NRA

Urban Waste Water Treatment Directive
Monitoring of Designated and Candidate Sensitive Areas (eutrophic)

Macrophyte Survey Results 1994
Preliminary Assessment

June 1995 (Version 2)

National Rivers Authority
Anglian Region

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Preliminary Assessment

1. Introduction

The aims of the macrophyte surveys, which are being carried out over three seasons 1994 -1996, are to monitor designated Sensitive Areas (eutrophic) (SA(e)s) and to collect data on candidate SA(e)s for the review in 1997. The data collected from the macrophyte surveys will be used for two purposes:

1) to assess whether an SA(e) is eutrophic and
2) to assess the impact of qualifying discharges on SA(e)s.

Although macrophyte data collected in 1993 for the initial designation of SA(e)s were very effective it was acknowledged that some form of summary statistic would be a valuable tool in the future assessment of the data. It was also recognised that the current systems for calculating 'trophic indices' were not very suitable for use in the Anglian Region. As a result an initial list of Regionally relevant macrophytes was compiled, together with associated 'trophic scores', by Nigel Holmes.

The National Group, convened to co-ordinate UWWTD monitoring, agreed that a national system for assigning trophic status was also required. Nigel Holmes was, therefore, contracted to further develop the Trophic Ranking system to make it nationally applicable and to incorporate the relative abundance of plant species making the system more sensitive to subtle effects.

The preliminary analysis of the macrophyte data collected in the Anglian Region during 1994 and presented in this paper uses the final Trophic Ranking system presented in the **'Macrophytes for Water and other River Quality Assessments'** report recently circulated by Peter Bird as part of the guidance for UWWTD monitoring. In addition a variety of other methods have been used, including diversity indices and multivariate statistics. The aim is to assess the usefulness of the macrophyte data for monitoring SA(e)s and the performance of the Trophic Ranking system.

2. Methods

Macrophyte surveys were carried out by the Areas between July and October 1994 using the Standard methodology[1] developed in the Anglian Region and issued for guidance by the National group.

[1] Standard methodologies. Assessment of Freshwater Riverine Environments using Macrophytes. NRA Anglian Region. Final Draft 1994.

Briefly, comparable 100m stretches of the river channel upstream and downstream of qualifying discharges were surveyed. All taxa present on the issued checklist(s) were recorded together with an estimate of the abundance of each on a 9 point abundance scale. In addition, the total percentage cover was estimated. A variety of other habitat variables were also assessed, including, width, depth, water clarity, substrate composition, flow habitat, bed stability and shading.

3. Data analysis

3.1 Mean Trophic Rank (MTR)

A Trophic Score of 1 to 10 has been assigned to each of 126 aquatic macrophyte species. Those species which indicate eutrophic (nutrient rich) conditions score 1 and those which are intolerant to high nutrient levels score 10. Mean Trophic Rank can be calculated as follows:

$$\frac{\textit{Total of (Trophic Score} \times \textit{Abundance Category)}}{\textit{Total of Abundance Categories}} \times 10$$

The lower the Mean Trophic Rank, the more eutrophic the river. If, therefore, the MTR is lower downstream of a STW input then this suggests that the effluent is having an impact on the macrophyte community due to increased nutrient levels in the river. With only a limited data set it is, at present, difficult to assign what a significant decrease is. As part of the development of the Trophic Ranking system MTRs were calculated for over 1500 NCC sites throughout the UK at which macrophyte surveys had previously been carried out. This information will assist in deciding what is significant. In addition, when more local data have been accumulated a better assessment will be possible.

3.2 Other univariate methods

In addition to Mean Trophic Rank the following criteria have been used to analyse the results:

Total percentage cover,
Shannon Weiner diversity and
Number of (scoring) taxa.

3.3 Multivariate methods

Multivariate statistics have been used to look for structure in the data and, where possible, which factors may be contributing to these patterns.

Cluster Analysis and Non-metric Multi-dimensional scaling

These methods are based on the similarity between any pair of samples, in terms of the biological communities they contain. A similarity coefficient (0-100%) is calculated between every pair of samples. These coefficients can then be used to cluster sites into groups such that the similarity within each group of sites is higher than the similarities between different groups.

Dendrograms are constructed by fusing samples into groups, starting with the highest mutual similarities and then gradually lowering the similarity level at which groups are formed. The order of samples is not unique. Dendrograms are best visualised as a child's mobile so that the groups are able to rotate. This means that the ordering of samples along the x-axis can be misleading.

An MDS plot is 2-dimensional 'map' of the samples based on the relative values of the similarity coefficients. For example, if sample 1 has higher similarity to sample 2 than it does to sample 3, then sample 1 will be placed closer on the map to sample 2 than it is to sample 3. MDS can be calculated in 3 or more dimensions but cannot be presented graphically.

As outlined in the introduction one aim of the monitoring programme is to make statements about the impact of specific inputs. In order to use multivariate techniques to answer this question, it is necessary to analyse the results of replicate samples. It is, therefore, not appropriate to assess the data set as a whole and make statements regarding individual U/S-D/S differences. How would we expect the data to cluster? Certainly it is not reasonable to expect all U/S sites to group together with a separate cluster of D/S sites, especially in a linear system like a river. It is not surprising that when large sets of data are analysed in this way that sites in particular rivers or catchments tend to group together.

Generally, the data have been assessed on an Area basis to limit the size of the data sets and attempt to make the results most relevant.

Despite the limitations of the present data set some interesting analyses have been possible.

4. Results

4.1 Summary statistics

Graphs showing the Mean Trophic Rank, total percentage cover, diversity indices and number of scoring taxa are presented for each Area (Figures 1-3).

Ideally, one would expect that the MTR would go down while the total percentage cover increases. In addition, the diversity index should also reduce together with number of taxa. It is, however, recognised that when small stress perturbations occur community diversity initially increases and it is only once a perturbation becomes more severe and long term that diversity declines. Care is, also required with the diversity index as it does not take in to account which taxa are present, only the number and abundance. It is possible to have two very different communities with the same diversity.

4.1.1 Comments

Northern Area (Figure 1)

- Of 7 STWs surveyed 6 have a lower MTR D/S compared with U/S of the input (Broadholme marginally higher).
- All the sites show an increase in total percentage cover D/S of the STW input.
- The diversity index and number of taxa do not always coincide with what may be expected.
- Those where all criteria change as might be expected are Louth and Whilton.

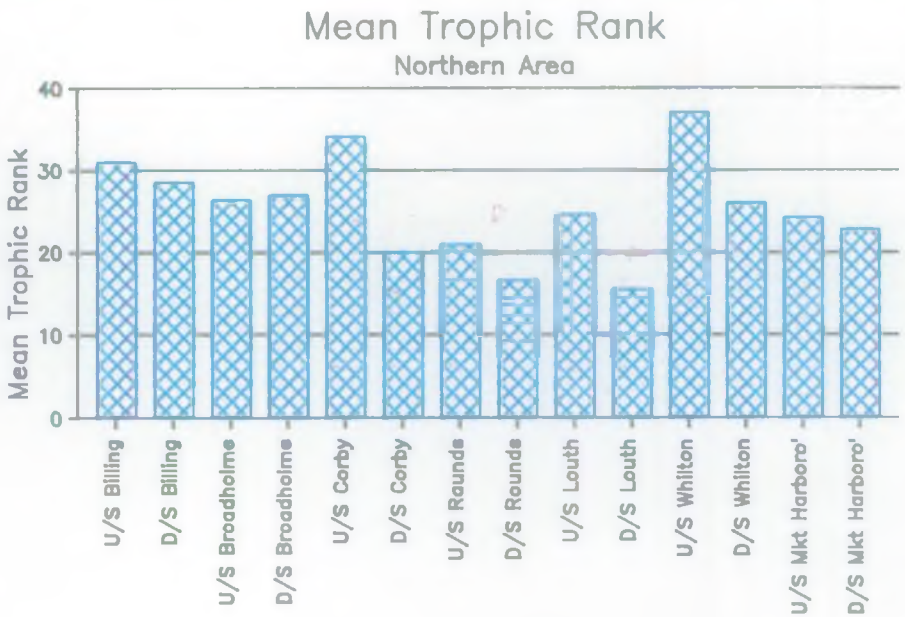
Eastern Area (Figure 2)

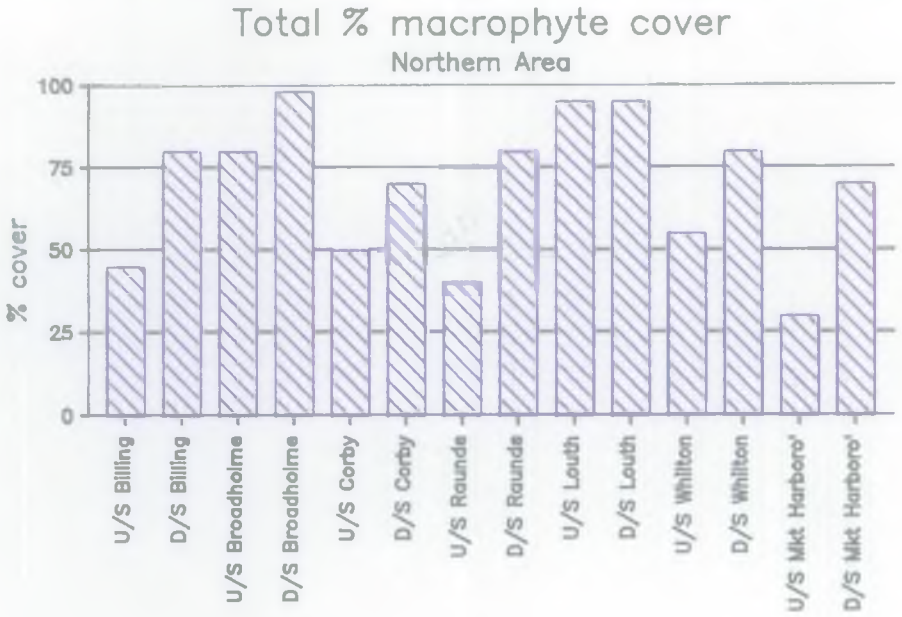
- Of 17 STWs which have complete data, 8 have a lower MTR D/S.
- 8 of the 17 also show increased % cover D/S but they do not necessarily coincide.
- Those where all 4 criteria change as might be expected are Shenfield, Stalham and Sudbury.

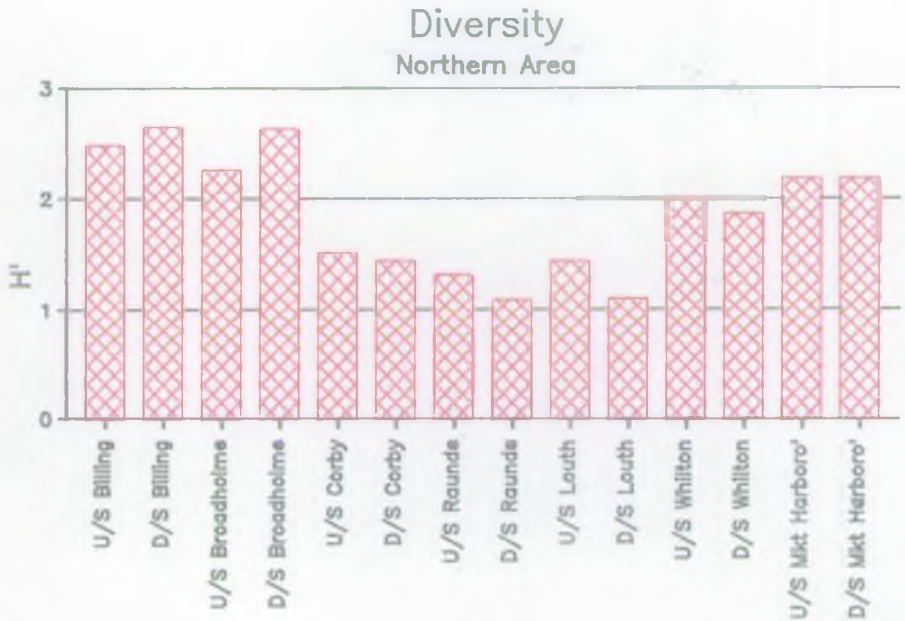
Central Area (Figure 3)

- Of 9 STWs surveyed only 1 shows a decrease in MTR D/S (Towcester).
- 5 show an increase in % cover.
- Generally the total % cover for this data is lower than for the other Areas (mean 45.6% compared with 69.1% Northern and 62.3% Eastern). This may be due to the surveys having been carried out late in the season.

Undoubtedly, some of the sites are impacted by factors other than the STW input, such as maintenance and prevailing physical characteristics. Such sites highlight the importance of selecting suitably paired survey sections.


Mean Trophic Rank
Northern Area
Mean Trophic Rank
40
30
20
10
0
U/S Billing
D/S Billing
U/S Broadholme
D/S Broadholme
U/S Corby
D/S Corby
U/S Raunds
D/S Raunds
U/S Louth
D/S Louth
U/S Whilton
D/S Whilton
U/S Mkt Harboro'
D/S Mkt Harboro'


Total % macrophyte cover
Northern Area
% cover
100
75
50
25
0
U/S Billing
D/S Billing
U/S Broadholme
D/S Broadholme
U/S Corby
D/S Corby
U/S Raunds
D/S Raunds
U/S Louth
D/S Louth
U/S Whilton
D/S Whilton
U/S Mkt Harboro'
D/S Mkt Harboro'


Diversity
Northern Area
H'
3
2
1
0
U/S Billing
D/S Billing
U/S Broadholme
D/S Broadholme
U/S Corby
D/S Corby
U/S Raunds
D/S Raunds
U/S Louth
D/S Louth
U/S Whilton
D/S Whilton
U/S Mkt Harboro'
D/S Mkt Harboro'

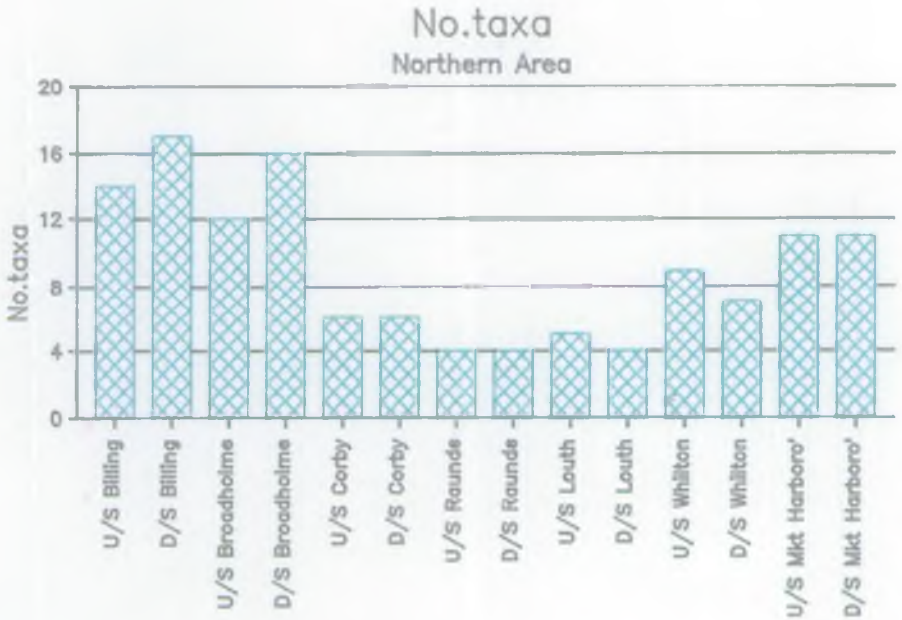
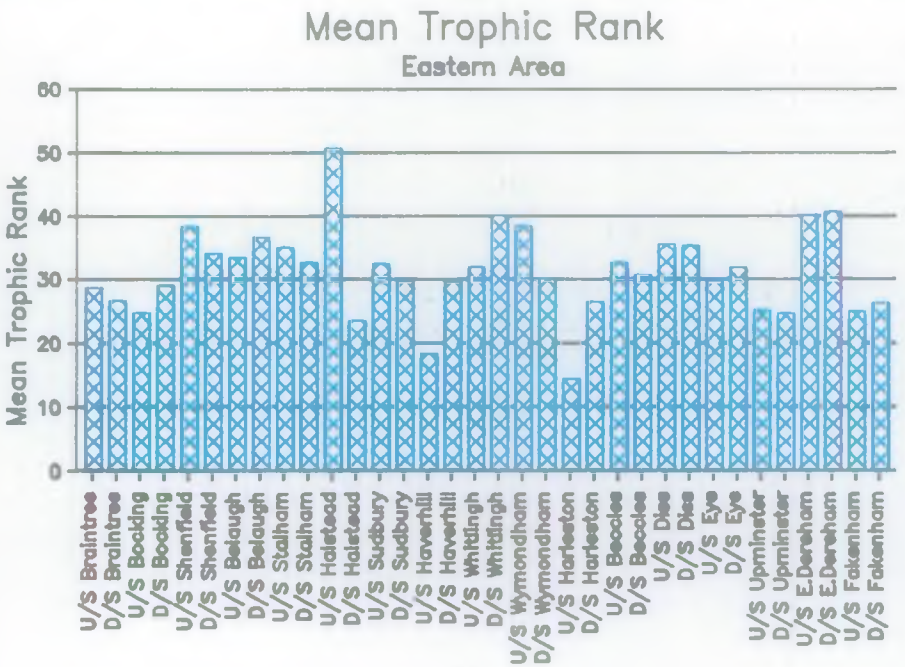
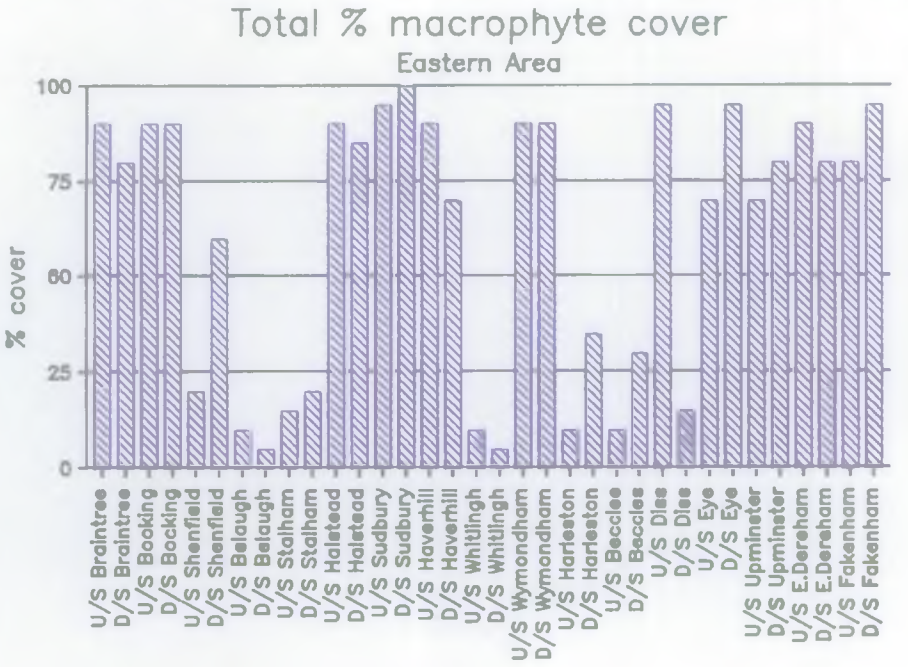
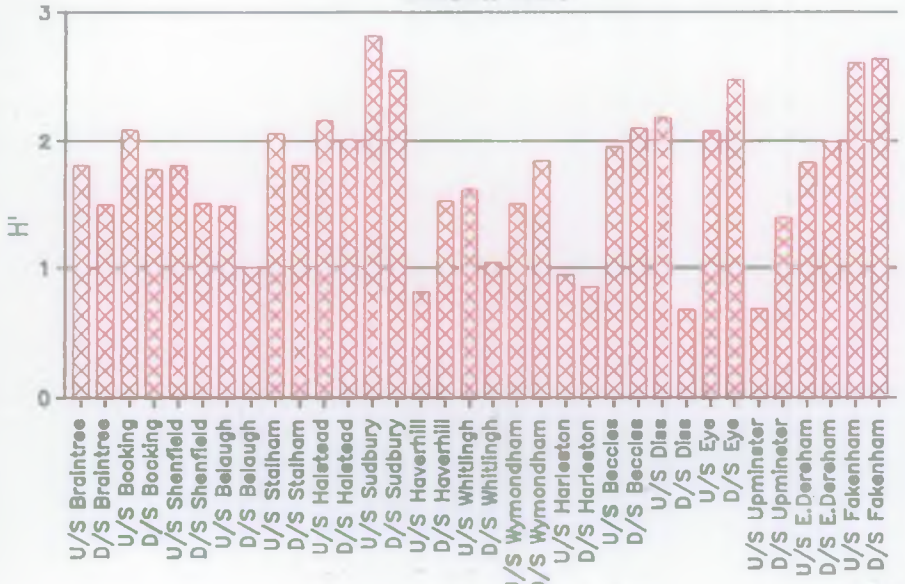

No.taxa
Northern Area
No.taxa
20
16
12
8
4
0
U/S Billing
D/S Billing
U/S Broadholme
D/S Broadholme
U/S Corby
D/S Corby
U/S Raunds
D/S Raunds
U/S Louth
D/S Louth
U/S Whilton
D/S Whilton
U/S Mkt Harboro'
D/S Mkt Harboro'

FIGURE 1


Mean Trophic Rank
Eastern Area
Mean Trophic Rank
0
10
20
30
40
50
60
U/S Braintree
D/S Braintree
U/S Booking
D/S Booking
U/S Shenfield
D/S Shenfield
U/S Belaugh
D/S Belaugh
U/S Stalham
D/S Stalham
U/S Halstead
D/S Halstead
U/S Sudbury
D/S Sudbury
U/S Haverhill
D/S Haverhill
U/S Whitlingh
D/S Whitlingh
U/S Wymondham
D/S Wymondham
U/S Harleston
D/S Harleston
U/S Beccles
D/S Beccles
U/S Diss
D/S Diss
U/S Eye
D/S Eye
U/S Upminster
D/S Upminster
U/S E.Dereham
D/S E.Dereham
U/S Fakenham
D/S Fakenham


Total % macrophyte cover
Eastern Area
% cover
0
25
50
75
100
U/S Braintree
D/S Braintree
U/S Booking
D/S Booking
U/S Shenfield
D/S Shenfield
U/S Belaugh
D/S Belaugh
U/S Stalham
D/S Stalham
U/S Halstead
D/S Halstead
U/S Sudbury
D/S Sudbury
U/S Haverhill
D/S Haverhill
U/S Whitlingh
D/S Whitlingh
U/S Wymondham
D/S Wymondham
U/S Harleston
D/S Harleston
U/S Beccles
D/S Beccles
U/S Diss
D/S Diss
U/S Eye
D/S Eye
U/S Upminster
D/S Upminster
U/S E.Dereham
D/S E.Dereham
U/S Fakenham
D/S Fakenham


Diversity
Eastern Area
H'
0
1
2
3
U/S Braintree
D/S Braintree
U/S Booking
D/S Booking
U/S Shenfield
D/S Shenfield
U/S Belaugh
D/S Belaugh
U/S Stalham
D/S Stalham
U/S Halstead
D/S Halstead
U/S Sudbury
D/S Sudbury
U/S Haverhill
D/S Haverhill
U/S Whitlingh
D/S Whitlingh
U/S Wymondham
D/S Wymondham
U/S Harleston
D/S Harleston
U/S Beccles
D/S Beccles
U/S Diss
D/S Diss
U/S Eye
D/S Eye
U/S Upminster
D/S Upminster
U/S E.Dereham
D/S E.Dereham
U/S Fakenham
D/S Fakenham

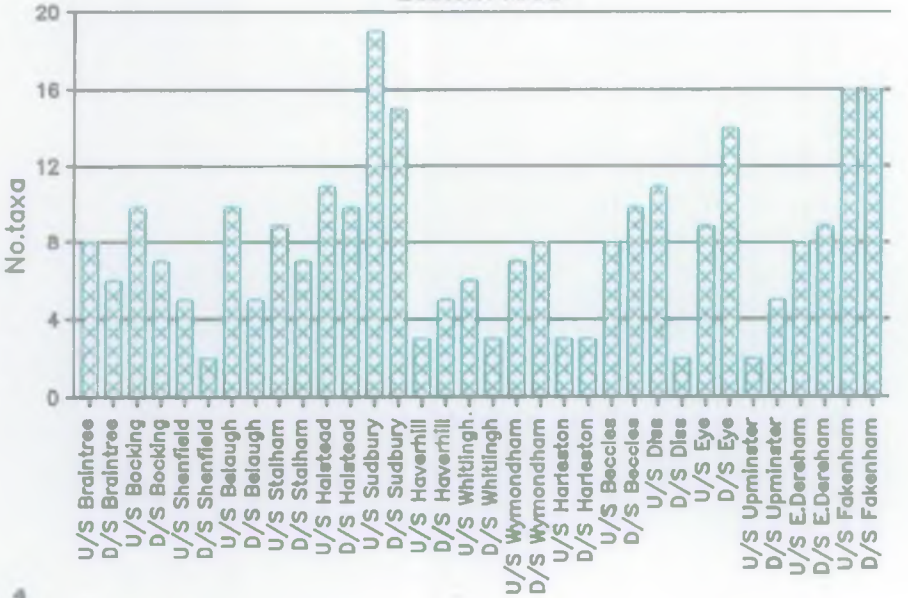
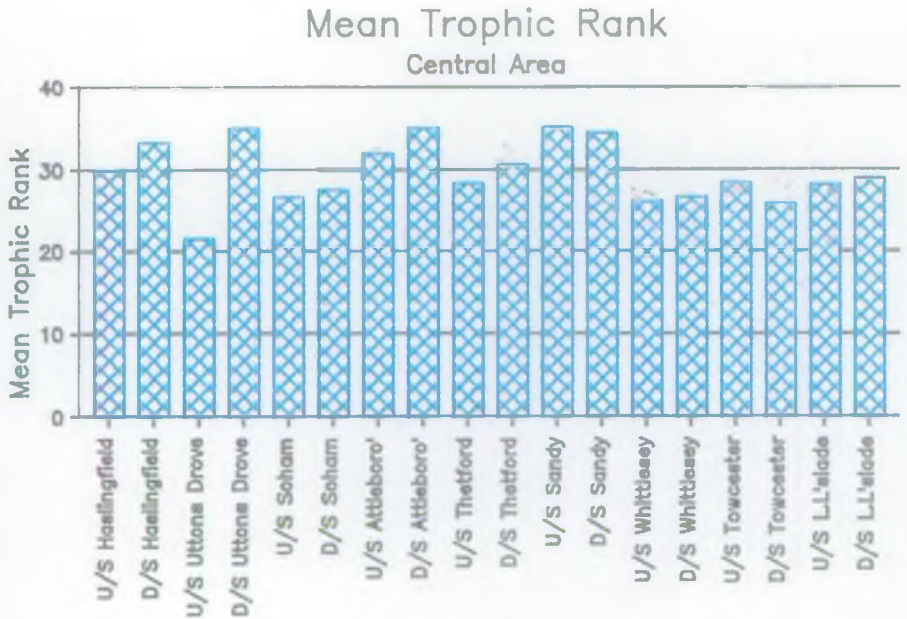
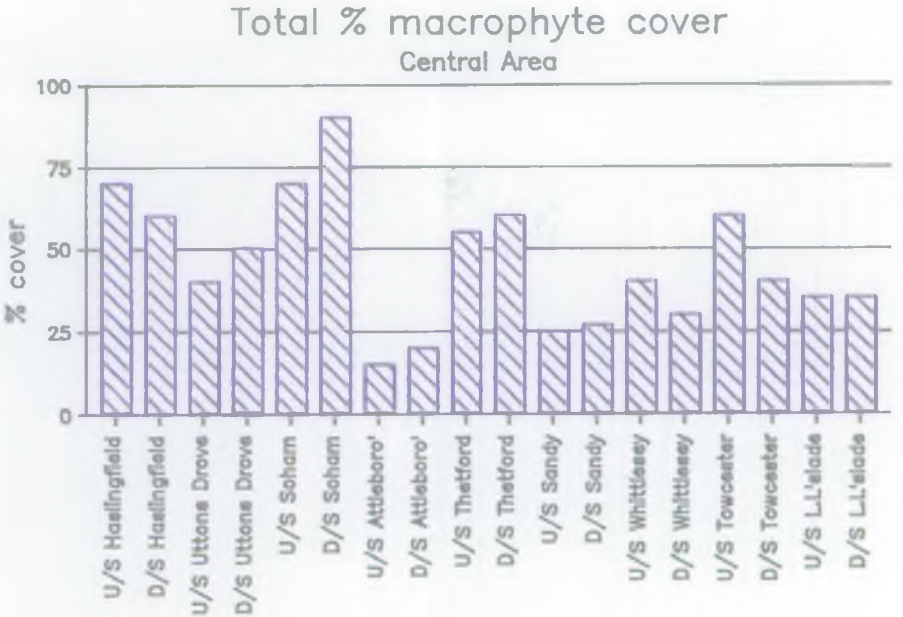
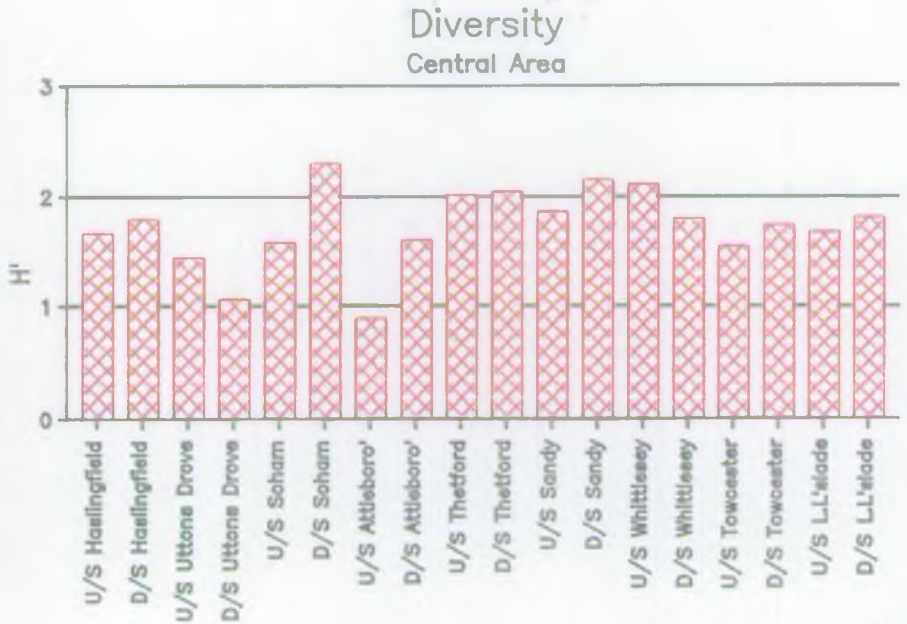

No.taxa
Eastern Area
No.taxa
0
4
8
12
16
20
U/S Braintree
D/S Braintree
U/S Booking
D/S Booking
U/S Shenfield
D/S Shenfield
U/S Belaugh
D/S Belaugh
U/S Stalham
D/S Stalham
U/S Halstead
D/S Halstead
U/S Sudbury
D/S Sudbury
U/S Haverhill
D/S Haverhill
U/S Whitlingh
D/S Whitlingh
U/S Wymondham
D/S Wymondham
U/S Harleston
D/S Harleston
U/S Beccles
D/S Beccles
U/S Diss
D/S Diss
U/S Eye
D/S Eye
U/S Upminster
D/S Upminster
U/S E.Dereham
D/S E.Dereham
U/S Fakenham
D/S Fakenham

FIGURE 2


Mean Trophic Rank
Central Area
Mean Trophic Rank
40
30
20
10
0
U/S Haslingfield
D/S Haslingfield
U/S Uttons Drove
D/S Uttons Drove
U/S Soham
D/S Soham
U/S Attleboro'
D/S Attleboro'
U/S Thetford
D/S Thetford
U/S Sandy
D/S Sandy
U/S Whittlesey
D/S Whittlesey
U/S Towcester
D/S Towcester
U/S L.L'elade
D/S L.L'elade


Total % macrophyte cover
Central Area
% cover
100
75
50
25
0
U/S Haslingfield
D/S Haslingfield
U/S Uttons Drove
D/S Uttons Drove
U/S Soham
D/S Soham
U/S Attleboro'
D/S Attleboro'
U/S Thetford
D/S Thetford
U/S Sandy
D/S Sandy
U/S Whittlesey
D/S Whittlesey
U/S Towcester
D/S Towcester
U/S L.L'elade
D/S L.L'elade


Diversity
Central Area
H'
3
2
1
0
U/S Haslingfield
D/S Haslingfield
U/S Uttons Drove
D/S Uttons Drove
U/S Soham
D/S Soham
U/S Attleboro'
D/S Attleboro'
U/S Thetford
D/S Thetford
U/S Sandy
D/S Sandy
U/S Whittlesey
D/S Whittlesey
U/S Towcester
D/S Towcester
U/S L.L'elade
D/S L.L'elade


No.taxa
Central Area
No.taxa
20
16
12
8
4
0
U/S Haslingfield
D/S Haslingfield
U/S Uttons Drove
D/S Uttons Drove
U/S Soham
D/S Soham
U/S Attleboro'
D/S Attleboro'
U/S Thetford
D/S Thetford
U/S Sandy
D/S Sandy
U/S Whittlesey
D/S Whittlesey
U/S Towcester
D/S Towcester
U/S L.L'elade
D/S L.L'elade

FIGURE 3

4.2 Multivariate analyses

Cluster analysis followed by dendrogram construction and Multi-dimensional Scaling have been carried for each Area as well as for the whole Region. When analysing these outputs it is important to note the limitations of the methods. For example, the stress value on MDS plots gives an indication as to whether the plot is meaningful or whether it is little better than a random scatter of points. For the Regional data (Figure 4) this is the case and there is little benefit in pursuing the analysis - it does not help us to understand the data.

Each site has been assigned a number for use in MDS plots (see Table 1).

Northern Area (Figure 5)
The Northern Area data are more promising. They form four distinctive groups when a dendrogram is constructed. The groups identified have been plotted using MDS (Figure 6). An assessment of the taxa causing such grouping has then been made.

It can be seen that three of the groups are characterised by macrophyte species which are considered to be good indicators of nutrient rich conditions.

It is interesting to note that the U/S sites of Raunds and Corby cluster together (Group C) while the respective D/S sites are part of a separate group (B). Group B is characterised by *Cladophora* agg. an indicator of eutrophic conditions while group C is characterised by a less nutrient tolerant species *Sparganium erectum*. The influence of spatial distribution of sites is also evident. The R.Nene sites form one group while the Louth Canal sites form another.

Eastern Area
A dendrogram (Figure 7) of the Eastern Area data produces 9 groups, however, when an MDS plot is made the groups are somewhat confused (Figure 8). In addition, the stress value is high indicating that the plot may not be valid. It is important to note that groups I and G overlap. If it were possible to make a 3D plot there may be more separation of the groups.

Central Area
Five distinct groups of survey sites are indicated by the cluster analysis (Figures 9 and 10). A large number of the sites (group D) are characterised by *Sparganium emersum* and *Sagittaria sagittifolia*. The sites U/S and D/S of Utton's Drove are very dissimilar. The U/S site is characterised by *Enteromorpha* sp(p) and *Cladophora* agg. (both good indicators of nutrient rich conditions, trophic score = 1) compared with *Apium nodiflorum* (trophic score 4) at the D/S site.

Table 1 - Site numbers

a) Northern Area

Site number	Macrophyte Survey name
1	U/S Billing
2	D/S Billing
3	U/S Broadholme
4	D/S Broadholme
5	U/S Whilton
6	D/S Whilton
7	U/S Raunds
8	D/S Raunds
9	U/S Corby
10	D/S Corby
11	U/S Market Harborough
12	D/S Market Harborough
13	U/S Louth
14	D/S Louth

b) Central Area

Site number	Macrophyte Survey name
1	U/S Haslingfield
2	D/S Haslingfield
3	U/S Utton's Drove
4	D/S Utton's Drove
5	U/S Soham
6	D/S Soham
7	U/S Attleborough
8	D/S Attleborough
9	U/S Thetford
10	D/S Thetford
11	U/S Sandy
12	D/S Sandy
13	U/S Whittlesey
14	D/S Whittlesey
15	U/S Towcester
16	D/S Towcester
17	U/S Leighton Linslade
18	D/S Leighton Linslade

Table 1 - Cont/d...

c) Eastern Area

Site number	Macrophyte Survey name
1	U/S Sudbury
2	D/S Sudbury
3	U/S Whitlingham
4	D/S Whitlingham
5	U/S Harleston
6	D/S Harleston
7	U/S Beccles
8	D/S Beccles
9	U/S Belaugh
10	D/S Belaugh
11	U/S Stalham
12	D/S Stalham
13	U/S Haverhill
14	D/S Haverhill
15	U/S Halstead
16	D/S Halstead
17	U/S Braintree
18	D/S Braintree
19	U/S Bocking
20	D/S Bocking
21	U/S Shenfield
22	D/S Shenfield
23	U/S Upminster
24	D/S Upminster
25	U/S Diss
26	D/S Diss
27	U/S Eye
28	D/S Eye
29	U/S Wymondham
30	D/S Wymondham
31	U/S East Dereham
32	D/S East Dereham
33	U/S Fakenham
34	D/S Fakenham

MDS Plot of UWWTD Macrophyte Data 1994 - Anglian Region, Stress = .26

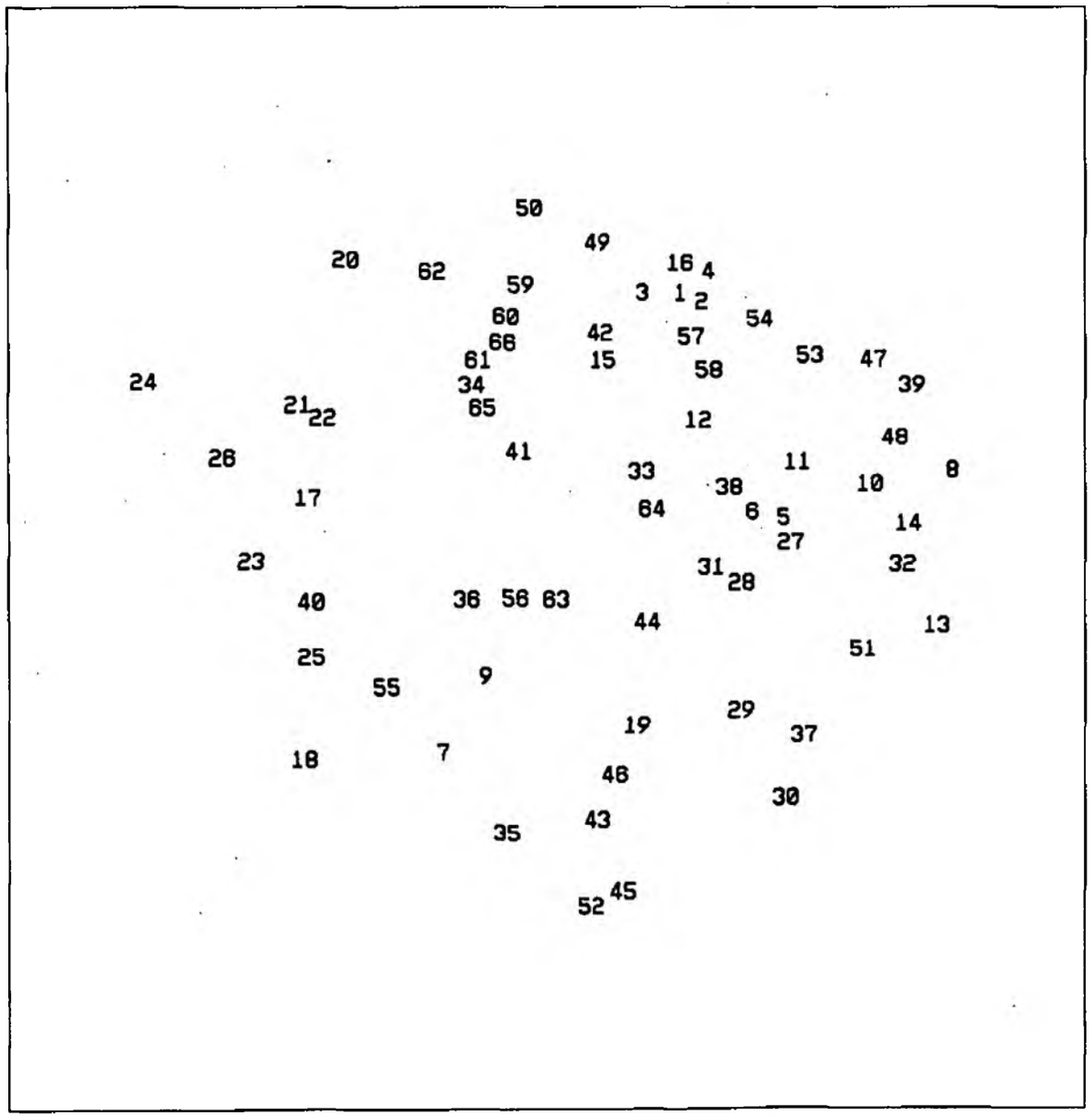
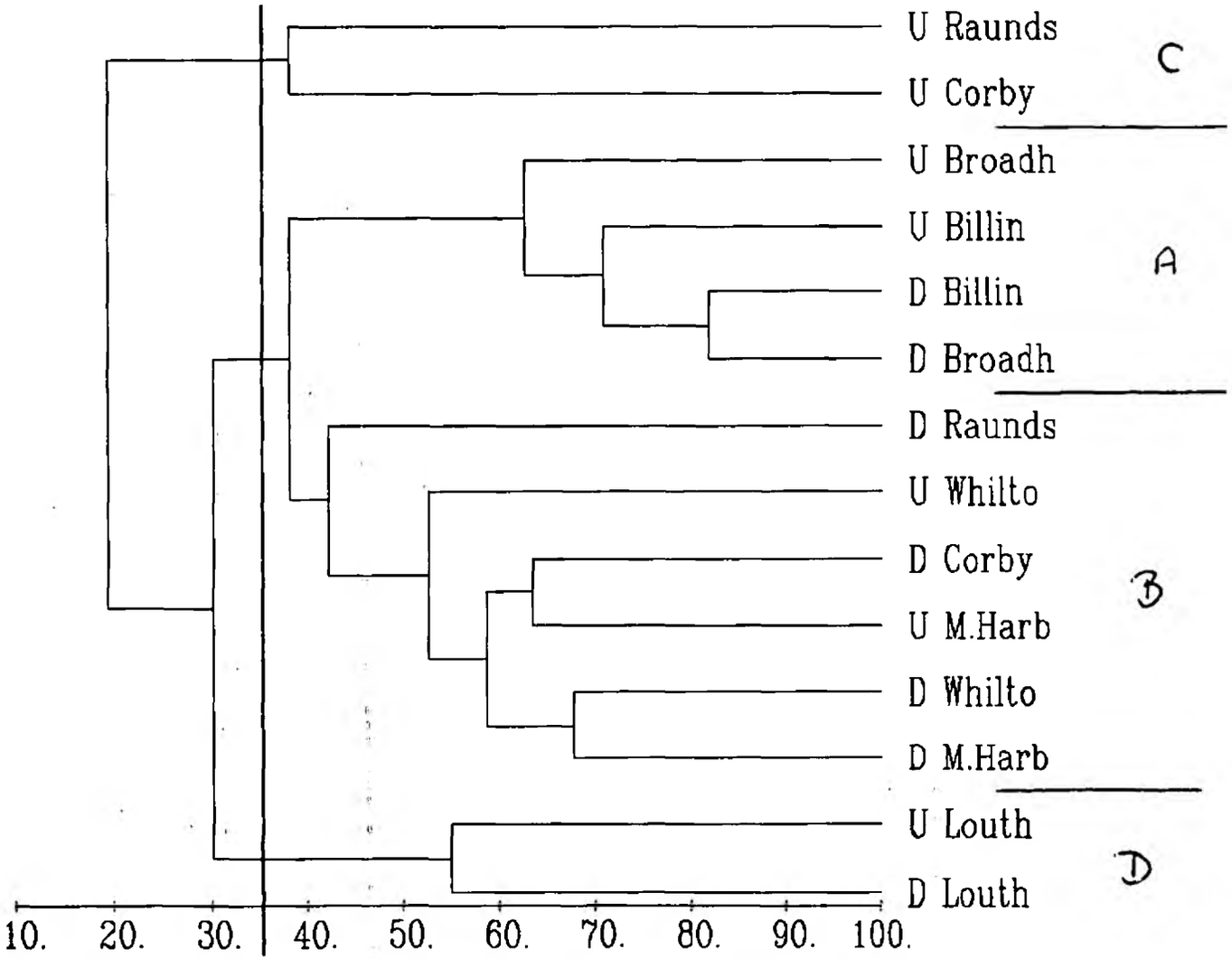


FIGURE 4

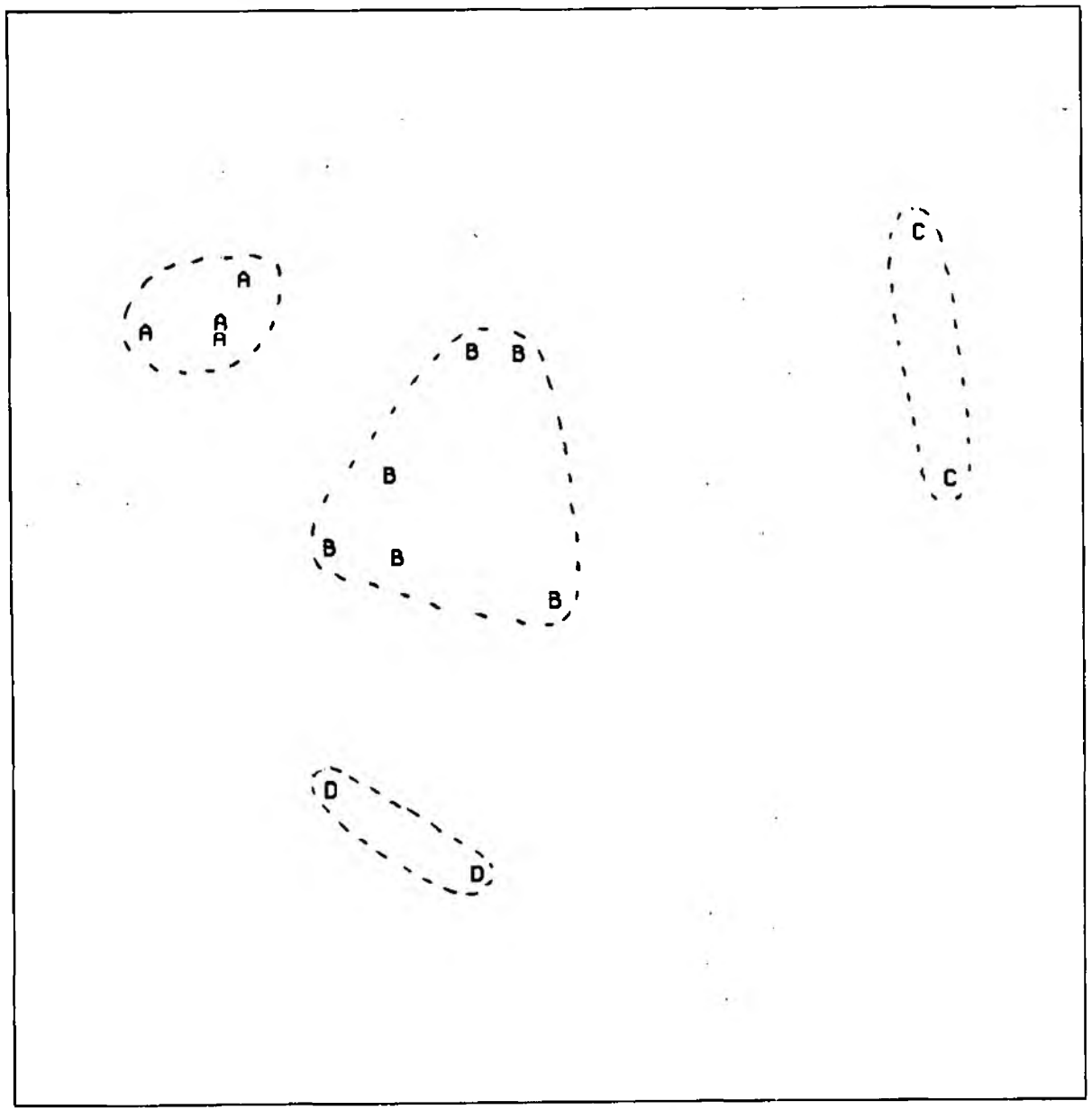
UWWTD MACROPHYTE DATA 1994 – Northern Area



BRAY–CURTIS SIMILARITY

FIGURE 5

MDS Plot of UWWTD Macrophyte Data 1994 - Northern Area, Stress = .11



A = *Glyceria maxima*
Cladophora agg.
Sagittaria sagittifolia
Lemna minor

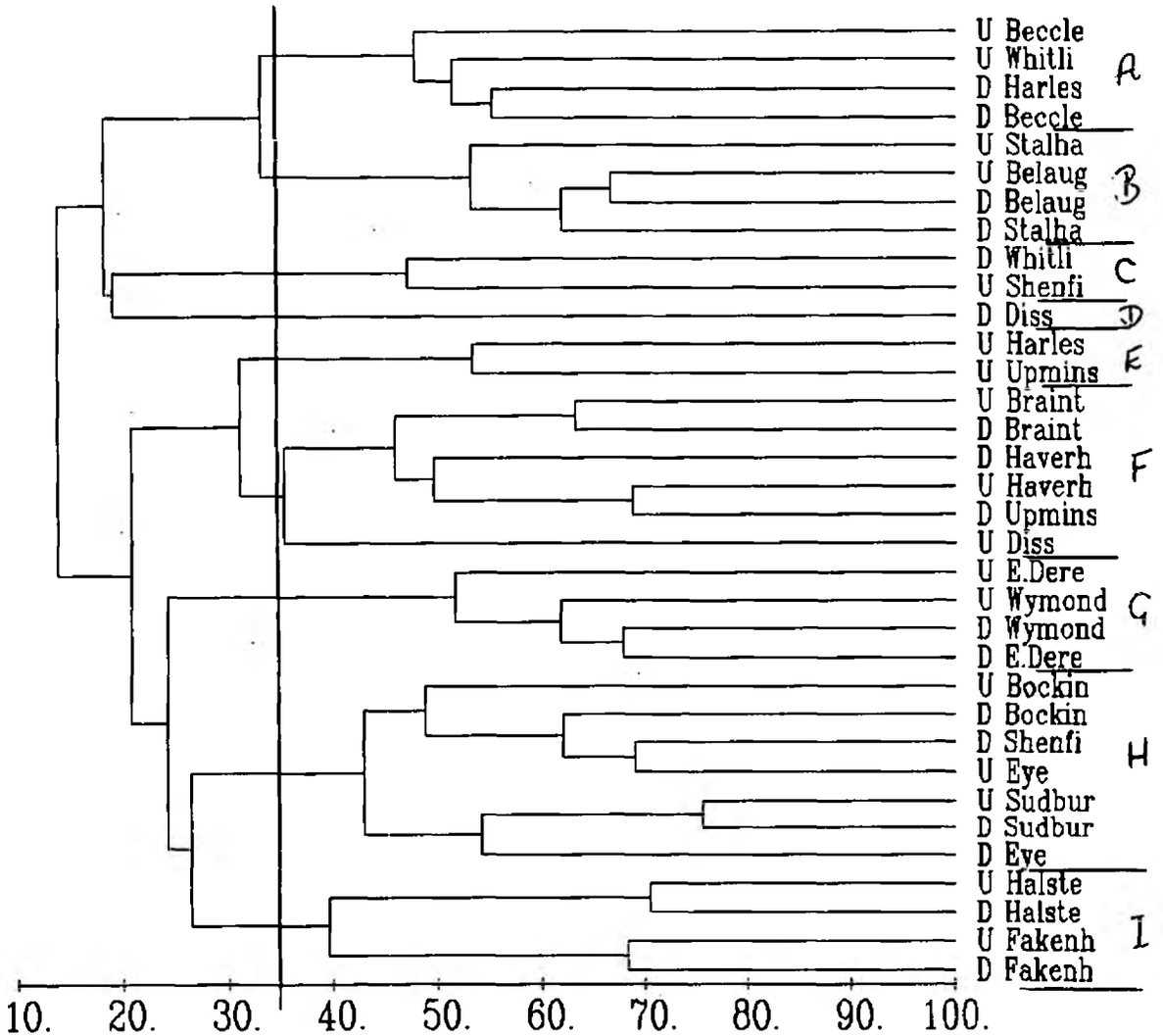
B = *Cladophora* agg.
Elodea nuttalli

C = *Sparganium erectum*

D = *Potamogeton pectinatus*
Potamogeton lucens

FIGURE 6

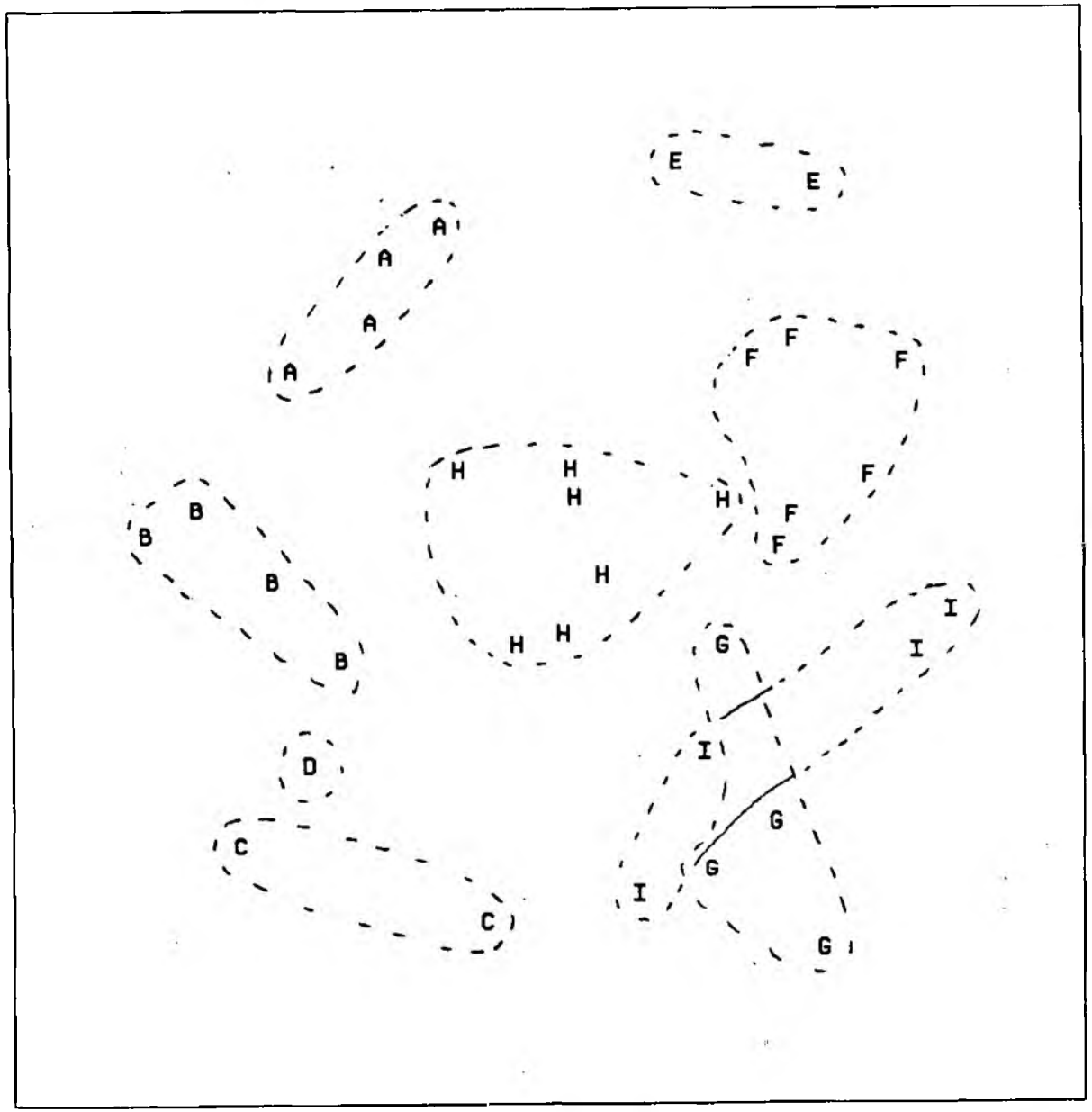
UWWTD MACROPHYTE DATA 1994 – Eastern Area



BRAY–CURTIS SIMILARITY

Figure 4

MDS Plot of UWWTD Macrophyte Data 1994 - Eastern Area, Stress = .21



A = *Nuphar lutea*
Cladophora agg.

B = *Nuphar lutea*
Carex riparia

C = Filamentous greens
Carex riparia

D = *Carex riparia*
Sparganium erectum

E = *Apium nodiflorum*
Cladophora agg.

F = *Cladophora* agg.
Sparganium erectum

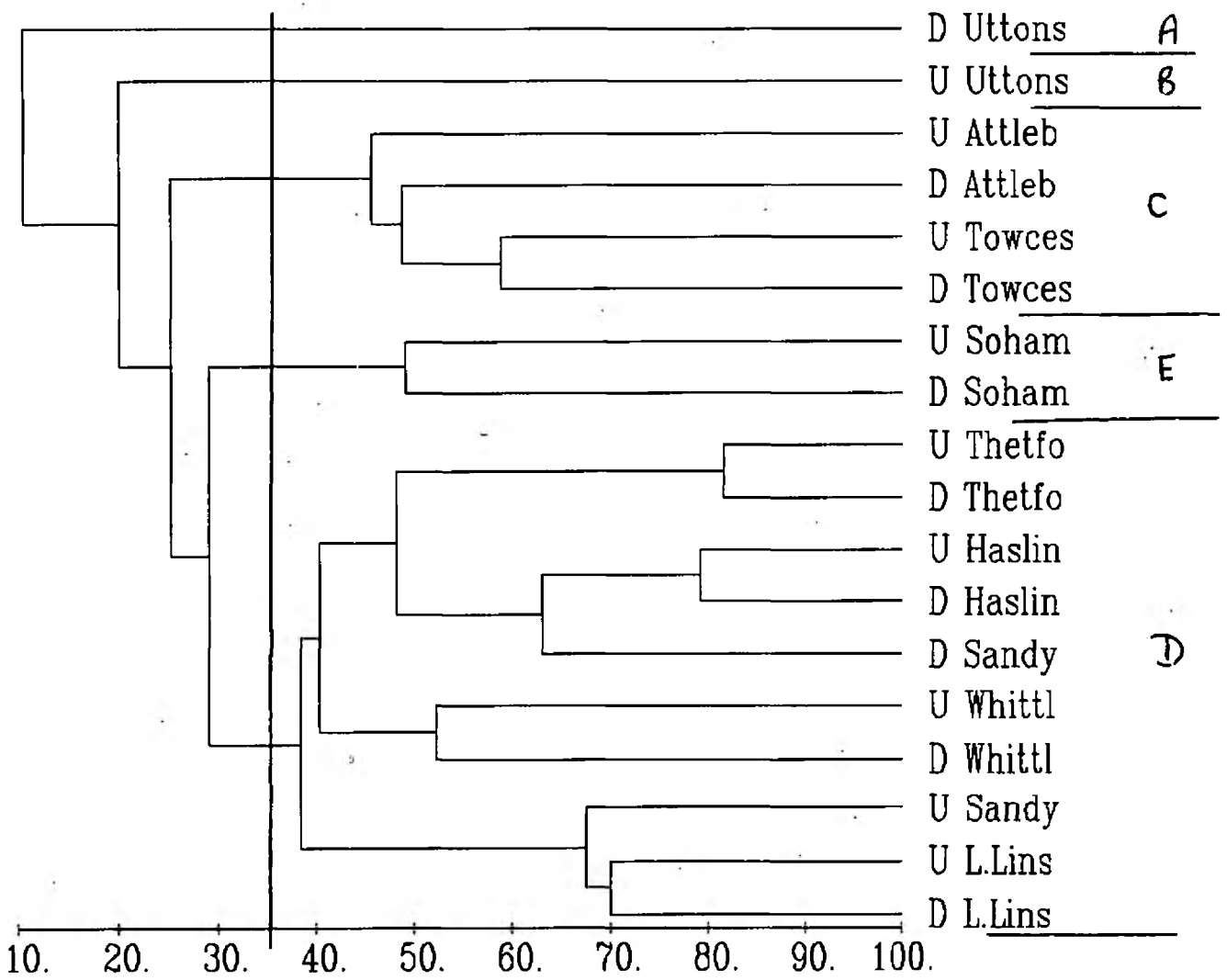
G = Thick diatom scum
Filamentous greens

H = *Sparganium erectum*
Sparganium emersum
Nuphar lutea

I = *Potamogeton pectinatus*
Zannichellia palustris
Enteromorpha sp(p)

FIGURE 8

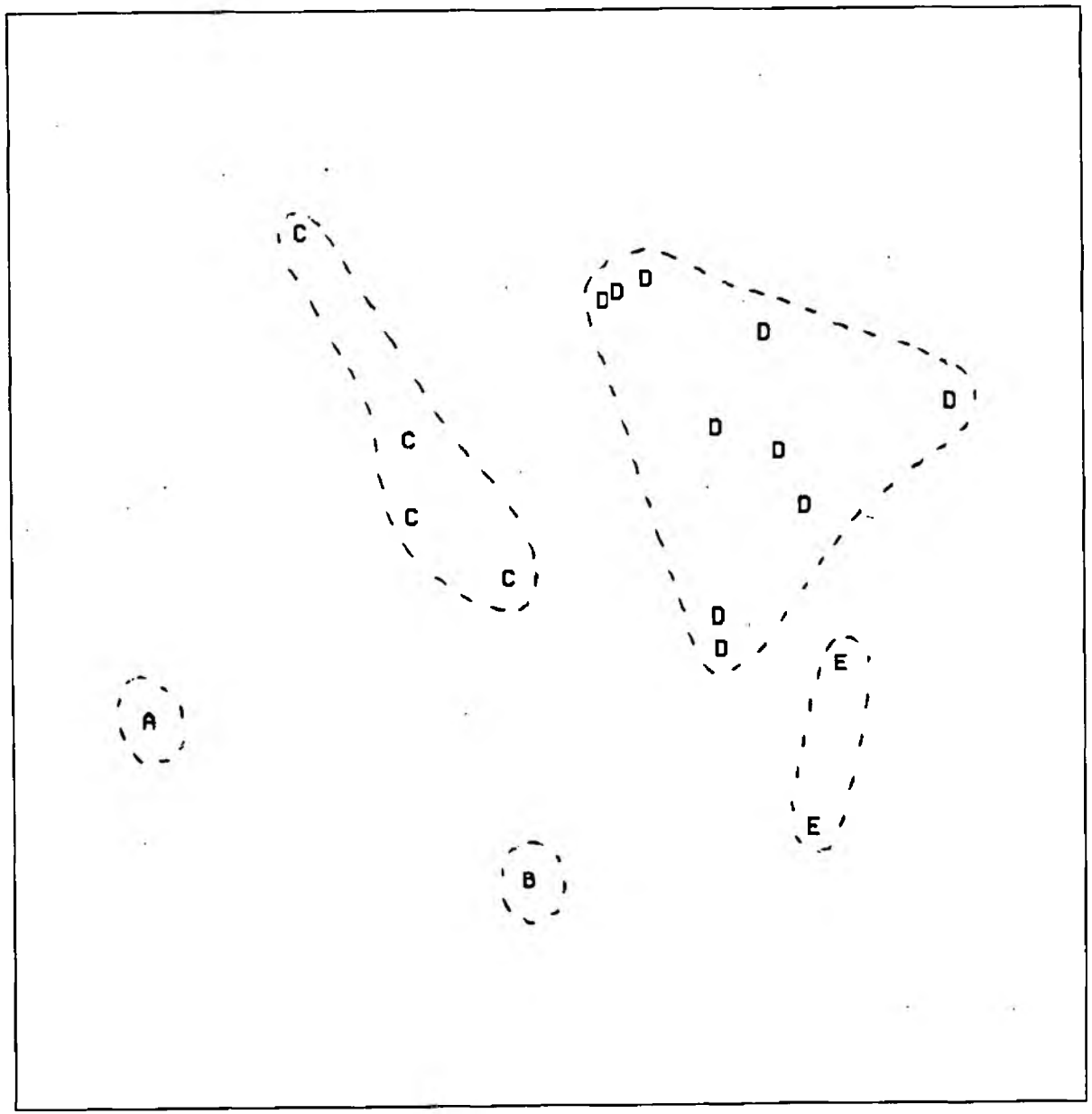
UWWTD MACROPHYTE DATA 1994 – Central Area



BRAY–CURTIS SIMILARITY

FIGURE 9

MDS Plot of UWWTD Macrophyte Data 1994 - Central Area, Stress = .14



A = *Apium nodiflorum*

B = *Enteromorpha sp(p)*
Cladophora agg.

C = *Sparganium erectum*
Cladophora agg.

D = *Sparganium emersum*
Sagittaria sagittifolia

E = *Cladophora* agg.
Lemna minor
Elodea nuttallii
Elodea canadensis

FIGURE 10

4.3 Environmental variables

Due to the way in which environmental variables such as substrate, width and depth were recorded (by category rather than actual values) it has not been possible to use this information in the multivariate analysis of the data. It is, however, well known that physical habitat has a significant influence on the macrophyte communities present. It is extremely important to control, as far as is possible, these variables when selecting survey sites.

Phosphate data from appropriate U/S and D/S chemical sample points has been collated (see Table 2). A 3 year mean (1992-94) value of Soluble Reactive Phosphate (SRP) in mg/L has been used. These values have been correlated against Mean Trophic rank for the Region as a whole and for each Area (Figure 11). The correlation is very poor.

For each Area MDS plots have been produced with SRP and MTR superimposed, these can be overlaid on to the MDS plot of the sites. (Figures 12-14 Northern Area, 15-17 Eastern Area and 18-20 Central Area).

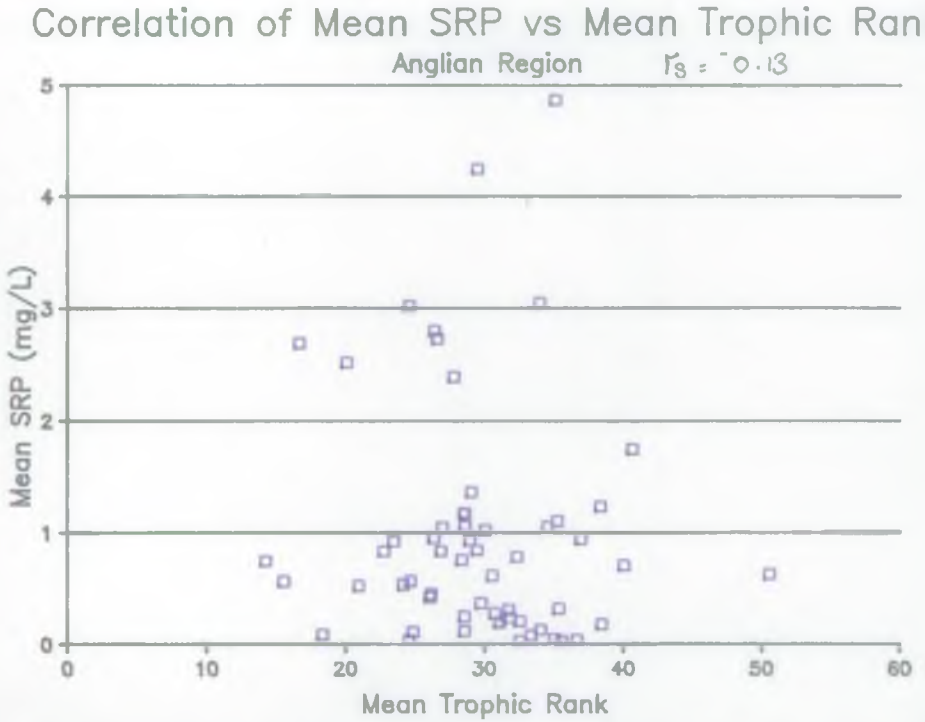
It can been seen that in the majority of cases SRP increases U/S to D/S of an STW input. In general, there is an inverse relationship between mean SRP and MTR U/S to D/S of a qualifying discharge. This indicates that, where the STW is increasing the nutrient status of the river, the macrophyte communities can reflect this in terms of Mean Trophic rank.

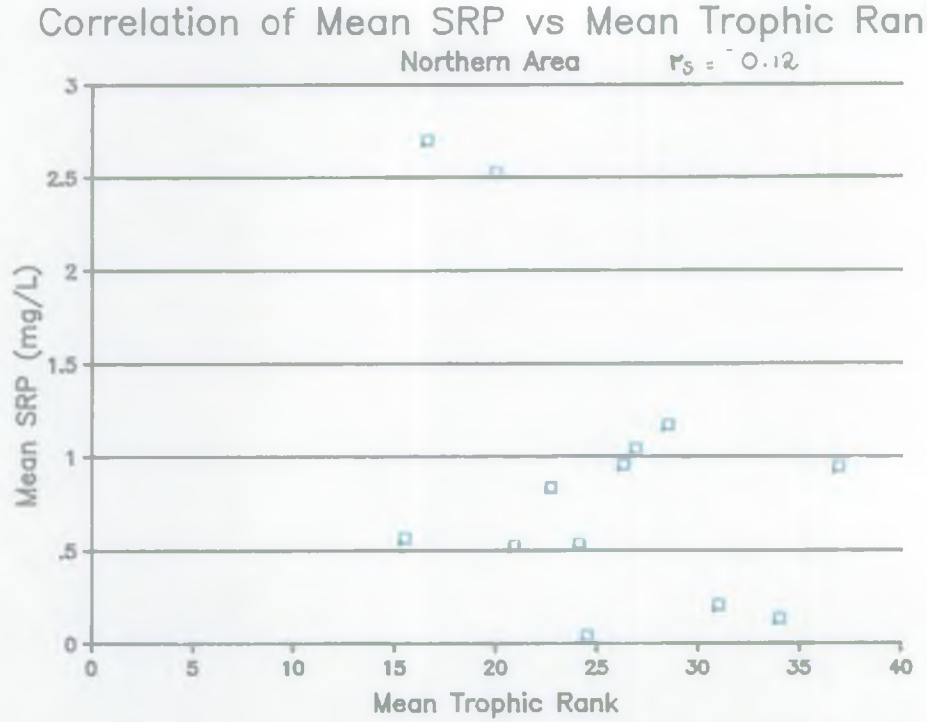
Table 2 - Mean SRP (mg/L) for qualifying discharges

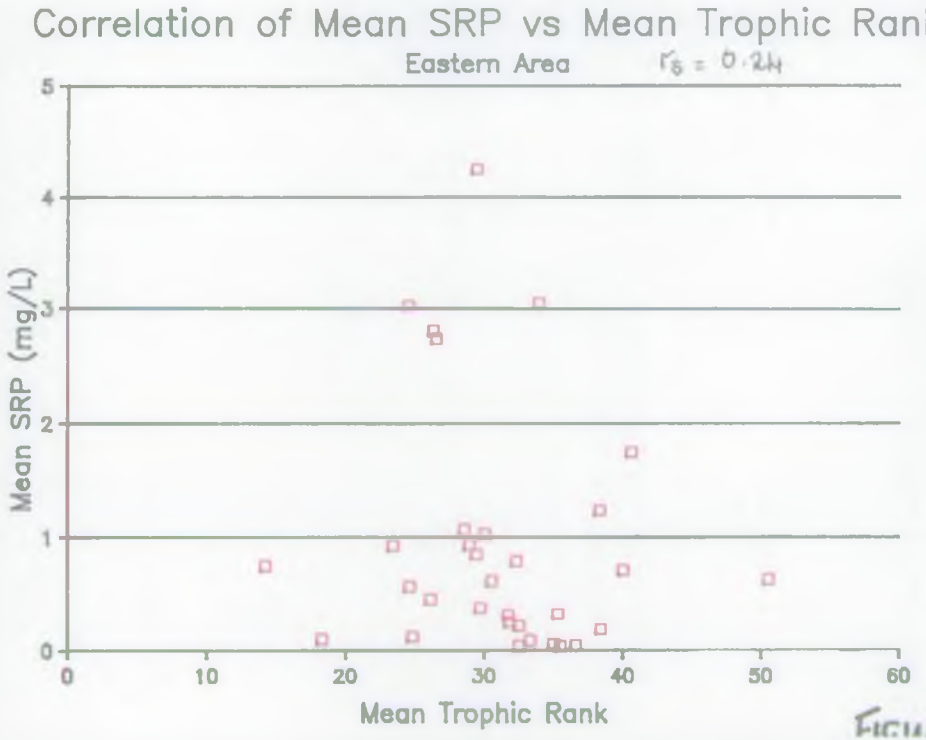
Qualifying STW	Chemical sample point	Mean SRP mg/L
Billing	U/S R05BFNENE170B D/S R05BFNENE200W	0.20 1.17
Broadholme	U/S R05BFNENE240W D/S R05BFNENE300I	0.95 1.04
Raunds	U/S R05BFHOGD090R D/S R05BFHOGD110R	0.52 2.69
Corby	U/S R05BFWILS020S D/S R05BFWILS040W	0.13 2.52
Whilton	U/S R05BFWHIL050S D/S R05BFWHIL090B	0.94 -
Louth	U/S R03BFLUD03T D/S R03BFLUD04T	0.04 0.56
Market Harborough	U/S R05BFWELL080G D/S R05BFWELL100W	0.53 0.83
Braintree	U/S R01BFBR03 D/S R01BFBR02	1.06 2.73
Bocking	U/S R01BFBL0675 D/S R01BFBL06	0 .56 0.93
Shenfield	U/S R01BFWD0540 D/S R01BFWD05	1.23 3.05
Belaugh	U/S R04BFBUR131 D/S R04BFBUR120	0.08 0.04
Stalham	U/S R04BFANT120 D/S R04BFANT180	0.05 0.03
Halstead	U/S R01BFCL06 D/S R01BFCL0488	0.62 0.92
Sudbury	U/S R01BFST0739 D/S R01BFST07	0.78 0.84
Haverhill	U/S R01BFST1370 D/S R01BFST13	0.09 4.25
Whitlingham	U/S R04BFYAR190 D/S R04BFYAR200	0.24 0.70
Wymondham	U/S R04BFTIF050 D/S R04BFTIF060	0.18 1.02
Harleston	U/S R04BFWAV100 D/S R04BFWAV110	0.74 2.80
Beccles	U/S R04BFWAV128 D/S R04NFWAV150	0.21 0.61

Diss	U/S R04BFWAV020 D/S R04BFWAV027	0.03 0.32
Eye	U/S R04BFDOV060 D/S R04BFDOV080	0.37 0.31
Upminster	U/S R01BFMD0518 D/S R02BFMD05	- 3.02
East Dereham	U/S - D/S R04BFWEN140	- 1.74
Fakenham	U/S R04BFWEN040 D/S R04BFWEN070	0.11 0.45
Haslingfield	U/S R02BF30M07 D/S R02BF33M02	0.81 0.88*
Utton's Drove	U/S - D/S R02BF26M19	- 4.86
Soham	U/S R02BF36M24 D/S R02BF36M09	1.34 2.39
Attleborough	U/S R02BF44M01 D/S R02BF44M02	0.10 1.99
Thetford	U/S R02BF44M08 D/S R02BF45M04	0.12 0.28
Sandy	U/S R02BF19M04 D/S R02BF19M07	1.10 1.05
Whittlesey	U/S - D/S R02BF53M04	- 0.83
Towcester	U/S R02BF04M04 D/S R02BF04M05	0.25 0.42
Leighton Linslade	U/S R02BF08M01 D/S R02BF08M02	0.75 1.36

NB - D/S sample point is D/S of confluence with R.Granta


Correlation of Mean SRP vs Mean Trophic Rank
Anglian Region
$r_s = -0.13$
Mean SRP (mg/L)
Mean Trophic Rank
0
1
2
3
4
5
0
10
20
30
40
50
60


Correlation of Mean SRP vs Mean Trophic Rank
Northern Area
$r_s = -0.12$
Mean SRP (mg/L)
Mean Trophic Rank
0
.5
1
1.5
2
2.5
3
0
5
10
15
20
25
30
35
40


Correlation of Mean SRP vs Mean Trophic Rank
Eastern Area
$r_s = 0.24$
Mean SRP (mg/L)
Mean Trophic Rank
0
1
2
3
4
5
0
10
20
30
40
50
60

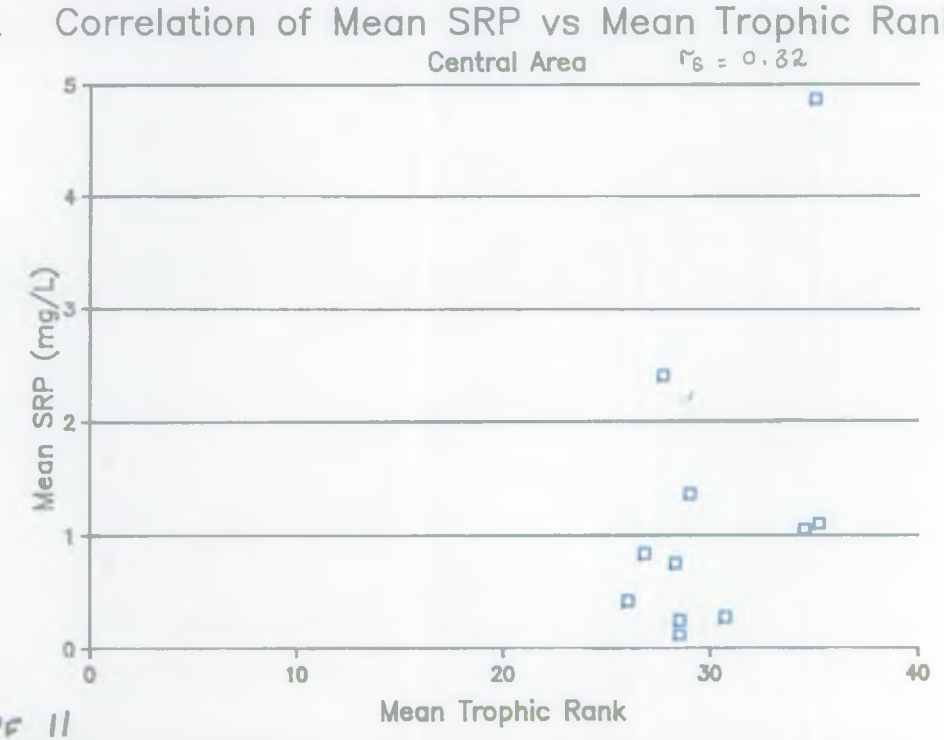

Correlation of Mean SRP vs Mean Trophic Rank
Central Area
$r_s = 0.32$
Mean SRP (mg/L)
Mean Trophic Rank
0
1
2
3
4
5
0
10
20
30
40

FIGURE 11

MDS Plot of UWWTD Macrophyte Data 1994 - Northern Area, Stress = .11

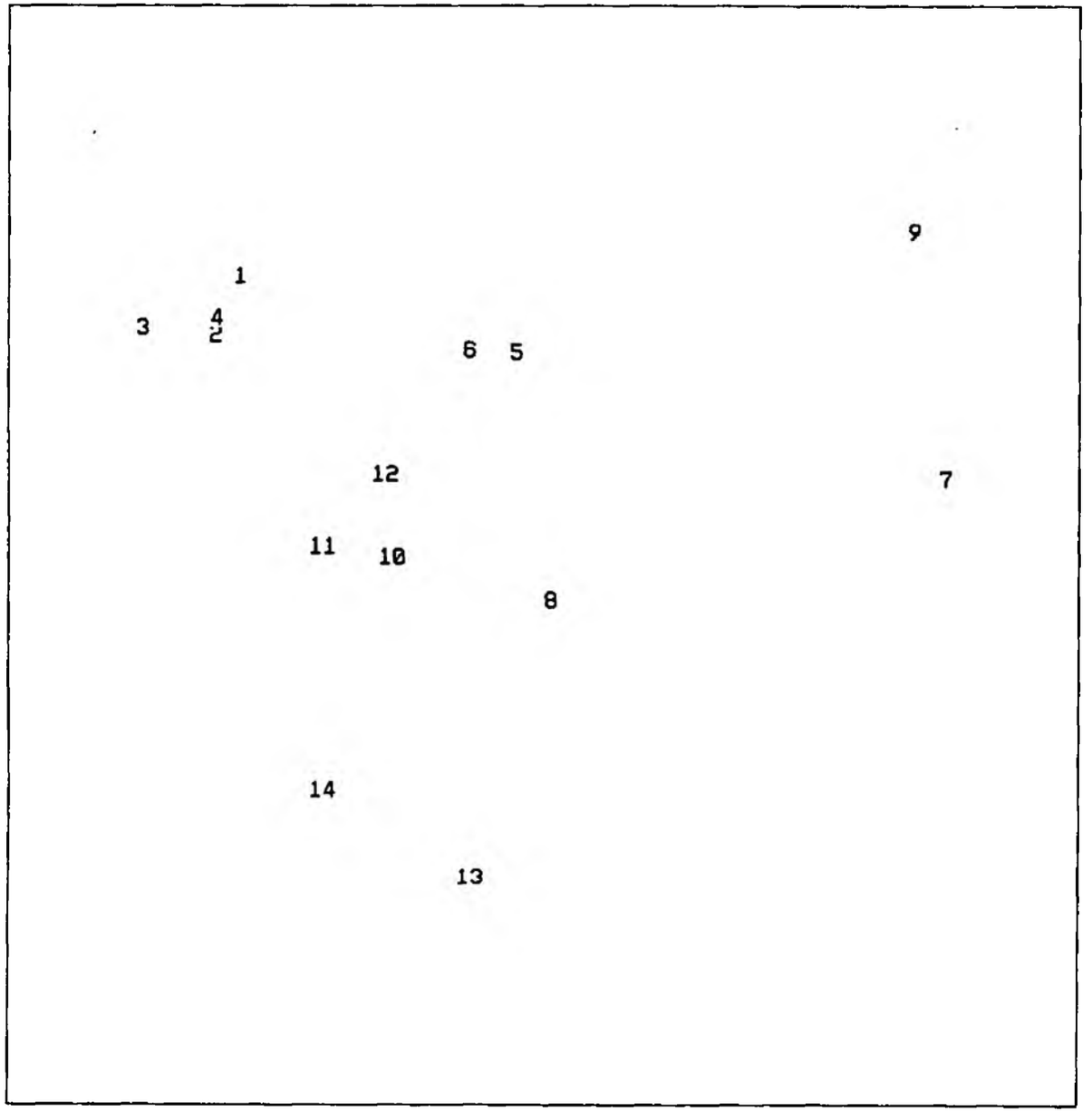


FIGURE 14

MDS Plot of UWWTD Macrophyte Data 1994 - Eastern Area, Stress = .21

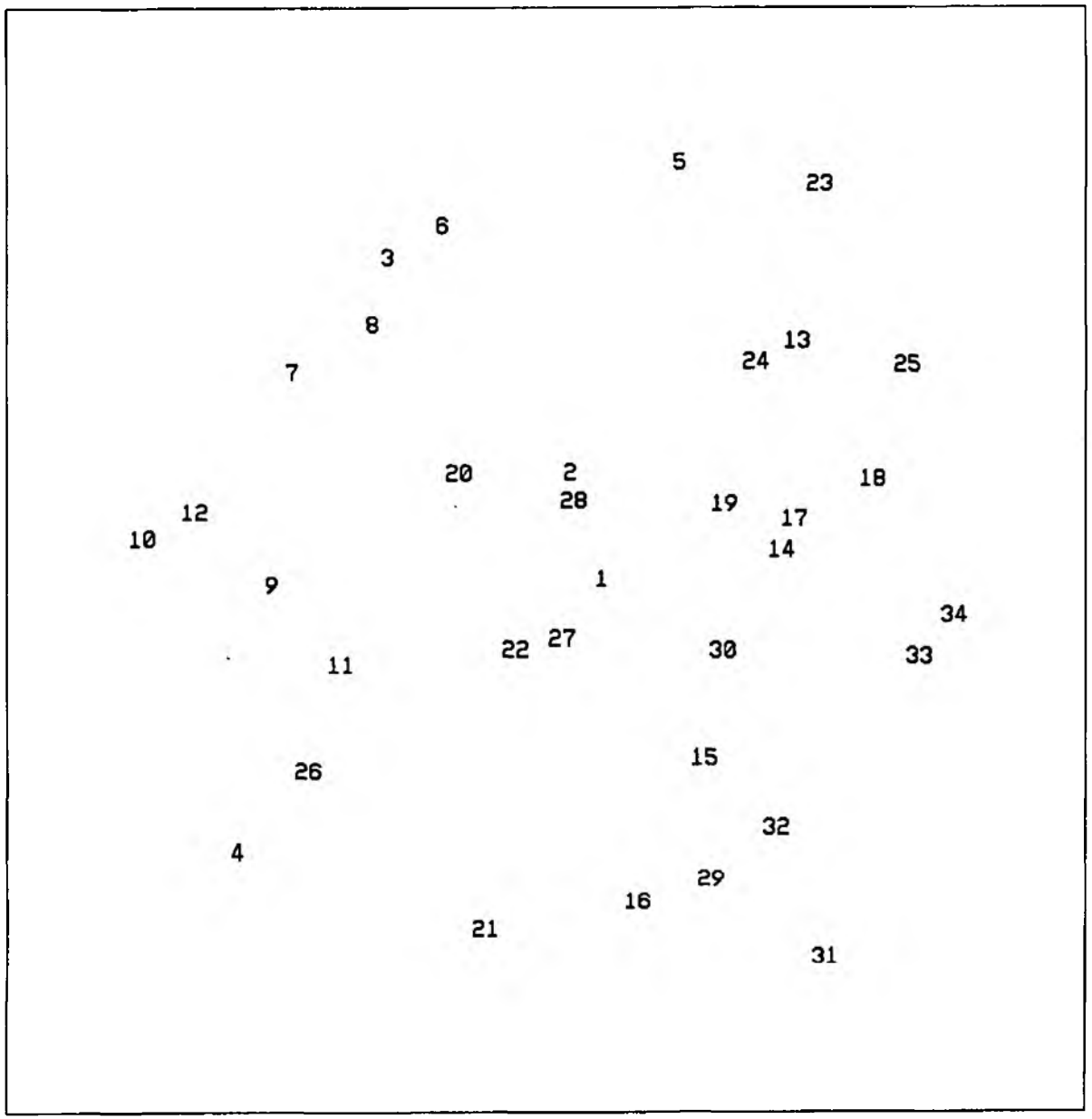


FIGURE 14

MDS plot of UWWTD Macrophyte Data 1994 - Central Area, Stress = .14

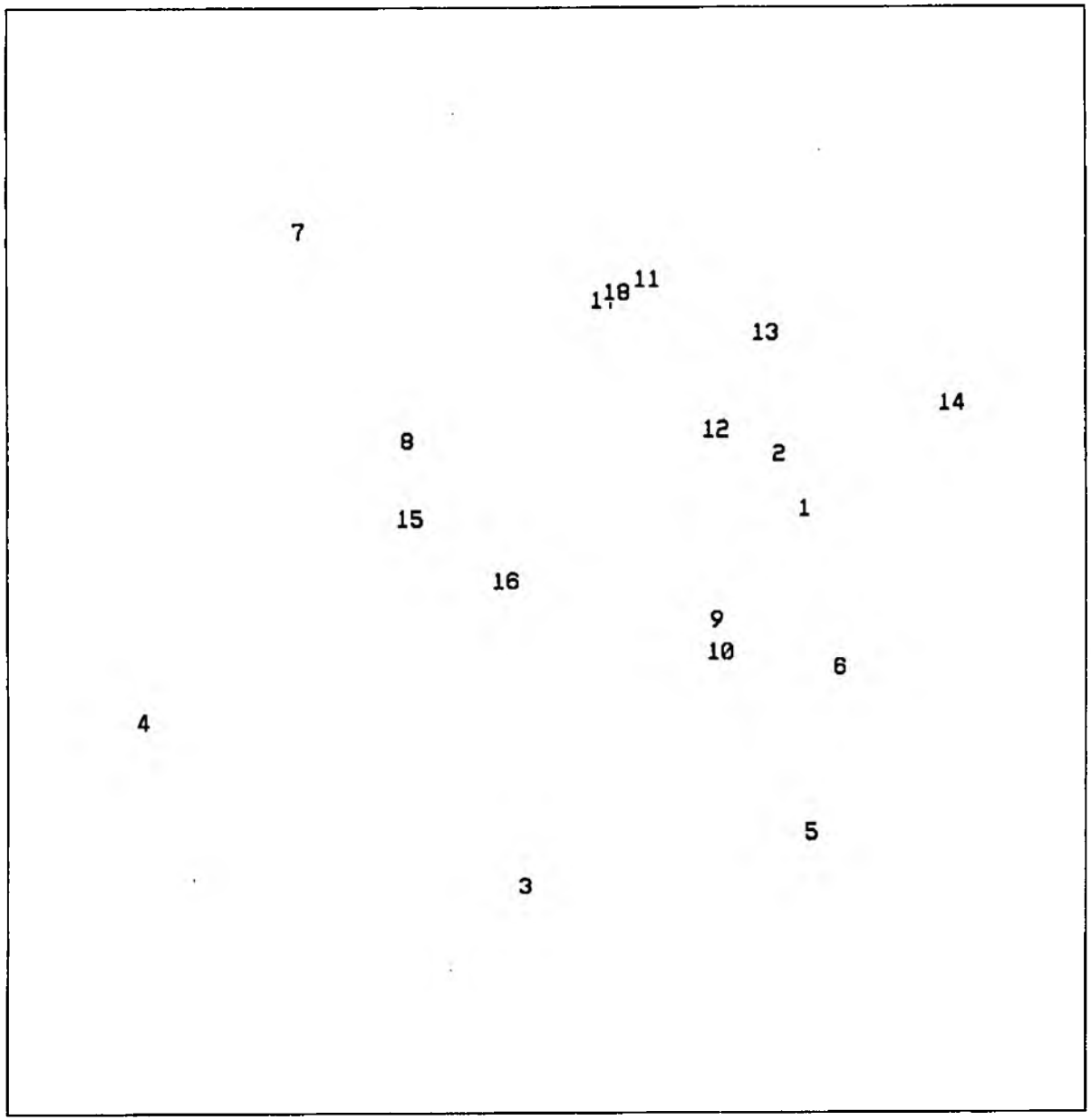


FIGURE 20

5. Comments

5.1 General

- The UWWTD macrophyte monitoring is trying to answer two questions:
  a) is the SA(e) eutrophic?
  b) does a particular input have an impact?

- Macrophyte data will only demonstrate an impact if one exists.

- Even if it is not possible to demonstrate the impact of a particular STW input the data is useful for establishing that the river is eutrophic. DoE will certainly expect data to be presented even if it is inconclusive.

- If a 'threshold' level of nutrient has been reached due to inputs higher up the catchment, whether diffuse or point source or due to 'natural' run-off, then it is possible that the macrophyte community may be disturbed already and will not respond to additional inputs, especially if these represent a relatively minor contribution.

- It may be necessary to monitor some 'control' sites higher up the catchment in order to obtain a 'baseline'. This will not be possible in some systems because STWs discharge in to the headwaters. The MTRs from the NCC sites may assist in such situations. The Mesotrophic Streams project may also provide additional information.

- Macrophytes respond to nutrients in the water column and in the sediment. Sediment is by far the most important for tall emergent/edge species whilst being less important for species with a large underwater surface area and rooted in coarse gravel. Even though macrophytes respond to sediment nutrients they still have a potential to be very useful as monitors of STW effluents to rivers because these inputs affect sediment chemistry as well.

- As sediment nutrients influence macrophyte communities it may not be valid to expect a simple correlation of water column phosphate with macrophyte community descriptors. It may be necessary to analyse sediment phosphate.

- There are sites at which macrophyte surveys may not be capable of demonstrating a trophic effect due to channel management or flow regime. Alternatives have been suggested, *eg* benthic algal growth on artificial substrate. At present, however, such methods are less well developed than the use of macrophytes.

- It should be recognised that macrophyte assessment is only one aspect of what should be a multi-faceted approach to the assessment of UWWTD SA(e)s.

5.2 Survey Methodology

- It is extremely important to ensure that **all** relevant **channel** macrophytes are accurately recorded (use the new checklist only for UWWTD monitoring).

- If it is not possible to wade or have clear view of the whole channel from both banks then a boat **must** be used.

- The underwater TV camera **must** be used at sites where it is not possible to see the bottom. All Areas now have a camera and battery charger.

- The surveys **must** be carried out during the summer months (mid-June to mid-September). It is best to avoid leaving surveys until very late in the season due to the risk of high flow events, early frosts and die-off.

6. Conclusion

Although the data set is limited it can be seen that macrophytes can be usefully used to assess the trophic status of rivers. Where macrophyte communities change D/S of an STW input the data can detect this. This can be related to changes in nutrient status.

This methodology is still developing and there are undoubtedly further refinements to be made, however, such improvements will only be possible once sufficient experience of using macrophytes in this way has been accumulated.