Vegetation Trend Analysis an Introduction

Christopher Hancock

November 2013, revised February 2016

Summary
Vegetation Trend Analysis is open access software based on Microsoft 'Excel' that allows the easy entry of plant species data and percentage frequency, if available. The software allocates published attributes for Ellenberg numbers and CSR (Grime et al 1998). It displays individual species attributes as well as total species and community means (if frequency scores are provided). The resulting data when compared with other data-sets allows numerical comparison of vegetation communities distributed physically and temporally. From this it is possible to identify the effects of both management and natural trends on those vegetation communities. Vegetation Trend Analysis is not seen as a stand-alone vegetation analysis tool but as one to be used in combination with others.

Introduction
Many nature conservation organisations manage botanically species-rich wildlife sites and carry out monitoring to assess whether their management is maintaining or improving the quality of the community. Similarly, many are attempting to create or restore such sites. Much time may be spent in the identification and recording of species data. These may be collected by a variety of methods including fixed, random or grid quadrats, line transects or merely whole field species lists with a frequency measure such as DAFOR. Repeat data sets may show changes in species composition or frequency and in some cases unexpected trends are observed. However having found these, it is not always easy to ascertain what the changes may indicate.

There are two commonly used sets of indices published that may help to throw light on the reasons for changes found in vegetation assemblages. These indices available for individual species provide mean indices for populations that may vary and allow comparison between two or more sets of data.

Ellenberg numbers have five indices that describe for each plant species, its response to light, nitrogen, wetness, pH and salinity. Attributing numbers to the whole species unit sampled provides an average value for that unit. Changes to one or more of those factors may result in changes to species presence and frequency within the unit and so corresponding changes to both mean species and mean species frequency scores for the indices.

In 1988 Grime *et al* published growth strategy indices for a limited number of flowering plants and grasses. Amongst other factors these evaluated their relative competitiveness, (their ability to compete well when constraints are removed), stress tolerance (their ability to survive well in the presence of constraints such as absence of nutrients, drought or other severe stresses) and their ruderal strategy (their ability to colonise available land quickly). These factors they referred to as CSR. In 2007 Grime *at al* published a second addition that considerably expanded the range of species covered and revised the characteristics of some of the species previously covered.

In the early 1990s Sheffield University produced draft vegetation analysis software based on CSR. This was called 'FIBS' analysis or Functional Interpretation of Botanical Surveys. However, it was not released and draft versions ran in DOS. No further releases have been made.

In 1998 the Centre for Ecology & Hydrology (CEH) produced 'Mavis'; free software available from their website http://www.ceh.ac.uk/products/software/cehsoftware-mavis.htm. This gives a best fit to NVC as well as giving values for CSR and Ellenberg amongst other classification systems. However the software is in effect a 'black box', providing bare results with no supporting information about the goodness of fit or indications of the main contributing factors. It was felt that a more transparent and easy to use method would be helpful.

Method

VTA utilises Ellenberg numbers adapted for UK conditions (Mountford et al 1999) and their growth strategy indices 'Established Strategy' (CSR) (Grime et al 2007).

The Ellenberg numbers associated with a species indicate the degree to which a species is associated with a number of different environmental variables.

These are:

Light, (values 1 – 9) the higher the value the more light demanding the species and conversely the lower the more shade tolerant;

Moisture, (values 1 – 12) the higher the value the more wet tolerant, the lower the more dry tolerant;

Reaction to pH, (values 1 – 9) the higher the value the more associated with alkaline conditions, the lower the more acidic the conditions;

Nitrogen (values 1 – 9) general indicator of soil fertility, the higher the value the richer the soil and the lower the more impoverished;

Salt (values 1 – 9) a general indicator of tolerance to salinity, the higher the value the more and lower the less salt tolerant.

A more detailed definition of Ellenberg's indicator values can be found in Ecofact (1999).

Grime does not publish numerical values for CSR. Values are expressed as the mean distribution of factors for each species within an equilateral triangle, where the highest values of competitiveness, ruderal ability and stress tolerance lie towards each of the points of the triangle and the lowest values lie at the base of the triangle. Grime expressed these as combinations or multiple combinations of the factors CS&R. For this software, numerical values were obtained by drawing a triangle so that each of the angle bisectors measured 4 units, and values for each CS&R combination were measured perpendicular to the zero axis of each factor (Fig 1).

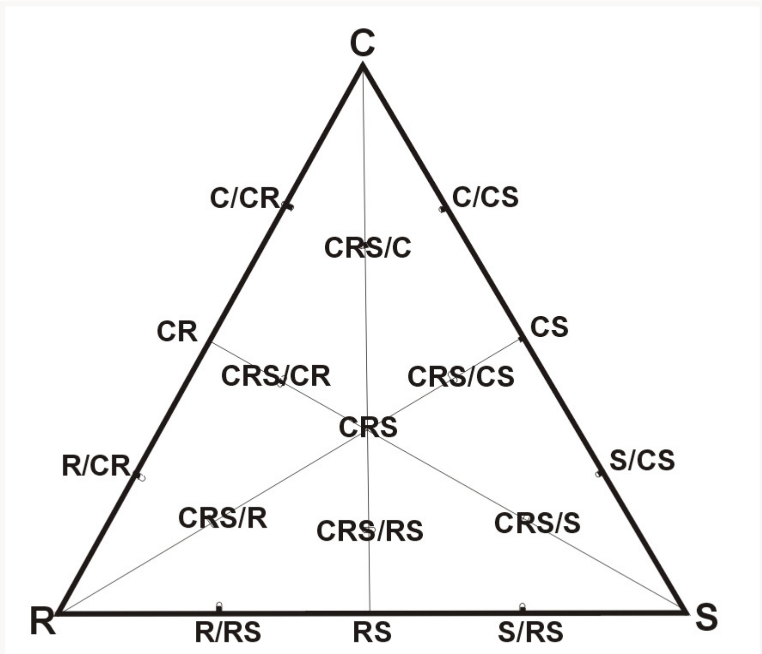

Figure 1: CSR triangle, after Grimes et al.

The highest values of Competitiveness, Ruderal characteristics and Stress tolerance are valued at 4 units and the lowest of each are 0 units. When the influence of one factor was at its maximum the other two were both touching the base (zero axis) and so have the value zero. Consequently on any point in the triangle the combined values of all three factors will always total 4. The values ascribed to each of Grime's published C, S & R combinations are shown in table 1.

	C	R	S	CS	CR	RS	CSR	CSR/C	CSR/R	CSR/S	CSR/CS	CSR/CR	CSR/RS	C/SC	C/CR	R/RS	R/RC	S/RS	S/CS
C	4	0	0	2	2	0	1.3333	0.675	0.675	0.675	1.7	1.7	0.6	3	3	0	1	0	1
R	0	4	0	0	2	2	1.3333	0.675	2.65	0.675	0.6	1.7	1.7	0	1	3	3	1	0
S	0	0	4	2	0	2	1.3333	2.65	0.675	2.65	1.7	0.6	1.7	1	0	1	0	3	3

Table 1: Shows the values derived for C, S and R (in rows) for each of the combinations of Competitiveness, Stress tolerance and Ruderal character (columns) used by Grime *et al.* *derived from Fig. 1 by physical measurement.*

When used together, the Ellenberg & Grime derived indices provide a numerical description of some of the factors that may be affecting both individual species and the plant community. Consequently these allow better identification of the reasons for changes in plant communities and so allow more informed decisions to be made about the future management of the community.

In order to fill the perceived gap, the lack of easy to use software to provide summary and easy to view information on Ellenberg and CSR, 'Vegetation Trend Analysis' was developed. This was developed for use in Microsoft Excel 2004 but continues to function in Excel 2010.

For data entry, the spreadsheet requires botanical scientific names and if available their percentage frequency. Species names can be entered either by typing, by selection from a drop-down or by copying a list from another file and pasting it into the species name (column 'A'). Once a species is accurately entered, the Ellenberg values and, if available, CSR data for that species will be generated in the columns representing Ellenberg and CSR for each individual species. If a percentage frequency value for the species is entered in column B, values will also appear in the columns giving the community values for Ellenberg and CSR. These are shown as a percentage of the total. Mean community values are also calculated.

<u>Discussion and application of Vegetation Trend Analysis (VTA)</u>
Comparison of mean values for species presence and mean values for community can give a strong indication of the vegetation community trend. Three examples of the possible uses for VTA are shown below.

The mean species-presence-values for species-rich neutral grassland may initially be broadly similar to grassland that has been enriched. However the community values may differ considerably due to a change in frequency of competitive species. Once such a difference is detected, a search through the rows of data looking at individual species can help identify which species are responsible for the change while their Ellenberg and CSR characteristics will help to identify possible reasons for change.

Vegetation Trend Analysis was demonstrated by comparing the values for NVC communities. Data was obtained by comparing typical species making up MG5, species-rich neutral grassland; MG6, semi-species rich neutral grassland and MG7, species-poor neutral grassland. Species data was sourced from Rodwell et al (1992)

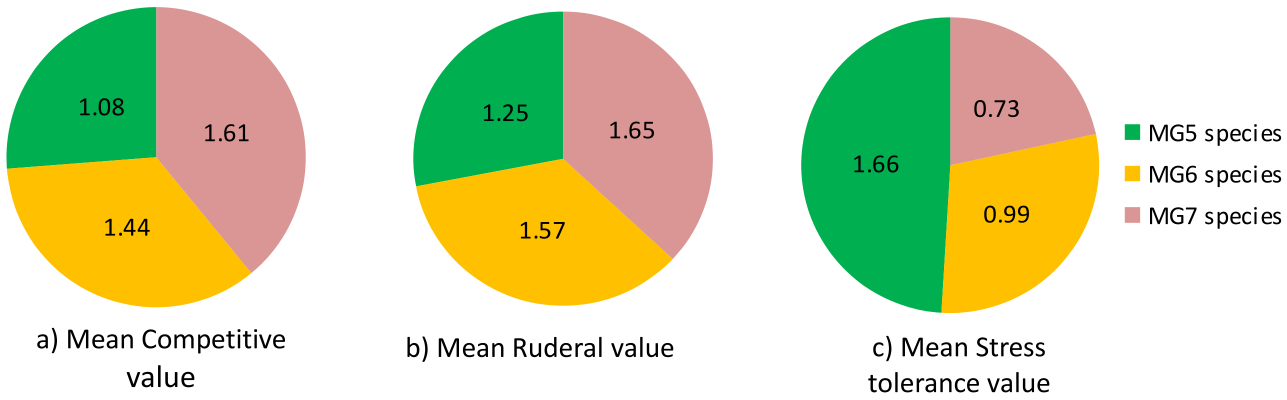

Figure 2: Pie charts comparing NVC communities – MG5, MG6 and MG7 for mean Competitive, Ruderal and Stress values.

Figure 2 shows that the competitive value was highest in MG7 and lowest in the MG5 community. Competitive species grow best when nutrients are plentiful and out-compete slower growing stress tolerant species, Figure 2c shows that MG5 species have a much higher value for stress tolerators. MG5 communities require soils with a relatively low nutrient status to avoid dominance by competitive species. These were present but were suppressed due to low nitrogen levels. When nitrogen levels were raised, the competitive species vigorously out-competed the slower growing stress tolerant species. This was further re-enforced by observing the pie charts in Figure 3 (below). There was a clear difference in nitrogen demand by the species found in the three communities, with MG5 the lowest and MG7 the highest. There is a similar but much less marked difference in light demand.

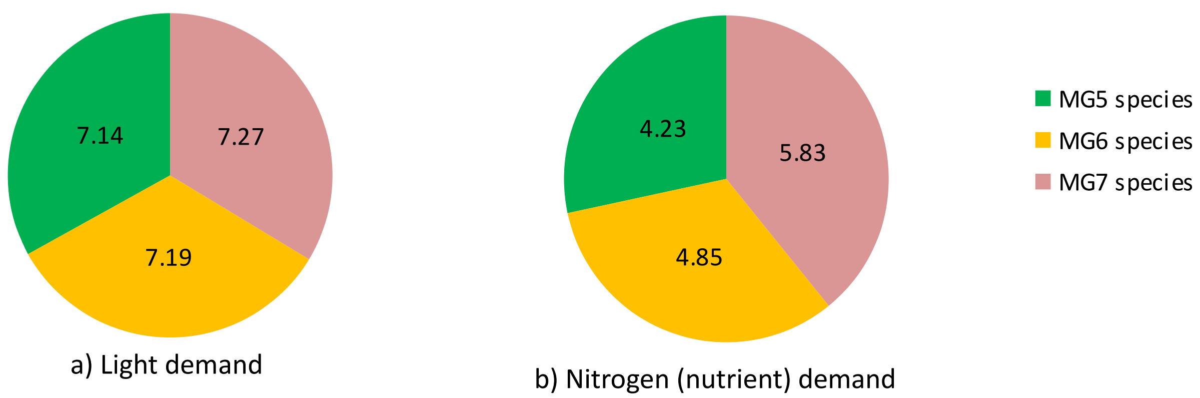

Figure 3: Pie charts comparing mean Ellenberg values from three NVC communities.

The reasons for small changes in species composition are not always immediately apparent. However, by using VTA it is possible to infer reasons for species change within neutral grassland communities. In particular it can be valuable where the species composition of a community remains the same but proportions of those species change. This can be illustrated by looking at the indices from two sets of 5, 1 metre quadrats taken at field 8 on either side of an access track at Chancellors Farm, Somerset (Table 2).

Location	Light	Moisture	pH - acidity	Nitrogen need	Salinity	Competitive	Ruderal	Stress tolerant
South of Drive	6.82	5.19	5.34	4.24	0.21	1.15	1.36	1.62
North of Drive	7.01	5.18	5.57	3.97	0.28	0.93	1.38	1.81

Table 2 shows the relative Changes within grassland on field 8 at Chancellors Farm. (Hancock unpublished data).

Both casual observations and rapid assessment suggested that part of the field south of the access drive was becoming increasingly grass dominated and rapid assessment monitoring showed a reduction in flowering plant content. The mean values of Ellenberg and CRS scores from each set of 5 quadrats show different trends. South of the drive, the vegetation scores higher for nitrogen need and competitiveness (highlighted blue), while north of the drive higher light demand, more alkaline pH, and a higher stress tolerance score (highlighted red). When tested for significance, none of these differences were significant ($p>0.05$), but considered together, the results can give numerical pointers, towards what may be happening and suggest possible changes in management needed to halt or reverse the decline.

On Westhay Moor, trend analysis was used to investigate the distribution of wetland vegetation to identify what was going on in an area of cut-over acid raised mire where restoration was being attempted. Water pumped onto the mire was more base rich and alkaline than ideal. There appeared to be a gradual increase in more typical fen species on parts of the site. The species present were put through VTA and then sorted by the pH index. Those most acidophilic showed much higher stress tolerance, lower competitiveness and ruderal ability along with a higher moisture, light demand and lower nitrogen tolerance.

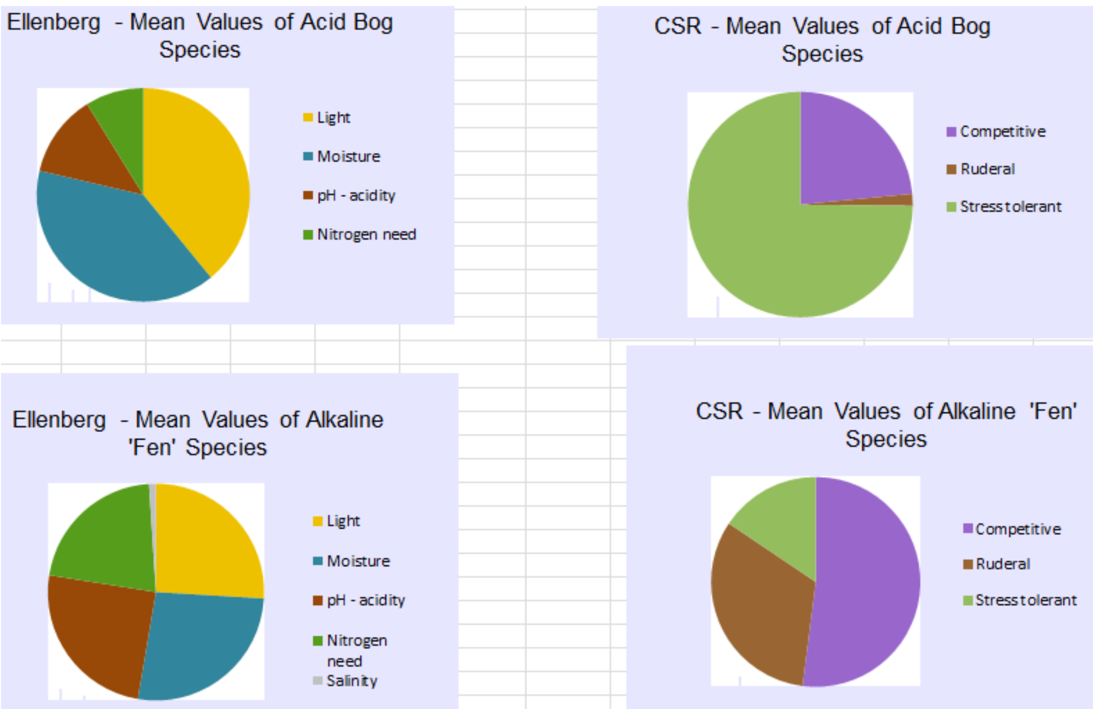

Figure 4: Comparing the characteristics of the vegetation at each end the Ellenberg pH index at Westhay Moor (Hancock unpublished data).

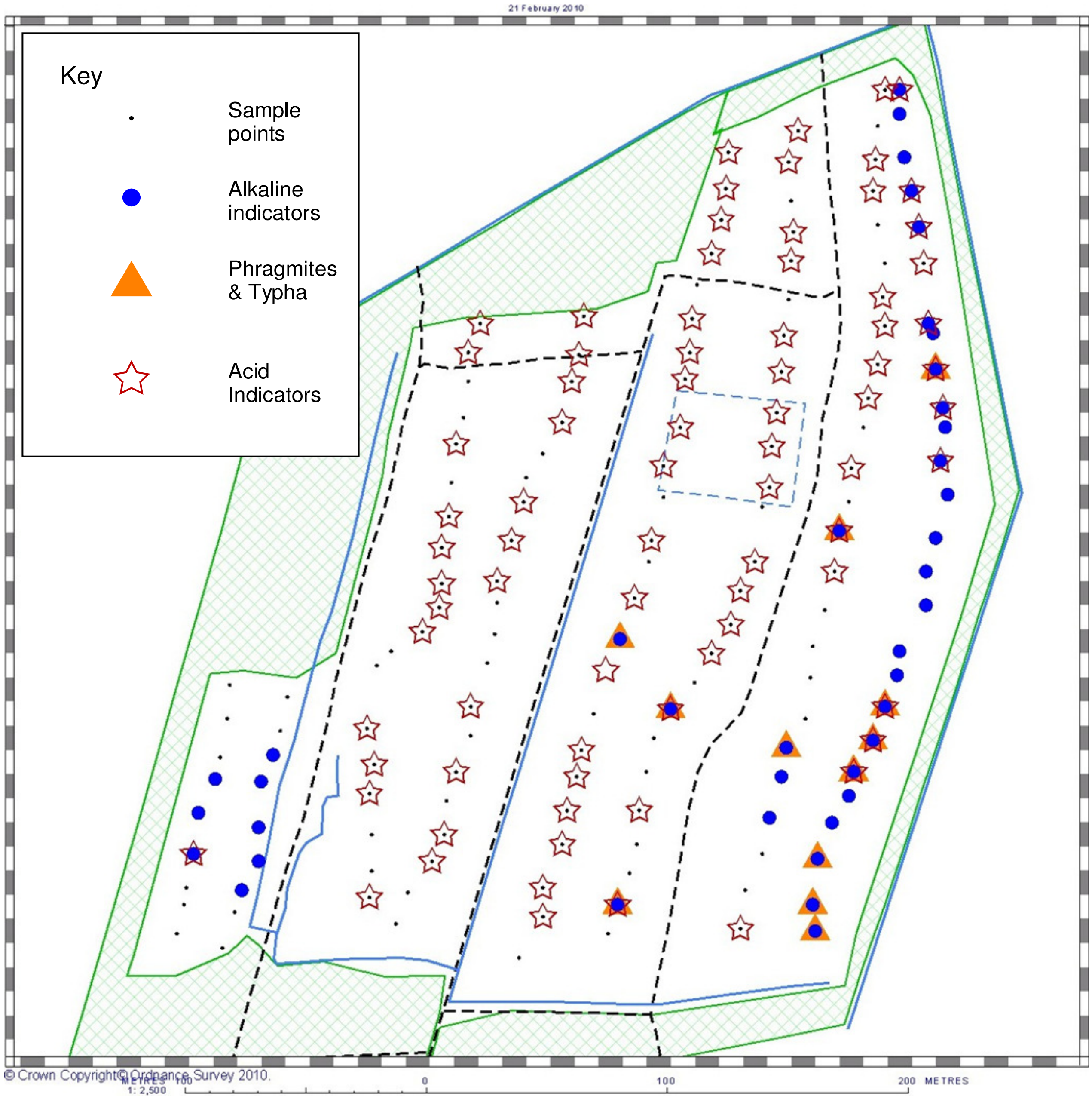

Figure 5 Map of Westhay Moor showing distribution of alkaline index species on Westhay Moor raised bog. (Hancock SWT presentation, 2009, Viridor funded project). By plotting the distribution of the species at each end of the pH index it was possible to show where pH changes were occurring.

Conclusion

Reasons for changes in a vegetation community or the difference of one community from another may be apparent but difficult to tie down. VTA gives the ability to provide a numerical description to inform a likely environmental or management change without the need to have previously collected environmental data. VTA is a useful tool, not only by providing a mean population score of the indices, but also direct access to the contribution made to that score by individual species. Direct comparison between the mean species scores with the mean species weighted by frequency scores gives direct insight into the influence of commoner species.

It is not always easy to deduce the main factors separating or grouping different species within a sample set. However the numerical description of the indices for each species provided by VTA makes the data highly amenable to ordination analysis.

A copy of VTA can be downloaded by opening http://www.somersetwildlife.org/Reports.html then click on 'Vegetation Trend Analysis'. While the software has been checked for viruses and errors in data, no liability can be accepted for any errors or losses caused by the use of the programme.

References

ECOFACT Volume 2 Technical Annex. http://nora.nerc.ac.uk/6411/1/ECOFACT2a.pdf

Grime J.P., Hodgson J.G., Hunt R., Comparative Plant Ecology; Published Botanical Society of the British Isles, 2007.

Hill, M.O.; Mountford, J.O.; Roy, D.B.; Bunce, R.G.H., (1999), Ellenberg's indicator values for British plants.

Hill M.O., Preston C.D., Bosanquet SDS, & Roy D.B., (2007), BRYOATT, Attributes of British and Irish Mosses, Liverworts and Hornworts, NERC Centre for Ecology & Hydrology and Countryside Council for Wales.

Rodwell J.S., Ed. (1992), For UK Joint Nature Conservation Committee, British Plant Communities Volume 3, Grasslands and Montane Habitats, Published Cambridge University Press 540pp.