# QUALITY ASSURANCE EXERCISE

# FINAL DRAFT (11/04/2008)

**Mike Prosser and Hilary Wallace**
**Ecological Surveys (Bangor)**

The School House, Canon Pyon, Herefordshire, HR4 8PF.
MikeHilary@ecosurvey.demon.co.uk

Report to Centre of Ecology and Hydrology, Lancaster.

# 2007 COUNTRYSIDE SURVEY: QUALITY ASSURANCE EXERCISE

## SUMMARY


### Introduction

It is recognised that in a field investigation on the scale of the Countryside 2007 Survey the large number of surveyors involved must produce an inherent degree of variation despite the provision of a training course, a field handbook and on-site visits by supervisors (Quality Control). It is therefore important to attempt a measure of the consistency and reliability of the work done within the major components of the field programme (Quality Assurance). This report addresses the quality of the botanical recording across the various plots types.

A sample comprising 44 of the squares surveyed in 2007 was selected and in each of these one quarter was re-surveyed. Wherever possible, squares used in the 1990 and 1998 QA exercises were used in the 2007 programme. The main QA survey was conducted between 9 August and 2 November 2007 although seven squares were surveyed early in the season. The re-survey involved the recording of 266 plots covering the eight principal plot types defined in the CS2000 and CS2007 methodology.

### Plot relocation

One aspect of the QA exercise addressed the efficiency of plate and plot location by the surveyors. Although the results indicate that in CS2007 only 36% of the 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%).

The reasons for the relatively poor rate of plate detection are unclear. That the majority of the metal plates are still in position is demonstrated by the equivalent figures for the QA assessors' searches. In 2007, 67% of plates were re-found only slightly down on the 69% tracked in 1998.

### Species-richness

A basic measure of the standard of botanical recording is given by comparing the mean number of species per plot recorded by the surveyors compared with that found by the assessors. The values across all plots for 2007 are CS surveyors 17.5 species/plot, QA assessors 21.7 species/plot, a very significant difference. The discrepancy (4.1 species/plot) is greater than that found in the two previous Countryside Surveys: 1990 (2.8 species/plot higher for the assessors) and 1998 (2.5 species/plot). It therefore appears, that the CS recorders are finding approximately 80% of the species present in an average plot. The effectiveness of search seems to be lowest in the small (2m x 2m) U plots at 74% and the similarly sized Y plots (77%) and greatest in the linear Hedge (94%) and Arable (96%) plots.

The results for the upland unenclosed U-plots may provide a clue to the nature of the overall deficiency – it was noted in the field that in these plots the standard recording of the principal bryophytes was poor and certainly less satisfactory than in previous countryside surveys. To test this impression, the species record for all plots was partitioned

into species groups and the effectiveness of recording of each group compared with that of the QA records. The results showed a highly efficient search image for forbs (90%) followed by a good value for grasses (85%), only adequate figures for woody species and cyperaceae and a very poor lower value of 40.2%, for the allowable bryophytes and lichens.

**Accuracy of species records**

The values for the effectiveness of recording are purely numbers of species recorded and do not address the accuracy of the record: this has been approached by allocating the sources of error in the species record between 10 categories of mis-matches. The total species record for CS2007 and its QA assessment was 6511: of these 3745 were correct records common to both surveyors and assessors giving a total mis-matched species record of 2766. When the individual categories of mis-match are examined it is clear that almost half (48.9%) may be attributed to species being overlooked within the plots by the surveyors and a further 14.5% due to location/orientation errors at the time of the initial survey. When values for each mis-matched category are compared with those for previous surveys an increase in the proportion of overlooked species can be demonstrated whilst errors due to mis-location of the plots have declined. The percentage of non-concordances attributable to incorrect species identification has remained broadly similar since 1990 (at c.7% of the species record). Mis-matches due to seasonal effects and changes in management of the plots have also changed little. It would seem that, judged by the results of the QA, the surveyors have been very conscientious in their searches for and erection of plots for recording but their level of field craft in the approach to quadrat scanning is lower than in the two previous surveys.

The percentage agreement between CS2007 and QA2007, when the mis-matches are expressed as a proportion of the species total, is 65.6%; which is lower than the equivalent value of 73.1% in 1998.

Percentage agreement is an underestimate of the true efficiency of recording since it takes no account of seasonal changes between the initial and QA recording and makes no allowance for errors in the QA assessment. It is not possible to arrive at an accurate, robust, value, for percentage accuracy since a measure of subjectivity is involved in the allocation of some time two errors. However, it seems that the real accuracy of recording would be between 5% and 6% higher than the crude agreement value which would give an accuracy of recording in 2007 of c.71% of the actual species composition of the plots.

**Use of computer tablet**

The use of a computerised field recording system has added a new 'potential' source of error. To test this possibility a subset of 90 plots were recorded simultaneously in the field on customised data sheets and by entry into the tablet. When the results both for species entry and species cover values were compared it was found that approximately 2% of the tablet entries contained errors. Almost half of these involved the wrong cover band being entered but some were species missed from the 'true' record. These omissions, if scaled up to the full QA, would have accounted for c. 10% of the 'overlooked' species. The appearance on the tablet printout of species records not in the field data – often for highly improbable taxa, could account for about one quarter of the 'Unknown' category of non-concordance; species records, apparently incorrect, for which no reasonable explanation could be advanced in the field.

**Estimates of species frequency and abundance**

The frequency of some species is consistently underestimated in CS surveys, whilst a smaller number tend to be over-recorded. When species frequency is compared across the

266 plots monitored, it can be shown that of the 65 species occurring in 10% or more of the plots, 19 were significantly under-recorded by the surveyors. Of these, eight were bryophytes and five were grass species. Only two species were over-represented in the surveyors' records: the mis-match in the frequency of *Anizantha sterilis* is likely to be, at least in part, attributable to a seasonal effect whilst the over-recording of *Poa trivialis* has been a feature of previous CS surveys.

The assignment of species cover is a notoriously imprecise art: the assessments made by the CS2007 surveyors are in general neither better nor worse than their predecessors. There has, however, been a general tendency in CS2007 to be markedly over-generous in the total covers assigned. Of the 35 species which are the main contributors to cover in the plots, 31 were awarded higher mean covers by the surveyors than by the assessors. The mean covers of one species, *Juncus effusus*, were identical. Only *Trichophorum cespitosum, Juncus acutiflorus* and *Lolium perenne* were given higher mean covers by the assessors. The results for rye-grass are interesting when compared with those for *Poa trivialis*, a species for which the mean cover given by the surveyors was more than four times that given by the assessors; – many re-seeds were considered by the surveyors to be overwhelmingly dominated by the meadow-grass, sometimes to the complete exclusion of rye-grass. All cover comparisons are restricted to plots in which the species was recorded by both the CS surveyors and QA assessors. For the 35 species considered, the covers awarded by the surveyors were significantly higher (Wilcoxon $p < 0.02$) than those of the assessors for 11 of the species. Five of the six species having the greatest difference were grasses.

**General**

In addition to the sections outlined above, the report contains a discussion on problems associated with variations in accuracy rates for vegetation recording and brief recommendations relevant to future surveys.

# INTRODUCTION

1 It is recognized that in a field investigation on the scale of the Countryside Survey the large number of recorders and surveyors involved must produce an inherent degree of variation despite the provision of a training course, a field handbook and on-site visits by supervisors (Quality Control). It is therefore important to attempt a measure of the consistency and reliability of the work done within the major components of the field programme (Quality Assurance).

2 The current exercise is confined to an examination of the botanical recording of vegetation plots and follows the same methodology as that developed for the quality assurance (QA) exercises conducted during the 1990 and 1998 Countryside Surveys (CS1990, CS2000 referred to as CS1998 in the text). The efficiency of the mapping component of CS2007 was tested in a separate exercise.

3 A sample comprising 44 of the squares surveyed during the 2007 survey was selected for QA and in each of these one quarter of the 1km square was targeted. As far as possible one example of each plot type was included in the QA programme for each square though the scarcity of U plots in the lowlands and A (arable) plots in the uplands resulted in these being under-represented in the total.

4 In addition to the need for a measure of the dependability of the botanical recording during the 2007 survey it was felt desirable to make some comparison between the current QA exercise and those of previous assessments. To meet this objective, priority was given in the selection of squares for monitoring to those for which previous QA data were available. Hence, 26 of the squares used in the current exercise form triplets with squares used for QA assessment in both the 1990 and 1998 QA programmes; a further 8 form couplets with squares introduced into the monitoring programme in 1998.

5 The reasons for a lack of total concordance between the different QA exercises are two fold; some squares had to be replaced since permission to survey, granted in previous years, was refused in 2007 whilst additional squares were introduced into the programme to reflect the increased representation of sites in Wales in the present CS survey.

6 In total, 266 plots were recorded across the eight plot types, an increase compared to the 234 plots from 38 squares used in 1998.

7 A number of parameters are considered in order to assess the efficiency of recording during the 2007 Countryside Survey; many of these are also used to make comparisons with the CS1990 and CS1998 surveys. The principal factors include the efficiency of plot relocations, measures of species-richness, reasons for discrepancies in the total species record, measures of species' frequency and cover. Finally, an assessment is made of the likely consequences of these variations on assessments of vegetation change.

# METHODS.

## Plot selection

8 The protocol for the selection of the quarter of the square to be used in the QA exercise was as follows:

> The quarter should ideally include six different plot types
> It should be relatively easily accessible
> It should have few land owners.

The map of plots recorded was initially studied for the SE quarter of the square: if this area met the criteria it was selected for QA, if not, attention shifted to the SW quarter, then NW and finally NE until the most appropriate quarter had been established.

9 The full list of squares monitored, with times of original survey and assessment resurvey, is given as Annex A. Those squares also selected in 1990 and 1998 for the QA exercise and repeated in 2007 are identified.

10 The eight plot types used in the CS2007 survey and re-examined as part of the QA exercise may be sub-divided into quadrats and linear plots:

Quadrats:

| | | |
|---|---|---|
| $200m^2$ | X plots | |
| $4m^2$ | Y plots | repeats of a plot type introduced for targeted habitats in 1990 |
| | U plots | an additional plot type introduced in 1998 for use in unenclosed (BAP) broad habitats. |

Linear plots, all 10m x 1m, which comprise:

R: Road verges, commencing adjacent to and parallel with the carriageway. A second parallel strip was originally surveyed in the case of wide verges (not included in the QA exercise and dropped from CS2007). Additional plots on minor roads and tracks are designated as 'V' on the maps but are combined with the 'R' plots in these analyses.

H: Hedges, running parallel with the hedge line and commencing at the mid-point of the hedge. Simple 50m hedgerow diversity plots, introduced in 1998, were also included in the QA exercise.

S: Streamsides, from normal water level or at the lower limit of vegetation cover in the case of water courses with extensive gravel or pebble beds etc. Additional plots on larger water ways are designated W and are amalgamated with the S plots in the analyses.

B: Boundaries, in enclosed land only; recorded at the boundary marker (plate) associated with the $200m^2$ X plot.

A: Arable. A small number of the more recently introduced 100m x 1m arable field margin plots were resurveyed and are discussed but, since the sample size was small, are omitted from some of the analyses.

## Field survey

### Plate and plot relocation

11 An attempt was made in each case to relocate the buried metal plate marking one corner of each quadrat using the original sketch map (and sometimes an amended version annotated by the surveyors), the surveyor's photograph of plot location and a metal detector. The plot may often in practice be accurately relocated on the basis of the sketch map measurements and a good photograph. It was, however, considered important to investigate the effectiveness with which the plates themselves could be physically relocated. Given changes in the appearance of some plots over the time which has elapsed between the 1990CS and the current survey, and the longer-time for potential losses of buried plates, it was also thought to be essential that a comparison be made of changes over time in the efficiency of plate and plot relocation by the CS recorders and that achieved by the QA assessors.

### The species record

12 The same basic methodology for recording the species complement of the plots was adopted as that used for the CS1990 and CS1998 QA exercises. Plots were recorded using a standardised data sheet, all species of vascular plant and allowed cryptogams were listed and then assigned cover values using 5% cover bands. The plots were first recorded 'blind' (without reference to the CS surveyors data) and then compared with the CS surveyors record. Discrepancies between the two species lists were then identified and reasons sought for the non-concordant records. An additional feature of the CS2007 survey was the use of field computers for the recording of plots. For the QA exercise a dual approach to field recording was adopted whereby some plots were recorded both as paper copy and on the computer, thus allowing possible errors due to computer usage to be separately assessed.

## DATA PRESENTATION

13 *Plate and plot location.* A summary of the percentage plate and plot relocation rates for all QA exercises is presented.

14 *Species richness*. The simplest comparison between the CS and QA species records involves assessment of species number/plot. Data are also presented for the 1990 and 1998 QA exercises. ANOVA and Tukey Pairwise comparisons are used to test for significant differences between CS surveyors and QA assessors each year and for any changes over time. For these comparisons care was taken to ensure that all species amalgamations were similarly used in all data sets.

15 *Mis-matches in the species record*. Although a basic comparison for each plot can be made between the results of the initial survey and the subsequent QA record, it is more instructive to compare the species lists critically and to apportion the mis-matches into a series of categories which reflect the nature of individual non-concordances. Ten such categories have been established and these have been used to arrive at values for the actual efficiency of the surveyors recording both by plot and by square.

**16 T1 variations.** Species recorded by CS Surveyors but not confirmed for the plot by the assessors or species present in the QA assessors plot but omitted from the CS surveyors

plots. Some categories recognised in the CS1990 QA assessment have been amalgamated for the 1998 and 2007 assessments.

***A:*** *mis-identifications.* Three forms of non-concordance are amalgamated under this heading.

i. Species incorrectly identified and forming a couplet with the, hopefully, correctly identified species recorded at QA; *Poa trivialis (*CS) *versus Poa annua* (QA) being a common example.

ii. Species not apparently forming a couplet with any species recorded during the QA exercise e.g. where both *Convolvulus arvensis* and *Calystegia sepium* appear in the T1 record but only one of these species was found at T2.

iii. Apparent inputting errors: in previous surveys it was not unusual for a surveyor to tick the wrong box on the data sheet thus allocating a record to an adjacent species. *Primula vulgaris-Prunella vulgaris* and *Ranunculus flammula-Ranunculus ficaria* were the most frequently encountered examples. An analogous error seems to occur with the use of the Tablet. For example; on several occasions a hazel hedge plot had no record for *Corylus avellana* but included *Convolvulus arvensis,* the adjacent species on the species list.

***B:*** *Species considered to have been overlooked during the initial recording*

The allocation of species to this category was relatively straightforward, especially for linear plots, when the QA assessors were confident that the surveyors had accurately relocated the plot. However, in situations where it was apparent that the CS2007 surveyors plot and the assessors plot did not exactly overlap, or where the surveyors were clearly in the wrong place, the assessment was extended to include a search of that area of the CS2007 plot which was not part of the 'real' plot in order to distinguish between species not recorded by the surveyors because of their incorrect plot location (J-errors) and species which were present in their plot but overlooked, a true 'overlooked' (B) error.

***C:*** *Over-zealous recording***.** During the QA exercise particular care was taken to restrict recording to the exact plot size stipulated. The surveyors had, in some instances, not adequately measured the plot or had included species adjacent to but not strictly within the defined area. Such errors were most prevalent with stream plots where an inflated distance from water level was sometimes used and hedge plots where the recording area extended too far into the adjacent sward.

***D:*** *Mysteries*. Species records, apparently incorrect, for which no reasonable explanation could be advanced. Some of these are likely to be 'tablet' errors where a ghost record of a most improbable record may occur.

***J:*** *Location / orientation errors.* In previous QA exercises distinctions were made between non-concordances due to the incorrect orientation of a plot which was otherwise adequately located and mis-matches in the records due to the surveyors either being in the wrong place e.g. a B plot starting from the wrong whitebeam, or recording in the wrong direction e.g. going the wrong way from a plate. A further distinction was made between species recorded that should not have been and species missed as a result of incorrect position. These causes of mis-matches with the QA have been amalgamated into a single T1 location error.

17 **T2 Variations.** Species not recorded by the QA assessors but recorded by the CS surveyors or, *vice versa,* where the species concerned was most probably part of the 'real' plot record.

***E:*** *Species mis-matches due to management changes in plots between CS2007 survey and QA assessment.* These involve changes in crop type, changes in species recorded due to crop management, verge mowing etc. They represent species which were very probably present when the CS2000 surveyors recorded the plot but which were no longer evident at the time of the QA. Conversely, regrowth of species by the time of the QA assessment in plots which had been recently mown at time of the CS2007 survey, especially on road verges.

***F:*** *Species mis-matches due to seasonal changes between CS2007 and QA assessment.*

These non-concordances often represent vernal species which were not identifiable late in the season when the QA was undertaken. In these cases, as in other current mis-matches, examination of the plot record for the previous surveys and QA recordings often enabled a decision to be made as to the likelihood of the species being correctly recorded earlier in the season by the surveyors.

***G/H mis-matches:*** *Orientation errors.* In the 1990 and 1998 QA work a distinction was made between non-concordances due to misalignment of the position of the plot by the assessors and misorientation of a plot. These have been amalgamated in 2007. As with 'J' mis-matches, recourse to previous plot records was often helpful in recognising these errors of positioning on the part of the assessors.

***I:*** *Species missed by the QA assessors*. Species which were in the plot but only recorded when the plot was searched a second time during the comparison of the initial QA record with the CS2007 surveyors record.

18 **Other variations.**

***K:*** *Species mis-match due to location problems.* In some instances, especially when recording plots in squares for which there were no previous records, non-concordances involving species close to plot margins could not satisfactorily be assigned to orientation or misalignment errors between surveyors and assessors. Such situations, usually occurring when neither CS nor QA found the plate, were comparatively rare and the ensuing variations have been equally partitioned between T1 and T2 errors as the only pragmatic solution for completing the species comparison record.

19 *Percentage Agreement*. A crude but objective means of comparing two species lists. Percentage Agreement = Species common to both samples/Aggregated species list from both samples expressed as a percentage. % Agreement is presented for each plot in each square (Annex B) and summarised by plot type and broad landscape category.

20 *Percentage Efficiency*. This is a measure of the surveyors' accuracy and is calculated having removed discrepancies which can be attributed to the QA assessor, usually relating to changes in species present due to seasonal effects, management or location errors.

21 *Species frequency*. Some species are more reliably recorded than others; a comparison of the frequency of occurrence of the more common species in the two records identifies those species that appear to be over- or under- recorded by the CS Surveyors.

22 *Species cover*. The allocation of cover values to species is also prone to error and a comparison of the mean cover values for the common species recorded by the surveyors and QA assessors is also presented.

# RESULTS

23 Annex A presents a summary of the squares surveyed during the CS2007 QA exercise with dates of initial survey and QA assessment. Annex B provides a summary of the allocation of species mis-matches and Annex C summarises these data by landscape.

**Plot and plate relocation.**

24 One of the specific objectives of the QA exercise was to assess the efficiency of plot location prior to recording. Using a combination of plate relocation, the sketch maps and, crucially, the original photographs, the assessors failed adequately to locate only 36 of the 266 plots: a percentage recovery of 86.5%. This recovery rate is remarkably similar to equivalent values for CS1998 QA (86.7%) and CS1990 QA (87.1%). This is a clear demonstration of the effectiveness of the trinary approach to the re-finding of plots.

25 The CS2007 surveyors appeared to have quite precisely relocated 70% of the plots and to have approximately (but acceptably) positioned a further 16%, giving a relocation rate of 86%. This figure for precise relocation is higher than that for CS1998 (only c.60%) whilst the percentage of failures (i.e. plots inadequately relocated) was remarkably similar (1998 = 15%, 2007 = 14%).

26 Plate relocation. Although it was not possible to arrive at a precise figure for the number of plates relocated by the surveyors in CS1998 it would appear to have been approximately 45%. For the CS2007 the comparable figure is 36.4%.

27 This decline does not reflect the true situation. The same pair of assessors, using the same metal detector in all three QA exercises, had a consistently higher plate recovery rate each year: CS1990 = 65.2%, CS1998 = 69.3%, CS2007 = 70.2% plate detection. The value for 2007 includes new squares in Wales for which the assessors were locating plates only recently placed by the surveyors. If these plots are eliminated to make the comparison more fair, the QA recovery value becomes 67.2%, a value intermediate between those for 1990 and 1998.

28 The plates are still out there!

29 However, on a more positive note, the lower number of found plates does not seem to have had a significant impact on the surveyors' ability to adequately re-find the plots; the importance of thoughtfully positioned photographs and clear, unambiguous, sketches is once more emphasised.

**The species record**

*Species richness.*

30 Across the 266 plots assessed in 2007 the CS2007 surveyors recorded, on average, significantly fewer species per plot than the QA assessors. The pattern of under-recording was fairly uniform across all plot types, only the Hedge and Arable plots showed no significant difference between the surveyors and assessors.

31 The expression of the CS surveyor's species richness value as a percentage of the QA assessor's value provides a simple means of comparing the efficiency of recording of the different plot types. The overall value of only 80.71% across all plots compares with a value of 87.7% for the 1998 Countryside Survey QA exercise. In CS 1998 there was a

greater consistency of recording across the different plot types, with a range of 82.4 to 90.2. In 2007 most plot types fell below the 80% with only the Arable and Hedge plots achieving higher scores.

**Table 1.Comparison of species number per plot recorded by the CS 2007 surveyors (CS2007) and the 2007 Quality Assurance assessment (QA 2007). Values are mean species/plot; *p* values are for paired t-test. The final column expresses the CS 2007 surveyors' records as a percentage of the QA assessors.**

| Plot type | Number of samples | CS 2007 | QA 2007 | Paired t-test | CS 2007 % of QA |
|---|---|---|---|---|---|
| All plots | 266 | 17.49 | 21.67 | <0.001 | 80.71 |
| X | 51 | 19.82 | 24.57 | <0.001 | 80.67 |
| Y | 44 | 12.23 | 15.82 | <0.001 | 77.31 |
| H | 26 | 18.04 | 19.19 | 0.257 | 94.01 |
| R | 39 | 20.59 | 25.90 | <0.001 | 79.50 |
| B | 43 | 16.86 | 21.37 | <0.001 | 78.90 |
| U | 19 | 12.84 | 17.32 | <0.001 | 74.13 |
| A | 7 | 19.71 | 20.57 | 0.861 | 95.82 |
| S | 37 | 19.60 | 24.73 | <0.001 | 79.26 |

32 In common with the results from the two previous Countryside Surveys and their QA programmes, the mean species per plot recorded by the assessors was greater than that for the same plots at the time of the initial survey. The impression gained in the field was that grasses in particular had been poorly recorded and that the lack of attention to those allowable bryophytes and lichens present had depressed significantly the level of concordance between the surveyors and assessors. Table 2 presents values for the under-recording of species (as a percentage of the QA record) when partitioned into species groups. Data presented are the total records for each taxanomic group.

**Table 2. Effectiveness of recording by species group.**

| Species group | CS 2007 Records | QA 2007 Records | Percentage recorded by surveyors |
|---|---|---|---|
| All species | 4653 | 5765 | 80.7 |
| Forbs (+ ferns) | 2611 | 2912 | 89.7 |
| Grasses | 1167 | 1368 | 85.3 |
| Trees and shrubs | 445 | 573 | 77.7 |
| Cyperacea | 146 | 206 | 70.9 |
| Allowed cryptogams | 284 | 706 | 40.2 |

33 Can the data be reliably used to assess changes in species-richness over time? Using the full data set from each of the QA exercises the mean species/plot has been compared using ANOVA and Tukey pairwise comparisons. From these comparisons the CS surveyors' data indicate a decline in species richness between 1990 and 1998 but only a modest further decline in 2007; the overall result is however a significant decline in richness between 1990 and 2007. For the QA assessors, the apparent decline between 1990 and 1998 has been reversed, and no overall decline in richness is noted between the 1990 and 2007 assessments. In both 1990 and 2007 the QA assessors recorded significantly more species than the surveyors (Table 3).

**Table 3. Comparison of mean species number/plot, CS surveyor *v* QA assessor, 1990 –2007.**

| Year | Number of records | CS Surveyor | QA assessor | ANOVA CS v QA |
|---|---|---|---|---|
| 1990 | 207 | 20.57 | 23.40 | 0.038 |
| 1998 | 210 * | 17.89 | 20.41 | NS |
| 2007 | 266 | 17.49 | 21.67 | <0.001 |

* The total of 234 plots recorded, given in para. 6, includes hedgerow diversity and arable plots excluded from the 1998 QA analysis.

*Allocation of sources of error in the species record*

34 The total species record for the CS2007 and its QA assessment was 6511. Of these, records that were common to both T1 (CS surveyor) and T2 (QA assessor) = 3745. Thus the total mis-matched species record = 2766.

35 Table 4 presents a summary of the allocation of the mis-matched species records as a proportion of the total mis-matches. For example, there were 1353 records of species having been over-looked by the CS surveyors, this equates to 48.9% of the total errors. Annex B presents the attribution of mis-matches to each of the 10 categories used for each plot recorded together with the values for % accuracy by plot.

36 Table 5 presents a summary of the equivalent values for the 1990 and 1998 QA exercises.

**Table 4. Allocation of sources of error in the species record for the CS2007 survey. Total errors = 2766 mis-matched species records. These can be apportioned between errors arising from the CS 2007 surveyors (T1 errors) and those occurring during the QA exercise (T2 errors).**

**T1 MIS-MATCHES**

| Category | Description | Number of records | % of total |
|---|---|---|---|
| A | Species mis-identified | 217 | 7.8 |
| B | Species overlooked | 1353 | 48.9 |
| C | Over-zealous recording | 54 | 1.9 |
| D | Mysteries | 143 | 5.2 |
| J | Plot mis-alignment/orientation | 400 | 14.5 |

**T2 MIS-MATCHES**

| | | | |
|---|---|---|---|
| E | Species change due to management | 45 | 1.6 |
| F | Seasonal changes | 139 | 5.0 |
| G/H | T2 Location/orientation uncertain | 143 | 5.2 |
| I | Overlooked by the assessor | 116 | 4.2 |

**UNCERTAIN LOCATION ERRORS**

| | | | |
|---|---|---|---|
| K | Location problems: unclear if CS or QA in wrong place | 156 | 5.6 |

**Table 5. Allocation of mis-matched records: Summary comparison with 1990 and 1999 CS surveys.**

| Type | % total error 1990 | % total error 1998 | % total error 2007 |
|---|---|---|---|
| **CS Surveyor mis-matches** | | | |
| A | 6.3 | 8.5 | 7.8 |
| B | 34.5 | 39.8 | 48.9 |
| C | 5.8 | 1.9 | 1.9 |
| D | 2.8 | 4.6 | 5.2 |
| J | 3.7 | 19.9 | 14.5 |
| **QA mis-matches** | | | |
| E | 3.4 | 2.0 | 1.6 |
| F | 20.8 | 3.7 | 5.0 |
| G/H | 17.7 | 9.2 | 5.2 |
| I | 5.0 | 10.4 | 4.2 |
| **Uncertain location errors** | | | 5.6 |

37 An alternative approach is to express the mis-matches as a proportion of the total species record: in this case the combined CS2007 and QA2007 species record is 6511. This compares with a value of 5841 for the CS1998 QA exercise and reflects the greater number of plots recorded in the present exercise. This is the crudest form of comparison, and gives an overall % agreement based on the total species record. The cumulative T1 error of 34.4% equates to a % agreement of 65.6%. The comparable figures were 73.1% in 1998 and 79.3% in 1990 (Table 6).

**Table 6. Summary of allocation of variation in species record as a % of the total species record.**
Values for the 1990 and 1998 QA exercises are presented for comparison.

| | | **1990** | **1998** | **2007** |
|---|---|---|---|---|
| A | Species mis-identified | 2.5 | 3.4 | 3.3 |
| B | Species overlooked | 13.5 | 14.1 | 20.8 |
| C | Over-zealous recording | 2.3 | 0.7 | 0.8 |
| D | Mysteries | 1.1 | 1.6 | 2.2 |
| J+K | Plot mis-alignment/orientation | 1.4 | 6.9 | 7.3 |
| | **Total T1** | **20.7** | **26.9** | **34.4** |
| | | | | |
| E | Species change due to management | 1.3 | 0.7 | 0.7 |
| F | Seasonal changes | 8.2 | 1.3 | 2.1 |
| G/H/K | Location/orientation unclear | 6.9 | 3.2 | 3.4 |
| I | Overlooked by the assessor | 1.9 | 3.7 | 1.8 |
| | **Total T2** | **18.4** | **8.9** | **8.0** |
| | | | | |

*Tablet errors.*

38 An attempt has been made to assess the likely increase in recorder error introduced through the use of the computer tablet (Table 7). During the QA exercise a number of plots were recorded simultaneously on the tablet and as paper copy by the pair of QA assessors. Subsequent comparison of the species record, and cover values, have given some insight into the likely errors arising from tablet use.

**Table 7. Tablet test: 4188 records for species and species cover from 15 squares and 90 plots.**

| Error | Number | % of species record |
|---|---|---|
| Missing species code on tablet | 34 | 0.81 |
| Wrong species code entered on tablet | 10 | 0.24 |
| Extra species code entered | 11 | 0.26 |
| Missing cover value | 5 | 0.12 |
| Wrong cover value | 36 | 0.86 |
| **Total** | **96** | **2.29%** |

39 Of the 2094 species recorded in the test 34 were omitted from the tablet, an equivalent of an overlooked value of 1.62% (B type error).

40 Similarly, the wrong code entries on the tablet, 10 out of 2094 (0.477%), are equivalent to **D** (unknown errors).

41 The use of the computer tablet has introduced an additional dimension to the recording which is akin to the 'wrong' box 'mis-identification' error of the 1990 QA exercise. Wrong entries on the tablet may also account for some of the unknowns where the wrong species is selected from the drop-down extended species list. Whether the increases in overlooked species can in any way be attributed to the use of the tablet is less clear; it is possible that in trying to add extra species from the drop down menu a previously recorded species has been over-written, also the time taken to find species might have resulted in the next called species being missed; however, on balance it would seem that the greater reason for an increase in overlooked species is the failure of the recorder to recognise species that are present.

*Percentage Agreement*

42 This is the crudest, and simplest, measure of the level of agreement between two independently collected species lists. The number of species common to both lists is divided by the aggregate of all species recorded at time one (T1) and at time two (T2) and then expressed as a percentage (Annex B).

**43 Percentage agreement = Common species / cumulative species list from T1 and T2 * 100.**

*Percentage accuracy*

44 A number of species mis-matches will have resulted from the time elapsed between the surveyors recording and the QA assessment; these arise from management activities (crop harvesting, herbicide treatment, silage/hay cutting, hedge and verge cutting) and seasonal changes (die-back of early spring flowers e.g. *Arum maculatum, Ranunculus ficaria)*. In addition, there will be instances of the QA plot being slightly mis-placed, and of the QA assessor overlooking species that are present. If these mis-matches are removed from the calculation then a new value of efficiency of initial recording is arrived at (Annex B).

**45 Percentage accuracy = Common species / cumulative species list from T1 plus (T2 species minus T2 errors ) * 100**

46 In 2007 it was apparent that the recording of species on the list of common cryptogams (mosses, liverworts and lichens) was very inconsistent and was often depressing both the species richness and the number of 'common' species records, especially in the upland plots. In order to assess the impact of deficiency on the overall species record the Percentage accuracy index has been recalculated for all plots omitting all cryptogam records (Annex B).

47 A summary by broad landscape type of percentage agreement and percentage accuracy is given in Table 8. It is clear from Table 8 that recording of cryptogams has had a marked impact on the accuracy of the upland squares where bryophytes are often a major component of the vegetation whilst in the lowland squares, where bryophytes are less prominent, the increase in accuracy has been only modest.

**Table 8. Summary of percentage agreement and percentage accuracy for CS2007 plots, grouped according to broad landscape types (LC).**

| LC | Plots | % Agreement | (Range) | % Accuracy | Range | % Accuracy (-cryptogams) | (Range) |
|---|---|---|---|---|---|---|---|
| All plots | 266 | 57.29 | (5 –100) | 62.18 | (5.9-100) | 66.83 | (5.9-100) |
| 1 | 63 | 51.58 | (13.6-77.8) | 58.18 | (20-84.6) | 61.19 | (20-87.5) |
| 2 | 88 | 62.16 | (20 -84.6) | 66.37 | (20.0-94.1) | 68.50 | (22.2-94.1) |
| 3 | 73 | 57.22 | (5-85.7) | 62.32 | (5.9-94.4) | 66.71 | (5.9-94.4) |
| 4 | 42 | 55.80 | (21.1-100) | 59.17 | (21.1-100) | 71.97 | (30.8-100) |

LC definitions: 1 = Arable (lowland cultivated), 2 = Pastural (lowland grassland),
3 = Marginal upland, 4 = Upland.

48 Annex C presents a summary of the % agreement and % accuracy for each of the 44 squares in the QA exercise.

49 A summary of these data by plot type forms Table 9. The poor results for the few arable plots monitored is largely a reflection of the presence of significant number of species in seedling condition which were poorly identified as they were in the 1998 survey. It might be expected that accuracy in the small ($4m^2$) U and Y plots would be depressed in comparison with the linear plots but this has not proved the case. For the U plots this may be largely explained by the relative homogeneity of the upland vegetation in which these are concentrated: a failure to precisely relocate the plot is likely to have a much lesser effect than for other plot types.

**Table 9. Summary of agreement by plot type.**

| Plot type | Number | % Agreement | % Accuracy | % Accuracy (-cryptogams) |
|---|---|---|---|---|
| X | 50 | 55.57 | 59.99 | 66.25 |
| B | 43 | 55.34 | 59.41 | 63.23 |
| Y | 44 | 53.39 | 59.20 | 64.27 |
| R | 40 | 60.60 | 65.70 | 67.80 |
| H | 26 | 60.73 | 65.43 | 67.74 |
| U | 18 | 60.70 | 67.21 | 76.91 |
| A | 7 | 50.44 | 55.74 | 59.56 |
| S | 38 | 60.08 | 64.53 | 69.44 |

*Species frequency of occurrence.*

50 It is clear from the previous sections that the number of species recorded in a plot by the CS2007 surveyors was often less than that recorded by the QA assessors. In order to see whether there was a tendency for some species to be consistently under (or over) recorded by the surveyors a simple table (Table 10) has been produced listing the frequency of occurrence of the principal species within the 266 sampled plots. The data

in the table provide the % frequency of each species (i.e. number of occurrences / 266 * 100 ) as recorded by the CS surveyors and QA assessors during the CS2007 survey.

51 Only species occurring in >10% of plots in either the CS or QA data sets are included.

52 Species denoted by bold type have a discrepancy of more than 25% between the two lists. In most cases the QA data has a greater number of records; this is particularly common for grass species (*Agrostis stolonifera, Elytrigia repens, Festuca rubra, Holcus mollis, Poa pratensis)* and for mosses, most notably *Brachythecium spp., Eurhynchium spp., Hypnum spp.* and *Pleurozium schreberi.*

53 Species in italics are those which display a greater frequency in the surveyors plots than in those of the QA assessors. Most notable are *Anizantha sterilis* and *Poa trivialis;* the apparent over-recording of the latter was also a feature of the 1998 QA exercise.

**Table 10. Summary of species frequency of occurrence CS Surveyor and QA assessor (CS2007).**

| | CS Surveyor | QA assessor | | | CS Surveyor | QA assessor |
|---|---|---|---|---|---|---|
| | | | | | | |
| Achillea millefolium | 31 | 34 | | **Plantago major** | **26** | **40** |
| Agrostis capillaris | 76 | 86 | | Poa annua | 56 | 56 |
| **Agrostis stolonifera** | **78** | **106** | | **Poa pratensis** | **23** | **34** |
| ***Anizantha sterilis*** | ***27*** | ***17*** | | ***Poa trivialis*** | ***87*** | ***65*** |
| Anthoxanthum odoratum | 59 | 72 | | Potentilla erecta | 49 | 52 |
| Anthriscus sylvestris | 43 | 43 | | Prunella vulgaris | 28 | 35 |
| Arrhenatherum elatius | 57 | 64 | | Prunus spinosa | 31 | 37 |
| **Bellis perennis** | **18** | **29** | | Quercus spp | 28 | 31 |
| Calluna vulgaris | 42 | 45 | | **Ranunculus acris** | **34** | **49** |
| **Cardamine pratensis** | **16** | **39** | | Ranunculus repens | 98 | 107 |
| Cerastium fontanum | 63 | 80 | | Rubus fruticosus agg. | 72 | 83 |
| *Cirsium arvense* | *44* | *42* | | Rumex acetosa | 63 | 72 |
| Cirsium palustre | 30 | 35 | | *Rumex obtusifolius* | *48* | *43* |
| Cirsium vulgare | 22 | 27 | | Stellaria media | 25 | 28 |
| Corylus avellana | 26 | 30 | | Taraxacum sect. vulgaria | 66 | 87 |
| Crataegus monogyna | 49 | 51 | | Trifolium repens | 72 | 87 |
| Cynosurus cristatus | 29 | 38 | | Urtica dioica | 95 | 103 |
| Dactylis glomerata | 86 | 99 | | Veronica chamaedrys | 26 | 30 |
| **Elytrigia repens** | **25** | **35** | | Viola riv/reich | 22 | 26 |
| Erica tetralix | 27 | 25 | | | | |
| **Eriophorum angustifolium** | **23** | **32** | | **Brachythecium spp** | **14** | **67** |
| Festuca ovina | 22 | 28 | | **Eurhynchium spp** | **16** | **56** |
| **Festuca rubra** | **65** | **93** | | **Hylocomium splendens** | **22** | **33** |
| Fraxinus excelsior | 34 | 33 | | **Hypnum cup/jut** | **14** | **50** |
| *Galium aparine* | *74* | *68* | | **Pleurozium schreberi** | **8** | **27** |
| **Galium saxatile** | **25** | **38** | | **Pseudoscleropodium purum** | **15** | **26** |
| Geranium robertianum | 28 | 31 | | **Rhytidiadelphus squarrosus** | **32** | **46** |
| Glechoma hederacea | 25 | 32 | | Sphagnum green thin | 21 | 27 |
| Hedera helix (g) | 50 | 60 | | **Thuidium tamariscinum** | **11** | **26** |
| Heracleum sphondylium | 35 | 40 | | | | |
| Holcus lanatus | 124 | 139 | | | | |
| **Holcus mollis** | **20** | **27** | | | | |
| Juncus effusus | 56 | 61 | | | | |
| Lolium perenne | 86 | 103 | | | | |
| Luzula campestris/multiflora | 33 | 38 | | | | |
| Molinia caerulea | 35 | 38 | | | | |
| Plantago lanceolata | 35 | 39 | | | | |

*Species cover*

54 Many comparisons of change can be carried out on the species record alone without regard to the amount of each species present. However, shifts in the proportions of some species, especially potentially aggressive species or those indicative of increased nitrogen loading eg. *Urtica dioica, Arrhenatherum elatius, Eriophorum vaginatum* and *Lolium perenne,* might also be considered important for assessments of community change. Analyses of earlier QA exercises highlighted poor cover assignment as one of the potential causes of apparent shifts in the position of plots in multivariate analyses.

55 Table 11 presents a summary of the mean cover values for the principal species, across all 266 plots recorded during the CS2007 QA exercise. Differences in overall cover values awarded have been tested using Wilcoxon matched pair analysis and the significance values of this test are presented in the final column of the table. Comparisons have been restricted to plots in which a species was recorded by both the CS surveyor and the QA assessor.

56 In contrast to the recording of species lists, the surveyors were in general over-generous with their allocation of species cover values. In all cases where there was a significant difference in the mean cover values awarded the CS surveyor's value was higher than the QA assessors. The most notable discrepancy was for *Poa trivialis* (a species that was also more frequent in the CS surveyors record). Other species with notably higher values in the CS surveyors records are *Agrostis stolonifera, Dactylis glomerata, Eriophorum angustifolium, Holcus lanatus* and *Rubus fruticosus*. Higher cover values in the surveyors record for *Anthoxanthum odoratum* and *Galium aparine* might be due partly to the earlier timing of their survey.

**Table 11. Comparison of assessments of species cover values across all plot types. Comparisons are restricted to plots in which the species was recorded by both the CS surveyor and the QA assessor.**

| Species | N of couplets | CS 2007 | QA 2007 | Wilcoxon p |
|---|---|---|---|---|
| Agrostis capillaris | 61 | 13.3 | 12.8 | 0.614 |
| **Agrostis stolonifera** | **68** | **15.3** | **10.0** | **0.008** |
| **Anthoxanthum odoratum** | **51** | **7.9** | **2.9** | **<0.001** |
| Arrhenatherum elatius | 52 | 13.9 | 10.0 | 0.173 |
| Anthriscus sylvestris | 33 | 7.1 | 3.8 | 0.15 |
| Calluna vulgaris | 41 | 25.2 | 22.5 | 0.196 |
| Cirsium arvense | 32 | 2.2 | 1.4 | 0.107 |
| Corylus avellana | 25 | 26.9 | 23.8 | 0.501 |
| Crataegus monogyna | 45 | 22.1 | 19.9 | 0.666 |
| Cynosurus cristatus | 25 | 6.4 | 4.7 | 0.460 |
| **Dactylis glomerata** | **75** | **12.0** | **8.0** | **0.003** |
| Elytrigea repens | 17 | 15.7 | 11.0 | 0.102 |
| **Eriophorum angustifolium** | **20** | **5.3** | **3.3** | **0.015** |
| Eriophorum vaginatum | 12 | 21.7 | 16.8 | 0.479 |
| Festuca rubra | 59 | 8.5 | 7.8 | 0.475 |
| Fraxinus excelsior | 28 | 24.7 | 20.6 | 0.325 |
| **Galium aparine** | **51** | **4.0** | **1.8** | **0.005** |
| Hedera helix | 47 | 17.3 | 15.3 | 0.555 |
| **Holcus lanatus** | **115** | **13.5** | **9.0** | **<0.001** |
| Hylocomium splendens | 19 | 13.0 | 9.3 | 0.345 |
| Juncus a/a | 19 | 11.5 | 12.2 | 0.888 |
| Juncus effusus | 52 | 15.4 | 15.4 | 0.791 |
| Lolium perenne | 82 | 23.3 | 25.9 | 0.337 |
| Molinia caerulea | 29 | 22.5 | 18.7 | 0.153 |
| **Quercus spp** | **22** | **33.3** | **19.4** | **0.001** |
| **Poa annua** | **46** | **5.4** | **1.9** | **0.001** |
| **Poa trivialis** | **45** | **11.0** | **2.7** | **<0.001** |
| Prunus spinosa | 28 | 32.4 | 28.3 | 0.499 |
| Pteridium aquilinum | 23 | 27.2 | 23.5 | 0.314 |
| Ranunculus repens | 83 | 5.7 | 5.3 | 0.414 |
| Rhytidiadelphus squarrosus | 27 | 5.9 | 3.8 | 0.185 |
| **Rubus fruticosus** | **67** | **15.8** | **12.1** | **0.006** |
| Trichophorum cespitosum | 21 | 11.9 | 15.4 | 0.294 |
| Trifolium repens | 67 | 8.1 | 6.0 | 0.057 |
| **Urtica dioica** | **89** | **12.4** | **9.2** | **0.021** |

# DISCUSSION.

57 Problems associated with variations in accuracy rates in vegetation recording have long been appreciated, especially in the identification of grassland species (Ellison 1942; Hope-Simpson 1940; Smith 1944) but also in mire (Clymo 1980) and forest situations (Hall & Okali 1978).

58 Many long-term plot-based monitoring programmes rely on teams of surveyors, often with new teams being recruited for each repeat survey. This inevitably introduces variation in the data set, within and between years, due to differences in the surveyors' accuracy of species recording (Kirby *et al*. 1986; Prosser & Wallace 1992; Scott & Hallam 2002) and in their assessment of species cover (Kercher *et al.* 2003; Klimes 2003; Sykes *et al.* 1983) over and above genuine vegetation change.

59 Studies have used various measures to assess the level of mis-match between teams of surveyors. Within and between team sampling errors have been assessed using pseudo-turnover (Leps & Hadincova 1992; Nilsson & Nilsson 1985) which estimates the magnitude of species turnover due to recorder error above any natural change in species lists. It is based on the non-concordance of species in two lists collected in the same area at two different times, or by two different surveyors at the same time, expressed as a proportion of the total number of species recorded at each time. Nilsson & Nilsson (1985) found an average between-team pseudo-turnover of 13% for species lists from stands on small islands. Leps & Hadincova (1992) also report a turnover of 13% for two experienced observers recording 40 releves in 5m x 5m plots. A similar value (16%) can be calculated from the data of Hope-Simpson (1940) for chalk grassland plots. A rather higher value of 22% was found in small plots within a wide range of habitat types by Scott and Hallam (2002).

60 Other workers have approached the problem by considering the level of agreement between two lists; the number of common species is expressed as a percentage of the cumulative species list from the two records; reported values include a value of 83% for chalk grassland (Hope-Simpson 1940), a range of 32 to 80% for woodland (Kirby *et al.* 1986) and an average of 57% over a range of habitats (Scott & Hallam 2002). Prosser and Wallace (1992), as part of pre-CS1990 trial, reported average percentage agreements of 56% when two surveys were undertaken by different recorders, compared to 62% when the same recorders were used for both studies.

61 Where causes for differences in the lists are considered it seems that misidentification is relatively uncommon but the inability of surveyors to identify young plants and hence their omission from the record is probably often underestimated (Klimes, *et.al.* 2001). Similarly, surveyors with more field experience tend to overlook (omit) fewer species; the importance of training is emphasized (Smith 1944) as is care in the choice of surveyors (Oredsson 2000); Nilsson (1992) proposes that all vegetation analyses be based on teams of two investigators rather than a single recorder. Individual surveyors can thus have very different levels of survey accuracy; this may pose serious limitations in the use of such data sets for the assessment of changes in species diversity over time (Rich & Woodruff 1992; West & Hatton 1990).

62 The accuracy of plot relocation will also affect measures of species and community turnover (Prosser & Wallace 1992; West & Hatton 1990) and in this respect many authors have stressed the value of permanent quadrats (Bakker *et al.* 1996; Dodd *et al*.

1995; Herben 1996; Hill & Radford 1986). Klimes *et.al.* (2001) found a greater lack of concordance in smaller plots compared to larger quadrats.

63 In CS2007 the overall % agreement, based on the total species record, of 65.6% is lower than the values of 73.1% and 79.3% for the 1998 and 1990 QA exercises respectively. The range of % agreement values obtained on a plot by plot basis are similar to those from the previous QA exercises for the marginal upland habitats but are considerably poorer for the upland plots. Values for the arable and lowland grassland habitats are fairly comparable. The poor results from the upland squares stems partly from the inadequate recording of cryptogams, but also from a very wide variation in the % agreement values of individual plots within a square. The range of efficiency of recording suggests that within the teams some members were much more competent field botanists than others.

64 Average % agreement values for individual squares show a similar range to that of previous QA exercises. Some squares seem to produce consistently low scores (e.g. 336, 657, 366) indicating the original 1990 surveyors provided inadequate sketch maps and photos for efficient relocation of plots. The remaining variation reflects the inherent variability in field ID skills that will inevitably occur in a survey of the scale of CS2007.

## RECOMMENDATIONS.

65 *No new plates please*. On a number of occasions the CS 1998 surveyors failed to find the original plot and either put in a new plate or erected a new plot whilst subsequent visits by the QA assessors refound the original plate and plot. In CS2007 this problem has been confounded. There were a number of instances when only the 1998 data were provided to the CS2007 surveyor when the original 1990 plot was still present and recordable. It would be best for future surveyors to note when they fail to find a plot and record their best estimate but not to erect yet more plots.

66 *Cryptogams*. Either eliminate or concentrate on identification during training course. Since changes in the profile of many mosses in the uplands might be indicative of changes in nutrient status it seems unfortunate if these are not adequately recorded through lack of training at the start of the survey. They also often contribute significantly to the species richness of a plot.

67 *Grasses*. Need for more practice in vegetative ID during training courses.

68 *Photos*. Emphasise importance of photographs – do not take close-ups of plots if poorly illuminated; include salient background features; always indicate position of photo on plot sketch.

69 *Tablet.* Default for 'presence' cover value in the 'selected species' table to avoid lengthy data inputting

70 *Species cover values.* Some very high total cover values were noted in the CS2007 surveyors records. A few of these appear to have resulted from tablet errors where two adjacent species have been given a high value when only one species was present at high cover, but more generally the scores reflect the lack of experience on the part of the surveyors. Cover values in excess of 200 were common and one plot had >300% cover, even in woodland and heathland situations total covers of >180% are relatively uncommon.

71 *Tablet.* Needs an intelligent system for typing in and recognising additional species from the long list. The keyboard tab could be used to input the first 3 letters of the generic name and first 3 letters of the species name thus providing a short list (or a unique ID) for the target species which can then be selected.

72 *Photos and sketches.* Draw attention for the need to check photos and sketches before searching for hedge and streamside plots to establish whether the plot is roadside or fieldside of hedge, and which side of stream is to be recorded; mistakes are still evident.

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