10	10	W2	0	1
	<i>Hebrus ruficeps</i>	15	50	W3	0	2
	<i>Hesperocorixa linnaei</i>	13	56	W2	0	1
	<i>Hesperocorixa sahlbergi</i>	9	12	W2	0	1
	<i>Hydrometra gracilentata</i>	2	3	W3	W314	16
	<i>Hydrometra stagnorum</i>	14	22	W2	0	1
	<i>Ilyocoris cimicoides</i>	9	22	W2	0	1
	<i>Microvelia buenoi</i>	29	64	W3	W314	8
	<i>Microvelia reticulata</i>	33	88	W2	0	1
	<i>Nepa cinerea</i>	20	32	W2	0	1
	<i>Notonecta glauca</i>	25	69	W2	0	1
	<i>Notonecta viridis</i>	1	1	W2	W211	1
	<i>Plea minutissima</i>	4	6	W2	W211	1
	<i>Ranatra linearis</i>	2	4	W2	W211	2
	<i>Sigara dorsalis</i>	6	30	W2	0	1
	<i>Sigara fossarum</i>	1	3	W2	0	1
	<i>Sigara semistriata</i>	4	18	W3	0	2
Diptera – craneflies (Limoniidae + Ptychopteridae + Tipulidae )	<i>Austrolimnophila ochracea</i>	3	3	A2		1
	<i>Cheilotrichia cinerascens</i>	1	1	0		1
	<i>Cheilotrichia imbuta</i>	11	39	W1		4
	<i>Dicranomyia autumnalis</i>	5	5	W3		1
	<i>Dicranomyia danica</i>	17	33	W2		8
	<i>Dicranomyia lucida</i>	10	17	W1		4
	<i>Dicranomyia modesta</i>	20	43	W3		1
	<i>Dicranomyia morio</i>	1	1	W1		2
	<i>Dicranomyia ventralis</i>	12	17	W3	W314	4
	<i>Dictenidia bimaculata</i>	1	1	A2	A211	2
	<i>Ellipteroides lateralis</i>	6	27	W1		2
	<i>Erioconopa trivialis</i>	14	28	W3		1
	<i>Erioptera ?neilseni</i>	2	2	#N/A		0
	<i>Erioptera bivittata</i>	2	3	M3	M311	16
	<i>Erioptera flavata</i>	4	48	W3		2
	<i>Erioptera fuscipennis</i>	23	68	W3		1
	<i>Erioptera fusculentata</i>	1	1	W3		1
	<i>Erioptera lutea</i>	4	5	W1		1
	<i>Erioptera meijerei</i>	53	242	W3	W314	16
	<i>Erioptera squalida</i>	1	3	W3	W314	2
	<i>Gonempeda flava</i>	1	1	W1		1
	<i>Gonomyia bifida</i>	1	1	W3	W314	4
	<i>Gonomyia recta</i>	1	1	W1		2
	<i>Helius flavus</i>	62	298	W3		2
	<i>Helius longirostris</i>	32	131	W2		1
	<i>Helius pallirostris</i>	40	180	W3	W314	4
	<i>Limonia macrostigma</i>	3	3	W1		1
	<i>Limonia nubeculosa</i>	1	1	F3		1
	<i>Limonia phragmitidis</i>	2	2	F3		1
	<i>Lipsothrix nervosa</i>	1	1	W1	W126	2
	<i>Molophilus bifidus</i>	1	1	W1		1
	<i>Molophilus bihamatus</i>	6	29	W1	W126	4
<i>Molophilus corniger</i>	1	1	W1	W126	4	

	<i>Molophilus griseus</i>	2	5	W3		1
	<i>Molophilus medius</i>	29	162	W1		1
	<i>Molophilus obscurus</i>	26	50	W1		1
	<i>Molophilus ochraceus</i>	1	1	W3		1
	<i>Molophilus pleuralis</i>	22	137	W3		2
	<i>Molophilus serpentiger</i>	1	2	W1		1
	<i>Neolimnomyia batava</i>	5	15	W2		2
	<i>Neolimnomyia nemoralis</i>	26	79	W1		1
	<i>Nephrotoma analis</i>	1	1	W1	W114	2
	<i>Nephrotoma submaculosa</i>	1	1	F1	F111	2
	<i>Paradelphomyia czizekiana</i>	6	61	#N/A		0
	<i>Paradelphomyia senilis</i>	5	15	W1		1
	<i>Phylidorea abdominalis</i>	8	9	W3		4
	<i>Phylidorea ferruginea</i>	52	112	W3		1
	<i>Phylidorea fulvonervosa</i>	21	54	W3		1
	<i>Pilaria scutellata</i>	8	9	W3		4
	<i>Pilaria sp A of Stubbs</i>	7	8	#N/A		0
	<i>Prionocera turcica</i>	5	6	W3		2
	<i>Pseudolimnophila lucorum</i>	2	4	W3		1
	<i>Pseudolimnophila sepium</i>	5	25	W1		1
	<i>Ptychoptera contaminata</i>	4	4	W2		2
	<i>Ptychoptera minuta</i>	15	35	W3	W314	2
	<i>Symplecta stictica</i>	11	25	W2		1
	<i>Tasiocera murina</i>	4	4	F3		1
	<i>Thaumastoptera calceata</i>	5	12	W1	W126	4
	<i>Tipula fascipennis</i>	1	1	F2		1
	<i>Tipula marginella</i>	13	20	W3		8
	<i>Tipula oleracea</i>	6	6	W3		1
	<i>Tipula pierrei</i>	18	28	W2		2
	<i>Tipula pruinosa</i>	2	3	W3		2
	<i>Tipula unca</i>	2	4	W1		1
Diptera - Anthomyzidae	<i>Anagnota bicolor</i>	22	44	W3		4
	<i>Anthomyza collini</i>	113	1268	W3		0
	<i>Anthomyza gracilis</i>	13	16	0		1
	<i>Anthomyza neglecta</i>	32	62	W3		0
	<i>Anthomyza pallida</i>	4	6	W3		2
	<i>Paranthomyza nitida</i>	1	2	W3		0
	<i>Stiphrosoma cingulatum</i>	9	43	W3		2
	<i>Stiphrosoma sabulosum</i>	1	1	F2		0
	<i>Typhamyza bifasciata</i>	11	32	W3	W314	4
Diptera - Aulacigastridae	<i>Stenomicroa cogani</i>	49	188	W3	W313	8
	<i>Stenomicroa delicata</i>	1	1	W3	W314	16
Diptera - Chamaemyiidae	<i>Chamaemyia polystigma</i>	11	19	F2		1
	<i>Parochthiphila coronata</i>	1	1	F1	F111	16
Diptera - Chaoboridae	<i>Chaoborus crystallinus</i>	19	127	W2		0
	<i>Chaoborus flavicans</i>	4	6	W2		0
	<i>Chaoborus pallidus</i>	7	9	W3		0
Diptera - Culicidae	<i>Aedes cinereus</i>	6	15	W2		2
	<i>Anopheles algeriensis</i>	2	2	W3		0
	<i>Anopheles claviger</i>	1	1	W2		1
	<i>Coquillettidia richiardii</i>	9	23	W3		1
	<i>Culex pipiens</i>	1	1	W2		1
	<i>Culiseta annulata</i>	1	1	W2		1
	<i>Culiseta morsitans</i>	4	4	W2		1
	<i>Ochlerotatus annulipes</i>	2	2	W2		2
Diptera - Diastatidae	<i>Campichoeta obscuripennis</i>	4	13	F2		1
	<i>Campichoeta punctum</i>	1	4	F2		2
	<i>Diastata adusta</i>	39	82	0		1
	<i>Diastata costata</i>	2	2	F2		0
Diptera - Dixidae	<i>Dixella amphibia</i>	28	60	W3		1

	<i>Dixella autumnalis</i>	57	258	0			2
	<i>Dixella serotina</i>	22	180	W3	W314		2
Diptera - Dolichopodidae	<i>Achalcus britannicus</i>	2	2	W3			0
	<i>Achalcus cinereus</i>	48	177	W3			2
	<i>Achalcus flavicollis</i>	20	49	W3			2
	<i>Achalcus nigropunctatus</i>	3	4	#N/A			0
	<i>Achalcus thalhammeri</i>	23	60	W3			0
	<i>Achalcus vaillanti</i>	63	430	W3	W314		0
	<i>Anepsiomyia flaviventris</i>	9	34	W1			2
	<i>Argyra ?grata</i>	1	2	#N/A			0
	<i>Argyra diaphana</i>	1	1	W1			1
	<i>Argyra elongata</i>	4	4	W3			2
	<i>Argyra leucocephala</i>	3	4	W1			1
	<i>Argyra vestita</i>	12	17	W3			2
	<i>Campsicnemus armatus</i>	7	10	M3			2
	<i>Campsicnemus curvipes</i>	21	81	W1			1
	<i>Campsicnemus loripes</i>	1	1	W3			1
	<i>Campsicnemus picticornis</i>	1	2	W3	W314		2
	<i>Campsicnemus pusillus</i>	4	5	W3			2
	<i>Campsicnemus scambus</i>	93	940	W3			1
	<i>Chrysotimus molliculus</i>	2	2	0			2
	<i>Chrysotus blepharosceles</i>	1	3	0			2
	<i>Chrysotus cilipes</i>	9	14	W3			1
	<i>Chrysotus gramineus</i>	28	61	0			1
	<i>Chrysotus neglectus</i>	4	7	0			1
	<i>Chrysotus suavis</i>	1	1	0			2
	<i>Diaphorus nigricans</i>	4	4	W3			2
	<i>Dolichopus atripes</i>	8	39	W3			1
	<i>Dolichopus brevipennis</i>	6	17	W3			2
	<i>Dolichopus campestris</i>	7	10	W3			1
	<i>Dolichopus discifer</i>	2	3	W1			1
	<i>Dolichopus festivus</i>	1	1	W2			1
	<i>Dolichopus laticola</i>	5	6	W3	W314		16
	<i>Dolichopus latilimbatus</i>	17	29	W3			2
	<i>Dolichopus lepidus</i>	5	8	W3			2
	<i>Dolichopus longitarsis</i>	24	60	W3			2
	<i>Dolichopus nigripes</i>	4	5	W3			16
	<i>Dolichopus nubilus</i>	49	107	W2			1
	<i>Dolichopus pennatus</i>	14	36	W1			1
	<i>Dolichopus phaeopus</i>	1	1	W3			2
	<i>Dolichopus picipes</i>	11	24	W1			2
	<i>Dolichopus plumipes</i>	61	189	W2			1
	<i>Dolichopus popularis</i>	19	48	W1			1
	<i>Dolichopus signatus</i>	4	4	W3			2
	<i>Dolichopus simplex</i>	24	72	W2			1
	<i>Dolichopus subpennatus</i>	1	1	0			1
	<i>Dolichopus trivialis</i>	2	2	0			1
	<i>Dolichopus ungulatus</i>	6	11	W2			1
	<i>Dolichopus urbanus</i>	4	11	W1			1
	<i>Dolichopus vitripennis</i>	3	9	W3			2
	<i>Dolichopus wahlbergi</i>	2	3	W1			2
	<i>Gymnopternus aerosus</i>	60	464	W3			1
	<i>Gymnopternus assimilis</i>	49	280	W3	W314		2
	<i>Gymnopternus blankaartensis</i>	22	66	W3	W314		0
	<i>Gymnopternus celer</i>	2	5	W1			2
	<i>Gymnopternus chalybeus</i>	60	202	W3			2
	<i>Gymnopternus cupreus</i>	1	1	W1			2
	<i>Gymnopternus metallicus</i>	4	8	W1			1
	<i>Gymnopternus silvestris</i>	1	1	W1			2
	<i>Hercostomus nanus</i>	5	6	W1			2

	<i>Hercostomus plagiatus</i>	6	14	W1		4
	<i>Hydrophorus balticus</i>	2	3	W1		2
	<i>Hydrophorus bipunctatus</i>	1	1	W1		1
	<i>Lamprochromus bifasciatus</i>	19	169	W3		2
	<i>Medetera saxatilis</i>	1	1	A2		2
	<i>Micromorphus albipes</i>	21	100	0		2
	<i>Rhaphium caliginosum</i>	2	3	W1		1
	<i>Rhaphium fasciatum</i>	9	47	W3		2
	<i>Rhaphium monotrichum</i>	6	8	W1		1
	<i>Sciapus platypterus</i>	2	2	F3		1
	<i>Sympycnus aeneicoxa</i>	6	12	W3		1
	<i>Sympycnus desoutteri</i>	20	77	W2		1
	<i>Syntormon bicolorellum</i>	1	1	W3		2
	<i>Syntormon denticulatum</i>	1	2	W1		2
	<i>Syntormon filiger</i>	1	1	M3	M311	4
	<i>Syntormon monile</i>	2	2	W3		2
	<i>Syntormon pallipes</i>	1	1	W1		1
	<i>Syntormon pumilum</i>	9	33	W3		2
	<i>Syntormon tarsatum</i>	19	82	W3		2
	<i>Telmaturgus tumidulus</i>	5	17	W3		4
	<i>Teuchophorus spinigerellus</i>	60	537	W3		2
	<i>Thrypticus ?atomus</i>	2	3	#N/A		0
	<i>Thrypticus cuneatus</i>	1	6	W3	W313	8
	<i>Thrypticus intercedens</i>	1	1	#N/A		0
	<i>Thrypticus laetus</i>	1	1	W3		2
	<i>Thrypticus nigricauda</i>	2	5	W3		4
	<i>Thrypticus paludicola</i>	3	5	#N/A		0
	<i>Thrypticus smaragdinus</i>	16	22	W3	W314	0
	<i>Telmaturgus tumidulus</i>	1	1	W3		0
	<i>Teuchophorus spinigerellus</i>	12	61	W3		2
Diptera - Empididae	<i>Chelifera precatatoria</i>	1	1	W1		1
	<i>Chelipoda albisetia</i>	12	61	W1		2
	<i>Chelipoda vocatoria</i>	1	1	W1		2
	<i>Dolichocephala irrorata</i>	1	1	W1		1
	<i>Dolichocephala oblongoguttata</i>	14	18	W1		2
	<i>Empis aestiva</i>	7	8	0		1
	<i>Empis albinervis</i>	1	1	0		2
	<i>Empis planetica</i>	1	1	F2		2
	<i>Hemerodromia raptoria</i>	36	250	W1		2
	<i>Hilara apta</i>	1	2	W1		2
	<i>Hilara chorica</i>	4	42	0		1
	<i>Hilara longifurca</i>	15	61	0		1
	<i>Hilara lurida</i>	1	1	W1		2
	<i>Hilara nigrina</i>	5	7	0		2
	<i>Hilara quadriseta</i>	2	2	W3		4
	<i>Hilara subpollinosa</i>	1	1	W3		2
	<i>Phyllodromia melanocephala</i>	22	190	F3		1
Diptera - Ephydriidae	<i>Rhamphomyia caliginosa</i>	29	98	0		4
	<i>Axysta cesta</i>	40	188	W3		2
	<i>Coenia curvicauda</i>	83	750	W3		1
	<i>Coenia palustris</i>	107	5159	W3		1
	<i>Discocerina obscurella</i>	4	32	W2		1
	<i>Ditrichophora calceata</i>	2	5	W1		1
	<i>Ditrichophora fuscella</i>	8	18	W1		1
	<i>Ditrichophora near fuscella</i>	1	1	#N/A		0
	Ephydriidae sp. n.	1	1	#N/A		0
	<i>Hyadina ?nigricornis</i>	1	1	#N/A		0
	<i>Hyadina guttata</i>	11	22	0		1
	<i>Hyadina humeralis</i>	10	19	0		1
	<i>Hydrellia albiceps</i>	1	1	0		0

	<i>Hydrellia albilabris</i>	3	3	W3		1
	<i>Hydrellia griseola</i>	3	3	0		1
	<i>Hydrellia maura</i>	5	10	0		1
	<i>Hydrellia obscura</i>	4	7	W3		1
	<i>Hydrellia tarsata</i>	2	3	W3		2
	<i>Hydrellia thoracica</i>	10	50	W3		1
	<i>Ilythea spilota</i>	33	53	0		1
	<i>Limnellia quadrata</i>	1	1	W3		1
	<i>Limnellia surturi</i>	4	8	0		1
	<i>Notiphila caudata</i>	26	52	W3		1
	<i>Notiphila cinerea</i>	40	269	W2		1
	<i>Notiphila dorsata</i>	9	14	W3		1
	<i>Notiphila graecula</i>	7	12	W2		1
	<i>Notiphila guttiventris</i>	25	220	W3		0
	<i>Notiphila maculata</i>	3	17	W3		1
	<i>Notiphila nubila</i>	3	16	W3		2
	<i>Notiphila riparia</i>	89	1456	W3		1
	<i>Notiphila subnigra</i>	67	519	W3	W314	4
	<i>Notiphila uliginosa</i>	12	75	W3		2
	<i>Notiphila umbrosa</i>	64	948	W3		0
	<i>Notiphila venusta</i>	1	2	W3		2
	<i>Ochthera manicata</i>	21	113	W3		8
	<i>Paracoenia fumosa</i>	9	31	W3		1
	<i>Parydra coarctata</i>	12	82	W1		1
	<i>Parydra fossarum</i>	56	511	W2		1
	<i>Parydra hecate</i>	4	4	W3		2
	<i>Parydra littoralis</i>	4	5	W1		1
	<i>Parydra pusilla</i>	54	173	W3		2
	<i>Parydra quadripunctata</i>	4	10	W2		1
	<i>Parydra undulata</i>	11	33	W3		0
	<i>Pelina aenea</i>	4	6	W3		1
	<i>Pelina nitens</i>	1	1	W3		2
	<i>Pelina similis</i>	5	6	W3		1
	<i>Philotelma defectum</i>	4	6	0		2
	<i>Philotelma nigripenne</i>	55	167	0		2
	<i>Philygria interstincta</i>	1	1	0		0
	<i>Psilopa nigrivetula</i>	9	15	0		1
	<i>Psilopa nitidula</i>	8	9	F2		1
	<i>Scatella lutosa</i>	1	1	W3		2
	<i>Scatella paludum</i>	2	140	W2		1
	<i>Scatella stagnalis</i>	54	500	W2		1
	<i>Scatella tenuicosta</i>	46	597	W3		1
	<i>Scatophila contaminata</i>	4	4	#N/A		0
	<i>Scatophila despecta</i>	2	3	0		2
	<i>Scatophila noctula</i>	12	31	0		0
Diptera - Hybotidae	<i>Bicellaria simplicipes</i>	2	3	F3		0
	<i>Bicellaria vana</i>	2	4	0		1
	<i>Drapetis ephippiata</i>	3	4	0		2
	<i>Hybos culiciformis</i>	1	1	F3		1
	<i>Hybos femoratus</i>	15	34	F2		1
	<i>Ocydromia glabricula</i>	4	10	F3		1
	<i>Platypalpus ?biapicalis</i>	1	1	#N/A		0
	<i>Platypalpus annulipes</i>	3	6	F3		1
	<i>Platypalpus articulatoides</i>	1	1	0		4
	<i>Platypalpus calceatus</i>	4	4	F2		1
	<i>Platypalpus cothurnatus</i>	2	4	F2	F212	2
	<i>Platypalpus cursitans</i>	6	8	F2		1
	<i>Platypalpus flavicornis</i>	1	1	0		2
	<i>Platypalpus kirtlingensis</i>	2	2	W3		0
	<i>Platypalpus longicornis</i>	1	1	0		1

	<i>Platypalpus longiseta</i>	8	10	0		1
	<i>Platypalpus minutus</i>	1	1	F2		1
	<i>Platypalpus near pallidicornis</i>	1	1	#N/A		0
	<i>Platypalpus notatus</i>	2	4	F2		1
	<i>Platypalpus pallidicornis</i>	47	108	W3		2
	<i>Platypalpus pallidiventris</i>	57	115	0		1
	<i>Platypalpus parvicauda</i>	1	2	F3		2
	<i>Platypalpus pseudofulvipes</i>	5	8	F2		1
	<i>Platypalpus pulicarius</i>	1	1	0		8
	<i>Platypalpus pygialis</i>	12	15	0		0
	<i>Stilpon graminum</i>	34	116	F2		1
	<i>Symbalophthalmus dissimilis</i>	1	2	0		4
	<i>Symbalophthalmus fuscitarsus</i>	1	1	0		2
	<i>Tachydromia aemula</i>	1	7	0		1
	<i>Trichina clavipes</i>	12	20	F3		1
	<i>Trichina pallipes</i>	2	2	F3		2
Diptera - Lauxaniidae	<i>Calliopum aeneum</i>	2	3	F3		1
	<i>Calliopum elisae</i>	4	5	0		2
	<i>Meiosimyza decipiens</i>	12	77	0		1
	<i>Meiosimyza rorida</i>	1	1	F3		1
	<i>Minettia fasciata</i>	1	1	0		1
	<i>Minettia inusta</i>	1	1	F3		0
	<i>Minettia longipennis</i>	1	1	F3		1
	<i>Sapromyza opaca</i>	1	1	0		4
	<i>Trigonometopus frontalis</i>	43	99	0		2
Diptera - Lonchopteridae	<i>Lonchoptera bifurcata</i>	22	48	0		1
	<i>Lonchoptera lutea</i>	69	281	0		1
	<i>Lonchoptera nitidifrons</i>	2	8	W3	W314	2
	<i>Lonchoptera scutellata</i>	32	148	W3	W314	4
Diptera - Micropezidae	<i>Neria cibaria</i>	3	3	0		1
Diptera - Opomyzidae	<i>Geomyza balachowskyi</i>	7	36	F2		1
	<i>Geomyza tripunctata</i>	13	14	F2		1
	<i>Opomyza germinationis</i>	20	47	F2		1
	<i>Opomyza petrei</i>	18	37	F2		1
Diptera - Psilidae	<i>Loxocera albisetia</i>	1	1	0		1
Diptera - Rhagionidae	<i>Chrysopilus cristatus</i>	37	137	W3		1
	<i>Rhagio lineola</i>	2	5	F3		1
	<i>Rhagio scolopaceus</i>	7	7	F2		1
	<i>Rhagio tringarius</i>	1	1	F2		1
Diptera - Scathophagidae	<i>Chaetosa punctipes</i>	4	6	W3		2
	<i>Cleigastra apicalis</i>	33	76	W3		2
	<i>Cordilura aemula</i>	1	1	W3	W314	8
	<i>Cordilura ciliata</i>	2	6	W3		2
	<i>Cordilura impudica</i>	1	1	W3		2
	<i>Cordilura pubera</i>	3	3	W3		1
	<i>Leptopa filiformis</i>	1	1	0		2
	<i>Norellisoma spinimanum</i>	5	5	F2		1
	<i>Scathophaga furcata</i>	17	25	F2		1
	<i>Scathophaga inquinata</i>	4	4	F2		1
	<i>Scathophaga stercoraria</i>	11	14	F2		1
	<i>Scathophaga suilla</i>	13	52	F2		1
	<i>Spaziphora hydromyzina</i>	1	1	W2		2
	<i>Trichopalpus fraternus</i>	1	1	W3		2
Diptera - Sciomyzidae	<i>Antichaeta analis</i>	1	1	W3	W314	8
	<i>Antichaeta brevipennis</i>	2	2	W3	W314	16
	<i>Colobaea bifasciella</i>	18	29	W3	W314	4
	<i>Colobaea distincta</i>	2	2	W3	W314	4
	<i>Colobaea pectoralis</i>	1	2	W3	W314	16
	<i>Colobaea punctata</i>	1	3	W3	W314	4
	<i>Elgiva cucularia</i>	6	8	W3		2

	<i>Elgiva sollicita</i>	18	32	W3		1
	<i>Euthycera fumigata</i>	1	1	0		2
	<i>Hydromya dorsalis</i>	2	2	W2		1
	<i>Ilione albisetia</i>	21	73	W3		1
	<i>Ilione lineata</i>	12	20	W3	W313	2
	<i>Limnia paludicola</i>	25	65	W3		1
	<i>Pherbellia albocostata</i>	2	2	F3		1
	<i>Pherbellia argyra</i>	13	27	W3	W314	16
	<i>Pherbellia cinerella</i>	1	2	F2		1
	<i>Pherbellia dorsata</i>	16	40	W3	W314	4
	<i>Pherbellia nana</i>	2	2	W2		4
	<i>Pherbellia pallidiventris</i>	1	1	W3		1
	<i>Pherbellia schoenherri</i>	21	34	W3		2
	<i>Pherbellia ventralis</i>	2	2	W3		2
	<i>Pherbina coryleti</i>	33	120	W2		1
	<i>Psacadina verbekei</i>	16	29	W3		4
	<i>Psacadina zernyi</i>	9	11	W3	W314	16
	<i>Pteromicra angustipennis</i>	21	31	W3		2
	<i>Pteromicra leucopeza</i>	2	2	W3		16
	<i>Renocera pallida</i>	6	10	0		1
	<i>Renocera striata</i>	2	2	W3	W313	4
	<i>Sciomyza dryomyzina</i>	2	2	W3		16
	<i>Sciomyza simplex</i>	10	14	W3		4
	<i>Sciomyza testacea</i>	1	2	W3		0
	<i>Sepedon spegea</i>	2	2	W3		2
	<i>Sepedon spinipes</i>	20	27	W3	W314	2
	<i>Tetanocera arrogans</i>	15	20	W3	W314	2
	<i>Tetanocera elata</i>	7	9	F2		1
	<i>Tetanocera ferruginea</i>	48	94	W3		1
	<i>Tetanocera freyi</i>	21	37	W3	W313	8
	<i>Tetanocera fuscinervis</i>	35	95	W3		2
	<i>Tetanocera hyalipennis</i>	2	2	0		1
	<i>Tetanocera robusta</i>	4	4	W3		1
	<i>Tetanocera silvatica</i>	3	4	W3		1
Diptera - Sepsidae	<i>Nemopoda nitidula</i>	1	1	F2		1
	<i>Sepsis cynipsea</i>	3	3	0		1
	<i>Sepsis flavimana</i>	5	11	0		1
	<i>Sepsis fulgens</i>	13	17	0		1
	<i>Sepsis punctum</i>	24	39	0		1
	<i>Themira annulipes</i>	6	9	W3		1
	<i>Themira lucida</i>	3	66	0		1
	<i>Themira minor</i>	3	17	0		1
	<i>Themira superba</i>	2	16	0		2
Diptera - Stratiomyidae	<i>Beris vallata</i>	14	20	F2		1
	<i>Chloromyia formosa</i>	1	1	F2		1
	<i>Microchrysa cyaneiventris</i>	1	1	F2		1
	<i>Nemotelus nigrinus</i>	1	1	W3		2
	<i>Nemotelus pantherinus</i>	19	35	W3		2
	<i>Nemotelus uliginosus</i>	1	1	M3		2
	<i>Odontomyia tigrina</i>	1	1	W3	W314	4
	<i>Oplodontha viridula</i>	16	29	W3	W314	2
	<i>Oxycera nigricornis</i>	2	4	W1		2
	<i>Stratiomys singularior</i>	4	4	W3		4
	<i>Vanoyia tenuicornis</i>	5	7	W1		4
Diptera - Syrphidae	<i>Anasimyia contracta</i>	1	1	W2		2
	<i>Episyrphus balteatus</i>	2	2	0		1
	<i>Eristalis intricarius</i>	2	2	W3		1
	<i>Eumerus strigatus</i>	1	1	F2		1
	<i>Eupeodes corollae</i>	3	4	F1		1
	<i>Eupeodes luniger</i>	1	1	F1		1

	<i>Helophilus pendulus</i>	3	5	W3		1
	<i>Lejops vittatus</i>	1	1	M3	M311	16
	<i>Melanostoma scalare</i>	1	1	0		1
	<i>Neoascia tenur</i>	75	319	W3		2
	<i>Platycheirus angustatus</i>	2	2	F2		1
	<i>Platycheirus clypeatus</i>	3	3	F2		1
	<i>Platycheirus granditarsus</i>	3	3	W3		1
	<i>Platycheirus occultus</i>	2	3	W3		2
	<i>Platycheirus rosarum</i>	3	3	W3		2
	<i>Platycheirus scutatus</i>	1	1	F2		1
	<i>Pyrophaena granditarsa</i>	2	2	W3		1
	<i>Syrirta pipiens</i>	1	1	F2		1
	<i>Tropidia scita</i>	4	6	W3		2
	<i>Volucella bombylans</i>	1	1	F2		1
Diptera - Tabanidae	<i>Chrysops relictus</i>	6	6	W3		1
	<i>Chrysops viduatus</i>	5	6	W3		2
	<i>Haematopota crassicornis</i>	1	1	W3		2
	<i>Haematopota pluvialis</i>	25	34	W3		1
	<i>Hybomitra bimaculata</i>	7	7	W3		2
	<i>Hybomitra distinguenda</i>	1	2	W3		1
	<i>Hybomitra muhlfeldi</i>	16	38	W3	W314	8
Diptera - Tephritidae	<i>Philophylla caesio</i>	1	1	F2		2
	<i>Terellia ruficauda</i>	1	1	F2		1
Diptera - Therevidae	<i>Thereva nobilitata</i>	1	1	F2		1
Diptera - Ulidiidae	<i>Melieria crassipennis</i>	2	3	W3		2
	<i>Melieria omissa</i>	1	1	W2		2

Group	Species	No. samples	No. specimens	IS/S BAT code	IS/S SAT code	IS/S Rarity Score
Hoppers (Auchenorrhyncha)	<i>Anakelisia fasciata</i>	8	19	W3		2
	<i>Aphrodes albifrons</i>	1	3	F2		1
	<i>Aphrodes albiger</i>	3	4	W2		4
	<i>Aphrodes bicinctus</i>	1	1	F2		2
	<i>Aphrodes bifasciatus</i>	2	3	F2		1
	<i>Aphrodes flavostriatus</i>	1	1	F2		1
	<i>Aphrodes makarovi</i>	5	5	F2		1
	<i>Aphrophora alni</i>	2	4	0		1
	<i>Aphrophora major</i>	2	2	W3		4
	<i>Arthaldeus pascuellus</i>	5	6	F2		1
	<i>Athysanus argentarius</i>	1	1	F2		2
	<i>Calligypona reyi</i>	3	8	W2		4
	<i>Chloriona dorsata</i>	4	7	W3		4
	<i>Chloriona glaucescens</i>	2	2	W3		1
	<i>Chloriona smaragdula</i>	21	63	W3		1
	<i>Chloriona unicolor</i>	1	1	W3		1
	<i>Chloriona vasconica</i>	6	14	W3		4
	<i>Cicadella viridis</i>	4	8	W3		1
	<i>Cicadula flori</i>	4	12	W3		4
	<i>Cicadula frontalis</i>	22	48	W3		1
	<i>Cicadula quadrinotata</i>	2	3	F2		1
	<i>Conomelus anceps</i>	11	64	W3		1
	<i>Conosanus obsoletus</i>	4	7	F2		1
	<i>Delphax pulchellus</i>	24	34	W3		1
	<i>Euides speciosa</i>	21	26	W3		1
	<i>Eupelix cuspidata</i>	1	1	F1		1
	<i>Eupteryx aurata</i>	8	17	0		1
	<i>Eupteryx cyclops</i>	19	68	F3		2
	<i>Eupteryx florida</i>	2	3	0		2
	<i>Eupteryx thoulessi</i>	1	3	0		2
	<i>Eupteryx vittata</i>	8	11	0		1
	<i>Evacanthus acuminatus</i>	1	1	F2		1
	<i>Evacanthus interruptus</i>	4	4	F2		1
	<i>Idiocerus confusus</i>	1	1	A1		1
	<i>Javesella dubia</i>	5	9	F2		1
	<i>Javesella pellucida</i>	16	24	F2		1
	<i>Kelisia punctulum</i>	7	12	W3		2
	<i>Macustus grisescens</i>	1	3	F2		1
	<i>Megamelodes lequesnei</i>	18	88	W3		4
	<i>Megamelodes quadrimaculatus</i>	1	1	W3		2
	<i>Megamelus notula</i>	4	4	W3		1
	<i>Megophthalmus scanicus</i>	4	5	F2		1
	<i>Metalimnus formosus</i>	1	1	W3		4
	<i>Mocuellus metrius</i>	4	13	W2		2
	<i>Muellerianella extrusa</i>	1	1	W3	W312	0
	<i>Neophilaenus lineatus</i>	10	26	F2		1
	<i>Notus flavipennis</i>	18	52	W3		1
	<i>Paradelphacodes paludosus</i>	1	1	W3	W312	4
	<i>Paralimnus phragmitis</i>	20	37	W3		4
	<i>Philaenus spumarius</i>	19	39	0		1
	<i>Stenocranus major</i>	1	3	W2		2
	<i>Streptanus aemulans</i>	6	8	F2		1
	<i>Streptanus marginatus</i>	1	1	F2		1
<i>Streptanus sordidus</i>	8	11	F2		1	

<i>Stroggylocephalus agrestis</i>	9	10	W3		2
<i>Stroggylocephalus livens</i>	2	2	W3	W312	4
<i>Struebingianella lugubrina</i>	2	3	W2		2
<i>Zyginidia scutellaris</i>	2	2	F2		1

Group	Species	No. samples	No. specimens	ISIS BAT code	ISIS SAT code	ISIS Rarity Score
Spiders (Araneae)	<i>Agelena labyrinthica</i>	1	2	F2		1
	<i>Agyneta decora</i>	1	1	F2		2
	<i>Agyneta subtilis</i>	1	1	F2		1
	<i>Allomengea vidua</i>	2	2	W3		2
	<i>Anelosimus vittatus</i>	1	2	A1		1
	<i>Antistea elegans</i>	11	11	W3		2
	<i>Aphileta misera</i>	6	7	W3		2
	<i>Araneus marmoreus</i>	2	3	0		2
	<i>Arctosa leopardus</i>	1	1	W3		2
	<i>Baryphyma trifrons</i>	53	98	W3		2
	<i>Bathyphantes approximatus</i>	46	173	W3		2
	<i>Bathyphantes gracilis</i>	73	197	0		1
	<i>Bathyphantes nigrinus</i>	2	3	F3		1
	<i>Bathyphantes parvulus</i>	16	18	F2		1
	<i>Carorita paludosa</i>	3	6	W3		16
	<i>Centromerus semiater</i>	2	2	W3		16
	<i>Centromerus sylvaticus</i>	1	1	F3		1
	<i>Ceratinella brevipes</i>	8	9	F3		1
	<i>Ceratinella scabrosa</i>	2	2	F2		2
	<i>Clubiona juvenis</i>	14	16	W3		16
	<i>Clubiona phragmitis</i>	49	61	W3		2
	<i>Clubiona reclusa</i>	1	1	W3		1
	<i>Clubiona stagnatilis</i>	12	15	W3		1
	<i>Clubiona subtilis</i>	3	3	W3		2
	<i>Dictyna arundinacea</i>	1	1	F2		1
	<i>Diplocephalus permixtus</i>	2	3	W3		1
	<i>Dismodicus bifrons</i>	3	3	0		2
	<i>Donacochara speciosa</i>	23	31	W3		4
	<i>Drepanotylus uncatus</i>	1	3	W3		2
	<i>Enoplognatha ovata</i>	1	1	F2		1
	<i>Entelecara omissa</i>	39	133	W3		4
	<i>Episinus angulatus</i>	5	6	F2		2
	<i>Erigone atra</i>	12	14	0		1
	<i>Ero cambridgei</i>	4	4	0		1
	<i>Floronia bucculenta</i>	7	8	F2		2
	<i>Gnathonarium dentatum</i>	78	493	W3		1
	<i>Gongylidiellum vivum</i>	4	5	F2		1
	<i>Gongylidium rufipes</i>	1	1	F3		1
	<i>Hypomma bituberculatum</i>	43	90	W2		1
	<i>Hypomma cornutum</i>	1	1	A1		1
	<i>Hypomma fulvum</i>	60	117	W3		4
	<i>Hypselistes jacksoni</i>	1	1	W3		2
	<i>Kaestmeria pullata</i>	30	82	W3		1
	<i>Labulla thoracica</i>	1	2	F3		1
	<i>Larinioides cornutus</i>	32	53	W3		1
	<i>Lepthyphantes ericaeus</i>	6	7	F2		1
	<i>Lepthyphantes flavipes</i>	1	1	F3		1
	<i>Lepthyphantes insignis</i>	1	2	F2		4
	<i>Lepthyphantes mengei</i>	1	1	F2		1
	<i>Lepthyphantes tenebricola</i>	1	1	F3		2
	<i>Lepthyphantes tenuis</i>	68	267	0		1
	<i>Lepthyphantes zimmermanni</i>	1	1	0		1
	<i>Leptorhoptrum robustum</i>	1	1	W3		1
	<i>Lophomma punctatum</i>	16	24	W3		2

## Spiders (cont.)

<i>Marpissa radiata</i>	19	45	W3		4
<i>Maso sundevalli</i>	3	5	F2		1
<i>Metellina segmentata</i>	3	8	0		1
<i>Microlinyphia impigra</i>	8	9	W3		2
<i>Microlinyphia pusilla</i>	1	1	F2		1
<i>Neon reticulatus</i>	1	2	F3		1
<i>Neottiura bimaculata</i>	7	7	0		1
<i>Neriere clathrata</i>	7	10	F2		1
<i>Nuctenea umbratica</i>	1	1	A2		1
<i>Oedothorax agrestis</i>	2	5	W3		2
<i>Oedothorax fuscus</i>	3	3	0		1
<i>Oedothorax gibbosus</i>	30	60	W3		1
<i>Oedothorax retusus</i>	2	2	0		1
<i>Ozyptila brevipes</i>	12	15	W3		2
<i>Ozyptila praticola</i>	1	1	F2		1
<i>Ozyptila trux</i>	1	1	F2		1
<i>Pachygnatha clercki</i>	35	59	W3		1
<i>Pardosa amentata</i>	3	4	W3		1
<i>Pardosa prativaga</i>	17	29	F2		1
<i>Pirata hygrophilus</i>	17	29	W3		1
<i>Pirata latitans</i>	1	1	W3		2
<i>Pirata piraticus</i>	18	27	W3		2
<i>Pisaura mirabilis</i>	6	22	F2		1
<i>Platybunus triangularis</i>	1	1	F3		1
<i>Pocadicnemis juncea</i>	10	17	F2		1
<i>Pocadicnemis pumila</i>	7	13	F2		1
<i>Porrhomma pygmaeum</i>	17	22	0		1
<i>Robertus arundineti</i>	2	3	0		2
<i>Rugathodes instabilis</i>	23	41	W3		2
<i>Savignia frontata</i>	6	6	F2		1
<i>Silometopus elegans</i>	13	21	W3		2
<i>Tallusia experta</i>	8	12	W3		1
<i>Taranucnus setosus</i>	12	19	W3		2
<i>Tetragnatha extensa</i>	51	120	W3		1
<i>Tetragnatha montana</i>	15	24	W3		2
<i>Tetragnatha striata</i>	3	3	W3		4
<i>Theridion hemerobium</i>	10	15	W3		0
<i>Theridion pictum</i>	2	3	F2		2
<i>Theridiosoma gemmosum</i>	14	16	W3		4
<i>Tibellus maritimus</i>	1	1	F2		2
<i>Tibellus oblongus</i>	2	2	F2		1
<i>Walckenaeria alticeps</i>	8	11	W3		2
<i>Walckenaeria kochi</i>	3	3	W3		2
<i>Walckenaeria monoceros</i>	1	1	F1	F111	2
<i>Walckenaeria nudipalpis</i>	1	1	0		1
<i>Walckenaeria unicornis</i>	5	5	F2		1
<i>Xysticus kochi</i>	1	1	F1		2
<i>Xysticus ulmi</i>	2	2	W3		2
<i>Zora spinimana</i>	3	3	0		1

### **Appendix 3: Scores for ISIS wetland broad assemblage types by compartment**

W3 = permanent wet mire, W2 = mineral marsh & open water, W1 = flowing water; representation score = percentage of species that are characteristic of BAT; rarity score = average species rarity score for species characteristic of BAT.

<i>Compartment</i>	W3		W2	W1
	<i>Representation (1-100)</i>	<i>Rarity score</i>	<i>Representation (1-100)</i>	
Barton Fen 1	57	254	25	3
Barton Fen 3	56	305	25	5
Catfield Fen (BC) 1	63	341	18	4
Catfield Fen (BC) 2	66	337	17	2
Catfield Fen 3	57	291	21	4
Catfield Great Fen 1	63	300	17	7
Catfield Great Fen 2	71	339	15	4
Common Fen	62	261	14	3
Ebb and Flow	56	286	21	5
Hassingham Fen 1	56	262	23	10
Hassingham Fen 2	52	238	28	4
Hickling Broad (Bygraves Marsh)	66	267	17	1
Hickling Broad 1	57	272	19	4
Hickling Broad 2 (Skoyles Marsh)	52	240	20	3
Hickling Broad 3 (Lings Mill)	62	237	20	3
Hickling Broad 4 (Lings Mill)	48	260	22	6
Hickling Broad 5 (Lings Mill)	64	230	16	3
Hickling Broad 6 (The Smea)	53	217	20	4
Horning Marsh Farm	60	305	17	5
How Hill (opposite bank)	58	259	27	1
Hulver Ground	49	211	23	4
Kirby Marsh	41	229	20	8
Little Reedham	55	275	17	8
Meadow Dyke	62	300	20	2
Reedham Marsh	54	264	18	7
Rockland Island	54	211	14	11
Sharp Street	63	302	21	2
Snipe Marsh	53	232	19	4
Stalham Fen	43	215	20	7
Strumpshaw Fen 1	58	274	21	6
Strumpshaw Fen 2	54	259	23	3
Surlingham Church Marsh	50	232	15	10
Surlingham Broad	40	233	20	14
Surlingham Marsh	53	218	9	10
Sutton Fen	61	302	15	6
Turf Fen	63	323	21	4
Upton Fen	55	263	11	9
Woodbastwick Fen 1	61	223	20	2
Woodbastwick Fen 2	60	254	19	3
Woodbastwick Fen 3	62	277	18	3

#### **Appendix 4: Recorded species numbers for ISIS specific assemblage types by compartment**

W314 = reed-fen and pools, W313 = moss & tussock fen, W312 = Sphagnum bog, W221 = undisturbed fluctuating marsh, W211 = open water on disturbed sediments, W126 = seepage.

<i>Compartment</i>	<i>W314</i>	<i>W313</i>	<i>W312</i>	<i>W221</i>	<i>W211</i>	<i>W126</i>
Barton Fen 1	12	5			3	
Barton Fen 3	13	2	1	1		
Catfield Fen (BC) 1	22	9	1		1	
Catfield Fen (BC) 2	21	17				
Catfield Fen 3	13	6	1		2	
Catfield Great Fen 1	18	8		1		
Catfield Great Fen 2	16	13	1			
Common Fen	10	7			2	
Ebb and Flow	14	4		1	1	
Hassingham Fen 1	11	1				
Hassingham Fen 2	10	1			1	
Hickling Broad (Bygraves Marsh)	8	2				
Hickling Broad 1	15	4	1		1	
Hickling Broad 2 (Skoyles Marsh)	12	4		2		
Hickling Broad 3 (Lings Mill)	10	8			2	
Hickling Broad 4 (Lings Mill)	21	8		1	3	
Hickling Broad 5 (Lings Mill)	12	5			1	
Hickling Broad 6 (The Smea)	9	5			1	
Horning Marsh Farm	18	4	1		1	1
How Hill (opposite bank)	14	8			1	
Hulver Ground	12	6			1	
Kirby Marsh	13	2		1		1
Little Reedham	11	5	1			1
Meadow Dyke	14	1			1	
Reedham Marsh	19	2		1	1	
Rockland Island	7	4		2		
Sharp Street	13	15			1	
Snipe Marsh	16	10		1	2	
Stalham Fen	12	5	2		1	
Strumpshaw Fen 1	13	5	1	2		1
Strumpshaw Fen 2	14	6		2		
Surlingham Church Marsh	15	3				2
Surlingham Broad	14	1		3		4
Surlingham Marsh	8	2				
Sutton Fen	19	10				
Turf Fen	17	6				
Upton Fen	13	5		1	1	1
Woodbastwick Fen 1	9	11		2		
Woodbastwick Fen 2	12	8		1		
Woodbastwick Fen 3	13	7	1		1	1