Table 7.1: Review of research on indicators to detect and measure change

Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
	Ellenberg				
169	Calibrating Ellenberg indicator values for moisture, acidity, nutrient availability and salinity in the Netherlands. Plant Ecology. 1998. 135. 113-124. Ertsen, A.C.D., Alkemade, J.R.M., Wassen, M.J.	General	Calibration of Ellenberg indicators- moisture, acidity, nutrient availability and salinity. Calibration results to be applied in the multi-stress model developed to predict changes in species composition due to acidification, eutrophication and effects of lowering ground water.	Ellenberg - F, R, S, N.	Linear regression to relate Ellenberg indicator values to empirically measured soil variables, verified model by graphically checking the residuals.
171	Use and improvement of Ellenbergs indicator values in deciduous forests of the boreo-nemoral zone in Sweden. Ecography. 1995. 18. 178-189. Diekmann, M.	Deciduous forests.	Testing Ellenberg indicator values, calibration of values according to regional deviations.	Ellenberg-light, moisture, reaction.	Weighted averages, presence/absence, cover/abundance, optima and ecological amplitudes of the most common species calculated, compared to published Ellenbergs.
172	The flora of a cultural landscape: environmental determinants of change revealed using archival sources. Biological conservation. 2000. 92. 249-263. McCollin, D., Moore, L., Sparks, T.	General	To detect changes in plant species distribution since the 1930's in Northamptonshire, to detect the effects of environmental changes using indicator scores.	Relative abundance (e.g. very rare, ubiquitous) Ellenberg - L, T, K, F, N, R, S, climate change indicators (major biome category, eastern limit category). Species assigned categorical ranks with respect to estimates of potential for lateral spread, defined by sizes of clonal patches occupied by connecting branching systems of stems, number of habitats occupied, abundance in the seed bank and dispersal weight.	Relationship between number of pentads occupied by plant species in Gent and Wilson's flora and Druce's abundance rankings was highly significant. The form of the relationship was compared with that from linear regression, both similar subsequent analyses were carried out using residuals from linear regression.Standard deviations from regression line were examined. Spearmans rank correlation between Ellenberg Ns and residuals from regression.
173	Vegetation analysis along a successional gradient from heath to oak forest. Nordic Journal of Botany. 2000. 537-546. 20. Sorenses, M.M. and Tybirk, K.	Heath, oak forest.	To use information about site and succession in combination with detailed data on vegetation and soil chemical parameters to elucidate and discuss general features of soil-vegetation interactions at different stages of autogenic succession.	Ellenberg indicator values for light, nitrogen and acidity calculated as average indicator values weighted by frequency of vascular species	Plots divided into clusters using Steinhaus coefficient, group average method on PC-ORD, CANOCO. Correlations between the first DCA axis and measured environmental parameters calculated using Spearmans rank, first two DCA axes and Ellenberg values calculated. To measure successional gradient first axis of PCA based on environmental variables highly correlated with first DCA. Using CANODRAW first PCA axis used to fit curves for the distribution of the most common species along the gradient.
174	Ecological indicator values of British species: an application of Gaussian logistic regression. Annales Botanici Fennici. 2000. 37. 219-226. Roy, D.B, Rothery, P., Bunce, R.G.H.	General	To produce a standardised set of British Ellenberg values using a technique based on Gaussian logistic regression.	Ellenberg - L, T, K, F, R, S.	Gaussian logistic regression as a means of estimating ecological indicator values and amplitudes of species. For each sample quadrat calculate the mean indicator score use Gaussian logistic regression to calculate an optimum and tolerance based on the quadrat means. Significance of optimum judged by whether the quadratic coefficient is less than 0. A small number of species didn't have optima, where these had significant linear logistic regression coefficients they were assigned to the category Linear logit.
175	The use of ground vegetation and humus type as indicators of soil nutrient regime for an ecological site classification of british forests. Forest ecology and management. 2001. 140. 101-116. Wilson, S. M., Pyatt, D. G., Malcolm, D. C., Connolly, T	Woodland	Using ground vegetation to indicate soil nutrient regime.	Ellenbergs R and N.	PCA on soil chemical data, CCA on soil chemical and vegetation datasets (vegetation as site mean ellenberg indicator values).
176	Hedgerows as habitat for woodland plants. Journal of Environmental Management. 2000. 60. 77-90. McCollin, D., Jackson, J.I., Bunce, R.G.H., Stuart, R	Hedgerows	To investigate the autecological and habitat characteristics of woodland species in relation to their relative frequencies in hedgerows and woodlands. To establish what conditions are necessary for hedgerows to serve as corridors.	Habitat preference index based on whether species are more frequent in hedgerows or woodlands. Ellenberg L, F, R, N, T and K, weight of dispersal, capacity for lateral spread, perennials, presence of a seedbank, C,S,R, measures of ecological amplitude in habitats NHABTS-range of primary habitats in which species are found and in woodland plant communities NVC-number of NVC communities in which species occur.	Enter HPI values into Spearman rank correlation tests with habitat and autecological indicator scores. To control for the range of habitats, repeated analyses using partial correlation coefficients. To test whether differences in dispersal mode could explain relative frequencies of plants classified by dispersal mode (anemochores, endozoochores, epizoochores, hydrochores, myrmecochores and unspecified). G tests were used to test for differences in frequencies in dispersal modes.
177	How to determine a regional species pool: a study in two Swedish regions. Oikos. 2000. 89. 128-136. Dupre, C	Dry calcareous grasslands, coastal meadows, deciduous forests.	1.To improve the ecological method for screening species and to introduce a new phytosociological method. 2. Test which of the methods is most effective in defining the regional species pool.	Ellenbergs - L, T, K, F, R, N, S.	To calculate regional species pool, those species in the regional flora that are able to occur in the target community are filtered out. This is done by using Ellenbergs, mean Ellenberg for each vegetation type. 6 methods were tested with species using different criteria such as 3 values matching means and 4th unimportant, Phytosociological. Floristic similarity between the regional pool and the community pool determined using Sorensons similarity index.

Table 7.1: Review of research on indicators to detect and measure change

Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
169	Relationships between indicator values and measured variables linear and non-linear.	Chloride concentration in groundwater is clearly related to the indicator value for salinity. Mean indicator values give significant insight into environmental conditions of a plot.	Variation around the regression line, one explanation may be the lack of a tolerance value to be used as well as the optimum.	Standing crop and N stock much better predictors for nutrient availability than soil variables i.e. Ellenberg N = productivity.	
171	Presence/absence values preferable considering ordinal and non linear scale of cover/abundance scales. Standard deviation used for	May help to estimate the value of an environmental factor in the past for which only vegetation data are available. Integrated information on temporarily fluctuating factors.	When dealing with species poor and/or extreme environments averages are used, as Ellenbergs are ordinal it is proposed that medians should be used instead. Cover/abundance for reaction worked better for bryophytes as there are few species.		
172	Significant correlation with climate variable ELC not matched by a significant correlation for related Ellenberg climate variable-K, this was not necessarily expected due to Central European focus of Ellenbergs data.	Gives information on causes of change. Increase in Ellenbergs N, number of habitats in which species is found, changes in plant status were significantly correlated with degree of lateral spread and seed weight, and inversely with abundance of seed bank i.e. variables indicative of the effects of habitat fragmentation generated significant correlations. Uses wider flora rather than focusing on selected species.	Possible inaccuracies and differences in the level of effort in historical data. Need to put in context to national trends, compared to other county datasets but these may not be independent.		
173		Used to integrate vegetation and environmental data with succession, Ellenberg scores reflect changing successional conditions.			
174		Reprediction using methods based on large scale quadrat samples best way of extending Ellenbergs to a new area.	Univariate approach takes no notice of correlation between variables.	Ecological optima of species dependent on presence or absence of potential competitors which change with geographic location, ecological amplitude of species may be narrower at the edge of their range. Progress in extrapolating ecological indicator values to new geographical areas will be greatest when the variables can be defined by external criteria.	
175		Relative abundance of a small number of common species in the ground vegetation on a site gives a quantitative way of predicting the soil nutrient regime. Relationship of NVC woodlands to soil nutrient regime clarified.			
176	Difference in plot size between woodland and hedgerow plots.	Habitat preference indicators significantly correlated with Ellenberg indicators for microclimate, soil nitrogen and pH. Gives information about habitat quality.			
177		Phytosociological data consider actual distribution of species. Ellenbergs and phytosociological methods work best for deciduous factors probably due to light screening factor.			

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Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
178	Reliability of Ellenberg indicator values for moisture, nitrogen and soil reaction: a comparison with field measurements. Journal of Vegetation Science. 2000. 11. 225 244. Schaffers, A.P., Sykora, K.V.	Roadside communities.	To test the reliability of the Ellenberg F, A and N, using measured parameters.	Biomass, Ellenbergs.	Species based and site based weighted averages. Calculated species optima correlated with species indicator values F, N and A, correlation coefficients calculated for vascular plants and bryophytes, site mean indicator values correlated with parameter values measured at sites.
179	Factors influencing vegetation gradients across ancient-recent woodland borderlines in southern Sweden. Journal of vegetation science. 2000. 11. 515-524. Brunet, J. von Oheimb, G., Diekmann, M.,	Woodland	To determine how distance from the borderline between ancient and recent woodland influences species distributions, as compared with soil factors and degree of canopy closure.	Ellenberg - moisture, reaction, and nitrogen, light not used because woodland species have low L values- canopy cover calculated as the sum of all cover species in the tree layer.	Weighted averages for Ellenbergs, ordination to study the floristic structure of the recent woodlands and adjacent ancient woodland, Correspondence analysis (CCA) with variance partitioning - CCA using one of the explanatory variables and removing covariation with th remaining variables by using them as covariables. Linear regression of the sample scores of the first CA axis vs explanatory variables used to determine which variable was closest. Differences between environmental conditions in ancient and recent woodlands tested by Mann Whitney U tests. Differences between amount of variation explained by the different supplied explanatory variables, tested with Wilcoxon paired sample. The relationship between amount of variation explained and stand age tested with linear regression analysis. Field layer species - wooded and non-wooded, to determine differences in species frequency between ancient and recent parts, two way contingency G test. Population considered to be advancing if linear regression analysis showed a significant decrease between observed mea maximum cover and the farthest occurrence of a species.
180	Extending Ellenberg's indicator values to a new area: an algorithmic approach. Journal of Applied Ecology. 2000. 37. 3-15. Hill, M.O., Roy, D.B., Mountford, J.O., Bunce, R.G.H.	General	Repredicted Ellenberg values for vascular flora of Britain. Added values for L, F, R, and S not in dataset. Resulting table 1503 native species, 33 possibly native species, 220 introduced species.	Ellenbergs - L, T, K, F, A, N and S.	Reprediction algorithm, CANOCO, local weighted regression, goodness of fit measured by root mean square error.
199	Water regime requirements of British wetland vegetation - using the moisture classifications of Ellenberg and Londo. 1993. Journal of Enviromental Management. 38. 275-288. Mountford, J.O.	Wetland vegetation (Somerset grazing marshes, Cambridgeshire ditches and ponds, and Somerset wet peat grasslands).	Reports on use of Londo and Ellenberg classifications to interpret field data.	Ellenbergs, Londo.	Contrast between mean % covers, species where contrast is significant separated into those commoner in pumped fens and unpumped fens. Average Ellenbergs for site or community, CANOCO- variables;management, grazing, adjacent landuse, depth, width, % shade of ditch.
200	Prediction of yield in the Rothamsted Park Grass Experiment by Ellenberg indicator values. Journal of Vegetation Science. 1997. 8. 579-586. Hill, M.O., Carey, P.D.	Grassland	To see how effectively Ellenberg values indicate the ecological condition of the plots.	Mean Ellenberg indicator values for R and N.	Species composition, ordination using DCA.
202	Using Ellenberg indicator values to assess soil quality in British forests from ground vegetation: a pilot study. Journal of Applied Ecology. 1997. 34. 375-387. Hawkes, JC	Woodland	To use plants as indicators of soil quality.	Ellenbergs- F, R, N, mean indicator values using cover abundances for each species as weighting values.	Variation in soil chemical variables analysed by PCA and PCA site scores, compared with site mean indicator values.
203	Acidification and eutrophication of deciduous forests in northwestern Germany demonstrated by indicator species analysis. Journal of Vegetation Science. 1997. 8. 855-864.Diekmann, M., Dupre, C.	Woodland	A species based indicator method that allows the comparison of releves from different points in time without having to exactly relocate the points.	Weighted average Ellenberg calculated for all releves.	All releves used to determine the equation for the regression of N on R and to calculate predicted values of N for all R. Four scenarios of floristic changes due to acidification.
206	The partial influence of Norway spruce stands on understorey vegetation in montane forests of the Bavarian Alps. Mountain Research and Development. 2000. 20. 364-371. Ewald, J	Montane forests.	To investigate how species composition of canopy cover affects the character species, indicators of acid conditions and high nitrogen supply.	Species richness, Ellenberg R and N.	Stratification into stand types, mean Ellenbergs for each 144 m^2 plot. Explaining variable - proportion of spruce cover in the canopy, covariables - depth of mineral soil development and free carbonate, total horizontal cover of tree layer, partial correlation analysis, partial correlation coefficients tested for two tailed significance.

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Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
178		1. Ellenberg N values should be 'productivity values', strong correlations with vegetation parameters and most noticeably above ground biomass. 2. Site based correlations consistently higher than species based - assemblages of species yield more accurate indications.	Uneven distribution of indicator values for the species of a given region. For Ellenberg R, individual species, geographical changes in species preferences and site mean reaction values, don't indicate soil pH satisfactorily. Indicator values summarise a complex of parameters associated with the factor indicated. Additional weighting with species tolerances required (e.g. pH, species with pH optima near the extremes show narrow tolerances while species with intermediate pH optima show wide tolerances. Ellenberg N values only weakly correlated with soil parameters).	Using abundance values as weights when calculating mean indicator values generally improved the results.	
179	Explanatory variables often intercorrelated.	Gives environmental information on characteristics of woodlands to use as context for distribution of woodland species between ancient and recent woodland. Although distribution is the main limiting factor, Ellenbergs allov understanding of the environmental conditions.	Interaction between factors, e.g. in this case pH affecting distribution of some species whilst high P levels favours establishment of tall herb species.		
180		Universality - permits comparisons of differing communities on scales that are ecologically meaningful.	Quadrat size - $200m^{2,}$ some discrepancies with L values, large quadrats may have contained light and dark patches. Sampling strategy for dataset meant that for some species the realised niche was not sampled. Scale - Ellenbergs refer to environment of plant whereas mean value for quadrat refers to a larger area - best to average across species. Best way to achieve an adequate original scaling is to ensure that values correspond to measurable physical or chemical variables, L-illumination in July, T avg. temperature, R-pH, F and S large seasonal fluctuations, N- very vague, K-geographical rather than climate.	Indicator values general reference system to be calibrated against measured variables in a specific context.	
199		1. Ellenberg approach simple. 2. Phreatophyte classification determines how much of flora at a site depends on influence of groundwater.	Ellenberg system does not take account of interactions between environmental variables.		
200	Unweighted mean better predictor of yield than weighted mean.	Unweighted mean Ellenberg N values predicted annual yield.	Ability of abundance weighted Ellenberg R to predict soil reaction disappointing.		
202		Use of mean indicator values for F, R and N may provide a simple and effective means of assessing and displaying soil quality. Abundance-weighting of Ellenbergs essential.	Needs more calibration of species' Ellenberg values to soil conditions.		
203		Method suitable for demonstrating floristic change, allows comparison of sites from different time periods and localities.			
206		Ellenbergs used to look at variation in species composition resulting from changes in the canopy cover. Used successfully to determine that introduction of spruce into canopy affects Ellenberg R and species richness of ground vegetation.			

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Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
265	Temporal analysis of the Brussels flora as indicator for changing environmental quality. Landscape and Urban planning. 2001. 52. 203-224. Godefroid, S	Urban	Comparing past to present flora datasets to see what human impacts have been.	Ellenbergs - F, L, A, T, N, comparison of native and non-native species.	Mean Ellenbergs compared across all sites between years and for native and non-native.
269	Computed ecograms of Swiss forests. 1999. 109. 169-191. Wohlgemuth, T., Schutz, M., Keller, W., Wildi, O.	Forest	To discover: 1. Which are the predominant gradients causing differences in forest vegetation allover the country. 2. How does a calculated gradient system of forests fit Ellenberg's ecogram of a well defined region.		
336	Ellenberg's indicator values for British plants 1999. Hill, MO, Mountford, Roy, DB and Bunce, RGH. Report for DEFRA.	General	To make Ellenberg indicator values available for the whole British and Irish Flora.	Ellenberg indicators for 1791 taxa , F, L, N, R and S.	Ellenberg values are a mixture of objective results based on calculation and subjectively derived values based on field experience. Can be used as mean sample indicator values to look at changes over time and as a means of interpreting ordinations
16	Multi-scaled and multi-species pattern analysis in boreal forest communities. Maslov, A.A. in Spatial Processes in Plant Communities pp83-88.	Boreal forest.	To detect typical sizes of multi-species spatial patterns, to describe groups of associated species, to identify causes of pattern at different spatial scales.	Landolts and Ellenberg indicator values Indicators for L, F, A and N, calculated for each quadrat by averaging values for species. Ground layer species affinities with single tree species.	Nested blocks and Principal Components Analysis, species grouped according to loadings on first two PCA axes. Axes interpretation in ecological terms using Landolts and Ellenbergs indicator values. Indicators for L, F, A and N, calculated for each quadrat by averaging values for species. Improved estimates made using these values, niche values for communities. Ground layer species affinities with single tree species studied by performing direct ordination of species along the gradients that reflect influence of species . Intensity of influence studied using different formula. Weighted average for each species
353	Ecological assessment of vegetation from a nature reserve using regional reference data and indicator scores. 2000 Smart, SM	Soligenous mire	To use regiona.l reference data and indicator scores to test a method for establishing a context for spatial and temporal comparison	Ellenberg A, F and N, species richness, Berger Parker Dominance index.	Radar plots, plotting percentile values for indicator scores for each regional reference unit and for newly sampled patches.
329	Measuring change in British vegetation. 1999 Bunce, RGH, Smart, SM, van de Poll, HM, Watkins, JW and Scott, WA.	General	Extended analysis of Countryside Survey (CS) data and developed a range of indicators of Botanical diversity.	Ellenbergs: N, L and F.	Gradients of nutrient level, shade/disturbance, and soil moisture dominate the main vegetation analysis. Ellenbergs weighted by cover, Ellenberg scores related to the position of the vegetation class on the first 3 axes of the DECORANA ordination.
	Community classification				
329	Measuring change in British vegetation 1999 Bunce, RGH, Smart, SM, van de Poll, HM, Watkins, JW and Scott, WA.	General	Extended analysis of CS data and developed a range of indicators of Botanical diversity.	CVS - identify groups with similar ecological affinities. For statistical tests and derivation of indicators, vegetation classes have been grouped into 8 Aggregate classe. CVS and aggregate classes related to functional and diversity analyses, enable changes to be noted at the landscape scale. The average number of vegetation classes in each 1km square provides a measure of botanical diversity at the landscape scale.	CVS - Twinspan into 100 vegetation classes arranged using DECORANA to reveal patterns of similarity, grouped by aggregate class. Habitat conversion - net shifts of plots between aggregate classes used to measure change. Species groups determined by Ward's minimal variance clustering of the first four axes of the species scores from the DECORANA analysis. Change in species groups, changes between aggregate classes.

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Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
265		Combines species data with functional data to investigate how human impacts have affected the flora over time.			
269	Landholt, Ellenberg				
336			Species not always constant in ecological requirements, some have different indicator values in different parts of their range. Intermediate value used.	Neither T or K are included because they are unsatisfactory in an oceanic climate such as Britain.	
16		1. Analysis methods allow observations to be made on structure and vegetation dynamics rather than just ordination to classify into communities. 2. Results, such as affinities of ground flora species to particular tree species by weighted averages of certain traits, seems like a good/novel way of using this kind of data.	1. Bit unsure about using weighted averages gained from the data to analyse the data, paper isn't that clear about how this is done. 2. Bit short of info on methods, whether quadrats were done systematically, same numbers, same sizes etc.		
353		Ellenberg wetness scores indicated vegetation characterised by wetland plan species. Identified differences between reference data and sample data relating to management/site condition.	Wide species tolerances of Ellenbergs restrict usefulness, could calibrate Ellenbergs for each region.		
329		Relationships between veg classes (CVS and Aggregate) and environmental variables are used to help interpret and predict changes in vegetation at a given location. If a plot changes its' vegetation class along a particular gradient then the change is likely to have resulted from the associated environmental change such as an increase in soil fertility.			
329		CVS provides a statistically valid means of describing vegetation character and its distribution in the wider countryside and summarises vegetation in a manner directly interpretable with respect to key environmental drivers. Comparisons to other classifications. Comparisons made between 100 CVS and 89 major categories of CORINE. CS-Phase 1 reasonable equivalents with most of the categories, some vegetation classes need to be combined. Expert judgement comparisons between BH's and CVS - poor agreement. CS1990 landcover and CVS - no exact correspondence. SIMIL used to assign average composition of CVS classes to NVC, comparisons difficult because plots in CVS placed at random within 1km squares rather than homogeneous stands of NVC.			

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Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
409	Vegetation monitoring in English Environmentally Sensitive Areas: The potential role of the Countryside Vegetation System. 1999., ADAS	General	To asess the role that CVS might play in the vegetation monitoring programme, to assess the ability of the CVS to distinguish between vegetation types sampled in the ESA's and to assess the interpretative value associated with classifying vegetation in this way.	CVS- two roles, as general classification framework for the description and grouping of ESA samples prior to analysis and to provide a link between ESA and Countryside Survey datasets. ESA datasets were classified using MATCH and NVC and TWINSPAN to adjust before analysis carried out.	
	FIBS				
50	Monitoring Grasslands Volume I. Hodgson, J.G., Colasanti, R. and Sutton, F	Grasslands	Simple method for analysing functional changes in the floristic composition of vegetation. Examines differences over time or between sites.	FIBS, CSR values available for 501species. Commonest habitat in which species occurs. Monocarpic species (separated into summer annuals, winter annuals and monocarpic perennials) canopy structure - basal, semi-basal, leafy, maximum canopy height, lateral vegetation spread, regenerative strategies-persistent seed bank, wind dispersed spores, regeneration from vegetative fragments. Phenology, association with acidic soils, species richness, status, flowering time, seed weight.	Method 1; presence/absence for small quadrat, 2; quantitative, using cover or rooted/shooted frequencies, 3; sp. subdivided into those that have increased, intermediate between, decreased. Database accessed by FIBS. Compare values using non-parametric tests.
188	Functional interpretation of archeobotanical data: making hay in the archaeological record. Vegetation History and Archaeobotany. 1999. 8. 261-271. Hodgeson, J.G., Halstead, P., Wilson, P.J., Davis, S.	Hay meadows	Botanical composition of present day communities was analysed in terms of functional attributes in relation to management regime and compared to historical data.	FIBS, life history, canopy height, canopy structure, and stress tolerance. Average value of stress index, proportion of biennials, presence or absence of woody species, distribution of canopy height classes, canopy structure using data for taller polycarpic perennials.	Botanical composition of modern British grasslands analysed using FIBS, Archaeological records of grassland composition are then analysed and changes in the frequency of functional attributes used to infer past management practices. Non-parametric tests of differences between mean index values (Spearman's rank).
204	Distinguishing the effects of agricultural practices relating to fertility and disturbance: A functional ecological approach in archaeobotany. Journal of Archaeological Science. 2000. 27. 1073-1084. Jones, G., Bogaard, A.,	Agricultural	Differences in weed floras associated with different scales of cultivation, related to differences between plots in the degree of fertility, disturbance and watering.	FIBS, 17 attributes measured; attributes relating to duration and quality of growth period -canopy size attributes, leaf size attributes, weed size, capacity to regenerate under high disturbance -length of flowering period, vegetative spread, attributes relating to water use - mean stomatal size and density, epidermal cell size, cell wall undulation, root diameter, attributes relating to shade tolerance.	CANOCO, discriminant analysis best linear combination of variables, five different cultivated plots as groups to be discriminated, attribute scores related to fertility, water use and disturbance as discriminating variables.
329	Measuring change in British vegetation 1999 Bunce, RGH, Smart, SM, van de Poll, HM, Watkins, JW and Scott, WA.	General	Extended analysis of CS data and developed a range of indicators of Botanical diversity.	Plant strategy theory- C,S,R, Functional analysis of botanical change, plant traits, derived from plant species distributions, plant morphology, species ecology.	Classify plant species into functional groups using responses to gradients of productivity and disturbance, main gradients of CVS, Aggregate classes classified by Functional strategy composition. 3 types of analysis, change in mean characteristics of plots by aggregate classes, stay-the-same analyses - same aggregate classes, more subtle changes in species composition. Type 3 1978 based analysis, matched pairs by aggregate class in 1978 irrespective of class in 1990.
352	Sensitivity and calibration of Plant Community Variables for Grassland monitoring in English ESA's 1999 Critchley, CNR, Burke, MJ and Fowbert, JA	Grassland	Testing community variables.	CSR	MANOVA - all variables tested simultaneously with regard to their response to treatment factors and a Rao R statistic. The sensitivity of the community variables in detecting differences between different treatments over time were ranked by the F statistic.

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Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
409		CS data could be used to test whether vegetation responses relevant to ESA objectives also occurred in the wider countryside or whether confined to land under ESA agreement - carry out ESA methods on CS data. Could also analyse ESA data using CS methods to see if the same trends are taking place. To compare the state and quality of vegetation in ESA's with the wider countryside need to calibrate community variables in the same way as has been done for high conservation value plant communities.	Poor differentiation of ESA lowland grassland datasets possibly due to differences in sampling - the wider countryside is dominated by fertile disturbed habitats with scarce unimproved grasslands, in contrast semi-improved and unimproved grasslands targeted for ESA's. Most of the lowland grassland sample fell into only 5 CVS classes, not sufficient for analysis of change. Differences in timescal Compatibility with NVC - plot size may incorporate more than one NVC community. CVS aggregate classes too generalised to convey information about vegetation at sufficient detail.		
50		Analyses functional changes in the floristic composition of vegetation and is particularly suited to studying the impacts of modern landuse.	1. Problems of measurement. 2. Problems of using species as descriptive ecological units - variation in genotypes, different life-historys in different locations. 3. Problems associated with ecologica theory - strategy theory only attribute in FIBS that identifies eutrophication, understanding of factors affecting regeneration incomplete. 4. Constraints imposed by floristic dataset - number of species, ecological similarity of species. 5. inadequacy of climate change component.	1. Attributes must be equivalent for each species. 2. Attributes must be quickly and easily measured and ecologically useful. 3. Vulnerability to a particular ecological factor should be assessed independently.	
188	Using method to analyse an incomplete dataset, data not normally distributed, non-parametric tests.	Using plant functional attributes to assess botanical composition and management regimes of communities in this case comparing present day with past. 2. Can use incomplete dataset to gain some understanding of community function. 3. Once species have been characterised the method is straightforward to use.	1.Need more information on intraspecific variation. 2. Variation in attributes. Life history - one of the attributes can vary under different circumstances.		
204		Functional attributes discriminate between plots cultivated at different levels of intensity.			
329					
352		CSR provides standardised, easy to interpret measures of change in species composition.	CSR must be appropriate to the community chosen as if it is applied to functional attributes or habitat associations which are poorly represented may be oversensitive to changes in individual species.		

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Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
339	Calibration of plant community variables for mires, wet grasslands and upland communities. 2000 Fowbert, JA and Critchley, CNR.	Mires, wet grassland, upland	Calibration of community variables to external datasets.	CSR	Could not compare results statistically, presented graphically.
337	Comparative Plant Ecology: a functional approach to common British species Grime, JP, Hodgson, JG and Hunt, R.		To provide autecological accounts of the biology and ecology of common Vascular plants of the British Flora.	CSR, regenerative strategies, canopy structure and height, flowers, seeds.	Screening experiments and literature searches to collect plant trait information.
	Suited species				
338	Ecological assessment of plant communities by reference to species traits and habitat preferences. Critchley, CNR.	Arable field boundaries.	Testing suited species method.	Suited species - D, M and N.	For each criterion D, N, M, score calculated as measure of relative contribution to total vegetation of species suited to specified condition. For a transect suited species score = total suited species/total species. Suited species calculated for each transect and then derived for each site. Comparative assessment of sites from expert judgement.Spearmans rank used to compare experts ranks with site scores. Site foci-overall comparison between sites of degree to which management objective had been met. Analysed using a mixed model ANOVA, with two random factors site and transect.
410	Monitoring the consequences of vegetation management in Environmentally Sensitive Areas. Critchley, C.N.R., Smart, S.M., Poulton, S.M.C., & Myers, G.M.	Grassland, mires, heaths.	To highlight specific aspects of the methods used to monitor vegetation in the ESA's.	Suited species, G, Nu and W.	Two suited species scores, one for proportion of species in the quadrat and one for proportion weighted by DOMIN values. Differences between scores analysed using GLM, significance testing by randomisation tests.
352	Sensitivity and calibration of Plant Community Variables for Grassland monitoring in English ESA's 1999 Critchley, CNR, Burke, MJ and Fowbert, JA	Grassland	Testing community variables	Suited species scores - A, G, Nu, W, C.	MANOVA - all variables tested simultaneously with regard to their response to treatment factors and a Rao R statistic. The sensitivity of the community variables in detecting differences between different treatments over time were ranked by the F statistic.
339	Calibration of plant community variables for mires, wet grasslands and upland communities. 2000 Fowbert, JA and Critchley, CNR.	Mires, wet grassland, upland.	Calibration of community variables to external datasets.	Suited species scores - A, G, Nu, W, C.	Could not compare results statistically, presented graphically.
	Condition assessment				
260	Monitoring the condition of lowland grassland SSSI's II. A test of the rapid assessment approach. English Nature reports No. 315. ISSN 0967876X. 2000. Robertson, H.J., Bingham, J., Slater., I.	Lowland grassland	To assess whether nature conservation features of sites are in a favourable condition, this report assess the common standards methodoloy by comparing condition assessment of sites with more detailed monitoring and quadrats. Comparison of common standards with functional groups.	3 NVC types of lowland grassland were examined in 15 sites. Noting frequency of community character species, negative indicator species, proportion of herbs, sward height, litter and bare ground. Also mapped damaged areas. Also detailed recording in 40 quadrats - vascular plant species and vegetation height recorded in all quadrats, % cover of herbs, bare ground, dead plant litter, recorded for random sub sample of 10 quadrats in each of 12 sites. Species composition of a random sub sample of damaged areas, 3 per NVC type recorded for 10 quadrats for each area. Analysis of species composition by nutrient suited species to assess eutrophication, grazing suited species, wet suited species, ruderal strategy-disturbance, total number calcareous indicators and total number mesotrophic.	Comparison of attributes (condition assessment method) and functional species groups. Differences in averages of each category between sites (within NVC type) - Kruskal Wallis comparing undamaged and damaged sites. Differences in average values between pairs of sites tested using non-parametric comparisons of ranks.
106	A simple method for monitoring grassland vegetation. Hodgson, J.G.; Colasanti, R.; Philipson, P.; Leach, S.; Montgomery, S.; Dickson, M.	Grassland	Paper- detecting vegetation change.	Ecological attributes - CSR, FIBS computer program.	n/a

Table 7.1: Review of research on indicators to detect and measure change

Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
339		Mire communities well differentiated by community variables.	There was a variation between habitat types as to how well the community variables could differentiate. Wet mesotrophic grasslands were on a gradient. Mosaics of heathland/grassland can be a problem particularly where management cause a shift in vegetation type rathe than changes in quality within the community.		
337		The sets of attributes associated with the primary strategies suggest many opportunities to interpret the distribution and population dynamics of species and to predict the consequences of changes in their environment or management regime.			
338		Where relationships are known between different environmental factors they should be manifested in the suited species score, known relatioship between soil moisture and nutrient availability reflected by a positive correlation between M and N scores. Predicted that variation in biophysical conditions between sites would be reflected and this was the case. Management information: regular cultivation expected to maintain communities with high proportion of annuals (high D scores), in study area 2 where there was less frequent cultivation the D score was lower. Good correlation between judgements of experts and site scores.	Habitat preferences are not true surrogates for traits as they are the product of the interaction between the attributes of individual species and their biotic and abiotic environment. Difficulties in using data from a variety of sources, defining rules for each criterion and applying systematically produces a repeatable, accountable method. Some adjustments to habitat preference may be needed when applied in other geographical regions as species preference varies in different parts of their range.	To determine whether the conservation objective has been met at the site necessary to compare scores against a threshold level representing the minimum standard of the goal vegetation. In current example the SSSi acted as a stable benchmark against which other site foci could be compared.	
410		Targets the monitoring programme at the specific objectives of the ESA.	External factors such as winter flooding can produce large changes that may hide the effects of management practices. To assess the effects of deliberate management you need to address the issue of rate of recovery.	Whole field analysis failed to detect changes in W score, demonstrates the need to partition data by community types prior to analysis. Recording species data at different scales within quadrats was also demonstrated to be necessary.	
352		Suited species provide standardised easy to interpret measures if change in species composition. Suited species tailored to AE objectives.	Suited species must be appropriate to the community chosen as, if applied to functional attributes or habitat associations which are poorly represented, may be oversensitive to changes in individual species.		
339		Mire communities well differentiated by community variables.	There was a variation between habitat types as to how well the community variables could differentiate. Wet mesotrophic grasslands were on a gradient. Mosaics of heathland/grassland can be a problem particularly where management causes a shift in vegetation type rather than changes in quality within the community.		
260		Total numbers of community character species appeared to be related to nutrient levels of CG sites, sites with lower nutrient levels judged by nutrien suited species had more community character species. Adequately reflected the variation in functional groups based on full species information and differences in management.	Negative indicator *Trifolium repens* did not clearly relate to high nutrients or heavy grazing disturbance. Abundance of *Senecio jacobea* not clearly related to the proportion of ruderal species which should indicate disturbance and overgrazing.		
106	n/a				

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Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
340	Approaches to vegetation monitoring by English Nature Porter, K.	General	To develop monitoring methodologies which can be applied consistently to all sites across GB.	Optimal condition - explicitly described for interest feature, limits of acceptable change - set for each interest feature.	
	BU				
51	Monitoring the Maintenance and Enhancement of Heather Moorland. ADAS	Heather moorland	To review current performance indicators, sampling strategies and monitoring techniques. Number of problems highlighted - between moor variation in change, ineffectiveness of ESA prescriptions, observer error, validity of biomass utilisation and suppression measurements.	Biomass utilisation to assess heather condition, monitoring extent of heather through production of landcover map.	Stratification by management unit.
52	Statistical assessment of techniques for monitoring species composition in upland plant communities. Final Report to MAFF. ADAS	Uplands	Results from a review which suggested that using BU and heather suppression measures was not the best way of assessing changes in the extent and condition of heather. This study is an assessment of four field techniques.	DOMIN, first hit, dominant species and percentage cover, species cover, abundance, community composition.	Key species selected from different methods - standard data, other techniques, DOMIN, first hit, dominant species and % cover tested with respect to ability to predict the trends for species abundance, cover, ANOVA. Community composition-ordination, ANOVA applied to quadrat scores, Spearmans. Description and detection of change most effectively determined by DOMIN and first hit techniques.
	Changes in Individual Species				
329	Measuring change in British vegetation. 1999 Bunce, RGH, Smart, SM, van de Poll, HM, Watkins, JW and Scott, WA.	General	Extended analysis of CS data and developed a range of indicators of Botanical diversity.	Changes in cover of individual species.	Chi-squared tests.
	Changes in indicator species				
329	Measuring change in British vegetation. 1999 Bunce, RGH, Smart, SM, van de Poll, HM, Watkins, JW and Scott, WA.	General	Extended analysis of CS data and developed a range of indicators of Botanical diversity.	Changes in habitat indicator species, changes in NVC indicator species, quality-lists based on expert judgement, published plant community profiles, statistically derived measures, known ecological associations, rare species, changes in CVS preferential species used to interrogate CS database.	Chi-squared tests used to test differences in numbers of indicator species. Indicator lists are created by defining criteria, one or more indicator species present, differences in the proportion of plots of each type having at least one recorded occurrence. Rarity indicator species - proportion of plots containing rare species. NVC diagnostic - define a list of species whose joint occurrence is considered characteristic of a particular vegetation type, species with a constancy of 3 or more selected, species excluded if common in other habita types. Look at distribution of indicator species amongst plot type, changes between years in number of plots classified as target community.
	Species diversity/species richness				
346	The combined effects of scale and productivity on species richness 1999, Weiher, E.	General	To test the relationship between species diversity, scale and productivity.	Species diversity.	n/a
329	Measuring change in British vegetation. 1999 Bunce, RGH, Smart, SM, van de Poll, HM, Watkins, JW and Scott, WA.	General	Extended analysis of CS data and developed a range of indicators of Botanical diversity.	Species diversity: change in species numbers, mean number of species present per plot, mean species number per plot type, per landscape type.	

Table 7.1: Review of research on indicators to detect and measure change

Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
340		1. Quick, cheap, able to be used on a wide scale. 2. Answers specific question on whether feature is being maintained.	1. No detailed information. 2. Applying general criteria to complex local habitats. 3. Doesn't help determine how feature can be improved only that it is unfavourable. 4. Although most other schemes where detailed information has been collected can be described by common standards you can't go the other way, i.e. once you have general information you can't make it more detailed so it is limited in use.		
51		Standardised and objective methodology for the assessment of heather grazing. Estimation of grazing index robust, well tested technique.	In removing the top 4cm of shoots it is a possibility that heavily grazed shoots are omitted from the sample and it is biased towards ungrazed vegetation. The inclusion of an indeterminate pile in the sorting of grazed and ungrazed shoots reduces subjectivity and quantifies a potential source of observer error. Are variations in BU estimates observer related or due to real differences in heather response to grazing? High degree of field experience of heather growth forms to match grazed and ungrazed shoots, different ESA's have a different range of grazers. Difficult to determine whether calibrations differ from year to year and from ESA to ESA due to biological or observer variation. MLURI suppression thresholds are a coarse predictor of suppression, it is likely that suppression thresholds vary geographically and in association with environmental factors, the transformation of GI to suppression data involves making a number of assumptions of the data.	Recommendations - training, source documentation and quality control vital. Need to strengthen deriving suppression data.	
52			Change in species cover detected best by first hit approach for grass species *N. Stricta* and *M. caerulea*		
329		Gives insight into ecological processes operating and significance of effects.			
329		Notable changes in certain key species can provide a general indication of changes in quality. Use of NVC and characteristic community indicators would be one way of looking at rarer habitats and priority habitats in the CS dataset.	Presence of one or more indicator species does not necessarily imply good habitat condition. Rare indicator species - there was a low frequency of rare species in the survey so difficult to use them as change indicators. Distribution and abundance of rarer habitats as defined by habitat indicator species may be too small to detect change.		
346		Species-area curves increase with biomass suggesting that richness-productivity relationships are dependent upon spatial scale. The size of the species pool has a positive effect on the slope of species-area curves suggesting that these slopes might be an indicator of the size of the species pool.			
329		Pielou (1991) emphasises that mean number of species is a direct measure, CS analyses demonstrate that it has real ecological meaning.			

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Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
352	Sensitivity and calibration of Plant Community Variables for Grassland monitoring in English ESA's.1999. Critchley, CNR, Burke, MJ and Fowbert, JA.	Grassland	Testing communty variables.	Species richness and Shannon-Wiener Diversity Index, CSR.	MANOVA - all variables tested simultaneously with regard to their response to treatment factors and a Rao R statistic. The sensitivity of the community variables in detecting differences between different treatments over time were ranked by the F statistic.
339	Calibration of plant community variables for mires, wet grasslands and upland communities. 2000. Fowbert, JA and Critchley, CNR.	Mires, wet grassland, upland.	Calibration of community variables to external datasets.	Species richness and Shannon-Wiener Diversity Index, CSR.	Could not compare results statistically, presented graphically.
14	Whittaker's plant diversity sampling method 1984. Shmida, A.	General	Proposes a method for producing a species diversity measure which can be applied to other diversity measures measured at a variety of spatial scales.	Species diversity, equability or dominance.	
102	Monitoring for Conservation and Ecology 1991. Goldsmith, B.	General		Species richness.	
25	A highly targeted approach to vegetation recording in the agricultural ecosystem 1997. Smith, H.	Arable	Established different experiments with different objectives. Field margins: measure effects of management regimes on species richness, weed populations.	Species richness and frequency, density, vegetation height, biomass.	
95	Structure and floristic diversity in permanent monitoring plots in forest ecosystems of Tuscany 2001. Chiarucci, A.; de Dominicis, V.; Wilson, J.B.	Forest		Structural diversity and habitat heterogeneity measured by species richness, habitat heterogeneity h index.	Species richness in relation to the spatial scale analysed by fitting species-area curves for th linear model, the log S model, the Arrhenius power function, the Gleason exponential model, and the general root model.
	Extending botanical information to other species				
329	Measuring change in British vegetation. 1999 Bunce, RGH, Smart, SM, van de Poll, HM, Watkins, JW and Scott, WA.	General	Extended analysis of CS data and developed a range of indicators of Botanical diversity.	Butterfly and bird food plants.	Butterfly food plants - mean counts of butterfly host plants generated from 1990 data only. Bird food plants - relevant food plant species expressed as % of total number of species in CS, changes in frequency and cover.
170	The relationship between butterflies and environmental indicator values: a tool for conservation in changing landscape. Biological Conservation. 1998. 86. 271-280. Oostermeijer, J.G.B., van Swaay, C.A.M.		To quantify the relationship between the butterfly species that occur in the Netherlands and Ellenberg's indicators N, A and F.	Ellenberg N, A and F.	Relationship between presence of butterfly species and environmental parameters investigated using logistic regression analysis. Basic hypothesis that butterfly-environment relationships would have the shape of a Gaussian or unimodal response curve. 3 parameters from the Gaussian regression curve - optimum, Pmax and tolerance (butterfly's ecological amplitude for parameter), Pearsons product moment correlation coefficient to check correlations between ecological indicators. Multiple logistic regression to study relative effect of one parameter.
	Indices derived from the ADAS plot method				

Table 7.1: Review of research on indicators to detect and measure change

Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
352		Species richness and Shannon index consistently detected vegetation change responsive to addition of fertilisers and cessation of grazing. Short term effects detected by the Shannon index which went undetected by analyses of species richness. In species poor vegetation the Shannon index provides a better measure of diversity.	Species richness and Shannon index and vegetation height provide no insight into changes in species composition.		
339		Mire communities well differentiated by community variables.	There was a variation between habitat types as to how well the community variables could differentiate. Wet mesotrophic grassland were on a gradient. Mosaics of heathland/grassland can be a problem particularly where management causes a shift in vegetation type rather than changes in quality within the community.		
14	Gives equation to relate measures of species diversity calculated at different scales to one another.	1. Enables diversity measurements made at different scales to relate to one another. 2. Can compare species richness at different spatial scales.	1. Bases first level of diversity on 1 m^2 quadrat, extrapolates from there (spatial autocorrelation). 2. Assumes diversity can be extrapolated in this way, may be assuming too much. 3. Plot shape may affect results in non-homogeneous areas.		
102			Similar sized areas should be compared, does not include informatio on the commonness or rarity of species,		
25					
95					
329					
170		Direct quantification of the effects of environmental scenarios on the butterfly fauna without having to make prior predictions about the vegetation. Butterflies are 'process indicators' indicative of changes in the environment - best ones relatively common species with clear responses to changes in soil nutrient status, acidity or moisture. Models based on Ellenbergs enable better predictions than when only ecology of food plant considered.	Only used presence/absence data. Calculation of mean Ellenbergs di not take the abundance of plant species into account -butterflies sensitive to rare individuals so argues that presence/absence is sufficient, national data doesn't allow for regional variation.		

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Endnote number	Title and Authors	Habitats	Method objective	Indicators/Analysis	Analysis
3	Indices of spatial dynamics from the ADAS plot method for monitoring grassland vegetation 2000. ADAS report to MAFF Burke, M.J.W.; Critchley, C.N.R.; Allen, D.S.	Grassland	To use existing ADAS plot data and assess methods of analyses for spatial distribution of species.	Community stability index - proportion of species retained in nests between years, mean values across nests-plot mean, measure of consistency in species composition of nests. Individual species indices, species consistency index - number of nests retained.	ANOVA and Tukey tests between indices.
	Other				
24	Methods for long-term biodiversity inventory plots in protected tropical forest 1992 Dallmeier, F.; Kabel, M.; Rice, R.	Tropical forests	Long term forest inventories provide information for conservation priorities, enables changes to be detected and related to natural and man-made disturbances. Help to integrate management of protected areas with compatible development on surrounding lands.	This paper is mostly a methods paper but gives one case study. Indicators used include Basal area (basal area of individuals expressed as a proportion of all species), Relative density (no. individuals species/total number individuals all species), Relative dominance (combined basal area single species/total basal area all species), Relative frequency (frequency of given species proportion of sum of frequencies for all species), Relative diversity (no. species in one family/ total number species) and Importance value index (sum of relative density, relative dominance and relative frequency.	
9	Nested spatial patterns in seed bank and vegetation of Mediterranean old-fields 1991. Lavorel, S.; Lebreton, J.D.; Debussche, M.; Lepart, J.	Old fields.	To test whether observations of spatial structure are scale dependent, fields of different successional ages are homogeneous within field, that patterns of spatial heterogeneity in vegetation and seed bank are related.	Species abundance, seed counts and environmental variables.	CCA partitioned into different levels to account for variation in spatial scale.

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Endnote number	Statistical Issues	Strengths	Weaknesses/risks	Points to note	
3	Limitation of species consistency index - at low baseline nest frequencies - limited precision, baseline frequency should be between 10 and 28, change in frequency no greater than 4.	1. Looks at spatial variation as well as temporal variation, i.e. increases usefulness of dataset. 2. Community indices give good information of stability of community i.e. how much flux there is, this was verified by the differences between communities, e.g. arable/agricultural had lower indices of stability than heathlands. 3. This analysis also gives an indication of how frequently monitoring visits are required.	1. Not so good for individual species, constraints limit application to only a few plots, within these plots some useful information about certain individual species can be obtained. 2. Community stability index provides no information on nature of species or functional attributes so needs to be used in conjunction with other methods.		
24		1. Gives lots of information at the individual level, from there you can follov demography of individual species, group together to look at populations, compare across plots and countries to compare communities. 2. Methods and analysis have been standardised to enable comparisons	1. Very time consuming. 2. Expensive. 3. More applicable to forests measurements of DbH, distinguishing between species, time scale fo re-recording would not apply to other habitats, e.g. grasslands too difficult to identify individuals, most smaller vascular plant communities would need more constant recording to get any valuable demographic information.		
9		1. Attempts to explain variation in field survey data using a more precise complex method that will allow better understanding of the dynamics and processes at work. 2. Looking at field data in an experimental way.	1. The analysis depends on the quality of the data it's based on, it is using a more rigorous method than is necessarily used on field data, treating it as an experiment but the fields have not been treated in exactly the same way and variation cannot be explained as precisely as an experiment. 2. Not completely convinced about the methods and whether sufficient information was collected. i.e. see above point.		