Countryside Survey

State of the Welsh Countryside
results from 2007

▲ Diverse Clwydian landscape • © *Richard Evans*

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By comparing data collected in each survey, the gradual and subtle changes that occur in the UK countryside can be studied.

In the 2007 survey, observers in Wales visited many more locations than in previous surveys. As a result of this, Countryside Survey has for the first time been able to produce a separate set of results for Wales.

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Key messages...

1. Has botanical diversity in the countryside changed?

Botanical diversity, including richness of food plants for butterfly larvae in sample plots, declined between 1990 and 2007. Non-native species were rare in the Welsh countryside in 2007 (occurring in less than one in every five sample plots) and decreased between surveys alongside the decline in native species richness. Plant species that increased between 1998 and 2007 favoured wetter conditions or tended to be taller.

2. Has the length and condition of hedges changed?

In parallel with the rest of Britain, there has been a reduction in the length of managed hedgerow in Wales over the 23 years since the first survey in 1984 and an increase in unmanaged lines of trees and shrubs.

3. Which habitats have increased or decreased in area?

The area of most habitats remained stable between 1998 and 2007 but some notable changes did occur. Built land, arable and broadleaved woodland all increased in different parts of Wales, reflecting changes in land-use. The areas of Dwarf Shrub Heath, Bog, Fen, Marsh & Swamp, and Inland Rock showed no significant change during the same period. The area of Bracken-dominated land (>95% cover) decreased by 55% between 1998 and 2007 and this was probably linked to an increase in Acid Grassland.

4. Has the condition of freshwater habitats continued to change?

The physical characteristics of headwater streams improved between 1998 and 2007 and there was no change in the nutrient status of stream communities. Streamsides have become much more overgrown since 1978 favouring reduced plant species richness but providing conditions more suitable for shade-tolerant plants. The number of ponds increased between 1998 and 2007 by 17%.

5. Have there been detectable changes in surface soil (0-15cm) characteristics?

Soil pH has progressively increased since 1978 although rate of change is slowing in many habitats. This trend is consistent with the reduction in pollution from acidic deposition.

Soil carbon concentration decreased in coniferous woodland between 1998 and 2007. No changes were detected in other habitats or for Wales as a whole. Changes in carbon concentration are important as losses could contribute to climate change.

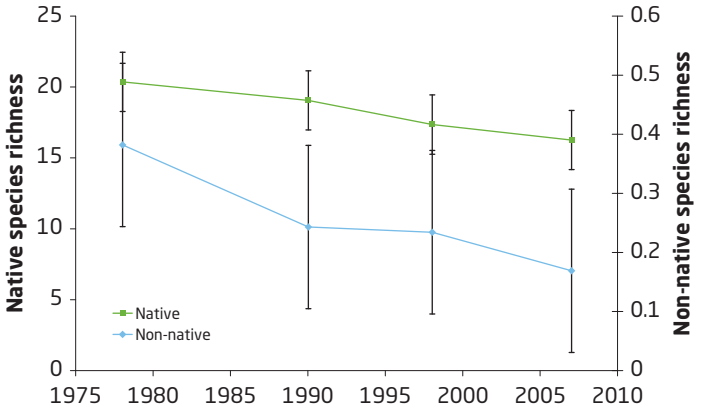
Summary of results

How might changes have affected the ability of landscape and habitats in Wales to cope with climate change?

▲ Hedgrerow connectivity, Powys • © *C.Hurford, CCW*

- Greater species diversity provides greater resilience and adaptability to environmental change. Therefore the general reduction in species diversity across Wales *(Figure 1)* could reduce the adaptive capacity of the landscape and ecosystems to respond to climate change.
- There is evidence of an increase in wooded habitat in the landscape which will have resulted in a more ecologically 'connected' landscape but only for species that can move through wooded corridors.
- While the diversity of common non-native species has declined recently *(Figure 1)*, non-native species are likely to benefit from climate change. While some can pose a threat to native biodiversity, others are likely to become benign occupants of a countryside slowly adapting to warmer conditions.

▼ **Figure 1:** Changes in native and non-native species richness in all Welsh repeat plots (n=115) first sampled in 1978. Error bars are 95% Confidence Intervals on the mean counts in each survey year.

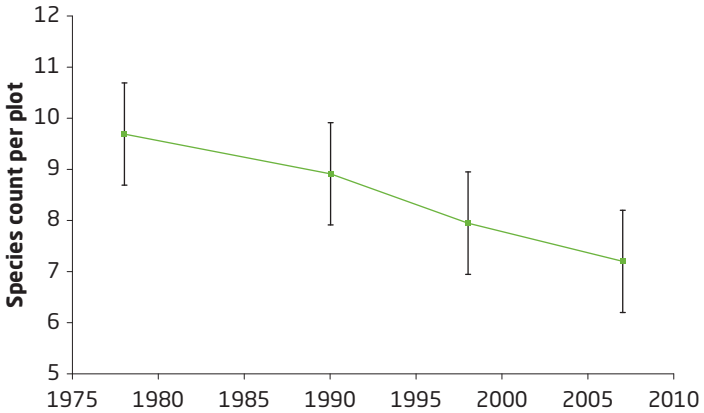


Food plants for butterfly larvae are in decline.

▲ Small Tortoiseshell • © *Richard Evans*

- A statistically significant reduction in butterfly larval food plant richness per plot has been seen across Wales since 1978 ***(Figure 2)***. The decline was especially evident in the lowlands.
- Many of the larval food plants are small flowering plants and grasses which are intolerant of high nutrient levels. Their reduction is consistent with higher fertility caused by agricultural improvement and atmospheric nitrogen deposition, as well as an increase in cover of taller shrubs and trees.

▼ **Figure 2:** Changes in count of butterfly larval food plants in all vegetation types sampled in Wales in plots that were visited in 1978, 1990, 1998 and 2007 (n=115). Error bars are 95% Confidence Intervals on the mean counts in each survey year.



Are Welsh soils recovering from acid rain?

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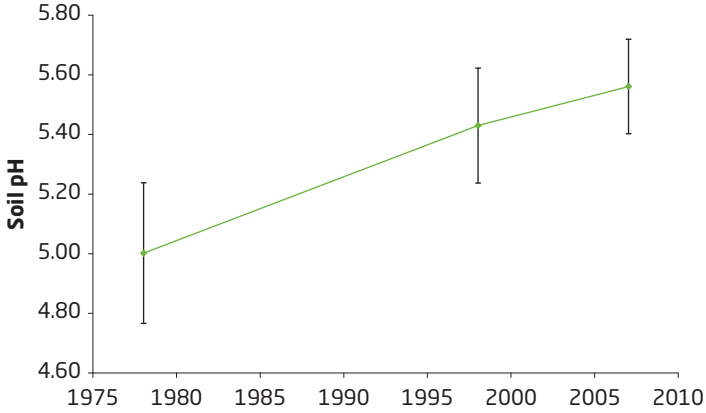
- Since the early 1970s the atmospheric deposition of sulphur dioxide, which was a large contributor to "acid rain", has declined greatly across the UK.
- In Wales, average soil pH increased between 1978 and 2007 and stabilised between 1998 and 2007 ***(Figure 3)***.
- This pattern is consistent with soils recovering from the effects of acidification and is a positive sign of ecosystem recovery from earlier pollution.

▼ **Figure 3:** Change in soil pH (0-15cm) based on all Welsh samples collected in 1978, 1998 and 2007. Error bars are 95% Confidence Intervals on the mean pH in each survey year.

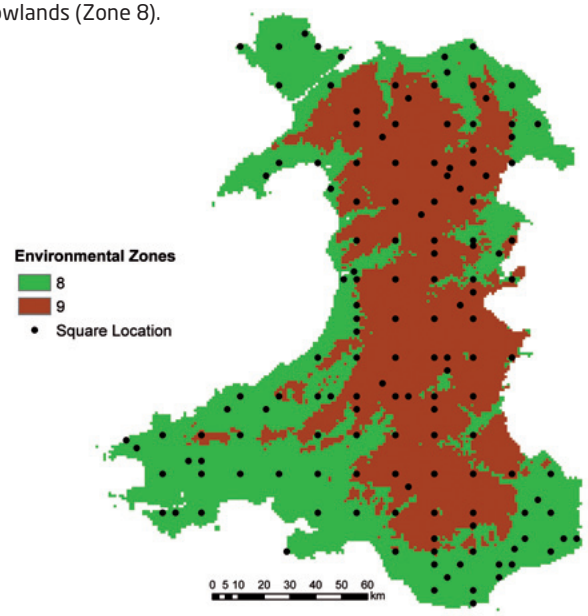


A new baseline for Wales against which to compare findings from future surveys.

▲ Field mapping • © *CEH*

- With devolution there is an increased need for high quality information about the state of the Welsh countryside. To achieve this goal, in 2007 the number of sample squares was increased from 64 to 107 *(Figure 4)*.
- This has increased the statistical power of the sample resulting in an immediate improvement in the estimates available for 2007 and providing a baseline for more precise measurement of change between 2007 and future surveys.

▼ **Figure 4:** Countryside Survey sampling. Black dots show the location of the sample squares in 2007 (not to scale) superimposed on a division of Wales into two Environmental Zones; uplands (Zone 9) and lowlands (Zone 8).



Results in context

The expanded Countryside Survey carried out in 2007 has provided us with an improved understanding of the current state and recent change in the Welsh Countryside as well as an enhanced baseline for the detection of future change. Positive changes have been identified in the 2007 survey including an increase in the area of broadleaved woodland, an improvement in the physical condition of streams, an increase in the number of ponds, and a reduction in soil acidity in line with reduced emissions of sulphur dioxide. But these changes have taken place against a general backdrop of decreasing plant species richness, which is at odds with the aim of halting biodiversity loss.

▲ Welsh topsoil • © *B. Williams, CEH*

These early results from Countryside Survey have highlighted the often complex trade-offs to be made in making decisions about the management of the countryside. Often changes are neither wholly positive nor wholly negative, and one environmental benefit may only be realised at the expense of another valued resource. Future work will help us to better understand the results in relation to key challenges identified in the Environment Strategy for Wales such as climate change, degraded ecosystems, loss of biodiversity, and loss of landscape quality.

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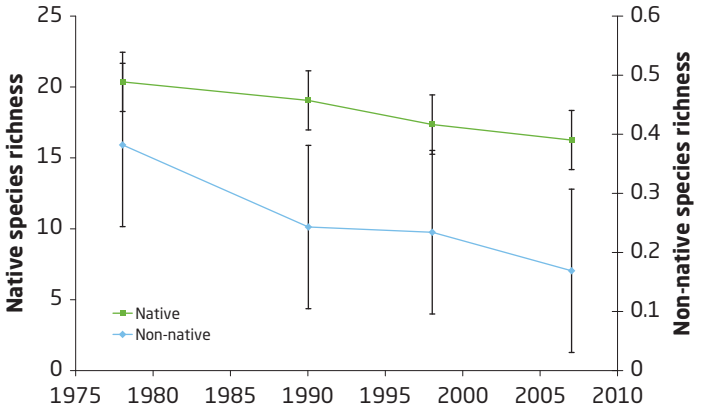

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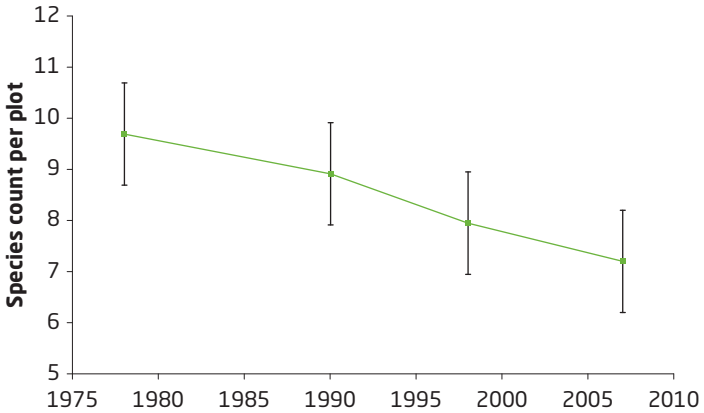

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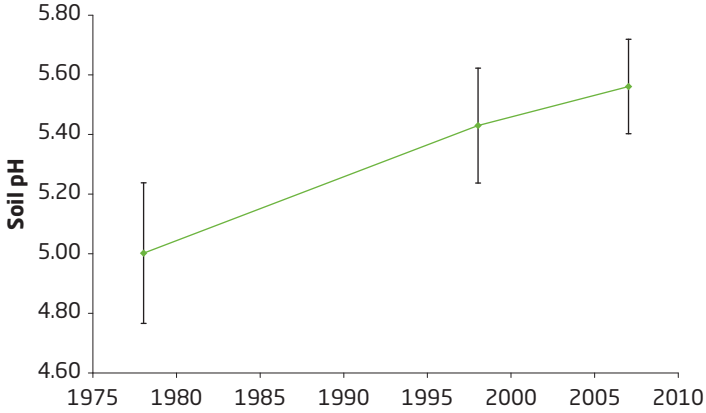

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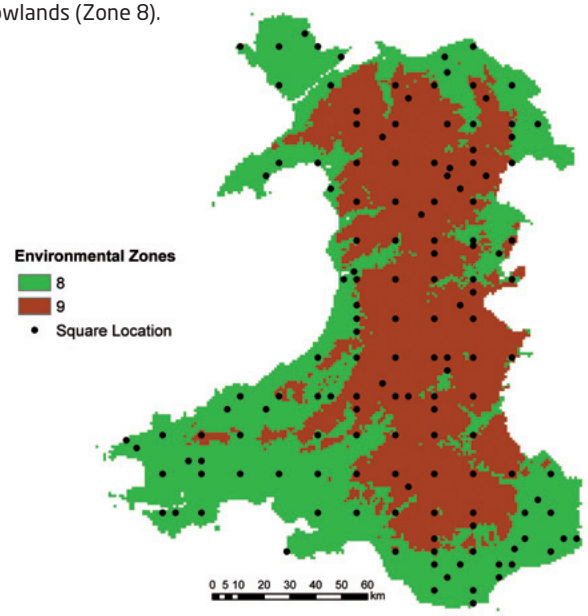

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Arolwg Cefn Gwlad

Cyflwr cefn gwlad Cymru
canlyniadau arolwg 2007

▲ Tirwedd amrywiol Clwyd • © *Richard Evans*

Astudiaeth unigryw yw'r Arolwg Cefn Gwlad sy'n cynnig tystiolaeth ynglŷn â nifer o agweddau ar gefn gwlad y DU a'r ffordd y mae'n newid dros amser. Ei sail yw cyfres o arolygon lle mae pobl sydd wedi cael eu hyfforddi'n arbennig yn mynd i wahanol rannau o'r DU i gofnodi gwybodaeth am gynefinoedd, planhigion ac agweddau eraill ar yr amgylchedd. Cafodd yr arolwg cyntaf ei wneud yn 1978, a'r un diweddaraf yn 2007.

Mae'n bosib cymharu'r data sy'n cael eu casglu yn y gwahanol arolygon i astudio'r mân newidiadau sy'n digwydd yn raddol yng nghefn gwlad y DU.

Ar gyfer arolwg 2007, aeth yr arolygwyr yng Nghymru i lawer mwy o lefydd nag yn yr arolygon blaenorol. Oherwydd hyn, mae'r Arolwg wedi gallu creu set o ganlyniadau ar wahân ar gyfer Cymru am y tro cyntaf un.

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Y prif negeseuon...

1. A yw amrywiaeth fotanegol cefn gwlad wedi newid?

Roedd dirywiad yn yr amrywiaeth fotanegol rhwng 1990 a 2007. Roedd hyn yn cynnwys gweld llai o'r planhigion yn y safleoedd samplu y mae larfau glöynnod byw (ieir bach yr haf) yn eu bwyta. Nid oedd rhywogaethau estron yn gyffredin o gwbl yng nghefn gwlad Cymru yn ystod 2007 (roedden nhw i'w gweld mewn llai nag un o bob pum safle samplu) ac roedd y gostyngiad rhwng yr arolygon yn cyd-fynd â'r gostyngiad yn nifer y rhywogaethau brodorol. Roedd y rhywogaethau o blanhigion a gynyddodd rhwng 1998 a 2007 yn ffafrio amodau gwlypach neu'n tueddu i fod yn blanhigion talach.

2. A yw hyd a chyflwr gwrychoedd wedi newid?

Fel sydd wedi digwydd yn y rhannau eraill o Brydain, yn ystod y 23 o flynyddoedd ers yr arolwg cyntaf yn 1984, mae gostyngiad wedi bod yn hyd y gwrychoedd sy'n cael eu rheoli yng Nghymru. Ar yr un pryd, mae yma fwy o resi o goed a llwyni sydd heb eu rheoli.

3. Pa gynefinoedd sydd wedi gweld eu maint yn cynyddu neu'n lleihau?

Arhosodd maint y rhan fwyaf o gynefinoedd yn sefydlog rhwng 1998 a 2007, ond fe fu rhai newidiadau pwysig. Roedd mwy o adeiladu, a mwy o dir âr a choetiroedd o goed collddail yn y gwahanol rannau o Gymru. Mae hyn yn arwydd o newid yn y ffordd y mae tir yn cael ei ddefnyddio. Nid oedd fawr o newid yn ystod yr un cyfnod ym maint Rhostiroedd o Gorllwyni, Corsydd, Corsydd Calchog, Mignen a Chreigiau Mewndirol. Roedd tir sydd â Rhedyn yn brif dyfiant ynddo (>95% wedi'i orchuddio) wedi lleihau o 55% rhwng 1998 a 2007. Mae'n debyg mai cynnydd mewn Glaswelltiroedd Asidig sy'n gyfrifol am hyn.

4. A yw cyflwr cynefinoedd mewn dŵr croyw wedi parhau i newid?

Fe gafwyd gwelliant yn nodweddion ffisegol nentydd blaenddwr rhwng 1998 a 2007, ac nid oedd unrhyw newid yn statws y maeth yng nghymunedau'r nentydd. Mae'r tyfiant ar hyd glannau'r nentydd wedi tyfu llawer gormod ers 1978, ac mae hyn yn golygu bod llai o rywogaethau o blanhigion yn tyfu yno a bod yr amodau'n fwy addas i blanhigion sy'n gallu tyfu mewn cysgod. Rhwng 1998 a 2007 fe fu cynnydd o 17% yn nifer y pyllau.

5. A oedd unrhyw newidiadau i'w gweld yn nodweddion yr haen uchaf o bridd (0-15cm)?

Mae pH y pridd wedi cynyddu'n gyson ers 1978 er bod y cynnydd yn arafu yn nifer o'r cynefinoedd. Mae'r cynnydd hwn yn cyd-fynd â'r lleihad mewn llygredd o ganlyniad i ddyddodiad asidig.

Gostyngodd crynodiad y carbon yn y pridd mewn coetiroedd coniffer rhwng 1998 a 2007. Ni welwyd unrhyw newidiadau mewn cynefinoedd eraill ac nid oedd newid cyffredinol yng Nghymru. Mae newidiadau mewn crynodiad carbon yn bwysig oherwydd fe allai colledion gyfrannu at newid hinsawdd.

Crynodeb o'r canlyniadau

Ym mha ffyrdd y gallai newidiadau fod wedi effeithio ar allu tirwedd a chynefinoedd Cymru i ymdopi â newid yn yr hinsawdd?

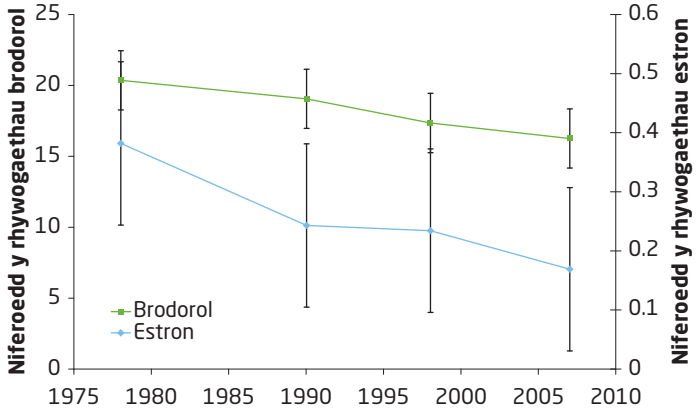
▲ Cysylltu gwrychoedd, Powys • © *C.Hurford, CCW*

- Mae mwy o amrywiaeth o rywogaethau'n rhoi'r rhywogaethau mewn gwell sefyllfa i ddelio â'r pwysau sy'n dod yn sgil newid yn yr amgylchedd, ac i addasu i'r newid. Oherwydd hyn, gallai'r lleihad cyffredinol yn amrywiaeth y rhywogaethau ar draws Cymru *(Ffigur 1)* leihau gallu'r dirwedd a'r ecosystemau i ymateb i newid yn yr hinsawdd.

- Mae peth tystiolaeth i'w gweld o gynnydd yn nodweddion coediog y dirwedd. Bydd hyn wedi creu mwy o lwybrau 'cysylltu' ecolegol yn y dirwedd ond dim ond ar gyfer y rhywogaethau hynny sy'n gallu symud ar hyd llwybrau coediog.

- Er bod amrywiaeth y rhywogaethau estron cyffredin wedi dirywio'n ddiweddar *(Ffigur 1)*, mae'n debyg y bydd y newid yn yr hinsawdd o fudd i rywogaethau estron. Er bod rhai o'r rhain yn gallu bygwth bioamrywiaeth frodorol, mae'n debyg y bydd rhai eraill yn tyfu'n ddiniwed mewn cefn gwlad sy'n addasu'n raddol i amodau cynhesach.

▼ **Ffigur 1:** Newidiadau yn niferoedd y rhywogaethau brodorol ac estron ar bob safle yng Nghymru (n=115) yr aethpwyd yn ôl ato ar ôl ei samplu yn gyntaf yn 1978. Mae'r barrau gwallau yn 95% cyfwng hyder ar y cyfrifon cymedrig ym mhob blwyddyn arolygu.

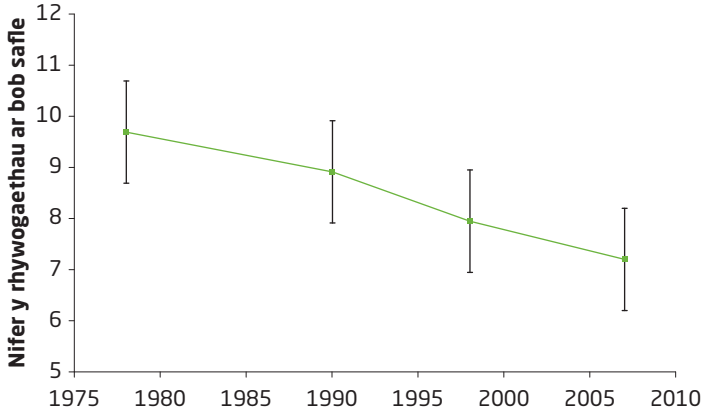


Mae'r planhigion y mae larfau glöynnod yn eu bwyta'n lleihau.

▲ Trilliw Bach • © *Richard Evans*

- Ers 1978 gwelwyd lleihad ar bob safle yng Nghymru yn niferoedd y planhigion y mae larfau glöynnod yn eu bwyta *(Ffigur 2)*. Mae'r lleihad yn arwyddocaol yn ystadegol ac roedd yn arbennig o amlwg ar dir isel.
- Mae llawer o'r planhigion bwyd larfa'n weiriau a phlanhigion blodeuog bach ac nid yw'r rhain yn gallu tyfu'n dda mewn tir sy'n llawn maeth. Mae'n debyg mai amaethyddiaeth yn gwella tir ac yn cynyddu ffrwythlondeb, dyddodion o nitrogen yn yr atmosffer a mwy o gysgod o'r llwyni a'r coed talach sy'n gyfrifol am ddirywiad y planhigion yma.

▼ **Ffigur 2:** Newidiadau yn nifer y planhigion o bob math o lystyfiant y mae larfau glöynnod yn eu bwyta ar safleoedd yng Nghymru a gafodd eu harolygu o'r blaen yn 1978, 1990, 1998 a 2007 (n=115). Mae'r barrau gwallau yn 95% cyfwng hyder ar y cyfrifon cymedrig ym mhob blwyddyn arolygu.

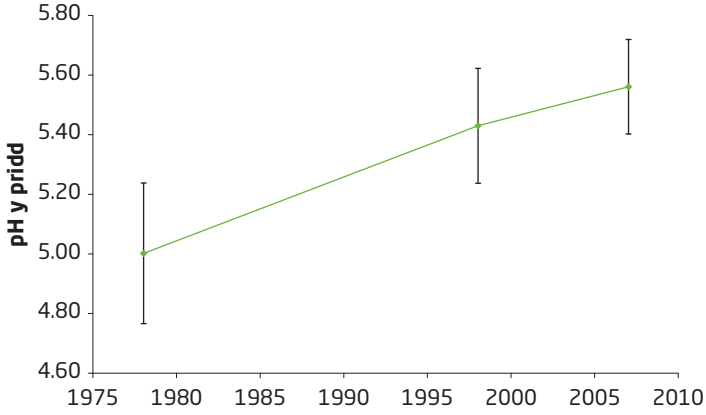


A yw priddoedd Cymru'n gwella ar ôl effaith glaw asid?

▲ Tirwedd ddiwydiannol • © *Richard Evans*

- Ers dechrau'r 1970au, mae'r dyddodion o sylffwr deuocsid, un o'r prif bethau a oedd yn creu "glaw asid", yn yr atmosffer wedi lleihau'n sylweddol ym mhob rhan o'r DU.
- Yng Nghymru, cynyddodd pH cyfartalog y pridd rhwng 1978 a 2007 ond roedd yn sefydlog rhwng 1998 a 2007 *(Ffigur 3)*.
- Mae'n debyg bod y patrwm yma'n arwydd fod y pridd yn gwella o effeithiau'r asideiddio, ac mae'n dangos yn glir fod ecosystem yn gallu dod ati ei hun ar ôl cael ei llygru.

▼ **Ffigur 3:** Newid yn pH yr haen uchaf o bridd (0-15cm) ar sail yr holl samplau a gafodd eu casglu yng Nghymru yn 1978, 1998 a 2007. Mae'r barrau gwallau yn 95% cyfwng hyder ar y pH cymedrig ym mhob blwyddyn arolygu.

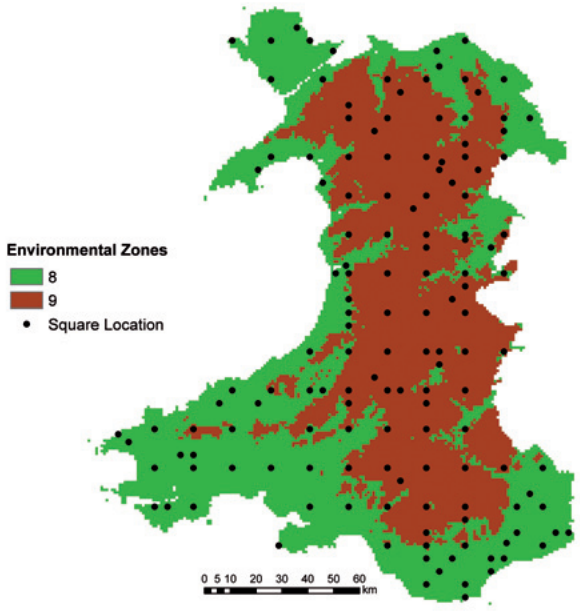


Llinell sylfaen newydd i Gymru ei defnyddio wrth gymharu darganfyddiadau'r arolygon nesaf.

▲ Mapio caeau • © *CEH*

- Yn sgîl datganoli, mae'n bwysicach i ni gasglu gwybodaeth o safon uchel am gyflwr cefn gwlad Cymru. I wneud hyn, cafodd y nifer o sgwariau samplu eu cynyddu yn 2007 o 64 i 107 ***(Ffigur 4)***.
- Roedd hyn yn golygu bod y gwaith samplu ystadegol yn fwy gwerthfawr a chafwyd gwelliant ar unwaith yn yr amcangyfrifon a oedd ar gael ar gyfer 2007. Cafwyd hefyd linell sylfaen i fesur yn fwy manwl y newid rhwng 2007 a'r arolygon nesaf a fydd yn cael eu gwneud.

▼ **Ffigur 4:** Gwaith samplu'r Arolwg Cefn Gwlad. Y dotiau duon yw safle'r sgwariau samplu yn ystod 2007 (nid yw wrth unrhyw raddfa) dros fap o Gymru sydd wedi'i rannu'n ddau Barth Amgylcheddol; yr ucheldiroedd (Parth 9) a'r iseldiroedd (Parth 8).



Trafodaeth o'r polisïau

Roedd ymestyn cylch gorchwyl yr arolwg a gafodd ei wneud o gefn gwlad Cymru yn 2007 yn gyfle i ni ddod i ddeall mwy am ei gyflwr presennol ac am y newidiadau diweddar sydd wedi digwydd iddo. Mae ei ymestyn hefyd yn gwella'r llinell sylfaen ar gyfer adnabod unrhyw newid a fydd yn digwydd o hyn ymlaen. Daeth arolwg 2007 â nifer o newidiadau cadarnhaol i'r amlwg, yn cynnwys cynnydd ym maint coetiroedd collddail, gwelliant yng nghyflwr ffisegol y nentydd, cynnydd yn nifer y pyllau, a lleihad yn asidedd y pridd wrth i lai o sylffwr deuocsid gael ei ollwng. Ond mae'r newidiadau yma wedi digwydd ochr yn ochr â lleihad cyffredinol yn nifer y rhywogaethau o blanhigion. Mae hyn yn mynd yn groes i'r nod o atal y broses o golli bioamrywiaeth.

▲ uwchbridd Cymru • © *B. Williams, CEH*

Mae'r canlyniadau cynnar yma o'r Arolwg Cefn Gwlad wedi tynnu sylw at y ffyrdd cymhleth y mae'n rhaid cyfaddawdu weithiau wrth ddod i benderfyniadau ynglŷn â rheoli cefn gwlad. Mae'n aml yn bosib gweld nad yw newidiadau'n gwbl gadarnhaol neu'n gwbl negyddol, ac efallai fod yn rhaid aberthu un elfen amgylcheddol werthfawr er mwyn gwireddu mantais amgylcheddol arall. Bydd mwy o waith yn ein helpu i ddeall y canlyniadau'n well er mwyn mynd i'r afael â'r prif heriau a nodir yn Strategaeth Amgylcheddol Cymru, megis newid yn yr hinsawdd, ecosystemau sydd wedi'u diraddio, colli bioamrywiaeth, a dirywiad yn safon y dirwedd.

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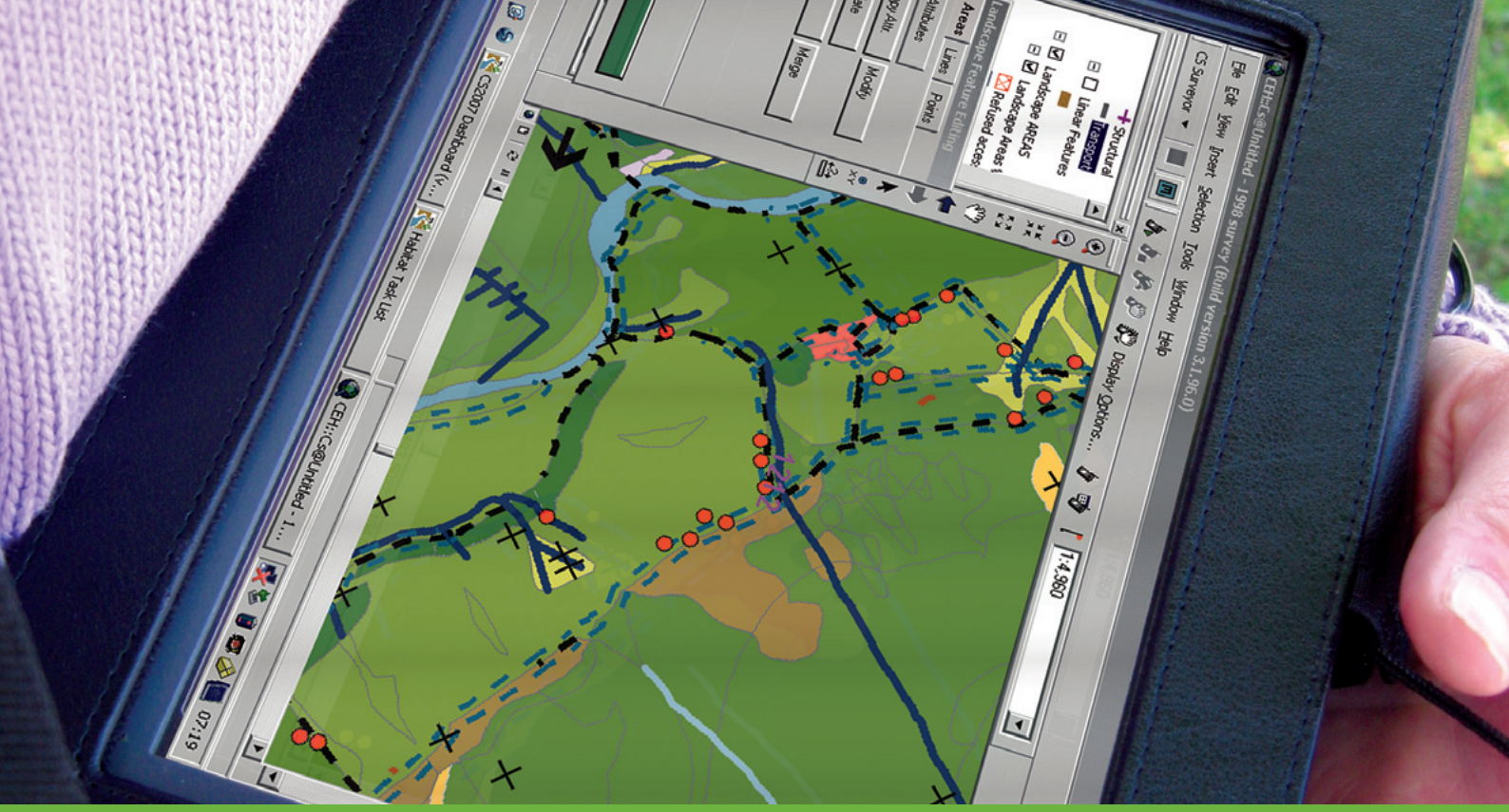


▲ Field mapping • © *CEH*

1. Introduction and Countryside Survey Methodology

Countryside Survey is a unique study of the natural resources of the countryside. The survey has been carried out in the UK at intervals since 1978 with the latest in 2007. The countryside is sampled and studied using rigorous scientific methods so that the results can be used to measure and analyse change based on comparisons with previous surveys. Whilst the emphasis in this report is on the 2007 data and change since 1998[9], where possible comparisons have been made with the data from earlier surveys in 1990, 1984 and 1978. These provide valuable contextual information on the direction and strength of trends prior to the most recent interval. The evidence produced can be used to review and develop policies that influence the management of our countryside, for example by providing information on progress against the UK Biodiversity Action Plan[10], Soil Action Plans[11] and providing an evidence base to aid the design of agri-environment schemes.

A new baseline for Wales in 2007

Countryside Survey is based on measurements made in a sample of 1 km squares across each country in Great Britain. Wales has been surveyed as part of the Countryside Survey of Great Britain since 1978 but the number of 1 km squares surveyed in Wales, prior to the 2007 survey was relatively small compared to the other countries. An outcome of devolution in 1999 was the requirement to produce estimates for Welsh habitats to an equivalent level of precision as those that could be achieved for the other larger countries. Since precision is related to sample size not just the number of samples per area, the number of survey squares in Wales needed to be increased[12]. In 2007 the number of squares in Wales was therefore increased from 64 to 107 ***(Fig 1.1)***.

[9] The Survey carried out in 1998 was published as: Haines-Young *et al* (2000). *Accounting for Nature, assessing habitats in the UK countryside, Countryside Survey 2000.* Department for the Environment, Transport and the Regions (DETR), London.

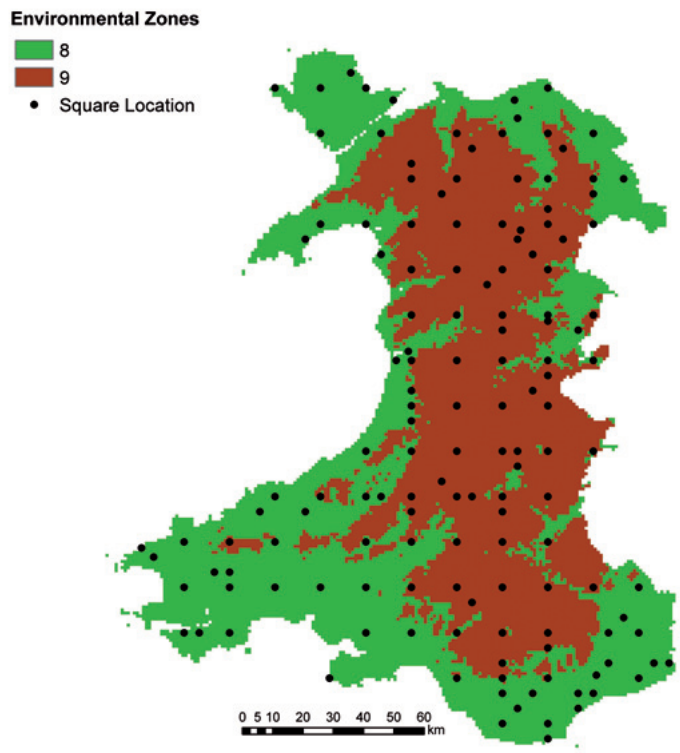
[10] www.ukbap.org.uk

[11] new.wales.gov.uk/consultation/desh/2008/welshsoils/welshsoilscctionplan.pdf?lang=en

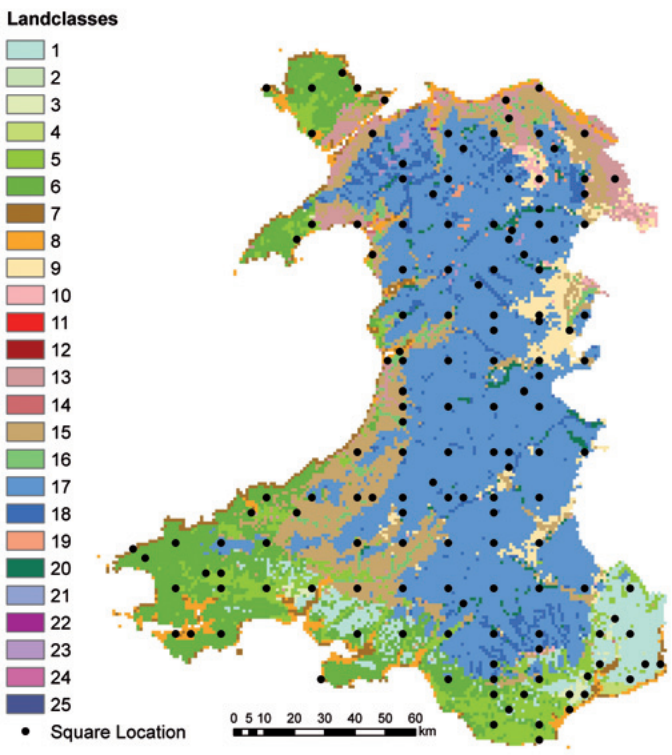
[12] Clarke, RT *et al* (2006) *Countryside Survey: Sampling for Wales – Only Reporting.* CEH Lancaster.

▼ **Figure 1.1:** ***a) Division of Wales into two Environmental Zones based on aggregating Land Classes, b) The distribution of Land Classes in Wales used as the basis for stratified, random selection of 1-km survey squares.***
Black dots also show the location of the sample squares in 2007 (not to scale).

a)



b)



Individual survey squares in Wales were randomly selected so that they are an unbiased sample of the range of variation in climate, landscape, soils and geology across the country *(Fig 1.1)*. All widespread terrestrial habitat types are sufficiently well represented to enable robust and reliable statistical analysis. In addition, the increased number of squares also allowed estimates to be made separately in the uplands (zone 9) and lowlands (zone 8) of Wales *(Fig 1.1)*. This enables the results to capture ecologically important differences in species and habitat composition between these two Environmental Zones *(Fig 1.1a)* although note that differences in the definition of upland versus lowland Environmental Zones in Wales can result in differences in estimates compared to other surveys (see *Box 1*). The increase in number of sample squares in Wales has had an immediate effect on improving the estimates of Broad Habitat area in 2007 and also provides a new baseline for producing improved estimates of change between 2007 and future surveys.

There are two main elements to Countryside Survey: field surveys (reported here) which focus on habitats, vegetation, soils (0-15 cm) and freshwater; and the Land Cover Map which uses vegetation data collected in the field survey and remotely sensed data from satellites to form a digital map of the land cover across the UK. The field survey provides estimates of the extent of the different Broad Habitats (see *Section 1.2 UK report*) and in 2007, for the first time, some Priority Habitats[13]. The results of the field survey describe aspects of the soil and the character and condition of the different vegetation types associated with these Broad Habitats, including both land and freshwater habitats.

The UK results of the latest 2007 survey were published in November 2008 and the summary data made accessible on the Countryside Survey website[14]. More detailed reports on soils, freshwaters and an integrated assessment of selected ecosystem services will be produced over the coming year. This report presents further results of the analysis of Welsh data. The results are presented in chapters structured around the same Broad Habitat groupings used in the UK report. The format of the report largely follows that used in reporting results for the UK but differs in three important respects. First, each chapter, covering one or more Broad Habitats, has two parts – the first and largest part is a presentation of the results of analysis of the Welsh Countryside Survey dataset; the second part provides, in summary form, a description of the nature conservation context of the habitats included in the chapter, a comparison of Countryside Survey results with those from other key sources[15], and a series of questions that are addressed in the concluding overview chapter. The second difference to the UK report is in the ordering of chapters, with the National Picture chapter following the individual habitat chapters. The third, and perhaps most important difference from the UK report format, is

[13] Priority Habitat assessment is a topic of ongoing research work and results are not reported here.

[14] www.countrysidesurvey.org.uk/data.html

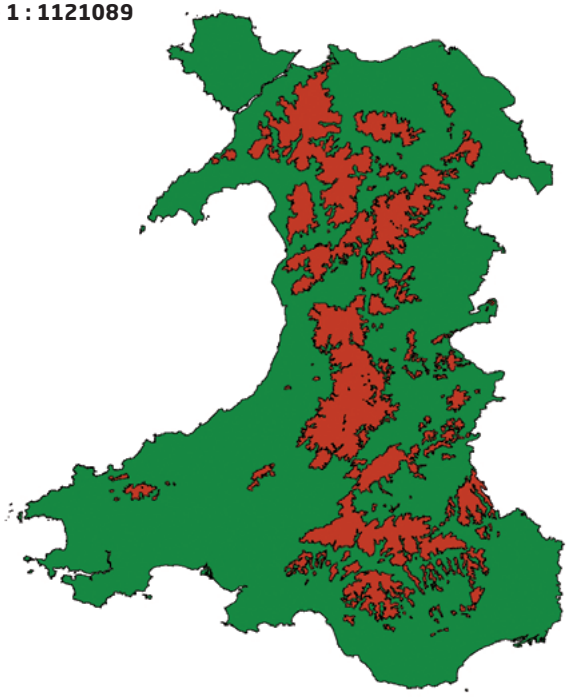
[15] Comparing Countryside Survey estimates with those from other sources is not straightforward because of differences in survey design, timing of survey, and by the different definitions of habitats used. No single source can be considered definitive – but often Countryside Survey provides the most recent estimate based on recording in the field.

Box 1: Defining upland and lowland areas of Wales

The differentiation in Countryside Survey of two environmental zones, characterised broadly as upland Wales and lowland Wales, is based on an amalgamation of the ITE Land Classes that form the basis of the survey design. These Land Classes are the product of a multivariate classification of data relating to topography, climate, geology and soil. The environmental zones formed from these classes therefore reflect an array of characteristics rather than any single characteristic. This differs from classification systems based on a single or a few characteristics. The Countryside Council for Wales for example, defines upland areas as land lying above 300m or above the limits of enclosure ***(Fig B1)***. These different approaches produce different pictures of the extent of upland and lowland areas, though the Countryside Council for Wales distribution based largely on altitude is clearly a subset of the Countryside Survey distribution based on a wider array of characteristics. Readers should be aware that all references in this report to upland and lowland Wales refer to the broader characterisation used by Countryside Survey ***(Fig 1.1)***.

▼ **Figure B1:** The separation of upland (in red) from lowland Wales used by the Countryside Council for Wales based on the 300m contour and the limit of enclosed land.

Scale 1 : 1121089



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the inclusion of an additional, concluding chapter that presents a preliminary evaluation of the significance of the results in relation to Welsh environmental policy objectives; and here the questions posed at the end of the individual habitat chapters are revisited.

The Centre for Ecology and Hydrology[16] had lead responsibility for the scientific evidence presented and the project partners Countryside Council for Wales[17] and Welsh Assembly Government[18] for the contextual discussions. Equivalent reports are being produced in parallel for England and Scotland.

Details of the field survey methods used to collect the data for Countryside Survey in 2007 and preceding Surveys are presented in *Chapter 1 of the "UK Results from 2007"* and these are not reproduced in full in this report. However, an overview of the sampling strategy is provided below.

1.1. Methodology

Sampling design

Countryside Survey uses a sample-based design to estimate the amount and condition of habitats and landscape features in the countryside. Measurements of each component are made in a sample of 1 km squares, and statistical techniques are used to scale up from the measured sample to the whole of Wales. This is rather different from a census, in which all parts of the countryside would be visited – a field survey based on a census design would be prohibitively expensive to carry out.

An important consideration in the design of the survey is that the sampled 1 km squares are representative of the whole of Wales. Countryside Survey aims to do this by ensuring that the sample of recorded squares includes the range of variation in soils, geology, topography and therefore in land-use and habitats, across the landscape, without bias toward any particular region or type of habitat. This is achieved by randomly selecting squares from a set of Land Classes that collectively capture the range of variation in the Welsh countryside ***(Fig 1.1a)***. Because only a proportion of the whole of Wales is sampled, the estimated values for the entire Welsh resource of a particular habitat or other measure include some amount of uncertainty. The degree of such imprecision is strongly influenced by the number of samples available – where more sample squares are available, as is the case for common habitats and features, estimates are more precise; where fewer samples exist, as with rare habitats, estimates are less precise. This 'uncertainty' around each estimate is conveyed in this report mainly by the use of 95% confidence intervals[19] or in some cases by standard errors.

[16] www.ceh.ac.uk

[17] www.ccw.gov.uk

[18] www.wales.gov.uk

[19] The 95% CI for significant changes in extent of Broad Habitats are referred to in parentheses in the text alongside the estimated mean change. They are also tabulated in ***Chapter 9***.

▲ Soils analysis • © *CEH*

The locations of the survey squares are not disclosed to avoid influencing their management in any way. This helps ensure that the survey squares remain representative of changes in the wider countryside and will continue to provide a reliable comparison for future surveys.

Recording vegetation, soil and freshwaters

The sample squares provide the basic recording units for Countryside Survey. Within these squares a range of data was collected. The area, shape and position of habitats including linear features were mapped across the whole square. In addition, lists of plant species with estimates of their percentage cover, were made in a smaller subset of fixed vegetation sampling plots. These plots varied in size and shape depending on the feature being sampled. Soil (0-15cm) samples were also collected from five plots in each square, and a stream and a pond were also sampled in many of the squares. See Carey *et al* (2008) for further information on vegetation, soil and freshwater sampling methods[20]. The data collected enables estimation of:

- **the extent and change in area of habitats;**
- **the extent and condition of landscape features such as hedges and walls;**
- **the changing condition of vegetation in habitats;**
- **the pH, carbon concentration, carbon stock and bulk density of soils (0-15cm); and**
- **the condition of headwater streams and ponds.**

Further analysis of soils is ongoing to enable estimation of nutrient status, contaminant levels, soil biotic diversity and soil function, and will be reported in November 2009.

The recording framework within Countryside Survey makes it possible to report on both the area and the change in area for Broad Habitats using the data from the 1990, 1998 and 2007 Surveys. A modified coding system for habitat mapping was introduced in 1998 to enable reporting on Broad Habitats but, given the smaller number of 1 km squares visited in 1990, this report focuses on the 1998 to 2007 interval. The modified system has backwards compatibility to 1990 for most Broad Habitats. Similarly, the methods of recording linear features have been refined over time and so, where there has been consistency of recording over time, the length of linear landscape features and the numbers of point features including trees and ponds (and changes in those lengths and numbers) can be reported. Assessments of the condition of linear features are confined largely to more recent Countryside Surveys, in particular 1998 and 2007.

The condition of the vegetation sampled within each Broad Habitat can also be reported for the 1990, 1998 and 2007 Countryside Surveys. This is because the position of each vegetation plot is known and so the species data recorded in each plot can be referenced to a Broad Habitat. The large number of plots available in 1990 for most Broad Habitats also makes it possible to quantify change from that survey onwards. A range of 'condition measures' were produced from the species lists in each plot and these data analysed to convey aspects of change in quality e.g. change in numbers of food plants for butterfly larvae, as well as indications of species response to change in conditions such as fertility, soil pH and light. This report also includes details of individual plant species which increased and decreased the most across Wales in terms of frequency of occurrence in sample plots between 1998 and 2007.

Two issues impacted the analysis of the vegetation data and have required the application of additional methods to address them. Analysis of the Quality Assurance results for the vegetation plots surveyed in 2007 was followed by further statistical analyses of the full time-series combining Quality Assurance surveys carried out in parallel with the field surveys in 1990, 1998 and 2007. These follow-up analyses were carried out by external and internal statisticians who recommended that a correction factor should be added to the mean Ellenberg scores for 1990 when analysed together with 1998 and 2007 data. Despite the fact that the Quality Assurance analysis carried out after the 1998 survey found no change in bias between the 1990 and 1998 datasets, the simplest approach to correct for the gradual change in bias revealed by the full time-series analysis was to adjust the 1990 data. No significant change in bias was found for any of the other condition measures[21].

[20] Carey *et al* (2008) *Countryside Survey: UK results from 2007*. Online at www.countrysidesurvey.org.uk/reports2007.html

[21] The full vegetation plot Quality Assurance results and analysis can be viewed at www.countrysidesurvey.org.uk/tech_reports.html

▲ Southern Marsh Orchids • © *Richard Evans*

The possibility of variation in recording efficiency between 1998 and 2007 also required a precautionary approach to the analysis of change in individual plant species. A relative change index was calculated from the paired species frequency data for individual taxa in 1998 and 2007. This method expresses the relative change in number of plots occupied having taken account of any overall tendency for more or less species to have been recorded in plots. The approach was a modification of the one applied to calculate change in occupancy of 10km grid squares in the New Atlas of the Flora of the British Isles[22]. Species with the largest change in both numbers of plots occupied and change index are more likely to have shown a real change in abundance between surveys.

Highlighting the ecological importance of statistically significant changes

Variation in the numbers of samples available for analysis can influence the probability of a particular size of change being declared statistically significant. With a relatively large sample size, quite small changes can be significant whilst with small sample numbers a major change in the mean between two samples may not be significant. Hence, statistical significance alone may incompletely represent the potential importance of observed changes. In terms of their ecological impact, statistically significant but small changes may be of little consequence. Conversely, large changes may reflect more profound ecological effects. But our ability to detect large changes is somewhat constrained by small sample sizes, especially in earlier surveys. To address this, the analysis presented here has, in addition to looking at statistical significance, examined the magnitude of changes between surveys. In addition to directly comparing the value of a measure in one year with its value in another year (an approach largely restricted here to comparisons of species richness), an approach based on the calculation of standardized effect sizes has been used (see ***Appendix 1***).

Potentially important ecological impacts are highlighted by referring to these effect sizes. Large effect sizes indicate that the size of the change in the sample mean was substantial relative to the amount of variation in the sample. Smaller effect sizes could still be important especially as they may capture part of a longer, ongoing trend. However, smaller effects could also be driven by factors such as weather impacts in each year of survey, which shift condition measures significantly but still within the range of variability typical of the vegetation type.

Where changes in species richness are discussed, the importance of the size of the change is more easily evaluated since the units (species) have more meaning. In these cases, the size and therefore importance of the observed change is discussed alongside the calculated effect size.

▲ Grazed pasture • © *CEH*

[22] Telfer *et al* (2002) *Biol. Cons.* **107**, 99-109.

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

Contacts

For further information on Countryside Survey see **www.countrysidesurvey.org.uk** or contact:
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Telephone: **01524 595811**
Email: **enquiries@ceh.ac.uk**

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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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▲ Enclosed farmland • © *Clive Hurford*

2. Enclosed Farmland: Arable & Horticulture and Improved Grassland Broad Habitats

Summary

Area

- There were no significant changes in area of Improved Grassland between surveys.
- No significant changes in area of Arable & Horticulture occurred overall across Wales but a small significant increase in area (4,300 ha) was detected in the upland zone between 1998 and 2007.
- 87% of the mapped increase in Arable in survey squares occurred on land mapped as Improved Grassland in 1998.

Vegetation condition

- Too few plots were available for representative analysis of Arable & Horticultural vegetation character reflecting the scarcity of the Broad Habitat in Wales.
- In Improved Grassland, patterns of change in vegetation characteristics in Wales resembled those at the Great Britain level, in particular the increased representation of species favouring wetter and more acid conditions. However, the significant reduction in species richness between 1998 and 2007 in Wales was not observed at the Great Britain level.

Soils

- pH increased significantly in Improved Grassland between 1978 and 2007. No change in pH was detected in Arable & Horticultural land.
- No significant changes were detected in soil carbon concentration.

2.1 Introduction

The two Broad Habitats covered in this chapter are managed primarily to maximise food production. The soils are naturally the most productive in Britain, inputs of energy are high and so outputs of meat, dairy products and crops are also high. Since intensive management aims to divert energy into the growth of the crop, these habitats generally support relatively few other species. However, where management intensity is lower or refuges are provided, such as uncropped and unfertilised margins, a wider range of plants and animals can persist. For example, Arable Field Margins are a Priority Habitat within the UK Biodiversity Action Plan because these areas of transition between crop and adjacent land have the potential to support a range of specialist plant species and invertebrates that may in turn provide food for bird species associated with cultivated land. In Wales, Arable & Horticulture is relatively localised whilst Improved Grassland is extensive and indeed more common than in either England or Scotland.

In landscapes dominated by intensive farming, additional habitat features such as watercourses, hedges, field boundaries and fragments of semi-natural habitat including woods and less intensively managed grassland, can make a valuable contribution to farmland biodiversity. In Wales, intensive farmland is dominated by grassland and the most productive land is restricted in extent by soil depth, geology and slope within the context of a mild yet wet climate. The most improved grasslands tend to be in the lowlands where they dominate the landscape. Smaller areas of less productive habitats and landscape features are then typically embedded in this highly productive matrix. Intensive agriculture therefore has the potential to negatively impact more diverse adjacent habitats but there is also potential for these smaller habitat patches to act as sources for recolonisation when management intensity is reduced. In the unenclosed uplands the situation is reversed because inherently low productivity puts an ecological and economic constraint on the extent to which habitats can be improved so that Improved Grassland and Arable & Horticulture are rare.

The Arable & Horticulture and Improved Grassland Broad Habitats are among those most likely to change in both area and condition over time, because their management is so responsive to the economics of farming, the introduction of new technologies and to changes in agricultural policy.

▲ Young maize, Clwyd • © *Stuart Smith*

2.2 The Area of Enclosed Farmland in Wales

2.2.1 Arable & Horticulture

In Wales the Arable & Horticultural Broad Habitat made up 3.4% of land cover in 2007 compared with 18.8% of the land cover of the UK ***(Table 2.1)***. A significant increase in area of 4,300 ha (95% CI; 1,956 ha to 9,764 ha) was estimated to have occurred in the upland Environmental Zone from a small total extent of 5,600 ha in 1998 to 9,900 ha in 2007 ***(Table 2.1)***. No significant change was detected in Wales as a whole, in contrast to a significant UK wide reduction between 1998 and 2007[23]. Examination of the mapped changes in the Welsh upland survey squares showed that small increases were noted within 6 squares, the largest increase being stubble (26% of the mapped change) and then Barley (12%). When surveyed previously in 1998, 87% of the new arable land was then Improved Grassland and 10% Neutral Grassland.

2.2.2 Improved Grassland

Improved Grassland was estimated to make up 34% of Wales in 2007, a much higher proportion than any other country in the UK apart from Northern Ireland[13]. No significant change in area of Improved Grassland occurred in Wales between 1998 and 2007 ***(Table 2.2)***.

[23] Carey *et al* (2008) *Countryside Survey 2007; UK results*. Online at: www.countrysidesurvey.org.uk

▼ **Table 2.1:** Estimates of the area ('000s ha) and percentage of land area of Arable & Horticultural Broad Habitat in Wales and in each environmental zone from 1998 to 2007 are shown. Arrows denote significant change ($p<0.05$) in the direction shown.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	55	5	63	6	
Upland	6	0.6	10	1	↑
Wales	61	3	73	3	

▼ **Table 2.2:** Estimates of the area ('000s ha) and percentage of land area of Improved Grassland Broad Habitat in Wales and in each environmental zone from 1998 to 2007 are shown. No statistically significant changes were seen between survey years.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	457	42	467	43	NO SIGNIFICANT CHANGE
Upland	249	24	263	26	
Wales	706	33	731	34	

▼ **Table 2.3:** Change in the characteristics of vegetation in 200m² Main Plots in the Arable & Horticulture Broad Habitat across Wales between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. No statistically significant changes were seen between survey years.

	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	14.1	11.3	11.8	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	8.5	6.2	6.6									
No. of Butterfly Food Species	4.9	4.2	4.8									
Grass:Forb Ratio	-0.12	1.26	1.42	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
Competitor Score	2.16	2.36	2.39									
Stress Tolerator Score	1.42	1.59	1.71									
Ruderal Score	3.75	3.49	3.55									
Light Score	7.05	6.96	7.02									
Fertility Score	6.40	6.24	6.28									
Ellenberg pH Score	6.55	6.39	6.51									
Moisture Score	5.11	4.94	5.00									

2.3 The condition of the Broad Habitats of enclosed farmland

2.3.1 Arable & Horticulture

Very few Main Plots were available for analysis of vegetation condition on cultivated land (n_{1990}=13, n_{1998}=16, n_{2007}=19). Such small sample sizes have low power to detect statistically significant changes and hence to make conclusions about changes across the population of arable fields in Wales. Indeed, no significant changes were detected across Wales or within either of the environmental zones *(Table 2.3)*. In addition, all changes in vegetation characteristics were examined for effect size but all were either small or medium. This suggests that despite small sample size no major ecological changes had occurred in the sample.

Because of the limited extent of the Broad Habitat in Wales there were too few Targeted Plots associated with the Arable & Horticultural Broad Habitat for analysis to be carried out.

2.3.2 Improved Grassland

The most common species recorded in Main and Targeted Plots within areas mapped as Improved Grassland are listed in *Table 2.4*.

Main Plots: Between 1998 and 2007, species richness of Improved Grassland declined significantly in both upland and lowland zones and across Wales *(Table 2.5)*. Overall, numbers of lowland farmland bird food plants also declined significantly between 1998 and 2007, and 1990 and 2007. Numbers of butterfly larval food plants also declined significantly between 1998 and 2007 with an overall significant decline between 1990 and 2007 of 1.5 species per plot *(Table 2.5)*. None of the standardized effect sizes were large suggesting possibly minor impacts on the vegetation.

Other significant changes included an increase in Moisture Score across Wales, especially in the upland zone between 1998 and 2007, and between 1990 and 2007 *(Table 2.5)*. At the same time as Moisture Score increased, Ellenberg pH Score declined

significantly, indicating that species preferring relatively more acid conditions increased their representation among the species present in plots *(Table 2.5)*.

The increase in Moisture Score and decrease in Ellenberg pH Score in the upland zone were based on large standardized effect sizes *(Table 2.5)*. This indicates that the changes in species composition tracked by these indices were substantial relative to the variation across the sample, and could indicate important ecological impacts on the vegetation as well as detectable responses to possible drivers such as rainfall in the years of survey. However, Improved Grassland is typically species-poor and of low conservation value so that any change is likely to be relatively unimportant in biodiversity policy terms. An increase in Moisture Score was also seen across Britain in the same intervals in Improved Grassland Main Plots.

Targeted Plots: Within the Improved Grassland Broad Habitat, the Targeted Plots would have sampled a range of species assemblages less typical of the Broad Habitat, often including fragments of more valuable semi-natural habitat as evidenced by their lower mean Fertility Score, higher Moisture Score and higher Stress Tolerator Score relative to the Main Plots in *Table 2.5*. Overall, fewer changes were seen in the Targeted Plots than in the Main Plots. Across Wales only plant species richness showed a significant change between 1998 and 2007, declining by an average 3 species per plot between 1998 and 2007 *(Table 2.6)*. However, all three species richness measures declined significantly in the lowland zone in the same interval. Across Wales, Grass:Forb Ratio and Fertility Score both increased significantly between 1990 and 1998 while Fertility Score also increased overall from 1990 to 2007. Stress Tolerator Score decreased overall between 1990 and 2007. This pattern of change indicates a reduction in the contribution of species more typical of unproductive habitats *(Table 2.6)*.

All but one of the significant changes were based on medium or small standardized effect sizes suggesting minor impacts on the vegetation. The only large effect size in the Improved Grassland Targeted Plots was the reduction in Stress Tolerator Score in the upland zone between 1990 and 1998 *(Table 2.6)*. This highlights a substantial decline in the contribution of this sensitive species group. The effect size for the overall change between 1990 and 2007 was 0.7, just below the criterion for a large effect (0.8)[24] but indicating that a possibly important decline was seen over the whole 17 year period covered by the three surveys *(Table 2.6)*.

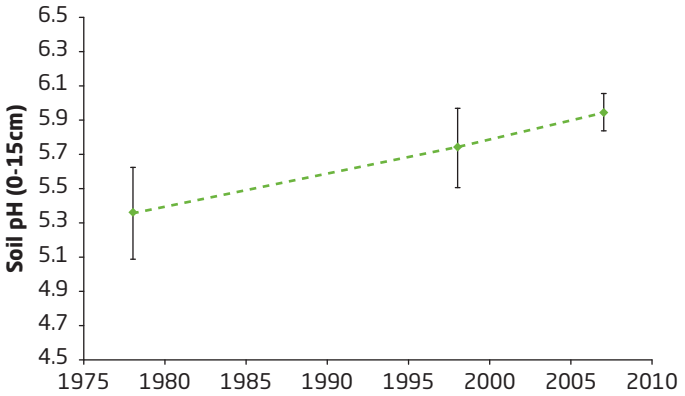
▲ Pass above Dinas Mawddwy • © *Michael D Smith*

2.4 Changes in soils (0-15cm) in the Broad Habitats of enclosed farmland

2.4.1 Soil (0-15cm) pH

The mean pH of soils (0-15cm) increased significantly in the Improved Grassland Broad Habitat in Wales between 1978 and 1998, and between 1978 and 2007 but did not change significantly between 1998 and 2007 *(Fig 2.1)*. For the Arable & Horticulture Broad Habitat, there was only sufficient data for analyses to be carried out between 1978 and 2007, and no significant change was detected.

▼ **Figure 2.1:** The change in pH in soils (0-15cm) in the Improved Grassland Broad Habitat in Wales, between 1978 and 2007. Significant change (at least $p<0.05$) occurred between 1978 and 1998, and 1978 and 2007. Error bars are the 95% CI on the mean soil pH in each survey year.



[24] See Appendix 1.

▼ **Table 2.4:** Most frequent 15 species in 2007 in the Improved Grassland Broad Habitat in Wales. See ***Appendix 2*** for English & Welsh common names.

a) Main Plots (n=201)			b) Targeted Plots (n=40)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
95	48	*Lolium perenne*	58	6	*Holcus lanatus*
91	12	*Trifolium repens*	53	8	*Agrostis stolonifera*
81	3	*Ranunculus repens*	48	16	*Lolium perenne*
74	1	*Cerastium fontanum*	40	7	*Juncus effusus*
72	11	*Holcus lanatus*	40	5	*Trifolium repens*
66	1	*Taraxacum agg.*	38	9	*Agrostis capillaris*
63	10	*Agrostis capillaris*	38	3	*Festuca rubra agg.*
50	7	*Agrostis stolonifera*	35	1	*Ranunculus repens*
47	1	*Rumex obtusifolius*	33	1	*Dactylis glomerata*
35	1	*Rumex acetosa*	30	2	*Anthoxanthum odoratum*
32	1	*Cirsium arvense*	28	1	*Rumex acetosa*
32	3	*Cynosurus cristatus*	25	2	*Poa annua*
32	1	*Poa annua*	23	3	*Rubus fruticosus agg.*
30	2	*Poa trivialis*	20	<1	*Cardamine pratensis*
27	1	*Dactylis glomerata*	20	<1	*Cerastium fontanum*

▼ **Table 2.5:** Change in the characteristics of vegetation in 200m² Main Plots in the Improved Grassland Broad Habitat across Wales, between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. Red indicates large effect sizes.

	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	17.3	17.1	14.7	↓	↓	↓				↓		
No. of Bird Food Species	9.9	10.6	9.1	↓	↓	↓	↑	↑		↓		↓
No. of Butterfly Food Species	9	8.5	7.5	↓		↓				↓	↓	↓
Grass:Forb Ratio	1.34	1.53	1.39						↑			
Competitor Score	2.67	2.70	2.73		↑				↑			↑
Stress Tolerator Score	2.02	2.02	1.97	↓		↓						
Ruderal Score	3.19	3.19	3.16		↓			↑	↓			
Light Score	7.05	7.06	7.02	↓		↓						
Fertility Score	5.50	5.49	5.48									
Ellenberg pH Score	6.03	5.98	5.90	↓		↓				↓	↓	↓
Moisture Score	5.34	5.38	5.46	↑		↑			↑	↑		↑

2.4.2 Soil (0-15cm) carbon concentration

No significant changes were detected in the Improved Grassland Broad Habitat. For the Arable & Horticultural Broad Habitat, there was only sufficient data for analyses to be carried out between 1978 and 2007, and no significant change was detected.

2.4.3 Bulk density and soil (0-15cm) carbon stock

The bulk density of soils (0-15cm) in the Arable & Horticultural Broad Habitat in Wales was 1.1 g/cm³, which when combined with soil carbon concentration in the same horizon indicated a soil (0-15cm) carbon stock of 33 t/ha. The comparable figure for Great Britain was 43 t/ha reflecting the larger area of organic matter rich, high grade agricultural land in parts of England and Scotland.

In Improved Grassland in Wales, the bulk density of soil (0-15cm) was 0.9 g/cm³ indicating a soil (0-15cm) carbon stock of 62 t/ha comparable to 61 t/ha for the Improved Grassland Broad Habitat at the Great Britain level.

2.5 The results in context

This chapter has considered two Broad Habitats that occupy the intensively managed end of the habitat spectrum that characterises most enclosed farmland in Wales. Other less intensively managed habitats that occur within farmed landscapes, including more biologically diverse types such as unimproved forms of grassland, are considered in *Chapters 3 and 6*. Boundary features associated with these habitats, such as hedges and walls, are also dealt with separately in *Chapter 4*.

▼ **Table 2.6:** Change in the characteristics of vegetation in 4m² Targeted Plots in the Improved Grassland Broad Habitat across Wales, between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change (p<0.05) in the direction shown. Red indicates large effect sizes.

	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	**1990**	**1998**	**2007**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	15.8	15.4	12.6	↓	↓		NO SIGNIFICANT CHANGE			↓	↓	
No. of Bird Food Species	6.1	6.1	5.0		↓						↓	
No. of Butterfly Food Species	6.1	6.25	5.3		↓						↓	
Grass:Forb Ratio	0.36	1.19	1.05	NO SIGNIFICANT CHANGE			↑					
Competitor Score	2.74	2.73	2.84									
Stress Tolerator Score	2.56	2.45	2.35						↓	↓		↓
Ruderal Score	2.65	2.67	2.61									
Light Score	6.8	6.79	6.78									
Fertility Score	4.46	4.74	4.88				↑			↑		
Ellenberg pH Score	5.36	5.46	5.51									↑
Moisture Score	6.12	6.04	6.08									

Improved Grassland is generally perceived as having limited biodiversity value though one localised type – Coastal and floodplain grazing marsh – is recognised as a Priority Habitat in the UK Biodiversity Action Plan. Much arable land is viewed similarly, though in some specific situations conservation interest is high, as reflected in the identification of Arable Field Margins as a Priority Habitat in the UK Biodiversity Action Plan. A high proportion of the land cover of Wales is Improved Grassland. Arable & Horticulture occupies a much smaller area with concentrations confined to areas such as South Pembrokeshire, the Vale of Glamorgan and the Vale of Clwyd.

▼ **Table 2.7:** Comparative estimates of the extent of these habitats ('000s ha) are available from the Habitat Survey of Wales, and from Welsh Agricultural Statistics. 95% CI on the 2007 estimates are given in brackets.

	Arable & Horticulture	Improved grassland
Countryside Survey (2007)	73 (42.4-110.9)	731 (625.4-875.3)
Habitat Survey of Wales (1979 - 1997)	60	1,037
Welsh Agricultural Statistics (2007)	67	1,001*

* 'Permanent grass'

▲ Enclosed farmland, Montgomeryshire • © *David Allen*

In comparing estimates of extent from Countryside Survey with the Habitat Survey of Wales, perhaps especially the extent of Arable & Horticulture, account must be taken of the long interval between the different surveys. Agricultural statistics for the period 1992-1997 (coinciding roughly with the period during which Habitat Survey of Wales surveyed lowland Wales) show the area of arable fluctuating between 68,000 and 76,000 ha, consistently higher than the Habitat Survey of Wales estimate. The Countryside Survey estimate is higher than that shown in Agricultural Statistics though the Agricultural Statistics figure falls within the 95% confidence interval of the Countryside Survey estimate, as does the Habitat Survey of Wales figure *(Table 2.7)*. There is some difference between surveys in how they treat temporary grasslands, and this is likely to have contributed to some degree to differences in estimates of the extent of arable.

[25] The difference between the 1994-99 mean and the 2000-08 mean amounts to 47,000 ha.

This different treatment of temporary grasslands, combined with variation between surveys in where the line is drawn in differentiating Improved Grassland from other grassland types, probably accounts for a large part of the variation between surveys in estimates of the extent of Improved Grassland. Hence, much of the Neutral Grassland mapped in Countryside Survey is likely to have been described as Improved Grassland by Habitat Survey of Wales, and included within the definition of permanent grassland used in agricultural statistics.

Trends in data reported annually as Welsh Agricultural Statistics provide a useful context for assessing changes recorded by Countryside Survey. Readily available data exist for the period 1994-2006, and some additional data for 2007 and 2008 have been made available. The total area of agricultural land has decreased, with a step change amounting to a reduction of 45-50,000 ha[25] occurring in 1999. Within this total area of agricultural land, the proportion of different types of farmland has changed:

- Permanent grassland increased steadily from 55% in 1994 to 62% in 2008.
- Rough grazing decreased steadily from 29% in 1994 to 23% in 2008.
- Temporary grassland decreased steadily from 9% in 1994 to 5% in 2008.
- Total tillage mostly remained stable at around 4%.
- Woodland was stable at around 2% from 1994 to 2003, but increased thereafter to 3% by 2006 (the latest date for which data has been made available).

Permanent grassland includes a range of grassland types and is difficult to compare directly with Countryside Survey data. The decrease in rough grazing suggests a possible loss of semi-natural vegetation, and is consistent with the decrease in bracken reported by Countryside Survey but is not obviously reflected in reductions of other semi-natural habitats. The recent increase in woodland is consistent with the increase in broadleaved woodland detected by Countryside Survey in lowland Wales (see *Chapter 5*).

Key results and follow-up questions:

- **An increase in the extent of arable land in the upland zone – is this consistent with biodiversity and/or agri-environment objectives?**
- **A decrease in the species richness of Improved Grassland – what implications for achievement of biodiversity objectives?**
- **What is the ecological significance of the reduction in Stress-tolerator Score in habitat fragments embedded within areas of Improved Grassland in the uplands?**
- **Is the increase in pH of surface soils under Improved Grassland part of a general trend of recovery from acidification?**

These questions, together with those identified in each of the other habitat chapters, are considered further in *Chapter 9*.

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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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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▲ Semi-natural grassland • © *CEH*

3. Semi-Natural Grasslands: Neutral, Calcareous and Acid Grassland Broad Habitats

Summary

Area

- Of the three Broad Habitats, Neutral Grassland covered the largest area in 2007 at 12% of the area of Wales with 60% of this being found in the lowland zone. Acid Grassland covered 10% of the land area of Wales in 2007 and Calcareous Grassland just 0.06%.
- No significant change in any of the Broad Habitats was seen across Wales between 1998 and 2007. However, within the upland zone Neutral Grassland decreased and Acid Grassland increased significantly in area although the confidence intervals for the size of the changes were large.

Vegetation condition

- Few significant changes were detected between 1990, 1998 and 2007, and none were based on large effect sizes. Hence ecological impacts are likely to be minor.

Soils

- Soil pH increased in Neutral Grassland between 1978 and 2007 but not between 1998 and 2007. No change in pH occurred in Acid Grassland.
- Carbon concentration did not change in either Broad Habitat.

3.1 Introduction

This chapter covers the three Broad Habitats – Acid Grassland, Calcareous Grassland and Neutral Grassland. The characteristic species composition ***(Tables 3.4 and 3.6)*** of all three habitats differs along a continuum of changing soil pH. Neutral Grassland occurs on soils that are neither strongly acid nor lime-rich; Calcareous Grassland occurs on lime rich soils – largely Carboniferous limestone in Wales; and Acid Grassland occurs on acid soils. These differences reflect the natural influence of the underlying soil and rock. Indeed in Acid and Calcareous Grasslands, soils are often thin with rock sometimes exposed at the surface. The productivity of these grasslands is lower than Neutral and Improved Grasslands and it is not as economically advantageous to reseed them or apply the high levels of fertiliser typical of Improved Grasslands.

Acid and Neutral Grassland are particularly common in Wales. Calcareous Grassland is much more scarce being almost entirely restricted to the outcrops of Carboniferous Limestone in the north and south. In Wales, these areas include the Great Orme, the Alyn and Eglwyseg Valleys in the North East, and locations in Pembrokeshire and the Gower peninsular in the South West.

Neutral Grassland can be difficult to separate clearly from Improved Grassland because varying levels of agricultural improvement have resulted in a continuum of variation in species composition. At one end of the continuum, the Neutral Grassland Broad Habitat includes those remaining areas of less productive but species-rich pastures and also traditionally managed meadows that are still managed by grazing during Spring and Autumn and then shut up to grow a hay crop harvested at the end of the Summer. The soils are typically deeper and inherently more productive than Acid or Calcareous Grassland hence, many species-rich meadows were reseeded and fertilised and thereby changed into Improved Grasslands in the latter part of the 20th century. In other parts of the UK, new areas of Neutral Grassland have also arisen in the past 20 years with the removal of arable land from cultivation but such areas are more limited in extent in Wales because of the smaller area of cultivated land associated with less productive soils. More common in Wales are areas of semi-improved grassland that lack the overwhelming dominance of palatable grasses such as *Lolium perenne* (Perennial Rye-grass) yet also lack the very high density and cover of forbs typical of unimproved neutral grassland referable to the scarce Lowland and Upland Hay Meadows Priority Habitats.

Grazing is required to maintain all three Broad Habitats. Where grazing is no longer applied the vegetation usually becomes taller and more species-poor, and over time is likely to turn into scrub and woodland. This is most likely to impact often small areas of grassland or other vegetation types no longer accessible to grazing animals, for example, fenced off margins of ponds and swamps, and new woodland planting. The fate of many of these smaller fragments of Neutral Grassland is captured in Countryside Survey by changes seen in the Targeted Plots.

▲ Species-rich hay meadow • © *Clive Hurford*

3.2 The Area of Semi-Natural Grasslands

3.2.1 Neutral Grassland

Of the three Broad Habitats, Neutral Grassland covered the largest area in 2007 estimated at 12% of the area of Wales with 60% of this being found in the lowland zone. Between 1998 and 2007 no significant change in extent was identified across Wales as a whole but a significant decrease of 33,200 ha (95% CI: -1,964 ha to -53,127 ha) was detected in the upland zone although with a large confidence interval ***(Table 3.1)***. This contrasts with an estimated increase of 163,000 ha (95% CI: 37,550 ha to 291,735 ha) in area in England, probably attributable to setaside associated with arable farming systems (setaside is far less common in Wales due to the small area of arable farming), and compares with an estimated 12.5% loss (33,000 ha) of Neutral Grassland in Northern Ireland in the same period[26].

[26] Carey *et al* (2008) *Countryside Survey: UK results from 2007*. Online at www.countrysidesurvey.org.uk/reports2007.html

▼ **Table 3.1:** Estimates of the area ('000s ha) and percentage of land area of Neutral Grassland in Wales from 1998 to 2007. Arrows denote significant change (p<0.05) in the direction shown.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	149	14	159	15	
Upland	137	13	104	10	↓
Wales	287	14	263	12	

▼ **Table 3.2:** Estimates of the area ('000s ha) and percentage of land area of Acid Grassland in Wales from 1998 to 2007. Arrows denote significant change (p<0.05) in the direction shown.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	13	1.2	19	1.7	
Upland	179	17	192	19	↑
Wales	191	9	211	10	

▼ **Table 3.3:** Estimates of the area ('000s ha) and percentage of land area of Calcareous Grassland in Wales from 1998 to 2007. No statistically significant changes were seen between survey years.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	0.8	0.07	0.7	0.06	NO SIGNIFICANT CHANGE
Upland	0.4	0.04	0.4	0.04	
Wales	1.2	0.06	1.2	0.06	

▲ Acid grassland. Wales • © *Lindsay Maskell*

3.2.2 Acid Grassland

This Broad Habitat covered 10% of the land area of Wales in 2007 with 91% of the total being found in the upland zone. No significant change in area occurred across the whole of Wales but a significant increase of 13,000 ha (95% CI; 1,100 ha to 25,022 ha) was detected in the upland zone between 1998 and 2007 *(Table 3.2)*. It is possible that this is the corollary of the estimated decrease in Bracken Broad Habitat in the same zone (see *Chapter 6*). It may also have gained area at the expense of declining Neutral Grassland indicative of the improved, semi-improved neutral and acid grassland continuum described earlier.

3.2.3 Calcareous Grassland

This is a relatively uncommon habitat in Wales and in Britain as a whole. All areas are classified as Priority Habitat depending upon whether their species composition is indicative of the uplands or lowlands. Because the habitat type is so scarce and unevenly distributed, its extent is imprecisely estimated by Countryside Survey. The total area in Wales in 2007 was estimated as 1,200 ha. This amounts to 0.06% of the area of Wales with a higher proportion found in the lowland zone *(Table 3.3)*. No change in area was detected between 1998 and 2007.

3.3 Changes in the vegetation condition of Semi-natural Grasslands

3.3.1 Neutral Grassland Broad Habitat

The most common species recorded in Main and Targeted Plots within areas mapped as Neutral Grassland are listed in *Table 3.4*.

Main Plots: Both the Ruderal Score and Ellenberg Fertility Score declined between 1998 and 2007. No other significant changes were seen in vegetation characteristics *(Table 3.5a)*. Neither of the changes were based on a large standardized effect size.

▼ **Table 3.4:** Most frequent 15 species in 2007 in the Neutral Grassland Broad Habitat in Wales.

a) Main Plots (n=74)			b) Targeted Plots (n=67)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
93	16	*Holcus lanatus*	84	12	*Holcus lanatus*
92	28	*Agrostis capillaris*	61	15	*Agrostis capillaris*
82	6	*Trifolium repens*	48	1	*Rumex acetosa*
81	1	*Cerastium fontanum*	46	9	*Agrostis stolonifera*
81	12	*Lolium perenne*	46	3	*Lolium perenne*
74	3	*Ranunculus repens*	46	3	*Trifolium repens*
72	1	*Taraxacum agg.*	45	3	*Anthoxanthum odoratum*
66	3	*Anthoxanthum odoratum*	43	6	*Festuca rubra agg.*
65	1	*Rumex acetosa*	42	1	*Ranunculus acris*
57	4	*Cynosurus cristatus*	40	2	*Ranunculus repens*
54	2	*Ranunculus acris*	37	3	*Plantago lanceolata*
50	5	*Festuca rubra agg.*	36	1	*Cerastium fontanum*
43	5	*Agrostis stolonifera*	34	2	*Cynosurus cristatus*
36	3	*Juncus effusus*	33	1	*Dactylis glomerata*
35	1	*Cirsium arvense*	31	2	*Juncus effusus*

▼ **Table 3.5:** Change in the characteristics of vegetation in ***a) 200m² Main Plots*** and ***b) 4m² Targeted Plots, in the Neutral Grassland Broad Habitat across Wales between 1990, 1998 and 2007.*** W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

a) Main Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	21.3	21.5	21.1	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	11.6	11.4	11									
No. of Butterfly Food Species	10.6	10.8	10.4									
Grass:Forb Ratio	1.08	1.10	1.07							NO SIGNIFICANT CHANGE		
Competitor Score	2.75	2.79	2.77									
Stress Tolerator Score	2.29	2.26	2.32									
Ruderal Score	2.94	2.98	2.93	↓								
Light Score	7.02	7.01	6.98									
Fertility Score	5.00	4.99	4.83	↓	↓	↓						
Ellenberg pH Score	5.79	5.72	5.61									
Moisture Score	5.43	5.52	5.53									

b) Targeted Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	15.8	18.3	15.5	↓	↓		↑	↑		NO SIGNIFICANT CHANGE		
No. of Bird Food Species	6.1	7.5	6.2	↓	↓		↑	↑				
No. of Butterfly Food Species	7.1	8.1	7	↓	↓			↑				
Grass:Forb Ratio	0.54	0.93	0.88					↑			↑	
Competitor Score	2.81	2.81	2.82									
Stress Tolerator Score	2.58	2.48	2.45					↓			↓	
Ruderal Score	2.58	2.63	2.66									
Light Score	6.89	6.91	6.91									
Fertility Score	4.62	4.66	4.68									
Ellenberg pH Score	5.64	5.54	5.55				↓	↓				
Moisture Score	5.99	6.07	5.89	↓	↓							

▼ **Table 3.6:** Most frequent 15 species in 2007 in the Acid Grassland Broad Habitat in Wales.

a) Main Plots (n=49)			b) Targeted Plots (n=54)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
88	3	*Galium saxatile*	48	5	*Festuca ovina agg.*
80	6	*Rhytidiadelphus squarrosus*	48	14	*Molinia caerulea*
76	11	*Festuca ovina agg.*	48	3	*Rhytidiadelphus squarrosus*
71	13	*Agrostis capillaris*	44	1	*Potentilla erecta*
71	15	*Nardus stricta*	41	8	*Agrostis capillaris*
61	5	*Vaccinium myrtillus*	41	2	*Galium saxatile*
59	2	*Anthoxanthum odoratum*	37	3	*Anthoxanthum odoratum*
57	4	*Juncus effusus*	37	2	*Vaccinium myrtillus*
55	22	*Molinia caerulea*	33	2	*Deschampsia flexuosa*
53	3	*Deschampsia flexuosa*	33	4	*Nardus stricta*
53	4	*Juncus squarrosus*	31	1	*Luzula campestris/multiflora*
53	1	*Luzula campestris/multiflora*	28	4	*Calluna vulgaris*
51	2	*Potentilla erecta*	28	2	*Polytrichum commune*
43	3	*Polytrichum commune*	26	3	*Agrostis canina sens.lat.*
41	1	*Pleurozium schreberi*	24	1	*Festuca rubra agg.*

Targeted Plots: These plots focus on changes in the smaller fragments of habitat too small and uncommon to have been sampled by the randomly placed Main Plots. The only overall trend to be seen between 1990 and 2007 was an increase in Grass:Forb ratio. Species richness increased between 1990 and 1998 but decreased between 1998 and 2007. However, in no case were standardized effect sizes large so that all changes may have resulted in only minor ecological impacts on the vegetation *(Table 3.5b)*.

3.3.2 Acid Grassland Broad Habitat

The most common species recorded in Main and Targeted Plots within areas mapped as Acid Grassland are listed in *Table 3.6*.

Main Plots: The only significant change was an increase in Grass:Forb ratio between 1990 and 1998. The standardized effect size was not large suggesting possibly minor ecological impact on the vegetation structure *(Table 3.7a)*.

Targeted Plots: A larger number of significant changes were seen in the smaller Targeted Plots that pick out rarer fragments of habitat embedded within mapped areas of the Broad Habitat. Between 1998 and 2007, Ellenberg Fertility Score increased, Competitor Score increased and Stress-tolerator Score decreased. These changes were not seen between 1990 and 1998 where only Ellenberg Light Score and Grass:Forb ratio increased. Therefore over the 17 year period between 1990 and 2007, little net change had occurred with an overall reduction in Stress-tolerator Score and an increase in Ellenberg Light Score suggesting a minor increase in species of more open conditions *(Table 3.7b)*. Again, none of the changes were based on large standardized effect sizes so that ecological impacts on the vegetation are likely to have been small relative to the variation in the sample although confirmation requires further research.

3.3.3 Calcareous Grassland Broad Habitat

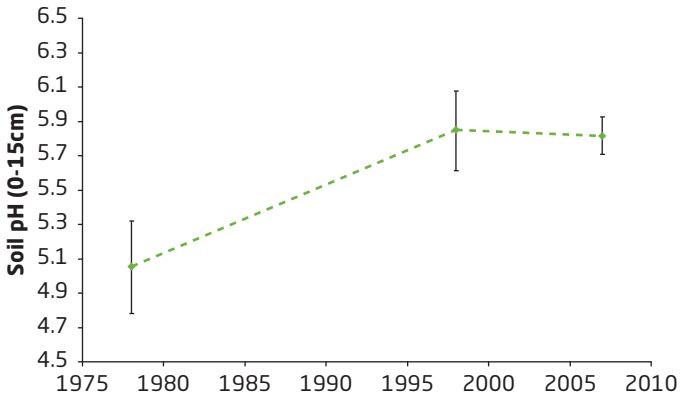
Too few plots were available for analysis of this habitat type.

3.4 Changes to the soils (0-15cm) of semi-natural grasslands

3.4.1 Neutral Grasslands

Soil (0-15cm) pH: The mean pH of soil (0-15cm) in Main Plots within Neutral Grassland in Wales increased significantly between 1978 and 1998, and overall from 1978 to 2007 *(Fig 3.1)*. The significant increase in pH between 1978 and 1998 has not continued between 1998 and 2007. This is consistent with a response to decreased acid deposition during the earlier period of the survey and subsequent stabilisation. However, stronger support for a correlative link between the two awaits further analysis.

▼ **Figure 3.1:** Change in soil pH in Neutral Grassland in Wales between 1978 and 2007. Error bars are the 95% confidence intervals on mean soil pH in each survey year. Significant change (at least $p<0.05$) occurred between 1978 and 2007, and 1978 and 1998.



▼ **Table 3.7:** Change in the characteristics of vegetation in ***a) 200m² Main Plots*** and ***b) 4m² Targeted Plots, in the Acid Grassland Broad Habitat across Wales between 1990, 1998 and 2007.*** W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

a) Main Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	19.0	18.5	20.0	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	6.0	6.0	6.4									
No. of Butterfly Food Species	9.0	9.0	9.0									
Grass:Forb Ratio	1.54	1.98	1.71	NO SIGNIFICANT CHANGE			↑			NO SIGNIFICANT CHANGE		
Competitor Score	2.36	2.31	2.37									
Stress Tolerator Score	3.32	3.29	3.25									
Ruderal Score	1.91	1.97	1.95									
Light Score	6.81	6.89	6.89									
Fertility Score	3.24	3.26	3.22									
Ellenberg pH Score	3.85	3.88	3.89									
Moisture Score	6.15	6.14	6.19									

b) Targeted Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	13.4	12.1	12.6	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	3.7	3.1	3.3									
No. of Butterfly Food Species	5.4	5.4	5.4									
Grass:Forb Ratio	1.47	2.06	1.83				↑					
Competitor Score	2.29	2.30	2.40	↑	↑							
Stress Tolerator Score	3.43	3.43	3.27	↓		↓				↓		↓
Ruderal Score	1.76	1.83	1.89									
Light Score	6.80	6.93	6.94				↑		↑	↑		↑
Fertility Score	3.07	2.93	3.07	↑		↑						
Ellenberg pH Score	3.80	3.71	3.77									
Moisture Score	6.53	6.47	6.50									

Soil (0-15cm) carbon concentration: There was no significant change in carbon concentration between surveys.

Bulk density and soil (0-15cm) carbon stock: The mean bulk density of Neutral Grassland soils (0-15cm) in Wales in 2007 was 0.86 g/cm^3 which when combined with mean soil carbon concentration indicated a soil (0-15cm) carbon stock of 63 t/ha.

3.4.2 Calcareous Grasslands

An insufficient number of soil samples were taken from the Calcareous Grassland Main Plots for a statistical analysis to be undertaken for this Broad Habitat.

3.4.3 Acid Grasslands

Soil (0-15cm) pH: There was no significant change in the mean pH of soil (0-15cm) samples in the Main Plots within Acid Grasslands in Wales between 1978, 1998 and 2007.

Soil (0-15cm) carbon concentration: There was no significant change in carbon concentration between surveys.

Bulk density and soil (0-15cm) carbon stock: The mean bulk density of Acid Grassland soils (0-15cm) in Wales was 0.48 g/cm^3 which, when combined with mean soil carbon concentration indicated a soil (0-15cm) carbon stock of 75 t/ha.

3.5 The results in context

This chapter has considered three Broad Habitats that collectively represent much of the grassland resource within Wales; types not included here include those wetter forms, such as Purple-moor grass Meadows & Rush pastures, that fall within the Fen, Marsh & Swamp Broad Habitat, and the most intensively modified forms that are dealt with in the Enclosed Farmland chapter. That said, two types considered here – Neutral and Acid Grassland – will include areas of vegetation subject to significant agricultural modification. Most of the Neutral Grassland especially but perhaps also some part of Acid Grassland recorded by Countryside Survey probably falls within the broad category of grasslands commonly referred to as semi-improved grassland. Very small amounts of the Neutral Grassland described here will relate to unimproved forms of high conservation value (these are a scattered, fragmented resource in Wales as elsewhere in the UK). Larger amounts of the Acid Grassland will correspond to forms that grade into Dwarf Shrub Heath and Bog in the unenclosed uplands, and probably very little to lowland unimproved Acid Grassland, a type of high nature conservation value that is scarce and highly localised in Wales.

None of the Welsh grassland types considered to be of high conservation interest within each of these three broad habitats, namely the Priority Habitats Lowland Hay Meadows, Lowland Dry Acid Grassland, Lowland Calcareous Grassland, and Upland Calcareous Grassland, is recorded sufficiently often by Countryside Survey to enable assessment of its state.

With the exception of Neutral Grassland, Habitat Survey of Wales figures fall within the confidence intervals of Countryside Survey estimates *(Table 3.8)*. In the case of Neutral Grassland, there is a particularly large difference between the two surveys. But, as discussed in relation to Improved Grassland, the Countryside Survey definition of Neutral Grassland includes semi-improved types that Habitat Survey of Wales allocated to Improved Grassland (this may be the case also in relation to Acid Grassland, though perhaps to a lesser degree). Perhaps more than anything, this simply reinforces the difficulty of drawing hard lines between classes of vegetation that in reality grade into one another. This is difficult in any single survey; drawing comparisons between surveys only compounds the difficulties. It should also be recalled that neither Habitat Survey of Wales nor Countryside Survey used the Broad Habitat classification as its primary means of description, and Broad Habitat estimates are derived by subsequent allocation of recorded types to Broad Habitats.

Key results and follow-up questions:

- **No evidence of long-term change in species richness in either Neutral or Acid Grassland – what are the implications for the aim of halting biodiversity loss?**
- **Few long-term changes in condition of Acid and Neutral Grassland – how consistent is this apparent stability with changes in other habitats, and with biodiversity and/or agri-environment objectives?**
- **An increase in pH of surface soils under Neutral Grassland – is this part of a general trend of recovery?**

These questions, together with those identified in each of the other habitat chapters, are considered further in *Chapter 9*.

▲ Upland semi-natural grasslands, north Wales • © *CEH*

▼ **Table 3.8:** Comparative estimates of the semi-natural grassland habitat extent ('000s ha) are available from the Habitat Survey of Wales. 95% CI on the Countryside Survey 2007 estimates are given in brackets.

	Neutral Grassland	Acid Grassland	Calcareous Grassland
Countryside Survey (2007)	263 (214.8-317.8)	211 (136.3-330.0)	1 (>0-3.3)
Habitat Survey of Wales (1979 - 1997)	35	153	2

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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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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▲ Line of trees • © *David Allen*

4. Boundary and Linear Features Broad Habitat

Summary

Length and condition

- Woody linear features (managed hedges and lines of trees and shrubs) made up an estimated 51% of the total length of the Boundary & Linear Features Broad Habitat in Wales in 2007. This compares with 53% in England and 13% in Scotland.
- In parallel with the rest of Britain, there has been a reduction in the length of managed hedgerow in Wales over the 23 years since the first survey in 1984. This long-term loss reflects a combination of removal and shift to less frequently managed or unmanaged lines of trees and shrubs. Hedge removal was much more important between 1984 and 1990[27, 28], and has declined since 1990. However, the trend for a reduction in hedge management and increasing recruitment to unmanaged lines of trees and shrubs has been ongoing since 1984 up to and including the 1998 to 2007 interval.
- Tree and shrub species richness in Welsh woody linear features was the highest in Britain at 4.2 species per 30m length compared with 2.2 in Scotland and 3.7 in England.
- Fences were the next most common boundary feature making up 35% of the total length in Wales.
- Walls were evenly distributed between upland and lowland zones but were much more likely to be in poor condition in the uplands.

Vegetation condition

- A small number of statistically significant changes occurred in Hedgerow and Roadside Plots but the effect sizes of these changes were all medium or small suggesting possibly minor importance in terms of shifts in population means.
- The clearest ecological pattern occurred in Roadside Plots where changes were also small in effect size but suggested an overall trend toward less disturbance and greater shade.

[27] Barr *et al* (1991) *Changes in hedgerows in Britain between 1984 and 1990.* NERC/ITE.

[28] Barr *et al* (1993) *Countryside Survey 1990: Main Report.* Department of the Environment. HMSO. London.

4.1 Introduction

This Broad Habitat comprises hedgerows, lines of trees (if less then 5m wide or of single tree width), walls, fences, stone and earth banks *(Table 4.1)*[29]. While the Countryside Surveys of 1984, 1990, 1998 and 2007 all recorded these different features, improvements in methodology and in definitions of feature types have enabled more consistent national estimates to be made across the surveys. This has meant changing the way feature types have been defined across surveys but constrained by the number and type of attributes measured and the ways these attributes can be combined. Information in this report is provided at a general level for the six major types of feature *(Table 4.1)*.

Each type of feature was given a place in a hierarchy consistent with previous Countryside Survey reporting. This ensured that there would be no double counting of a section of a linear feature that was made up of two components such as a hedge and a ditch; nor triple counting for a hedge, ditch and fence. Hedges were considered to be more ecologically important than other linear features and were given precedence in reporting when they were found alongside other features. While other features, such as banks and walls are significant in a landscape policy context, hedge condition and stock are particularly important to measure because of the requirement to report progress on their Habitat Action Plan[30].

Data were also collected on the structural condition of the different feature types. Because there is more work to be done in exploring the uncertainties introduced by changing definitions over the previous, and particularly earlier surveys, this report emphasises the most reliable and comparable estimates that derive from the surveys of 1998 and 2007.

▲ Mixed boundary types • © *Colin Barr*

▼ **Table 4.1:** Boundary and Linear Feature types.

Linear Features	Description/condition criteria
Hedge	A line of woody vegetation that has been subject to management so that trees no longer take their natural shape. Hedges may be present with any feature below including alongside ditches, tracks and roads. These are also known as managed hedgerows.
Wall	A built structure of natural stone or manufactured blocks, mostly of traditional dry stone wall construction but including mortared walls. Includes walls with fences or banks/grass strips and/or lines of trees or shrubs.
Line of trees/ shrubs and relict hedge and fence	Line of trees or shrubs, in which trees/shrubs take their natural shape, including those originally planted as hedges with a fence. May also include banks/grass strips.
Line of trees/ shrubs and relict hedge	Line of trees or shrubs, in which trees/shrubs take their natural shape, including those originally planted as hedges. Includes avenues of trees. May also include banks/grass strips.
Bank/grass strip	An earth or stone-faced bank or grass strip with or without a fence.
Fence	A permanent post and wire or rail structure, including wooden, concrete or metal posts without any other associated feature other than a ditch or stream. Fences made from slate pillars bound by wire in Wales are included in this category.

In addition to the recording of structural features and measurement of overall length, fixed vegetation plots have been used to record the plant species composition of vegetation associated with linear features, such as that occurring on road verges, track sides and in hedge bottoms. These data are used to explore the current ecological condition of such vegetation, and how it has changed since 1990.

Hedge Diversity Plots were introduced in 1998 to measure the number of woody species in each hedge. In 2007 these were extended to other kinds of 'woody linear feature' such as lines of trees. The Hedge Diversity Plots span the width of the woody linear feature and are 30m long. In addition to species information, other data on the dimensions and condition of the feature were collected as was information on the presence and width of adjacent buffer strips. These attributes contribute to an assessment of condition that allows progress to be measured against the UK Habitat Action Plan for hedgerows.

4.2 Length of Boundary and Linear Features

In 2007, woody linear features (unmanaged and managed) made up 51% of the total length of boundary features in Wales *(Table 4.2)*. A further 35% of the total was fences, and the remainder was made up of walls (6%) and banks/grass strips (8%) *(Table 4.2)*. While most lengths of linear feature did not change

[29] Jackson, D.L (2000) *Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications.* Online at: www.jncc.gov.uk

[30] See www.ukbap.org.uk

▼ **Table 4.2:** The length ('000s km) and change in length of Boundary and Linear Features in Wales and Welsh Environmental Zones between 1998 and 2007. Arrows denote significant change ($p<0.05$) in the direction shown. Standard errors (SE) are shown for each length estimate.

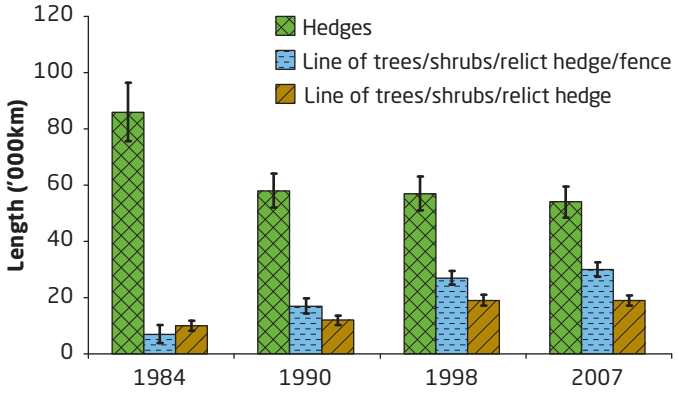
	Country and zone	1998		2007		1998-2007
		Length ('000s km)	SE	Length ('000s km)	SE	Direction of significant shanges
Total woody Linear Features	Wales	107	8.0	106	7.9	
	Lowland	68	4.9	70	5.2	
	Upland	40	6.0	37	5.8	↓
Hedges	Wales	57	6.0	54	5.6	↓
	Lowland	36	4.2	36	4.0	
	Upland	21	4.0	18	3.7	↓
Line of trees/ shrubs/relict hedge/fence	Wales	27	2.4	30	2.5	↑
	Lowland	17	2.0	20	2.0	↑
	Upland	10	1.4	10	1.5	
Line of trees/shrubs/relict hedge	Wales	19	1.9	19	1.8	
	Lowland	13	1.6	14	1.5	
	Upland	6	1.1	5	0.9	
Wall	Wales	13	2.8	13	2.8	
	Lowland	7	2.4	7	2.2	
	Upland	6	1.6	6	1.6	
Bank/grass strip	Wales	16	1.8	16	1.7	
	Lowland	10	1.4	10	1.4	
	Upland	6	1.0	6	0.9	
Fence	Wales	74	4.3	74	4.5	
	Lowland	40	2.8	40	2.8	
	Upland	34	3.3	34	3.4	

type between 1998 and 2007, a significant 7.5% decline in total length of woody linear features was detected in the Welsh upland zone. The confidence interval of this change was large however: 1,500 to 4,000 km. Across Wales as a whole, managed hedges also declined significantly by an estimated 3,200km in length between 1998 and 2007 but again with a large confidence interval (95% CI; -700 km to -5,800 km). In the same period, a net significant increase of 2,700 km (95% CI; 1,200 km to 3,900 km) was estimated for the category 'Line of trees/shrubs/relict hedge/fence' associated with a lack of recent management and where trees and shrubs have regained their natural shape *(Table 4.2)*.

In Wales, evidence from all four Countryside Surveys indicates that woody linear features whose shape suggests recent management (i.e. managed hedges) have always been, and still are, more common than unmanaged woody linear features. However, since 1984, there has been a steady reduction in length of managed hedges and an increase in relict hedges *(Fig 4.1)*. Spatial analyses of these patterns has shown that the small gains to the unmanaged woody linear features were largely from managed hedges, indicating a trend toward less frequent management in a small but significant proportion of the resource in Wales. The biggest reduction in managed hedge length occurred between 1984 and 1990, and slowed thereafter *(Fig 4.1)*. A similar pattern occurred across Britain as a whole in the same period and also reflected a major gain in unmanaged woody linear features recruited from managed hedges.

Removal of hedgerows was a more important driver of hedgerow loss between 1984 and 1990. Since then removal has been less influential than the unchecked growth of previously managed hedges leading to reclassification as an unmanaged line of trees and shrubs although often with signs of historical management still evident[31].

▼ **Figure 4.1:** The change in total length ('000s km) of woody linear feature types in Wales between 1984 and 2007. Error bars are the standard errors on the mean length in each survey.



[31] Barr *et al* (1993) *Countryside Survey 1990. Main Report.* Department of the Environment, HMSO London, UK.

▲ Unmanaged woody linear features • © *Colin Barr*

4.3 The condition of vegetation associated with Boundaries & Linear Features

The most common species recorded in Roadside and Hedgerow Plots are listed in *Table 4.3*.

None of the statistically significant changes seen in vegetation measures in the Hedgerow or Roadside Plots in Wales translated into large standardized effect sizes. However, since 1978, patterns of statistically significant changes across the whole of Britain in condition measures in Hedgerow Plots, and to a lesser extent Roadside Plots, indicated greater shade, lower herbaceous species richness and a greater representation of species favouring higher fertility[32]. When examined, none of the changes that were significant across Britain but not statistically significant in Wales between 1990 and 2007 were based on large standardized effect sizes.

4.3.1 Condition of vegetation in Hedge Plots

Species Richness: On average the number of butterfly larval food plants per 1x10m length of hedgerow in Wales declined by 0.8 species per plot between 1990 and 2007 but the standardized effect size was small *(Table 4.4)*.

Other vegetation characteristics: All other statistically significant changes were also small or medium in size and therefore probably of minor ecological importance in terms of shift in the population, although further research would be needed to confirm this. Grass:Forb ratio declined across Wales and especially in the lowland zone, while the proportion of species favouring more disturbed conditions increased between 1990 and 1998, and then declined again between 1998 and 2007 *(Table 4.4)*.

4.3.2 Condition of vegetation in Roadside Plots

Species Richness: Statistically significant reductions in butterfly larval food plant richness were detected across road verges in Wales between 1990 and 2007 (0.8 species fewer on average per 1x10m length), and between 1998 and 2007, especially in the lowland zone *(Table 4.5)*. However, all of these changes were either small or medium standardized effect sizes and so probably of minor ecological importance.

Other characteristics: The clearest pattern occurred in Roadside Plots between 1990 and 2007, where Ellenberg Light Score and Ruderal Score both declined, indicating an overall trend toward species favouring greater shade and less disturbance *(Table 4.5)*. However, none of the statistically significant changes were large in terms of their standardized effect size and so do not convey a marked shift in sample means.

4.4 Condition of Boundary and Linear Features

4.4.1 Woody species richness of hedgerows

Tree and shrub species richness in Welsh woody linear features was the highest in Britain at 4.2 species per 30m length compared with 2.2 in Scotland and 3.7 in England.

4.4.2 Condition of hedgerows

Agreed criteria for assessment of hedgerow condition are measured by structural attributes of the hedge itself or relate to the margin immediately adjacent to the hedge *(Table 4.6)*. Taking into account purely structural attributes, 44% of Welsh hedges were in good condition in 2007. This dropped to 7% when all attributes were taken into account *(Fig 4.2)*. On arable land 2% were in good condition taking into account the distance to adjacent disturbed ground and only 1% were in good condition taking into account all other condition criteria including the width of perennial vegetation between the hedge and disturbed ground.

▲ Traditionally laid hedge • © *Colin Barr*

[32] Carey *et al* (2008) *Countryside Survey: UK results from 2007*. Online at www.countrysidesurvey.org.uk/reports2007.html

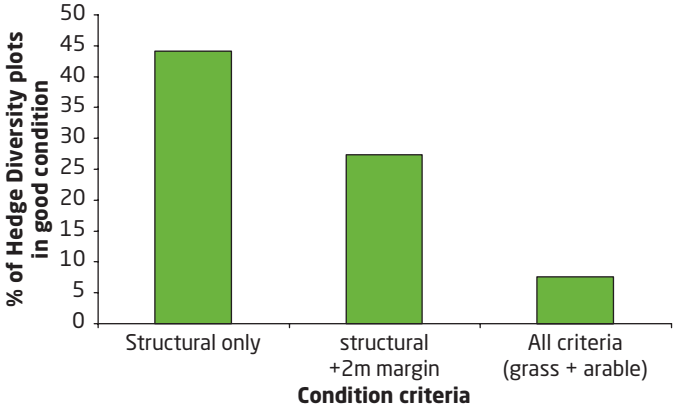
▼ **Table 4.3:** Most frequent 15 species in 2007 in the Boundaries & Linear Features Broad Habitat in Wales, comprising Roadside and Hedgerow Plots.

a) Hedgerow Plots (n=134)			b) Roadside Plots (n=403)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
81	24	*Crataegus monogyna*	70	7	*Dactylis glomerata*
72	8	*Urtica dioica*	65	9	*Holcus lanatus*
69	9	*Rubus fruticosus agg.*	65	2	*Taraxacum agg.*
68	6	*Holcus lanatus*	60	11	*Lolium perenne*
63	15	*Hedera helix*	59	9	*Agrostis stolonifera*
63	22	*Prunus spinosa*	53	3	*Poa annua*
57	4	*Dactylis glomerata*	50	8	*Agrostis capillaris*
54	16	*Corylus avellana*	47	7	*Festuca rubra agg.*
47	5	*Agrostis capillaris*	47	3	*Rubus fruticosus agg.*
46	2	*Galium aparine*	45	2	*Ranunculus repens*
45	4	*Arrhenatherum elatius*	43	3	*Trifolium repens*
40	3	*Festuca rubra agg.*	43	3	*Urtica dioica*
40	3	*Agrostis stolonifera*	37	5	*Arrhenatherum elatius*
34	1	*Digitalis purpurea*	31	3	*Hedera helix*
31	4	*Lolium perenne*	30	1	*Heracleum sphondylium*

▼ **Table 4.4:** Changes in the characteristics of vegetation in 10m x1m Hedge Plots across Wales between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	19.3	18.9	18.1	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE					
No. of Bird Food Species	10.1	9.8	9.4									
No. of Butterfly Food Species	9.4	8.7	8.2							↓		↓
Grass:Forb Ratio	0.65	0.25	0.04				↓	↓		↓	↓	
Competitor Score	3.18	3.13	3.17									
Stress Tolerator Score	2.28	2.29	2.29									
Ruderal Score	2.12	2.21	2.13	↓			↑	↑				
Light Score	6.14	6.14	6.13									
Fertility Score	5.78	5.77	5.75									
Ellenberg pH Score	6.06	6.06	6.06									
Moisture Score	5.48	5.48	5.52									

▼ **Figure 4.2:** The percentage of 30m long Hedge Diversity Plots in managed hedges in Wales that met condition criteria in 2007 (n=406).



▲ Cut hedge • © *Colin Barr*

▼ **Table 4.5:** Changes in the characteristics of vegetation in 10m x1m Roadside Plots across Wales between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change (p<0.05) in the direction shown. None of the significant changes reflected a large effect size.

	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	19.2	19.1	19.0				NO SIGNIFICANT CHANGE					
No. of Bird Food Species	8.9	9.0	9.2									
No. of Butterfly Food Species	9.3	8.9	8.5	↓	↓					↓	↓	
Grass:Forb Ratio	1.15	1.21	0.87	↓	↓					↓	↓	
Competitor Score	2.77	2.79	2.86	↑		↑				↑		↑
Stress Tolerator Score	2.24	2.21	2.21									
Ruderal Score	2.76	2.80	2.68	↓	↓	↓				↓		
Light Score	6.70	6.73	6.58	↓	↓	↓				↓	↓	↓
Fertility Score	5.41	5.43	5.47									
Ellenberg pH Score	5.88	5.90	5.91									
Moisture Score	5.40	5.43	5.46				↑			↑		↑

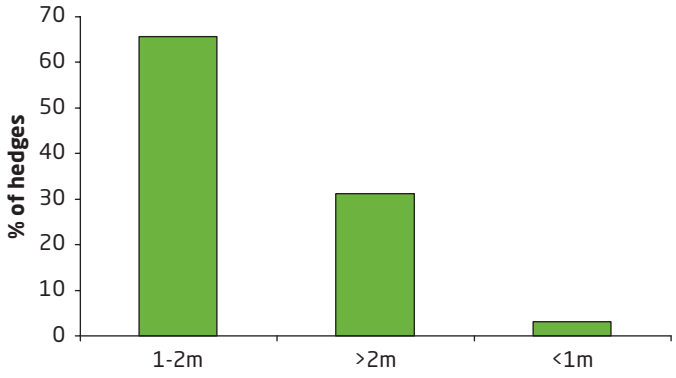
▼ **Table 4.6:** The structural and margin condition criteria assessed by surveyors in Countryside Survey 2007.

Structural Condition Criteria	Margin Condition Criteria
Height >1m	Distance between centre of hedge and disturbed ground >2m
Width >1.5m	Width of perennial vegetation 1m
Vertical gappiness <10%	
No gaps >5m	
Non-native species at >10% cover	
Height of base of canopy <0.5m	

4.4.3 Hedgerow height and management

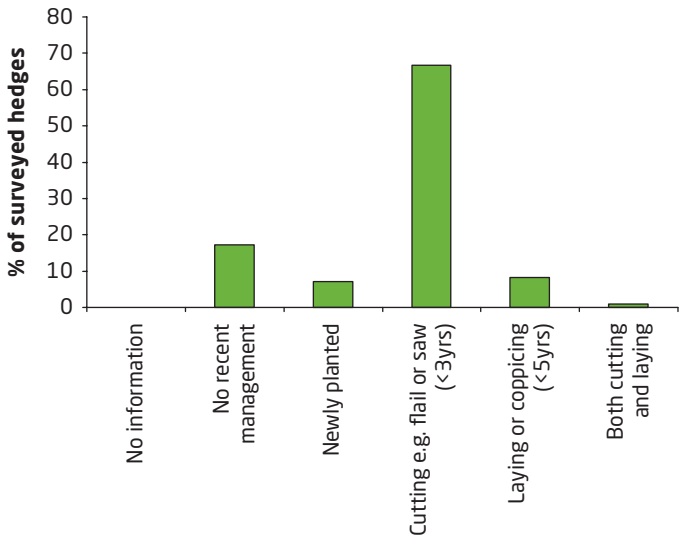
In 2007, 66% of sampled hedges were between 1m and 2m in height *(Fig 4.3)* despite a significant decrease in the proportion of hedges in this category between 1998 and 2007. No other significant changes were detected.

▼ **Figure 4.3:** Percentage of length of hedgerows in different height categories across Wales in 2007.



Recorded evidence of management indicated that most woody linear features (67% of sampled hedges) had been cut in the last 3 years, 7% had been newly planted and 17% showed no sign of recent management *(Fig 4.4)*.

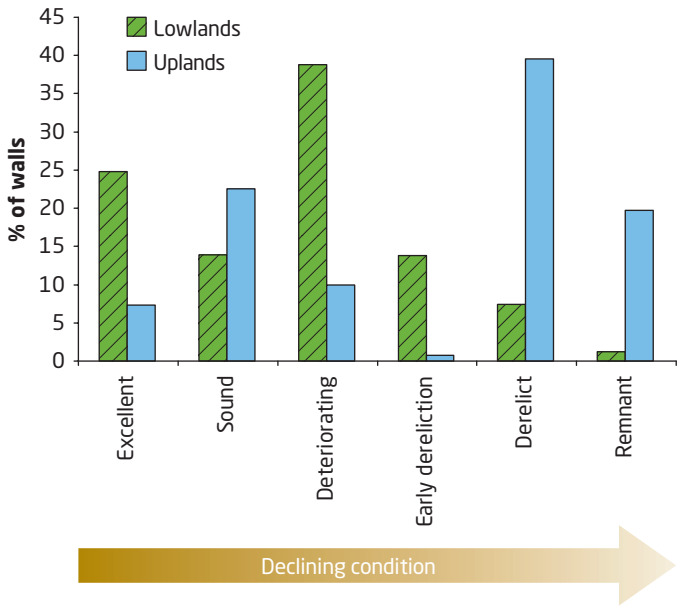
▼ **Figure 4.4:** Management practices in 2007 in Welsh hedges.



4.4.4 Structural condition of walls

In 2007, the estimated total length of walls in Wales was 13,000 km, evenly split between the upland and lowland zones *(Table 4.2)*. Marked differences in condition were seen between these two zones. Walls in the uplands were much more likely to be in poor condition (derelict or remnant) than in the lowlands where more importance probably attaches to the maintenance of stockproofing. In the lowlands a higher proportion of walls were deemed either in excellent condition or deteriorating *(Fig 4.5)*. The results suggest relatively more walls in lowland Wales were in good condition but a substantial proportion seem to be moving toward increasing disrepair. Nevertheless, far fewer lowland walls were in the worst possible condition categories.

▼ **Figure 4.5:** The percentage of the total length of walls in different structural condition categories across Wales in 2007.



4.5 The results in context

This chapter has considered the Broad Habitat that includes hedgerows, lines of trees, walls, fences, stone and earth banks. Some, though not all, of these provide habitats for animals and plants. But all are additionally important as components of the Welsh landscape, and the presence, relative abundance and state of different types contributes to the landscape character of particular areas. Hedgerows are recognised as a Priority Habitat within the UK Biodiversity Action Plan[33], and hedges generally provide habitats for birds, mammals, and other animal species. Hedges may be additionally important in providing connectivity between otherwise fragmented habitats.

No comparative estimates of the extent of these habitats are available from other sources. Countryside Survey is therefore a key source of information about the state of these features.

Key results and follow-up questions:

- **A reduction in the length of managed hedges and corresponding increase in lines of trees – are they consistent with biodiversity, landscape and/or agri-environment objectives?**
- **Very few hedges in good condition – what does it mean for biodiversity?**

These questions, together with those identified in each of the other habitat chapters, are considered further in *Chapter 9*.

▲ Stone walls, Gwynedd • © *Richard Evans*

[33] www.ukbap.org.uk

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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.

▲ Sessile oak woodland • © *Clive Hurford*

5. Woodlands: Broadleaved, Mixed & Yew Woodlands and Coniferous Woodland

Summary

Area

- Broadleaved, Mixed & Yew Woodland covered 8.6% (173,600 ha) of the total area of Wales in 2007. No significant net change in area was estimated to have occurred across Wales between 1998 and 2007 however, in the Welsh lowlands a significant increase of 8,900 ha was detected between 1998 and 2007.
- Coniferous Woodland covered 5.0% (105,900 ha) of Wales in 2007. No significant net change in area was seen between 1998 and 2007.
- The total area of woodland in Wales is consistent with other recording schemes although Countryside Survey allocates a much larger proportion of woodland to Broadleaved, Mixed & Yew Woodland relative to Coniferous Woodland.

Vegetation condition

- No significant changes in plant species composition occurred between 1998 and 2007 in either Coniferous or Broadleaved, Mixed & Yew Woodland but a significant reduction in species richness in Broadleaved, Mixed & Yew Woodland was seen between the 1990 and 2007 surveys. Significant changes during this longer time interval were also consistent with a general trend seen elsewhere in Britain for a reduction in abundance of species associated with canopy gaps, disturbance and an increase in more nutrient-demanding taller plants.
- In Broadleaved, Mixed & Yew Woodland only, the significant increase in Competitor Score in the upland zone in Main Plots between 1990 and 2007 was associated with a large standardized effect size. The decrease in butterfly larval food plant richness in the lowland zone in Main Plots between 1990 and 2007 was just below the large effect size threshold reflecting a reduction of an average 3 species per plot over the 17 year period. Both changes may indicate more substantial ecological impacts on the woodland ecosystem.

Soils

- **There was no significant change in soil (0-15cm) pH in Broadleaved, Mixed & Yew Woodland in Wales between 1998 and 2007 but soils (0-15cm) in this Broad Habitat were significantly less acid in 2007 than they were in 1978. No change in soil (0-15cm) pH in Coniferous Woodland has been observed since 1978.**
- **Soil (0-15cm) carbon concentration has remained stable in Broadleaved, Mixed & Yew Woodland in Wales since 1978 but decreased in Coniferous Woodland between 1998 and 2007.**
- **The estimated soil (0-15cm) carbon stock in 2007 for Broadleaved, Mixed & Yew Woodland and Coniferous Woodland was 71t/c/ha and 61t/c/ha respectively.**

5.1 Introduction

In Countryside Survey, woodland is defined as 'consisting of over 25% canopy cover of trees and shrubs, over a metre high'[34]. The two woodland Broad Habitats include all broadleaved and coniferous woodlands as well as scrub including Gorse (*Ulex europaeus*)[35]. Lines of trees and hedges are covered separately as woody linear features, in the Boundary and Linear Features Broad Habitat *(Chapter 4)*.

Two Broad Habitat types distinguish woodland types in Wales: Broadleaved, Mixed & Yew Woodland; and Coniferous Woodland, the only type native to Wales being Juniper scrub. Areas of mapped woodland Broad Habitat often include small patches of other habitats below the minimum mappable unit (20m x 20 m) but located within the surveyed woodland boundary. While small, these nonetheless contribute diversity and distinctiveness to the wooded environment. These habitats maybe associated with past and present human activity within the woods such as paths, ponds and rides. They may also reflect natural variability in conditions for tree growth. For example windthrow, grazing, wet conditions, rock exposures and steep slopes can all interrupt the tree canopy making way for patches of bracken, grassland, bog, flushes and inland rock. In commercial woodland there will also be clear-felled areas awaiting replanting or left to develop as new areas of heathland, grassland or bog (and mapped as such by Countryside Survey). Areas of natural regeneration can also occur, typically along the forest edges where a more natural structure is being encouraged. In addition many commercial plantations are increasingly subject to thinning regimes that open out mature conifer canopies but would not result in a change to the Broad Habitat type. The use of the two plot types, Main Plots and Targeted Plots, enables the differences between the larger areas of wooded habitat and these smaller patches to be examined.

▲ Coniferous woodland and clear fell, mid Wales • © *Simon Smart*

5.2 The Area of Woodland in Wales

5.2.1 Broadleaved, Mixed & Yew Woodland

Broadleaved, Mixed & Yew Woodland covered an estimated 173,600 ha of Wales but with wide 95% confidence intervals (135,100 to 233,900 ha). This amounts to an estimated 8.6% of the total land area of Wales in 2007, nearly equally distributed between the upland and lowland zones *(Table 5.1)*. Across Wales as a whole, no statistically significant change in area was detected between 1998 and 2007 but there was an estimated 12% increase of 8,900 ha (95% CI; 1,200 ha to 15,800 ha) in the lowlands between 1998 and 2007 *(Table 5.1)*.

▼ **Table 5.1:** Estimates of the area ('000s ha) and percentage of land area of Broadleaved, Mixed & Yew Woodland in Wales and in each environmental zone from 1998 to 2007 are shown. Arrows denote significant change ($p<0.05$) in the direction shown.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	75	6.9	84	7.7	↑
Upland	97	9.4	90	8.8	
Wales	172	8.1	174	8.2	

5.2.2 Coniferous Woodland

Woodland dominated by conifers covered an estimated 105,900 ha making up 5.0% of the total land area of Wales in 2007.
No significant change to the total area of Coniferous Woodland was observed in Wales between 1998 and 2007 *(Table 5.2)*.

[34] Field Mapping Handbook. On-line at: www.countrysidesurvey.org.uk/tech_reports.html

[35] Note that in Countryside Survey a woodland mappable unit with >20% cover of Conifers is assigned to Conifer Woodland. Hence mapped areas of Broadleaved, Mixed & Yew may have much less conifer cover than allowed by the Broad Habitat definition.

▼ **Table 5.2:** Estimates of the area ('000s ha) and percentage of land area of Coniferous Woodland in Wales and in each environmental zone from 1998 to 2007 are shown. No statistically significant change was seen between survey years.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	7	0.6	4	0.4	NO SIGNIFICANT CHANGE
Upland	89	8.7	102	9.9	
Wales	96	4.5	106	5	

▲ Bluebells, Ceredigion • © *Richard Evans*

▼ **Table 5.3:** Most frequent 15 species in 2007 in the Broadleaved, Mixed & Yew Woodland Broad Habitat in Wales.

a) Main Plots (n=41)			b) Targeted Plots (n=72)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
61	6	*Holcus lanatus*	85	13	*Rubus fruticosus agg.*
59	8	*Agrostis capillaris*	64	17	*Fraxinus excelsior*
51	3	*Rubus fruticosus agg.*	60	9	*Hedera helix*
46	4	*Anthoxanthum odoratum*	46	7	*Agrostis capillaris*
46	9	*Pteridium aquilinum*	46	5	*Holcus lanatus*
39	1	*Crataegus monogyna*	40	4	*Agrostis stolonifera*
37	1	*Dactylis glomerata*	38	2	*Ranunculus repens*
37	2	*Ranunculus repens*	36	3	*Urtica dioica*
34	1	*Festuca rubra agg.*	35	21	*Alnus glutinosa*
34	4	*Fraxinus excelsior*	35	1	*Geranium robertianum*
34	3	*Juncus effusus*	33	2	*Dryopteris dilatata*
32	2	*Agrostis stolonifera*	32	3	*Thuidium tamariscinum*
32	1	*Cerastium fontanum*	31	10	*Corylus avellana*
32	<1	*Digitalis purpurea*	29	3	*Juncus effusus*
32	1	*Rhytidiadelphus squarrosus*	28	8	*Chrysosplenium oppositifolium*

5.3 Changes in the vegetation of woodland Broad Habitats

5.3.1 Broadleaved, Mixed & Yew Woodland

The most common species recorded in this Broad Habitat are listed in *Table 5.3*.

Main Plots: Between 1990 and 2007, statistically significant changes in vegetation condition were mostly observed in the lowland zone or across Wales as a whole *(Table 5.4a)*. In lowland Main Plots the Grass:Forb ratio decreased between 1998 and 2007 whilst, between 1990 and 2007, a reduction in species richness, an increase in proportion of more competitive species and a decrease in proportion of ruderal species suggests a response to lack of disturbance and a decrease in species suited to lighter, open conditions. These same changes were significant across Great Britain broadleaved woodland between 1998 and 2007 but were not found to be significant across Wales between 1998 and 2007 *(Table 5.4a)*. Three of the significant changes in vegetation condition between 1990 and 2007 were based on noteworthy effect sizes: the decrease in butterfly larval food plant richness in the lowland zone (mean loss of 3 species per plot) and increase in Competitor Score across Wales both had a standardized effect size of 0.7 and so just below the threshold for a large effect.
The increase in Competitor Score in the upland zone in the Main Plots was a large standardized effect size. This means that the increase in representation of more competitive species moved beyond values typical of the natural variability in the sample. This indicates that an ecologically important change in vegetation character may have occurred.

Targeted Plots: The Targeted Plots represent small fragments of other habitats embedded within larger areas of woodland. Within these, a similar response to shading was seen. Ellenberg Light Score decreased significantly between 1998 and 2007 as

▼ **Table 5.4:** Change in the characteristics of vegetation in ***a) 200m² Main Plot*** and, ***b) 4m² Targeted Plots located within mapped areas of the Broadleaved, Mixed & Yew Woodland Broad Habitat across Wales between 1990 and 2007.*** W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change (p<0.05) in the direction shown. Large effect sizes are highlighted in red.

a) Main Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	**1990**	**1998**	**2007**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	25.8	22.8	21.5	NO SIGNIFICANT CHANGE						↓	↓	
No. of Bird Food Species	11.2	9.5	9.6					↓			↓	
No. of Butterfly Food Species	11.1	10	8.9					↓		↓	↓	
Grass:Forb Ratio	0.61	0.39	-0.06		↓		NO SIGNIFICANT CHANGE					
Competitor Score	2.73	2.81	2.87							↑		↑
Stress Tolerator Score	2.73	2.72	2.66									
Ruderal Score	2.28	2.18	2.10							↓		
Light Score	6.38	6.33	6.28									
Fertility Score	4.49	4.55	4.62									
Ellenberg pH Score	5.08	5.10	5.06									
Moisture Score	5.58	5.62	5.67									

b) Targeted Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	**1990**	**1998**	**2007**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	12.1	12.8	11.3	↓			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	4.6	4.9	4.3									
No. of Butterfly Food Species	4.3	4.5	3.7	↓								
Grass:Forb Ratio	-0.11	0.27	-0.79	↓	↓						↓	
Competitor Score	2.81	2.93	2.95					↑			↑	
Stress Tolerator Score	2.76	2.67	2.63									
Ruderal Score	2.13	2.11	2.01									
Light Score	6.01	6.08	5.84	↓	↓	↓						
Fertility Score	4.67	4.78	5.00									
Ellenberg pH Score	5.13	5.23	5.37	↑						↑		
Moisture Score	5.82	5.92	5.95									

did species richness. Between 1990 and 2007, Grass:Forb ratio decreased significantly and the proportion of more competitive species increased significantly. Ellenberg pH Score also increased indicating a greater representation of species typical of less acid conditions *(Table 5.4b)*. None of the significant changes in the Targeted Plots were based on large standardized effect sizes, hence ecological impacts on the vegetation are likely to have been minor although possibly part of a longer term and more ecologically significant trend.

Ancient Woodland Indicator species

There was no statistically significant change in mean number of indicators in either Main or Targeted Plots either at the country level or within each Environmental Zone.

5.3.2 Coniferous Woodland

The most common species recorded in this Broad Habitat are listed in *Table 5.5*.

Soon after planting, Coniferous Woodland understoreys can be subject to a number of management regimes. In the past, increasingly heavy shading would have occurred as the canopy developed, until felling decades later. Whilst this is still a common regime in many plantations, forest management has recently shifted toward the maintenance of continuous cover in many places with thinning cycles carried out to open out the canopy and promote new regeneration. In both situations however, established plantation is often associated with a species-poor understorey reflecting the influence of acidic soils and dense shade. As expected therefore, few changes were detected over the 1990 to 2007 period.

Main Plots: Only Grass:Forb ratio increased significantly between 1990 and 1998 before declining again, but not significantly, between 1998 and 2007 *(Table 5.6a)*. The increase in Grass:Forb ratio between 1990 and 1998 was based on a large standardized effect size. Hence, despite decreasing again between the most recent surveys, the increase in cover of grasses relative to forbs was substantial between 1990 and 1998 relative to the variability in values across the sample.

▼ **Table 5.5:** Most frequent 15 species in 2007 in the Coniferous Woodland Broad Habitat in Wales.

a) Main Plots (n=30)			b) Targeted Plots (n=18)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
73	47	*Picea sitchensis*	39	1	*Vaccinium myrtillus*
60	2	*Dryopteris dilatata*	33	1	*Galium saxatile*
57	6	*Rubus fruticosus agg.*	33	4	*Juncus effusus*
43	2	*Sorbus aucuparia*	33	5	*Polytrichum commune*
43	3	*Vaccinium myrtillus*	33	4	*Rubus fruticosus agg.*
40	4	*Agrostis capillaris*	28	5	*Agrostis capillaris*
37	1	*Deschampsia flexuosa*	28	2	*Agrostis stolonifera*
37	1	*Galium saxatile*	28	4	*Holcus lanatus*
33	1	*Betula seedling/sp*	28	19	*Picea sitchensis*
33	1	*Holcus lanatus*	22	4	*Calluna vulgaris*
33	1	*Polytrichum commune*	22	2	*Deschampsia flexuosa*
33	2	*Pteridium aquilinum*	22	6	*Molinia caerulea*
30	<1	*Blechnum spicant*	22	<1	*Potentilla erecta*
30	1	*Digitalis purpurea*	22	6	*Sphagnum (green/thin)*
30	1	*Juncus effusus*	17	1	*Deschampsia cespitosa*

▼ **Table 5.6:** Change in the characteristics of vegetation in ***a) 200m² Main Plot*** and, ***b) Targeted Plots located within mapped areas of the Coniferous Woodland Broad Habitat across Wales between 1990 and 2007.*** Arrows denote significant change (p<0.05) in the direction shown. Large effect sizes are highlighted in red.

a) Main Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	12.2	15.7	13.9	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	3.9	4.8	4.4									
No. of Butterfly Food Species	4.1	5.3	4.9									
Grass:Forb Ratio	-0.58	0.41	-0.32	NO SIGNIFICANT CHANGE			↑			NO SIGNIFICANT CHANGE		
Competitor Score	2.80	2.80	2.89									
Stress Tolerator Score	3.05	2.98	2.93									
Ruderal Score	1.51	1.57	1.58									
Light Score	6.11	6.24	6.11									
Fertility Score	3.56	3.65	3.84									
Ellenberg pH Score	3.65	3.79	3.88									
Moisture Score	5.94	6.05	6.04									

b) Targeted Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	11	11.6	8.8	↓		↓	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	3.4	2.9	2.7									
No. of Butterfly Food Species	3.7	3.9	3.1									
Grass:Forb Ratio	1.26	0.81	-0.24	↓			NO SIGNIFICANT CHANGE					
Competitor Score	2.54	2.74	2.89							↑		
Stress Tolerator Score	3.13	3.04	2.90									
Ruderal Score	1.80	1.79	1.74									
Light Score	6.36	6.45	6.38									
Fertility Score	3.94	3.84	3.71									
Ellenberg pH Score	4.35	4.06	4.03									
Moisture Score	6.25	6.29	6.30									

▼ **Table 5.7:** Changes in the pH and carbon concentration of soils (0-15cm depth) within all the vegetation types and woodland Broad Habitats across Wales. Arrows denote a significant change (p<0.05) in the direction shown.

Broad Habitat	Mean pH			Direction of significant changes			Mean carbon concentration (g/kg)			Direction of significant changes		
	1978	1998	2007	1998-2007	1978-1998	1978-2007	1978	1998	2007	1998-2007	1978-1998	1978-2007
Broadleaved, Mixed and Yew Woodland	4.5	5.2	5.4		↑	↑	63.1	68.4	79			
Coniferous Woodland	3.7	4.2	3.7				161.5	197.8	144	↓		

▼ **Table 5.8:** Comparative estimates of the extent of woodland habitats ('000s ha) are available from the Habitat Survey of Wales, and from Forestry Statistics. 95% CI on the Countryside Survey estimates are given in brackets.

	Broadleaf, Mixed & Yew Woodland	Conifer Woodland	Total Woodland
Countryside Survey (2007)	174 (135.1-233.9)	106 (33.7-180.8)	280 (Not avail)
Habitat Survey of Wales (1979 - 1997)	113	172	285
Forestry Statistics (2008)*	128	157	285

* Forestry statistics are derived from the National Inventory of Woodland and Trees (1995-1999) adjusted for new planting and sales of FC woodlands.

Targeted Plots: Few changes were also seen in the Targeted Plots that pick out patches of different vegetation types within the Coniferous Woodland environment. Mean species richness declined across Wales and in the upland zone between 1998 and 2007. Grass:Forb ratio also decreased between 1998 and 2007 *(Table 5.6b)*, however none of the significant changes were based on large standardized effect sizes.

5.4 Changes in woodland soils in Wales (0-15cm)

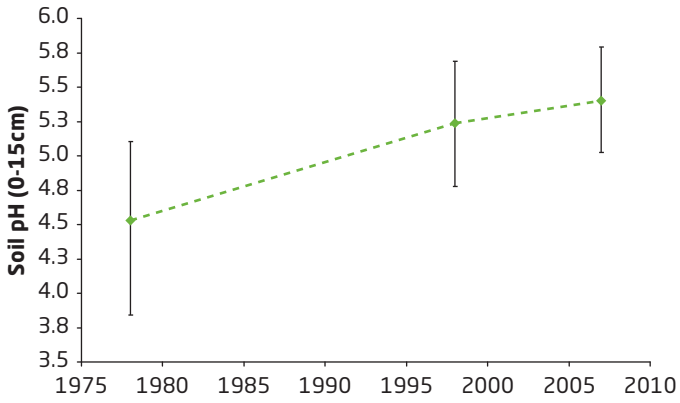
5.4.1 Broadleaved, Mixed & Yew Woodland

Soil (0-15cm) pH: There was no significant change in the mean pH of soil (0-15cm) samples in Broadleaved, Mixed & Yew Woodland across Wales between 1998 and 2007 *(Table 5.7)*. However, over the longer period the mean pH increased significantly from 4.50 in 1978 to 5.21 in 1998 which mainly accounted for the significant increase in pH between 1978 and 2007 *(Fig 5.1)*.

Soil (0-15cm) carbon concentration: There was no observed significant change in the mean carbon concentration of soil (0-15cm) in Main Plots within Broadleaved, Mixed & Yew Woodland in Wales between any of the surveys *(Table 5.7)*.

Bulk density and soil (0-15cm) carbon stock: The mean bulk density of Broadleaved, Mixed & Yew Woodland soils (0-15cm) in Wales was 0.7 g/cm^3. Combined with mean soil (0-15cm) carbon concentration, the estimated soil (0-15cm) carbon stock is 71 t/c/ha. Bulk density data and hence soil carbon stock estimates are only available from the 2007 survey.

▼ **Figure 5.1:** The change in pH in soils (0-15cm) from Broadleaved, Mixed & Yew Woodland in Wales between 1978 and 2007. Significant change (at least p<0.05) occurred between 1978 and 1998, and 1978 and 2007. Error bars are the 95% Confidence Intervals on the pH in each survey year.

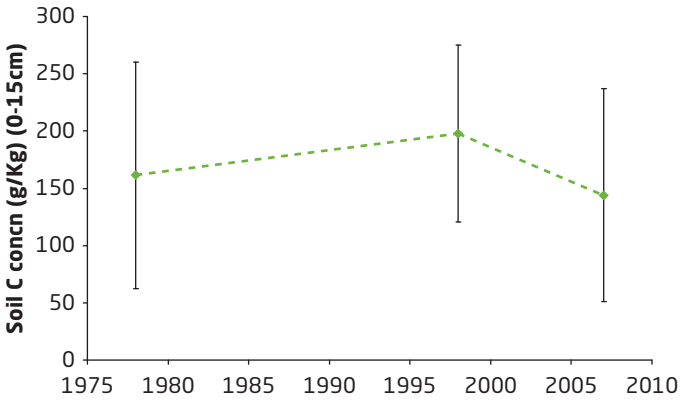


5.4.2 Coniferous Woodland

Soil (0-15cm) pH: No change in the mean pH of soils (0-15cm) in Coniferous Woodlands was detected in Wales between 1978, 1998 and 2007 *(Table 5.7)*, which is consistent with the results for Great Britain as a whole.

Soil (0-15cm) carbon concentration: Overall there was no significant change in the carbon concentration in Coniferous Woodland between 1978 and 2007. However, there was a significant decrease in the carbon concentration of soil (0-15cm) in the Coniferous Woodland Broad Habitat for Wales between 1998 and 2007 *(Fig 5.2; Table 5.7)*. These findings are consistent with the results for Great Britain as a whole.

▼ **Figure 5.2:** The change in mean carbon concentration in soils (0-15cm) from Coniferous Woodland in Wales between 1978 and 2007. Significant change (at least p<0.05) occurred between 1998 and 2007. Error bars are the 95% CI on the mean carbon concentration in each survey year.



Bulk density and soil (0-15cm) carbon stock: The mean bulk density of Coniferous Woodland soils (0-15cm) in Wales was 0.4 g/cm^3, which when combined with mean soil (0-15cm) carbon concentration indicated a soil (0-15cm) carbon stock of 61 t/c/ha. Bulk density data and hence soil carbon stock estimates are only available from the 2007 survey.

5.5 The results in context

This chapter has considered the two Broad Habitats that make up the woodland resource in Wales. Of the UK countries, Wales has the highest percentage cover of Broadleaved, Mixed & Yew Woodland although this is low by European standards. Of the UK countries, only Scotland has a higher total woodland cover, a consequence of the much higher percentage cover of Coniferous Woodland there than elsewhere.

▲ Improved Grassland Broad Habitat with young trees • © *Lindsay Maskell*

In Wales, only broadleaf-dominated woodland is native, and this type is the main focus of nature conservation interest. It includes eight Priority Habitat types recognised in the UK Biodiversity Action Plan, and Broadleaved, Mixed & Yew Woodland is recognised as a feature of interest on many SSSIs. Most Coniferous Woodland is managed as commercial forestry, and has a restricted and more localised conservation interest (e.g. black grouse use the coniferous woodland – heather moorland transition zone).

Estimates of total woodland extent are much closer across surveys than are estimates of Broadleaved, Mixed & Yew Woodland and Coniferous Woodland *(Table 5.8)*. This tends to suggest that differences in definition of woodland types contribute to the reported differences. The estimates of Coniferous Woodland extent from Habitat Survey of Wales and Forestry Statistics, in any case, fall within the confidence interval of the Countryside Survey estimate. But comparisons at this level do tend to suggest that Countryside Survey might overestimate the amount of Broadleaved, Mixed & Yew Woodland in Wales – further work is needed to better understand whether the sample design of Countryside Survey is adequately representing the distribution of the woodland resource in Wales.

A further source of comparative data arises from the 20 woodland sites (320 plots) revisited in Wales as part of the Great Britain-wide resurvey of the 'Bunce' 1971 sites[36]. Similar to the patterns recorded by Countryside Survey, changes in the 'Bunce' plots were consistent with an impression of Broadleaved, Mixed & Yew Woodland undergoing a successional response to relaxed disturbance and less intensive management. Between 1971 and 2001, basal area of trees and shrubs increased, site level counts of tree seedlings decreased, and the abundance of open habitats and signs of recent management all decreased. These changes accompanied a highly significant decrease of 12 ground flora species per plot. Despite no significant changes in mean Ellenberg or CSR scores, the same strong signals of change were seen at the Great Britain level and were associated with a shift toward a more shade-tolerant ground flora.

[36] Kirby *et al* (2005) *Long term ecological change in British woodland (1971-2001).* English Nature Research reports. No 653. Peterborough.

Key results and follow-up questions:

- **An increase in the area of Broadleaved, Mixed & Yew Woodland in lowland Wales – how does this relate to biodiversity objectives?**

- **A decrease in species richness and other changes in vegetation condition – a negative change or a reflection of a maturing woodland resource as well as other factors such as progressively wetter survey seasons?**

- **An increase in pH of surface soils under Broadleaved, Mixed & Yew Woodland – is this part of a general trend of recovery?**

These questions, together with those identified in each of the other habitat chapters, are considered further in *Chapter 9*.

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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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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▲ north Wales • © *Richard Evans*

6. Mountain, Moor and Heath: Dwarf Shrub Heath, Bog, Fen, Marsh & Swamp, Bracken, Inland Rock and Montane

Summary

Area

- The area of land mapped as Bracken decreased by 55% in Wales between 1998 and 2007. This is not thought likely to be explained by land-use change alone but may reflect the suppressive effect on bracken growth of extreme rainfall in the summer of 2007. If bracken cover was extensively reduced to below 95%, then large areas would no longer be mapped as Bracken Broad Habitat despite bracken still being abundant or dominant, and this may account for some of the recorded change.
- Dwarf Shrub Heath, Bog, Fen, Marsh & Swamp, and Inland Rock showed no significant change in area between 1998 and 2007.

Vegetation condition

- Few significant changes in vegetation characteristics were detected across the Mountain, Moor and Heath habitats in Wales.
- Total species richness and richness of butterfly larval food plants increased in the Bracken Broad Habitat between 1998 and 2007, and effect sizes were large. These changes could be correlated with the apparent reduction in bracken cover in 2007.
- In Fen, Marsh & Swamp in Wales, and in the Welsh lowland zone, a reduction in richness of butterfly larval food plants occurred between all survey intervals. Although the change was not large in terms of standardized effect size, mean richness dropped by a noteworthy 3 species per plot across the 17 year period between 1990 and 2007.
- Stress-tolerator Score also decreased in small fragments of habitat within areas of Bog Broad Habitat between 1998 and 2007. Despite the small sample, the large standardized effect size points to a possibly substantial impact on the species composition.

Soils

- **Enough soil samples were only available for analysis of Dwarf Shrub Heath. No changes in mean soil pH or carbon concentration were detected between surveys.**

6.1 Introduction

Countryside Survey divides the area of Wales into an upland and a lowland environmental zone. This chapter concerns six Broad Habitats largely but not exclusively found in the upland zone of Wales (48% of the total area of the country). These habitats are: Dwarf Shrub Heath; Bog; Fen, Marsh & Swamp; Bracken; Inland Rock and Montane. Although extensive, the occurrence of these characteristically upland habitats are constrained to some extent by altitude, slope, soil type and land-use. In particular, high sheep numbers have helped shape and maintain a grassland-dominated landscape in upland as well as lowland areas.

Acid Grassland and mosaics of Acid Grassland, Neutral Grassland and Bracken make up much of the marginal uplands and lowland of Wales. Results for these are covered in *Chapter 4*.

6.2 The Area of Mountain, Moor and Heath Broad Habitats

6.2.1 Bracken

The Bracken Broad Habitat was estimated to make up 1.8% of the land cover of Wales in 2007. It was unevenly distributed between upland and lowland zones, with 87% occurring in the uplands *(Table 6.1)*. The area of Bracken Broad Habitat declined significantly across Britain between 1998 and 2007, a result that was largely influenced by the decline in area of 46,700 ha (95% CI; -7,400 ha to -55,500 ha) in Wales *(Table 6.1)*.

The 95% bracken cover threshold used in Countryside Survey to define the Bracken Broad Habitat means that even a modest yet widespread reduction in bracken cover could translate into a large estimated loss of the Broad Habitat yet bracken could still remain dominant in the vegetation. Analysis of Welsh Unenclosed Plot data for areas that were Bracken Broad Habitat in 1998 but recorded as a different habitat in 2007 (n=43) showed a highly significant reduction in bracken cover from an average of 29% down to 7% *(Fig 6.1)*. Because the Unenclosed Plots were located entirely at random within mapped areas of unenclosed habitat, they can be used as an independent check on whether changes in species composition were consistent with mapped Broad Habitat change. The result therefore offers a degree of support for the explanation that a reduction in bracken cover underlies the recorded reduction in Bracken Broad Habitat area in Wales. In addition, the species covers recorded by the surveyors in each mapped bracken polygon also show that in 47% of the surveyed land in Great Britain that moved out of Bracken Broad Habitat by 2007, bracken was still

▲ Bracken, north Wales • © *CEH*

present at between 10 and 95% cover. While there is known to have been local managed reduction in bracken between 1998 and 2007, this is unlikely to explain the size of the estimated decline in area and another explanation is likely. Bracken growth is known to be debilitated by particularly wet growing seasons[37] and in Wales and England, the May to July period in 2007 was the wettest since records began in 1766[38]. Rainfall was well over double the usual levels so the above average rainfall in Wales during 2007 could have contributed to less vigorous bracken growth, with cover peaking below the critical 95% threshold. The change in Bracken Broad Habitat could therefore be a seasonal effect reflecting reduced bracken biomass while also indicating the sensitivity of the Broad Habitat definition to a small but widespread change in cover. Further support for this suggested mechanism would come from establishing a spatial correlation between the cover of bracken in plots and cumulative rainfall for the local 1-km^2 during the 2007 growing season, up to the time at which plots were surveyed. Differences in timing of survey between 1998 and 2007 were ruled out as a contributory factor since squares were surveyed somewhat later in the season in 2007 rather than earlier, but not so late as to have moved appreciably beyond the timing of peak seasonal cover.

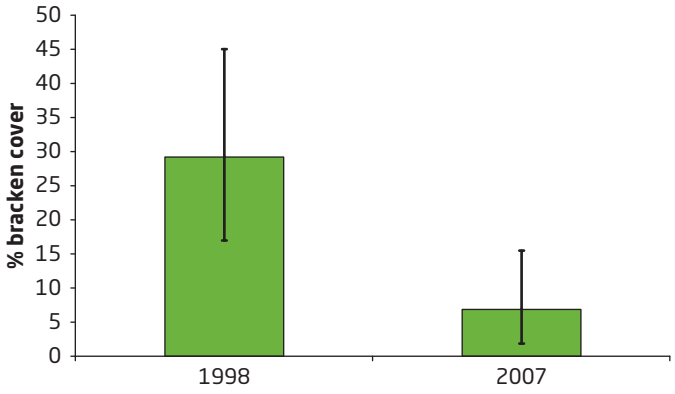
▼ **Table 6.1:** Estimates of the area ('000s ha) and percentage of land area of Bracken Broad Habitat in Wales from 1998 to 2007. Arrows denote significant change ($p<0.05$) in the direction shown.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	24	2.2	4	0.4	
Upland	60	5.8	33	3.2	↓
Wales	84	4	38	1.8	↓

[37] Le Duc, M.G. *et al* (2003) *J. Appl.Ecol.* **40**, 508-522.

[38] Pitt, M. (2008) *The Pitt Review: Learning Lessons from the 2007 Floods.* Online at: http://archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html

▼ **Figure 6.1:** Bracken cover in Unenclosed (4m²) Habitat Plots (n=43) that were mapped as Bracken Broad Habitat in 1998 but not in 2007. Error bars are the 95% confidence intervals on the mean cover in each survey year. The difference between years was significant at p<0.001.



▲ Cotton grass, Snowdonia • © *Richard Evans*

6.2.2 Dwarf Shrub Heath

Dwarf Shrub Heath was estimated to cover 117,000 ha (5.5%) of Wales in 2007 with 96% of the total occurring in the upland zone *(Table 6.2)*. No significant change in extent occurred between any of the surveys since 1990.

▼ **Table 6.2:** Estimates of the area ('000s ha) and percentage of land area of Dwarf Shrub Heath Broad Habitat in Wales from 1998 to 2007. No statistically significant change was seen between survey years.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	8	0.7	5	0.5	NO SIGNIFICANT CHANGE
Upland	91	8.9	112	11	
Wales	99	4.7	117	5.5	

▲ Upland heath, Carneddau • © *Clive Hurford*

6.2.3 Bog

Bog was estimated to make up 2.4% of Wales in 2007, 83% of which was found in the upland environmental zone *(Table 6.3)*. No changes in the extent of the Bog Broad Habitat were detected in Wales in line with the pattern across Great Britain.

▼ **Table 6.3:** Estimates of the area ('000s ha) and percentage of land area of Bog Broad Habitat in Wales from 1998 to 2007. No statistically significant change was seen between survey years.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	8	0.7	8	0.7	NO SIGNIFICANT CHANGE
Upland	36	3.5	40	3.9	
Wales	45	2.1	48	2.3	

6.2.4 Fen, Marsh and Swamp

The area of this habitat did not change significantly between 1998 and 2007 in Wales or across the rest of Britain *(Table 6.4)*. The habitat type is found in lowland (1.3% of the zone) as well as upland (2.1% of the zone) areas favoured by the wet oceanic climate and the presence of poorly drained soils that are found throughout the country.

▼ **Table 6.4:** Estimates of the area ('000s ha) and percentage of land area of Fen Marsh and Swamp Broad Habitat in Wales from 1998 to 2007. No statistically significant change was seen between survey years.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	15	1.4	14	1.3	NO SIGNIFICANT CHANGE
Upland	24	2.3	22	2.1	
Wales	40	1.9	36	1.7	

▲ Fen, lowland Wales • © *Sue Wallis*

6.2.5 Montane and Inland Rock Broad Habitats

Although in 2007, proportionally more of Wales was sampled than any other country, the survey is still not optimal for estimating highly localised habitats. Hence, no estimate is available for the Montane Broad Habitat.

Inland Rock includes natural rock exposures as well as quarries, and was estimated to make up 0.3% of Wales in 2007 although the confidence interval was large (3,100 ha to 12,200 ha). No change in area of Inland Rock was detected between 1998 and 2007 *(Table 6.5)*.

▼ **Table 6.5:** Estimates of the area ('000s ha) and percentage of land area of Inland Rock Broad Habitat in Wales from 1998 to 2007. No statistically significant change was seen between survey years.

	1998		2007		Direction of significant changes 1998-2007
	Area ('000s ha)	%	Area ('000s ha)	%	
Lowland	1	0.1	1	0.1	NO SIGNIFICANT CHANGE
Upland	7	0.7	6	0.6	
Wales	8	0.4	7	0.3	

6.3 Changes in the vegetation condition of Mountain, Moor and Heath Broad Habitats

6.3.1 Bracken Broad Habitat

The most common species recorded in this Broad Habitat are listed in *Table 6.6*.

▼ **Table 6.6:** Most frequent 15 species in 2007 in Main Plots in the Bracken Broad Habitat in Wales (n=10).

% frequency	Mean cover (%)	Plant name
90	3	*Galium saxatile*
90	44	*Pteridium aquilinum*
80	17	*Agrostis capillaris*
70	4	*Festuca ovina agg.*
60	4	*Holcus lanatus*
60	1	*Juncus effusus*
60	1	*Potentilla erecta*
60	11	*Rhytidiadelphus squarrosus*
50	1	*Anthoxanthum odoratum*
50	1	*Cerastium fontanum*
50	1	*Digitalis purpurea*
50	1	*Luzula campestris/multiflora*
50	1	*Vaccinium myrtillus*
40	3	*Agrostis canina sens.lat.*
40	<1	*Cirsium palustre*

Main plots: Increases in species richness (total species number and numbers of butterfly larval food plants) were detected within the Bracken Broad Habitat between 1998 and 2007 *(Table 6.7)*. Total species richness also increased in Bracken plots in the upland zone. The Grass:Forb ratio decreased across Wales and in the upland zone. Sample sizes were small (n_{1998}=17, n_{2007}=10) for all Welsh Main Plots in Bracken yet the changes in species richness between 1998 and 2007 were based on large standardized effect sizes and reflect a substantial increase of 6 species on average per plot. The increase may be correlated with the apparent decrease in bracken cover in 2007.

Targeted plots: No significant changes were observed in small patches of habitat targeted within the Bracken Broad Habitat.

▲ Reedbed; part of the Fen, Marsh & Swamp Broad Habitat • © *Richard Evans*

▼ **Table 6.7:** Change in the characteristics of vegetation in 200m² Main Plots in the Bracken Broad Habitat across Wales between 1990, 1998 and 2007. Lo=Lowland zone, Up=Upland zone. Arrows denote significant change (p<0.05) in the direction shown. Large effect sizes are indicated in red.

	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	**1990**	**1998**	**2007**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	17.8	14.9	20.6	↑		↑	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	5.8	4.8	6.8									
No. of Butterfly Food Species	7.3	6.4	8.8	↑								
Grass:Forb Ratio	-0.31	-1.00	-0.71	NO SIGNIFICANT CHANGE			↓		↓	NO SIGNIFICANT CHANGE		
Competitor Score	2.63	2.65	2.63									
Stress Tolerator Score	2.99	3.04	2.99									
Ruderal Score	1.95	1.84	1.97									
Light Score	6.34	6.44	6.50									
Fertility Score	3.88	3.56	3.66									
Ellenberg pH Score	4.26	3.93	4.03									
Moisture Score	5.68	5.64	5.78									

▼ **Table 6.8:** Most frequent 15 species in 2007 in the Dwarf Shrub Heath Broad Habitat in Wales.

a) Main Plots (n=27)			b) Targeted Plots (n=21)		
% frequency	**Mean cover (%)**	**Plant name**	**% frequency**	**Mean cover (%)**	**Plant name**
96	30	*Vaccinium myrtillus*	67	14	*Calluna vulgaris*
89	6	*Deschampsia flexuosa*	52	5	*Festuca ovina agg.*
74	23	*Calluna vulgaris*	48	11	*Vaccinium myrtillus*
74	9	*Festuca ovina agg.*	43	3	*Deschampsia flexuosa*
70	3	*Galium saxatile*	43	6	*Nardus stricta*
70	13	*Pleurozium schreberi*	43	2	*Rhytidiadelphus squarrosus*
63	4	*Agrostis capillaris*	38	2	*Agrostis capillaris*
63	2	*Cladonia sp.*	33	1	*Potentilla erecta*
52	9	*Hylocomium splendens*	29	2	*Cladonia sp.*
52	4	*Juncus squarrosus*	29	<1	*Danthonia decumbens*
52	11	*Nardus stricta*	29	2	*Erica tetralix*
52	5	*Rhytidiadelphus squarrosus*	29	7	*Molinia caerulea*
44	2	*Carex binervis*	29	<1	*Polygala vulgaris/serpyllifolia*
41	1	*Potentilla erecta*	24	1	*Carex panicea*
37	1	*Erica cinerea*	24	1	*Galium saxatile*

6.3.2 Dwarf Shrub Heath Broad Habitat

The most common species recorded in this Broad Habitat are listed in *Table 6.8*.

Main plots: No significant changes were detected in the vegetation characteristics of Dwarf Shrub Heath in Wales *(Table 6.9a)*.

Targeted plots: No significant changes in vegetation character were observed in Wales within small fragments of other habitats embedded in areas of Dwarf Shrub Heath *(Table 6.9b)*.

6.3.3 Bog Broad Habitat

The most common species recorded in the Bog Broad Habitat are listed in *Table 6.10*.

Main plots: Despite the very low sample size (n_{1998}=9, n_{2007}=13), a significant reduction in Grass:Forb ratio was detected between 1998 and 2007 *(Table 6.11a)* but the effect size was not large hence the size of the change would have been minor in comparison with the variability on the sample. The direction of the change was different in Wales from the rest of Britain where a significant increase occurred largely reflecting changes in the Scottish uplands.

▼ **Table 6.9:** Change in the characteristics of vegetation in ***a) 200m² Main Plots*** and ***b) 4m² Targeted Plots, in the Dwarf Shrub Heath Broad Habitat across Wales between 1990 and 2007.*** W=Wales, Lo=Lowland zone, Up=Upland zone. No statistically significant change was seen between survey years.

a) Main Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	14.9	14.5	13.9	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	2.9	3.2	2.9									
No. of Butterfly Food Species	7.2	7.4	6.6									
Grass:Forb Ratio	0.89	1.36	0.76	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
Competitor Score	2.24	2.2	2.27									
Stress Tolerator Score	3.66	3.65	3.64									
Ruderal Score	1.47	1.48	1.37									
Light Score	6.73	6.74	6.68									
Fertility Score	2.62	2.63	2.57									
Ellenberg pH Score	2.82	3.12	2.91									
Moisture Score	6.14	6.15	6.08									

b) Targeted Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	7.6	8.7	9.5	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
No. of Bird Food Species	1.5	1.6	1.6									
No. of Butterfly Food Species	4.3	4.0	4.8									
Grass:Forb Ratio	2.8	1.72	1.97	NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE			NO SIGNIFICANT CHANGE		
Competitor Score	2.38	2.19	2.21									
Stress Tolerator Score	3.66	3.73	3.74									
Ruderal Score	1.25	1.32	1.38									
Light Score	6.82	6.88	6.88									
Fertility Score	2.44	2.43	2.35									
Ellenberg pH Score	3.26	3.08	2.98									
Moisture Score	6.48	6.33	6.22									

▼ **Table 6.10:** Most frequent 15 species in 2007 in the Bog Broad Habitat in Wales.

a) Main Plots (n=13)			b) Targeted Plots (n=16)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
85	3	*Vaccinium myrtillus*	81	13	*Molinia caerulea*
77	27	*Molinia caerulea*	75	25	*Eriophorum angustifolium*
77	10	*Polytrichum commune*	63	13	*Eriophorum vaginatum*
77	11	*Sphagnum (green/thin)*	50	24	*Sphagnum (green/thin)*
69	15	*Eriophorum vaginatum*	44	4	*Erica tetralix*
69	3	*Festuca ovina agg.*	44	20	*Sphagnum (green/fat)*
69	1	*Galium saxatile*	38	<1	*Anthoxanthum odoratum*
69	8	*Juncus squarrosus*	38	4	*Calluna vulgaris*
69	5	*Rhytidiadelphus squarrosus*	38	2	*Juncus squarrosus*
54	16	*Calluna vulgaris*	38	3	*Polytrichum commune*
54	1	*Carex panicea*	31	1	*Carex echinata*
54	2	*Eriophorum angustifolium*	31	4	*Festuca ovina agg.*
54	4	*Pleurozium schreberi*	31	1	*Narthecium ossifragum*
46	<1	*Cladonia spp.*	31	2	*Rhytidiadelphus squarrosus*
46	2	*Deschampsia flexuosa*	25	<1	*Agrostis vinealis*

Targeted plots: Within mapped areas of the Bog Broad Habitat, the Targeted Plots reflect the fortunes of other small fragments of habitat such as flushes, eroded patches and drier areas of grassland and heath too small to map. The mean Stress-tolerator and Ellenberg pH Scores of the small Welsh sample suggest that the vegetation targeted was not very different in these respects from the Main Plots located within the wider areas of Bog. Two significant changes were observed in the Targeted Plots; an increase in Competitor Score and a decrease in Stress-tolerator Score *(Table 6.11b)*. Although the small size of the dataset (n=14 in both 1998 and 2007) cautions against over-interpreting the importance of the reduction in Stress-tolerator Score, the mean changed by 92% of the standard deviation of the combined sample indicating a large effect size and therefore a potentially ecologically important shift in the abundance of some of the most sensitive plant species found in the habitat.

▼ **Table 6.11:** Change in the characteristics of vegetation in ***a) 200m² Main Plots*** and ***b) 4m² Targeted Plots, in the Bog Broad Habitat across Wales in 1998 and 2007.*** W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. Large effect sizes are indicated in red.

a) Main Plots	Mean values (Wales)		Direction of significant changes 1998 - 2007		
Vegetation Condition Measures	**1998**	**2007**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	16.2	16.8	NO SIGNIFICANT CHANGE		
No. of Bird Food Species	2.1	2.1			
No. of Butterfly Food Species	6.8	6.1			
Grass:Forb Ratio	2.92	2.14	↓		↓
Competitor Score	2.24	2.26			
Stress Tolerator Score	3.71	3.69			
Ruderal Score	1.3	1.29			
Light Score	7.05	7.02			
Fertility Score	2.15	2.25			
Ellenberg pH Score	2.91	2.97			
Moisture Score	6.93	6.76			

b) Targeted Plots	Mean values (Wales)		Direction of significant changes 1998 - 2007		
Vegetation Condition Measures	**1998**	**2007**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	12.9	11.1	NO SIGNIFICANT CHANGE		
No. of Bird Food Species	1.7	1.6			
No. of Butterfly Food Species	4.6	4.5			
Grass:Forb Ratio	1.47	1.44			
Competitor Score	2.1	2.31	↑		↑
Stress Tolerator Score	3.79	3.56	↓		↓
Ruderal Score	1.46	1.48			
Light Score	7.3	7.33			
Fertility Score	2.1	2.15			
Ellenberg pH Score	3.12	3.14			
Moisture Score	7.23	7.33			

▲ Rush pasture species; part of the Fen, Marsh & Swamp Broad Habitat • © *Ian Simpson*

6.3.4 Fen, Marsh and Swamp Broad Habitat

The most common species recorded in this Broad Habitat are listed in *Table 6.12*.

Main Plots: A significant decline in richness of butterfly larval food plants was detected in Fen, Marsh & Swamp across Wales between 1998 and 2007 and 1990 and 2007. The reduction was largely concentrated in the lowland zone *(Table 6.13a)*. While the standardized effect size for the reduction between 1990 and 2007 was medium, indicating a variable sample relative to the mean change, the estimated loss of an average of 3 species per Main Plot in the 17 year interval is noteworthy. The 1990 to 2007 changes compare with a large effect sized reduction in Fen, Marsh & Swamp in lowland Scotland but contrast with a large effect sized increase in England in the same interval. A significant reduction in richness of food plants for lowland farmland birds was also seen in the Welsh lowland zone between 1990 and 1998, and between 1990 and 2007.

Significant increases in Competitor Score and decreases in Ruderal Score also occurred in the Welsh lowland zone *(Table 6.13a)* but none of these changes were based on large standardized effect sizes and so their impact on the vegetation may well be minor.

Targeted plots: Within areas of habitat mapped as Fen, Marsh & Swamp, the Targeted Plots will have picked out slightly atypical patches of vegetation missed by the random Main Plots. Comparing the vegetation characteristics of the Targeted versus Main Plots shows that the vegetation targeted by surveyors reflected wetter conditions but was similar in other respects *(Tables 6.13 a and b)*. Between 1998 and 2007, the only significant changes to have occurred in the Targeted Plots were a reduction in richness of food plants for lowland farmland birds and a reduction in Ruderal Score suggesting less open and disturbed vegetation. Between 1990 and 1998 the only significant change was an increase in Grass:Forb ratio *(Table 6.13b)*. None of the changes were based on large standardized effect sizes hence the impact on the vegetation of any of the significant changes is likely to have been modest.

▼ **Table 6.12:** Most frequent 15 species in 2007 in the Fen, Marsh & Swamp Broad Habitat in Wales.

a) Main Plots (n=16)			b) Targeted Plots (n=53)		
% frequency	Mean cover (%)	Plant name	% frequency	Mean cover (%)	Plant name
81	4	*Holcus lanatus*	58	16	*Juncus effusus*
81	22	*Juncus effusus*	57	7	*Juncus articulatus/acutiflorus*
75	5	*Agrostis stolonifera*	51	6	*Holcus lanatus*
69	1	*Rumex acetosa*	51	2	*Lotus pedunculatus*
63	4	*Agrostis capillaris*	49	1	*Cirsium palustre*
63	1	*Galium palustre*	43	5	*Agrostis stolonifera*
63	6	*Juncus articulatus/acutiflorus*	40	<1	*Galium palustre*
56	7	*Festuca rubra agg.*	38	12	*Molinia caerulea*
50	1	*Cirsium palustre*	34	4	*Festuca rubra agg.*
50	1	*Lotus pedunculatus*	34	1	*Rumex acetosa*
50	1	*Potentilla erecta*	28	4	*Filipendula ulmaria*
50	3	*Rhytidiadelphus squarrosus*	25	3	*Agrostis capillaris*
44	1	*Anthoxanthum odoratum*	25	1	*Anthoxanthum odoratum*
44	4	*Deschampsia cespitosa*	25	<1	*Cardamine pratensis*
44	1	*Luzula campestris/multiflora*	25	<1	*Potentilla erecta*

▼ **Table 6.13:** Change in the characteristics of vegetation in ***a) 200m² Main Plots*** and ***b) 4m² Targeted Plots, in the Fen, Marsh & Swamp Broad Habitat across Wales 1990 and 2007.*** W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

a) Main Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	26.8	26.4	23.3									
No. of Bird Food Species	10.1	8.0	6.9					↓			↓	
No. of Butterfly Food Species	11.7	10.8	8.5	↓	↓			↓		↓	↓	
Grass:Forb Ratio	0.51	1.12	0.93				NO SIGNIFICANT CHANGE					
Competitor Score	2.69	2.6	2.79	↑	↑							
Stress Tolerator Score	2.69	2.84	2.73									
Ruderal Score	2.45	2.35	2.25		↓						↓	
Light Score	6.84	6.94	6.95									
Fertility Score	4.23	3.97	4.05									
Ellenberg pH Score	4.98	4.78	4.83									
Moisture Score	6.39	6.38	6.53									

b) Targeted Plots	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	15.6	15.1	13.5				NO SIGNIFICANT CHANGE				↓	
No. of Bird Food Species	5.2	5.0	4.1		↓						↓	
No. of Butterfly Food Species	5.4	5.6	5.2									↑
Grass:Forb Ratio	0.67	1.2	1.25						↑			
Competitor Score	2.67	2.74	2.84							↑		
Stress Tolerator Score	2.75	2.71	2.64									
Ruderal Score	2.33	2.39	2.30		↓						↓	
Light Score	6.94	6.97	6.93									
Fertility Score	3.83	3.9	3.96									
Ellenberg pH Score	4.78	4.73	4.8									
Moisture Score	7.02	6.92	6.93									

▼ **Table 6.14:** Comparative estimates of the extent of the mountain, moor and heath Broad Habitats ('000s ha) are available from the Habitat Survey of Wales. 95% CI on the Countryside Survey estimates are given in brackets.

	Dwarf Shrub Heath	Bog	Fen, Marsh & Swamp	Bracken	Inland rock
Countryside Survey (2007)	117 (39.3-174.0)	48 (4.8-80.1)	36 (23.5-59.1)	38 (22.5-50.9)	7 (3.1-12.2)
Habitat Survey of Wales (1979 - 1997)	92	58	85	63	Not available

6.4 Changes in soils (0-15cm) in mountain moor and heath vegetation

Of the Broad Habitats reported in this chapter, sample size was only sufficient for meaningful analysis within the Dwarf Shrub Heath Broad Habitat.

6.4.1 Dwarf Shrub Heath

Soil (0-15cm) pH: There was no significant change in the mean pH of soils (0-15cm) within plots in the Dwarf Shrub Heath Broad Habitat in Wales between any of the survey years. This contrasts with the significant increase across Britain between 1978 and 2007[39].

Soil (0-15cm) carbon: There was no significant change in the mean carbon concentration of soil (0-15cm) in the Dwarf Shrub Broad Habitat across Wales between any of the surveys. Nor was any change found across Britain in the same period.

Bulk density and soil (0-15cm) carbon stock: The mean bulk density of Dwarf Shrub Heath soils (0-15cm) in Wales in 2007 was 0.34 g/cm^3 which when combined with soil (0-15cm) carbon concentration indicated a soil (0-15cm) carbon stock estimate of 88 t C/ha. Bulk density and therefore C stock estimates, were only available for 2007.

6.5 The results in context

This chapter refers to six Broad Habitats that are especially characteristic of upland Wales, though all but one type – Montane – also have a significant, albeit smaller, presence in the lowlands. Dwarf Shrub Heath is found from sea level to high peaks in the uplands, being replaced by Montane heath at high altitude only in the mountains of Eryri in North Wales. Dwarf Shrub Heath is divided into two Priority Habitats covered by the UK Biodiversity Action Plan – Lowland Heathland and Upland Heathland. Two Priority Habitats Blanket Bog and Lowland Raised Bog are recognised within the Bog Broad Habitat. The Fen, Marsh & Swamp Broad Habitat includes a range of habitat types, of which Lowland Fens; Upland Flushes, Fens and Swamps; Purple Moor-grass and Rush Pastures; and Reedbeds are recognised as Priority Habitats. Various priority types occur within the Inland Rock Broad Habitat, and a single type with the Montane Broad Habitat. Bracken-dominated stands are recognised as a separate Broad Habitat but this type has no associated Priority Habitats. The Montane Broad Habitat is encountered too infrequently by Countryside Survey to allow for its extent to be estimated separately in Wales.

Countryside Survey encounters most of the Priority Habitats too infrequently to enable separate assessments of their state in Wales. However, in an attempt to optimise coverage of these habitats, the 2007 survey mapped Priority Habitat areas where they were found in each survey square and recorded new vegetation plot data from within these areas. These data have yet to be fully analysed. However, in Wales it is possible that the new baseline data could make a contribution to assessment of the condition or extent of a number of Priority Habitat assemblages in the wider countryside. These included Fens, Purple Moor-grass and Rush Pasture, Upland Dwarf Shrub Heath, Blanket Bog and a number of woodland Priority Habitats.

For Dwarf Shrub Heath and Bog, the estimates from Habitat Survey of Wales fall within the confidence interval of the Countryside Survey estimate *(Table 6.14)*. However, in the cases of Fen, Marsh and Swamp, and Bracken, the Habitat Survey of Wales estimates lie outside the confidence intervals. Again, the different approaches taken by the two surveys in allocating vegetation types to Broad Habitats may have contributed to this. Furthermore, the Countryside Survey estimate of bracken may have been influenced by interaction between weather and classification sensitivity. The largest difference is in relation to Fen, Marsh & Swamp. This is likely to reflect the greater allocation in Countryside Survey of wet, species-poor yet rush-dominated acid grassland to the Acid Grassland Broad Habitat rather than to Fen, Marsh & Swamp.

Key results and follow-up questions:

- **The large change in area of land mapped as bracken – can we tell how much is related to classification sensitivity and how much to management intervention?**
- **A progressive decrease in species richness of plants used as food by butterfly larvae in Fen, Marsh & Swamp – is this part of a more general pattern?**

These questions, together with those identified in each of the other habitat chapters, are considered further in *Chapter 9*.

[39] Carey *et al* (2008) *Countryside Survey: UK results from 2007*. Online at www.countrysidesurvey.org.uk/reports2007.html

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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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7. Freshwaters: Standing Waters and Canals, Rivers, Streams and Ponds

Summary

Broad Habitat area

- The area of Standing Waters & Canals, and Rivers & Streams remained stable between 1998 and 2007.

Ponds

- The number of ponds increased by 18% Wales between 1998 and 2007, with most of the increase taking place in the lowlands.
- In 2007, ponds supported an average of 10.7 wetland plant species per pond. Only 5% of ponds were in good condition.

Vegetation condition on watercourse banks

- Plant species richness of streamsides, in particular the richness of butterfly larval food plant species, decreased in Wales between 1990 and 2007. Over time there has been a successional process with vegetation becoming taller, particularly in lowland areas. This trend has also been seen across the whole of Britain since 1978.
- None of the significant changes between 1990, 1998 and 2007 seen on streamsides was based on large standardized effect sizes. However, the size of the change in species richness between plots recorded in the first survey in 1978 and 2007 was a large effect size with an estimated 36% reduction in mean richness from 22 species per plot to 14 species per plot.

Condition of headwater streams

- Plant species richness in streams remained stable between 1998 and 2007 though there was considerable turnover of species.
- The physical characteristics of streams improved between 1998 and 2007.

Note to readers of Chapter 7:

- **The methodology for sampling these freshwater habitats differs substantially from the terrestrial habitats. See the *2007 UK Report* for further details at *www.countrysidesurvey.org.uk***

7.1 Introduction

This chapter presents the results for the two freshwater Broad Habitats: Standing Waters & Canals; and Rivers & Streams. Both habitats are important features of the Welsh landscape, as they collect and move water, sediment, nutrients and pollutants through the countryside and also add aesthetic character. When in good condition, these freshwater habitats can support a wide range of plants and animals, many of which are listed in the UK Biodiversity Action Plan. Particular types of freshwater habitat are also listed as Priority Habitats e.g. ponds, rivers and lakes. Freshwater habitats also provide a valuable economic and recreational resource for people.

The Standing Waters & Canals Broad Habitat includes ponds, lakes, canals, ditches and reservoirs. The Rivers & Streams Broad Habitat includes running watercourses ranging from small headwater streams to large rivers. Both these Broad Habitats include the open water itself and the vegetation along the water's edge. They can be extremely variable in character depending on the size of the water body and the nature of the local terrain.

In 2007, Countryside Survey estimated the current area of both Broad Habitats in Wales and the changes from previous surveys. For the first time, Countryside Survey also reported the estimated number and changing number of ponds across Wales.

▲ Upland lake, north Wales • © *CEH*

The condition of certain water body types within these Broad Habitats was assessed by recording the composition of the plants and animal communities they supported.

7.2. Area of Habitat

The area covered by the two Broad Habitats is relatively small, together representing about 1.2% of Wales. No change in the extent of either habitat was detected over the past decade, even though there are some apparently substantial changes in the estimated areas *(Table 7.1)*. These area estimates have changed primarily because they have become more precise (as indicated by the 95% confidence limits around each estimate), due to the increased number of squares surveyed in successive surveys. This means that the 2007 estimates are currently the most reliable.

7.2.1 Number of Ponds

The number of ponds increased in Wales between 1998 and 2007. This change was most pronounced in the lowlands with no significant change in the uplands *(Table 7.2)*.

▲ New pond, Wales • © *CEH*

7.3 Habitat Condition

7.3.1 Biological condition of Ponds

The 2007 data provide a baseline describing the condition of ponds across Wales, based on their plant communities. However, being based on only 29 surveyed ponds, care must be taken when interpreting the findings. There were not sufficient ponds surveyed to reliably report on plant species richness separately for the lowland and upland environmental zones.

In 2007, ponds supported an average of 10.7 (± 2.2 95%CI) wetland plant species per pond. Across the 29 ponds surveyed, 102 different species were recorded; 12 were submerged species, 5 were floating-leaved species and 85 were species associated with the pond margins.

▼ **Table 7.1:** Change in the area ('000s ha) of ***a) Standing Waters & Canals,*** and ***b) River & Streams Broad Habitats in Wales from 1990 to 2007.*** Arrows denote significant change (p<0.05) in the direction shown. No statistically significant change was seen between survey years.

a) Standing Waters & Canals	1990			1998			2007			Change 1998-2007
	Area	95% confidence limits	%	Area	95% confidence limits	%	Area	95% confidence limits	%	
Lowland	6	(2, 10)	0.5	6	(2, 14)	0.5	3	(1, 7)	0.3	
Upland	14	(0, 41)	1.4	15	(1, 37)	1.5	15	(1, 38)	1.5	
Wales	20	(4, 48)	0.9	21	(5, 45)	1	18	(3, 42)	0.9	

b) Rivers & Streams	1990			1998			2007			Change 1998-2007
	Area	95% confidence limits	%	Area	95% confidence limits	%	Area	95% confidence limits	%	
Lowland	12	(3, 23)	1.1	9	(3, 16)	0.8	5	(3, 8)	0.5	
Upland	4	(1, 9)	0.4	3	(1, 5)	0.3	3	(2, 5)	0.3	
Wales	16	(7, 28)	0.8	12	(6, 19)	0.6	8	(5, 12)	0.4	

▼ **Table 7.2:** Change in the number of ponds ('000s) in Wales between 1998 and 2007. Arrows denote significant change (p<0.05) in the direction shown.

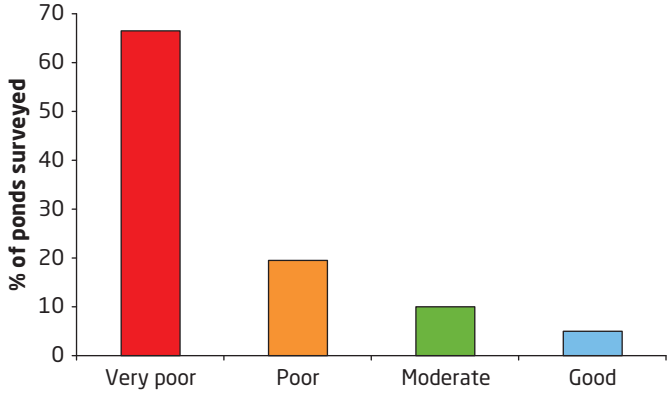
	1998 number (x 1000)	95% confidence limits	2007 number (x 1000)	95% confidence limits	Change 1998-2007
Lowland	27	(8, 56)	33	(15, 63)	↑
Upland	13	(5, 23)	14	(7, 23)	
Wales	40	(18, 70)	47	(26, 78)	↑

7.3.2 Ecological quality of Ponds

The ecological quality of the ponds was evaluated by applying the software package PSYM[40] (the Predictive SYstem for Multimetrics) to the data collected. PSYM assesses pond quality using a range of biological measures which give an indication of the level of degradation e.g. number of plant species.

Most ponds (86%) fell into one of the two lowest PSYM categories: Poor or Very Poor. Only 5% were Good quality (i.e. similar to the reference state) *(Fig 7.1)*. These findings suggest that there may well be considerable and widespread stresses affecting ponds in Wales.

▼ **Figure 7.1:** The percentage of ponds falling into four PSYM quality categories in Wales in 2007.



7.4 Change in the condition of vegetation alongside Rivers and Streams

The most common species recorded in Streamside Plots are listed in *Table 7.3*.

▼ **Table 7.3:** Most frequent 15 species in 2007 in the Rivers & Streams Broad Habitat in Wales on stream and river banks (n=455).

% frequency	Mean cover (%)	Plant name
54	7	*Agrostis stolonifera*
53	6	*Holcus lanatus*
47	6	*Agrostis capillaris*
47	7	*Juncus effusus*
46	3	*Ranunculus repens*
37	4	*Rubus fruticosus agg.*
35	2	*Urtica dioica*
25	2	*Festuca rubra agg.*
25	3	*Hedera helix*
24	<1	*Cirsium palustre*
24	<1	*Rumex acetosa*
23	1	*Anthoxanthum odoratum*
23	5	*Fraxinus excelsior*
23	1	*Dactylis glomerata*
22	1	*Athyrium filix-femina*

[40] See www.pondconservation.org.uk/aboutus/ourwork/surveys/psym.htm for further details.

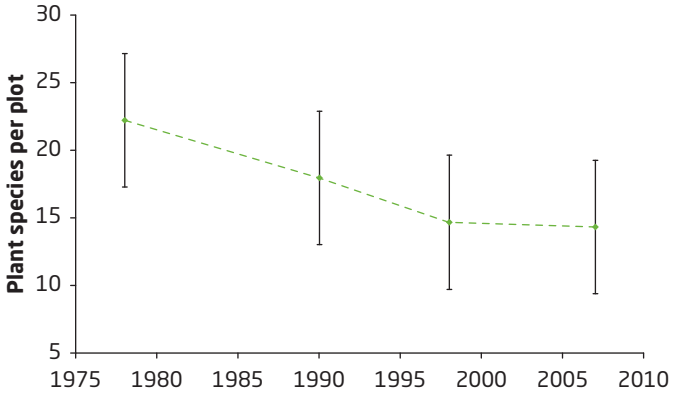
Species richness: All three richness measures declined significantly in the 17 year period between 1990 and 2007 but total species richness and richness of food plants for lowland farmland birds did not change in the most recent interval between 1998 and 2007. These changes in richness appeared to be more a reflection of trends in the lowlands than the uplands ***(Table 7.4)***. Richness of butterfly larval food plants decreased between 1998 and 2007, and 1990 and 1998, with an overall mean loss of 1 species per plot in the 17 year period. The overall change in total species richness amounted to a loss of 2 species per plot in 17 years ***(Table 7.4)***. While none of the standardized effect sizes were large, the total species richness change represents a 4% loss and the decline in butterfly larval food plants a 13% loss.

Nineteen Streamside Plots have been recorded in the same place four times: in 1978, 1990, 1998 and 2007. Despite the small sample size this is an unbiased, random sample. Over the 29 year period, species richness declined by 36% whilst the difference between 1978 and 2007 was also a large standardized effect size ***(Fig 7.2)***. The changes recorded between 1990 and 2007 therefore seem to be part of a more ecologically significant longer-term trend.

Other vegetation characteristics: The largest number of statistically significant changes took place on lowland streamsides, where the Grass:Forb ratio, Ruderal, Light and Moistures Scores all decreased since 1998. Competitor Score increased between 1990 and 1998 but not between 1998 and 2007. Ruderal Score declined between the same intervals partly reflecting its negative correlation with Competitor Score ***(Table 7.4)***. These trends together indicate that streamside vegetation has become less managed and more overgrown, over the period 1990 to 2007. This trend is consistent with changes observed elsewhere in Britain. Evidence from the total sample of Streamside Plots indicates a Great Britain-wide successional trend toward taller, more species-poor vegetation typified by a marked increase in cover of trees and shrubs since 1978[41] with the largest increase in woody cover seen in Wales. It is therefore possible that the increasing representation of stress-tolerant species in the lowland zone ***(Table 7.4)*** reflects increased abundance of shade-tolerant species. However, none of these changes in vegetation characteristics were based on large standardized effect sizes so even though clear trends have been detectable in Welsh streamsides, the impact of these may have been modest compared to the spatial variability across the sample. Further research is required to confirm this whilst it seems likely that the observed changes are also correlated with aspects of the longer-term trend in species richness.

▲ Snowdonia • © *Chris Evans*

▼ **Figure 7.2:** Species richness change on watercourse banks (1x10m plots) between 1978 and 2007. Error bars are the 95% CI on the within-year means (n=19 repeat plots). The differences between 1978 and the years 1990, 1998 and 2007 were all significant (at least $p<0.05$).



[41] Carey *et al* (2008) *Countryside Survey: UK Results from 2007. Chapter 8. Rivers, Streams and Standing Waters, Figure 8.5.* www.countrysidesurvey.org.uk/pdf/reports2007/CS-UK-2007-Ch08.pdf

▼ **Table 7.4:** Change in vegetation characteristics of vegetation in 10 x 1m Streamside Plots in the Rivers & Streams Broad Habitat between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	**1990**	**1998**	**2007**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	20.4	19.3	18.5				↓	↓		↓	↓	
No. of Bird Food Species	7.6	7	6.8				↓	↓		↓	↓	
No. of Butterfly Food Species	7.2	6.7	6.3	↓	↓		↓			↓	↓	
Grass:Forb Ratio	0.38	0.45	0.29		↓							
Competitor Score	2.85	2.92	2.92				↑	↑	↑	↑	↑	↑
Stress Tolerator Score	2.45	2.47	2.49		↑						↑	
Ruderal Score	2.38	2.29	2.21	↓	↓		↓	↓	↓	↓	↓	↓
Light Score	6.48	6.45	6.33	↓	↓					↓	↓	
Fertility Score	4.96	4.93	4.98			↑						
Ellenberg pH Score	5.4	5.4	5.41									
Moisture Score	6.41	6.41	6.32	↓	↓	↓			↓		↓	↓

▼ **Table 7.5:** Change in the biological (as measured by the plant species richness and the Mean Trophic Rank score) and physical (as measured by the Habitat Quality Assessment score) condition of headwater streams between 1998 and 2007. Arrows denote significant change ($p<0.05$) in the direction shown.

	1998		2007		Direction of significant changes 1990 - 2007
		95% confidence limits		95% confidence limits	
Mean plant richness	2.4	(1.7, 3.1)	3.2	(2.3, 4.1)	
Pooled plant richness	51		48		
Mean Trophic Rank score	56.8	(46.1, 67.9)	63.2	(54.7, 72.3)	
Habitat Quality Assessment score	42.3	(38.8, 46.0)	49.2	(43.8, 54.6)	↑

7.5 Changes in the vegetation and physical quality of streams

The diversity and cover of aquatic (within the river) plants were recorded over a 100m length of stream channel at 33 sample squares in both 1998 and 2007. This is a relatively small number of sites to reliably report on the condition of headwater streams therefore care must be taken when interpreting the findings. Furthermore, due to insufficient replication it has not been possible to reliably report on the biological and physical condition of streams separately for either of the two environmental zones.

7.5.1 Vegetation of Headwater streams

There was no significant change in headwater stream plant richness between 1998 and 2007 ***(Table 7.5)***, though there was a suggestion of an increasing trend; with greater replication it may have been possible to detect a significant trend. Pooled plant species richness also did not change between 1998 and 2007 ***(Table 7.5)***.

There was considerable variation in recorded plant species composition between the two surveys. Only 50% of the 66 aquatic plant taxa encountered were recorded in both years. Of the 33 persistent taxa, 15 had increased in frequency across Wales since 1998, while only 5 decreased in frequency; none of which had substantial declines. It was the predominantly emergent vascular plants such as Creeping Bent grass (*Agrostis stolonifera*) and Hemlock Water Dropwort (*Oenanthe crocata*) that became more prevalent between the two Surveys. The Common Feather Moss (*Eurhynchium praelongum*), Fennel Pondweed (*Potamogeton pectinatus*) and River Water-crowfoot (*Ranunculus penicillatus var. penicillatus*) were among the 15 species newly-recorded at Countryside Survey stream sites in 2007. The between-survey variability inevitably reflects sampling error[42] as well as a component of true turnover related to the dynamic nature of the habitat which could be a combination of both its inherent characteristics and the changes brought about in the quality of the water and the physical structure of streams.

There was no change in biological condition of headwater streams, as assessed by the Mean Trophic Rank score ***(Table 7.5)***, indicating that the degree to which such small watercourses are impacted by nutrient enrichment has neither decreased nor increased over the past decade.

[42] See the *Freshwaters Survey QA report* online at: www.countrysidesurvey.org.uk/pdf/QA_FRESHWATER.pdf

7.5.2 *Headwater stream Physical Habitat Diversity*

A River Habitat Survey (RHS) was included in Countryside Survey for the first time in 1998; the repeat survey in 2007 provided the first comparison over time. The Habitat Quality Assessment (HQA) score, derived from the recorded RHS data, provides a measure of the diversity and 'naturalness' of the physical structure of the stream.

The significant improvements in habitat quality of headwater streams *(Table 7.5)* were driven by an increased occurrence of in-stream and bank-side gravel bars, river-side trees and a greater diversity of natural features e.g. fallen trees and debris dams.

7.6 Results in context

This chapter has considered the two Broad Habitats that include all standing and running waters. Countryside Survey focuses, in particular, on headwater streams and ponds, the latter recognised as a Priority Habitat in the UK Biodiversity Action Plan. This focus reflects the lesser coverage of these types of water body in other surveys, and no comparative estimates are available. No comparative estimates of the extent of the larger Welsh resource of standing and running waters is available.

Key results and follow-up questions:

- **An increase in the number of ponds but mostly of poor quality – how much progress does this represent towards achievement of biodiversity objectives?**
- **A decrease in plant species richness and changes in other characteristics of streamside vegetation – a wholly negative change or a consequence of work to deliver other environmental benefits through the creation of streamside corridors?**
- **An improvement in the physical characteristics of streams – how much of this was deliberate amelioration or an indirect effect of waterside succession?**
- **No change in Mean Trophic Rank score of headwater streams – to what extent does this convey either lack of improvement of poorer condition watercourses or maintenance of good condition?**

These questions, together with those identified in each of the other habitat chapters, are considered further in *Chapter 9*.

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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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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▲ Welsh landscape • © *Michael D Smith*

8. The National Picture

Summary

Broad Habitat Area

- Most Broad Habitats did not change significantly in area between 1998 and 2007 when averaged across Wales as a whole.
- Within the two environmental zones a number of statistically significant changes in area were detected between 1998 and 2007. In the lowland zone Broadleaved, Mixed & Yew Woodland increased. In the uplands, Arable & Horticultural land increased, Neutral Grassland decreased and Acid Grassland increased. The possible drivers of these changes and their uncertainties require further research.
- Land dominated by bracken was estimated to have decreased by 55%. Since the Bracken Broad Habitat is defined as having >=95% cover of bracken present, many areas no longer classified as Bracken Broad Habitat nevertheless still support high bracken cover and the change in status reflects the high cover threshold included in the definition. Possible reasons for reduced bracken cover in the 2007 survey include the impact of very high rainfall and its debilitating effect during the growing season of 2007, as well as local managed reduction. Differences in date of survey between years did not appear to be implicated in the change.
- The area of the Built-up areas & Gardens Broad Habitat increased by 13% between 1998 and 2007. This resulted from small increases in the area of buildings within survey squares and spread across many squares rather than few, large increases.

Vegetation condition

- Plant species richness declined between 1998 and 2007, and over the longer period between 1990 and 2007. This particularly impacted richness of butterfly larval food plants. Species richness per sample plot declined significantly in all landscape locations sampled: fields and larger areas of common habitat; on linear features including road verges, field boundaries, streamsides and hedgerows, and also in small habitat fragments.

- Non-native plant species were uncommon in vegetation plots in 2007 (on average, one in every six plots) and average non-native richness declined alongside native species richness between 1978 and 2007. A very small subset of such species are known to be invasive but assessment of their location and recent change awaits further analysis.

- Changes in vegetation character indicated a successional trend toward more shaded vegetation with fewer species of open ground and larger numbers of taller, more competitive species including trees and shrubs. The importance of this trend varied, the strongest being on linear features.

- Most changes in vegetation indices were small when evaluated against the amount of variability in the sampled vegetation. This was especially so in the combined analysis of all habitats, reflecting the high variability in the data as a result of aggregation across habitat types. But this pattern of relatively small changes is consistent with that seen in individual habitats. This suggests that, whilst ecological patterns are often clearly detectable, no large step-change in ecological condition has occurred. Further analysis is required to determine whether these relatively small changes are of ecological significance.

Boundary and Linear features

- In common with the rest of Britain, managed hedgerow reduced in length between 1998 and 2007, continuing a trend seen since the first survey in 1984. Rather than resulting from loss of the woody linear feature altogether, this was more likely to reflect a reduction in management and consequent increase in unmanaged lines of trees and shrubs.

Soils

- When averaged across all Broad Habitats the pH of the soil (0-15cm) did not change between 1998 and 2007 despite an overall increase between the first survey in 1978 and the latest in 2007. Soil pH did however increase in Improved Grassland and Neutral Grassland between 1998 and 2007.

- The only significant change detected in soil carbon concentration (0-15cm) was a reduction in Coniferous Woodland between 1998 and 2007.

- The mean soil (0-15cm) carbon stock in 2007 was highest for Dwarf Shrub Heath but too few samples were available for analysis of the other peat-dominated Broad Habitats.

Headwater streams and ponds

- The number of ponds increased by 18% between 1998 and 2007 but only 5% of ponds in 2007 were in ecological good condition.

- On river and stream banks, a clear ongoing successional trend was observed, consistent with a marked increase in cover of trees and shrubs and continuing reductions in species richness especially of butterfly larval food plants.

- Species richness within sampled watercourses did not change between 1998 and 2007 whilst the physical characteristics of the watercourse improved.

8.1 Introduction

In this chapter, results are drawn together to give a national overview of changes seen across Wales between Countryside Surveys. Changes in vegetation condition are also presented based on analyses combining plots in all Broad Habitats to give a summarised picture of the key ecological changes between 1998 and 2007, set within the longer 17 year timescale from 1990 to 2007. Results are also summarised for soils and freshwaters. Information is presented on:

- estimated areas of Broad Habitats, and changes in those areas;

- changes in vegetation condition in fields and larger areas of habitat, small habitat fragments and alongside boundaries, hedges, roads and streams;

- changes in linear landscape features;

- changes in headwater streams and ponds;

- changes in soil (0-15cm) characteristics;

The emphasis here and in all chapters is on the estimates from the 2007 survey since these are based on an increase in the number of sample squares. This increase provides greater statistical power for quantifying change in area and condition among habitats, soils, vegetation and landscape features for the future and provides the most precise baseline for the present. Because of the historically small sample size in Wales and the way in which the sample has gradually increased from the 1978 survey onwards, estimates of change in area and length of Broad Habitats focus on the 1998 to 2007 interval. Reference is made to previous surveys where the results are particularly clear and helpful in understanding longer term trends in Wales and the rest of the UK. A similar approach is taken when describing changes in vegetation characteristics. Occasionally, as in this chapter, enough plots can be combined to produce robust analyses back to 1978. However, because of the marked increase in sample size and numbers of plot types in the 1990 survey and the lack of Broad Habitat information for 1978, the main emphasis in the vegetation change results is on the 17 year period covering the 1990, 1998 and 2007 surveys.

8.2 Estimated area of Broad Habitats

Wales makes up about 9% of the area of the UK. Compared to the whole of Great Britain and the UK, Wales has proportionally more Improved Grassland (34% compared to Great Britain 20% and UK 21%), more Broadleaved, Mixed & Yew Woodland (8% compared to Great Britain 6% and UK, 6%), more Acid Grassland (10% compared to Great Britain 7% and UK 7%) but much less Arable & Horticultural (3% compared to Great Britain 20% and UK 19%)[43]. It also has less urban land than England but more than Scotland and Northern Ireland.

In order, the most common Broad Habitats in 1998 and 2007 were Improved Grassland, Neutral Grassland, Acid Grassland, Broadleaved, Mixed & Yew Woodland and Built-up areas & Gardens ***(Table 8.1)***.

8.3 Change in area of Broad Habitats

As a whole, few changes in area of Broad Habitats were detected between 1998 and 2007. The area of built land increased by 12.5% ***(Table 8.1)*** while the proportion of the Boundaries & Linear Features Broad Habitat that comprised mappable areas decreased between 1998 and 2007. These areas include major roads and associated land, a proportion of which was subsumed into the new extent of Built-up areas & Gardens consistent with the definition of both Broad Habitats[44]. Across Wales the Bracken Broad Habitat decreased by 55%. This was a large change in estimated area. A possible explanation that is being investigated is that this might be a result of the sensitivity of the mapping definition (only areas >=95% bracken cover qualify) combined with the potentially debilitating impact of high rainfall on bracken growth in the very wet summer of 2007 (see ***Chapter 6*** for more details). It could also include local managed reductions but more work is required to understand the reasons for this change. In any event, the vegetation plot data indicated that many areas no longer mapped as bracken in 2007 still had a high cover of bracken although this had reduced significantly; in these areas at least, the reduction in bracken area did not mean disappearance of bracken, but a reduction below the critical 95% threshold used in Countryside Survey to define stands of Bracken Broad Habitat.

The area of the Built-up areas & Gardens Broad Habitat increased in Wales by 14,600 ha (95% CI; 5,800 ha to 24,00 ha) ***(Table 8.1)***. This reflected increases in both upland and lowland zones in Wales, neither of which were statistically significant when tested separately. The increases reflected numerous small changes (median increase 0.04 ha in repeat survey squares between 1998 and 2007) rather than a small number of very large gains. The increase was largely attributable to new or extended buildings. 40% of the new Built-up areas & Gardens was on land mapped as Improved Grassland in 1998 and 38% on Neutral Grassland. 5% was Broadleaved, Mixed & Yew Woodland in 1998 and 8% linear habitat area, which is most likely to have been a reclassification of major road and railway having been surrounded by new built land.

Changes in area of other Broad Habitats were detected within either the upland or lowland zones in Wales between 1998 and 2007. Broadleaved, Mixed & Yew Woodland was estimated to have increased by 12% across lowland Wales. In the uplands, Neutral Grassland decreased by 33,000 ha and Acid Grassland increased by 13,000 ha. Arable land also increased in the uplands by an estimated 4,000 ha with 87% of the increase having occurred on land mapped as Improved Grassland in 1998. The possible drivers of these changes and their uncertainties require further research.

▲ **Main Plot** in bracken • © *CEH*

[43] Carey *et al* (2008) *Countryside Survey: UK results from 2007*. Online at www.countrysidesurvey.org.uk/reports2007.html

[44] Jackson, DL (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. www.jncc.gov.uk/page-2433

▼ **Table 8.1:** Estimated area ('000s ha), percentage of land area and change in area of Broad Habitats in Wales from 1998 to 2007. Arrows denote significant change ($p<0.05$) in the direction shown.

	1998		2007		1998 - 2007		Direction of significant changes 1998-2007
Broad Habitats	Area	% area of Wales	Area	% area of Wales	Change in area	% area of Wales	
Broadleaved, Mixed and Yew Woodland	172	8.1	174	8.2	1.8	1.1	
Coniferous Woodland	96	4.5	106	5	10	10.4	
Linear Features[45]	54	2.5	48	2.2	-6.3	-11.6	↓
Arable and Horticulture	61	2.9	73	3.4	12	19.8	
Improved Grassland	706	33.3	730	34.4	24.2	3.4	
Neutral Grassland	287	13.5	263	12.4	-24.2	8.4	
Calcareous Grassland	1.2	0.1	1.2	0.1	-0.07	-6	
Acid Grassland	191	9	211	9.9	19.3	10.1	
Bracken	84	4	37	1.8	-46.7	-55.4	↓
Dwarf Shrub Heath	99	4.7	117	5.5	17.9	18	
Fen, Marsh, Swamp	40	1.9	36	1.7	-4.3	-10.8	
Bog	45	2.1	48	2.3	3.1	7	
Standing Open Waters	6	0.3	5	0.3	-0.6	-10.2	
Rivers and Streams	5	0.3	6	0.3	0.3	5.9	
Montane	0.1	0.006	0.1	0.004	-0.03	-26.6	
Inland Rock	8	0.4	8	0.4	-0.7	-8.4	
Built-up Areas and Gardens	117	5.5	132	6.2	14.7	12.5	↑
Other land	134	6.3	111	5.2	n/a	n/a	
Unsurveyed Urban Land	15	0.7	15	0.7	n/a	n/a	
Total	**2121**	**100**	**2121**	**100**			

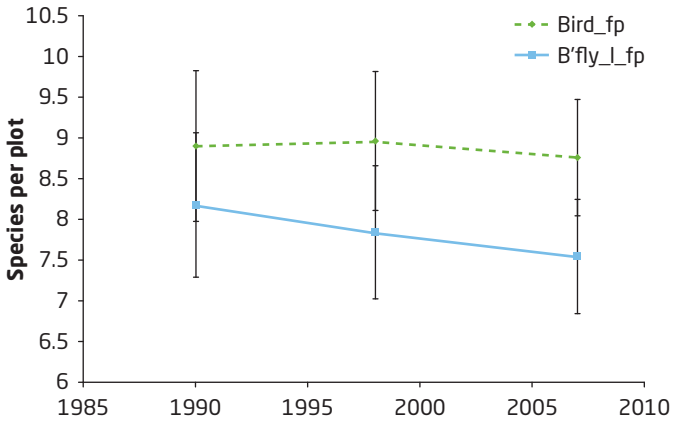
[45] Linear features were largely mapped as lengths except where >5m wide and >80m long i.e. above the Minimum Mappable Unit. Consequently, Linear Feature areas tend to comprise land occupied by larger roads and the railway network.

▼ **Table 8.2:** Change in the characteristics of all types of vegetation in 200m² Main Plots in Wales and in each of the Environmental Zones between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

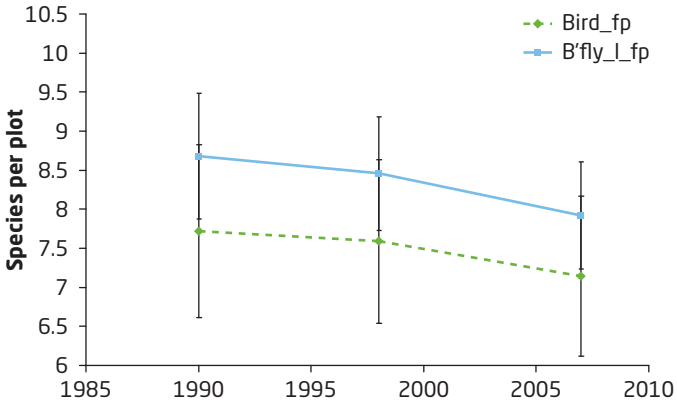
	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	1990	1998	2007	W	Lo	Up	W	Lo	Up	W	Lo	Up
Species Richness (No. of Species)	18.0	17.6	16.7	↓		↓	↓	↓		↓	↓	↓
No. of Bird Food Species	8.3	8.3	8.0			↓		↓			↓	↓
No. of Butterfly Food Species	8.4	8.2	7.7	↓		↓		↓		↓	↓	↓
Grass:Forb Ratio	1.00	1.27	1.10	↓		↑	↑	↑	↑			
Competitor Score	2.60	2.61	2.67	↑					↑	↑		↑
Stress Tolerator Score	2.46	2.45	2.42									
Ruderal Score	2.67	2.68	2.64	↓	↓			↑			↓	
Light Score	6.87	6.90	6.87	↓								
Fertility Score	4.71	4.71	4.72									
Ellenberg pH Score	5.26	5.23	5.21									
Moisture Score	5.64	5.69	5.72				↑			↑		

▼ **Figure 8.1:** Changes in number of food plants for butterfly larvae (B'fly_l_fp) and lowland farmland birds (Bird_fp) in Main Plots in Wales between 1990 and 2007 across all Broad Habitat types in the lowland zone a) and in the upland zone b). See ***Table 8.2*** for statistical significance of changes between surveys. Mean values for each year are shown (+/-95% CI).

a) lowland zone



b) upland zone



8.4 Changes in vegetation condition across all habitat types

8.4.1 Main Plots

The Main Plots (200m^2) were located at random within fields, woods and unenclosed habitats, and away from boundary and linear features. These plots therefore provide an unbiased picture of vegetation composition and characteristics in the most common habitats in Wales.

The analyses presented here address average change across all sampled habitats in Wales, and therefore they reflect the aggregation of various, sometimes habitat-specific, trends seen in individual Broad habitats (see previous chapters). These results provide a useful high-level summary but may also average out changes in different directions that occurred among different habitats.

Species richness: A progressive loss of species diversity occurred in the 17 year interval *(Table 8.2)*, which in turn meant significant reductions in food plants for butterfly larvae and lowland farmland birds *(Fig 8.1)*. However, effect sizes for changes in species richness were all small or medium indicating small magnitude change relative to the variation in the sample.

A highly significant mean loss of 2.5 butterfly larval food plant species per plot between 1978 and 2007 was detected across the much smaller sample (n=58) of repeated Main Plots first sampled in 1978. Taking into account the confidence intervals around the mean change, this amounts to a reduction of between 12% and 37% in the mean over the 29 year period. The standardized effect size was 0.62 for the 1978 to 2007 change. Although below the threshold value of 0.8 for a large effect, the sample was highly variable given that all habitat types were included hence this loss over the 29 year period should be considered potentially significant in its ecological impact on common habitats and butterflies in Wales.

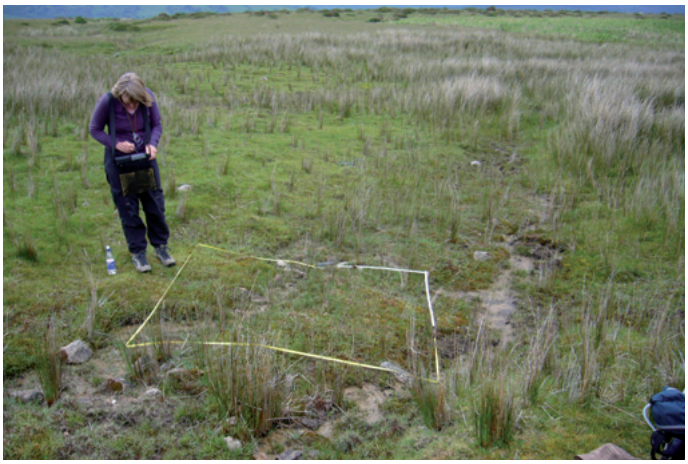
Other vegetation characteristics: None of the significant changes in the Main Plots were based on large standardized effect sizes hence ecological impacts may well be minor. The pattern of changes does not reveal any especially clear signal of movement along an ecological gradient. This is perhaps not surprising given that habitat-specific trends are here averaged across all sampled habitats. The most obvious signal was for an increase in competitive species at the expense of ruderal species of more open conditions and an increase in species preferring more moist conditions *(Table 8.2)*.

▲ Shaded **Streamside Plot** • © *CEH*

8.4.2 Linear Plots

Species richness: Total species richness, richness of food plants for lowland farmland birds and richness of butterfly larval food plants all decreased significantly over the 17 year period. Total species richness and richness of butterfly larval food plants also decreased between the two most recent surveys in 1998 and 2007 *(Fig 8.2; Table 8.3)*. None of the significant changes were based on large standardized effect sizes hence impacts on the vegetation may be modest although this can only be confirmed after further analysis.

▲ Overgrown **Hedgerow Plot** • © *CEH*



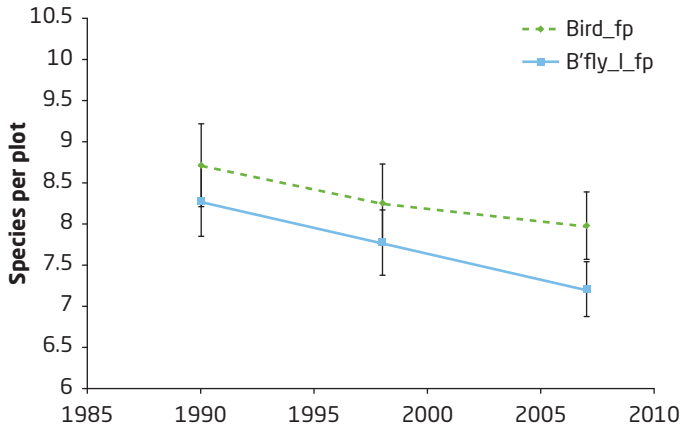
▲ Calcareous flush in **Targeted Plot** • © *CEH*

▼ **Table 8.3:** Change in the characteristics of all types of vegetation in 10m² Linear Plots (Boundary, Hedgerow and Roadverge) in Wales and in each of the Environmental Zones between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

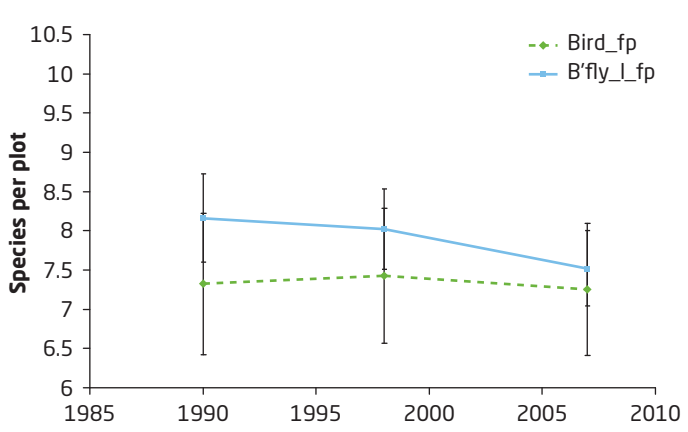
	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	**1990**	**1998**	**2007**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	18.6	18.1	17.4	↓			↓			↓		
No. of Bird Food Species	8.1	7.9	7.6							↓		
No. of Butterfly Food Species	8.2	7.9	7.4	↓		↓	↓			↓		↓
Grass:Forb Ratio	0.99	0.99	0.72	↓	↓	↓				↓	↓	
Competitor Score	2.85	2.88	2.94	↑						↑		
Stress Tolerator Score	2.34	2.33	2.32									
Ruderal Score	2.56	2.58	2.46	↓	↓					↓		
Light Score	6.62	6.62	6.51	↓	↓					↓		
Fertility Score	5.19	5.23	5.26							↑		
Ellenberg pH Score	5.63	5.67	5.67				↑					
Moisture Score	5.43	5.52	5.56	↑			↑			↑		

▼ **Figure 8.2:** Changes in number of food plants for butterfly larvae (B'fly_l_fp) and lowland farmland birds (Bird_fp) in Linear Plots in Wales between 1990 and 2007 across all Broad Habitat types in the lowland zone a) and upland zone b). See ***Table 8.3*** for statistical significance of changes between surveys. Mean values for each year are shown (+/-95% CI).

a) lowland zone



b) upland zone

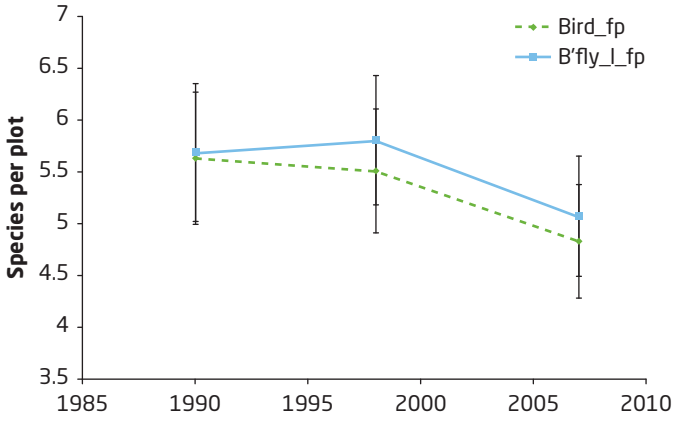


▼ **Table 8.4:** Change in the characteristics of all types of vegetation in 4m² Targeted Plots in Wales and in each of the Environmental Zones between 1990 and 2007. W=Wales, Lo=Lowland zone, Up=Upland zone. Arrows denote significant change ($p<0.05$) in the direction shown. None of the significant changes reflected a large effect size.

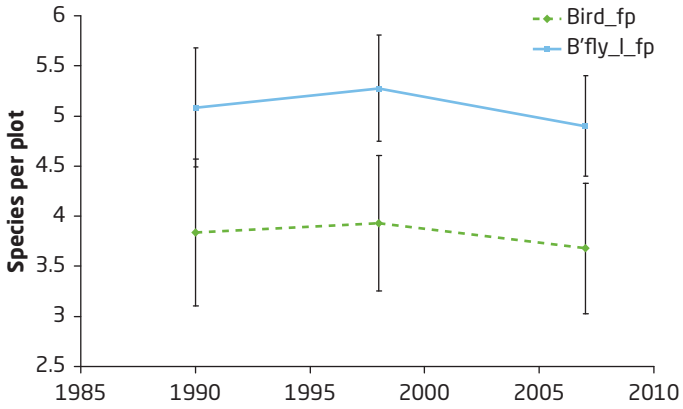
	Mean values (Wales)			Direction of significant changes 1998 - 2007			Direction of significant changes 1990 - 1998			Direction of significant changes 1990 - 2007		
Vegetation Condition Measures	**1990**	**1998**	**2007**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**	**W**	**Lo**	**Up**
Species Richness (No. of Species)	14.0	14.0	12.5	↓	↓	↓				↓	↓	
No. of Bird Food Species	4.8	4.7	4.3	↓	↓					↓		
No. of Butterfly Food Species	5.4	5.5	5.0	↓	↓							
Grass:Forb Ratio	0.64	1.06	0.68	↓			↑					
Competitor Score	2.61	2.68	2.75	↑		↑	↑	↑		↑	↑	↑
Stress Tolerator Score	2.90	2.85	2.76	↓		↓	↓		↓	↓		↓
Ruderal Score	2.20	2.22	2.19		↓	↑		↓	↑		↓	↑
Light Score	6.70	6.74	6.66	↓	↓	↓			↑	↓		
Fertility Score	4.08	4.14	4.25	↑		↑				↑		↑
Ellenberg pH Score	4.89	4.92	4.95			↑						
Moisture Score	6.24	6.31	6.27				↑					

▼ **Figure 8.3:** Changes in number of food plants for butterfly larvae (B'fly_l_fp) and lowland farmland birds (Bird_fp) in Targeted Plots in Wales across all Broad Habitat types in the lowland zone a) and upland zone b). See ***Table 8.4*** for statistical significance of changes between surveys. Mean values for each year are shown (+/-95% CI).

a) lowland zone



b) upland zone



Other vegetation characteristics: Reductions in Ruderal Score and Light Score along with increases in Competitor Score indicate a clearer pattern of ecological changes in the Linear Plots. It seems likely that species less tolerant of shade and competition for light have declined in response to more relaxed management while the increase in Fertility and Moisture Scores also indicate greater abundance of more nutrient-demanding species that prefer more moist conditions *(Table 8.3)*.

8.4.3 Targeted Plots

Targeted Plots (2m x 2m) were introduced in Countryside Survey in 1990 to sample the vegetation in areas of botanical interest not otherwise sampled by the Main or Linear Plots. These include smaller fragments of less frequently occurring habitats. The 1990 Targeted Plots have been re-sampled in 1998 and 2007. Like the Linear Plots, they provide a unique indication of ecological changes in parts of the landscape that, while often intimately associated with land under intensive management, may also act as refuges for plant species that were formerly more common in the countryside[46].

Species richness: Total species richness, richness of food plants for lowland farmland birds and richness of butterfly larval food plants decreased significantly between 1998 and 2007 particularly in the lowland zone. Total species richness and richness of food plants for lowland farmland birds decreased significantly over the 17 year period between 1990 and 2007 *(Fig 8.3; Table 8.4)*. None of the significant changes were based on large effect sizes hence ecological impacts on the vegetation may be modest.

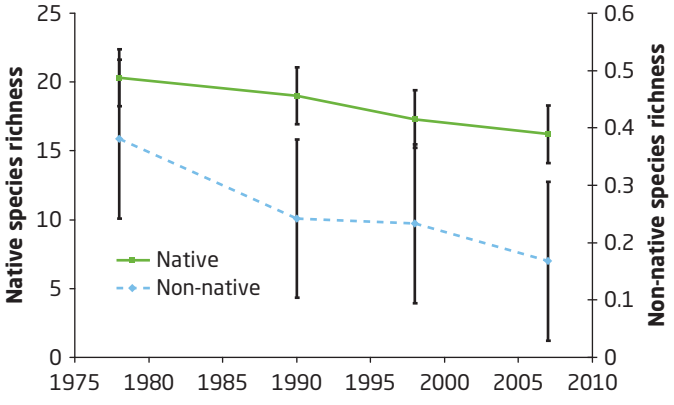
[46] Smart *et al* (2006) *J.Appl.Ecol.* **43**, 1128-1137.

Other vegetation characteristics: The clearest signal over the 17 year period as well as between 1998 and 2007, was an increase in the frequency of more competitive species and decreased representation of more stress-tolerant species, especially so in the uplands where also accompanied by an increase in ruderal species of more open conditions ***(Table 8.4)***. Overall, patterns of change did not compellingly indicate succession and lack of disturbance. For example, the Ruderal Score increased in the upland zone and decreased in the lowlands, while the Light Score increased significantly between 1990 and 2007. The lack of clear directional patterns may well reflect different changes among the different habitats included in the sample. A more evident trend over the 17 year period was for increased representation of more nutrient-demanding generalist species especially in the upland zone ***(Table 8.4)***. None of the significant changes were based on large standardized effect sizes hence impacts on the vegetation were minor compared to variation in the sample. The ecological impact of these changes could well be slight but further research would be required to explore this.

8.4.4 Changes in species richness since 1978

Countryside Survey began in 1978 with a sample of 256 1 km squares located across Britain. In the squares surveyed in Wales a series of vegetation plots were established and have been visited in every survey since. This time series is the longest and while based on a relatively small number of plots, the sample is large enough to show change over all landscape locations and vegetation types over the 29 year period ***(Fig 8.4)***. A significant decline in species richness was observed for both native[47] and non-native[48] species between 1978 and 2007. Non-native plant species were uncommon in vegetation plots in 2007 (on average, one in every six plots). A very small subset of such species are known to be invasive but an updated assessment of their location and recent change awaits further analysis.

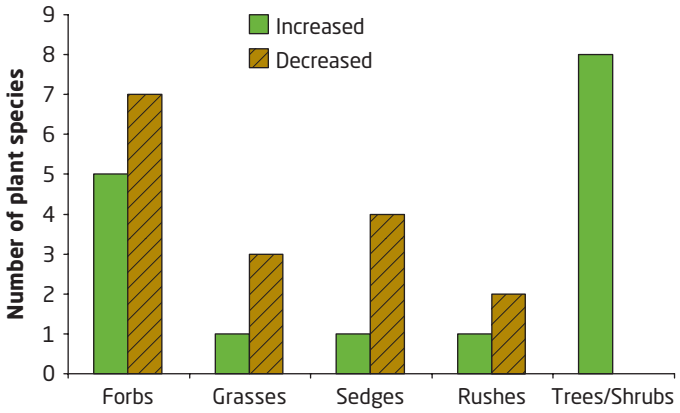
▼ **Figure 8.4:** Changes in native and non-native species richness in all Welsh repeat plots (n=115) first sampled in 1978. Error bars are 95% CI on the mean counts in each survey year. Changes in native species richness were significant ($p<0.05$) between all years except 1978-'90 and 1998-'07. Changes in non-native species richness were significant ($p<0.05$) between 1978 and all other survey years.



8.4.5 Individual species changes within plots surveyed in 1998 and 2007

To account for any variation in observer efficiency between surveys an index of relative change was calculated that conveys change in frequency for each species having averaged out any 'global' within-survey difference in species frequency. ***Table 8.5*** lists those species that had the highest and lowest change indices but excluding species that were recorded separately but whose identifications may be confused with one another. The plant species that increased or decreased the most between 1998 and 2007 segregate clearly in terms of canopy height and growth form; tall woody species tended to have increased ***(Fig 8.5)*** whilst shorter herbs decreased ***(Fig 8.6)***. These patterns are consistent with those seen among increasers and decreasers in England and Scotland. This raises the possibility of a common response to factors operating to some extent across Britain between 1998 and 2007 and continuing trends seen from 1978 especially on linear features and, since 1990, in small habitat remnants[49, 50]. They also resemble patterns of change in larger scale grid square occupancy seen among both the common and rare species in the British Flora since the 1960s[51, 52]. In addition to land-use change, weather impacts in each year of survey may also have played a role in driving the observed trend in Countryside Survey plots. Explanation of these signals in terms of land-use and other drivers is a matter for ongoing analysis.

▼ **Figure 8.5:** The species that increased or decreased the most between 1998 and 2007 are classified here by their growth form (see ***Table 8.5***).



[47] Comprises the categories Archaeophyte (alien introduced before 1500), Native (not endemic), Native (endemic) and Spontaneous hybrid between two native parents.

[48] Comprises the categories Neophyte (alien introduced after 1500) and Alien casuals (mostly crops). See PLANTATT (www.brc.ac.uk/resources.htm).

[49] Smart *et al* (2005) *Biol. Cons.* **124**, 355-371.

[50] Smart *et al* (2003) *J.Env.Man.* **67**, 239-254.

[51] Preston *et al* (2000) *Changing Flora of the UK*. DEFRA, London.

[52] Braithwaite *et al* (2006) *Change in the British Flora 1987 – 2004*. Botanical Society of the British Isles, London.

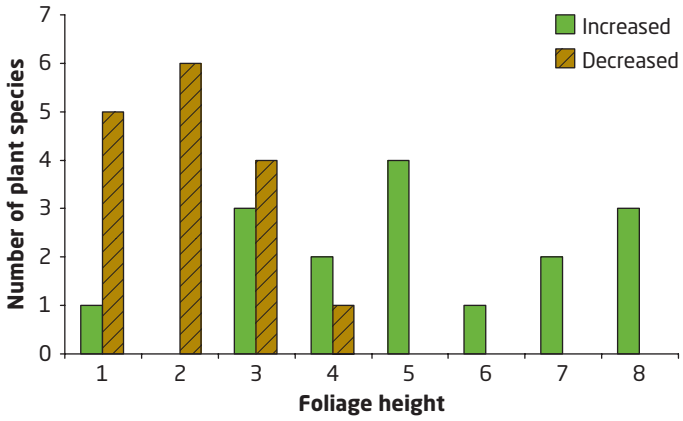
▼ **Table 8.5:** Plant species whose indices of change between 1998 and 2007 were in the top 16 or bottom 16 of all species ordered firstly by change in numbers of plots occupied and then by Change Index calculated using an adaptation of the method presented in the New Atlas of the British and Irish Flora (see ***Chapter 1***). Growth form: w = woody; f = forb; g = grass, s= sedge, m=rush. Excludes species pairs that were likely to have shown patterns of correlated change linked to identification bias between surveys.

Latin name	Growth form	Number of records in 1998	Change index
Crataegus monogyna	w	349	0.55
Fraxinus excelsior	w	161	0.56
Galium palustre	f	117	0.59
Equisetum arvense	f	17	0.6
Juncus effusus	m	342	0.6
Corylus avellana	w	228	0.62
Tamus communis	w	18	0.64
Sonchus asper	f	12	0.67
Blechnum spicant	f	33	0.68
Dryopteris dilatata/carthusiana	f	78	0.74
Hedera helix	w	188	0.81
Salix cinerea	w	17	0.82
Quercus robur/petraea	w	114	0.88
Carex seedling/sp	s	70	0.91
Aira caryophyllea	g	4	0.94
Rubus fruticosus agg.	w	315	0.99
Cerastium glomeratum	f	39	-1.8
Eleocharis palustris	m	32	-1.69
Ranunculus ficaria	f	43	-1.08
Carex flacca	s	51	-0.96
Carex nigra	s	120	-0.75
Juncus bulbosus	m	73	-0.73
Poa pratensis sens.lat.	g	328	-0.69
Elytrigia repens	g	125	-0.43
Potentilla anserina	f	95	-0.29
Phleum pratense sens.lat.	g	116	-0.22
Carex pilulifera	s	95	-0.19
Trifolium pratense	f	94	-0.16
Sagina sp.	f	177	-0.08
Leontodon autumnalis	f	165	-0.07
Carex echinata	s	109	-0.05
Apium nodiflorum.	f	47	-0.72

8.5 Changes in landscape features

Woody linear features (managed hedges and lines of trees and shrubs) made up an estimated 51% of the total length of boundary and linear features in Wales in 2007 compared with 53% in England and 13% in Scotland, where unenclosed land is a much more common component of the landscape. In parallel with the rest of Britain, there was a reduction in the length of managed hedgerow in Wales over the 23 years since the first survey in 1984.

▼ **Figure 8.6:** Increasing and decreasing species in ***Table 8.5*** classified by average foliage height as follows: ***1,*** <100mm; ***2,*** 101-299mm; ***3,*** 300-599mm; ***4,*** 600-999mm; ***5,*** 1.0-3.0m; ***6,*** 3.1-6.0m; ***7,*** 6.1-15m; ***8,*** >15m.



Rather than removal of the feature, which was a more important process between 1984 and 1990, the loss between 1998 and 2007 reflected a shift to less frequently or even unmanaged lines of trees and shrubs.

Fences were the next most common boundary feature, making up 35% of the total length. Walls were evenly distributed between upland and lowland zones but were much more likely to be in poor condition in the uplands.

8.6 Changes in soils (0-15cm) in all habitats

8.6.1 Introduction

Soil samples (0-15cm) were collected in Main Plots in 1978, 1998 and 2007 for chemical and physical measurements. Initial results for soil (0-15cm) pH, carbon concentration, bulk density and stock of carbon are presented here for habitat types for which sufficient samples were available *(Table 8.6)*.

▲ Soil cores • © *CEH*

▼ **Table 8.6:** Changes in the pH and carbon concentration of soils (0-15cm depth) within all vegetation types and in Broad Habitats across Wales. Arrows denote a significant change ($p<0.05$) in the direction shown. Grey cells with diagonal strikethrough indicate insufficient data for analysis.

	Mean pH		Mean carbon concentration (g/kg)		Direction of significant changes 1998 - 2007		Direction of significant changes 1978 - 1998		Direction of significant changes 1978 - 2007	
Broad Habitat	1998	2007	1998	2007	pH	Carbon Conc.	pH	Carbon Conc.	pH	Carbon Conc.
Broadleaved, Mixed and Yew Woodland	5.24	5.40	68.40	78.95			↑		↑	
Coniferous Woodland	4.22	4.14	197.81	144.01		↓				
Arable and Horticulture		6.48		20.93						
Improved Grassland	5.74	5.94	60.67	55.07			↑		↑	
Neutral Grassland	5.85	5.82	49.24	56.73			↑		↑	
Acid Grassland	4.41	4.74	179.77	186.26						
Bracken										
Dwarf Shrub Heath	4.53	4.40	243.48	240.92						
Fen, Marsh and Swamp										
Bog										
All vegetation types	5.43	5.56	99.54	98.58			↑		↑	

8.6.2 Soil (0-15cm) pH

The pH of soil (0–15 cm) averaged across all Broad Habitats increased significantly from a mean pH of 5.00 to 5.56 between 1978 and 2007 but did not change between 1998 and 2007 *(Table 8.6)*. When broken down by Broad Habitat no significant changes in soil pH were seen between 1998 and 2007 but pH did increase between 1978 and 1998 and between 1978 and 2007 in Broadleaved, Mixed & Yew Woodland, Improved Grassland and Neutral Grassland *(Table 8.6)*.

8.6.3 Soil (0-15cm) carbon concentration

The only significant change detected was a reduction in soil (0-15cm) carbon concentration in Coniferous Woodland between 1998 and 2007 *(Table 8.6)*.

8.6.4 Soil (0-15cm) bulk density and carbon stock (0-15cm)

Bulk density of soil (0-15cm) was measured for the first time in 2007. This is a critical property of the soil and needs to be taken into account when calculating total carbon stock because differing soil density yields a different mass for the same unit volume. Measurements showed that the densest soils were those in the intensively managed Improved Grassland and Arable Broad Habitats typically associated with lower organic matter content. The more organic matter rich Acid Grassland and Dwarf Shrub Heath had the least dense soils *(Table 8.7)*.

The least dense soils tend to be richer in carbon but also have a lower mass of carbon for the same volume. To some extent these differences in bulk density even out the differences in carbon stock in the top 15cm although Dwarf Shrub Heath and Acid Grassland still emerged as having the highest estimated stock *(Fig 8.7)*.

▼ **Table 8.7:** Bulk density in soils (0-15cm) in Broad Habitats in Wales in 2007. Grey cells with diagonal strikethrough indicate insufficient data for analysis.

Broad Habitat	Mean bulk density g/cubic cm
Broadleaved, Mixed and Yew Woodland	0.72
Coniferous Woodland	0.44
Arable and Horticulture	1.07
Improved Grassland	0.92
Neutral Grassland	0.86
Acid Grassland	0.48
Bracken	
Dwarf Shrub Heath	0.34
Fen, Marsh and Swamp	
Bog	
All vegetation types	0.76

▲ Grassland soil structure • © *Ian Rugg, Welsh Assembly Government*

▲ Upland soil profile • © *Ian Rugg, Welsh Assembly Government*

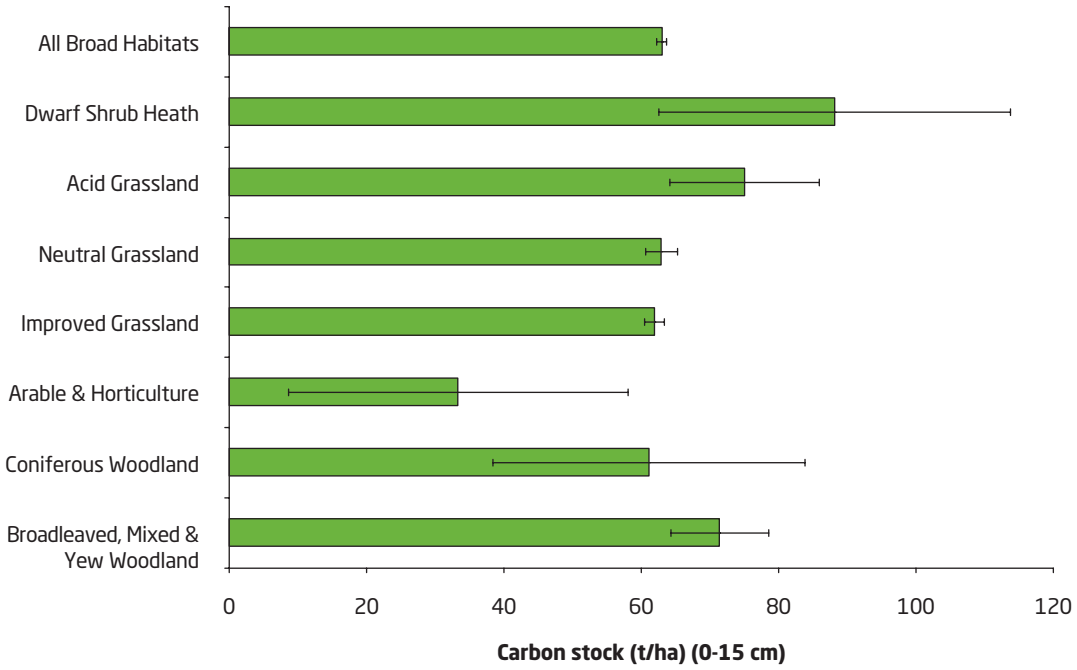
8.7 Changes in condition of headwater streams and ponds

The area of Standing Waters & Canals, and Rivers & Streams remained stable between 1998 and 2007. The number of ponds increased by 18% between 1998 and 2007, with most of the increase taking place in the lowlands. In 2007, ponds supported an average of 10.7 wetland plant species per pond yet only 5% of ponds were in good ecological condition.

On streamsides and riverbanks, plant species richness, and in particular the richness of butterfly larval food plant species, decreased between 1990 and 2007. Over time there has been a clearly identifiable successional process with vegetation becoming taller and more dominated by trees and shrubs.

In the stream channel itself, plant species richness remained stable between 1998 and 2007. Lastly, evidence from the surveyed stream lengths in each square indicated that the physical characteristics of streams improved between 1998 and 2007 whilst the nutrient status of streams, as inferred from the macrophyte species recorded, did not change.

▼ **Figure 8.7:** Carbon stock (tonnes per hectare) in the top 0-15cm of soil in Welsh Broad Habitats in 2007. Means are shown (+/-95% CI). Too few samples were collected for analysis of other Broad Habitats.



Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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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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▲ Wye Valley, nr Rhayader • © *Michael D Smith*

9. An overview from a user's perspective

9.1 Introduction

At some level, change is a continuous feature of the countryside. This is readily apparent, for example, in seasonal patterns of vegetation growth and death, in the rotational nature of farming systems, in longer-term trends of natural succession, and in forestry cycles of felling and planting. At another level, however, much of this change takes place within what often seem to be largely stable landscapes: enclosed farmland, within which rotational practices result in a shifting pattern of arable crops, remains, for the most part, enclosed farmland; timber is removed from woodland, which then regenerates or is replanted, and remains woodland.

As individuals, our perception of change in the countryside is influenced both by the length of time over which we are able to observe our environment, and by the area of land (and water) we are able to regularly observe. The nature of change is important too in determining how easily we might observe it – large step-changes are more obvious than gradual changes that may take many years to become visually apparent. So, our impression of how dynamic or stable our immediate surroundings are, will be gleaned from the frequency of dramatic or sudden changes we see in the landscape.

More gradual changes, in the floristic composition of fields or hedge bottoms, for example, may be less readily observed. More difficult still for an individual observer, is combining a set of such local changes into a picture of change across a wider area – change across Wales as a whole, for instance, which is the subject of this report.

▲ Windfarm, mid Wales • © *Richard Evans*

Constructing an objective picture of change that is, as far as possible, immune to such spatial and temporal influences as those described above is a large part of what Countryside Survey aims to do. Through the use of a systematically designed sampling scheme based on randomly located 1 km squares, Countryside Survey aims to construct a representative picture of the Welsh countryside; by repeating the work periodically (and surveys have now been completed in 1978, 1984, 1990, 1998 and 2007) Countryside Survey aims to detect changes within it.

Why is this important? In part, because it helps to support an informed, objective evaluation of the success of efforts in Wales to manage natural resources in a sustainable way. Countryside Survey can help to identify changes that might be consistent with or, alternatively, be at odds with society's aims and needs, and thus contributes to the evidence base that is required to adapt and develop policy. This evidence base will grow with the continued analysis of the data to determine the drivers of change in the countryside such as land management, air pollution, variable weather patterns and climate change and their interaction. For example, is current land management resulting in the sustainable use of our soils? Will climate change make soils more or less vulnerable to particular land management practices? The data will also help answer some basic scientific questions such as what is the effect of changing biodiversity of plants on soil biodiversity and how do they interact and affect the different functions which the countryside provides for us? To what extent does the changing successional status of linear features and small habitat patches affect their viability as refuges for previously more widespread species? How do these same changes impact the permeability of the landscape for the movement of biota (native and non-native) in the face of climate change? To what extent can we use information on plant species composition and habitat structure from Countryside Survey to infer likely climate-driven changes in habitat suitability for animals such as birds and butterflies?

Countryside Survey has itself changed since its beginning in the late 1970s. This has included changes to bring a clearer alignment with the terminology of newer policies (especially the UK Biodiversity Action Plan), changes to take advantage of new technology, and – especially relevant here – changes in the number of 1 km squares recorded that now provide a basis for separate country-level assessments of state and trend. In Wales, the 2007 survey saw a large increase in the number of squares recorded (from 64 in 1998 to 107 in 2007) with the intention of being better able to report on the state of the Welsh countryside, and on changes occurring within it. With 2007 being the first survey in Wales to be based on an enhanced sample, the immediate benefits relate to the increased precision with which Countryside Survey estimates the current extent and condition of different elements of the countryside. Some additional benefit is apparent in the ability of Countryside Survey to reliably detect changes in these elements, but the full benefit of this increase in sample size will be realised in the future when comparing results from future surveys with those from the 2007 survey.

This report presents some early findings of the 2007 survey. In particular, it presents an improved baseline of the amounts and condition of habitats, key soil parameters and other elements of the landscape such as hedges and ponds. Changes in these are also presented where statistically significant, but in the knowledge that future surveys will provide a more powerful means of detecting geographically representative changes. Given the smaller sample size in previous surveys, a cautious approach has been taken in interpreting reported changes. Also, this report presents the first reporting round of an ongoing programme of research and analysis that will, over time, enable a more refined interpretation of the results.

9.2 The policy context

A hierarchical framework of policy and decision-making impinges upon the Welsh environment. Policy and legislative context is provided by the European Union and UK government; then, within Wales, the hierarchical pattern is manifest in the development and implementation of strategies at national, regional and local levels. Decisions made at each of these levels, and the actions that flow from such decisions, all contribute to the changes that are recorded in the countryside by Countryside Survey. In addition to these strategic decisions, there exists a further layer of decision-making, that performed by individuals whose actions directly affect the environment in which they live and work. Whilst sometimes influenced by policy, decision-making at this level may be subject to a wide range of additional individual motivations resulting from both economic and social factors. Moreover, some pressures on the environment may be rather more resistant to policy influences, most notably climate change. As a result of such less controllable factors, the relationship between policy and observed patterns of environmental change may not always be a strong and direct one.

A number of strategies at national level have been worked out that, in combination, aim to provide a framework for the integrated delivery of economic and social objectives. This finds its current expression in the Cymru'n Un/One Wales agenda of the Welsh Assembly Government. Within this suite of strategies, and of particular relevance to this report, is the vision of a distinctive and sustainable Welsh environment which lies at the heart of the Environment Strategy for Wales[53].

9.2.1 Environment Strategy context

The Environment Strategy both identifies and seeks to address a series of challenges that reflect the various pressures acting upon the environment:

- **Climate change**
- **Unsustainable resource use**
- **Degraded ecosystems**

[53] Note that some of the objectives of the Environment Strategy are also taken forward by other strategies, notably the Sustainable Development Scheme, the Climate Change Strategy, the Waste Strategy, the Wales Spatial Plan and the Wales Rural Development Plan.

- **Loss of biodiversity**
- **Poor quality local environments**
- **Environmental hazards**
- **Loss of landscape and heritage quality and distinctiveness**

Countryside Survey provides information that is relevant to most of these, and an initial assessment of Countryside Survey results in relation to each of these is presented later in this chapter.

Within this high-level framework, a range of sectoral strategies and programmes exist that variously impact on those aspects of the environment investigated by Countryside Survey. In the context of Countryside Survey, especially important are those relating to agricultural policy. In addition woodland policy, water policy, and the Town and Country planning system also impinge on aspects of countryside change that Countryside Survey records, to varying degrees. The new devolved Wales Biodiversity Action Plan process also aims to address countryside change, by influencing national and regional policies and strategies, and by promoting and supporting direct action for habitats and species.

Given the particular influence that agriculture exerts over the Welsh countryside, additional information is provided below on changes that have occurred between 1998 and 2007. Additional information is also provided in relation to woodland policy.

▲ Mathry, grazing pasture • © *Clive Hurford*

9.2.2 Agricultural Context

1. There has been a major change in the type of subsidies provided under Pillar 1 of the Common Agricultural Policy (CAP), which although somewhat reduced still accounts for some two-thirds of Welsh agricultural spending.

- During the period 1997- 2005, subsidies for sheep and cattle were provided on a headage basis. Since 2005 however, most farmers have been entitled to claim the Single Farm Payment. Whilst this is related to the level of subsidy paid during the period 2000-2002, it no longer depends on the actual level of production.

- The introduction of the Single Farm Payment removed the incentive to maximise livestock numbers, whilst at the same time driving a greater focus on market requirements. For example, the total number of sheep and lambs declined from 10.8 million in 1997 to just under 9 million in 2007. At the same time there has been a trend towards the use of larger heavier animals with anecdotal evidence suggesting that farming activity may now be focussing on the better quality land coupled with less use of rougher and more remote areas of grazing.

- All farmers in receipt of the Single Farm Payment must now abide by the terms of the cross-compliance system retaining their land in Good Agricultural and Environmental Condition[54]. Support payments can be reduced or may be withheld entirely should there be a breach in the required standards. The bulk of these relate to existing legal obligations, together with a smaller number of non-statutory requirements covering issues such as the management of soils and traditional field boundaries.

2. There has been a significant increase in participation in agri-environment schemes since they were launched in 1986 and throughout the period of the survey.

- Between 1999 and 2008, the number of agri-environment agreements increased from 4,120 to 8,620 whilst the coverage increased from 262,000 ha (16% of the Welsh agricultural area) to 680,000 ha (41%)[55]. This increase has been driven partly by the increased funding available under the Wales Rural Development Plan, but also reflects the significant coverage (c.300,000 ha) achieved under the less demanding Tir Cynnal entry-level scheme which was introduced in 2005.

- The replacement of Environmentally Sensitive Areas (ESA) and Tir Cymen schemes by the more demanding Tir Gofal scheme in 1999 placed a much greater emphasis on field boundary restoration; re-introduction of mixed farming practices (incorporating small-scale arable cropping and the use of cattle alongside sheep) and the use of streamside corridors and unfenced buffer strips. Participants were

[54] See www.wales.gov.uk

[55] Rural Development Plan for Wales 2000-2006 (page 294) and Sustainable Farming and Environment: Action towards 2020 (page 56).

also required to make a significant commitment to habitat restoration as well as to habitat maintenance. Over 330,000 ha (20% of the Welsh agricultural area) had been entered into Tir Gofal agreements by March 2007[56].

3. There has been a steady increase in the area of land devoted to organic farming.

- Between 1999 and 2008, the area of land managed under organic farming schemes increased from 2,350 ha[57] to 75,400 ha[58] whilst the number of agreements increased from 61 to 797.

4. Market forces are likely to have had a major impact throughout the survey period:

- The milk price has fallen in real terms driving many farmers out of the dairy industry. The remaining farms tend to be larger or more specialised. Despite the continued loss of dairy farms (reducing from 4,960 in 1997 to 4,200 by 2007) the size of the national dairy herd has actually increased (from 280,000 to 340,000)[59] but these cows are likely to be located on more profitable units better placed to invest in measures designed to reduce pollution such as slurry stores, separation of clean and dirty water etc.

- Beef and sheep prices improved towards the end of the survey period, but overall profitability has remained low in real terms. Prices for key inputs such as fertiliser and fuel increased significantly towards the end of the survey period, increasing the incentive to use such inputs more efficiently.

- Arable prices increased sharply towards the end of the survey period, but have now fallen back. Specialised arable farms occupy a very small proportion of the Welsh agricultural area (<3%) meaning that any changes within this sector are unlikely to have had a major impact on the countryside, other than in primarily arable areas such as the lowlands of South Pembrokeshire, Vale of Glamorgan and Vale of Clwyd.

5. Other factors likely to have affected agricultural land use during the survey period include:

- The delivery of significant support from European Structural Funds (in particular Objective 1 of the European Regional Development Fund) using the mechanism of the Wales Rural Development Plan during the period 2000-2006. In particular, a large number of Farm Investment Grants and a smaller number of Farm Enterprise Grants were provided as part of the Farm Development Planning process, with some £21.5M disbursed over the period 2000/01 – 2007/08[60]. Farm Investment Grants were used to improve on-farm infrastructure (livestock housing, slurry stores etc) whilst Farm Enterprise Grants were used to help farm businesses diversify into a wider range of commercial activities.

- The housing market remained strong throughout much of the survey period. This is likely to have accelerated the ongoing trend (driven by a complex mix of factors including changing lifestyle aspirations as well as market forces) towards greater specialisation, the decline of medium sized farms and the simultaneous formation of increased numbers of both larger and smaller enterprises. In particular, a strong residential market will have contributed substantially to the growth in the number of small-holdings, hobby farms, livery stables and blocks of land used primarily for keeping horses.

6. The Environmental Impact Assessment (Agriculture) (Wales) regulations were first introduced in 2002 and apply to all uncultivated and semi-natural areas in Wales:

- The regulations are designed to allow agricultural changes that do not significantly affect the environment or landscape whilst providing protection for land of special environmental, cultural or historical value. The regulations require that a screening decision be obtained from the Welsh Assembly Government before agricultural intensification is undertaken on semi-natural or uncultivated land.

- Since 2002 the Assembly have dealt with 348 applications under the regulations (to end of 2008).

- A benefit of these regulations is the educational value of discussions with the farmer during a site visit from an ecologist. Farmers are often willing to protect habitats on their farm but are often unaware of what areas may be of special importance.

9.2.3 Woodland context

Established policy largely protects woodland from change to agricultural use. The underlying principles of forestry policy over the last twenty or so years have been: (1) the sustainable use of our existing woods and forests; and (2) a steady expansion of tree cover to increase the many, diverse benefits that forests provide. Woodlands for Wales (2009) reiterates this with objectives that include:

- more woodlands and trees are managed sustainably;

- woodlands are better adapted to deliver a range of benefits;

- woodland cover in Wales increases.

[56] Wales Audit Office Report on Tir Gofal, November 2007 (page 52).

[57] Wales Rural Development Plan 2000 - 2006, (page 306).

[58] Sustainable Farming and Environment: Action towards 2020 (page 56).

[59] Data accessed from 'Farming Facts & Figures, Wales 2005' and 'Farming Facts & Figures, Wales 2008'. Welsh Assembly Government.

[60] Data accessed from 'Farming Facts & Figures, Wales 2005' and 'Farming Facts & Figures, Wales 2008'. Welsh Assembly Government.

Since the mid-1970s, when aggressive agricultural expansion threatened woodlands in parts of the UK, mechanisms such as the felling licence system[61], and latterly the Environmental Impact Assessment Regulations[62] have reduced the risk of woodland being removed for agriculture. The pressures to increase the area of land in agricultural use have been low over the past decade. Such losses of woodland cover as have occurred are thought largely to reflect the provision of new infrastructure (such as roads) or development.

Planning Policy Wales (2002) emphasises the importance of trees and woodlands as wildlife habitats and for their contribution to landscape character and beauty. Local planning authorities are directed to protect trees and woodlands where they have natural heritage value or contribute to the character or amenity of local areas. Special emphasis is placed on the protection of Ancient Semi-natural Woodlands, because they are irreplaceable[63].

Most woodland under management in Wales is grant aided by the Forestry Commission Wales. In 2006 the Woodland Grant Scheme was replaced by Better Woodlands for Wales, which is based on production of a management plan and is designed to deliver a range of environmental benefits. Grant rates are tiered so that, for example, restocking coniferous woodland is likely to be funded at a lower rate than broadleaf woodland. Incentives to restore Plantations on Ancient Woodland Sites (PAWS) are greater than the incentive to maintain plantation woodland. This is in line with the commitment to increase the area of restored ancient woodland and deliver Biodiversity Action Plan targets for woodland restoration.

▲ Woodland conservation management • © *CEH*

More than half of the 178,000 ha of privately owned woodland in Wales has never been in a woodland grant scheme and therefore is unlikely to be actively managed[64]. Agri-environment schemes have helped to increase the area of woodland which is fenced to allow levels of grazing to be controlled, but extensive areas of native woodland remain heavily grazed. There are some benefits as certain bird species such as pied flycatcher, are more common in heavily grazed oak woodlands. But in the longer term uncontrolled grazing represents a threat to the continued survival of these woods, and the poorer woodland structure is generally lower in biodiversity value.

Woodland expansion has been generally low in the past decade, largely due to high prices for agricultural land, and an unwillingness to commit land to such a significant change of use.

9.3 Synthesis of Countryside Survey results

9.3.1 A snapshot of the Welsh Countryside in 2007

▲ nr Llanrhaeadr • © *Michael D Smith*

The snapshot of Wales that the 2007 survey provides largely mirrors pictures of the Welsh countryside that other surveys and studies have provided in recent years[65]. Countryside Survey indicates that, together, semi-natural grassland and enclosed farmland (91% of which is Improved Grassland) make up 60% of Wales ***(Figure 9.1)***. Of the semi-natural grassland types, Neutral Grassland is most extensive (accounting for 55% of all semi-natural grassland) and species records indicating a high frequency of Perennial Rye-grass (*Lolium perenne*) ***(Chapter 3)*** suggest that most of this has undergone some degree of agricultural improvement. Improved Grassland and Neutral Grassland combined, account for 47% of the land cover of Wales.

Comprehensive surveys by CCW indicate that patches of unimproved Neutral Grassland are often small and very localised. Calcareous Grassland has an even more local distribution. Acid Grassland by contrast often occupies much larger areas, especially throughout upland Wales. Woodland is the next most extensive type, and occurs as patches of various sizes from small to very large. Coniferous Woodland especially often takes the form of very large blocks in some areas. A similar pattern of infrequent, localised but locally large areas characterises the distribution of Broad Habitats such as Bog and Dwarf Shrub Heath, as well as the distribution of most urban and other built land.

[61] Forestry Commission (2007) *Tree Felling – Getting permission* (Page 4 Proposed conversion to agriculture).

[62] Environmental Impact Assessment (Forestry) (England & Wales) Regulations 1999.

[63] Planning Policy Wales (2002) Welsh Assembly Government.

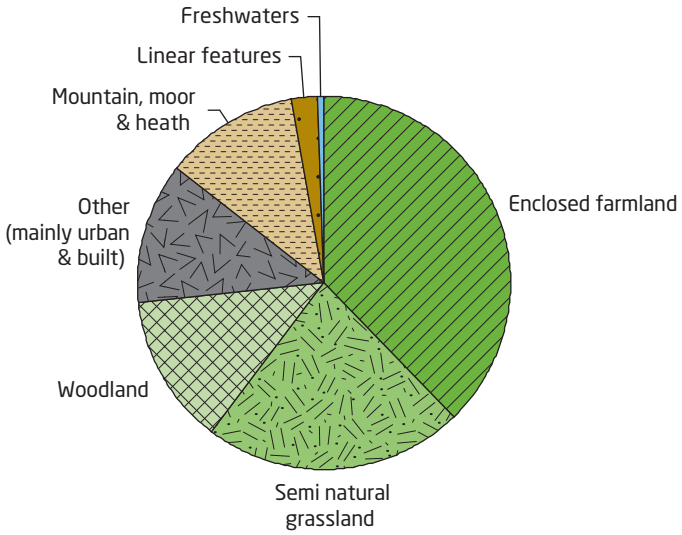
[64] *Woodlands for Wales, The Welsh Assembly Government's Strategy for Woodlands and Trees.* WAG, 2009.

[65] Habitat Survey of Wales, Land Cover Map 2000, earlier Countryside Surveys.

Our soils in Wales contain important stores of carbon which have accumulated over the last 11,000 years since the last glaciation. Across all vegetation types the stock of carbon in soil (0-15cm) is an average 63 t/ha. When calculated for Wales as a whole carbon in soil (0-15cm) is 144 Teragrams (10^{12} grams) equivalent to 10% of the value for Great Britain as a whole. It should be remembered, these values for soils (0-15cm) do not represent the total soil carbon stock of the different habitats. For example, there are large stocks of carbon in bog soils, since they are deeper and richer in carbon compared to most other habitats. Nevertheless, the top soil horizons are thought to be the most susceptible to change over time as they are more immediately affected by land management activities and environmental change and thus resources have been focussed on this top soil layer. Mean pH of this topsoil in Wales is 5.56 which is intermediate between that of Scotland (5.09) and England (6.51) and is an average pH arising from a complex mix of geology, soil types and land management in Wales.

Countryside Survey provides information on two freshwater Broad Habitats: Standing Waters & Canals; and Rivers & Streams. Combined, these represent only 1.2% of the area of Wales *(Figure 9.1)* but are important habitats for people and wildlife. The majority (83%) of open water bodies (Standing Waters & Canals Broad Habitat) are in the upland zone whilst the majority (62%) of watercourses (Rivers & Streams Broad Habitat) are in the lowland zone. Additionally, there are 47,000 ponds in Wales with 70% of these in lowland areas.

▼ **Figure 9.1:** Relative proportions of land cover in Wales in 2007. Composed of seven Broad Habitat groups (equivalent to chapter groupings).



9.3.2 Changes in the Welsh Countryside

A simple comparison of the pictures of Wales painted by the various surveys mentioned above suggests that the Welsh countryside has not undergone enormous changes in its make-up in recent decades. The dominant components of the Welsh countryside – various types of grassland and woodland – have remained as such. Semi-natural habitats of high nature conservation value occur within this matrix – in the uplands, extensive areas of heath and bog are present in some areas; in the lowlands, less modified habitats often exist only as small fragments, and larger areas are less common (raised bogs and coastal habitats are examples). Greatest losses of semi-natural habitats occurred during an earlier period, through conversion for more intensive agricultural use.

The changes (and the lack of changes) in habitat extent reported by Countryside Survey are in line with this broadly stable pattern. For many habitats, Countryside Survey provided no evidence of any change in extent, but for a few habitats, there was evidence of change, sometimes restricted to just the upland or lowland zone *(Table 9.1)*.

It is tempting to try to relate some of these changes directly to one another – to balance up an increase in one type against a decrease in another (for example, to suggest that the increase in Acid Grassland in the upland zone is in part a result of the reduction in Neutral Grassland in the same zone, perhaps as a consequence of relaxation of management of semi-improved grassland allowing the influence of the underlying acid geology to become more prominent). In most cases it would be premature to do this. Further analysis of spatial turnover of habitat area in the survey squares, and their associated uncertainty, is required before we can be confident about the actual exchanges between types and the extent to which these can be generalised across the countryside. Having said that, it is possible that exchanges between Acid and Neutral Grassland have occurred, and we should probably expect some of this anyway, simply as a result of the difficulty in differentiating between types that, in reality, grade into one another. Changes in the area mapped as Bracken Broad Habitat is another instance where mapping sensitivity, perhaps combined with weather effects and differences in timing of survey, may have made a significant contribution to reported change. It is also entirely plausible that the increase in Acid Grassland is a consequence of areas no longer being recorded as Bracken Broad Habitat even though bracken appears to have remained a major component of the vegetation. In a few cases (the increase in bracken, for example), methodological issues seem likely to have contributed to results; but such limitations are present in most large surveys and, through further analysis, it should be possible to identify the contribution that real change has made to reported changes.

The reported changes that we expect to be less sensitive to mapping sensitivity include the increase in Built-up areas & Gardens across Wales, the increase in Arable & Horticulture in the uplands and the increase in Broadleaved, Mixed & Yew Woodland in the lowlands. Of these, the change in arable and built land can only reflect actual changes in land use (neither type develops naturally from another type through shifts in management intensity).

▼ **Table 9.1:** Summary of changes in Broad Habitat extent in Wales between 1998 and 2007 based on results from Countryside Survey.

a) No evidence of change	
• Improved Grassland	• Dwarf Shrub Heath
• Calcareous Grassland	• Bog
• Coniferous Woodland	• Fen, Marsh & Swamp
• Standing Water & Canals	• Montane
• Rivers & Streams	• Inland rock

b) Evidence of increase (1998 to 2007)				
	Broad Habitat	Size of change (ha)	95% confidence limits	
Upland Zone	Arable & Horticulture	+ 4,272	+ 1,956	+ 9,764
"	Acid Grassland	+ 13,045	+ 1,100	+ 25,022
Lowland Zone	Broadleaved, Mixed & Yew Woodland	+ 8,851	+ 1,243	+ 15,814
All Wales	Built-up Areas & Gardens	+ 14,674	+ 5,809	+ 24,030

c) Evidence of decrease (1998 to 2007)				
	Broad Habitat	Size of change (ha)	95% confidence limits	
Upland Zone	Neutral Grassland	- 33,255	- 1,964	- 53,127
"	Bracken	- 26,589	- 3,366	- 55,521
All Wales	Bracken	- 46,659	- 7,413	- 94,473

▼ **Table 9.2:** Summary of changes in landscape features in Wales between 1998 and 2007 based on results from Countryside Survey.

a) No evidence of change	
• Lines of trees/shrubs/relict hedge	• Bank/grass strip
• Wall	• Fence

b) Evidence of increase (1998 to 2007)				
	Landscape feature	Size of change (km - linears; no. - ponds)	95% confidence limits	
Lowland Zone	Lines of trees/shrubs/relict hedge/fence	+ 2,039	+ 788	+ 3,080
"	Ponds	+ 5,903	+ 2,639	+ 13,152
All Wales	Lines of trees/shrubs/relict hedge/fence	+ 2,666	+ 1,153	+ 3,943
"	Ponds	+ 5,976	+ 1,605	+ 14,841

c) Evidence of decrease (1998 to 2007)				
	Landscape feature	Size of change (km - linears; no. - ponds)	95% confidence limits	
Upland Zone	Total woody linear features	- 2,740	- 1,499	- 3,942
"	Hedges	- 3,030	- 1,739	- 4,356
All Wales	Hedges	- 3,228	- 706	- 5,835

Similarly, the increase in woodland might reflect a change in land use through new planting, but could also result from successional changes – the development of scrub for example resulting from a reduction in management on other habitats.

For the increase in Built-up areas & Gardens, some further analysis has been completed that provides additional details about the nature of the change and the type of habitat that has moved into this category since 1998. Most of the change is a result of many small changes, typically related to new buildings (both urban and agricultural) but also to the creation of new gardens, with most change at the expense of either Improved or Neutral Grassland.

This change also appears to be consistent with increased funding to farmers under EU Objective 1 funding for new buildings and waste storage facilities.

Changes in the abundance of landscape features are summarised in *Table 9.2*. Among the various types of boundary features characterising enclosed farmland, changes were recorded only in the woody types (hedges and lines of trees). The emerging pattern suggests reduced management of hedges resulting in an increase in 'lines of trees' at the expense of more regularly managed hedges. During the same period, the number of ponds increased substantially, mainly in lowland Wales.

▲ Overgrown streamside plot, south Wales • © *CEH*

Beneath this level of gross change, where one habitat is transformed into another, an additional layer of changes occurs within habitats. These changes are usually less immediately apparent to the casual observer but can provide an indication of the first signs of changes in habitat composition that, in some cases, eventually lead to one habitat type changing into another. In other cases, it might simply reflect a sustained change in the quality or condition of the habitat. Rather than the step-changes in habitat type resulting from changes in land use, changes within habitats provide an indication of the more subtle shifts that can occur as a result of pressures such as climate change, air pollution, changes in management intensity and invasive alien species. At this early stage, no attempt has been made to establish links between individual changes and the action of individual pressures. This is a complex area, with suites of pressures potentially interacting and contributing in combined fashion to any single recorded change. Work to identify some of these relationships is currently underway and will be reported separately in 2010 as part of a project to quantify the status and delivery of ecosystem services across Britain. At this stage, however, we are able to attempt some preliminary assessment of whether recorded changes are consistent with existing understanding of the impact of particular pressures on the environment and whether recorded changes are thought to have additional significance ecologically, for example by impacting on fauna not recorded directly by Countryside Survey. There is also interest as to whether recorded changes are consistent with environmental policy aspirations.

Looking across the full range of habitats, a number of patterns emerge. First, there is a general trend for decreasing species richness ***(Figure 8.4)***. The size of the reduction was relatively small over the most recent survey period when averaged across all habitat types, but larger when examined over the longer period between 1978 and 2007, and particularly large within some habitats or locations (most notably along the banks of watercourses). Within this general pattern, there were more specific declines in the species richness of food plants used by butterfly larvae and farmland birds; this is particularly pronounced for butterfly larval food plants. Changes within other measures of vegetation condition suggest a general tendency for vegetation to have become characterised by an increased component of shade-tolerant species and taller, more competitive species. At the same time, species characteristic of open ground have tended to become less prominent in defining vegetation character. However, trends in these attributes (and others such as Ellenberg pH Score and Ellenberg Fertility Score) do vary somewhat between different habitats and landscape locations, and more detailed accounts can be found in the individual chapters of this report. Another notable change was the improvement in the physical characteristics of streams between 1998 and 2007.

▲ Unmanaged semi-natural grassland • © *David Allen*

Countryside Survey reports on a growing number of indicators that convey aspects of soil quality and the potential for supporting a range of key ecosystem services. Outcome 14 of the Environment Strategy for Wales is to manage soil to safeguard its ability to provide ecosystem services. The importance of these different services varies from place to place so that for example, crop production is important on fertile, level, well-drained lowland soils whilst downstream flood control and carbon storage are ensured by intact peatlands at the head of upland catchments. Countryside Survey is one of the few national datasets available which enable trends in soil (0-15cm) to be objectively followed for a wide range of habitats and thus to be scaled up to report for Wales as a whole.

▼ **Table 9.3:** Overall ecological trends in vegetation in Main or Linear Plots in each Broad Habitat for Wales between 1990 and 2007. Based on summarising significant changes in vegetation characteristics given in each Broad Habitat chapter. Species richness change is indicated if either the total number of species, number of butterfly larval food plants or number of lowland farmland bird food plants changed.

Broad Habitat	Species richness	Succession/shading (S) or disturbance/more open conditions (D)	More (M) or less (L) competitive species
Broadleaved, Mixed & Yew Woodland	↓	-	M
Coniferous Woodland	-	-	-
Linear Features	↓	S	M
Improved Grassland	↓	S	M
Neutral Grassland	-	-	-
Acid Grassland	-	-	-
Bracken	↑	-	-
Dwarf Shrub Heath	-	S	M
Fen, Marsh & Swamp	↓	-	-
Rivers & Streams	↓	S	M

The results indicate no major change in soil (0-15cm) carbon concentration for Wales as a whole and for all habitats with one exception; coniferous forests between 1998 and 2007. The message of no major change in soil carbon concentrations is consistent with that reported for Great Britain. It should be remembered these are results for soil 0-15cm only and not the whole soil profile. It does not include soil lost by erosion although a reduction in carbon concentration would be expected if the latter was widespread as soil decreases in carbon concentration down the soil profile. This result does not match the large decrease in soil carbon concentrations (0-15cm) reported by the National Soils Inventory monitoring programme in England and Wales between 1978 and 2003. The reasons for the difference in results between the two surveys are being investigated. Analysis is also focussed on spatial patterns of soil carbon concentration observed across Wales and their association with different vegetation types, land use and management, and other drivers of change.

A major change for Countryside Survey in 2007 was the introduction of data which enables calculation of carbon stock (0-15cm). This takes into account not only the carbon concentration of soil in the top 15cm but also the amount of soil. The amount of soil may change due to changes in compaction for example due to the use of heavy machinery or increased animal numbers. The increased information this provides has resulted in soil carbon stock being selected as an indicator of soil quality for State of the Environment Reporting. In Wales future surveys will contribute to determining change in soil carbon stock and the State of the Environment Reporting process. However, the 2007 baseline is extremely valuable in its own right. For example, when the 2007 carbon stock of soils (0-15cm) under arable land in Wales is compared to that which is observed in England, it may in the first instance appear that such soils (0-15cm) in Wales are degraded of carbon in comparison to those in England, but actually this result is very positive as it illustrates that in Wales the majority of soils used for arable cultivation are mineral in nature with a naturally low carbon stock and thus more appropriate for such land use.

The data from Countryside Survey reported here suggest that reductions in emissions of sulphur from industrial and power plants driven by UK-level air pollution control strategies have been successful in increasing the pH of soils (0-15cm) between 1978 and 2007. This is important as this will help buffer acidity in streams and rivers and also help plants which could not tolerate increased soil acidity. However, the rate of recovery appears to have slowed recently as there were sustained increases in pH only in some Broad Habitats dominated by less organic and less acidic soils between 1998 and 2007. Reasons for this are being investigated to help determine if this is a natural equilibrium for the more organic soils, an effect of continued elevated nitrogen deposition, which contributes to acidic rain, or land management practices or climate-driven phenomenon.

9.4 An initial evaluation of Countryside Survey results

In this section, an attempt is made to evaluate the significance of the reported results from two perspectives. An assessment is made of both the ecological and policy significance of the results. These assessments draw upon results relating both to the current state of habitats and landscape features, and results relating to change in these. In a few cases, assessments of state are made by comparing current estimates with established reference values or explicit targets reflecting environmental/countryside policy objectives.

No attempt is made here to evaluate the current habitat composition of Wales described by the 2007 'snapshot' against any broader vision of a Wales that seeks to meet multiple societal demands. Spatial planning is a major area of growing interest – how to plan (in a spatially explicit way) for an environment that delivers a required range of ecosystem goods and services. An evaluation of this sort requires present-day national habitat maps, a more explicit expression of what such a Wales could look like, and analysis of what trade-offs would need to be made. Is it possible, for example, to target improved food production in areas not valued for other

functions such as carbon storage, water flow regulation, and support of biodiversity? Countryside Survey helps to meet the need for up-to-date habitat maps through the production of an updated UK Land Cover Map based on satellite imagery. Another initiative relevant here, again using remote imagery, is the work by CCW to update the maps of the 1979-1997 Habitat Survey of Wales. The Integrated Assessment of Countryside Survey data is being used to identify potential trade-offs between different land uses and will be an essential data source for the UK National Ecosystem Assessment[66].

While the Countryside Survey field survey provides spatially restricted information about the distribution of habitats (limited to that within 1-km sample squares), the minimal representation of certain types in the sample does tend to emphasize the localised nature of their distribution. Such localised, fragmented distribution of habitats has a potentially profound ecological significance, especially in the face of pervasive pressures such as climate change. Improved connectivity of habitats is seen as an important means of making the environment more resilient to the effects of climate change, facilitating the movement of species through landscapes as the climatic limits to their distribution alter. Some of the changes recorded by Countryside Survey are considered below in terms of what they might mean in relation to habitat connectivity.

9.4.1 The influence of land use

Countryside Survey has detected clear patterns of increase and decrease in some habitats, namely an increase in Arable & Horticulture in the uplands, an increase in Broadleaved, Mixed & Yew Woodland in the lowlands, and an increase in Built-up areas & Gardens across Wales. The increase in built land and cultivated land has been mainly at the expense of Improved and Neutral Grassland (itself mostly showing signs of agricultural improvement, see above), both generally seen as being of fairly low nature conservation value, so probably of limited ecological significance. The ecological significance of the increases in arable and woodland will be influenced by the landscape context in which they have occurred, and by the nature of the habitats that they have replaced. Assuming they have not replaced habitats of existing high nature conservation value (an assumption that requires checking through further analysis), these increases could be viewed positively – the increase in Broadleaved, Mixed & Yew Woodland is consistent with the aims of the UK Biodiversity Action Plan, and the increase in arable is consistent with aims of agri-environment schemes, in particular with the objective of schemes such as Tir Gofal in seeking to restore farmland bird populations. Both of these changes may reflect responses to the financial support available to farmers and other land managers. Planting of new woodland has been supported by Better Woodland for Wales. Changes in arable production within the uplands may be related to the increased uptake of agri-environment schemes; the expansion of organic farming and the introduction of new agricultural practices (such as the production of arable silage) as part of a continued effort by livestock farmers to reduce the costs of inputs such as straw and animal feeds by growing more of their own supplies.

▲ Poppies and Corn Marigolds • © *Clive Hurford*

Other changes in habitat extent (Bracken, Neutral and Acid Grassland) might be related to changes in management or the action of other pressures but they may also be influenced by methodological issues, and further work is required to determine the relative contributions of these factors to reported change.

The pattern of stability across many habitats suggests, at least, that they are not being converted in any large degree for more intensive land uses. But equally, such stability provides little evidence of progress towards meeting the habitat expansion targets set out in the Biodiversity Action Plan. Some caution should be exercised here, however, and we should not exclude the possibility that Countryside Survey has too little statistical power to detect all changes that are taking place – this is especially likely for rare habitat types of high nature conservation value, where both gains and losses might go undetected; the apparent stability of Calcareous Grassland might be a case in point. In some cases, policy encourages a degree of stability – for example, woodland is protected by the felling licence system and a presumption against the transfer of woodland to agricultural land use. Similarly, conversion of semi-natural vegetation to Improved Grassland is protected by the Environmental Impact Assessment (EIA) (Agriculture Wales) Regulations 2007.

9.4.2 The influence of land management practices

Among the various changes in condition recorded within individual habitat types, and in certain landscape locations, for example along hedges, roadsides and streamsides, the declining pattern of species richness is striking and seemingly at odds with the aim of reducing or halting biodiversity loss[67]. But we should be cautious in rushing to a simplistic conclusion. A decline in species richness might not always be viewed negatively; in some situations it may be a consequence of other, desirable changes. In woodland, for example, a reduction in species richness may in part be a consequence of the gradual maturation of woodland that is recovering from major disruption caused by extensive felling in both World Wars, combined with a generally low level of management intervention in the last few decades.

[66] www.unep-wcmc.org/eap/ukNationalEA.aspx

[67] Explicit aim of biodiversity action at global and national levels, with target to achieve this by 2010.

Even the most dramatic of reported declines in species richness – the decline on streamsides – need not be viewed as universally negative. A range of measures (including Agri-Environment Schemes and management agreements on Sites of Special Scientific Interest) have provided support for the creation of streamside corridors, and streams have been fenced and managed to meet a number of objectives – provision of improved habitat for fish, provision of corridors for mammals, buffering of watercourses from the impacts of adjacent agriculture, and improvement of bankside stability. The exclusion of grazing animals from such areas results in increased growth of vegetation and successional change – and Countryside Survey results suggest that changes of this sort have indeed occurred. These changes may in turn have contributed to the improvement in the physical characteristics of streams. So, there is a tension here between the provision of some specific environmental benefits and the less desirable, but general reduction in species richness. Examples such as this serve to illustrate that complex trade-offs are required if the countryside is to be managed in a balanced way for the achievement of multiple objectives.

Observed patterns of change are not only consistent with specific changes in management of the sort described above. Some of the changes recorded by Countryside Survey might be related to more general long-term trends in land use and management. Many of these changes appear consistent with successional processes that may in turn be a result of changes in the way the countryside has been managed over the last 50 or more years. In lowland Britain in particular, evidence from a range of sources points to a shift away from landscapes characterised by a mixture of farming practices and lower nutrient inputs[68]. Instead, many rural landscapes have become progressively more simplified and generally richer in nutrients[69]. Agriculturally marginal habitats are now much less likely to be exploited (with a greater risk of abandonment, particularly in the lowlands) whilst agricultural activity on the more productive land is focused on maximising profitability through economies of scale and increasing specialisation.

9.4.3 The influence of air pollution, weather and climate change

Air pollution, including sulphur dioxide, is of particular concern to Wales where 58% of semi-natural habitats receive acidic deposition at rates likely to cause damage in the long term i.e. the critical load for acidity is exceeded[70]. There is clear evidence this acidic deposition has led to a decrease in the pH of both soils and waters in Wales with associated change in plant and animal communities. However, emission control policies have been successful in reducing sulphur deposition which is a major component of acid rain. The observed increase in soil pH over the survey period corresponds to this decrease in sulphur deposition over a similar time period suggesting a positive policy impact related to reduction of sulphur emissions and atmospheric deposition. Initial exploration of the data suggests that changes in soil pH are correlated with consistent changes in plant species composition, however quantitative analysis of the role of changes in sulphur deposition in driving these interactions has yet to be completed.

▲ Port Talbot • © *Richard Evans*

Another component of air pollution identified in previous Countryside Surveys as a potential driver of ecosystem change, is nitrogen deposition. Atmospheric nitrogen originates from power plants, transport, industrial and agricultural sources making it a complex pollutant to control. Currently, 87.5% of semi-natural habitats in Wales receive nitrogen deposition at rates likely to cause damage to sensitive components of the ecosystem (i.e. their critical load for nutrient nitrogen is exceeded). Previous analysis of Countryside Survey data across the whole of Britain showed that small but significant amounts of the observed change in plant species composition were widespread and indeed correlated with atmospheric nitrogen deposition[71]. Analyses that incorporate the 2007 data and seek to attribute observed changes to nitrogen deposition among other contending drivers, are ongoing and not yet complete. Whilst signals of eutrophication are present in the results presented here – most notably in small habitat fragments within areas of Improved Grassland ***(Table 2.6b)*** and Acid Grassland ***(Table 3.7b)*** – detection of change in vegetation condition is not in itself a reliable indicator of correlative relationships with possible causal factors.

Further analyses are also needed to determine if the weather around the time at which each 1-km square was surveyed translate into detectable impacts on vegetation condition measures. For example, changes in weather may have encouraged more moisture-loving species and greater accumulation of biomass, with the result that fewer seasonal vegetation gaps exist to be exploited by weedy species. It has also been proposed that the substantial change in bracken cover may be linked to the impact of very high rainfall in parts of Wales in the summer of 2007 (see ***Chapter 6***). Even for soils, weather may be important – the expansion of soil in wetter conditions may lead to the soil sample coring technique sampling to a shallower depth. Analyses are underway to examine all these possibilities as it is important to differentiate the impact of within-year weather effects from those that might be linked to the recent warming trend as well as other drivers highlighted above.

[68] Chamberlain *et al* (2000) *J. Appl. Ecol.* **37**, 771-788.

[69] Smart *et al* (2006) *J. Appl. Ecol.* **43**, 1128-1137.

[70] www.critloads.ceh.ac.uk

[71] Smart *et al* (2004) *WASP Focus.* **4**, 269-278.

▲ Passing rain • © *Richard Evans*

Warmer conditions may also be expected to cause a reduction in soil carbon concentrations but Countryside Survey data suggests no change is detectable to date.

A warming climate might be expected to favour a range of non-native species. However, Countryside Survey suggests that such species are relatively scarce in the wider countryside, and that overall, non-native species richness has decreased since 1978 *(Fig 8.4)*. Depending upon the non-native species type and landscape location, different factors could be involved; gap-colonising ruderals would not be favoured by increased biomass linked to wetter and warmer growing seasons whilst shade-intolerant herbs are likely to be reduced by increased growth of shrubs and trees.

▲ Flooding in the Welsh borders • © *Colin Barr*

9.5 Implications for policy

The development of more wooded vegetation on streamsides and other linear features, along with the shifts in physical structure of some hedges, and the increase in extent of Broadleaved, Mixed & Yew Woodland in lowland Wales might be seen as contributing to the increased connectivity of the countryside. Increased connectivity theoretically makes is easier for a range of species to move across patchy landscapes thereby ameliorating the impacts of previous fragmentation and increasing resilience in the face of climate change. Increased woody cover will also tend to favour shade-tolerant rather than shade-intolerant species, the latter more typical of non-wooded semi-natural habitats such as grasslands and fens. Once again, there appears to be a trade-off here between the realisation of an environmental benefit (increased connectivity) and a potential loss of diversity. Given the strong probability of ongoing climate warming, the loss of species is not consistent with maintaining a diverse species pool that has maximum flexibility to respond to expected environmental change.

Maintenance of biodiversity within habitats depends in part on the existence of habitats in a range of different states, with different species typically favouring different stages of development. If most stands of any particular habitat converge towards a uniform structure and composition, then opportunities are reduced for the wider range of species that can exist when a range of habitat states is present. So, while the reduction in species richness seen in streamsides (for example) can be associated with measures that bring some particular environmental benefits, if the measures are applied very widely, then a balanced delivery of environmental objectives is unlikely to be achieved. Previous work on Great Britain-wide patterns of change showed that between 1978 and 1998, reductions in mean species richness have been accompanied by a reduction in the variety of types of plant across the countryside[72]. This has tended to result in a residual mosaic of more species-poor habitats characterised by their own typical dominants. The situation is not quite so simple though since, in some situations species richness increased. Further work is needed that includes the latest survey data and determines the extent to which these patterns can be detected in the separate UK countries and whether changes in species richness are correlated with changes in habitat diversity or area, and therefore with land-use change.

The loss of species from streamsides, or from other habitats, might not be viewed negatively if these same species were retained elsewhere in the immediate countryside (the loss might be viewed as an appropriate trade-off against delivery of other environmental benefits). Analysis of earlier Countryside Survey data has proposed the importance of small fragments of semi-natural habitat (such as exists on streamside, alongside hedges, and in other small patches (as measured in Countryside Survey by targeted plots)) as refuges for species declining elsewhere in the countryside. But analysis of current data suggests that species richness is decreasing across a wide range of such locations, suggesting that there may be limited scope for declines in some areas to be compensated for by maintenance of higher levels elsewhere.

[72] Smart *et al* (2006) *Proc.Roy.Soc.B.* **263**, 2659-2665.

▲ Diverse successional habitats across the Welsh landscape, Epynt • © *Michael D Smith*

The decline of species used as food plants by farmland birds and butterfly larvae suggests an immediate additional significance. This trend in food plant abundance is in line with trends shown by the two species groups since the 1970s. UK farmland bird populations have declined by 48% since 1970, and woodland birds by 21% (though since 2000 the trend in the latter has stabilised)[73]; UK populations of butterfly species associated with semi-natural habitats ('specialists') have declined since 1976 while populations of species found in the wider countryside ('generalists') have remained stable (and both appear to have been stable since 2000)[73]. A similar pattern of decreasing populations of birds of farmed habitats is evident within Wales. Further work is required to produce equivalent trend indices for butterfly populations in Wales.

▲ Small Tortoiseshell • © *Richard Evans*

The value for biodiversity conservation of retaining a wide range of habitat states in the countryside (reflecting different stages in their development) was mentioned above. A similar argument might be advanced in relation to other features – maintenance of landscape diversity (as well as associated biodiversity) might be served through the retention of features such as hedges, walls and ponds in a range of states, contributing to what has been called 'ecological infrastructure' in the EU Biodiversity Action Plan for Agriculture[74]. Convergence towards a single or just a few states would result in increased uniformity across landscapes (though it may be that a degree of such uniformity at local levels helps define local landscape character). The decrease in length of managed hedge and corresponding increase in lines of trees, detected by Countryside Survey, suggests one pattern of change among woody field boundaries that is indicative of reduced management intervention. But other results are more consistent with the opposite trend – the low proportion of hedges meeting the criteria that define good condition is likely to be at least partly a result of intensive management. This suggests the possibility that there may be a degree of polarisation occurring in relation to hedgerow management, with quite intensive intervention in some instances, and minimal intervention in others. In any case, most hedges fail to meet biodiversity objectives.

Hedgerows are one Priority Habitat type where we can, without additional analysis, compare results from 2007 with targets set under the UK Biodiversity Action Plan. Targets have been developed that reflect the aims of maintaining and increasing the extent of hedgerows, and of achieving a particular structural and compositional state. The lack of any significant change in the length of woody linear features across Wales suggests that some combination of agri-environment schemes, cross-compliance and the Hedgerow Regulations has effectively halted net loss. The length of hedgerows covered by the UKBAP is likely therefore to have remained stable, though with no progress towards meeting hedgerow expansion targets. The results relating to hedgerow condition are less positive, and a higher proportion of Welsh hedges fail structural and margin criteria than hedges elsewhere in Britain. Assessed against all criteria, only 7% of Welsh hedges met the desired condition criteria. Over half of hedgerows have a structure that fails to reflect that sought under the UK Biodiversity Action Plan, and many of those that do have satisfactory structure are seen as having too narrow, missing or otherwise inadequate margins. In Wales, unlike in England, there is no cross-compliance for a 1 m strip of vegetation to be left uncultivated and unsprayed along boundary features, and agri-environment schemes offer the only mechanism for influencing this.

[73] *UK Biodiversity Indicators in Your Pocket* (2009). Online at www.jncc.gov.uk/biyp

[74] http://europa.eu/legislation_summaries/agriculture/environment/l28024_en.htm

The relative abundance of walls in different states *(Chapter 4)* also hints at a degree of polarisation, with a relatively high proportion of walls in excellent or sound condition but also a high proportion in deteriorating or worse condition. This same pattern is apparent in both the upland and lowland zones, though proportionately more walls in the uplands are in a worse condition. There is some suggestion in the data that the pattern seen in the upland zone may, over time, be observed in the lowland zone. Without intervention, the high proportion of lowland walls in the earlier stages of deterioration will only become increasingly derelict. It seems likely that, at some point, such changes as these would translate into an impact on the distinctive character of certain Welsh landscapes.

The increase in the number of ponds is a positive result, helping to reverse the substantial losses experienced as a result of agricultural intensification during the mid 20th Century. However, when compared against reference values indicating unmodified conditions, most are seen to be of poor or very poor ecological quality. Lowland ponds are created for a variety of reasons, and some may have been created only recently as a result of attempts to store water, an activity supported by grants and incentives. However, the young age of ponds does not alone appear to account for the high proportion of poor/very poor quality – initial evidence suggests that longer established ponds are also often of poor ecological quality. This is not surprising since lowland standing waters are at significant risk of nutrient enrichment from agricultural run-off in Wales, and are particularly vulnerable owing to their high water residence times and proximity to agricultural activity. If an improvement in the ecological quality of ponds is desired, in addition to an increase in their number, then advice on location of new ponds might need changing. Action to address nutrient enrichment through agri-environment schemes or other measures is also likely to be needed.

For soils, the benefit of continued reductions in sulphur emissions are clear in the increased soil pH observed for the more mineral soils. Data analysis is ongoing to determine if other drivers of change such as nitrogen deposition or land management are slowing recovery in the organic soils where pH did not significantly increase between 1998 and 2007. If this is the case, then this may need to be considered in future policy development. Soil carbon concentration results indicate no major changes over the last 30 years. However, this could be a combination of a complex mix of factors some of which may increase soil (0-15cm) carbon concentrations e.g. increased carbon inputs from plants due to nitrogen deposition and increased carbon dioxide in the atmosphere, whilst some may reduce carbon concentrations e.g. intensive land management and a warmer climate. Only by further analysis of Countryside Survey datasets in combination with experimental and survey data from other studies and modelling approaches will be able to advise on the likely future trends of soil carbon and the causes of these changes.

▲ Lowland pond plants; *Potamogeton natans* and the invasive non-native *Azolla filiculoides* • © *Clive Hurford*

Overall, what emerges from this initial evaluation of the results of Countryside Survey, is a mix of both positive and negative changes. This is outlined in *Table 9.4*. In some cases change may imply a positive outcome for some Environment Strategy challenges and a negative outcome for others, reflecting the complex trade-offs sometimes involved in making decisions about land management.

▼ **Table 9.4:** An evaluation of the status of habitats, landscape features, soils and freshwaters in Wales from Countryside Survey in 2007 in light of Environment Strategy key challenges. **Red** = results suggest an undesirable outcome not consistent with tackling the challenge. **Green** = desirable outcome consistent with tackling the challenge. **Orange** = equivocal result with both inherently positive and negative aspects or where uncertainty prevents a more accurate evaluation.

Environment Strategy Challenge	Messages from Countryside Survey
Climate change	No change in soil carbon concentration (0-15cm) contrary to previous reports for England and Wales. The trend towards warmer conditions could be expected to increase carbon loss from soils but compensatory increases are possible due to increased plant growth due to elevated CO_2 and nitrogen deposition and reduced intensity of some land management practices.
	An increase in woodland extent, and in tree and shrub dominated vegetation on linear features might contribute to improved landscape connectivity.
	There is no direct evidence of climate change impacts though weather patterns in the short term, at least, could have influenced vegetation condition measurement. Analyses seeking to attribute observed signals to climatic drivers are scheduled but not yet complete.
	The general pattern of reduced species richness is at odds with maintaining a diverse pool of species able to respond to environmental change.
Unsustainable resource use	No change in soil carbon concentrations suggesting current land use and management practices are not causing wide-scale loss of soil carbon (0-15cm).
Degraded ecosystems	Physical characteristics of headwaters improved and number of ponds increased.
	Increase in tree and shrub cover on streamsides increases buffer-zone function and enhances interception of enriched run-off.
Loss of biodiversity	No change in species richness across the major areas of Acid Grassland, Neutral Grassland and Dwarf Shrub Heath.
	Non-native species, including invasives, are scarce in the wider countryside and non-native species richness has declined. The extent to which some of these declining species could be potentially important functional components of future communities requires further research.
	Increase in area of Broadleaved, Mixed & Yew Woodland in lowland Wales. Full evaluation requires information on habitats lost to new woodland and potential drivers of the change.
	36% reduction in plant species richness on streamsides since 1978 associated partly with increased tree and shrub cover.
	Declines in the species richness of food plants of butterfly larvae and farmland birds have direct implications for these animal groups.
Loss of landscape and heritage quality and distinctiveness	Rate of hedgerow removal has declined.
	Walls are in overall better condition in lowlands but a large cohort is deteriorating.
	There is a large proportion of derelict walls in the uplands.
Poor quality local environments	An increase in built environment category suggesting possible reduction of green space surrounding urban environments and in rural settings as much of the increase replaced Improved or Neutral Grassland and Boundary & Linear features.
Environmental hazards	Changes in pH of soils (0-15cm) are consistent with recovery of ecosystems from acidification following large-scale reductions in sulphur emissions.
	87.5% of the area of semi-natural habitats in Wales still receive atmospheric nitrogen above the Critical Load. Previous work has attributed a small part of the GB-wide change in plant species composition in Countryside Survey to nitrogen deposition. Further analyses are needed to extend this attribution work to the 2007 data and to determine the relative importance of the range of potential drivers of the eutrophication signal in Wales.
	Only 5% of ponds in Wales are in good condition possibly due to diffuse pollution sources.
	No change in the biological condition of headwater streams. Further analysis is required to distinguish between stretches showing a) lack of improvement from a degraded state, b) stability at good condition.

Countryside Survey

Further information and future analysis

More details of the methodology, analyses and results from Countryside Survey can be found in other companion reports and data resources available from the Countryside Survey website.

This report for Wales is one of a suite of reports that have either already been published or are scheduled for publication in the next year or two. The UK results of Countryside Survey were published in November 2008, and this report is one of several country reports that are being produced in summer 2009.

More detailed analysis of particular components of the survey – soils, streams and ponds – will be reported later in 2009 in separate themed reports. A detailed, integrated assessment of Countryside Survey data alongside other datasets, exploring what the results mean for provision of selected ecosystem goods and services, will be reported in 2010. While these reports will make use of the fuller Countryside Survey dataset, rather than a single country dataset, the results will have considerable relevance for Wales. Rather than marking the end of our evaluation of what Countryside Survey results mean for the Welsh countryside, this current report only marks the beginning.

Reports:

- UK Headline Messages – *published November 2008*
- UK Results from 2007 – *published November 2008*
- Detailed Northern Ireland Countryside Survey results – *published 2010*
- England Results from 2007 – *due to be published August 2009*
- Scotland Results from 2007 – *published 25th June 2009*
- Ponds – *due to be published Summer 2009*
- Streams – *due to be published October 2009*
- Soils – *due to be published November 2009*
- Integrated Assessment – *due to be published 2010*

Data resources:

- Web access to **summary data** – a systematic summary of the results used to inform the UK and country level reports – *launched in November 2008 and updated in January 2009*
- Web access to the **actual data** – data from individual survey squares used to generate all the results presented in Countryside Survey reports from the 2007 survey – *licensed access available from June 2009*
- The UK Land Cover Map for 2007 – *September 2009*

The data generated by Countryside Survey will continue to be investigated in conjunction with other information such as climate, pollution and agricultural statistics. It is anticipated that future analysis of Countryside Survey data will lead to many scientific journal articles over the coming years. These investigations will improve understanding about the possible causes of the changes detected in the countryside and, for example, provide an opportunity to explore the results for Priority Habitats in more detail.

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Further information on Countryside Survey can be found at:

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▲ 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

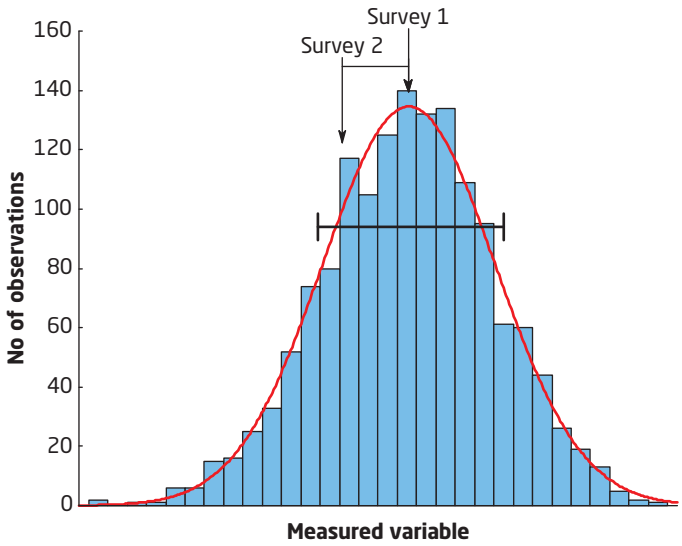
Ecological significance is not the same as statistical significance. An observed change can be statistically significant for large enough samples but unimportant in ecological terms, and vice versa. The ecological implications of an observed change can be assessed in terms of the standardized effect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

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▲ 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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