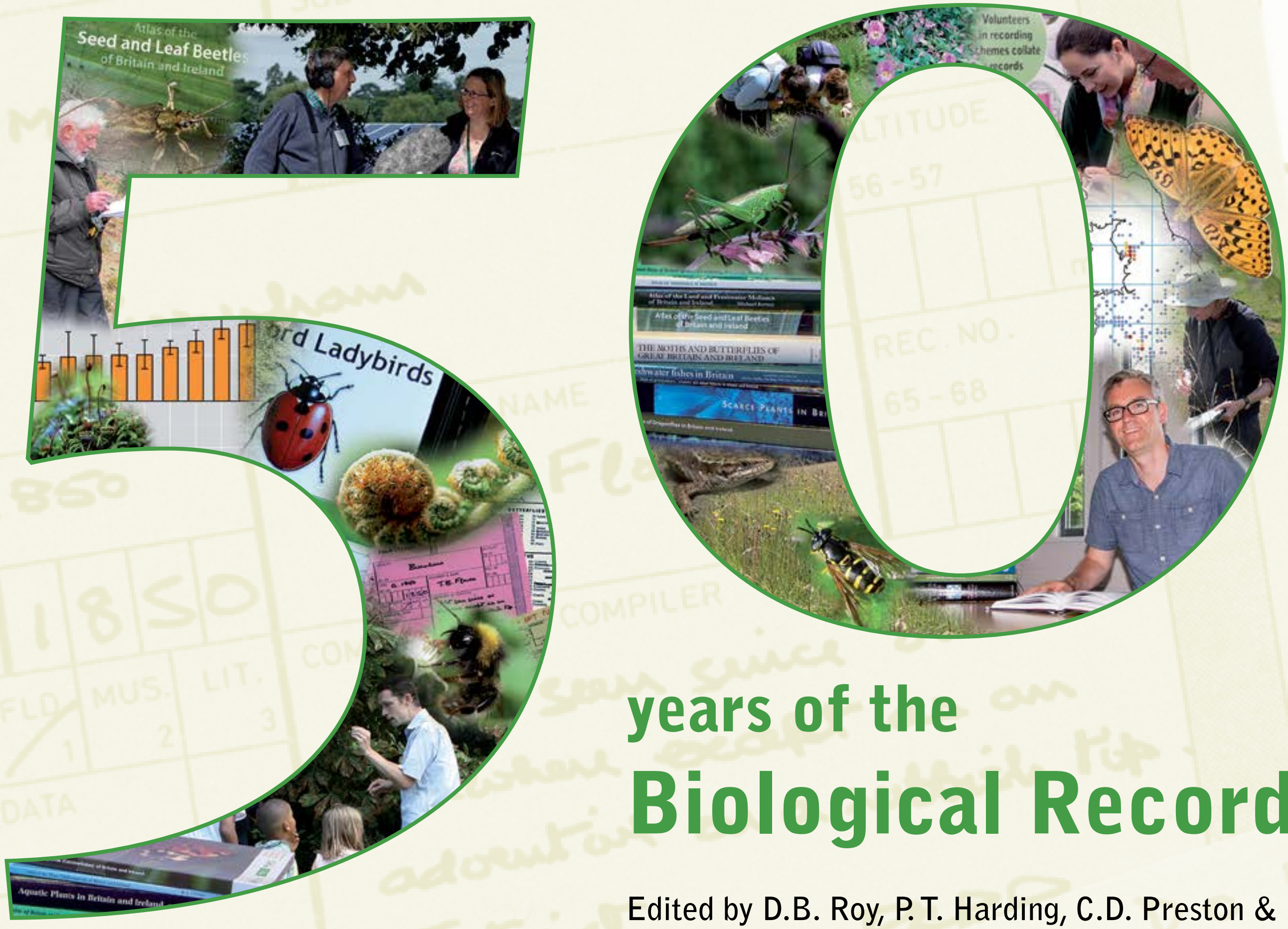
Celebrating



years of the Biological Records Centre

Edited by D.B. Roy, P.T. Harding, C.D. Preston & H.E. Roy (2014)

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

BRC Biological Records Centre

JNCC
Joint Nature Conservation Committee

BIOLOGICAL RECORDS CENTRE

50 years

19 current staff

C16th Earliest plant record

47K insect-plant interactions

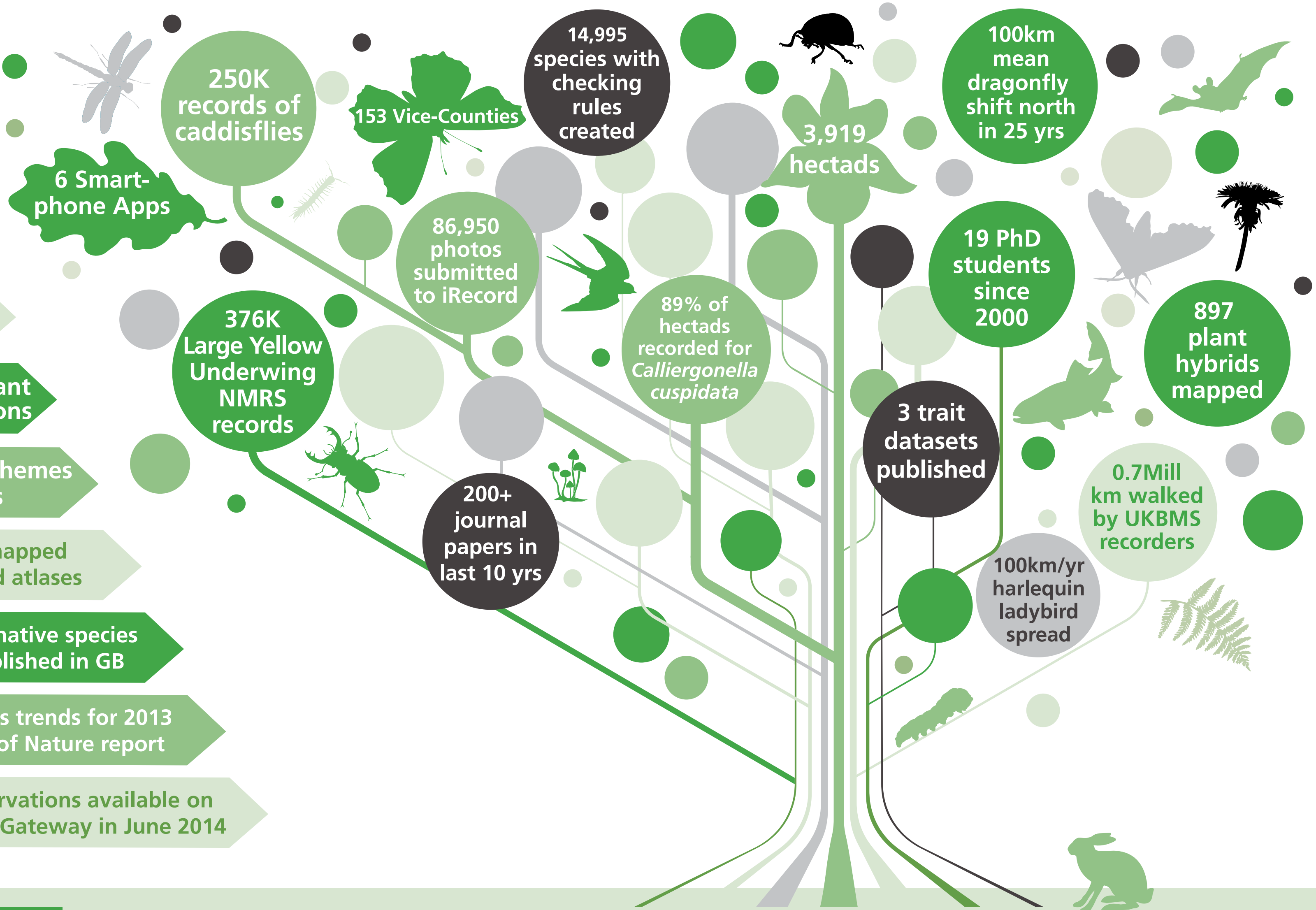
85 Recording Schemes and Societies

10K species mapped in printed atlases

1,919 non-native species established in GB

2,373 species trends for 2013 State of Nature report

96Mill observations available on NBN Gateway in June 2014



BRC Biological Records Centre

www.brc.ac.uk

Infographic based on information from BRC and the wider recording community. Photo of *Chorthippus parallelus*: Shutterstock.

FOREWORD

The UK is extremely fortunate in its rich history of naturalists – such as Gilbert White with his 1789 classic *Natural History and Antiquities of Selborne* or the army of Victorian enthusiasts (often vicars) who pressed flowers, collected butterflies and documented their parishes. These enthusiasts required structures, which led to an array of societies, such as Botanical Society of London formed in 1836, who became the Botanical Society of Britain and Ireland. Ambitious atlas projects generate a mass of important data of obvious value in the future so the Biological Record Centre (BRC) was born fifty years ago as a repository and to provide support.

The BRC has been central to much of UK conservation practice and research. The work on climate change impacts on distribution patterns is especially well known. The detailed distribution information means the BRC is central to much of the routine conservation practice in determining priorities and assessing possible threats. The BRC has also been fundamental to the National Biodiversity Network Gateway, an ambitious plan to bring together the main sources of UK biodiversity information.

We live in exciting times for monitoring, as seen by the BRC becoming increasingly more sophisticated in dealing with data. A range of novel techniques provide new opportunities for the application of natural history skills, such as the crowd sourced communities emerging to identify photographs or the apps that encourage field identification of neglected groups. We can be sure that everything will change: be it identification, documenting, feedback, or uses of the data. Thankfully I am sure that the real heroes of this story, the army of naturalists following in Gilbert White's footsteps, will relish these challenges.

Photo: Courtesy of Tessa Sutherland

Bill Sutherland
Miriam Rothschild Professor of Conservation Biology,
University of Cambridge

William Sutherland

William J. Sutherland

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CITATION

Roy, D.B., Harding, P.T., Preston, C.D. & Roy, H.E. (eds.) (2014). *Celebrating 50 years of the Biological Records Centre*. Centre for Ecology & Hydrology.

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The Biological Records Centre (BRC) is within the NERC Centre for Ecology & Hydrology and jointly funded by NERC and the Joint Nature Conservation Committee (JNCC). The BRC, established in 1964, is a national focus in the UK for terrestrial and freshwater species recording. BRC works closely with the voluntary recording community, principally by supporting national recording schemes and societies.

THE BRC - WHO ARE WE, WHAT WE DO, WHY WE DO IT

WHO WE ARE

The Biological Records Centre (BRC), part of the Centre for Ecology & Hydrology (CEH), provides a focus for the collation, management, dissemination and interpretation of species observations (biological records). BRC is based in Wallingford, near Oxford, having formerly been at Monks Wood near Huntingdon. Most records are collected by volunteer recording schemes and societies, which are integral to the work of BRC. We benefit from a long-term funding partnership between NERC and the Joint Nature Conservation Committee (JNCC).

WHAT WE DO

- Together with more than 80 recording schemes and societies, BRC supports biological recording for a wide range of plant and animal groups.
- BRC helps the recording community to publish atlases, data and other online resources and thus to provide essential information which informs research, policy and the conservation of our heritage of wildlife.
- Innovative use of technology helps to harness the enthusiasm and knowledge of naturalists and to enable them to collate and analyse their records.

WHY WE DO IT

- The historical legacy of biological recording in the United Kingdom is unique and inspiring.
- Many naturalists are committed to studying our flora and fauna, and BRC's work helps to ensure that we make the most of their observations.
- The vast datasets built up through the expertise and commitment of the volunteer recording community enable a range of ecological questions to be addressed.
- Distribution trends derived from the large-scale and long-term datasets provide evidence for many purposes, particularly in relation to understanding environmental change.

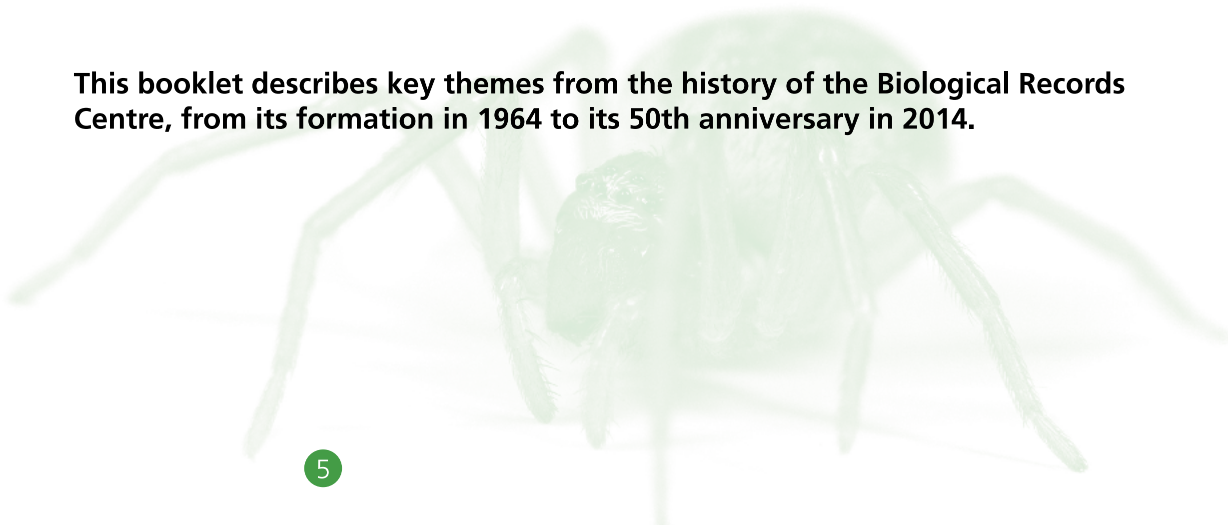


Photo of *Nigma walckenaeri*: Courtesy of Ed Phillips

This booklet describes key themes from the history of the Biological Records Centre, from its formation in 1964 to its 50th anniversary in 2014.

AD 70s
Pliny the Elder *Naturalis Historia*

10th/11th century
Manuscripts *Leechbook of Bald* and *Lacnunga*

1670
Publication of John Ray's *Catalogus plantarum Angliae*

1753
Publication of Carl Linnaeus' *Species Plantarum*

1836
Botanical Society of London formed

1852
Publication of H.C. Watson's *Cybele Britannica Vol 3*

1876
The Conchological Society of Great Britain and Ireland formed

The father of recording – John Ray

Photo: By permission of the Linnean Society of London

Although our ancient and medieval ancestors would have recognised plant and animal species of practical relevance to them, the recording of plants, birds and fishes out of intrinsic interest had become well established by the 17th century, mainly among educated and influential men. The Essex naturalist John Ray drew on their interest in plants for the Catalogus, effectively forming a recording community with his friends. As the Linnean system of species nomenclature became rapidly adopted internationally and, with advances in printing technology, the study and sharing of species information became possible for many people.

NATURAL HISTORY SOCIETIES

Natural history societies began to form as early as the mid 18th and throughout the 19th century. Initially, memberships mainly comprised well educated men, but by the mid 19th century women were increasingly involved. Some societies, particularly in cities, were associated with movements for the education of adults from less privileged backgrounds. The identification of species and documenting their distribution became important to many societies, often using the Watsonian vice-counties for such records. By the early 20th century most local and national societies had a healthy mix of both self-educated and academically qualified members, which continues to the present day.

SLOW PROGRESS TOWARDS DEVELOPING A NATIONAL SYSTEM

The Central Committee, formed in 1904 could have led to some coordination of biological recording, at least for plants. This was not followed up, in part due to World War I. Subsequent proposals for a national atlas, which would have included species distributions, later succumbed to World War II. Although a conference of the British Association in 1947 considered a proposal to produce "basic maps for the plotting, classification and correlation of natural history records", no action was taken.

A key member of this group of academics, Sir Arthur Tansley, recognised the potential role of amateurs, and stated that their "acquaintance with their local floras is absolutely unequalled".

1904 Central Committee for the Study of British Vegetation formed

1940 Plans for a national plant atlas published

1949 Nature Conservancy founded

1950 BSBI Conference "Aims and methods in the study of the distribution of British plants"

1954 BSBI's Atlas of the British Flora project launched at a 'special conference'

1962 *Atlas of the British Flora* published

1964 Biological Records Centre formed at Monks Wood

BOTANISTS TAKE THE LEAD

The resolution at the BSBI conference in 1950 to map the British (and Irish) flora resulted from a happy convergence of several inter-related factors [See right]. With funding from the Nuffield Foundation, and later from the Nature Conservancy, the Atlas of the British Flora project was launched in April 1954. Building on ideas and methods proposed and tested in the UK and in Europe over the previous 50 years the atlas aimed to record, and map, each species of vascular plant in the 10km squares of the Ordnance Survey National Grid. Perhaps the most critical aspect of the project was the adoption of data processing equipment using punched cards. This enabled 1.5 million records to be sorted and mapped mechanically and the use of information technology became integral to biological recording. It was from these origins that BRC was established in 1964 with Franklyn Perring as head.

People and factors leading to the BSBI Atlas project

Sir Arthur Tansley
Influential plant ecologist
Advocate of amateur recording specialists (1904)
First Nature Conservancy Chairman (1949)

Cyril Diver
Pioneering field ecologist
Advocate of species distribution maps (1938)
First Nature Conservancy Director-General (1949)

Professor Roy Clapham
Leading botanist
Secretary of the BSBI Maps Committee (1950)
Co-author of Flora of the British Isles (1952)

Ordnance Survey
National Grid used on all OS maps after World War II

Early British dot-maps
Good (1936) Lizard Orchid distribution using dots to indicate locations, without a grid

Ford (1945) distribution of 32 butterfly species using unspecified dots with latitude and longitude frames

Continental examples of species mapping
Hultén (1950) Atlas of the distribution of vascular plants in northwest Europe

Instituut voor det Vegetatie-Onderzoek in Nederland, distribution mapping of vascular plants using 5x4 km 'cells'

1964
BRC set up at Monks Wood as part of the Nature Conservancy

1967-1968
Invertebrate recording schemes initiated for butterflies, moths, dragonflies, grasshoppers and crickets

1968
First annual meeting for National Biological Societies organised by BRC

1964-1980
Forty recording schemes established, many run independently but closely allied to BRC

1990
25th Anniversary conference held at the Linnean Society

CURRENT ACTIVITY

BRC works in partnership to provide national capability to support and encourage biological recording for a wide range of plant and animal groups. We apply innovative use of technology and science excellence to help national societies and recording schemes improve how data is collected, made available and used. Together, we aim to record where species are distributed and understand how this is changing.

KEY OUTPUTS

Long-term support from BRC and others has helped establish over 80 recording schemes and societies; no other region across the globe has such a wide taxonomic breadth of recording activity. The key outputs from biological recording are detailed throughout this booklet. A major achievement has been the publication of atlases, data and other online resources which have enabled a wealth of subsequent uses to support conservation and research.

Senior and long-serving members of staff at BRC (1964-2010)

Person	Period	Role(s)
Franklyn Perring	1964-1978	Botany & Head of BRC
John Heath	1967-1978 1979-1982	Zoology Head of BRC
Diana Scott	1969-1979	Data manager
Mike Skelton	1970-1978	Zoological support
Henry Arnold	1972-2008	Scheme support & Data manager
Jane Croft	1978-2001	Botanical support
Dorothy Greene	1979-1989	Data manager
Paul Harding	1979-1982 1982-2003	Zoology Head of BRC
Val Burton	1982-2008	Data input & archives
Brian Eversham	1983-1997	Zoology
Mark Telfer	1997-2002	Zoology
Trevor James	2001-2008	Scheme development
Nick Greatorex-Davies	2002-2008	Butterfly Monitoring
Jon Cooper	2002-2008	Informatics
Gavin Broad	2003-2007	Zoology
Mark Hill	2003-2010	Head of BRC
Peter Brown	2005-2009	Scheme support

Photo of *Paris quadrifolia*: Shutterstock

2001
Heritage Lottery Fund and NBN support development of national societies and schemes

2008
BRC relocated from Monks Wood to Wallingford

2014
BRC celebrates its 50th anniversary with a symposium, journal special issue and celebratory meeting

Current staff. Many CEH staff contribute towards the work of BRC; those listed below spend more than 20% of their time on BRC work

Person	Year joining	Role(s)
Chris Preston	1980	Botany
David Roy	1994 2010	Data analysis Head of BRC
Helen Roy	2007	Zoology
Jim Bacon	2007	Websites
Björn Beckmann	2007	Scheme support & data analysis
Marc Botham	2007	Butterfly Monitoring
Steph Rorke	2008	Database Manager
Biren Rathod	2008	Websites
Stephen Freeman	2008	Statistician
Nick Isaac	2008	Macroecology
Tom Oliver	2008	Data analysis & modelling
Colin Harrower	2009	Databases and programming
Michael Pocock	2011	Ecologist
Tom August	2012	Data analysis & modelling
Jodey Peyton	2013	Scheme support
Oli Pescott	2013	Botany
Gary Powney	2013	Data analysis & modelling
Karolis Kazlouski	2014	Websites
Mark Jitlal	2014	Statistician

Photo: Paul Fisher, CEH

David Roy, current head of BRC

FUTURE CHALLENGES

It is a priority to maintain existing capacity for recording species across a broad range of taxonomic groups to provide the evidence needed to tackle ongoing environmental issues. Partnership with expert naturalists helps this capacity to grow and adapt, increasing the value of biological recording for understanding environmental change. The value of recording data is enhanced through innovative use of technology and analytical methods, plus integration with other data sources on the ecology of species and the physical environment.

1962
The Atlas of the British Flora, *a landmark publication setting a basis for the establishment of BRC in 1964*

1970s
Provisional atlases published for nine insect groups

1984
Atlas of Butterflies in Britain and Ireland *included detailed species accounts*

CURRENT ACTIVITY

Publishing and promoting atlases is an integral part of BRC's work. Atlases are important for encouraging biological recording while also providing a basis for periodic review of the distribution of species within a taxonomic group. Atlas datasets are often used for research, including many of the examples given throughout this booklet. In 2014, coinciding with its 50th anniversary, BRC is supporting the publication of major atlases of dragonflies and bryophytes.

KEY OUTPUTS

Printed atlases now cover over 10,000 species of plants and animals. Many atlases are richly detailed reference works which include much more than distribution data. Atlases and their associated datasets have revealed major changes in species' ranges over the past 50 years and are being used to address a growing number of research questions. Maps, species accounts and associated information within atlases are also increasingly used to make informative and attractive websites to support recording.

Group	Atlas	Number of taxa mapped
Animal: invertebrates		
Ants, bees and wasps	Edwards *et al*. (1997-2012)	461
Aquatic bugs	Huxley (2003)	61
Beetles, carabids	Luff (1998)	348
Beetles, click	Mendel & Clarke (1996)	73
Beetles, Cryptophagidae - Atomariinae	Johnson (1993)	48
Beetles, jewel and soldier	Alexander (2003)	58
Beetles, ladybirds	Roy *et al*. (2011)	47
Beetles, long-horn	Twinn & Harding (1999)	60
Beetles, seed and leaf	Cox (2007)	268
Beetles, water	Foster (1981-1995)	168
Bumblebees	Anon. (1980)	26
Butterflies	Asher *et al*. (2001)	66
Caddisflies	Marshall (1978)	32
Centipedes	Barber & Keay (1988)	41
Dragonflies	Cham *et al*. (2014)	57
Fleas	George (2008)	73
Flies, craneflies	Stubbs (1992, 1993)	93
Flies, ensign (Sepsidae)	Pont (1987)	27
Flies, hoverflies	Ball *et al*. (2011)	279
Flies, larger Brachycera	Drake (1991)	61
Flies, meniscus midges	Goldie-Smith (1989)	14
Flies, mosquitoes	Snow (1998)	35
Flies, snail-killing	Ball & McLean (1986)	63

Photo of *Aeshna cyanea*: Shutterstock

1991-1994
Over 1,000 species mapped in the three volume atlas of bryophytes

2001-2002
Second major atlases of butterflies and vascular plants published for the new millennium

2004
BRC plays a pivotal role in establishing the NBN Gateway

2010-2013
Atlas information provided online for several species groups

2014
Atlases for bryophytes and dragonflies to be published

Group	Atlas	Number of taxa mapped
Animal: invertebrates continued		
Grasshoppers and allies	Haes & Harding (1997)	37
Harvestmen	Hillyard (2005)	24
Lacewings and allies	Plant (1994)	71
Leeches	Elliott & Tullett (1982)	16
Millipedes	Lee (2006)	56
Molluscs, land and freshwater	Kerney (1999)	213
Moths, Incurvarioidea	Bland (1986)	32
Moths, macromoths	Hill *et al*. (2010)	867
Nematodes	Heath *et al*. (1977)	55
Pseudoscorpions	Legg & Jones (1988)	25
Spiders	Harvey *et al*. (2002)	648
Ticks	Martyn (1988)	22
Waterlice and woodlice	Gregory (2009)	47
Animal: Vertebrates		
Amphibians and reptiles	Arnold (1995)	14
Birds	Balmer *et al*. (2013)	510
Fish	Davies *et al*. (2004)	51
Mammals	Arnold (1993)	61

Group	Atlas	Number of taxa mapped
Green plants, lichens and myxomycetes		
Bryophytes	Hill *et al*. (1991-1994)	1,038
Charophytes	Moore & Greene (1983) Moore (1986)	47
Seaweeds	Hardy & Guiry (2003)	629
Lichens	Seaward & Hitch (1982)	176
Myxomycetes	Ing (1982)	100
Vascular plants	Preston *et al*. (2002)	3,354
Vascular plants, brambles	Newton & Randall (2004)	330
Vascular plants, dandelions	Dudman & Richards (1997)	178
Vascular plants, hawkweeds	McCosh & Rich (2011)	431

Further details: www.brc.ac.uk

FUTURE CHALLENGES

Planned atlases will continue to extend the taxonomic breadth of mapped species distributions. Repeat atlases, such as those already published for butterflies, moths, birds and vascular plants, often reveal important insights into the causes of change in species distribution, and generate new research questions. Additional ecological and environmental information, now integral to most atlases, help to interpret species distributions. A challenge is to incorporate complex new analyses of trends in an accessible way.

1977
British Red Data Book of Vascular Plants [1] is the first national-scale assessment

1991
Quantitative criteria for Red Lists established [2]

1994
BRC supports the UK Biodiversity Action Plan

2005
BRC supports an assessment of 2,000 fly species [3]

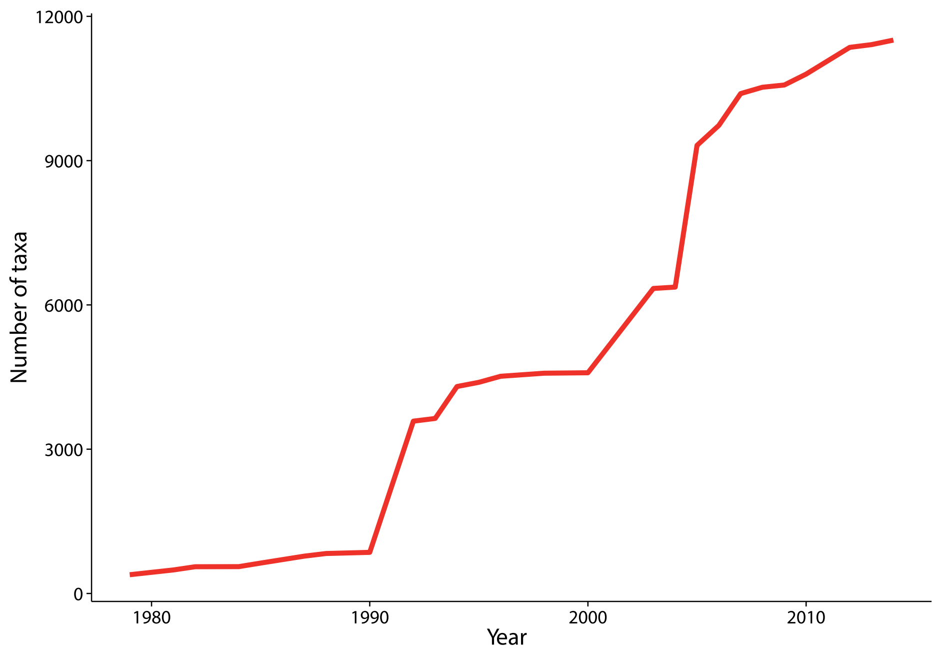
CURRENT ACTIVITY

In the past, species' status was often assessed on expert opinion, or by counting the number of occupied grid cells. Our recent work has used computer simulations of the recording process to inform how we can estimate the trends in species status over decadal timescales. BRC is working with recording schemes, government agencies and partner organisations to derive quantitative trend estimates and other metrics for use in Red Listing and the development of biodiversity indicators to assess the 2020 'Aichi targets'.

KEY OUTPUTS

Trend estimates were presented in recent atlases for ladybirds (2011), hoverflies (2011), dragonflies (2014) and bryophytes (2014), building upon earlier atlases for other groups. We continue to work with recording scheme experts to extend the availability of trend information to a much wider set of species groups. In 2013, BRC's innovative work on trends, modelling and indicator development made a substantial contribution to the State of Nature Report[4] (trends for ~2400 species) and the Priority Species Indicator[5] which tracks changes in the status of ~230 species of conservation concern.

Growth in threatened species status assessments



The cumulative number of UK taxa (species and subspecies) that have been formally assessed against criteria for conservation prioritisation.

Figure: Nick Isaac, CEH. Photo of *Chrysotoxum vernale*: Courtesy of Steven Falk

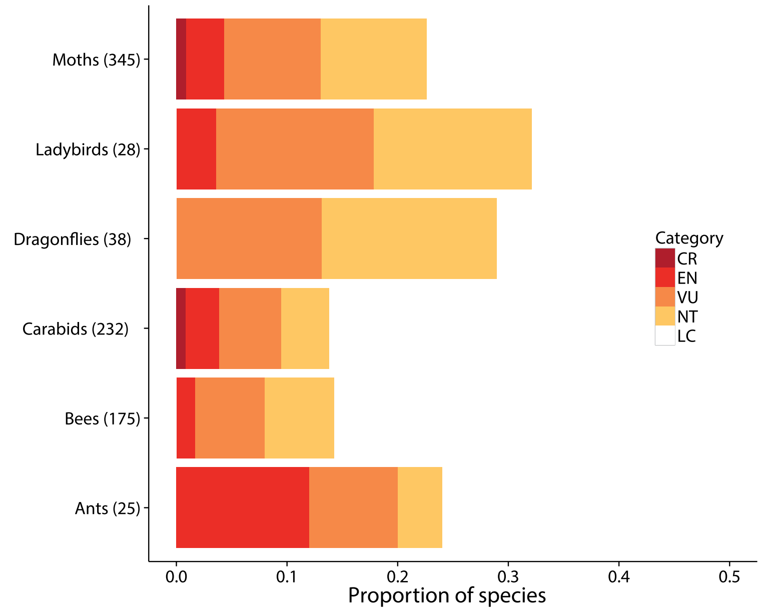
2013
The State of Nature Report [4] draws heavily on recording schemes and BRC analysis of trends

2013
Biological records are incorporated into a national index for priority species for the first time [5]

2014
BRC supports Red Lists for aculeate Hymenoptera and vascular plants

2020
CBD Aichi targets act as a major focus for conservation

Provisional extinction risk assessment of 1,026 species using biological records



Species were assessed against IUCN criterion A2c, based on rates of decline in frequency of occurrence since 2000. The categories are Critically Endangered (CR: >80% decline), Endangered (EN: >50%), Vulnerable (VU: >30%), Near Threatened (NT: >20%) and Least Concern (LC: stable or increasing).

Figure: Nick Isaac, CEH

The Priority Species Indicator, using biological records

For the first time in 2013, the UK Government published a biodiversity indicator for priority species based on opportunistic biological records data[5]. The indicator included ~230 insects (mostly moths & bees) listed as conservation priorities by the four national governments of the UK.

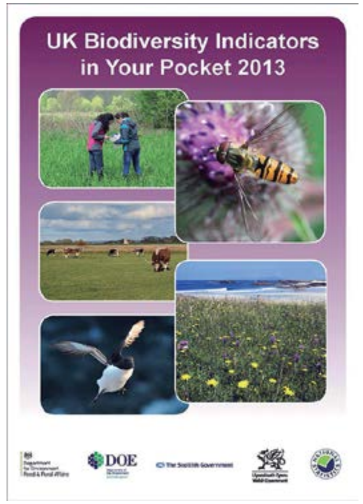


Photo: © JNCC

FUTURE CHALLENGES

Sophisticated statistics make it possible to estimate quantitative measures of species' trends (IUCN criterion A) and range size (criterion B) using biological records. In doing so, these models make a number of assumptions about how the data are collected. As analytical tools become more widely adopted, our challenge is to harmonize how criteria are applied across taxa and regions. Clear guidelines are needed to resolve conflicts between model results and expert opinion in order to provide robust species trend information.

1982
Review of BRC identifies potential for detecting climate change impacts

1990
Changes in species climatic suitability modelled for NERC TIGER programme

1994
Report on climate change and rare species in Britain published [1]

1999-2006
Modelling Natural Resource Responses to Climate Change (MONARCH) project using biological recording data [2]

2001
Interacting effects of climate change and habitat demonstrated for UK butterflies [3]

CURRENT ACTIVITY

Biological records represent an invaluable resource to document and understand the impacts of climate change on biodiversity. High quality data has enabled the UK to be at the forefront of climate change research. Internationally important publications have also been produced directly from the data provided by recording schemes and societies. Current projects using biological recording data include assessing the risks and opportunities faced by individual species during climatic changes and identifying refugia which may help promote the persistence of species.

KEY OUTPUTS

Analyses of distribution data provided some of the first demonstrations of the impacts of climate change on biodiversity. Climate warming has caused many species to shift their distributions, with their responses often influenced by land use changes. Biological records have made a major contribution to our understanding of these interacting effects. For example, predicting the risks and opportunities faced by species from climate change helps identify appropriate 'adaptation actions' to reduce undesired climate change impacts.

Expansion of *Conocephalus discolor*, the long winged conehead, under climate warming

Historical and recent biological records allow us to document changes in species' distributions, many of which are driven by changes in climatic suitability.

Figure: B. Beckmann, CEH. Inset photo of *Conocephalus discolor*: Courtesy of David Browne
Photo of *Aricia agestis*: Shutterstock

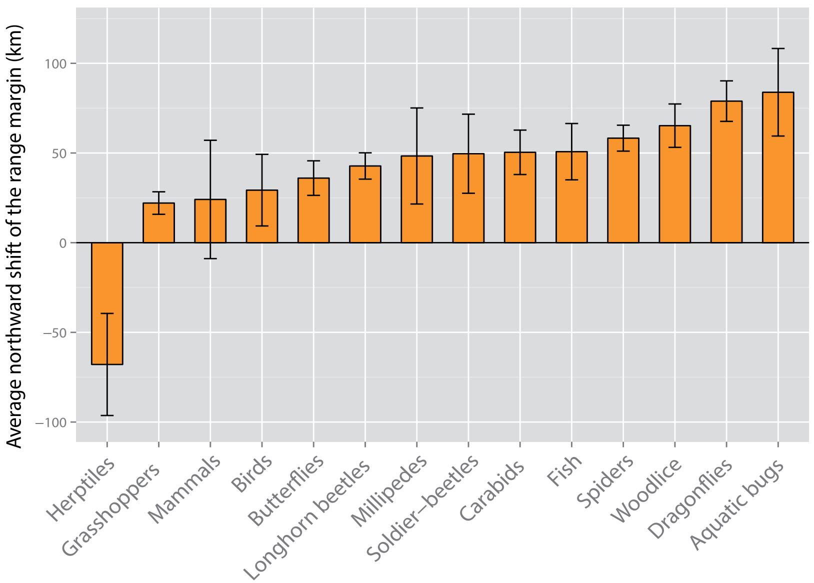
2006
First synthesis of changes in species' northern range margins [4]

2010
Tests of climate envelope models using species distribution data [5]

2011
Framework for classifying species risks and opportunities from climate change applied to 3,000 species [6, 7]

2012
Demonstration of the importance of current protected areas for facilitating range expansions in Great Britain [8]

General patterns of northward range shift across many different taxonomic groups



Based on distribution data from 1960-2002, most animal groups have shown an average northward shift in their British range margin, albeit with substantial variation within groups. Bars show results for hectads where 10% of the species in a group were recorded across two time periods; similar results were obtained with other cut-off values.

Figure: S. Mason, CEH

Example of projected distribution change, *Bombus ruderarius*, the red-shanked carder bee

Bioclimate models relate observed occurrences to various climatic variables to produce a modelled 'climatic suitability' surface for a species. This map shows changes relative to the historic baseline where new climate space is shown as yellow and red, white squares showing areas of climate overlap, blue squares showing adversely sensitive areas and grey squares indicate areas climatically unsuitable in both periods[6].

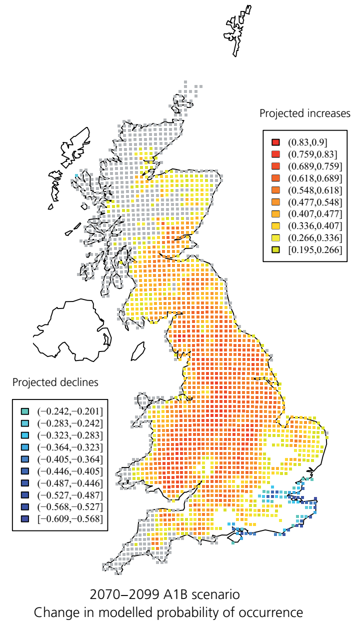


Figure: Tom Oliver, CEH. Data: BWARS

FUTURE CHALLENGES

Explaining the different responses of species, with similar initial ranges, to climate change remains an important challenge. We continue to improve models to predict future changes, taking into account species ecology and patterns of recording. The substantial role of volunteers in providing the geographic and taxonomic coverage of biological records is invaluable to increasing our understanding of the impacts of climate change. Ultimately, the development of robust evidence-based adaptation and conservation strategies is highly reliant on this unique data resource.

1860
The British Acclimatisation Society led to the establishment of several INNS

1932
Destructive Imported Animals Act

1992
*Introductions and their place in **British Wildlife** published* [1]

2004
Harlequin ladybird first detected in Britain [2]

2008
Alien Species Inventory for Europe available on-line

CURRENT ACTIVITY

The Millennium Ecosystem Assessment highlighted invasive non-native species (INNS) as one of the main drivers of biodiversity loss. INNS cost the British and European economies an estimated £1.7 billion and €12 billion, respectively, each year. INNS are being introduced into Europe at unprecedented rates and are best controlled through prevention, early detection and rapid response. BRC has developed integrated warning systems, leading the development of national and European-wide databases providing information on INNS coupled with detailed research on their ecology.

KEY OUTPUTS

Information systems contribute to the understanding and management of INNS. The DAISIE database identified over 12,000 non-native species (NNS) within Europe, while the GB-NNSIP covers about 2,000 non-native species. The GB-NNSIP early warning system was key to the Environment Agency's early identification of the newly arrived shrimp *Dikerogammerus haemobaphes*. BRC has recently co-ordinated experts from the volunteer recording community in an horizon scanning review to predict INNS not yet established in Great Britain, but that are likely to impact on native biodiversity.

Spread of the harlequin ladybird (2004-2014)

Over 12,000 people contributed harlequin ladybird records to the UK Ladybird Survey, helping to improve understanding of its ecology.

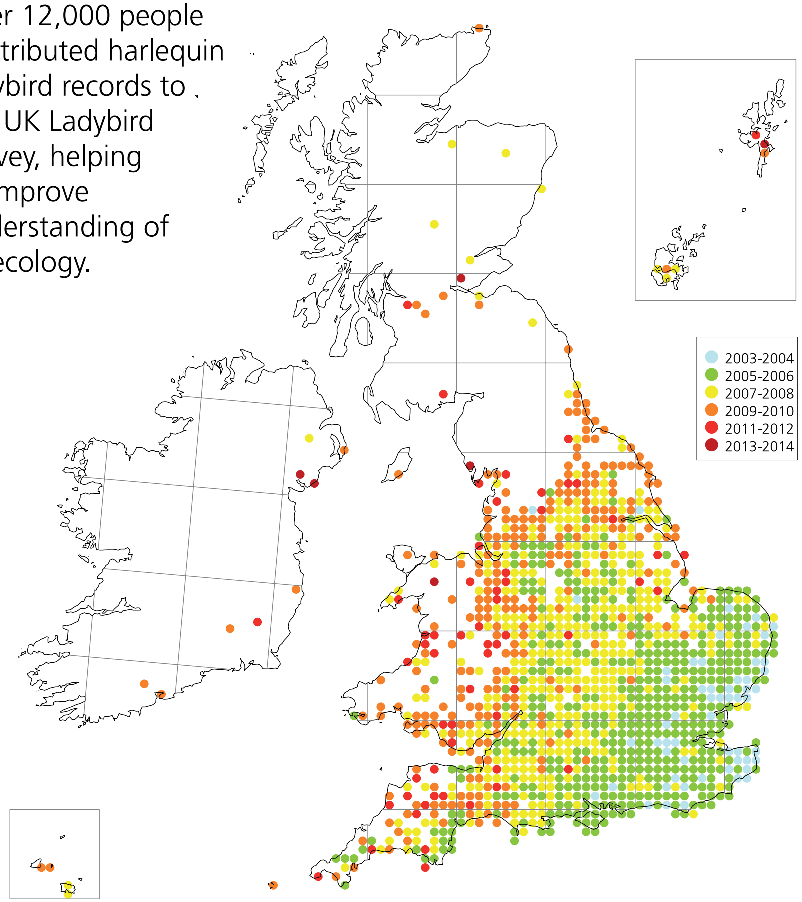


Figure: Colin Harrower, CEH. Data: UK Ladybird Survey. Photo of *Leptoglossus occidentalis*: Courtesy of Dr Africa Gómez

2008-2017
GB Non-Native Species Information Portal developed [3]

2012
Link between the harlequin ladybird and native ladybird declines [4]

2013-2017
European collaboration through ALIEN Challenge partnership

2014
Horizon scanning for non-native species in Britain [5]

2014
Draft EU Regulation on INNS

Number of established non-native species in Great Britain: an upward trend

There has been a dramatic increase in the number of species becoming established in GB over the last 400 years and there is no indication of this trend slowing. The number of established non-native species designated as having a negative ecological or human impact is also increasing.

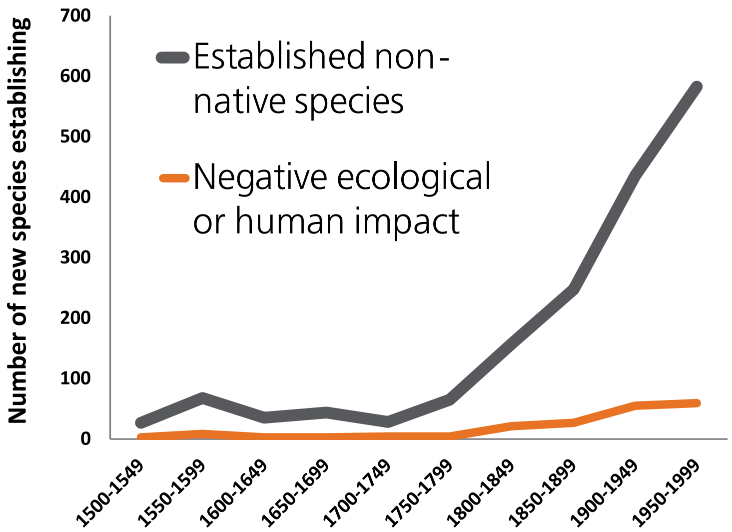


Figure: Steph Rorke, CEH

Horizon scanning for non-native species

Quagga mussel, *Dreissena rostriformis bugensis*, received maximum scores for risk of arrival, establishment and impact on biodiversity in an horizon scanning workshop involving volunteer experts from the recording community. The Asian shore crab, *Hemigrapsus sanguineus*, is another species ranked in the top ten list of species most likely to threaten biodiversity in Great Britain in the next 10 years. The first record of this crab was received one year after the workshop predicted its arrival.

Asian shore crab, *Hemigrapsus sanguineus*

Photo: Courtesy of Martin Burke

FUTURE CHALLENGES

Collaboration is critical for responding to INNS. BRC is leading a European network 'Towards a European information platform for alien species' through a COST Action called "ALIEN Challenge", which is facilitating collaboration between experts across the continent. The project aims to harmonise NNS databases and explore undiscovered sources of information. Such work is integral to the implementation of post-2010 EU Biodiversity Strategy. Within GB, BRC is supporting the rapid flow of INNS information from recorders to the GB-NNSIP and NBN Gateway to underpin effective decision-making.

1970
Habitat destruction identified as main reason for loss of rare plant species [1]

1974
Cross-taxon review highlights effect of habitat destruction in a wide range of groups [2]

1982
'Central Impoverished Region' detected by analysis of bumblebee atlas data [3]

1984
Major contractions in range of 18 British butterflies revealed [4]

CURRENT ACTIVITY

Habitat presence and quality is a controlling factor in the distribution and abundance of species. Widespread post-war habitat destruction led to a decline in many species and was one reason why BRC was established. Now changes to habitats are often more subtle, brought about by factors such as fluctuating grazing pressure, eutrophication or changing climate. Recording schemes are essential in documenting the effect of these changes and in understanding the habitat requirements of species.

KEY OUTPUTS

The publication of atlases provides the opportunity to analyse long-term changes in range in response to habitat changes and other variables. Categorisation of attributes, as in PLANTATT[8] and BRYOATT[9], allows species to be linked to their habitats, an important approach being extended to other species groups. Changes in well-recorded groups with dynamic ranges, such as butterflies, are summarised every five years. Records from recording scheme and society datasets are available for analysis in between major 'state of the nation' reports.

Catastrophic decline of a habitat specialist: *Argynnis adippe*, the High Brown Fritillary

The High Brown Fritillary (*Argynnis adippe*) requires warm microhabitats where the larval foodplants, various species of violet, occur with bracken; they include south-facing rocky slopes, coppice woodlands or woodland clearings. Its decline mirrors the loss of coppiced woodland and bracken/grassland mosaics with low intensity grazing by cattle or ponies.

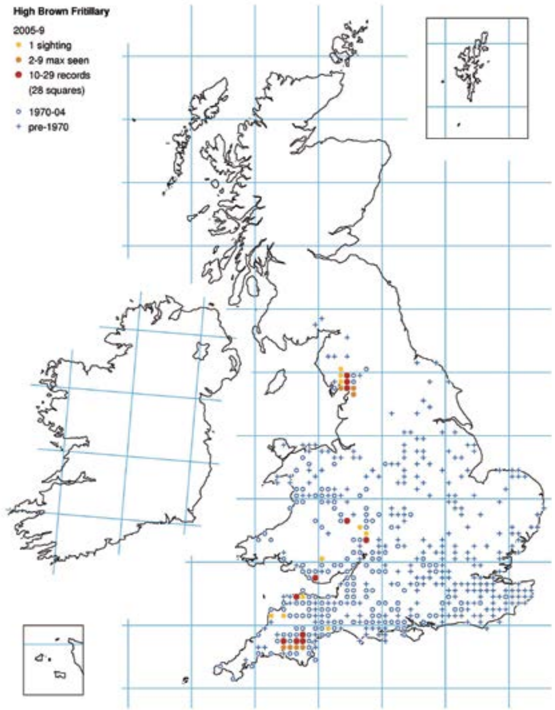


Figure: Jim Asher, Butterfly Conservation. Inset photo and tint: Shutterstock
Photo of *Bombus ruderatus*: Courtesy of Mike Edwards

1994
UK Biodiversity Action Plan covers species and habitats

1996
Expansion of dragonfly ranges mapped [5] and updated in 2014 atlas

2001
Continued decline of habitat specialists contrasts with expanding range of some wider countryside butterflies [6]

2004
Decline of arable weed species halted [7]

Expansion of a species able to colonise newly available habitats: *Brachytron pratense*, the Hairy Dragonfly

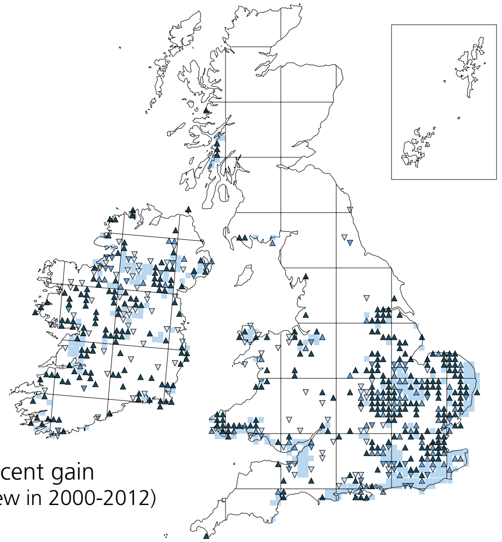


Figure: Steve Cham, British Dragonfly Society

As shown by the atlas published in 2014, the distribution of the Hairy Dragonfly (*Brachytron pratense*) was mainly coastal in Britain until recent years when it has colonised a number of inland gravel pits that were excavated in the 1960s and have acquired a mature vegetation cover. It may also have benefited from the more favourable climate in recent decades.

Designing a National Plant Monitoring Scheme

The National Plant Monitoring Scheme has been designed as a collaboration between the BSBI, Plantlife, CEH and JNCC. The Scheme aims to fill a gap in terrestrial habitat monitoring by focusing on the abundance of plant species within plots for a range of vegetation types. This should enable changes in plant diversity to be detected earlier than is possible with traditional biological recording conducted at broader scales.

Photo: Lucy Hulmes, CEH

FUTURE CHALLENGES

Biological recording has demonstrated habitat change effects on species with a very narrow habitat requirement, such as arable weeds or chalk grassland butterflies. Effects on species with a broader habitat range than specialist species are harder to measure. Linking records more precisely to habitats might make it possible to investigate the effects of habitat modification on generalist species, and to identify changes in their habitat requirements in response to changing climate. This is a rationale of the National Plant Monitoring Scheme and initiatives to enhance the capture of new biological records through systems such as iRecord.

1956
Clean Air Act passed following the Great Smog

1960 & 1963
British Bryological Society and British Lichen Society mapping schemes begin

1965
First use of distribution maps to investigate the links between air pollution and plants [5]

1968
Gilbert publishes a calibrated scale relating SO_2 pollution to lichen community composition

CURRENT ACTIVITY

Despite huge improvements in air quality in recent decades, research consistently indicates that nitrogenous pollutants from agriculture, industry and transport are continuing to cause declines in plant species richness across a variety of semi-natural habitats. Ongoing monitoring across all groups of species will continue to provide evidence for increases and declines associated with anthropogenic pollution. Evidence from across taxa can strengthen conclusions regarding large scale changes, particularly where multiple environmental drivers are acting in concert.

KEY OUTPUTS

Links with the Botanical Society of Britain and Ireland, the British Bryological Society, and the British Lichen Society are providing data and new analytical approaches to investigate drivers of environmental change, such as anthropogenic air pollution. Key publications[1, 2, 3, 4] have all contributed to our understanding of these drivers in Britain and Ireland, and have produced datasets that are allowing researchers around the world to address novel hypotheses.

The ongoing contribution of lichenologists to air quality research

The sensitivity of lichens to various types of pollution was first noted by observers in the early years of the Industrial Revolution. The calibrated sulphur dioxide scales of the 1960s and 70s have now been supplemented with similar assessment tools for nitrogen enrichment[8].

Inset photo: Courtesy of Janet Simkin
Photo of *Orthotrichum stramineum*: Courtesy of D.A. Callaghan. Tint - Shutterstock

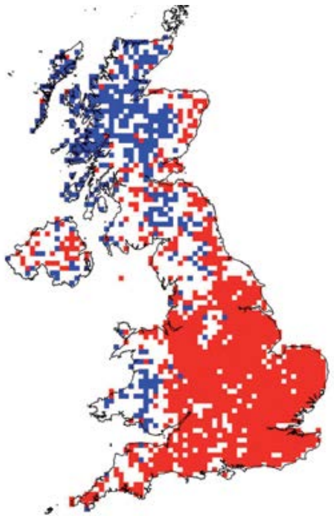
1988
UK Acid Waters Monitoring Network established [6]

1992
Adams & Preston review evidence for the beginning of a recovery in bryophyte epiphytes [7]

2002
New Atlas provides evidence for increases in plants of fertile habitats [1]

2014
New bryophyte atlas illustrates a now clear recovery of epiphytes [4]

Local extinctions of plants are related to increased fertility in areas of the UK with higher atmospheric nitrogen deposition[9]

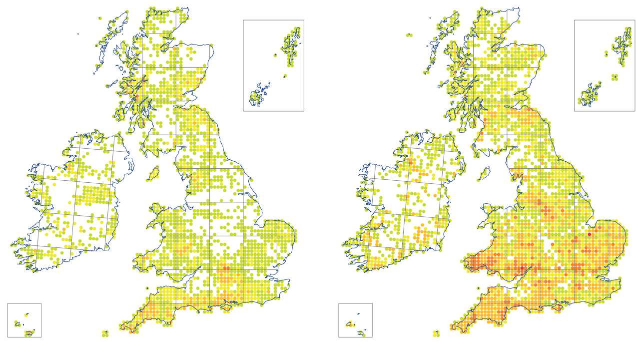


In the red 10km squares, those vascular plant species which have not been recorded since 1987 are characteristic of less fertile habitats, whereas the plants which are still present tend to thrive on more fertile substrates. This demonstrates that the loss of nutrient-poor sites, for example, by habitat destruction and eutrophication, has been the main driver of change in plant diversity across much of the UK. By contrast, in the blue 10km squares, lost species are characteristic of more fertile habitats. This more surprising result reflects the loss of species associated with arable land in areas where agriculture is now almost exclusively pastoral.

Data: Botanical Society of Britain & Ireland

Changes in the distributions of moss and liverwort epiphytes for the periods 1960-1980 and 1990-2010

The clearest signal of change in the British bryophyte flora over the last 50 years has been the recovery of sulphur dioxide-sensitive epiphytes and the corresponding decline in acidophiles. The 'heat' maps show how the number of epiphytes (for 28 selected species) per 10km grid cell increased significantly between the two time periods.



Data: British Bryological Society

FUTURE CHALLENGES

Changing the ways in which the monitoring of species takes place may allow for even more confidence to be placed on the results of analyses. More systematic approaches to recording, for example via the National Plant Monitoring Scheme, will create opportunities for finer-scale analyses of pollution-driven changes in species' distributions and abundances. Novel citizen science initiatives, driven by technological innovations such as personal pollution sensors, could enable more direct analyses of pollutants linked to species occurrence data at a local scale.

1960s
Key publications by Elton and Southwood on insect-plant associations [1, 2]

Late 1970s
Lena Ward establishes the Phytophagous Insects Data Bank (PIDB) of 45,000 insect-plant interactions [3]

1990s
PIDB data shows the determinants of phytophagous insect richness and distribution

Since 1997
BWARS atlases detail flower visitation

CURRENT ACTIVITY

No species exists in isolation: species are interdependent of each other and their local environment. Many of the interactions between species have been recorded by naturalists and collated in species distribution atlases. The Phytophagous Insects Data Bank (PIDB), in the 1970s, broke new ground in creating a comprehensive inventory of phytophagous insect interactions. PIDB was updated and made more accessible (as DBIF) in 2007. Gaining information on and understanding the impacts of ecological interactions has, hitherto, undeveloped potential.

KEY OUTPUTS

The Database of British Insects and their Foodplants is a collation of 47,000 feeding interactions of 9,300 invertebrate taxa with 5,700 plant taxa. This resource has been used to explain patterns of phytophagous insect richness (e.g. co-evolution and phytochemistry) and distribution patterns and trends of insects, by taking host plant into account. It has also been used in applied ecology to assess, for example, arable weeds' contribution to farmland biodiversity and the potential impact of ash dieback on invertebrate biodiversity.

Chalcidae parasitoid prospecting a *Phytomyza ranunculi* leaf mine on *Ranunculus lingua*

Capturing records of species interactions, such as plant-pollinator interactions, feeding relationships, fungal associations, habitat associations or even tri-trophic interactions is an important step for the future of biological recording because such interactions are more informative than simply recording species presence.

Inset photo: Michael Pocock, CEH. Photo of *Cyphostethus tristriatus*: Courtesy of Ed Phillips

2007 Database of British Insects and their Foodplants (DBIF)[4] published online

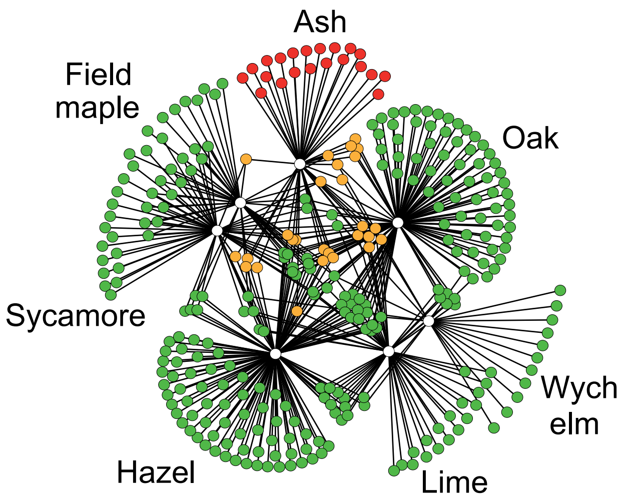
2011 Hoverfly Recording Scheme atlas describes adult and larval feeding interactions

Since 2011 British Bugs and Auchenorrhyncha Recording Scheme websites list feeding interactions

2013 BRC work with iSpot to visualize interactions[5]

2014 DBIF data contributes to predictions of the impact of ash dieback on biodiversity[6] and interpretation of moth trends[7]

A food web of the interactions of Lepidoptera (moths and butterflies: coloured circles) with woodland trees (white circles), as collated in DBIF



This shows the reliance of Lepidoptera species on ash: entirely (red), partially (orange) or not reliant (green), so illustrating potential impacts of the loss of ash. The individual plant species from DBIF (for oak and lime) have been aggregated for clarity.

Figure: Michael Pocock, CEH

Effect of plant traits on the trends of monophagous moths[7]

Moths that feed on plants that prefer high soil fertility (i.e. have high Ellenberg Nitrogen values) have tended to fare better than those feeding on plants that prefer low fertility sites, demonstrating the cascading impact of environmental change up food chains.

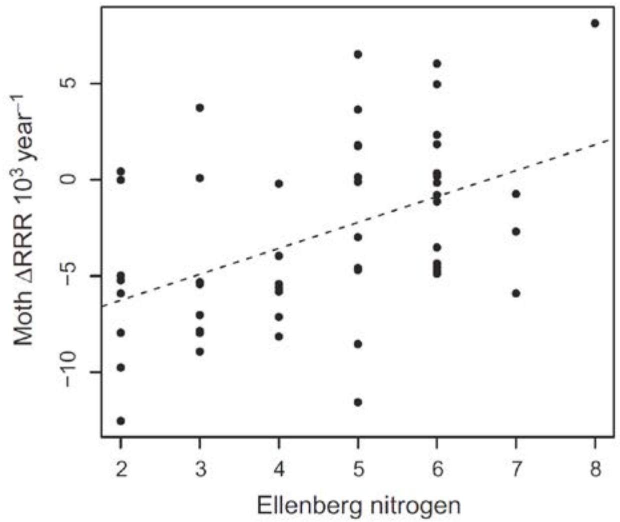


Figure: Tom Oliver, CEH

FUTURE CHALLENGES

Combining DBIF and biological records provides many opportunities for new research given the growing importance of food webs in ecology. Many biological records of insects are accompanied by host plant associations, providing opportunities for research on the cascading impacts of environmental change on whole food webs. Effective monitoring of insects eating non-native plants will enable us to track the colonisation of these species by new natural enemies.

1964
BRC established with capability for mechanical sorting of records and mapping

1978
2 million punched card records converted to digital form

1989
Migration of 5 million records to an ORACLE system

2001
First version of the National Biodiversity Network (NBN) Gateway launched - at the beginning of 2014, 96 million observations are shared by the site [1]

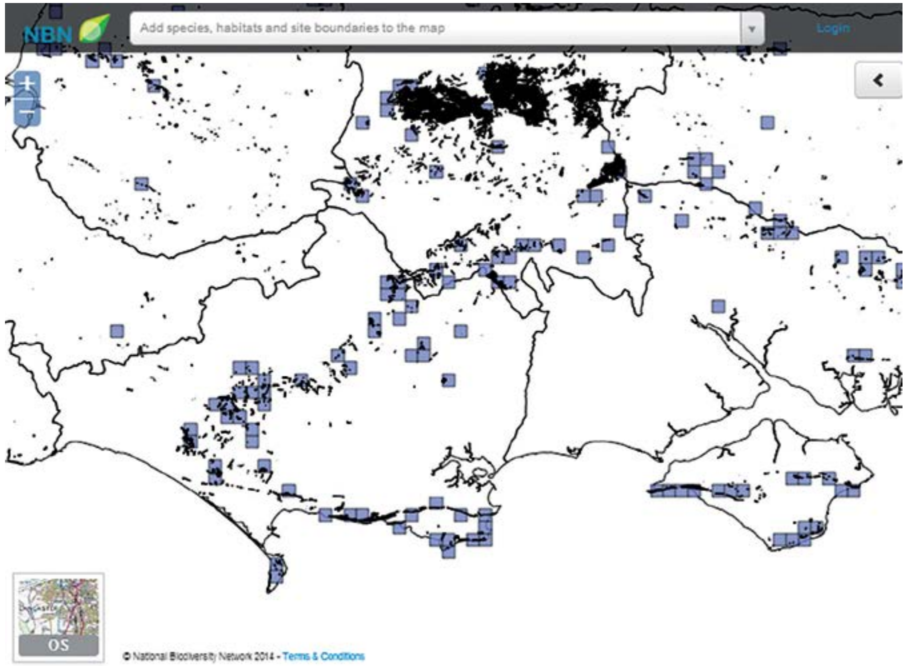
CURRENT ACTIVITY

The world has been undergoing an increasingly rapid technological revolution for the past 50 years. In 2014, almost all 16 to 24 year olds use the internet and 59% of the UK's population have a smart phone - a miniature pocket computer accessing the internet. These advances, among many others, have changed the way many of us live our lives. BRC is developing a number of smart phone apps, websites and analytical tools that harness technologies to support biological recording.

KEY OUTPUTS

The NBN Gateway is a world-leading system for sharing ~100 million observations. The iRecord website combines digital photography, the networking ability of the internet and statistical analyses to provide a robust means of collecting biological records for the 21st Century. iRecord links to a growing set of 'on-the-go' biological recording apps including those for ladybirds, butterflies, mammals and invasive non-native species. These apps allow users to submit records containing GPS location, photographic evidence and a range of useful supplementary information.

The NBN Gateway's Interactive map



The NBN gateway is not only the UK's central repository of biological occurrence data but is also a platform for sharing these data with policy makers, researcher, students and other volunteer recorders. Here we show the distribution of the Adonis Blue, *Polyommatus bellargus*, butterfly (supplied by Butterfly Conservation; blue 2km squares) overlaid on areas of chalk grassland (supplied by Natural England; areas in black).

Figure: NBN. Photo of *Mustela putorius*: Shutterstock

2004
Online survey for harlequin ladybird documents rapid invasion

2007
Indicia toolkit [2] developed to support a range of online recording projects

2013
iRecord [3] launched to make it easier for wildlife sightings to be collated, checked by experts and made available to support research and decision-making

2014
Smartphone apps for ladybirds, butterflies, mammals and invasive species linked to iRecord

Taxonomic coverage of iRecord[3]

The number of people submitting wildlife sightings online is increasing dramatically. The taxonomic breadth of data collected through iRecord on behalf of recording schemes is unrivalled. The quantity and quality of data offers great opportunities for research and conservation but also presents many technological challenges.

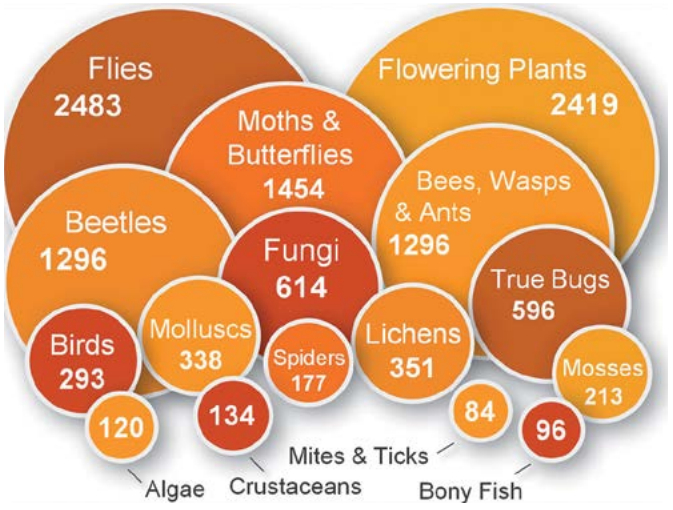
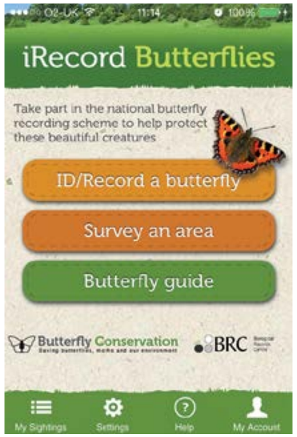


Figure: Tom August, CEH

Smartphone applications for biological recording



Smartphone apps allow volunteers to quickly access information and our technology 'on-the-go'. Using GPS and camera technology embedded in smart phones, these apps allow volunteers to collect verifiable records in the field which help to further our understanding of the world around us.

Photos: CEH

FUTURE CHALLENGES

Technology has increased and diversified the ways that biological records are submitted, analysed and shared. BRC is using its wealth of experience of biological recording and supporting technologies to develop and share tools, enabling schemes to meet the challenge of diverse data types from numerous providers. BRC has helped create tools such as the Indicia software, for developers of online recording systems, and rNBN for researchers, to help address these challenges.

1964
BRC set up at Monks Wood by Nature Conservancy

1972
BRC appeared on BBC TV Tomorrow's World

1988
BBC Going Live appeal for Flea records

1995
Butterflies for the New Millennium project launched by Butterfly Conservation and BRC

2005
First on-line recording form available (for ladybirds)

2009
BBC Breathing Places Ladybird Survey

CURRENT ACTIVITY

Citizen science can broadly be defined as the involvement of volunteers in science. BRC and the volunteer schemes have worked together to gather and analyse wildlife observations for 50 years, providing evidence to underpin science, policy and practical conservation. Recently biological recording has become accessible to more people than has traditionally been the case[2]. Combined with experience from other CEH-led citizen science environmental monitoring, BRC is becoming established as a leader in citizen science.

KEY OUTPUTS

A UK-Environmental Observation Framework project critically reviewed citizen science practice and highlighted lessons learnt, the requirements of data users, and also reviewed the potential benefits of new technologies[1, 2]. CEH acknowledged the importance of sharing good practice and produced a guide on the practical implementation of the review. More recently the 'Choosing and Using Citizen Science' guide has been developed by CEH in collaboration with SEPA[3, 4].

Conker Tree Science

The Conker Tree Science project engaged over 8,000 people. People were invited to report the occurrence of the horse chestnut leafminer (*Cameraria ohridella*). The project enhanced understanding of the invasion dynamics of this moth, the associated parasitoids and the value of citizen science[7].

Inset photo: Courtesy of Susie Pocock. Photo of *Coccinella septempunctata*: Shutterstock

2009
Selected for Royal Society Summer Science exhibition
Ladybird, ladybird: unravelling the story of an alien invader

2011, 2012, 2013
BRC exhibits at BBC Gardeners' World Live awarded "Highly Commended"

2012
Guide to citizen science [1, 2]

2013
BRC develops recording apps

2014
Choosing and using citizen science guide [3, 4]

'Choosing and using citizen science'[4] and 'Guide to citizen science'[2] are two documents produced from projects reviewing the breadth and utility of citizen science for environmental research and monitoring[1, 3]. Both recognize the value of citizen science as an approach for undertaking environmental studies and provide a critical framework for developing such initiatives.

Smartphone apps

The development of a smartphone app for recording ladybirds has enabled the UK Ladybird Survey to attract new recorders. More than 9,000 records have been submitted in its first year. The newly released iRecord Butterflies app received more than 4,000 records within a month of being available. Verification and validation methods within iRecord provide quality assurance and onwards flow of data.

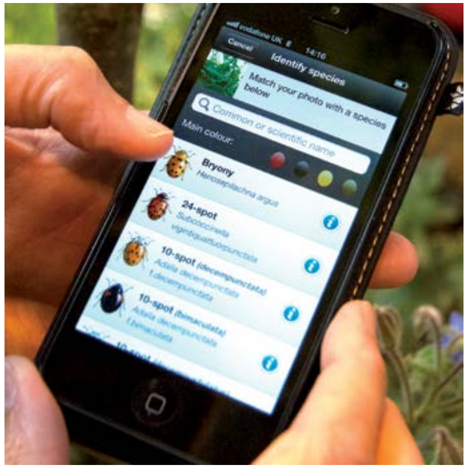


Photo: Heather Lowther, CEH

FUTURE CHALLENGES

Perception of poor data quality is a major challenge for citizen science approaches[5, 6]. A range of quality assurance methods maximise the usefulness of data collected by volunteers. Automated checks, developed by schemes and societies, when coupled with expert verification play a critical role in ensuring the accuracy of biological records. iRecord provides an example of this approach. New technologies will undoubtedly encourage further interest in citizen science and help to recruit and encourage new generations of recorders.

1964 BRC set up at Monks Wood with data and equipment from BSBI Atlas project (1954-62)

1978 Handbook for Local Records Centres published

1987 National Federation for Biological Recording established

1991 JNCC formed and continues to fund BRC in partnership with NERC

1994 UK Biodiversity Action Plan sets conservation and recording priorities

CURRENT ACTIVITY

In addition to the vital partnerships with national recording schemes detailed in the previous section 'Developing BRC', close collaboration with other organisations has been a major theme throughout the 50-year history of BRC. Hosted within the Centre for Ecology & Hydrology, BRC has benefited from a strong partnership between the research community (through CEH, its parent body NERC and other academic organisations) and statutory conservation bodies (through the Joint Nature Conservation Committee and associated bodies).

KEY OUTPUTS

BRC has played a pivotal role within networks that foster collaborations between the biological recording community and users of species data. BRC helped to establish and support the National Forum for Biological Recording and had a leading role in both the Coordinating Commission for Biological Recording report and UK Biodiversity Action Plan. The establishment of the National Biodiversity Network (NBN) in 2000 was a notable achievement for the recording community; BRC was instrumental in its inception and continues to have a major role.

The National Biodiversity Network (NBN)

NBN is a partnership of organisations who gather, use and share biological records. BRC has been a major contributor to the NBN since its formation in 1997.

Inset photo: NBN. Photo of *Moma alpium*: Shutterstock

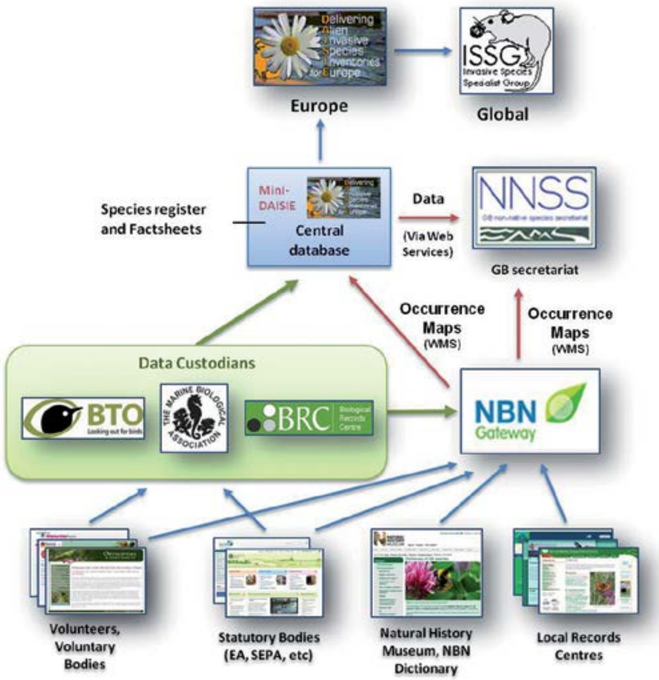
1995
Coordinating Commission for Biological Recording (CCBR) report

1997-2000
BRC are a major contributor to the formation of the National Biodiversity Network

2011-2013
BRC works with the BES to establish special interest groups for macroecology and citizen science

2013
BRC supports recording scheme contributions to the State of Nature Report

GB Non-Native Species Information Portal



Interactions between the GB-NNSIP and the wider community engaged in monitoring and surveillance of non-native species. Distributional data are collated from various organisations and bodies (national schemes and societies - including project collaborators BSBI, BTO and MBA - statutory bodies and Local Records Centres) through the NBN Gateway.

Figure: Colin Harrower, CEH

Paul Harding

Paul Harding has been a key figure in the development of BRC's wider partnerships with the biological recording community. As head of BRC between 1982 and 2003, he was at the forefront of development of the National Forum for Biological Recording in 1987 and the NBN partnership in 1997, and continues to be actively involved with both organisations. His contribution was given national recognition in 2001 when he was appointed MBE.

FUTURE CHALLENGES

It is a major challenge to ensure that partnerships between volunteer-based organizations and end-users of data continue to flourish. BRC's close working relationship with recording organisations, together with links to researchers, conservation bodies and other users of recording data gives us a unique role in helping to support and develop biological recording for future challenges.

6 A time before BRC

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8 Developing BRC

Author: David Roy (dbr@ceh.ac.uk)

10 Atlases and datasets

Authors: David Roy (dbr@ceh.ac.uk)
& Björn Beckmann (bjck@ceh.ac.uk)

12 Red listing and indicators

Author: Nick Isaac (njbi@ceh.ac.uk)

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14 Climate change ecology

Author: Tom Oliver (toliver@ceh.ac.uk)

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16 Invasion Biology

Author: Helen Roy (hele@ceh.ac.uk)

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18 Changing habitats

Author: Chris Preston (cdpr@ceh.ac.uk)

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Photo of *Lasioglossum smeathmanellum*: Courtesy of Ed Phillips

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Photo of *Dicyrtomina saundersi*: Courtesy of Ed Phillips

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28 BRC's wider partnership

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RECORDING SCHEMES AND SOCIETIES

BRC was established in recognition of the inspiring contributions made by amateur naturalists over centuries. Throughout its 50 year history, BRC has worked closely with recording schemes and societies. Without this partnership, the work detailed throughout this booklet would not have been possible. A notable achievement has been the publication of atlases for many species groups, supported by world-leading datasets to enable a wealth of uses to support conservation and research. We look forward to a continued close partnership with recording schemes and societies and other organisations that support the biological recording community.

Following is a list of recording schemes and societies that have worked with BRC since 1964.

Green plants, lichens and myxomycetes
Botanical Society of Britain & Ireland
British Bryological Society
British Phycological Society
British Lichen Society
Association of British Fungus Groups
British Mycological Society
Slime Mould Recording Scheme

Vertebrates
Mammal Society (various surveys)
National Bat Monitoring Programme
National Amphibian & Reptile Recording Scheme
British Trust for Ornithology (various surveys)
Freshwater Fish Recording Scheme

Invertebrates
Beetles
Atomariinae Recording Scheme
Balfour-Browne Club: Aquatic Beetles Recording Scheme
Bruchidae & Chrysomelidae Recording Scheme
Cerambycidae Recording Scheme
Dermestidae Recording Scheme
Elateroidea Recording Scheme
Ground Beetle Recording Scheme
Ladybird Recording Scheme
Orthocerous Weevils Recording Scheme
Ptiliidae Recording Scheme
Scarabaeoidea Recording Scheme
Scirtidae Recording Scheme
Scolytidae Recording Scheme
Soldier Beetles, Jewel Beetles and Glow-worms Recording Scheme
Staphylinidae Recording Scheme
Stenini Recording Scheme
Tenebrionoidea Recording Scheme

Photo of *Helix aspersa*: Shutterstock

Flies (Dipterists Forum)
Anthomyiidae Study Group
Chironomidae Study Group
Chloropid Study Group
Conopidae, Lonchopteridae & Picture-winged Fly Recording Scheme
Cranefly Recording Scheme
Culicoides (biting midges) Recording Scheme
Dixidae Recording Scheme
Drosophilidae Recording Scheme
Empididae & Dolichopodidae Recording Scheme
Fungus Gnat Recording Scheme
Hoverfly Recording Scheme
Mosquito Recording Scheme
Oestridae Study Group
Pipunculidae Study Group
Sciomyzidae Recording Scheme
Sepsid Recording Scheme
Soldierflies and Allies Recording Scheme
Stilt & Stalk Fly Study Group
Tachinidae Recording Scheme
Tephritidae Recording Scheme

Other Insects
Aquatic Heteroptera Recording Scheme
Terrestrial Heteroptera Recording Schemes
Auchenorrhyncha Recording Scheme
Barkfly Recording Scheme
Bees, Wasps and Ants Recording Society
Parasitic Wasps Recording Scheme
Symphyta Recording Scheme
British Dragonfly Society, Dragonfly Recording Network
British Isles Neuropterida Recording Scheme
Butterflies for the New Millennium
National Moth Recording Scheme
Crambidae & Pyralidae Recording Scheme
Gelechiid Recording Scheme
Incurvarioidea Recording Scheme
Leaf-mining Moth Recording Scheme
Plume Moth Recording Scheme
Orthoptera Recording Scheme
Psylloidea Recording Scheme
Riverfly Recording Schemes: Ephemeroptera
Riverfly Recording Schemes: Plecoptera
Riverfly Recording Schemes: Trichoptera
Siphonaptera Recording Scheme

Non-insect invertebrates
British Arachnological Society, Opiliones Recording Scheme
British Arachnological Society, Pseudoscorpion Recorders' Group
British Arachnological Society, Spider Recording Scheme
Tick Recording Scheme
British Myriapod and Isopod Group, Centipede Recording Scheme
British Myriapod and Isopod Group, Millipede Recording Scheme
British Myriapod and Isopod Group, Non-marine Isopoda Recording Scheme
Hypogean Crustacea Recording Scheme
Cladocera Interest Group
Collembola Recording Scheme
Conchological Society of Great Britain and Ireland
Earthworm Society of Great Britain and Northern Ireland
Freshwater Flatworm Recording Scheme
Terrestrial Flatworm Recording Scheme

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