POND ACTION

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PRELIMINARY RESULTS FROM THE NATIONAL POND SURVEY: SINGLE SEASON ANALYSIS OF MACROINVERTEBRATE SAMPLES FROM 111 NPS SITES.

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CONTENTS

PRELIMINARY RESULTS FROM THE NATIONAL POND SURVEY: SINGLE SEASON ANALYSIS OF MACROINVERTEBRATE SAMPLES FROM 111 NPS SITES.

As promised, here are some very early data from the National Pond Survey. The 111 samples used represent about a quarter of the samples which we have taken.

1. SUMMARY

In 1990, after trials of the methods in Oxfordshire, sampling began for the National Pond Survey. The NPS aims to further the understanding of the ecology of ponds by producing, initially, a classification system based on macroinvertebrate and macrophyte composition, and by investigating the environmental factors which affect community structure of ponds. The NPS is coordinated by Pond Action from Oxford Polytechnic with help from biologists around Britain.

To date, approximately 450 samples have been taken from 150 ponds around Britain, from northern Scotland to the south coast of England. The results of this first stage of surveying are currently being analysed. The results presented in this report are derived from, approximately, one quarter of the field work done so far.

The survey results have been analysed using the Fortran programmes DECORANA and TWINSPAN. The results of these analyses are presented in Figures 1 and 2. Both analytical techniques work by arranging samples in an order of similarity of community composition. The closer together two samples are, the more similar their community structure. TWINSPAN (Figure 2) produces a dendrogram which shows the relationship between sites. It also produces indicator species which enable us to recognise the type of any other site, given its community composition. In summary, moving across the bottom of the dendrogram (left to right), we go from large gravel pits to relatively deep but smaller sand, gravel and clay pits to ponds with stream connections, then to floodplain ponds, to more permanent field ponds, to seasonal and semi-seasonal field ponds, then to more acidic ponds and finally to upland oligotrophic lochans.

DECORANA analyses community composition in terms of major variations in community structure. The principal variation in community structure is shown by the first axis, the next major variation by the second axis etc. The sites from the various TWINSPAN end groups are plotted on the first two DECORANA axes in Figure 1. The polygons shown enclose the DECORANA co-ordinates from all the sites in a TWINSPAN end group. The variation in community structure as described by DECORANA should be related to environmental parameters. In this case the first axis is related to the pH of the water of the ponds (high on the left-hand side of the axis and low on the right). The environmental parameter associated with the second axis is not clear at the moment, but some relationship to size and vegetation cover is evident.

When fully analysed, the NPS data should allow us to predict the animal and plant communities of a pond using just environmental data. If survey results from a site show there to be less animals or plants than predicted, then we will know that something is 'going wrong' with the site. The difference between predicted and actual flora and fauna might be due, for example, to water pollution or some other form of damage.

So, the NPS results will provide us with a means of assessing whether or not a site is reaching its full potential for wildlife.

2. THE DATA-SET

310 species are included in the data set, including 3 RDB1 (endangered), 1 RDB2 (vulnerable) and 6 RDB3 (rare) species, from previously unknown locations.

The RDB1 species are:

Myxas glutinosa: LYMNAEIDAE: GASTROPODA: The Glutinous Snail. A schedule 5 (protected) species. Last seen in Britain in Windermere in 1951.

Leptocerus lusitanicus: LEPTOCERIDAE: TRICHOPTERA: previously known only from the River Thames and the River Thame on the Oxfordshire/Berkshire border. Now found in a gravel pit in London.

Hydrochara caraboides: HYDROPHILIDAE: COLEOPTERA: the Lesser Silver Water Beetle. Known to breed only on the Somerset Levels. This record, from a field pond in Cheshire, is probably of a refugee from the Levels which were dry at the time.

3. THE ANALYTICAL TECHNIQUES USED: TWINSPAN AND DECORANA

We've used the two computer-based statistical techniques TWINSPAN and DECORANA to describe the similarities between ponds (TWINSPAN = Two Way INdicator SPecies ANalysis and DECORANA = DEtrended CORrespondence ANAlysis). Both types of analysis use only the invertebrate species lists from each pond (they don't use environmental data).

TWINSPAN produces a classification of the sites and the results are generally shown in the form of dendrogram. TWINSPAN is the method of choice for grouping sites with similar invertebrate communities.

DECORANA shows the similarity of sites on a two or three dimensional graph (we've used two dimensions for this analysis). We can attempt to correlate the axes along which the sites are arranged, with environmental factors - because of this, DECORANA is used mainly to investigate the principal environmental factors which are associated with the differences between the pond communities.

For those not familiar with ordination and classification techniques, I have attempted a potted explanation of what the techniques tell us. I will stay clear of explaining how they do it! Enraged mathematicians and statisticians are asked not to write in and complain. Anyone familiar with the techniques should skip this bit and go straight to Section 4 (page 8).

The principles of ordination and classification are not impossibly difficult to understand. They are, however, not easy to explain without a good deal of hand waving! If the following sections prove too much, don't worry. The results section should be reasonably interpretable without a full understanding of the techniques.

3.1. The re-arrangement of the data

A very simple example gives us an idea of what the two techniques do - look at these two tables of data. 1. (Raw data) shows the way we put our basic species lists into one table before we begin to analyse them. They are then re-arranged by TWINSPAN and DECORANA (2. Re-arranged data) and finally we display the results in a dendrogram (TWINSPAN) or graph (DECORANA).

1. Raw data

SITES

Species	1	2	3	4	5
A	+	+	+		
B				+	
C	+		+		
D	+				+
E		+		+	+

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2. Re-arranged by TWINSPAN or DECORANA

Species	1	2	3	4	5
B	+				
E	+	+	+		
D		+		+	
A			+	+	+
C				+	+

In the raw data, it's not immediately obvious which of the sites are most like each other and which least like each other. Re-arranged, however, its immediately obvious that C and A are different from B and E, with D rather in the middle. Whilst you don't need a computer to work this out with only five sites and five species, it would be impossible to do it with 500 sites and 500 species. This is what TWINSPAN and DECORANA do.

So, running raw data through TWINSPAN and DECORANA leads to it being re-organised showing how similar sites are to each other in terms of the species they contain. The analysis, essentially, re-organises large data-sets in a way which allows them to be interpreted by the (rather limited) human mind.

The **first** axis of DECORANA will be roughly equivalent to the order of sites as shown in the re-arranged table. TWINSPAN also uses this order of sites to make the first split of the dendrogram, splitting the samples at the point in the sample order at which the difference (statistically) between the two sets of sites is greatest e.g between D and A.

Even in the simple example above you can see that there is more variation in the species composition than is explained by the site order. If the site order explained all the variation, then we might expect the 'diagonal' of species to be straight. In a more complex data set the variation which is not explained by the first axis might be quite considerable. How the two techniques handle this extra variation forms the fundamental difference between them.

DECORANA essentially ignores the variation in species composition which has been explained by the first axis and then orders the sites on the basis of the remaining variation. This order is then the basis of the **second** axis of DECORANA. Having done this, it can then ignore the variation explained by the first and second axes and produce a third axis, and so on.

TWINSPAN handles the data differently. Having made its first split, it then treats the two 'halves' (they may be unequal halves) of the data set independently, and in exactly the same way as it handled the whole data set. This **does not** produce a series of splits following the same sequence as the original site order.

If we imagine a data set in which the principal **source*** of variation is size, then we would expect that the first split of TWINSPAN would reflect this, and similarly that the first axis of DECORANA would be related to this. The second major source of variation in our data set might be pH and the third might be longitude. It might be, however, that the pH of the water has little effect on large sites but a large effect on small sites and the opposite might be true of longitude. In this case the second axis of DECORANA would be related to pH and the third to longitude. One of the splits of TWINSPAN (the split of the small sites group) could well be based on the pH of the sites whereas the split of the large sites group could be based on longitude. Alternatively, the effect of size might still prevail and one or both of the second splits of TWINSPAN might be related to size with the effects of pH and longitude becoming evident only at lower splits in the dendrogram.

(* I use **source** of variation rather than variation as this is easier to conceptualise. There is the tacit assumption that a particular variation in community structure has a source, e.g.. an environmental variable such as size)

Thus, TWINSPAN is in some ways more versatile than DECORANA in that it can handle more types of variation in a data set (DECORANA does not generate more than four axes - largely because the lesser sources of variation will not affect the whole data set, but only a part of it). DECORANA on the other hand can generate sample/site orders which allow us to evaluate the principal factors affecting sites which would be more difficult (though not impossible) to analyse with the information from TWINSPAN.

3.2. Indicator species

Some other features of TWINSPAN need mentioning. At each split, TWINSPAN produces a set of indicator species for each side of the split. These are the species which are most strongly associated with each branch of the dendrogram. They can also be used to make a dichotomous key for classifying new sites.

For example, looking at the first split of the dendrogram in figure 2, the indicator species for the left-hand split are on the left- hand side of the first vertical line and similarly for the right-hand side. You will also see a number below the indicators which is the 'classification score' which must be achieved before either side of the dendrogram is followed. Each indicator species for the left side scores -1 and for the right side scores +1. Thus a sample with *Hydroporus erythrocephalus* (HYDR ERYT), *Gyraulus albus* (GYRA ALBU), *Hyphydrus ovatus* (HYPH OVAT) and *Asellus aquaticus* (ASEL AQUA) would score (3X -1) + (1X +1) = -2. This would then follow the left-hand side of the split (-2 is equal to -2 indicated for the left-hand side of the split (anything lower would also have sufficed). If, say, GYRA ALBU had not been present then the total score would have been -1 and the sample would have followed the right-hand side of the split.

3.3. 'Pseudospecies'

Occasionally, an indicator species will appear in the form CLOE DIPT.2. The '.2' indicates a pseudospecies. TWINSPAN uses numerical data by classing data into pseudospecies. In this case I have used the following cut levels for pseudospecies: 1-5, 6-25, 26-121, 122-600, 601-. Thus, if we have, say, 50 *Cloeon dipterum* in a sample then TWINSPAN will treat this as *Cloeon dipterum* pseudospecies 3 (CLOE DIPT.3), CLOE DIPT.2 and CLOE DIPT.1, ie as three different entities. Obviously, then in the case of our first split we need to have more than 5 *Cloeon dipterum* in order to score our -1 for the left-hand split. If we have 150 *Cloeon dipterum* then we will have not just pseudospecies 4 of that species but also pseudospecies 1,2 & 3 and so we would also score -1.

One thing which may seem confusing at first glance is that, occasionally, a species occurs as a negative indicator for a split (e.g. *Asellus aquaticus* in our first split) but then occurs later as an indicator on the positive side of the split (e.g. furthest left split of the right-hand side of the dendrogram). This occurs because indicator species are species which are strongly associated with one side or other of a split, but not exclusively with that side of the split. If a species is an indicator at a split this doesn't prevent it from occurring at some sites on the other side of the split. It may even become an indicator at a later split.

For example, *Asellus aquaticus* might have occurred in 80 sites on the left and 5 sites on the right for the first split, which still leaves 5 sites with the species on the right-hand side. These might eventually form a group on their own for which *A.aquaticus* could be an indicator species.

3.4. Borderline sites

When TWINSPAN splits the sites in 'half' it tries to find as clear a discontinuity as possible in the community structure. It actually goes to some lengths to do this which I won't go into here. However, some sites will occasionally be borderline between the two sides of the split.

If this is the case then these will be highlighted and I have put all such sites to either side of the vertical stems in the dendrogram **(and marked them on the diagram).**

Sites which are borderline at one split will tend to come through close to the group from which they are borderline: e.g. ASHMSU just fails to get into the left-hand side at the first split and finally arrives at the far left of the right-hand split. In practice, however, many sites which are borderline at some point don't always arrive at the next best apparent position. This is because TWINSPAN analyses each 'half' of the data set independently and does not produce a final order representing a continuous gradient of community change.

3.5. Misclassified sites

When TWINSPAN chooses its indicator species (which it does after making the dendrogram - remember the indicators are only used for keying out new sites that we come to after doing our survey) it also checks how many of the sites in the dendrogram would have been misclassified using this key (ie would have ended-up in the wrong end-group).

Such sites are termed 'misclassified' and I have shown these on the dendrogram suffixed by (M). In this case 6 out of the 111 samples would have been misclassified using the key.

4. RESULTS OF THE ANALYSIS

The results are shown in Figures 1 & 2. Species abbreviations are given in Appendix 1 and brief (very) descriptions of each site are given in Appendix 2.

The number of species recorded in a single sample is shown next to the site names on Figure 2. Remember that this is the number of species in a single sample (when sampled in 3 seasons all sites will have more species).

4.1. Figure 1

Figure 1 shows the TWINSPAN groups plotted on the DECORANA plot. To obtain this plot I have plotted each site individually on the DECORANA axes and then drawn a polygon around all the sites in a particular TWINSPAN end group. I have not included sites which were borderline at any of the TWINSPAN splits, though I have included mis-classified sites. We would expect that the groups 1 to 8 would be separated from groups 9 to 16 on the first axis of DECORANA and this is quite evident. The gap between the groups is occupied by sites which were borderline (and hence are not plotted) and principally by a group of sites on the Isle of Wight (of which, more later). In general, the TWINSPAN groups are separated quite well on the two axes of DECORANA, suggesting that (though see later) the second axis is relevant to the left-hand (more permanent and alkaline) side of the diagram. On the left-hand side only group 8 doesn't seem to be adequately explained by the first and second axes. On the right, groups 9 to 12 are not brilliantly explained by the first two axes (nor by axes 3 or 4 for that matter!). Nevertheless the two techniques are producing results which are in reasonable agreement.

The first axis of DECORANA is explained largely by pH. 65% of the variation was explained by pH and no other environmental variable aided this explanation of variation. No single environmental variable appears to explain the second axis particularly well, though some relation to size and plant cover appears to be evident. The second axis, representing the second largest variation in community structure, appears to show-up mainly in the more acidic and less permanent (right-hand) sites. This may well be why it is difficult to get a good correlation between the second axis and an environmental variable. At the moment the number of sites on the right-hand side is much lower than that on the left. If this were the final data set I would probably take out some of the more extreme of the right-hand sites to allow a different interpretation of the second axis which would perhaps allow a greater separation of the left-hand sites.

4.2. Figure 2

Figure 2 shows the TWINSPAN dendrogram. 56 of the 310 species are used as indicator species at some time or other. All the indicator species are common and widespread (except *Corixa dentipes,* and this is only indicative of a minor split of one site from a group of 5 sites). In general the snails seem to be well favoured as indicator species, with 13 species of the 31 recorded used at some point as indicators.

In general, moving across the bottom of the dendrogram (left to right), we go from large gravel pits to relatively deep but smaller sand, gravel and clay pits to sites with stream connections, then to floodplain sites to more permanent field ponds, to seasonal and semi-seasonal field ponds to more acidic sites and finally to upland oligotrophic sites.

More details are given in the legend to Figure 2.

FIGURE 1

DECORANA ORDINATION OF 111 NPS SAMPLES SHOWING TWINSPAN END-GROUPS

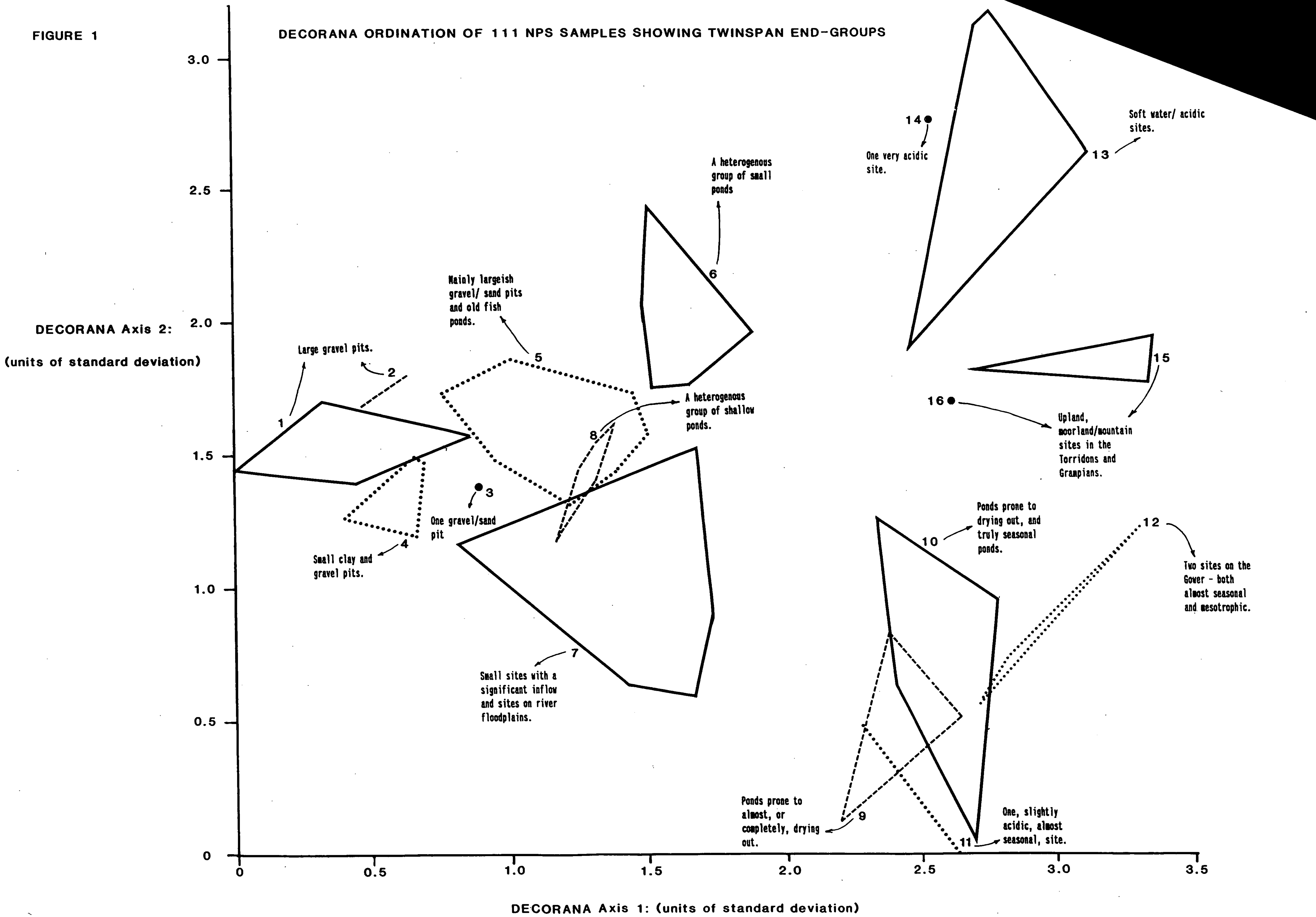
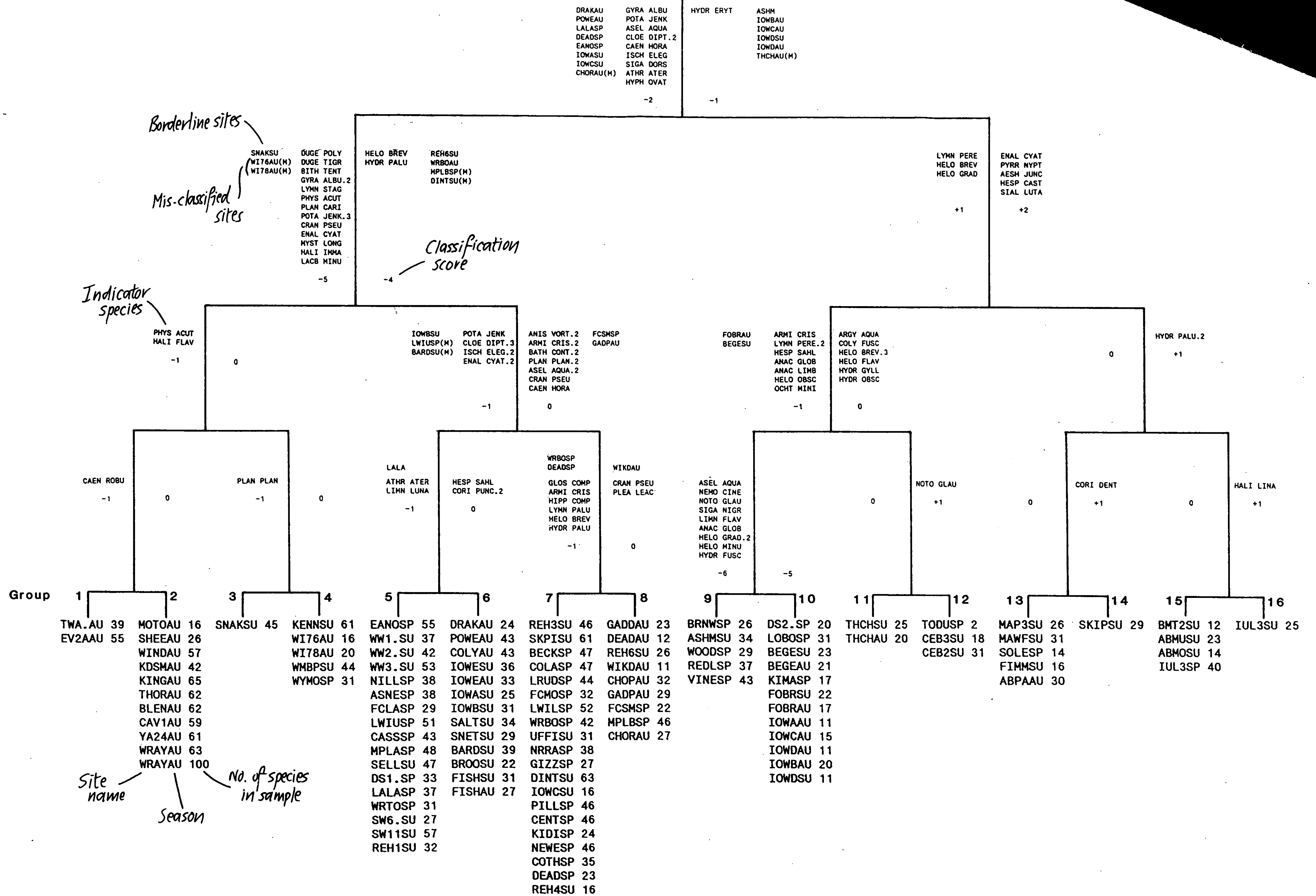


FIGURE 2 TWINSPAN DENDROGRAM OF 111 NPS SAMPLES



5. WHAT NEXT

Our main aim over the next two years will be to complete the selection of a range of sites from throughout Britain, on a variety of land-uses and rock types. However, apart from this general objective the preliminary analysis does suggest some trends which it would be interesting to investigate by surveying particular types of pond. It also suggests some places that we don't need any more of!

5.1. Alkaline sites in the north and in Scotland

We can't properly investigate a north-south geographical trend at the moment. This is because of the strength of the pH correlation and the dearth of neutral/alkaline sites from the north and Scotland. What we would like to be able to do is compare northern alkaline with southern alkaline. There is, of course, an indication that water quality may be more important than geography, as the southern acid sites do come out on the right-hand side of DECORANA and TWINSPAN along with northern sites (which are predominantly acid). Likewise the (one) large neutral Scottish site (EANO) comes out on the left (though only just) with the southern and predominantly neutral/alkaline lowland sites. So it would be nice to find some alkaline sites in the north of Britain and Scotland to investigate this a bit further.

5.2. True seasonal ponds

There appears to be a group of seasonal/semi-seasonal sites on the bottom right of the DECORANA plot. It would be a good idea to have some surveys of ponds which are truly seasonal and which have been so for a long time **(like the Norfolk pingo's).** Both acidic and alkaline sites would be useful to see what differences there are between them. Some seasonal sites will, of course, be relatively acidic when first filled (autumn/winter) and become progressively more alkaline throughout the year.

5.3. Floodplain sites

There appears to be a group of floodplain sites in the TWINSPAN analysis **and this, if anything, becomes slightly clearer with other analyses which I haven't shown here.** However, it's difficult to distinguish between the effects of flooding on a site per se (e.g. the addition of water and silt and the effects of scouring) and the colonising animals which will come with the flooding. This is especially so since at the moment the sites in this group are flooded by rivers which are generally slow flowing and which have macroinvertebrate communities very similar to some of the ponds in our survey. So, to disentangle the colonising effects of flooding from the non-colonising effects we need to find some sites on the flood-plains of faster flowing rivers.

5.4. Upland sites

As for the northern alkaline sites, we need more sites from Wales and the Pennines perhaps (we already have a few under way).

5.5 Sites which we don't want!

We probably picked some of the worst years this century to start a survey of small water bodies. Sites which had never previously dried out, or had only dried out in '76, have dried out in 90/91 - often in between the summer and autumn surveys. In effect, therefore, we have a good deal more 'new' or new and partially colonised sites than we bargained for. We'd like to try and limit the number of these in the data set. That doesn't mean that we don't want to try to understand the processes involved in their colonisation, but that this would probably be better done after an understanding of the more undisturbed sites has been achieved. The stats techniques which we are using work best on stable communities and to overload the data set with data from partially colonised sites (colonised initially from whatever happens to be around them at the time) might confuse the data from the more mature communities. We should therefore try to avoid sites which have endured a recent disturbance which is greater than that which they would have undergone under normal conditions.

POND ACTION

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APPENDIX 1. BRIEF DESCRIPTION OF SITES IN THE ANALYSIS

CODE	SITE NAME	DESCRIPTION
BERKSHIRE/BUCKINGHAMSHIRE/SURREY BORDER		
KING	Kingsmead Main Lake	Gravel-pit lake.
KDSM	Kingsmead Small Lake	Gravel-pit lake.
MOTO	Motorboat Lake	Gravel-pit lake.
SHEE	Sheepwalk East Lake	Gravel-pit lake.
THOR	Thorpe Park Lakes	Gravel-pit lake.
TWA	Th ames Water Lake	Gravel-pit lake no previous connection to other water courses.
WRAY	Wraysbury No. 2 Lake	Gravel pit lake.
BERKSHIRE		
BLEN	Blenheim Lake, Wraysbury	Gravel pit lake.
CAV1	Development Lake, Caversham.	Gravel pit lake.
DINT	The Moors Pond.	Large, shallow stream fed pond on flood plain. Urban catchment.
SOLE	Sole common	Sphagnum pool on heathland.
BORDER REGION		
EANO	Earshaig North	Stream-fed pond surrounded by conifer plantation on former moorland.
LOBO	Lockerbie Bottom	Shallow runoff fed pond surrounded by conifer plantation (formerly deciduous).
CAMBRIDGESHIRE		
WI76	Wicken Fen 76	Clay pit in fen. Groundwater fed.
WI78	Wicken Fen 78	Clay pit in fen, fed by drainage water and groundwater.
WMBP	Wicken Main Brick Pit	Clay Pit in fen, fed by drainage water and groundwater.
WIKD	Kings College Ditch	Ditch in Cambridge.
CHESHIRE		
BROO	Brook House Farm	Run-off fed field pond in buffer zone in improved pasture. Recent partial renovation.
DEAD	Dead Sheep Pond	Field pond in intensive grassland. Almost dry autumn 1990. Two of the eponymous beasts Spring 90
REH1	Rease Heath 1	Field pond in intensive grassland. Groundwater fed.
REH3	Rease Heath 3	Field pond in intensive grassland. Groundwater fed.
REH4	Rease Heath 4	Field pond in intensive grassland. Groundwater fed.
REH6	Rease Heath 6	Field pond in intensive grassland. Groundwater fed.

CODE	SITE NAME	DESCRIPTION
DORSET		
DRAK	Drakenorth A	Small spring-fed pond.
FISH	Fishpond Pond	(The village is called Fishpond!). Renovated spring-fed pond.
POWE	Powerstock Common	Groundwater/surface runoff pond on common over mixed strata (including acid sands).
COLY	Colly Lower	Spring-fed pond, recently dredged.
GLOUCESTERSHIRE		
FIMM	Fairplay Iron Mine Main	Acidic site on heathland.
HAMPSHIRE		
EV2A	Eversley 2A	Gravel pit lake.
IOWA	Isle of Wight pond A	Small, groundwater fed field pond - dry between summer and autumn 1990.
IOWB	Isle of Wight pond B	Small, groundwater fed field pond - dry between summer and autumn 1990.
IOWC	Isle of Wight pond C	Small, groundwater fed field pond - dry between summer and autumn 1990.
IOWD	Isle of Wight pond D	Small, groundwater fed field pond - dry between summer and autumn 1990.
IOWE	Isle of Wight Pond E	Small gravel pit on the Isle of Wight - newly re-excavated.
YA24	Yately 24	Gravel pit lake.
HERTFORDSHIRE		
CHOP	Chorley Wood Pond P	Newly renovated, groundwater fed pond on common.
CHOR	Chorley Wood Pond	Groundwater fed pond on common
GADD	Great Gaddesby Pond	
GADP	Great Gaddesby Pond P	Small spring fed pond
HIGHLAND REGION		
ABMO	Abernethy Moorland	Moorland lochan above Abernethy forest
ABMU	Abernethy Moorland Upper	Moorland lochan above Abernethy forest
ABPA	Abernethy Pathside	Lochan in Caledonian pine forest.
BMT2	Bienn Eighe Mountain 2	Small mountain lochan in NW Highlands NNR.
IUL3	Inshriach-Uath-Lochan 3	Spey Valley moorland/forest tarn. Groundwater fed (surrounded by bog).
LINCOLNSHIRE		
WOOD	Wood Farm Pond	Small field pond in improved gassland. Dry in 1990. Fed by groundwater/surface runoff.
REDL	Red Lane Pond	Small field pond in improved grassland. Fed by groundwater/surface runoff. Close to WOOD.
BARD	Bardney Forest Pond	Woodland pond (mixed replanted conifer/ancient deciduous). Groundwater fed.

CODE	SITE NAME	DESCRIPTION
LINCOLNSHIRE (continued)		
SALT	Saltfleetby	Pond in coastal fen NNR.
SNAK	Snakeholme Pit	Clay pit fed by groundwater.
SW6.	Swanholme Pond 6	Small sand/gravel pit, probably mesotrophic.
SW11	Swanholme Pond 11	Small sand/gravel pit, probably mesotrophic.
VINE	Viners pond	Small groundwater fed pond in improved grassland. Almost dry in 1990.
NORFOLK		
SNET	Snetterton Arable Pond	Pingo surrounded by arable land. Groundwater-fed, with water table fluctuation.
WYMO	Wymondham Gravel Pit	Small gravel pit lake. Groundwater fed (but considerable fluctuation)- heavily stocked with carp
NOTTS		
SELL	Sellars wood	Clay pit in deciduous woodland.
OXFORDSHIRE		
ASHM	Asham Meads	Field pond in unimproved (SSSI) meadow.
ASNE	Ashbury New Pond	New pond, fed by small stream.
BECK	Beckley Manor	Old moat. Spring-fed. Heavily shaded.
BRNW	Brasenose Wood	Small, shallow pond in ancient woodland. Dry in 1990.
CASS	Cassington Pit	Groundwater fed gravel pit. Relatively new.
CENT	Central Pond	Field pond in SSSI wet grassland (Otmoor). Recharged by winter floodwater.
CORN	Cornwell	Large fish-pond (brown trout). Spring-fed via two other ponds. 50 pr mallard for shootin'.
COTH	Cothill Fen	Pond in SSSI fen. Groundwater fed.
DS1	Dry Sandford 1	Pond in old quarry surrounded by SSSI fen. Spring-fed.
DS2	Dry Sandford 2	Small pond in old quarry. Runoff and rainwater. Practically dry in 1989.
FCMO	Friars Court Moat	Old moat. Heavily stocked with fish and ducks.
FCLA	Friars Court Large	Small new pond/gravel pit created in 1983 (small gravel-pit).
FCSM	Friars Court Small	Very small new pond/gravel pit created in 1983 (right next to FCLA).
GIZZ	The Gizzel	Spring-fed village pond (nitrate pollution).
KENN	Kennington Pond	Small riverside gravel-pit (seasonal connection).
KIMA	Kingston Marsh Pond	Pond newly excavated in riverside marsh (the marsh was included in the sampling).

CODE	SITE NAME	DESCRIPTION
OXFORDSHIRE (continued)		
KIDI	Kingston Ditch Pond	Pond near R.Thames, connected to river indirectly by ditch system -newly re-excavated 89/90.
LALA	Lashford Lane 1	Recently (1987) dammed up spring/stream in SSSI fen.
LRUD	Little Rudge	Pond indirectly connected to R.Thames by ditch system (on the same farm as FCMO, FCSM, FCLA).
LWIU	Little Wittenham Upper	Renovated fish pond in woodland nature reserve. Spring-fed.
LWIL	Little Wittenham Lower	Renovated fish pond in woodland nature reserve. Spring-fed. 4" deep of *L.miniscula* on surface.
MPLA	Milton Pools A	Gravel pit heavily stocked with coarse fish (put 'n' take fishery). Groundwater-fed.
MPLB	Milton Pools B	Gravel pit heavily stocked with coarse fish (ditto). Groundwater-fed (immediately next to MPLA).
NEWE	Newells Pond	Old groundwater-fed riverside pond (small seasonal connection).
NRRA	New River Ray	New (1987) riverside pond with direct (pipe) connection to river. On Otmoor (near to PILL and CENT).
NILL	Nill Farm	Renovated old fish-pond. Heavily stocked with fish.
PILL	The Pill	Large shallow pond in old (SSSI) grassland. Recharged by winter flooding. Dry 1990.
TODU	Towersey Manor Duck Pond	Extremely disturbed pond in garden of manor house. Duck and oil pollution.
UFFI	Uffington	Spring-fed pond.
WRTO	Wroxton Top Pond	Stocked, spring-fed fish pond. Stocked.
WRBO	Wroxton Bottom Pond	Spring-fed fish pond (below to WRTO).
WW1	Wychwood 1	Spring-fed fish pond in woodland NNR.
WW2	Wychwood 2	Spring-fed fish pond in woodland NNR.
WW3	Wychwood 3	Spring-fed fish pond in woodland NNR.
PEMBROKESHIRE		
FOBR	Ford Bridge	Small, muddy, shaded pond close to river. Prone to drying out.
THCH	Thomas Chapel Pond	Small village pond, partially drying in summer. Surface water fed.
BEGE	Begelly Pond	Small, shaded pond (former surface coal pit). Groundwater/surface runoff.
S. WALES		
CEB2	Cefn Bryn 2	Heathland pond on the Gower. Dry in summer.
CEB3	Cefn Bryn 3	Small heathland pond on the Gower. Dry in summer.

CODE	SITE NAME	DESCRIPTION
YORKSHIRE		
MAP3	Malham Pinewood Pond 3	Groundwater fed pond in old peat cutting.
MAWF	Malham West Fen	Old, small fish pond near above. Groundwater/ stream fed.
SKIP	Skipwith Common Acid Pond	Shallow pond on acid heath. ?Acid deposition from Trent Valley power stations. pH 3.4, Ca 30ppm
SKPI	Skipwith Pillwort Pond	Small, shaded alkaline pond near above.

APPENDIX 2. SPECIES ABBREVIATIONS USED IN THE TWINSPAN DENDROGRAM (FIG. 2.) (English names are given wherever possible)

TRICLADIDA (flatworms)

Duge poly	*Dugesia polychroa*	
Duge tigr	*Dugesia tigrina*	

HIRUDINEA (leeches)

Glos comp	*Glossiphonia complanata*	

GASTROPODA (snails)

Anis vort	*Anisus vortex*	The whirlpool ramshorn
Armi cris	*Armiger crista*	The nautilus ramshorn
Bath cont	*Bathyomphalus contortus*	A ramshorn snail
Bith tent	*Bithynia tentaculata*	The bithynia
Gyra albu	*Gyraulus albus*	The white ramshorn
Hipp comp	*Hippeutis complanatus*	The flat ramshorn
Lymn palu	*Lymnaea palustris*	The marsh snail
Lymn pere	*Lymnaea peregra*	The wandering snail
Lymn stag	*Lymnaea stagnalis*	The great pond snail
Phys acut	*Physa acuta*	A bladder snail
Plan cari	*Planorbis carinatus*	The keeled ramshorn
Plan plan	*Planorbis planorbis*	The ramshorn
Pota jenk	*Potamopyrgus jenkinsi*	Jenkins' spire snail

MALACOSTRACA (shrimps and slaters)

Asel aqua	*Asellus aquaticus*	A water slater
Cran pseu	*Crangonyx pseudogracilis*	A freshwater shrimp

EPHEMEROPTERA (mayflies)

Caen hora	*Caenis horaria*	A white midge
Caen robu	*Caenis robusta*	A white midge
Cloe dipt	*Cloeon dipterum*	The pond olive

ODONATA (dragonflies)

Aesh junc	*Aeshna juncea*	The common blue hawker
Enal cyat	*Enallagma cyathigerum*	The common blue damsel
Isch eleg	*Ischnura elegans*	The blue-tipped damsel
Pyrr nypt	*Pyrrhosoma nymphula*	The large red damsel

PLECOPTRA (stoneflies)

Nemo cine	*Nemoura cinerea*	A stone-fly

MEGALOPTERA (alder-flies)

Sial luta	*Sialis lutaria*	An alder-fly

ARANEAE (spiders)

Argy aqua	*Argyroneta aquatica*	The water spider

HETEROPTERA (bugs)

Cori dent	*Corixa dentipes*	A lesser water boatman
Hesp cast	*Hesperocorixa castanea*	A lesser water boatman
Hesp sahl	*Hesperocorixa sahlbergi*	A lesser water boatman
Noto glau	*Notonecta glauca*	A greater water boatman
Siga dors	*Sigara dorsalis*	A lesser water boatman
Siga nigr	*Sigara nigrolineata*	A lesser water boatman

TRICHOPTERA (caddis-flies)

Athr ater	*Athripsodes aterrimus*	A leptocerid caddis-fly
Limn flav	*Limnephilus flavicornis*	A limnephilid caddis-fly
Limn luna	*Limnephilus lunatus*	A limnephilid caddis
Myst long	*Mystacides longicornis*	A leptocerid caddis-fly

COLEOPTERA (beetles)

Anac glob	*Anacaena globulus*	A water scavenger beetle
Anac limb	*Anacaena limbata*	A water scavenger beetle
Coly fusc	*Colymbetes fuscus*	A diving beetle
Hali flav	*Haliplus flavicollis*	A crawling water beetle
Hali imma	*Haliplus immaculatus*	A crawling water beetle
Hali lina	*Haliplus lineatocollis*	A crawling water beetle
Helo brev	*Helophorus brevipalpis*	A water scavenger beetle
Helo flav	*Helophorus flavipes*	A water scavenger beetle
Helo grad	*Helophorus grandis*	A water scavenger beetle
Helo minu	*Helophorus minutus*	A water scavenger beetle
Helo obsc	*Helophorus obscurus*	A water scavenger beetle
Hydr fusc	*Hydrobius fuscipes*	A water scavenger beetle
Hydr gyll	*Hydroporus gyllenhalli*	A diving beetle
Hydr obsc	*Hydrporus obscurus*	A diving beetle
Hydr palu	*Hydroporus palustris*	A diving beetle
Hyph ovat	*Hyphydrus ovatus*	A diving beetle
Lacb minu	*Laccobius minutus*	A water scavenger beetle
Ocht mini	*Ochthebius minimus*	A water scavenger beetle

LEGEND TO FIGURE 2. TWINSPAN END GROUPS FROM THE NPS DATA-SET

TWINSPAN END GROUP	DESCRIPTION OF GROUP
1 & 2	Exclusively large (2 ha. +) gravel pits.
3	One small sand/gravel pit.
4	Sites at Wicken Fen (small clay pits) and two small gravel pits.
5	13 (largish) gravel/sand pits and old fish ponds, but also has two shallow fen ponds, one field pond, and one new pond with a stream intake.
6	A rather heterogeneous group with no obvious affinities except that none are particularly large. The group contains 5 borderline samples. Several of the Isle of Wight samples are in this group. There are two seasons of data for the five IOW sites. In between the summer and autumn surveys four of the sites dried out. The small gravel pit (IOWE) which did not dry out remains in the same position. I suspect that local affinities with the pit are pulling the other IOW sites around the dendrogram as the data set is probably already confused by the drying out of the other sites.
7	The largest group, composed largely of small sites with a significant inflow and sites on river floodplains, though there are two larger (stream fed) sites and four smaller unconnected sites.
8	Contains a high proportion of borderline sites. Most seem to be fairly shallow though there is no particularly obvious connection.
9	Contains ponds which are small and prone to almost or completely drying out.
10	Contains ponds which are prone to drying out or are truly seasonal. It also contains one, relatively new, Scottish site. The IOW sites (mainly Autumn samples) are here also.
11	Contains two samples from the same, slightly acid, almost seasonal site.
12	Contains two sites on the Gower - both almost seasonal and mesotrophic. It also contains a silty duck pond which had just suffered an oil pollution. This had a very short species list and is obviously in the wrong place!
13	Contains four acidic sites and a small, upland neutral site.
14	A heathland pond made particularly acid by precipitation from local power stations.
15 & 16	Upland, moorland/mountain sites in the Torridons and Grampians