

Interactive comment on “Long-term vegetation monitoring in Great Britain – the Countryside Survey 1978–2007 and beyond” by Claire M. Wood et al.

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Received and published: 9 June 2017

Response: Many thanks for the detailed and constructive comments regarding our manuscript which we have endeavoured to address as follows: 1) comments from Referees, (2) author's response, (3) author's changes in manuscript.

Response to Anonymous Referee #1

(1) I have no doubt about the excellence of the data. The collected data to monitor ecological and land cover change is very intensive with nested research design with huge number of records. It is a complication of three replications and the fourth one is

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already started. The good thing about this repeated survey is that they are improving the method by adding more and more types of plots such as the U, A and D plots were started from 1998 (second survey) and M plot was introduced in 2007. They also increased the number of plots from 256 to 596 and 591. Finally, the best thing is to make the data open access. However, I have a concern with limited open access of the data. The Authors clearly mentioned that "the location of the 1km sample squares is not disclosed(Line No.C1 120-121)". In such cases, the study cannot be replicated or resurvey by other parties. A philosophy behind an open access data is to allow interested parties to reanalyses the data, and if wish, to resurvey the area to verify or to replicate the study or to study the change from previous study. However, the authors clearly mention a reason behind not to disclose the location of 1km square plots as "so that the squares do not attract additional research on the land.... " (Line No. 121 - 122). This may fulfil the legal requirement, however it does not advocate good science. Finally, the authors write, "The intention is that a repeat survey will be undertaken in the near future..." (Line No 542 – 543). My impression here is, sorry to be rude, the authors are also in favour of repeated study, however in absence of the location of the plots, on one else can do it and only by themselves!!

(2) We agree that it is unfortunate that the site locations cannot be disclosed fully, however, as described in section 2.3 and as appreciated by the second reviewer - most of the survey land is private land and as a condition of survey, it was agreed with land owners that locations would not be published. Land owners (in particular, farmers) are increasingly subject to examination of their practices and consequently less open to repeated visits. Additionally, if the exact locations were disclosed, future land use decisions could be influenced and thus render them of no use for monitoring 'typical' land use change. Even without the exact location data, there are many analyses which may be (and are being) undertaken using the datasets, as published. In response to the last point, there are few (arguably no) other organisations in Britain placed to undertake such a large, national ecological survey as the Centre for Ecology & Hydrology. The design of the survey is such that it is not statistically worthwhile to collect data at a

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level smaller than the Land Class, therefore any follow up survey must necessarily be large and logistically complex. In the event CEH was not able to undertake another survey, appropriate arrangements would have to be made to transfer the substantial resources relating to the survey, including the site locations, to a suitable third party. The methods utilised in the survey are published and described in such a way as to be highly repeatable.

(3) We have further clarified section 2.1 to read 'Note that the location of the 1 km sample squares is not disclosed by agreement with land-owners. If the locations of the sites was made available this would not only threaten future surveys but would also prevent and future collaboration with the owners or their descendants, Furthermore, future land use decisions could be influenced and have an effect on the monitoring results. Thus this policy ensures that the squares do not attract additional research or land management activity that could potentially undermine their status as an unbiased, representative sample of the British countryside. The majority of the land in the sample squares is in private ownership.' We will provide additional supplementary information with the datasets to include the county, country and land class number of each survey square.

Response to Anonymous Referee #2

(1) The Countryside Survey of Great Britain is a unique long-term monitoring dataset looking at changes in vegetation over a 29 year period. Very few countries have set up such long-term monitoring programs of vegetation over such a wide scale and therefore tend to rely on remote sensing to conduct time series analysis. This manuscript is a summary of the Countryside Survey - covering much of the information that is apparently already available in many separate publications. Knowledge of these publications seems to be important to follow everything in the current manuscript - I needed to read a few of the background papers. It may be a prequel summary prior to repeating surveys of many of the plots.

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(2) As the Countryside Survey is a long-term, national survey, there are inevitably many publications arising from the work. There has previously never been a concise summary of the data publicly available; this paper is intended to fill the vegetation element of that gap. From the reviewer's comments, it appears we have included sufficient references to relevant background papers to enable a full appreciation of the survey background.

(1) The original sampling design was set up using random stratification. I understand that the initial stratification was done using a TWINSpan on environmental variables such as altitude, climate etc. (using either a binary classification or ranks). Normally, TWINSpan would have been used to derive groups (based on divisive clustering) from data on species composition and abundance (or presence/absence) and this is how I have personally used TWINSpan (from 1981 to about 1992). For patterns in environmental variables I would have used principal component analysis and looked for cluster groups (as was done by Owen et al. in "Cluster analyses: a case study for the UK West Midlands 2"). Perhaps the authors could mention that TWINSpan has been criticized (e.g., for the fact that it assumes a strong gradient in samples along the first axis, that the cut-levels are somewhat arbitrary, some samples which are extremely similar may end up being placed in different end groups (Legendre and Legendre 1998 page 49; Belbin and McDonald 1993 also compared TWINSpan to UPGMA and ALOC). As I am sure the authors are aware, TWINSpan is not used much today, and has now been replaced by a suite of other multivariate techniques. Canonical analysis of principal coordinates carries out discriminant analysis to test the efficacy of the classification (I believe that discriminant analysis was used in some of the earlier papers by the authors, e.g. Bunce et al. 1996). I realize that the authors were constrained by what was available at the origin of the survey but I wonder if they should say that the original stratification produced by TWINSpan has been compared with other, more modern, multivariate techniques (I think this has been done). Today Geographic Information Systems using remotely sensed data would be used to set up a sampling design, classify land cover types, develop digital elevation models and evaluate representativeness

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of vegetation plots using various tools. Current techniques that could also be used for this type of analysis would be classification and regression trees and other machine learning models that can be easily interfaced with GIS.

(2) The data analysed were a mixture of variables (for example, altitude) and attributes (for example, geology). The variables were converted into four discrete classes so that the database was suitable for analysis by TWINSpan, and stopped at 32 classes. It is true that there were constraints in available techniques back in the 1970s and it is certainly recognised that nowadays, with automated data capture, variables can be recorded for millions of 1 km squares. Recent Environmental Classifications, for example Metzger et al. (2008) and Villoslada et al. (2016), have used PCA and clustering. Although TWINSpan has been criticised (for example, Belbin and McDonald (1993)), Jones & Bunce (1985) compared classifications of European climate using both TWINSpan and PCA and concluded that the results were comparable. Bunce et al. (2002) compared classifications for similar regions using different databases and analytical techniques and showed that the basic patterns were sufficiently close that policy makers would be able to have confidence in the results. The many multivariate techniques which are now available will give slightly different boundaries to classes, but the core structure will always be identified. Finally, any inefficiencies in stratifications will be reflected in higher standard errors for the observed independent variables. The independent tests in papers such as Metzger et al. (2008) and Villoslada et al. (2016) are all highly significant and show that any potential improvements to the original land classification would likely have a marginal impact on national estimates derived from its use.

(3) We have inserted a summary of the above into section 2.2.

(1) Regardless of the original sampling design the data present a unique opportunity for modelling changes in plant species composition and abundance and have been used for many purposes and have the potential to be used for many more. It seems to be an ideal dataset for modelling using machine learning species distribution models (SDMs

C5

- one of the high performance platforms such as random forests, boosted regression trees or Maxent) but it is not apparent if this has been carried out (?). These could run as ensemble models and the model results compared. In addition more fully exploring spatial patterns could be done using generalized dissimilarity modelling. Comparing patterns from the ground-truthed plots with remotely sensed data (NDVI) would be very interesting. There is some mention of the great potential to use these data for predictive modelling to predict changes in the distribution and abundance of plant species in the UK with climate change (line 52).

(2) These are all good suggestions; the paper is intended to stimulate ideas for further analyses and modelling using the data. As mentioned in Section 7.2, the data have been used for species distribution modelling (Henrys et al., 2015b); we are also currently exploring patterns of NDVI with data from the plots. As there is a potentially long list of further analyses that could be done using the data, we have not explicitly included these in the text in the interests of brevity (unless the editor suggests otherwise).

(3) We have clarified the potential of the datasets in the conclusion: 'The data are collected in a statistically robust and quality controlled manner, follow standard, repeatable methods and cover wide temporal and spatial scales. As consequence of this, the data present a unique opportunity for inclusion in a wide range of analyses and models.'

(1) One question relates to the amount of time spent sampling as this can influence estimates of species richness: some work (e.g., Zhang et al. 2014 in Alberta) recommended that sampling time is taken into account as this can have an important effect on results.

(2) The exact amount of time taken to record each plot has not been measured explicitly during the survey, due to the practical difficulties in doing so. However, during the survey training course, surveyors are trained in order that they understand the level of effort required for each plot. This should ensure a consistent level of effort across each survey. The QA reports attempt to investigate this issue to some extent, in terms of

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'overlooked species'. As described in section 5, no bias was detected in recording in the surveys covered by QA.

(3) In section 5, we have inserted the word 'effort' into the sentence 'Each field survey was carried out by teams of experienced botanical surveyors, and was preceded by an intensive training course, ensuring high standards and consistency of methodology, effort, identification and recording across CS according to criteria laid out in the field handbooks'.

(1) The word 'habitat' is used incorrectly throughout the manuscript and should be replaced by vegetation type or some other phrase (habitat is species-specific and refers to "the resources and conditions present in an area that produce occupancy - including survival and reproduction- by a given organism. Habitat is organism-specific; it relates the presence of a species, population, or individual (animal or plant) to an area's physical and biological characteristics. Habitat implies more than vegetation or vegetation structure; it is the sum of the specific resources that are needed by organisms." (Hall et al. 1997). I have also used 'habitat' incorrectly in many of my papers but currently have a review paper on this topic with a journal.

(2/3) We have amended the word 'habitat' throughout the text, unless it specifically refers to a defined habitat category such as Broad/Priority Habitats (Jackson, 2000) (Maddock, 2008) or bespoke categories (such as described in Wood et al., 2012).

Specific comments:

(1) Line 37 (Abstract) - 'habitat' diversity. As noted above, this is not really the correct use of the term 'habitat' which is species-specific and should be called 'vegetation' diversity or 'land cover' diversity.

(2) See comment above.

(1) Line 41: This sentence starts with a number (256) - perhaps the sentence structure could be changed?

C7

(3) Sentence updated to read 'A total of 256 1 km sample squares. . .'

(1) Line 45: 'where practically possible' - I'm not sure what this means? Are there examples where original plots have disappeared? (human development, erosion etc.). Also by the mid to late 1990s handheld GPS were becoming sufficiently accurate to relocate plots.

(2) We agree this is not clear and have amended as below. Building, earthworks and other human development activities are the most common reasons for a plot to disappear. In the case of linear plots, for example plots next to a hedge, watercourse or track, it might be the case that the linear feature itself has been removed or disappeared and thus cannot be sampled as a linear plot any longer. Occasionally it may not be possible to revisit a plot because a landowner has refused access to the land in question. We have also clarified this in section 4.2.

(3) Amended to: '...can be relocated where possible (unless the plot has been lost, for example as a consequence of building work).'

(1) Line 46: This sentence is a bit repetitive since it is already stated that surveys began in 1978.

(2/3) Yes - sentence deleted.

(1) Line 53: I tried to access the links that were included for the data and two of the doi's don't work. Countryside Survey 1978 vegetation plot data (<https://doi.org/10.5285/67bbfabb-d981-554ced-b7e7-225205de9c96>), And Countryside Survey 2007 vegetation plot data (<https://doi.org/10.5285/57f97915-8ff1-473b-8c77-2564cbd747bc>) Please correct these links.

(2) It looks like the problem has arisen because those two particular DOIs are split across lines in the PDF document. The actual strings as typed, are correct. Possibly a technical problem arising when the document was converted to PDF when submitted?

(3) No change made, as correct.

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<https://doi.org/10.5285/67bbfabb-d981-4ced-b7e7-225205de9c96>

<https://doi.org/10.5285/57f97915-8ff1-473b-8c77-2564cbd747bc>

(1) What is the accuracy of plot locations?

(2) Accuracy of plot relocation was assessed in the 2007 QA Exercise (Prosser & Wallace, 2008). This addressed the efficiency of plate and plot location by the surveyors. Although the results indicate that in CS2007 only 36% of the metal marker plates were detected compared with approximately 45% in 1998, the use of the combination of sketch maps and plot photographs enabled the surveys to precisely locate 70% of the plots and adequately duplicate a further 16%. Thus, the figure for plots judged to have been unsatisfactorily located is 14%. This is almost exactly the same as the figure found for the 1998 survey (15%). Figures are not available for 1990.

(3) Inserted into section 4.2: Using a combination of metal plates, photographs and sketch maps, plots are estimated to have a precise relocation accuracy of 85-86% (Prosser and Wallace, 2008).

(1) Line 76 (similarly line 79, 86 etc.): Again this is not the correct use of the term 'habitat' which is species-specific and should be called 'vegetation' categories or 'land cover' categories.

(2) See previous comment.

(1) Line 98: It would be better to start this sentence with 'One' rather than a number (but not sure of the journal formatting advice on this).

(3) Changed to 'A sampling unit of 1km square.'

(1) Line 107: The authors indicate that ISA was carried out on "Altitude, climate, geology, human geography and location variables". ISA is a technique (later evolved into TWINSPAN) usually used for species composition and abundance data (see above) - I would have suggested another analysis method such as PCA, cluster analysis or per-

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haps, classification and regression trees (but the latter were not available until about 1984). I wondered if the authors mean also that they carried out ISA on the plant species data (e.g., abundance by species) and then analysed the relationship with the variables listed (e.g., mean altitude per plant species TWINSPAN group etc.).

(2) The paragraph refers to the ISA carried out in order to construction the stratification used as the sampling structure, as described in the previous comment. Although the paragraph doesn't mean to indicate that ISA was carried out on the plant data at this stage, it has been done, and published as the countryside vegetation system (CVS) as described in Bunce et al., (1999) and also Smart et al. (2003), as mentioned in section 7.2. Also see comment above regarding TWINSPAN.

(3) We have clarified the structure of the paragraph to include section '2.2 Stratification'; this ensures the description of the sampling framework is clear. The work done regarding the CVS is already referenced in Section 7.2.

(1) Line 120: I understand that the survey locations of the 1km squares are not being disclosed. The other reviewer has suggested that these data should be made available and open access. However, many of the survey squares occur on private land and presumably the only reason the authors were allowed access for monitoring was if they agreed that locations would not be disclosed. If they allowed these data to become publicly available then this would not only jeopardize future monitoring by the authors themselves but it would also prevent any future collaboration with current landowners or their descendants. There is also a possibility that if the exact locations are disclosed then this could influence future land use decisions that could impact the specific sites and render them of no use for future monitoring. So in this situation the issue of the data being open access is equivocal. (2) See comment under Reviewer 1 comments.

(1) Line 127: Is the statistically robust method here referring to ISA (later TWINSPAN)?

(2) Yes – see below.

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(1) Line 128: I'm not sure about the sentence referring to 'scaling up' from the sample sites to the population.

(2) We agree this is not clear and have amended as below.

(3) As a statistically robust method is used (i.e. ISA), it is possible to extrapolate the results from the sample sites into Land Class means, which can then be combined to describe an entire population (for example England, Scotland, Wales or Britain).

(1) Line 146: Autocorrelation The authors state "Initially, vegetation and soil data were recorded from five dispersed random ('X') plots in each 1 km square, which were located using a restricted randomization procedure designed to reduce auto-correlation. Sites within a 1 km square are always going to have some degree of spatial auto-correlation and I don't know if this can be controlled for using a randomization procedure. (Perhaps future modelling of plots would need to take spatial autocorrelation into account, or at least test how much variation is explained by spatial location versus measured biophysical features versus temporal variation).

(2) Although the location of the random plots has been designed to reduce spatial autocorrelation, yes, it may be possible that auto-correlation will exist, depending on the specific analysis in question. For example, the issue has been taken into account in Baude et al. (2016) and Reynolds et al. (2013). In many cases, as for example in the case of Henrys et al. (2015b) model checks have shown that spatial auto-correlation has not been an issue. (3) As the text says 'designed to reduce auto-correlation' rather than 'eliminate auto-correlation', we have not amended the text.

(1) Line 169-171: Could these species not be identified later by taking small samples for expert identification or herbarium comparison? (as long as they are not endangered or threatened?).

(2) Surveyors were expected to record to the species level, and pre-survey training took place to ensure this. Additionally, difficult specimens could be sent in to ex-

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perts throughout the survey if necessary. However, there are certain species which are notoriously difficult to separate, even by experts (for example, *Taraxacum* agg.). Very young specimens/seedlings might pose a particular problem. Many of the combination species may actually be hybrids (for example, *Juncus articulatus/acutiflora*). The combinations were determined on the basis of experience, where it is considered that unless perfect fully grown specimens are available it is not possible to identify the species accurately. Where the separate species name was known unequivocally, it should have been used; otherwise, the combination name could be used. A list of the combined species is given in Barr (1998).

(3) Text altered to clarify existence of field training course and help-desk. Additional reference to Barr (1998) inserted to reference list of combined species.

(1) Line 187: The authors may need to explain the 'phytosociological requirement of homogeneity' for general readers.

(2) We agree this is confusing and not a particularly necessary phrase.

(3) We have deleted the sentence and replaced it with '...within the plot'.

(1) Line 197: "The design is to ensure that the whole plot is covered, as tests had shown that a major difference between observers was their search routine." What were these tests?

(2) Unstructured search routines are more likely to lead to species being overlooked, as described as far back as 1940, by Hope-Simpson. As overlooking species is a common source of error in vegetation surveys, a nested approach ensures a systematic approach to searching the quadrat and thus is a way of minimising this source.

(3) Sentence amended to: 'The design is to ensure that the whole plot is observed consistently and systematically, as unstructured search routines are more likely to lead to species being overlooked, as described as far back as 1940, by Hope-Simpson'.

(1) Line 204: word missing 'in order to allow'

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(3) Corrected – ‘to’ inserted.

(1) Line 211: “In arable fields where full access is not possible, species records are made from plots taken from an estimated 14m square, starting three metres into the crop in order to avoid any edge effect.” Is 3 metres really a sufficient distance to avoid edge effects here? I would think it would depend on the nature of the edge vegetation (e.g. tall hedgerows and trees could cast shadows over great distances into a crop field).

(2) The intention is to avoid the field margin and outer crop. Previous studies (such as Marshall (1989)) have shown that species related to the edge of crops thin out sharply from the edge with values ranging from 2.5 m (Marshall, 1989) to a maximum of 4m (Wilson and Aebischer, 1995). Even if a small part of the crop edge is found one corner of the plot, the X plot is large and this would have negligible influence on the data for the whole plot. We have to be pragmatic about the survey as well as scientifically rigorous; 3m is based on the kinds of evidence provided above, as well as on the likelihood of damaging a growing crop. If we were to avoid all tree shadow we would have to go through (and potentially destroy) a lot of crop before we started sampling.

(3) We have amended the sentence to: ‘starting three metres into the crop in order to avoid edge effects in most cases’.

(1) Line 212: “in order to causing minimum disturbance to the crop.” Please correct sentence structure.

(3) Sentence amended to: ‘Access is made using drill lines where possible in order to avoid trampling the crop’

(1) Line 254: Later the authors state “The purpose of establishing the plots was to record the arable weed population at the edge of cultivated fields and any subsequent changes”. Presumably these plots were designed to look at edges of fields so are quite distinct from the arable field plots above?

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(2) Yes, correct – these plots are designed to look only at the edges of fields.

(3) Amended to read: The purpose of establishing the plots was to record the arable weed population at the edge of cultivated fields and any subsequent changes. These plots relate only to the edge of fields and are quite distinct from the (arable) X plots which are actually in the crop. They contribute an important source of biodiversity not present in the main plots, which cover the overall composition of arable crops because, as described above, the margin is specifically excluded.

(1) Line 358-360: No bias was found between QA and CS teams using DCA which is an unconstrained ordination. Presumably this was done using visual interpretation (no distinct grouping of QA and CS surveyed plots in the ordination). There are multivariate techniques available that could test this difference statistically (e.g., in nMDS ANOSIM, or using the test for the homogeneity of multivariate dispersions in PERMANOVA +).

(2) We have deleted the reference to DCA here, as further multivariate analyses were undertaken, as described in detail in Prosser and Wallace (2008), Scott et al. (2008) and also Smart et al (2008), the conclusions of which was there should be no adjustment of CS results to correct for any bias between CS and QA results.

(3) We have inserted a reference to Smart et al. (2008), which describes additional QA analyses in detail.

(1) Line 362: Is it a good idea to include bryophytes and lichens in the surveys if these cannot always be identified to species and if experienced bryologists and lichenologists are not deployed in field surveys? The authors mention that some differences in species richness could be attributed to this. The decline in ‘quality’ of recordings in 2007 was possibly attributable to the fact that bryophytes were not identified with the same degree of accuracy as in previous years. But surely whether or not the decline in quality was due to differences in bryophyte identification could be assessed by including or excluding bryophytes from statistical comparisons?

C14

(2) During the survey, surveyors are given a specific list of the simpler bryophytes to record. However, often the surveyors are keen bryologists and may record a wider range of bryophytes than stipulated on the list. Rather than lose information from the database, these species are included, however users of the data may remove bryophytes from their analyses if they are concerned by this aspect. Smart et al. (2008) have assessed this issue and recommend this course of action (i.e. removing bryophytes from the analyses) in relation to the vegetation analyses undertaken for the main reports for Countryside Survey 2007.

(3) We have amended the paragraph to explain the above.

(1) Line 372: "and strategic sampling at the landscape level was then tested successfully in regional surveys in Cumbria and Shetland (Bunce and Smith)" What does 'tested successfully' mean?

(2) We agree this is not very clear and have amended the sentence as below. Both surveys resulted in robust, reusable datasets and have been written up, as referenced.

(3) '..and strategic sampling at the landscape level was subsequently used successfully in defining the range of variation in vegetation in regional surveys in Cumbria and Shetland'.

(1) Line 401: It would also be possible to examine the performance of different model platforms by dividing data into two groups: 1) a training dataset used to create the initial model and 2) an independent test dataset which was used to test model quality (Fielding & Bell, 1997) and to ensure accuracy and repeatability.

(2) Thank you for the good suggestion, we do use this approach frequently with the data in modelling. As there are many things that could potentially be done with the data, we have not included this in the text in the interests of brevity (unless the editor suggests otherwise).

(1) Line 432: The scientific genus for hawthorn is *Crataegus* (not *Cratageous*).

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(3) Corrected.

(1) Line 441: I'm not sure how useful simple results of changes in species richness are – given spatial effects including environmental gradients.

(2) Although a simple measure, species richness is readily understood and appreciated by policy makers. It does need to be supported by the more detailed ecological analyses, as described in section 7.1. The figure was included here as it was one of the basic headline measures published after the 2007 survey.

(3) We have amended the text to explain the above.

(1) Line 513: link does not work

(2) Again it looks like the problem has arisen because the link is split across lines in the PDF document. The actual string as typed, is correct. Possibly a technical problem arising when the document was converted to PDF when submitted?

(3) No change, as correct.

<https://doi.org/10.5285/26e79792-5ffc-4116-9ac7-72193dd7f191>

(1) Line 519: link does not work

(2) As above.

(3) No change, as correct.

<https://doi.org/10.5285/07896bb2-7078-468c-b56d-fb8b41d47065>

(1) Line 524: link does not work.

(2) As above.

(3) No change, as correct.

<https://doi.org/10.5285/57f97915-8ff1-473b-8c77-2564cbd747bc>

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(1) Line 529: Page does not exist. . .

(1) Line : Page not found. . .

(2) Again it looks like a technical problem arising when the document was converted to PDF when submitted?

(3) No change as links are typed correctly.

<http://eidchub.ceh.ac.uk/administration-folder/tools/ceh-standard-licence-texts/ceh-open-government-licence/plain>

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