▲ Drumstick heather • © *Clive Hurford*

Appendix 1. Using Effect Size to assess the ecological significance of change

Although the proportion of the land area which is sampled by Countryside Survey in Wales is greater than in England or Scotland, the actual number of 1 km squares and vegetation plots sampled in Wales is smaller. This contributes to the detection of fewer statistically significant changes between surveys. In some cases, the size of the observed change in a surveyed attribute may be comparable to that in other countries but the smaller sample size means that the change is not as precise an indicator of the size of the change in the wider population from which the sample was drawn. This occurs because the statistical significance of an observed change between two surveys depends not only on the distribution (mean and variation about the mean) of change values for individual observations but also, crucially, on the sample size itself.

As an example, *Table A1* gives statistics representing two samples pairs from two surveys. The samples differ in size but have the same distribution in each survey and the same mean change occurs between surveys. The T value for the large sample is considerably larger than for the smaller sample. This reflects the much smaller standard error for the large sample. The standard error is calculated by dividing the standard deviation by the square root of the number of samples, hence the larger the sample the smaller the standard error. Only the larger sample pair yields a statistically significant difference between the two surveys because it is the standard error that is important in estimating whether the two populations might be significantly different.

▼ **Table A1:** Statistics for samples with the same mean and variability about the mean but with different sample sizes. Sample size influences standard errors and t values but may not change the mean, standard deviation and therefore the Effect Size.

Sample size	Mean (time 1)	Mean (time 2)	Standard deviation (time 1)	Standard deviation (time 2)	Standard error (time 1)	Standard error (time 2)	T value of mean difference between surveys	Effect Size for change between surveys
30	4.38	3.99	1.32	1.23	0.241	0.225	1.18	0.31
1000	4.38	3.99	1.32	1.23	0.042	0.039	6.84	0.31

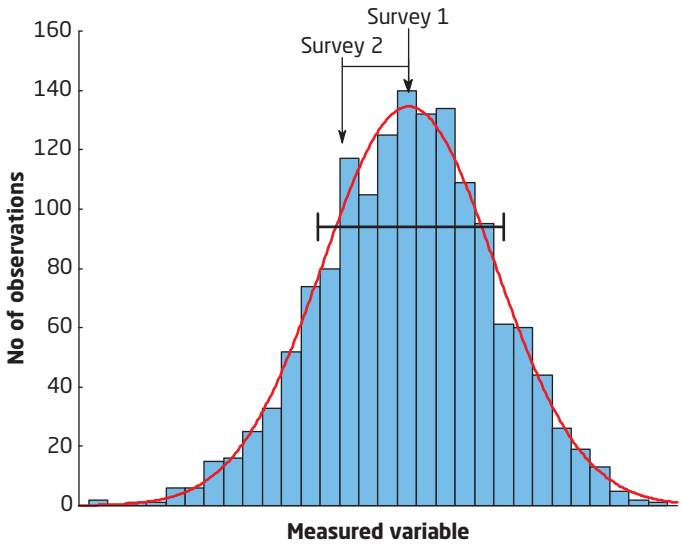
Ecological significance is not the same as statistical significance. An observed change can be statistically significant for large enough samples but unimportant in ecological terms, and vice versa. The ecological implications of an observed change can be assessed in terms of the standardized effect size -the mean change as a proportion of the variability of the sample;

$$\textit{Effect size} = (M_1 - M_2)/\sigma\text{pooled}$$

$$\sigma_{pooled} = \sqrt{[(\sigma_1^2 + \sigma_2^2) / 2]}$$

where σpooled is the pooled standard deviation combining the variability in the sample at time 1 with the variability at time 2[75]. The sample standard deviation is used as the yardstick against which changes in the mean over time are judged to be of potential ecological significance irrespective of whether the sample was powerful enough to infer a significant change in the *population*. In contrast to the T value or significance level, the effect size is the same for both samples in ***Table A1*** because it only depends upon the survey means and standard deviations. An observed standard deviation will not vary systematically with changes in sample size, as the standard error does, and for large sample sizes will vary very little. Hence effect sizes can be compared even if the numbers of measurements in each sample vary greatly as here.

▼ **Figure A1:** The distribution of values of a survey variable in one survey year for one sample from a particular landscape location eg. cover of butterfly larval food plants on road verges supporting neutral grassland in Wales. Arrows show the mean in the first survey year and the location of the mean in the second survey. The horizontal bar shows one standard deviation of the sample values either side of the mean. The change in the mean would be classed as a large effect (Cohen 1988).



Ways of interpreting the effect sizes of 0.31 in ***Table 1*** are;

a) the sample distributions from the two surveys overlapped by about 80%,

b) the change between surveys amounted to a shift of 31% of the size of the average differences between each value in the combined sample and the mean of the sample from which it came. A graphical example of change in the mean value of a survey variable is shown in ***Figure A1***. The change between surveys amounts to a shift of 83% of the *sample* standard deviation, hence the overlap in the sample distributions from the first and second surveys is about 53%.

What do these interpretations mean in terms of ecological significance? Cohen (1988)[76] classified effect sizes into small (<0.2), medium (>0.2 and < 0.8) and large (>=0.8). If a sample dataset is normally distributed, about 68% of the values are within 1 standard deviation of the sample mean. So a change of 30% of 1 standard deviation (effect size = 0.3) does not suggest that the mean of the sample at time 2 was greatly different from time 1. On the other hand, an effect size of 0.8 and above is considered large and would suggest that the two sample distributions only overlapped by about 53%. A precautionary interpretation might highlight medium effect sizes as noteworthy but not very substantial. Large effect sizes suggest a potentially important shift may have occurred in the wider population. If not accompanied by a statistically significant change, then the effect size might *suggest* a population-wide change had occurred but that the sample size may have been too low to give statistical support to this supposition. Alternatively, having many samples available may result in the detection of a very small change as statistically significant. In this report, the effect size is adopted as a tool for highlighting changes in mean vegetation variables that are potentially important in terms of their ecological impact (large effect sizes).

Interpretation of the effect size requires expert ecological judgement and the categories provided in Cohen (1988) are rather arbitrary in origin. Therefore smaller effects sizes cannot be ruled out as having no ecological importance especially as they may reflect the culmination of a longer term trend. In general, more research would be required to establish whether these smaller changes are of minor importance and just reflect normal variability in responses to differences in weather effects for example.

[75] Rosnow, R. L., & Rosenthal, R. (1996). Computing contrasts, effect sizes, and counternulls on other people's published data: General procedures for research consumers. *Pyschological Methods*, 1, 331-340.

[76] Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Countryside Survey

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Contacts

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The Countryside Survey partnership has endeavoured to ensure that the results presented in this report are quality assured and accurate. Data has been collected to estimate the stock, change, extent and/or quality of the reported parameters. However, the complex nature of the experimental design means that results can not necessarily be extrapolated and/or interpolated beyond their intended use without reference to the original data.

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Designed by Countryscape.

▲ Mature dry heath • © *Clive Hurford*

Appendix 2. List of plant species names used in tables and text

Latin name	English common name	Welsh common name
Agrostis canina sens.lat.	Velvet Bent	Maeswellt y Rhos
Agrostis capillaris	Common Bent	Maeswellt Cyffredin
Agrostis stolonifera	Creeping Bent	Maeswellt y Gwlypdir
Agrostis vinealis	Brown Bent	Maeswellt y Cŵn
Aira caryophyllea	Silver Hair-grass	Brigwellt Arian
Alnus glutinosa	Alder	Gwernen
Anthoxanthum odoratum	Sweet Vernal-grass	Perwellt y Gwanwyn
Apium nodiflorum.	Fool's Water-cress	Dyfrforonen Sypflodenog
Arrhenatherum elatius	False Oat-grass	Ceirchwellt Tal
Athyrium filix-femina	Lady-fern	Rhedynen Fair
Betula seedling/sp	Birch	Bedwen
Blechnum spicant	Hard Fern	Gwibredynen
Calluna vulgaris	Heather	Grug
Cardamine pratensis	Cuckooflower	Blodyn y Gog
Carex binervis	Green-ribbed Sedge	Hesgen Ddeulasnod
Carex echinata	Star Sedge	Hesgen Seraidd
Carex flacca	Glaucous Sedge	Hesgen Oleulas
Carex nigra	Common Sedge	Swp-hesgen y Fawnog
Carex panicea	Carnation Sedge	Hesgen Benigen-ddail

Latin name	English common name	Welsh common name
Carex pilulifera	Pill Sedge	Hesgen Bengron
Carex seedling/sp	Sedge	Hesgen
Cerastium fontanum	Common Mouse-ear	Clust Llygoden Culddail
Cerastium glomeratum	Sticky Mouse-ear	Clust Llygoden Llydanddail
Chrysosplenium oppositifolium	Opposite-leaved Golden-saxifrage	Eglyn Cyferbynddail
Cirsium arvense	Creeping Thistle	Ysgallen Gyffredin
Cirsium palustre	Marsh Thistle	Ysgallen y Gors
Cladonia sp.	Reindeer moss sp	
Corylus avellana	Hazel	Collen
Crataegus monogyna	Hawthorn	Draenen Wen
Cynosurus cristatus	Crested Dog's-tail	Rhonwellt y Ci
Dactylis glomerata	Cock's-foot	Byswellt
Danthonia decumbens	Heath-grass	Glaswellt y Rhos
Deschampsia cespitosa	Tufted Hair-grass	Brigwellt Cydynnog
Deschampsia flexuosa	Wavy Hair-grass	Brigwellt Main
Digitalis purpurea	Foxglove	Bysedd y Cŵn
Dryopteris dilatata	Broad Buckler-fern	Marchredynen Lydan
Dryopteris dilatata/carthusiana	Broad Buckler-fern / Narrow Buckler-fern	Marchredynen Lydan / Marchredynen Gul
Eleocharis palustris	Common Spike-rush	Sbigfrwynen y Gors
Elytrigia repens	Common Couch	Marchwellt
Equisetum arvense	Field Horsetail	Marchrawn yr Ardir
Erica cinerea	Bell Heather	Clychau'r Grug
Erica tetralix	Cross-leaved Heath	Grug Deilgroes
Eriophorum angustifolium	Common Cottongrass	Plu'r Gweunydd
Eriophorum vaginatum	Hares'-tail Cottongrass	Plu'r Gweunydd Unben
Eurhynchium praelongum	Common Feather-moss	
Festuca ovina agg.	Sheep's-fescue	Peisgwellt y Defaid
Festuca rubra agg.	Red Fescue	Peisgwellt Coch
Filipendula ulmaria	Meadowsweet	Erwain
Fraxinus excelsior	Ash	Onnen
Galium aparine	Cleavers	Llau'r Offeiriad
Galium palustre	Common Marsh-bedstraw	Briwydden y Gors
Galium saxatile	Heath Bedstraw	Briwydden y Rhosdir
Geranium robertianum	Herb-Robert	Llys y Llwynog
Hedera helix	Ivy	Iorwg
Heracleum sphondylium	Hogweed	Efwr
Holcus lanatus	Yorkshire-fog	Maswellt
Hylocomium splendens	Glittering Wood-moss	
Juncus articulatus/acutiflorus	Jointed Rush/Sharp-flowered Rush	Brwynen Gymalog/Brwynen Flodfain
Juncus bulbosus	Bulbous Rush	Brwynen Oddfog
Juncus effusus	Soft-rush	Brwynen Babwyr
Juncus squarrosus	Heath Rush	Brwynen Droellgorun
Leontodon autumnalis	Autumn Hawkbit	Peradyl yr Hydref
Lolium perenne	Perennial Rye-grass	Rhygwellt Lluosflwydd
Lotus pedunculatus	Greater Bird's-foot-trefoil	Pysen y Ceirw Fwyaf
Luzula campestris/multiflora	Field Wood-rush/Heath Wood-rush	Coedfrwynen y Maes/Coedfrwynen Luosben
Molinia caerulea	Purple Moor-grass	Glaswellt y Gweunydd
Nardus stricta	Mat-grass	Cawnen Ddu
Narthecium ossifragum	Bog Asphodel	Llafn y Bladur

Latin name	English common name	Welsh common name
Oenanthe crocata	Hemlock Water Dropwort	Cegid y Dŵr
Phleum pratense sens.lat.	Timothy	Rhonwellt
Picea sitchensis	Sitka Spruce	Spriwsen Sitka
Plantago lanceolata	Ribwort Plantain	Llwynhidydd
Pleurozium schreberi	Red-stemmed Feather-moss	
Poa annua	Annual Meadow-grass	Gweunwellt Unflwydd
Poa pratensis sens.lat.	Smooth Meadow-grass	Gweunwellt Llyfn
Poa trivialis	Rough Meadow-grass	Gweunwellt Llederw
Polygala vulgaris/serpyllifolia	Common Milkwort/Heath Milkwort	Llysiau Crist/ Llysiau'r Groes
Polytrichum commune	Common Haircap	
Potamogeton pectinatus	Fennel Pondweed	Dyfrllys Blaenllym
Potentilla anserina	Silverweed	Dail Arian
Potentilla erecta	Tormentil	Tresgl y Moch
Prunus spinosa	Blackthorn	Draenen Ddu
Pteridium aquilinum	Bracken	Rhedynen Gyffredin
Quercus robur & petraea	Pendunculate Oak & Sessile Oak	Derwen Goesog & Derwen Ddigoes
Ranunculus acris	Meadow Buttercup	Blodyn Ymenyn
Ranunculus ficaria	Lesser Celandine	Llygad Ebrill
Ranunculus penicillatus var. penicillatus	River Water-crowfoot	Crafanc y Frân y nant
Ranunculus repens	Creeping Buttercup	Crafanc y Frân
Rhytidiadelphus squarrosus	Springy Turf-moss	
Rubus fruticosus agg.	Bramble	Mwyaren Ddu
Rumex acetosa	Common Sorrel	Suran y Cŵn
Rumex obtusifolius	Broad-leaved Dock	Dail Tafol
Sagina sp.	Pearlwort	Corwlyddyn
Salix cinerea	Grey Willow	Helygen Lwyd
Sonchus asper	Prickly Sow-thistle	Llaethysgallen Arw
Sorbus aucuparia	Rowan	Cerddinen
Sphagnum (green/fat)	Bog-moss	
Sphagnum (green/thin)	Bog-moss	
Tamus communis	Black Bryony	Gwinwydden Ddu
Taraxacum agg.	Dandelion	Dant y Llew
Thuidium tamariscinum	Common Tamarisk-moss	
Trifolium pratense	Red Clover	Meillionen Goch
Trifolium repens	White Clover	Meillionen Wen
Urtica dioica	Common Nettle	Danhadlen
Vaccinium myrtillus	Bilberry	Llus

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