



TOMORROW'S BIODIVERSITY

Project Evaluation Report

Summary & recommendations from the FSC Tomorrow's Biodiversity project 2013-2017

Version 1 – 2nd March 2018

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FSC Tomorrow's Biodiversity project funded by the
Esmée Fairbairn Foundation.





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2 Executive summary

Tomorrow's Biodiversity was a Field Studies Council project funded by the Esmée Fairbairn Foundation from 2013 to 2017 inclusive. A two-year development phase, which included desk research and a public consultation, helped to frame a three-year delivery phase. Esmée Fairbairn has also funded the development of digital outputs from the project for a further year (2018).

The development phase defined several exemplar projects aimed at exploring ways to overcome barriers to participation in biological recording and survey.

There were two kinds of exemplar projects:

1. Those providing **training in biological identification & survey**, particularly for taxonomic groups which are under-represented in national biodiversity monitoring.
2. Trialling and production of **new digital tools** for biological identification and analysis & visualisation of biological records.

Our most successful biological identification & survey training projects were those for spiders (and other arachnids), earthworms and vascular plants. The success of each had its foundation in strong partnerships that we developed with the Shropshire Spider Group, the Earthworm Society of Britain (ESB) and the National Plant Monitoring Scheme (NPMS) respectively.

The Spider project resulted in the development of an integrated suite of *differentiated* courses, in recognition of the fact that people come to ID courses with different levels of skill and with different requirements. The courses facilitate moving people as far up the skills & engagement pyramid as they want to go, enabling them to make a valuable contribution to biological recording at that level. This idea has been developed and carried forward into the next FSC biodiversity project – BioLinks – which will run from 2018 to 2022 inclusive.

Participation in the NPMS and the ESB's national recording scheme – both very young recording schemes – was boosted by our projects, leaving both stronger than they were before our partnerships and better able to contribute towards national biodiversity monitoring. We also met with considerable success in training springtail identification and recording, particularly amongst the Shropshire entomological community, producing the UK's first detailed county atlas for springtails.

Our most significant work in the digital realm includes the development of the TomBio ID Framework – an open-source toolset for building new digital ID resources and visualisations. We published a new online resource – The Harvestmen of Britain & Ireland – using this framework. We developed an award-winning GIS analysis tool for biological recorders and ecologists called the TomBio QGIS Plugin which is used all over the world.

This report ends with a series of recommendations to providers of biological identification training (especially of specialist invertebrate courses), schemes & societies, identification resource developers, biological recorders and funders of natural history and biodiversity projects. A selection of these are listed below, but for the full list and expanded context, see the final section of the report.



Among our recommendations on providing joined-up natural history training via partnership working are:

- Look beyond the immediate (and necessary) goal of filling courses; where do participants go next to progress? How could they be better prepared to benefit from your current provision?
- Favour working with partners who are imaginative and creative and think beyond the limits of their own immediate requirements.
- Don't be dogmatic; don't let the fact that you've always done it a certain way blind you to new opportunities.

Among our recommendations to partners involved in staging residential specialist invertebrate courses are:

- If project (or other) funding is available, consider subsidising course fees whilst the course is becoming established, but *aim to increase the fees* over time to a level where the course can realistically cover its own costs.
- All members of partnerships should play an active role in marketing courses; the efforts of course tutors appear to have an extremely significant impact.
- Sufficient well-maintained specialist equipment, such as microscopes, can be hard to source; careful planning and communication between partners, may be required to secure the necessary equipment from several sources.

Among our recommendations to those who want to stay in touch with developments in the ID Framework project are:

- Sign-up for the ID Framework MailChimp newsletter: <http://www.tombio.uk/framework-signup>
- If you are aware of a number of people who are interested in exploring the idea of creating ID resources, contact us (see below) to talk about the possibility of organising a free one-day workshop.
- If you have created ID resources using the ID Framework, but do not have access to a website to deploy them, contact us (see below), we are likely to be able to host them.

Among our recommendations to those who want to engage with FSC's QGIS training provision and developments with the TomBio QGIS Plugin:

- To keep up to date with developments with the TomBio QGIS Plugin, check here for a 'current status' report: <https://github.com/burkmarr/QGIS-Biological-Recording-Tools/blob/master/README.md>
- To report problems with, or ask for new features for, the TomBio QGIS Plugin either raise and issue here: <https://github.com/burkmarr/QGIS-Biological-Recording-Tools/issues> (preferred) or email us: richardb@field-studies-council.org
- If you have training or consultancy requirements that are not met by 'off the shelf' courses, contact Matt Davies: <http://www.maplango.com/>



Among our recommendations to natural history projects or societies that wish to increase their reach and/or improve communications through digital media:

- Keep website content, particularly the homepage, dynamic and fresh, e.g. by regular blogging - short frequent blogs may be better than longer infrequent ones (though don't shy away from longer blogs if you've something important to say).
- Consider scheduling regular blog posts and do your utmost to stick to it.
- Carefully select which social media tools to engage with, and understand the reasons for your selection, but be prepared to change strategy in light of new knowledge, trends and the changing landscape of social media.

These are among our recommendations to funders of long-duration (3 or more years) natural history and biodiversity projects based on our successful partnership with Esmée Fairbairn:

- Develop a relationship, from the start, based *more* on trust and broad objectives and *less* on tightly defined and restrictive targets.
- Consider allowing time and space within the project, either at the start or perhaps in the middle, for reflection and adjusting of goals.
- Place *more* emphasis on linking to, and building on, work that has come before and that which will follow after and *less* on eye-catching novelty.



3 Introduction

Tomorrow's Biodiversity was a Field Studies Council (FSC) project funded by the Esmée Fairbairn Foundation for five years (2013-2017 inclusive). FSC has reported annually to Esmée Fairbairn over the course of the project. The current report does not form part of that reporting but looks at the project in the round, from start to finish, with the aim of producing a publicly accessible summary of the work of Tomorrow's Biodiversity and the lessons we have learned. Our hope is that this report will be useful to anyone in the future who is conducting or proposing work of a similar nature. Note that Esmée Fairbairn have also funded a further year of development on the digital outputs from the project (for 2018), but this report only covers the initial five-year project.



The original application to Esmée Fairbairn summarised the proposed work of the project thus:

"Tomorrow's Biodiversity will review the future priorities for a healthy UK biodiversity, identify indicator species or assemblages and develop practical identification resources and associated supporting training. Identification resources will be peer reviewed. The project aims to be relevant to both national organisations and local societies, to professionals and volunteers."

The application also included a procedural outline for the project as shown below:

1. Identification of the future issues that are going to have the biggest impact (using published research and new consultation).
2. Identification of critical groups of organisms that will be most affected.
3. Selection of indicator species/assemblages (groups of species).
4. Production of high-quality and rigorous identification resources to enable indicator groups to be surveyed by a range of audiences.
5. Training provision for specialist and non-specialist field surveyors.
6. Creation of strategically important special interest groups.
7. Publication and dissemination of good practice to be adopted by existing and newly-formed field and special interest groups.

FSC and Esmée Fairbairn agreed an innovative structure for the project which included an initial two-year 'development phase' (2013-2014) during which research and consultation was undertaken to focus the work of a subsequent three-year 'delivery phase' (2015-2017). Items 1-3 fell within the remit of the research & consultation phase of the project and items 4-7 fell within the remit of the delivery phase.

The original project plan included provision for one full-time project officer for the duration of the project and a half-time project assistant for 4.5 years, starting half way through the first year.



However, the project officer felt that the initial two-year development phase of the project did not warrant an additional half-time project assistant for 18 months and, with the agreement of Esmée Fairbairn, we did not recruit a project assistant until the start of the delivery phase. Importantly, Esmée Fairbairn also agreed that the savings on salary costs over those 18 months could be transferred to the delivery phase of the project to help resource the training.

To some extent this kind of flexibility was ‘baked in’ to the Tomorrow’s Biodiversity project from the beginning (as is evident from the inclusion of a development phase), but the willingness of Esmée Fairbairn to consider a request to modify the project in this way is unusual by the standards of many funders in this sector. Satisfied that the requested changes would be in the best interests of delivering the overall project objectives, Esmée Fairbairn agreed to them. This illustrates Esmée Fairbairn’s oversight of the project which can be characterised as firm but flexible with an absence of any tendency to micro-manage. This was very empowering for FSC as the project deliverer and Esmée Fairbairn deserve a huge amount of credit for enabling the dynamism and creativity which we think came to characterise the outputs of the Tomorrow’s Biodiversity project.

4 Development phase: desk research

The original application to Esmée Fairbairn summarised the questions that would be addressed by the research phase as follows.

- What are the major environmental impacts likely to affect UK biodiversity in the next 20 years?
- What do we need to know to enable us to measure, through biological recording, the accompanying environmental changes?
- What will the impact of the environmental changes be and how effective are the mitigating measures?
- Who and what could be used to build this knowledge?
- Which groups of animals, plants, fungi or other environmental measures, are likely to be the most effective indicators in providing this information?
- What level of experience is needed to build the knowledge?
- What resources and facilities would be needed to unlock the potential?

These questions were addressed through a year-long desk study in 2013 (and a consultation in 2014 described in the next section). For the desk study, we addressed these questions over three separate reports:

1. Drivers of Biodiversity Loss (<http://www.tombio.uk/sites/default/files/TomBioDrivers.pdf>).
2. Monitoring and Indicators of UK Biodiversity Change (<http://www.tombio.uk/sites/default/files/TomBioIndicators.pdf>).



3. The Shifting Paradigm of Biological Identification

(<http://www.tombio.uk/sites/default/files/TomBioIDResources.pdf>).

These comprehensive reports together contain some 46,000 words over 123 pages and can be downloaded in full from the URLs above. The main points arising from each are summarised in the subsections below.

We required access to academic literature to carry out the desk research and this was occasionally problematic. We overcame this, for the most part, thanks to academic associations between members of the FSC Biodiversity Team and Manchester Metropolitan University, which gave us the electronic access to many of the journals we needed. We were fortunate to have these links – access to scientific literature is a major problem for individuals and organisations not affiliated to a scientific institution. We used ‘Mendeley’, an excellent free citation manager program (<https://www.mendeley.com/>), and its associated MS Word plugin, to organise the literature (and associated references) we consulted.

4.1 Desk study: Drivers of Biodiversity Loss

The main points arising from this report (available at <http://www.tombio.uk/sites/default/files/TomBioDrivers.pdf>) are summarised in its first section – key findings – which is reproduced in the box below.

- Although biodiversity covers variability in natural systems at all levels, from the genetic, through organism to ecosystem, biodiversity loss metrics are most often expressed at the organism level, e.g. in terms of species richness and extinctions.
- Biodiversity is being lost at rates that far exceed any in recent geological history. This loss is anthropogenically driven and is operating at levels which exceed the putative ‘safe’ levels for mankind.
- Major global drivers in terrestrial ecosystems are:
 - land use change (encompassing habitat loss, degradation & fragmentation);
 - climate change;
 - eutrophication; and
 - biotic exchange (e.g. invasive alien species).
- Major global drivers in freshwater ecosystems are:
 - habitat degradation, including flow modification;
 - pollution, including eutrophication; and
 - biotic exchange (e.g. invasive alien species).
- Major global drivers in marine ecosystems are:
 - climate change (especially in coastal areas);
 - overfishing;
 - habitat degradation (e.g. from destructive fishing operations);
 - acidification; and



- pollution (including eutrophication of estuaries).
- A number of other drivers are important but do not currently attract so much attention, either because they operate at a local scale, their effects are not currently thought to be so great or their full effects are yet to be realised or understood. These include:
 - emerging Infection Diseases (EIDs) like Ash Dieback (*Chalara fraxinea*);
 - water abstraction for agricultural irrigation;
 - pesticides (e.g. neonicotinoids);
 - genetically modified organisms; and
 - sea level rise.

Furthermore new potential drivers, e.g. microplastic pollution, are constantly emerging as issues. Many of these emerging issues can properly be considered as new facets of known existing drivers of change.

- In the UK, the current major drivers of biodiversity loss are generally considered to be:
 - habitat change (broadly equivalent to land use change);
 - eutrophication (and pollution); and
 - overfishing;

However, it is also recognised that the following two drivers are increasingly important and may become extremely serious in the coming decades:

- climate change; and
- biotic exchange (e.g. invasive non-native or alien species).
- At the root of all anthropogenic drivers of biodiversity change are impacts associated with human population growth and increasing per capita consumption.
- The drivers of biodiversity loss are wide-ranging and complex and they interact in ways which we are only just beginning to appreciate, much less understand. Furthermore, the effects of these drivers on biodiversity operate through complex, and relatively poorly understood, ecological processes.
- The Tomorrow's Biodiversity Project should not address itself to unpicking the detail of the links between the complex web of drivers and the response of biodiversity, but rather to observing and recording the effects of drivers on biodiversity to facilitate better understanding and mitigation.

This part of the desk study required a great deal of work, but did little more than confirm what most of us already knew about the drivers of biodiversity change. The most useful points to arise from it reflect the complexity of the relationship between drivers of biodiversity loss and the changes in biodiversity we see on the ground and the conclusion that the Tomorrow's Biodiversity project should "*not address itself to unpicking the detail of the links between the complex web of drivers and the response of biodiversity, but rather to observing and recording the effects of drivers on biodiversity*".



4.2 Desk study: Monitoring and Indicators of UK Biodiversity Change

The main points of interest arising from this detailed assessment of biodiversity monitoring and indicators in the UK are presented in the conclusions section at the end of the report (available at <http://www.tombio.uk/sites/default/files/TomBioIndicators.pdf>), some of which is summarised below.

- Most monitoring that contributes towards strategic UK (and country-level) headline biodiversity indicators was initiated by people and groups interested in biodiversity for its own sake but subsequently adopted, for pragmatic reasons, by strategists building headline indicators.
- Therefore, the selection of headline indicators in the UK was not the result of an objective evaluation process and, as a result, there are considerable gaps in their taxonomic coverage and representativeness including:
 - lower plants;
 - fungi;
 - invertebrates;
 - all marine taxa
- The fact that a group of taxa is not well-represented by strategic headline indicators does not necessarily mean that no monitoring is taking place. In fact, a considerable amount of monitoring produces ‘operational indicators’* which are not incorporated into headline indicators.
- There are many potential barriers that could account for this and it may be possible to address these to fill some gaps in the representativeness of headline indicators without initiating entirely new monitoring. But there are certainly areas where new monitoring is required.
- Of the invertebrate taxa, those inhabiting soil may represent a particularly significant gap in our monitoring. There are also plenty of advocates for using lower plants and fungi in monitoring. The greatest limitation to the use of these taxonomic groups in monitoring remains the difficulty of practical identification.
- Marine monitoring around the UK is in its infancy. There are major differences between monitoring in marine and terrestrial habitats, not least of which is that the opportunities for volunteer and citizen science in the marine environment are more restricted because of the inaccessibility of the habitat without specialist equipment and training.
- Advances in systematics and taxonomy and the associated improvements in molecular techniques will offer opportunities for improving monitoring of biodiversity over the coming decades. It is likely that these new techniques will be integrated into the practice of biodiversity monitoring and the development of new indicators as appropriate and just as likely that they will be deployed with the aid of citizen scientists.
- The crucial role of non-professionals – whether characterised as volunteer biological recorders, citizen scientists, expert amateurs, natural historians, or whatever – in producing biodiversity indicators over the coming decades is clear. There is growing



interest in the development of analytical methods that allow more robust quantitative indices of change to be drawn from 'casual' biological records. But it also appears that volunteer biological recorders are themselves increasingly interested in contributing to structured surveys of the kind from which robust indicators of change are more reliably produced.

- Tomorrow's Biodiversity will target gaps in the coverage of biodiversity monitoring in the UK with new FSC training and resource development. The FSC cannot itself develop new monitoring programs, but it can support the development of new or existing operational indicators by other organisations which could, in turn, contribute towards strategic headline indicators. The priorities for the Tomorrow's Biodiversity project going forward are outlined below.
 - Identify, through consultation and further research, what operational biodiversity indicators exist within the UK that do not currently contribute towards headline indicators.
 - Identify, through consultation, barriers to the development of existing or new operational indicators.
 - Identify, through consultation, where the FSC could help to overcome such barriers.
 - Establish partnerships with other organisations to address some of the barriers in the delivery phase (years 3-5) of the Tomorrow's Biodiversity Project.
 - Align the outputs of the Tomorrow's Biodiversity project with the core operations of the FSC in ways that will ensure a legacy beyond the end of the Tomorrow's Biodiversity project.
- There are many ways in which we could work with partner organisations to support the development of existing or new operational indicators. Ways in which the Tomorrow's Biodiversity project can deliver this support include those outlined below.
 - Provision of training in taxonomic identification skills.
 - Provision of training in habitat survey and assessment skills.
 - Provision of training in the operation of survey protocols.
 - Provision of training in the use of new tools and resources that can contribute to the operation and management of operational indicators, e.g. online key development and GIS.
 - Provision of training and support to others providing training.
 - Trialling new ways of providing training and support (e.g. online).
 - Development of new resources in support of the development of operational indicators (including but not necessarily limited to ID resources).
 - Exploring delivery of such resources through multiple platforms (including paper and electronic).
 - Provision of support to others developing new resources.
 - Facilitating support and mentoring networks.
- Given the huge gaps in representativeness and taxonomic coverage of headline biodiversity indicators in the UK and at country-level, there is currently potential for almost any operational biodiversity indicator to contribute if it meets the criteria for inclusion. The FSC and the Tomorrow's Biodiversity Project cannot directly influence the development of national and UK indicators, but it can target resources on the



development of operational indicators that have potential to make a contribution and we can priorities work in those areas, identified above, for which few operational indicators currently contribute.

*In the report, *Operational Indicators* were loosely defined as biodiversity trend indices which were not incorporated into national headline indicators.

Together with the consultation (as we shall see later) this report underlined the huge taxonomic gaps in biodiversity monitoring in the UK, particularly with respect to invertebrates, and indicated that these gaps are so huge that almost any invertebrate group could, potentially, contribute to biodiversity monitoring. The suggestion that soil invertebrates could be a useful group to focus on, because of the important ecological services provided by soils, was something that we would pursue in the delivery phase of the project.

During the subsequent consultation, we attempted to identify operational indicators that could contribute to national biodiversity monitoring, but with little success: it seemed that most biological recording is not sufficiently structured to contribute towards effective operational indicators. However over recent years the success of new analytical methods to make more effective use of less structured biological recording (also mentioned in the review) – resulting largely from work done by the Biological Records Centre – has increased the value of all sorts of biological records and resulted in new operational indicators that have been used within the new series of ‘State of Nature’ reports generated in 2013 and 2016.

Tomorrow’s Biodiversity did subsequently do some work to directly impact the development of operational indicators, such as the National Plant Monitoring Scheme (see later section), but for the most part, we took the idea of ‘overcoming barriers’, which in the report applied to the development of operational indicators, and applied it more broadly to the problem of generating more biological records for under-recorded taxonomic groups, particularly invertebrates.

4.3 Desk study: Shifting Paradigm of Biological Identification

This report was a review of the ‘state of the art’ of biological identification resources for biological recorders viewed within a wider context of ‘eTaxonomy’. The section ‘Summary of main points’, which concluded the report, is summarised in the box below. (The full report is available at <http://www.tombio.uk/sites/default/files/TomBioIDResources.pdf>.)

- Two features of this review stand out above everything else:
 - the range of techniques and resources for biological identification is increasing dramatically and,
 - to make a meaningful contribution to the rapidly changing field of taxonomy – eTaxonomy – interoperability of new tools and resources is key.

Taxonomy is a collaborative venture and developments which don’t facilitate collaboration are wasteful. The outputs of biological recorders (their records) and the tools they use for biological identification are not exempt from this maxim.



- The degree to which the elements of eTaxonomy are interoperable and interrelated is reflected in extent to which they harvest information from, or provide information to, other elements. The Encyclopedia of Life (EOL), exemplifies this with over 250 ‘content partners’ including other major elements of the eTaxonomy framework like the Catalogue of Life (CoL).
- EOL itself makes its content discoverable and usable by other tools and facilities via its Application Programming Interface (API). So, for example, any third party could create a website or program and dynamically populate it with information or images from EOL through use of its APIs. APIs, like support for data interchange standards, are a feature of interoperable tools.
- The following are key points to consider when developing new electronic tools or resources for use by, or to support the development, mentoring and networking of, biological recorders. Tools and resources should:
 - Capitalise on existing developments, including other tools, standards and content available through APIs.
 - Bring something new to the party!
 - Be interoperable and ‘outward looking’ themselves.
 - Facilitate the evolution of user’s working methods rather than demanding a revolution.
 - Recognise the contribution of content providers/users.
 - Operate within a financially sustainable business environment.
- Biological identification and biological recording is on the cusp of a period of major and rapid change on the tails of a technological transformation already underway in the wider field of taxonomy & systematics. Accelerating advances in mobile computing and electronic publishing are helping to drive this transformation. These changes are fundamentally important to the delivery of the Tomorrow’s Biodiversity project and are of general importance for the delivery of biodiversity education and resources within the FSC.

These points reflect the growing importance of technology and tools delivered over the internet to biological recorders. Although not directly mentioned in the points above, the report included a major review of the use of computer-based keys, especially multi-access keys. This review had a great influence on the direction of the Tomorrow’s Biodiversity project and was central to the subsequent formation of our view that the project could maximise its impact by exploring, during the project’s delivery phase, the use of the latest web technologies for delivering interactive multi-access keys. This led directly to the development of the Tomorrow’s Biodiversity ID Framework (described later).



5 Development phase: consultation

The results of the desk studies helped frame a consultation with the UK biological recording and biodiversity surveillance & monitoring community which took place over 2014. A series of nine workshops was held over the UK as indicated below. Some people were invited to these consultations but an open invitation was also issued to the entire biological recording community in the UK.

- Royal Botanic Gardens Edinburgh
- FSC Margam, South Wales
- FSC Belfast, Northern Ireland
- FSC Blencathra, Cumbria
- FSC Slapton Ley, Devon
- FSC Preston Montford, Shropshire
- Attenborough Nature Centre, Nottingham
- Natural History Museum, London (two workshops)

Attendees of these workshops were offered a fixed-rate consultation fee of £50 to help offset their expenses.



In addition to these workshops, consultation meetings were also held with Scottish Natural Heritage (which included some external partners) in Inverness, the Biological Records Centre (including some partner organisation) in Wallingford and Natural England in Peterborough. Some formal telephone consultations were also undertaken.

Over the whole process 99 people affiliated with more than 100 organisations were consulted. Further particulars are available in the full consultation report which can be downloaded here: <http://www.tombio.uk/sites/default/files/TomBioConsultation.pdf>

During the consultations, we tried to identify where FSC could develop new training and resources, or modify its existing portfolio or practices, to provide greater facilitation of biodiversity surveillance & monitoring in the UK. Themes covered included:

- gaps in taxonomic coverage;
- habitat recording/monitoring;
- supporting surveillance & monitoring protocols;
- overcoming barriers to learning;
- overcoming barriers to contributing to surveillance & monitoring;
- supporting people outside the classroom; and
- identification resources (including new media) and techniques.

The consultations had a very open format. And whilst we had a list of questions and topics that we wished to cover, we were also cognisant of the fact that our main role was a 'listening' one and, consequently, the consultations often covered unexpected subjects that were, nonetheless, of great



interest to biological recorders. There was no executive summary in the consultation document, but the most relevant points are distilled in the box below.

- A wide range taxonomic groups, from birds to hydroids, were suggested as possible subjects for which FSC could play a role in providing more training and/or resources, but there were a few which were consistently suggested across the workshops including:
 - fungi;
 - lichens;
 - bryophytes;
 - earthworms;
 - freshwater invertebrates;
 - bees (and other aculeate hymenoptera); and
 - springtails.
- Perhaps surprisingly there wasn't a great deal of enthusiasm for identifying specific taxa for the focus of attention. People were more interested, for the most part, in identifying the barriers inhibiting effective monitoring that are common across a wide range of taxa.
- There was a striking range of attitudes towards habitats across those consulted. Some had "*no use for habitats*" whilst others (the clear majority) regarded habitat as a useful framework within which to study and make sense of natural history.
- Among the majority who valued the concept of habitats, there was a lot of interest in using them to frame ID training and resources as a way of incorporating more ecology and natural history learning (already common practice for some taxa, e.g. vascular plants).
- There was recognition that the practice of recording habitats is changing thanks to improvements in remote sensing and the increasing availability of hand-held technology. Barriers to involvement in habitat recording could be of two kinds:
 - technical knowledge of habitats (e.g. habitat ID skills); and
 - skills in using (and perhaps accessing) the technology.
- People are interested in associations between organisms and there was widespread support for the idea of identification/ecology courses that cover two or more different, but ecologically related, taxonomic groups.
- The National Plant Monitoring Scheme (NPMS), trialled in 2014 and due to be officially launched in 2015, has the potential to make a major contribution to vascular plant monitoring in the UK. The scheme is designed to accommodate both beginners and expert botanists which it does by incorporating four different, but related, protocols with a clear progression path between them.
- Future FSC training and ID resources could make a greater contribution to monitoring in the UK if FSC is mindful about how they relate to the monitoring protocols such as NPMS and people's participation in them.
- Several people made the point that there is a very important role for casual recording outside of the context of protocols and that it remains the greatest source of data for



many taxa including the majority of invertebrates. Casual recording of invasive species has great value, often alerting us to the extents of their expanding distributions.

- There was an often-expressed view that we need to think more about providing a greater range of training within specific taxonomic groups to cater for a greater range of abilities. Beginner's courses are often too hard and off-putting and we should provide more very simple introductory courses.
- All in all, we need to think more about training programmes, rather than individual training courses, considering what content is appropriate at what level and thinking about how the programmes and constituent courses provide paths for progression up the pyramid of engagement.
- Definite project endpoints, with interesting outputs like distribution atlases, can act as a major incentive to greater levels of participation - even to existing recorders. Many schemes & societies notice that participation from members waxes and wanes under the influence of such projects.
- Capitalising on developments in new technology can boost participation. Marine recording has benefitted greatly from new technology.
- A theme that cropped up more than once was based on the idea of partnerships between FSC and schemes & societies that go beyond the usual FSC Associate Tutor model. FSC could work in partnership with schemes & societies to develop and deliver programmes of courses that facilitate progression through the engagement pyramid.
- There was universal recognition of the value of follow-up support to learners once a course is over. But achieving this can be problematic. Some of the best examples of natural history teaching programmes – e.g. the Cyril Diver project, TCV's Natural Talent Project and FSC's Invertebrate Challenge project – have provided a high degree of support outside the classroom.
- Mentoring – where a learner can call on advice and support from a more experienced practitioner – is seen as a very valuable mechanism for learning and, of course, has been part of the tradition of teaching natural history for generations. Mentoring (and other 'after-course support') is often independent of teaching; teachers needn't be mentors, nor *visa versa*, but the two roles often go hand-in-hand.
- Social media such as iSpot, Facebook, Twitter and Yahoo mail-groups can provide access to communities of expertise spread over dozens or hundreds of people that would never physically meet in one place. Many examples of useful social media groups were cited. Factors common to the best among them include:
 - fast response times to queries;
 - top-level expertise amongst the contributors; and
 - an inclusive and friendly ethos.
- An advantage of social media over traditional websites is that content is dynamic for a well-subscribed group because it is naturally generated by the entire community of users rather than the 'webmaster'.



- A good tried-and-tested model for a natural history group to maintain a web presence is to use a simple website – e.g. one based around a blog – to act as a home for regularly contributed content-rich articles and information relevant to the group and connect social media to this.
- It is as well to use more than one social media tool (and be open to new ones) since each tends to reach a different audience (and the actual audience of each changes rapidly).
- Discussion of ID resources covered several interesting points including:
 - learning is most effective if people have access to a range of ID resources, sometimes approaching the same subject in different ways;
 - text-heavy resources put many people off;
 - we shouldn't dogmatic about using either photos, paintings or line drawings and should use each – or a mixture – as appropriate; and
 - there is very widespread support for annotated photos, including side-by-side comparisons of confusing species.
- Many could also see the value in more resources to explicitly explore habitats in themselves, for example “*what habitat am I in?*” or something to support specific classifications as used by the NPMS, Phase 1 or EUNIS.
- In general there was a great appetite for online, free PDF resources (unsurprisingly!) and also a lot of interest in other online resources, such as online keys, photographic libraries, and mobile apps which were often perceived as being easily updatable and able to cope with rapidly changing situations such as those presented by invasive species.
- There was almost universal enthusiasm for the idea of short education videos (of the kind that appear on YouTube) with some people stating that watching such videos was their preferred way of learning a new practical skill.
- Not everyone was aware of computer-based multi-access keys and how these differed from traditional dichotomous keys. Those that were aware of the technology were generally enthusiastic about their potential.
- A potential feature of online keys (whether multi-access or dichotomous) that captured the imagination of a number of people was the potential to keep them up-to-date with changes in taxonomic knowledge etc, but someone also made the interesting point that it is sometimes important for a verifier to know the identification resource, including the exact version, used in the original determination in order to assess whether or not it is likely to be correct.
- A theme which generated a lot of traction at all the workshops was that of central collation resources – one-stop-shops where people can get a handle on what training, ID and other biological recording resources are available and how to find them. The sorts of resources that could usefully be collated by such facilities include:
 - training providers;
 - courses;



- identification resources;
- biological recording software;
- outlets for studies and nature notes; and
- personal nature blogs.

The consultation exercise was a great success. Consulting with the wider biological recording community and a range of specialists within the sector genuinely informed the direction of the project over the subsequent three-year delivery phase. It also helped raise awareness of, and garner support for, the project. The £50 consultation fee was also generally welcomed – particularly by those attending in their own time as volunteers – and was an effective tool in encouraging participation in the consultation. Those attending in their professional capacities generally declined the consultation fee.

A possible down-side of such a wide-ranging consultation, which should be guarded against, is the danger of raising expectations in areas which aren't subsequently addressed by the project. Careful framing of any such consultation, before, during and afterwards, can mitigate this to an extent; when people understand the investigative spirit of a consultation like this, they are more inclined to value it for its own sake and view it in the correct context within the entire project.

6 Shaping the delivery phase from the development phase

The review of the drivers of biodiversity loss indicated that they are manifold, dynamic and largely unpredictable. It concluded: *"The drivers of biodiversity loss are wide-ranging and complex and they interact in ways which we are only just beginning to appreciate, much less understand. Furthermore, the effects of these drivers on biodiversity operate through complex, and relatively poorly understood, ecological processes. The Tomorrow's Biodiversity Project should not address itself to unpicking the detail of the links between the complex web of drivers and the response of biodiversity, but rather to observing and recording the effects of drivers on biodiversity to facilitate better understanding and mitigation."*

The review of 'indicators' of biodiversity change highlighted huge gaps in taxonomic coverage amongst existing indicators and concluded: *"FSC and the Tomorrow's Biodiversity Project cannot directly influence the development of national and UK indicators, but we can target resources on the development of operational indicators that have potential to make a contribution and we can prioritise work in those areas for which few operational indicators currently contribute."*

Our research did not produce any strong evidence to highlight particular groups of organisms that can address gaps in surveillance & monitoring linked to specific drivers of biodiversity change. On the contrary, it suggested that the gaps are so large, and the drivers so poorly understood and unpredictable, that almost any under-resourced taxonomic group could make a valuable contribution to surveillance & monitoring if supported by new identification resources, training and special interest groups.

This idea was also strongly supported by the results the consultation. Very few people firmly identified particular groups of organisms as potential new indicators of biodiversity change and no groups received overwhelming support (although some, such as earthworms, springtails and mosses



were suggested more often than others). The great majority of consultees were more interested in achieving a significant expansion of the suite of indicators of biodiversity change across the board, identifying barriers to realising this wide representation and suggesting possible solutions.

The following learning points from the research & consultation phase of the project had a significant impact on the delivery phase:

- The biosphere is a complex system in which drivers of biodiversity change interact in poorly understood and unpredictable ways. While it is possible to identify many of the current major drivers of biodiversity loss, and some of those that will become increasingly important over the next few years, it is *not* possible to predict with any confidence which will be most significant or to untangle the effects of interactions between them.
- To hedge against the general lack of understanding of drivers of biodiversity change and the functional links between drivers and the response of groups of organisms, we should promote the development of a broad range of indicators, and potential indicators, of biodiversity change, increasing the breadth of the surveillance & monitoring network, its resilience and its ability to adapt to conditions as they evolve.

It was clear that the “selection of indicator species/assemblages” could not be based *solely* on “the identification of critical groups of organisms that will be most affected” by “future issues which are going to have the biggest impact” (see procedural items 1-3 in the Introduction). The delivery phase of Tomorrow’s Biodiversity would need to work with groups of organisms identified as having the potential, to contribute towards biodiversity surveillance & monitoring, but it was considered more important for most of the outcomes of the delivery phase – products and learning points – to have wide utility across many groups or organisms.

This did not change the overall aim of the project (see Introduction), but it added an ‘exemplar’ dimension in which many of the projects we subsequently developed for the delivery phase explored certain ‘focal areas’ and/or showcased approaches to enabling surveillance & monitoring that are transferable across organism groups.

The focal areas we identified, where more research, development and/or resources could make improvements to the breadth, depth and effectiveness of the biodiversity surveillance & monitoring network, are described briefly below. Many of the focal areas are transferable across groups or organisms.

1. **ID Resources:** ID resources exploiting new techniques, new media and/or under-resourced groups.
2. **Recording:** Recording activities that contribute to biodiversity monitoring & surveillance, especially as biodiversity state/impact indicators.
3. **Habitats:** Promoting understanding of habitat concepts and their utility in framing biological recording and understanding ecology. Mapping and recording habitats.
4. **Protocols:** Understanding and use of surveillance and monitoring protocols.
5. **Pyramid:** Holistic focus on skills/engagement pyramid and the mobility of people within it.
6. **Signposting:** Collation and signposting of resources, facilities and opportunities for biological recorders.



7. **Networks:** Self-help support networks for learners that integrate social media and 'traditional' networking.
8. **Mentoring:** Personal relationships between learners and people with the expertise to provide effective natural history mentoring.
9. **Partnerships:** New models for delivering training cooperatively between FSC and partner organisations.
10. **Barcoding:** Understanding and awareness of developments in DNA techniques, their utility to natural historians and their role in biodiversity surveillance & monitoring.

The 'exemplar projects' we developed for the delivery phase were made with reference to the following criteria:

1. ability to test and showcase developments in one or more focal areas;
2. synergy with existing initiatives and skills (internal and external); and
3. fit with FSC's portfolio (or potential portfolio).

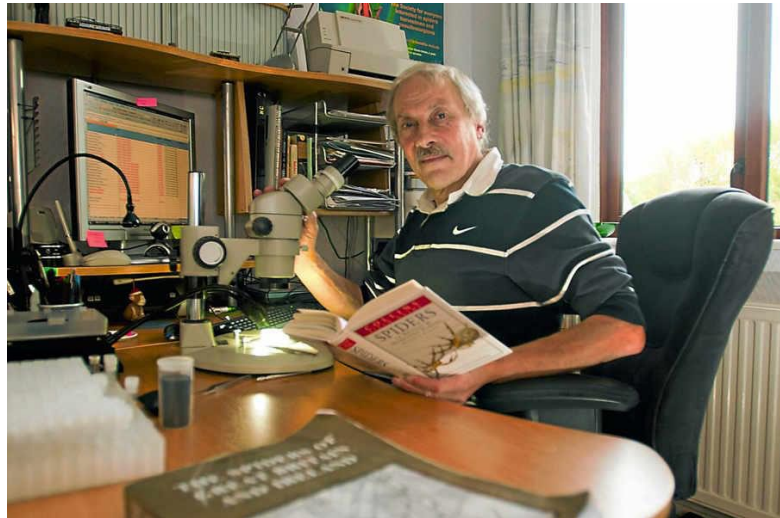
The criteria are listed in order of importance; the most important being the ability of a project to test and showcase developments in one or more focal areas. Synergy with existing FSC initiatives and skills, e.g. other FSC projects and core work, and those of partners, e.g. recording scheme and society projects, would enable us to get more 'bang for our buck' – we were able to create bigger and better exemplar projects by capitalising on synergies.

7 Delivery phase: exemplar projects

Towards the end of the two-year delivery phase of the project (end of 2014) we identified a number of projects (loosely referred to as 'exemplar projects') that we believed met the criteria defined in the previous section. By the end of 2014 these projects were at various stages of development. Where there were synergies with existing partnerships or skills, e.g. the spider project, plans were well developed. Others less so. In all cases we adopted a pragmatic and dynamic approach; thinking on our feet, capitalising on early successes and developing those projects most. Some earned the epithet of 'exemplar project', whilst one or two failed to meet expectations. In the sections below, we describe and summarise each of these projects as well as outlining successes, problems, lessons and recommendations.

7.1 Spider project

Several of our exemplar projects worked with *national* recording schemes/societies, but the spider project explored the idea of providing very high levels of support to recorders via a *local* recording group – the Shropshire Spider Group (SSG). The main thrust of project was to develop an integrated suite of *differentiated* training courses targeted at different longitudinal sections of the ‘skills & engagement pyramid’, from the engagement level at the base, right through to the expert level at its apex, and facilitating movement of people upwards through the levels. We also aimed to increase membership of the SSG and increase its resilience. The project was aimed, in particular, at the *pyramid, partnership, mentoring* and *networks* focal areas.



Nigel Cane-Honeysett, leader of the Shropshire Spider Group and partner in the Tomorrow's Biodiversity spider exemplar project.

Several factors made the SSG (and hence spiders & harvestmen) an obvious choice for this project:

1. The group was very new in 2014 with few members.
2. The group is led by a very committed and capable volunteer – Nigel Cane-Honeysett – who is also the county recorder for spiders (and, at that time, the treasurer of the British Arachnological Society). Nigel was keen to work with FSC; indeed it was a previous FSC biodiversity project – Invertebrate Challenge – that inspired and supported the foundation of the SSG and Nigel's development in the first place.
3. The Tomorrow's Biodiversity project officer (Rich Burkmar) has expertise and in spider identification and recording.
4. The FSC has a track record in running identification courses for these taxa.

We envisaged covering both spiders and harvestmen from the outset of this project but, as it progressed, we also included another arachnid group – pseudoscorpions – both in response to interest from our audience and opportunities that arose. (However, for the sake of readability, we generally simply refer to 'spider courses' below.)

7.1.1 Spider project: integrated suite of differentiated courses

The development of an integrated suite of repeatable training courses was the cornerstone of this project. Nigel and Rich led the most of the training for this suite of courses (ably assisted by the Tomorrow's Biodiversity assistant project officer, Charlie Bell) – an important consideration because buying in outside taxonomic ID expertise was a major expenditure item for the delivery of phase of the Tomorrow's Biodiversity project. Using our own taxonomic and teaching skills was beneficial to this project because it allowed us to provide high levels of training and support without worrying about the cost to the project (Nigel never accepted any payment from the project for work he did to further the aims of the SSG).

We differentiated four types of courses in this suite:

1. An engagement course called *Learn to Love Spiders* – not an identification course *per se*.
2. A beginners' course covering identification of live spiders and harvestmen in the field called *Field ID of Spiders & Harvestmen*.
3. An intermediate (to advanced) level course which covered only identification of preserved specimens using microscopes, which we just call *Spider ID with Microscopes*.
4. Various specialist training sessions (see below).

Learn To Love Spiders is a taught course giving an overview of the biology and ecology of spiders and other British arachnids in an engaging way. This course developed from an idea inspired directly from the Tomorrow's Biodiversity consultation where several people independently expressed the view that traditional beginners' ID courses were pitched at much too high a level. So when we set out to develop an integrated suite of differentiated spider ID courses, it seemed natural enough to think about a course pitched at the 'pre-beginners' level.

The course aims to inspire participants and really ignite their interest in spiders (and other arachnids) as a fascinating group of animals and key members of terrestrial ecosystems. It is not,

primarily, an ID course although we aim to fan the flames of any interest shown in spider ID and the course can be a stepping stone to an identification training course. The course title is intentionally 'soft' to encourage attendance by those that are interested in nature but who do not have the confidence to record wildlife.



The content includes sit-down presentations covering subjects that we think really excite interest in spiders such as silk, mating behaviour etc, often with the help of short YouTube videos. Participants are shown live spiders, normally collected by the tutors the day before. Participants assemble their own spi-pot (see below) before a field session where people are encouraged to find and collect live spiders. During the field session there is an emphasis on finding and looking at different sorts of webs since there are many fascinating ecological, biological and evolutionary stories related to these. Learning to recognise the different sorts of webs and associating different types of spiders with them is also a bit of a surreptitious introduction to ID.

During both the Learn to Love Spiders course and the Field Identification of Spiders participants make their own 'spi-pot'. This has a dual purpose; firstly each participant ends up with a useful piece of kit to use on the rest of the course (and to take away with them) and secondly the practical activity of building the spi-pot is an active and fun change from the sit-down sessions preceding it. We made a video to support this activity which can be seen here: <http://www.tombio.uk/spi-pot>. To save time in the classroom, we always prepare (i.e. pre-cut) the materials needed to build the spi-pots, so building one is really just a matter of assembling the prepared parts. This is always a popular activity, particularly because it results in a useful piece of kit for observing and identifying spiders.



Two more useful and cheap items of kit for the outdoor sessions are electric toothbrushes which can be used to tease some spiders from their webs (some very reliably such as the lace weaver *Amaurobius similis*) and fine misters (which we filled with cornflower) to spray on webs to increase their visibility. The excitement generated, amongst youngsters and adults alike, by an *Amaurobius* charging out of its retreat to grab the bristles of an electric toothbrush is ‘money for old rope’ for anyone running a course of this kind!

The course normally ends in the classroom where we use a cheap digital ‘USB microscope’, connected to a laptop and projector, to examine some of the spiders (in spi-pots) collected by the participants. We found this to be much more satisfactory than attempting to pass potted spiders around a group of people – each spider could be shown once and interesting features pointed out to everyone together.

At some point during the course we normally give a short presentation on the facts and fictions surrounding the subject of spider bites – generally aiming to reassure and explain the roots of the sensationalised misinformation on that subject. This can be useful because we have sometimes had self-confessed arachnophobes in attendance – people who were often desperate to overcome their fear of spiders. Over the course of the Tomorrow’s Biodiversity project we became sensitive to this and started to acknowledge the possible presence of arachnophobes as we introduced the course, with reassurances that they were both welcome and safe. Indeed during the last Learn to Love Spiders course we invited one such ‘recovering arachnophobe’ – a participant on a previous course – to come along and introduce herself as such; she wrote an account of this as a guest blog on our website - <http://www.tombio.uk/lovespiders>.

On this course we generally attempt to avoid using over-technical terms, preferring simple expressions like ‘telling different types apart’ over those like ‘species ID’ and we did not overly concern ourselves with precise identification. This helps us to avoid turning off people who are not yet ready for in-depth identification work. (We tend to use the FSC fold-out chart on spiders to illustrate the variety and types of spiders that can be found in the UK.) This can only work when course tutors are very mindful of the language they use and detail they are presenting. It can be a difficult job – much harder in many ways than presenting a highly technical course. It is made harder by the fact that we sometimes get individuals on the course who are clearly ready for more technical content. To avoid frustrating these participants, they can be given more technical information in the open sessions, e.g. the field sessions, when they can be talked to on a one-to-one basis or in small groups, something which is greatly facilitated by having two or more tutors on hand.

Field ID of Spiders & Harvestmen starts with a presentation session, but the emphasis of this session is on exploring the diversity, taxonomy and morphology of UK spiders, especially as a required grounding for identification skills (contrasting with the more general interest presentations *for Learn to Love Spiders*). There is normally a session where participants assembled their own spi-pots for use on the course and to take away with them. We always include a session on equipment, identification literature and searching/sampling techniques, during which participants are typically invited to leave their seats and gather around a table where many of the relevant resources were assembled together for them to look at, handle and discuss. Before going into the field, participants are invited to examine, at first hand, live spiders which have been collected and brought into the course by the

tutors. We would often point out identification features at this point and demonstrate handling live spiders, using the spi-pot etc.

Spiders are not collected for preservation on this course. Just like the Learn to Love course, all the collected spiders are released at the end of the day. This is important because it allows us to promote the course as one that only deals with living spiders. More and more people who are engaging with arachnology do not want to kill and preserve specimens. At the same time, technology (e.g. photography) and our knowledge of identification has improved to the point where many species can be reliably identified from live specimens (or photos) by properly trained people.



Identifying spiders in the field during one of our Field ID courses.

The new photo guide from the British Arachnological Society – Britain's Spiders – really embraces this and is the perfect text for the course. (Prior to the publication of this book we used a mixture of resources including the FSC fold-out chart, the Collins field guide, and Dick Jones' Countrylife guide.)

During the outdoor field session course participants are urged to find and collect live spiders (in pots provided to them) and bring them to course tutors for help with identification. The emphasis in this course is on identifying spiders (and harvestmen) with as much precision as possible in the field, but without going beyond to boundaries of what can be identified reliably without microscopic examination of preserved specimens. One of the teaching objectives of this course is to teach people that it is okay – in fact it is good practice – to say “that’s as far as we can take ID on a live specimen of this kind of spider”.



In the field, participants use hand lenses to examine spiders in spi-pots and we ask them all to collect one or two spiders to bring back to the classroom for examination with the USB microscope. We explain to participants that the USB microscope is simply a device for showing everyone, at once, similar views to those obtained with a hand lens. They are disabused of any thoughts that this is 'microscopic examination' in the sense that arachnologists use that term. During the USB microscope session we emphasise the identification features for each spider we look at and note what we can say for certain about its identification without preserving it for microscopic examination. This can mean identifying it to family or genus or species, depending on the specimen. We underline the importance of only being as precise as we can be with certainty.

Unlike the *Learn to Love Spiders* course, this course ends with a classroom session on recording during which we talk about the options available for people to submit records and the pros and cons of each. We try to cover local recording groups, SRS area organisers, the SRS record entry pages, LERCs and iRecord. We talk about the NBN – which is important to a lot of people – and the current disconnect between the SRS and the NBN. We show people the SRS species accounts pages. We also show them the area organisers page on the SRS website so that they can see who they can contact in order to engage with the SRS. We talk about virtual communities such as the excellent British Spider Identification Facebook group and we also talk about local groups – both 'actual' and 'virtual'! In short, we make it clear to them that they can make a valuable contribution to recording a limited number of spider species even without collecting and preserving them and that there is plenty of support available. We also point the way forward for anyone who wants to be able to identify more, or all, UK spiders.

Spider ID with Microscopes is entirely classroom-based and participants work only with preserved specimens supplied by the tutor (though they are also invited to bring along preserved specimens of their own). This is an intermediate-level course and we tend to assume some knowledge of spider morphology, though we do recap it in a presentation.

The main presentation we use to start the course is a walkthrough identification, to family level, using projected photographs (in a PowerPoint) taken down a microscope of all the relevant key features. Participants follow the identification in a copy of a family key which is photocopied for them. The specimen in our walkthrough was *Larinioides sclopetarius*, deliberately chosen because it requires quite a journey through the key to be identified as a member of the family Araneidae.

Next the participants are invited to select a specimen from a teaching collection (all in numbered tubes, but otherwise unidentified) and work through a family key themselves. When they think they have made an identification to family level, their IDs are checked by a tutor and, if correct, they are shown, on a one-to-one basis, the relevant section for the family, either in 'Big Roberts' or the Collins field guide, and how to identify to species level by examining genitalia and other features as appropriate. This doesn't generally stretch the teaching resources since numbers on these courses are limited by available equipment and space – usually to about eight people (which is generally fine because demand for these courses tends to be lower than for the field courses) – and we normally have two tutors on hand.

Although the Collins field guide does not include the majority of species from the family Linyphiidae (money spiders) it is fine because there are no linyphiids in the teaching collection. The identification of linyphiids requires a couple of additional techniques which are not covered in the course.



However we have had someone attend one of these courses with the express intention of practicing linyphiid identification under the eye of an experience tutor. This was arranged beforehand and we were able to accommodate it with some one-to-one support.

Participants continue to identify spiders from the teaching collection at their own pace and with plenty of one-to-one support from the tutors. One or two may bring their own specimens to use instead.

The course generally ends with a look at further identification resources, e.g. Lockett and Millidge and the supplementary ID guides on the SRS website. We also provide information on support and recording similar to that given for the Field Identification course, but with the emphasis on obtaining support and verification of difficult specimens.

Specialist training was not as clearly defined as other training. We did not define a single 'advanced spider course' since the available audience for a repeatable advanced course is limited due to the pointy nature of the skills pyramid! It would be easy to imagine a standard 'advanced' course on Linyphiid (money spider) identification but we never felt the demand for it during the Tomorrow's Biodiversity project.

Instead we attempted, from time to time, to run an event that would appeal to more advanced spider recorders. These were 'one off' events. For example, we engaged Richard Gallon to run a workshop on techniques for dissecting out, clearing and curating genitalia of difficult taxa. We arranged a workshop on Pseudoscorpions (actually testing the then draft FSC fold-out key) which was popular amongst experienced arachnologists, but also many others too. On another occasion we organised, at the request of Nigel Cane-Honeysett (leader of the Shropshire Spider Group), a workshop on the emerging tool for assessing the invertebrate interest of sites - Pantheon - which, again, was attended by invertebrate recorders with a variety of taxonomic interests.

The table below summarises the content of each of the three formal repeated courses.

	Learn to Love	Field ID	ID with Microscopes
Introductory presentations	Overview of arachnid taxonomy, basic spider & harvestman morphology, debunking spider bite misinformation, inspiring spider stories, e.g. silk production and uses & mating behaviour.	Overview of arachnid taxonomy, arachnid morphology to level required for ID. All presentations geared to ID more than 'inspiration'.	Detailed overview of spider morphology, including detail of genitalia, required for microscopic ID. Introduction to keys and walk through of family key.
Sampling techniques	Information on how best to 'find & observe' spiders.	Detailed information on sampling equipment and techniques that can be used to sample and collect live spiders.	Information on preservation & curation only.
Spi-pot	Assemble and use a spi-pot as a tool for close observation without harm.	Assemble and use a spi-pot with particular reference to using it to examine, with a hand	Not used.



		lens, features required for ID.	
Field session	To observe spiders in their webs (or without as the case may be) and collect some for a closer look.	To collect spiders for ID in the field and back in the classroom.	None.
Examine live spiders in classroom	To inspire and illustrate diversity of form and function.	With particular attention to identification features.	No.
Microscopic examination	No.	No.	Yes – this is the main feature of this course.
Level of ID	Only as much as required to feed people's curiosity. Teach how to distinguish males and females.	Accurate ID of live specimens to the most precise taxonomic rank possible, determined on a case by case basis.	Full ID to species level in all cases.
Final presentations	Information on where to go from here to take interest further.	Information on recording spiders, submitting records and connecting with schemes, societies and groups.	Information on recording spiders, submitting records and connecting with schemes, societies and groups with particular reference the practice of sending preserved specimens for verification.

Careful planning of content, as summarise in the previous table, is only the first step to building a suite of integrated by differentiated spider courses. The differences between the Learn to Love and the Field ID courses, in particular, are in both the *detail* of the content presented and the *manner* in which it is presented. It is very easy for a tutor to forget which course they are addressing, particularly in the Learn to Love courses, and slip into their own comfort zone, for example by using technical language which is too far outside the comfort zone of many of the participants.

The table below outlines some rules of thumb for presenting at the three different levels.

Learn to Love	<ul style="list-style-type: none"> • Keep language simple. • Use scientific names sparingly. • Inspire with aspects of biology and ecology which fascinate people, e.g. for spiders, web building and other use of silks, silk production, mating behaviour. • Debunk myths and reveal fascinating truths! • Use video resources. • ID should take a back seat. • Use diversity to inspire by considering 'different types', particularly at family level, e.g. for spiders, 'orb weavers', 'wolf spiders', 'jumping spiders' etc. • Use the field session to find and observe animals in situ and point out their behaviour. • Encourage people to handle animals if they are happy to do so. • Use simple literature simply, e.g. fold-out charts to picture match with live animals.
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	<ul style="list-style-type: none"> • Don't kill animals.
Field ID	<ul style="list-style-type: none"> • Don't shy away from using technical language but use it carefully, remaining sensitive to the reaction of participants. • Place the emphasis very firmly on proper ID of live animals. • Carefully explain the boundaries of what can be reliably identified and recorded from live animals (and photos). • Include a careful examination of the available literature and identify the best resources for field ID. • Include a session on the practice of biological recording and make sure that participants know how to take this forward if they want to submit records. • Don't kill animals.
ID with Microscopes	<ul style="list-style-type: none"> • Use technical language as necessary, but explain it – do not assume that participants already know the vocabulary. • Don't assume that participants have all used a microscope before, you may have to explain the basics of using a microscope to some. • Use pre-preserved specimens. On a day course, there is no time for a field session if participants are to have sufficient time at the microscopes. • Place the emphasis on reaching full identification of all preserved specimens. • Include a careful examination of the literature required for microscopic ID. • Demonstrate the use of identification resources before letting the participants loose. • Explain and/or demonstrate the best procedures for killing and preserving specimens. • Cover the code of conduct for taking specimens. • Include a session on the practice of biological recording and cover, in particular, the procedure for getting help with specimens that are difficult or white require confirmation.

The differentiated content and techniques for delivering these courses, as described in the tables above, represent the culmination of three years learning and development and our experience from delivering the courses. Delivering a differentiated suite of courses is a skill in itself and, as tutors, we became better at this as the project progressed. The hardest thing is to differentiate clearly between the Learn to Love and Field ID courses because many of the tools and activities are similar and there is some overlap in the content delivered. Furthermore, *the differentiation is itself only useful if the right audiences are attracted to each*. Therefore, these courses have to be promoted very clearly so that people know what to expect. Ideally, they should be promoted side-by-side so that potential participants can select the level that best suits their needs expectations.

An example of the promotion we used for the Learn to Love Spiders course is shown in Appendix A. In hindsight, this would have been even better if we had included something to make it clear that there was also a Field ID course available. The corollary of this is that promotion of our Field ID courses would have been improved if we had indicated that the Learn to Love courses were available. The lesson from this is that a differentiated suite of courses is most effective if the different levels are supported by an integrated promotional effect that draws attention to the whole suite, not just the individual courses. That way, potential participants are better informed and able to select the course (or courses) best suited to meet their needs.

We ran three Learn to Love Spiders courses over the delivery phase of the project (one each year) with a total of 28 attendances. We ran two Field ID of Spiders and Harvestmen course each year and



an additional three pilot courses in 2014, making a total of 9 courses, attracting a total of 103 attendances. We ran three ID with Microscopes courses (one each year) with a total of 22 attendances.

This is how Nigel-Cane Honeysett sees the partnership between the SSG and Tomorrow's Biodiversity and the training courses we developed together:

"The Shropshire Spider Group emerged as a special interest group from the Field Studies Council's Invertebrate Challenge Project back in 2011 and was formally inaugurated in February 2012. The IC project provided support to the SSG in the form of training in spider Identification, purchase of training publications and storage space for those and sundry equipment and consumables.

Since the end of the IC project, the Tomorrow's Diversity Project has expanded support into other areas. Training in more specialist study areas of spider and other arachnids and use of rooms and equipment for local training and networking has been provided but the most significant area has been in the joint development of an innovative set of courses and support material ranging from engagement through field identification and, finally, identification using a microscope. Continued support is provided to all attendees. This approach and the resulting courses have, to a great extent, broken the mold for courses in invertebrate identification which formally concentrated on microscope work only. Not only have these been of great benefit to the Shropshire Spider Group which has benefitted from increased membership but these courses have furthered one of the main aims of the British Arachnological Society which is to advance the wider understanding and appreciation of arachnids and to promote their conservation."

One objective of hosting a suite of differentiated courses is that novice spider recorders can start with a basic course and advance their skill incrementally by attending courses further up the skills pyramid as their skill and experience improves. The flexible 'entry and end points' is a great benefit. Some will not want to progress to the 'highest' level, especially those who would rather confine their recording to live animals in the field. Others, who are already experience field recorders, can simply go straight in to the suite at a higher level. One of our 'regulars' who attended all three levels, wrote up her experiences in a guest blog post here: <http://www.tombio.uk/LesleySpiderBlog>.

7.1.2 Spider project: other outputs and outcomes

As indicated previously, we did not create a single repeatable 'advanced' course for experienced arachnologists, but instead we tried hard to run, and support, a variety of events that appealed to people at this end of the skills pyramid. This included the following:

- A workshop, run by experience arachnologist Richard Gallon, on advanced identification techniques for linyphiids (money spiders) including dissecting out, clearing and curating genitalia of difficult taxa.
- A day workshop of the identification of pseudoscorpions and which we tested a draft version of a new FSC ADIGAP fold-out chart using specimens loaned to us for the purpose from Liverpool Museum's collection.



- Two day courses dedicated to the field ID of harvestmen alone with Paul Richards – author of the FSC fold-out chart to harvestmen (one of the most important resources for identification of UK harvestmen) as the tutor.
- We promoted and supported a residential course on spider photography and ID run by Lawrence Bee of the British Arachnological Society and photographer Alex Hyde. Lawrence is one of the key authors on the new BAS photographic ID guide to
- We organised and supported a Shropshire Spider Group lab day where members and associates of the spider group were invited to an open format workshop to work on the identification of specimens and support each other.
- We organised a workshop on Pantheon (<http://www.brc.ac.uk/pantheon/>) – a new and developing online application for assessing the quality of sites based on invertebrate species lists, including those for spiders.

These events attracted a total of 54 attendances. Note that several, e.g. the Harvestmen ID courses, attracted a wide range of people – not just experienced arachnologists – which helped make them viable.

In 2015 Liam Andrews was a 1st year zoology undergraduate at Nottingham Trent University. He was part of a group of students who came to one of our Field ID of Spiders & Harvestmen courses; their trip was an organised outing for members of The Conservation Society – a group associated with their Student's Union. These were all general naturalists, some with specialities other than arachnids. But during the course we showed the participants a pseudoscorpion. None of them had seen one before and Liam, in particular, was captivated. Liam went on to found the Facebook group *Pseudoscorpion UK* – a group that now has 600+ members – national experts among them. Liam rapidly became one of the UK's top pseudoscorpion recorders and we invited him back to attend the above-mentioned workshop of the identification of pseudoscorpions at which he was the leading expert! He is now studying for a Masters degree at Harper Adams University in Shropshire. Liam expresses the part Tomorrow's Biodiversity played in his development below:

"As I have progressed through my undergraduate study and into my postgraduate, fellow students have often asked where my area of interest lays. I answer without hesitation pseudoscorpions. Others have often expressed envy that I am so sure of what I want to go on and study and that I have already found a subject I found both fascinating and fulfilling. It is impossible to just assign someone a passion but Tomorrow's Biodiversity planted the seeds and provided the nutrition, water and sunlight needed to germinate my interest into one. I can say with some certainty that without attending the Tomorrow's Biodiversity arachnid course as a first year undergrad, I wouldn't even know what a pseudoscorpion is and without the communications with the course leaders after the course itself I wouldn't have the contacts and support needed to expand my knowledge."



Another Nottingham Trent student on that course was Meg Skinner who went on to create the facebook group *UK Harvestmen (Opiliones)* which now has over 500 members. Megan says of that event:

“The Arachnid workshops provided hands-on identification skills. We were introduced to equipment, literature and which features to look for when identifying specimens. The workshop was inspiring and helped me pursue an interest in recording UK arachnids.”

Apart from developing and trialling the idea of an integrated suite of differentiated training courses, another objective of providing a high level of support to a local recording group was to increase the membership of that group. The success or otherwise of this has been difficult to assess because the Shropshire Spider Group (SSG) does not have any formal membership status! It is therefore not a simple case of looking at the number of formal members immediately before and after the Tomorrow’s Biodiversity project and we are left with a rather more subjective assessment: Nigel maintains an email list of people that have expressed their wish to be kept in touch with the SSG – effectively our membership list – and this had 11 people on it when the Tomorrow’s Biodiversity project started, and now has 28. Another telling statistic is that since 2014 the number of people actively providing records to the SSG has increased from around 8 to 18.

As part of the partnership between the Tomorrow’s Biodiversity Project and the SSG we set up and maintained, on behalf of the SSG, a closed facebook group called, naturally enough, the ‘Shropshire Spider Group’ (<https://www.facebook.com/groups/shropshirespidergroup/>). This now has 97 members, but many of them are not local to Shropshire. All this speaks to the changing nature of natural history groups in today’s social media era. What we *can* say beyond any shadow of doubt is that the Tomorrow’s Biodiversity Project has had a very positive impact on the profile and *reach* of the SSG.

7.2 Earthworms project

The roots of the Earthworms project can be found in the project consultation of 2014. A participant at one of the London group consultations was Keiron Brown who was Recording Officer for the Earthworm Society of Britain (ESB), a relatively new voluntary recording society established in 2009. Keiron proved to be an enthusiastic consultee with a great interest in the general subject of biological recording and biodiversity monitoring. Subsequently a close and effective partnership developed between the ESB and Tomorrow’s Biodiversity for the full extent of the delivery phase (and beyond).



7.2.1 Earthworms project: two-day training format

A cornerstone of this partnership was that Tomorrow's Biodiversity facilitated the delivery of a weekend training format developed by the ESB which, crucially, benefitted both partners. The ESB benefitted because the partnership enabled them to increase their capacity to deliver training to more people in more places. The FSC Tomorrow's Biodiversity project benefitted because as an under-recorded but highly functional component of the invertebrate fauna of soils, earthworms



Participants and trainers at Powis Castle during the first joint event run by Tomorrow's Biodiversity and the Earthworm Society of Britain.

ticked virtually every box as an appropriate target taxonomic group and increasing the number of people reached by the ESB training was an outcome in line with all the project's objectives.

In 2015 we ran the inaugural FSC/ESB event at FSC Preston Montford. This was modelled on the ESB's original 2-day weekend format with a field day on the Saturday, where we split our sampling effort between the attractive site of Powis Castle and Preston Montford, and a lab-based identification and recording day on the Sunday. The event was very well attended and a great success. We used more resources on this initial event than on subsequent events (for example including lunch for the participants at Powis Castle and taking everyone to Powis Castle in a minibus), but it sealed the partnership between ESB and the FSC Tomorrow's Biodiversity project!

In 2016 we ran two courses of a similar format at other centres (Slapton Ley and Rhyd-y-creuau) and another two in 2017 (Malham Tarn and Castle Head). All of these were run in association with the ESB and followed the tried-and-tested two-day format. The cost of these two-day events to participants was kept low (around £20) in line with previous courses run by the ESB. In all cases



participants were able to separately book accommodation (for the Saturday) night at the hosting FSC centre (at a cost of around £40). In general, these courses booked well although bookings for the two 2017 courses in northern England were not as good as we had hoped for reasons that are unclear to us.

Together, these five events attracted a total of 40 attendances.

The format of these two-day courses remained essentially the same over the three-year delivery phase of Tomorrow's Biodiversity but there have been some changes. Before the partnership, the ESB recording weekend format had two objectives: one was to train new earthworm recorders (the primary objective) and another was to produce as many biological records as possible for a new site. The latter often involved visiting as many different locations within a site as possible on the field day. There has been a realisation that conflating these two objectives could compromise the quality of the training. Therefore, we now aim only to visit enough sites & locations during the course of a training weekend to:

1. sufficiently illustrate and practice the collection and sampling techniques; and
2. collect enough specimens/species of earthworms to support the identification and recording training on the second day.

The quantity of new records generated for a site is now considered less important for these weekends. However greater emphasis has been placed on the practice of biological recording (as distinct for biological identification) with trainees being encouraged to enter records via the ESB's iRecord activity form on the second day.

Running these two-day events at well-equipped FSC field centres enabled the format of the weekend to be adapted to suit the needs of participants, with some of the taught content provided at the field centres on the morning of the first day. Prior to the partnership events, the ESB had been unable to facilitate any classroom learning on the first day and all the classroom-based introductory information was delivered on the second morning. The provision of well-equipped classrooms at FSC centres enabled the ESB to increase capacity at these courses from around 6 (the typical number accommodated on courses before the partnership) up to around 15 people – meaning that ESB can now reach over twice as many people through a single course.

7.2.2 Earthworms project: supplementary training events

In summer 2015 we held a weekend field event designed to follow up on the very successful ESB field meeting at Powis Castle. We visited as many sites as possible, maximising the number of different habitats sampled for earthworms. Then on Sunday the earthworms were identified in a lab at Preston Montford. This was designed to be slightly different to the usual ESB training weekends, as no formal teaching on earthworm ID was given – instead, the idea was to provide an opportunity for people who came on the earlier ESB field event at Powis Castle to consolidate their learning. However, it was also open to new recorders, who were paired up with a more experienced mentor, in addition to receiving help from the Tomorrow's Biodiversity team and Keiron Brown. This event also provided an opportunity to work in partnership with Shropshire Wildlife Trust, as most of the field sites we visited were SWT reserves.

In spring 2016 another supplementary event was held – a Shropshire earthworm ID weekend, with fieldwork at the Shropshire Wildlife Trust reserve of Pontesford and Earls Hills. This weekend was notable for the attendance of the Eco Sapien team, who came to film a short educational film on earthworms. Eco Sapien (<http://www.ecosapien.org>) is an educational organisation created to illustrate the importance of biodiversity. They create videos, graphics and articles designed to ‘offer a portal into the spectacular world of biodiversity, and its relevance to our everyday lives’. This was a mutually beneficial partnership – Tomorrow’s Biodiversity paid the Eco Sapien team’s expenses and in return Eco Sapien produced their film free of charge. The resulting film (<http://www.youtube.com/watch?v=uFKaD6NFjDQ>) has had 6927 views as of 04/01/18 and ranks as one of their most successful films.

Tomorrow’s Biodiversity has played an important role in the ongoing revisions to the existing FSC Earthworm Key (Sherlock, 2012). In January 2017 we ran an earthworm key testing workshop led by the author of the key, Emma Sherlock, and the ESB recording officer, Keiron Brown. This provided earthworm recorders with a unique opportunity to be involved in the testing and development of the updated identification key. We encouraged a mix of abilities to attend, so both experienced earthworm recorders and those new to earthworm identification could test the key and provide feedback.



Sifting soil in search of earthworms in Doctor’s Field, adjacent to Darwin’s boyhood garden in Shrewsbury.

The final supplementary earthworm event of 2017 was ‘Darwin’s Garden earthworm weekend’ in October 2017. Charles Darwin, who grew up in Shrewsbury, was fascinated by earthworms. ‘The Formation of Vegetable Mould through the Action of Worms’ was his final publication. As a child, Darwin lived at the family home, The Mount, in Shrewsbury and The Shropshire Wildlife Trust (SWT) recently purchased part of its garden as a reserve. On the Saturday, with permission of SWT, we sampled for earthworms in Darwin’s garden and adjacent local nature reserve ‘Doctor’s Field’. As part of this, we arranged for an interpretative tour of the local area and of Darwin’s Garden from a local Darwin expert. On Sunday we identified the earthworms we collected under the microscope in



the classroom at Preston Montford. This was a very popular and well attended weekend, and the addition of the 'Darwin element' added great value and interest to it.

These supplementary events attracted a total of 31 attendances.

Two more earthworm events are planned for the Tomorrow's Biodiversity project (although due to time and availability constraints this will happen in February 2018, after the official end date of the project). The first of these is a day workshop for members of ESB who are involved (or want to be involved) in ESB training events – a kind of train the trainers day – where we will share experiences, disseminate good practice and plan the future of ESB training events. The following day a second event – an 'Earthworm Photography and ID Workshop' – will take place. Local amateur natural history photographers and local earthworm recorders have been invited to attend. At the workshop, we will investigate techniques for photographing live earthworms using a variety of equipment and attempting novel methods for 'restraining' the live earthworms. We will then preserve all the photographed earthworms and attempt identification using two methods: the normal method of examining dead specimens under a microscope, and also attempting to ID them from the photographs. We can then cross-reference the IDs from the photos to the corresponding confirmed IDs from the specimens. If there are a small number of species which can often be reliably identified from correctly photographed live specimens, this would be an interesting finding that may help the Earthworm Society engage with a much wider audience. We hope that another output from the workshop will be the start of a library of images of live earthworms that we can use to 'test' the concept of earthworm ID from photos with less experience recorders. Another output could be guidelines for photographing live earthworms with a view to ID, together with notes indicating which species can have ID attempted in this way. Finally, we expect to discover enough of interest to warrant a short paper in the FSC's online Field Studies journal on our findings, whatever they may be (all workshop attendees will be invited to be included as co-authors of this paper).

7.2.3 Earthworms project: other outputs and outcomes

The partnership between FSC and ESB was not entirely new; the FSC's Publications Unit had already worked with ESB president Emma Sherlock to publish her 'Key to the earthworms of the UK and Ireland'. This proved to be another major boon to the partnership because, with Emma's permission, we used the knowledge-base on earthworm morphology contained in that publication to create an online multi-access key for UK earthworm identification. This was, effectively, a pilot for what became the Tomorrow's Biodiversity ID Framework (see below). The multi-access key was a great success and is currently implemented on ESB's website (<http://www.earthwormsoc.org.uk/fullscreen/earthwormkey>). ESB guidance for recorders has been updated to indicate that this online key is considered as an 'appropriate resource' for earthworm identification. Emma Sherlock is currently working to produce a new version of the AIDGAP key to reflect new taxa, changes in taxonomy and other developments. The online resource will be further developed to reflect this new knowledge. It will also be updated to include new visualisations and tools as the Tomorrow's Biodiversity ID Framework continues to develop (more of which later).



Emma Sherlock said this of the partnership with FSC Tomorrow's Biodiversity:

"Our partnership with the Tomorrow's biodiversity project has made a huge difference to the Earthworm Society of Britain. As a small society with very little resources, running courses was extremely difficult, with committee members trekking long distances carrying heavy microscopes to halls which were often poorly equipped to host a course. There were no funds to pay for adequate room hire. It also restricted localities in the country and forced us to remain very London-centric. With the help of FSC's Tomorrow's Biodiversity we not only got to engage with many more incredible, willing and enthusiastic potential new recorders but we got access to fantastic labs already equipped with the microscopes we needed. This meant the numbers of courses we could run in a year more than doubled and crucially we could bring the courses to other parts of the country, establishing recorders in areas not sampled for earthworms before. This partnership has meant a small society with little reach, but plenty of enthusiasm and knowledge, can grow and start producing the meaningful earthworm records so desperately required."

There were a couple of unplanned spinoffs arising from the partnership between FSC Tomorrow's Biodiversity and the ESB. Firstly, the two Tomorrow's Biodiversity project officers, Rich Burkmar and Charlie Bell, became keen earthworm recorders and, from 2016, assisted as trainers on the partnership events. Both also joined the ESB committee with Charlie becoming membership secretary and Rich website officer (the latter appointment resulting in a new Drupal 8 website for the ESB built with the benefit of using lessons learned from constructing the Tomorrow's Biodiversity Drupal 7 website). The second spinoff was that in 2017 the FSC ran three one-day earthworm ecology courses with Keiron Brown as an associate tutor. These ran independently of the Tomorrow's Biodiversity project although they were promoted via the Tomorrow's Biodiversity website and social media. These courses were financially self-supporting and can be considered as one of the legacy benefits of the ESB/Tomorrow's Biodiversity partnership.

This story would not be complete without mentioning that during 2016 Keiron Brown worked with the FSC for nine months to develop a second stage bid to the Heritage Lottery Fund for a project called BioLinks. That bid was successful and in late 2017 Keiron re-joined the FSC as the full-time project manager for BioLinks which will, in many ways, take the FSC biodiversity projects baton (including a focus on earthworms) from Tomorrow's Biodiversity (more of which later).

7.3 Soil mesofauna project

The development phase of Tomorrow's Biodiversity (both desk research and consultation) suggested that soil biodiversity was a suitable target for the delivery phase. But 'soil biodiversity' covers a huge range of plants, animals, fungi and microorganisms; narrowing the focus to specific taxonomic groups would have been a challenge but for existing synergistic opportunities. We have described one such opportunity which gave rise to the partnership between Tomorrow's Biodiversity and the Earthworm Society of Britain and it was another existing relationship between FSC and a group of soil biodiversity scientists that gave rise to the soil mesofauna project.

The core of project was to ensure the continuation of an emerging soil mesofauna training course (see below) and to look at ways of supporting the learners – particularly in relation to becoming



active soil biodiversity recorders – beyond the classroom. The project would therefore be strong in the *recording*, *mentoring* and *networks* focal areas. At the outset we also recognised scope within this project to develop and trial new resources for identification (*ID resources* focal area). The project also had the potential to integrate developing DNA techniques (*barcoding* focal area).

7.3.1 Soil mesofauna project: residential soil mesofauna courses

When the Tomorrow's Biodiversity project started in 2013, there was an existing relationship between FSC and a group of soil biodiversity scientists led by Matthew Shepherd – a soil biodiversity specialist with Natural England. Matthew had been involved with the inaugural 'Soil Mesofauna Course', funded by Natural England and hosted by FSC at Preston Montford in 2012. This was a four-day residential course which introduced participants to the ecology and identification of a wide range of soil mesofauna (defined loosely as animals which are small enough to fit through a 2mm mesh but big enough to see). The course majored on the identification of springtails (collembola) and soil mites, with the springtail ID sessions led by national expert recorder Peter Shaw and the soil mite sessions led by Felicity Crotty, one of the few people in the country with expertise in the identification of these animals.

In 2013 FSC supported this course again through the Defra-funded Biodiversity Fellows project which Pete Boardman was managing (alongside his Invertebrate Challenge project) and the course ran at FSC's Juniper Hall in Surrey.

A meeting between Matthew Shepherd and Rich Burkmar early in the development phase of Tomorrow's Biodiversity led to an agreement that we would support the course in 2014 as a pilot for Tomorrow's Biodiversity and, if all went well, continue to support it for the next three years during the delivery phase of the project.

The Soil Mesofauna course is unique in the UK – we know of no other residential course that covers the ecology and identification of such a wide range of soil mesofauna. Furthermore, it is highly unusual for a single course to be attended and supported by so many leading national experts. Tomorrow's Biodiversity supported courses that ran in the spring of each of four years from 2014 to 2017. They were all hosted by Preston Montford field centre, starting at around mid-day on a Friday and running until mid-day on the following Monday. Sessions would generally run from around 9 in the morning until around 9 in the evening (sometimes later) covering the subjects listed below.

Friday (half day)	Introduction to soil biology, field collecting, extraction methods, microscopy, nematodes and functional feeding groups, other soil water organisms.
Saturday (full day)	Springtails day – collembola ecology, anatomy, taxonomy and identification, including field and lab sessions. Evening session on biological recording and support networks.
Sunday (full day)	Soil mites day – Felicity Crotty, mite ecology, anatomy, taxonomy, identification, then evening session on barcoding and metagenetic approaches, soil biodiversity in Natural England's work.
Monday (half day)	Soil meso-fauna bioblitz – attempt to identify/classify and record all the mesofauna from samples collected on day one, putting all new skills into practice.



Places are limited to 10 because of the amount of equipment and desk space that must be devoted to each participant. The course always filled to capacity during the four years Tomorrow's Biodiversity supported it – a total of 40 attendances. Although the course caters for people of all levels of experience the people who get most from it are generally those who already have some experience of either invertebrates, lower plants or fungi; in short, taxonomic groups that involve dealing with tiny organisms, usually with the aid of microscopes. Many attendees of this course have gone on to make an active contribution to soil mesofauna recording in the UK. For a flavour of what it is like to attend one of these courses, see this blog by Charlie: <http://www.tombio.uk/soilblog>.

Natural England soil biodiversity specialist, Matthew Shepherd, had this to say about the course:

"The Tomorrow's Biodiversity project has been instrumental in promoting the hugely important, and previously overlooked, area of soil biodiversity. The Soil Mesofauna course provided by FSC, and supported by Tomorrow's Biodiversity, remains the only regular course on soil mesofauna identification in Europe. Not only has it trained numerous students, biological recorders, amateurs and researchers to identify soil organisms, but it has also initiated the development of a national, and even international, community which shares and develops interest and expertise in soil biology. The network of several hundred people that has grown directly out of this course, has now become formalised into a Soil Biology Special interest group, supported by the Association of Applied Biologists. The momentum that the course, and Tomorrow's Biodiversity support for it, initiated is now beginning to inspire and enable the research, recording and other activities that are vital to recognising the importance of soil organisms."

The early courses were heavily subsidised by Natural England and course participants were not charged for attendance. When we took on the support for the courses, we also continued to subsidise participants to keep their costs very low. But mindful of the need move the course towards a self-sustaining financial model, we gradually reduced participants subsidies until, in 2017, the cost to participants was close to that normally charged by the Field Studies Council for a residential course of this duration. It still represents outstanding value for money, especially given that the course is supported, for most of its duration, by *three* tutors who are all regarded as national experts (sometimes four with the addition of Pete Boardman who has attended the springtails day).

We're delighted that even though Tomorrow's Biodiversity will not be able to provide any financial support to the soil mesofauna course after the project ends, Adrian Pickles – Head of Centre at Preston Montford – has agreed with the course tutors to run the course again in 2018 (<http://www.field-studies-council.org/individuals-and-families/courses/2018/pm/soil-mesofauna-73907.aspx>). If this is successful, there is every chance that the course will become a permanent fixture. This is largely due to the fact that the course has always filled to capacity and is likely therefore to be financially viable. Tomorrow's Biodiversity played an important role in sustaining this course as it moved from an entirely underwritten financial model to a self-supporting one. Over that time the profile and reputation of the course has gone from strength to strength.



The 2015 Soil Mesofauna course at FSC Preston Montford. Matthew Shepherd is standing in the centre and Peter Shaw is standing on the right. Notice the amount of equipment required by each participant.

One focal area that we thought this course might encompass – barcoding – didn't really feature as much as we'd hoped. The theory and potential of barcoding techniques for identifying and monitoring soil organisms is covered during the course, but there has, to date, been no practical involvement of the technique in the course. Despite promising signs, this exciting area of technology is yet to make a really significant contribution to the toolbox of most biological recorders. This will, no doubt, change, and the Soil Mesofauna course may yet be a useful forum for developing and disseminating information on molecular ID techniques, protocols and information flows to biological recorders.

7.3.2 Soil mesofauna project: the springtail atlas

The Shropshire Springtail Atlas was the idea of Pete Boardman who managed Invertebrate Challenge - the FSC biodiversity project that preceded Tomorrow's Biodiversity. Partly as a result of his involvement with the early soil mesofauna courses, Pete became very interested in springtails and a skilled springtail recorder. Towards the end of 2015, Pete suggested a collaborative project with Tomorrow's Biodiversity to create a Shropshire Springtail atlas. The atlas would not be a printed



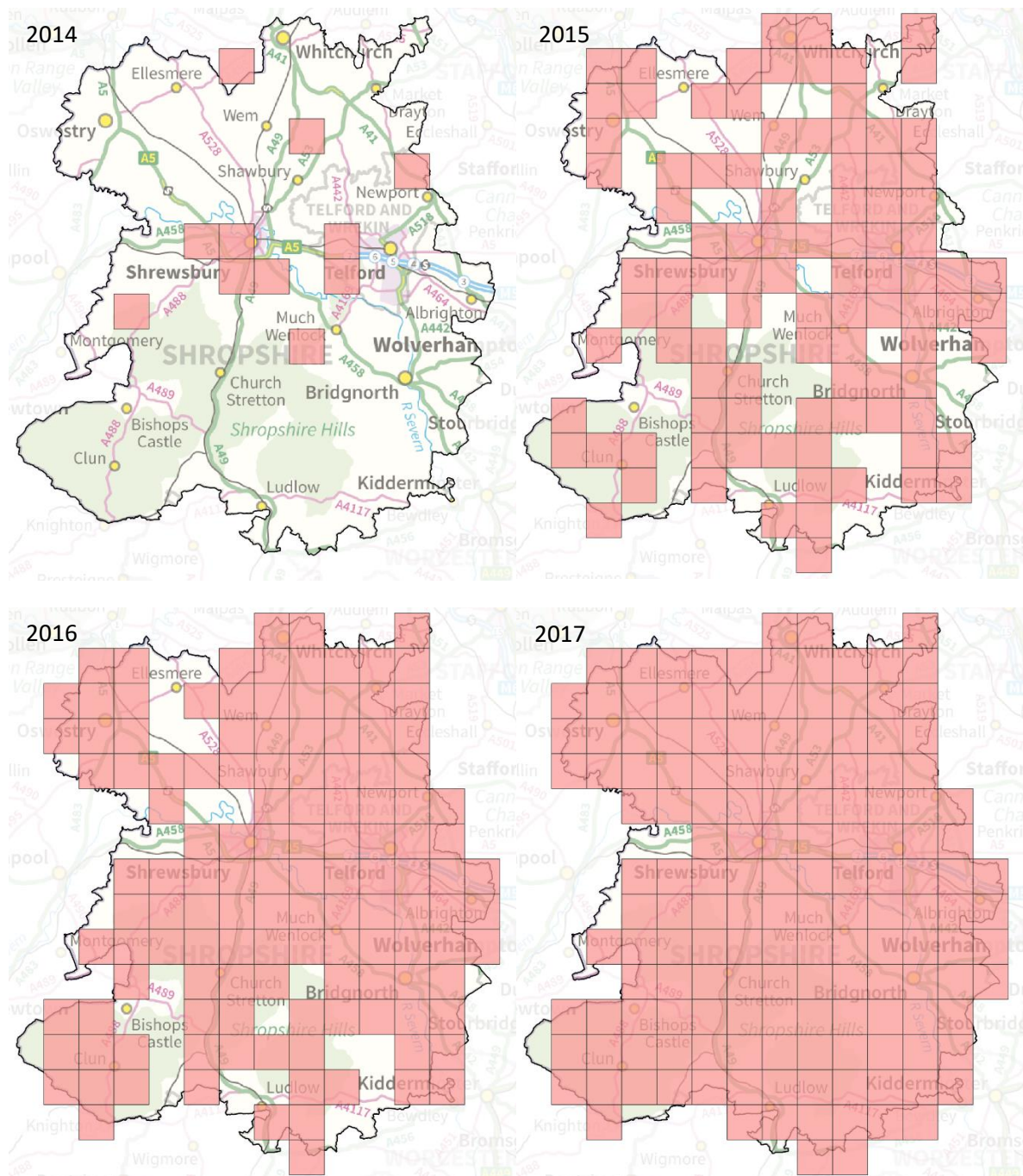
publication, but instead an online interactive map that would be rapidly updated as records were collected – we originally termed this a ‘progression atlas’. Pete ‘headed up’ the project as a volunteer and de facto Shropshire VC Recorder for Springtails, and Tomorrow’s Biodiversity provided support like promotion and the technical expertise to create and maintain the online atlas.

The project was launched at the annual *Shropshire Ento Day* event in December 2016. At this event we gave out ‘recorders packs’ that included a paint brush to pick up springtails, small tubes with alcohol to preserve them, a recording form and a pre-paid return envelope. We also shot an instructional video in which Pete demonstrated using the equipment in the recording pack: <http://www.tombio.uk/springtailvid>. As the tubes were returned to us at the FSC, we catalogued and stored them. Some of these were collected by Pete for identification and others were identified by Rich and Charlie and, eventually, volunteers attending ‘open lab days’ and workshops (see below).

In January 2016 we ran a couple of back-to-back day-long springtail ID workshops. We invited all previous attendees of the soil mesofauna course to attend. These were peer-mentoring workshops, so we didn’t have a tutor, as such, but we pooled our expertise and helped each other. Some people brought their own springtail specimens to look at, but most people helped us work through some of the springtails collected for the atlas. Over the two days, 9 people attended. Charlie wrote a blog inspired by these workshops: <http://www.tombio.uk/peersupport>. Matthew Shepherd also ran a similar ‘post-mesofauna course’ mentoring workshop in Devon in November 2015 which was supported by Tomorrow’s Biodiversity through the provision of kit.

In November 2017 we held another pair of back-to-back one-day workshops for springtail recorders, but this time the focus was on ‘square bashing’ to fill in gaps in springtail atlas at quadrant (5 km square) level. We thought, from the start of the atlas project, that we had a realistic chance of getting springtail records from every major 5 km square in Shropshire and by the end of 2017 there were just a few ‘missing squares’. On the morning of each of these days, we used a minibus to ferry recorders to a suitable location within a missing square, then we all piled out and collected as many springtails as we could before moving onto the next square. We spent the afternoons in the lab identifying the springtails. Nine people attended over the two days. By this point in 2017 we had several very competent springtail recorders in our local recording community (likely a higher concentration of amateur expert springtail recorders than anywhere else in the country) and the event was a great success.

The atlas project had a significant effect on the generation of springtail records and the participation in springtail recording in Shropshire. We created an interactive visualisation to demonstrate this for the *Shropshire Ento Day* in 2016: <http://www.tombio.uk/fullscreen/springtail16>. The maps below show how coverage of Shropshire has improved in terms of springtail recording over the last few years.



These maps show how coverage of Shropshire has changed over the course of the Shropshire Springtail Atlas project. All maps show 5 km squares (quadrants) which have at least one springtail record. The first map shows the situation at the end of 2014. The second map shows the situation at the end of 2015 after Pete Boardman started recording Shropshire Springtails. The third map shows the situation at the end of 2016 – one year into the Springtail Atlas project. The final map shows the situation at the start of 2018: we've almost achieved our target of 'turning Shropshire pink' at the 5 km level!

The atlas itself is almost certainly the first county atlas project for springtails in the UK and Shropshire is now, by far, the best covered county for these animals. The online atlas can be viewed here: <http://www.tombio.uk/fullscreen/springtailatlas>.

7.3.3 Soil mesofauna project: open lab days

One of the training event formats which was developed and trialled during Tomorrow's Biodiversity was that of 'open lab days'. Over the course of the project we set aside regular 'lab days' to



consolidate our own springtail identification skills. In the final 18 months of the project we made the decision to open these up to local entomologists. This decision was made due to a wish to keep local recorders engaged with soil mesofauna identification in the weeks and months after they had attended a training course. In particular, we wished to maintain the momentum produced by the annual Soil Mesofauna course, which focused on mites and springtails.

One of the barriers to biological recording of mites and springtails is the need for specialist equipment (both low and high-powered microscopes; solutions for clearing specimens etc). We had observed that this, coupled with the technical difficulty of identifying these groups, means that keeping recorders engaged with these groups was harder than with some of the more accessible invertebrate groups. The idea of these regular open lab days was to provide a friendly, informal setting for peer-supported soil mesofauna recording, with access to equipment and keys. No formal teaching was done during these open lab days, but both Charlie and Rich have become competent springtail recorders so were able to offer one-to-one peer support to attendees.

These open lab days have proved successful, and attendees have contributed many records to the Shropshire springtail atlas project as a result (see previous section). Over the course of the last year the remit of these days has expanded. For example, some attendees have also used them as opportunities to continue with their own biological recording interests outside of soil mesofauna, and have enjoyed the opportunity to do this alongside their peers and friends. Members of the local biological recording community have used these days to perform routine maintenance and cataloguing of the Preston Montford community invertebrate collections and library, and the Tomorrow's Biodiversity project has provided encouragement and support for this.

In total we have run seven of these open lab days since November 2016 with an average attendance around 5 people.

7.3.4 Soil mesofauna: other outputs and outcomes

During each of the four soil mesofauna courses that ran under the auspices of Tomorrow's Biodiversity, participants used a printed identification resource for soil mites developed by Matthew Shepherd and Felicity Crotty. This is a work in progress but it has moved on significantly since the early days, thanks in no small part to the heavy 'testing' it gets during the soil mesofauna courses and afterwards by many of the participants (who take their copies away with them) and their direct feedback to the authors. The key takes ID at least as far as family level for all known UK species and further for many of them. Matthew's intention is to publish this key and is working in partnership with FSC publications to bring this about. Tomorrow's Biodiversity has played a significant part in supporting its testing and development.

7.4 National Plant Monitoring Scheme (NPMS) project

The National Plant Monitoring Scheme (NPMS) developed from Plantlife's Wildflower Count scheme with the support of the Botanical Society of the Britain & Ireland (BSBI) and the Centre of Ecology and Hydrology (CEH). The NPMS was trialled in 2014 (Rich took part as a volunteer surveyor) and was rolled out formally in 2015. The Joint Nature Conservation Committee (JNCC) invited tenders to run the project in 2015 and Plantlife, BSBI and CEH were engaged to run it as a partnership.

As part of the Tomorrow's Biodiversity consultation, and wider conversations between FSC and the NPMS partner organisations, we expressed an interest to support the NPMS through the Tomorrow's Biodiversity project and that was well received. Potentially, we could support NPMS in many different ways including developing resources (*ID resources* focal area) and providing training and support (*recording and networks* focal areas). Working with the NPMS would allow us to directly support a survey & monitoring protocol – one of the major focal areas we identified (*protocols* focal area).



Although vascular plant recording is not itself under-recorded or under-resourced, the research phase of Tomorrow's Biodiversity highlighted how poorly represented vascular plants are in terms of surveillance & monitoring at the headline indicator level. The NPMS aims to address this and the involvement of the FSC would be strategically significant.

Felicity Harris, of PlantLife, had this to say about the partnership with Tomorrow's Biodiversity:

"The National Plan Monitoring Scheme is a new surveillance scheme which was launched in 2015. Tomorrow's Biodiversity has been a vital partner in supporting the scheme. Working with Tomorrow's Biodiversity the NPMS has been able to increase the breadth and depth of training offered to volunteers, a third of whom are new to biological recording of any sorts. Enhanced training and the development of training materials has meant NPMS volunteers have gained a greater understanding of NPMS habitats and species and are therefore supported to record at a higher level within the scheme. The NPMS partnership knows how invaluable the support of Tomorrow's Biodiversity has been during the scheme's infancy and looks forward to working with FSC in the future."

7.4.1 NPMS project: training

Over the first three years of the NPMS project – which coincided perfectly with our three-year delivery phase, NPMS developed and delivered a series of training courses to help volunteers get to grips with the NPMS methodology, the online recording forms and plant identification. Tomorrow's Biodiversity supported this programme, which was led by Plantlife's Hayley New, by facilitating the use of various FSC centres to deliver some of these courses.

In the spring and summer of 2015, we supported and facilitated the delivery of 9 NPMS introductory courses at FSC field centres, during which participants were introduced to the NPMS methodology, i.e. the protocol (Nettlecombe Court, Slapton Ley, Blencathra, Malham Tarn, Flatford Mill, Rhyd-y-creuau, Epping Forest, Juniper Hall and Orierton), which were attended by 120 people. In the autumn of 2015 we also supported and facilitated four data-entry courses at FSC centres (Margam Park, Nettlecombe Court, Juniper Hall and Preston Montford). In 2016 we supported the delivery of 8 NPMS specialist identification courses (looking, in particular, at grasses, sedges and rushes) which took place at various venues including some FSC centres and which were attended by 92 people. In 2017 we supported the delivery of 10 NPMS courses, a mixture of methodological (protocol) and specialist ID courses, which took place at various venues, including some at FSC centres, and which were attended by 74 people. In 2015, Charlie attended one of the NPMS methodology courses at FSC Nettlecombe and wrote a blog about it here: <http://www.tombio.uk/NPMScourse>.



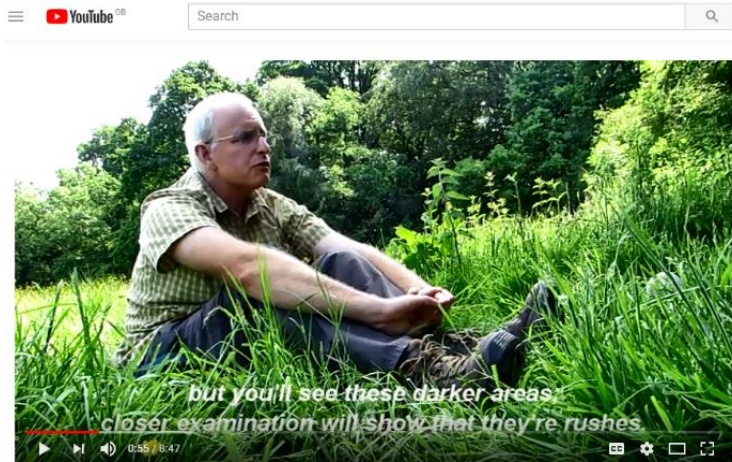
Participants of an NPMS training course make their way back to the centre at FSC Nettlecombe in 2015.

Working with the NPMS was an ‘easy win’ for the Tomorrow’s Biodiversity project. We are very proud to have supported the establishment of the NPMS over its first three years and thus supported the development of a major new operational biodiversity indicator which could, in time, contribute to biodiversity monitoring in the UK as a headline indicator. Our relationship with the NPMS kick-started a developing partnership between the wider FSC and the NPMS. In the first year, 2015, we brokered arrangements between the NPMS and the various FSC field centres, but as NPMS developed relationships directly with the field centres, we were able to take a more arms-length approach. It is likely that FSC centres will host further NPMS training events beyond the end of the Tomorrow’s Biodiversity project.

7.4.2 NPMS project: habitat films

In 2016 we worked with botanist and ecologist Nick Law to produce a series of video guides to habitats classified by the NPMS. These films are designed to help NPMS volunteers decide which habitat type their survey plots are in, a crucial step in the NPMS survey methodology, but one which many beginning botanists find difficult.

We deliberately focussed on those habitats which can be difficult to distinguish from each other, and which had been identified in NPMS feedback from volunteers as being problematic. Four videos were made, in two pairs:



Nick Law in a frame from one of our NPMS habitat videos.

- Dry acid grassland (contrasted with dry heath)
- Dry heath (contrasted with dry acid grassland)
- Neutral pastures/meadows (contrasted with neutral damp grassland)
- Neutral damp grassland (contrasted with neutral pastures/meadows)

The films were promoted by NPMS and are hosted on Tomorrows Biodiversity's YouTube channel but are also embedded in a page on our website: <http://tombio.uk/NPMShabitats>. The filming and editing was carried out by Charlie, who drew on her previous experience of making short films and who also completed a FutureLearn online course on digital filmmaking to help with this aspect of the project. At the time of writing (January 2018) these videos have received over 700 views.

7.4.3 NPMS project: other outputs and outcomes

In 2016 we also funded the Mentor Packs for use by NPMS mentors. The packs were designed to give voluntary NPMS mentors the information and some kit to help them deliver support to other NPMS volunteers and included a land lens, a USB stick (to support the delivery of presentations) and supporting information.

In 2017 we developed a simple online tool to help NPMS volunteers summarise the plants they have recorded in previous years on their plots in a format that helps them record in the field. The tool was born out of our experiences as NPMS volunteers ourselves (both Rich and Charlie contribute to the NPMS as volunteer surveyors). When revisiting an NPMS plot, it can save a considerable amount of time if you have a summary of what you recorded in previous years. It is possible to download spreadsheets (CSV files) of all records made in a plot in previous years, but summarising this in a useful format can be difficult. The online tool allows surveyors to navigate to a file of records downloaded from the NPMS and then creates a tabular summary suitable for use as a recording form in the field when printed. The tool is hosted here: <http://www.tombio.uk/nps/checklist.html> and there is a video showing how to use it here: <https://youtu.be/1xXFDkb6DE4>.

7.5 Bryophytes project

FCS's traditional model for delivering taxonomic training relies mostly on relationships with individual associate tutors running standalone courses. Discussions with members of the Training & Education Committee of the British Bryological Society (BBS), suggested that we could explore a different model for delivering training that develops a stronger partnership between FSC and the recording scheme. Such a partnership could utilise the taxonomic expertise of the BBS *and* tune into their wider training & education strategy to deliver integrated training programmes for bryophyte identification and recording using FSC field centres and training facilities (*partnerships* focal area).

Bryophytes were identified during the development phase as a taxonomic group that would make a good focus for a Tomorrow's Biodiversity exemplar project (*recording* focal area). A project of this kind could also be a good vehicle for exploring issues around the pyramid of engagement since a central theme is considering individual training courses as part of an integrated wider programme of training aimed at progressing learners up the skills and engagement pyramid (*pyramid* focal area), in a similar fashion to the spider exemplar project.

In 2015 we supported and/or facilitated two courses run by the BBS at Preston Montford – a one-day workshop on Sphagnum moss and a three-day residential course on Pleurocarp mosses which, between them, attracted an attendance of 20 people. It is fair to say that the Bryophytes project did not come together as we had hoped. It is hard to put a finger on why, but it could be because each partner had a different understanding of what the shape of the partnership should be and what shape the respective contributions of each would take. The lesson is that in any partnership of this kind, each partner should have a clear vision of what they are trying to achieve and, needless to say, the two visions should be compatible. Unfortunately, the partnership between Tomorrow's Biodiversity and BBS did not progress beyond the first year of the delivery phase. However, FSC and BBS continue a very successful partnership along the lines the traditional model.

7.6 Keys & visualisation project

The research & consultation phases of Tomorrow's Biodiversity highlighted the unfulfilled potential of computer-based multi-access keys for biological identification. It seems certain that recent technological advances in user-interface and hardware technology, such as mobile devices, have created an environment in which multi-access keys will, at last, start to realise some of their potential. FSC was involved in the development of multi-access keys in their early days (publishing a computer-based multi-access key for British *Carex* sedges for IBM-compatible PCs and BBC microcomputers in the early 1990s) but did not maintain its interest in this area.

Computer-based identification keys present both a challenge to FSC's existing paper-based publication model and an opportunity to diversify it. Since the Tomorrow's Biodiversity team included programming



This punch-card key to British Grasses published by FSC in 1985 prefigured computer-based multi-access keys, including FSC's own computer-based key to Sedges published in the 1992.



and development expertise, we concluded that Tomorrow's Biodiversity would be an opportunity for the FSC to explore multi-access keys without the problem of finding extra resource to do it. The keys & visualisation project concentrated largely on the *ID Resources* focal area, but could, potentially, make a serious contribution in the *Recording* focal area.

The aim of the early work we did on the keys & visualisations project was to reignite the interest of the UK biological recording community in multi-access keys. Our research and analysis led us to believe that there were four barriers that had stifled the progression of multi-access keys since their early development in the 1970s, namely:

1. Cumbersome hardware, making it hard to use online keys next to microscopes for example.
2. Unengaging user interfaces.
3. Intractable formats for expressing knowledge.
4. Limited tools and techniques for information visualisation.

The advent of mobile computing, e.g. laptops, tablets and smartphones, has largely removed the first barrier. Concomitant software improvements advanced the tools available to software designers for building graphical user interfaces (GUIs), although the few providers of multi-access key software have been slow to capitalise on this. Nevertheless, the second barrier can also be removed.

In the early days of multi-access key development, techniques for data storage and knowledge-representation were opaque (due to the need to minimise the use of computer memory) but now, throughout the digital sphere, there is much more emphasis on 'human-readable' data formats (which we can accommodate because computer memory resources are so much greater and cheaper). Our research phase uncovered one such format (based on XML) called Structured Data Description (SDD) which allows, among other things, the expression of knowledge that can be used to build keys for biological identification.

Our early intention was to build multi-access keys that used SDD to express taxonomic knowledge. This didn't work out for several reasons, the most important being 1) the SDD format appears to be stale (no one is developing it) and 2) flexibility to experiment and develop rapidly is easier if we don't have to honour an existing data format. So we chose to represent knowledge using a tool, and human readable format, that almost everyone can get along with: spreadsheets generating CSV (Comma Separated Values) text files. This removed the third barrier.

Finally, over the last decade there has been great interest and in data visualisation on the web resulting in many tools for visually expressing data and knowledge in new and exciting ways which frequently allow users to interact dynamically with the data and information they see on the screen. This means that the fourth barrier can be removed.

We took the decision to base our work on standard web technologies, making products that can be delivered over the internet. The main technologies we have used are:

- HTML.
- Cascading Style Sheets (CSS).
- Javascript (currently standardising on ES5).



- jQuery framework for Javascript.
- Data Driven Documents (D3) – a Javascript library for data/knowledge visualisation.
- Spreadsheets (e.g. MS Excel) to manage and generate CSV for knowledge representation.

These technologies allow us to create resources that are platform independent – both on the server and client side – and make the results of our work accessible to the widest possible audience. Any basic web server capable of serving HTML, CSS, Javascript etc, can host the resources we create and they can be used in any modern standards-compliant browser (regardless of hardware or operating system).

7.6.1 Keys & visualisation project: early prototypes

The first product of the keys & visualisation project was a multi-access key for the identification of UK earthworms based on the knowledge contained in the first edition of Emma Sherlock's FSC AIDGAP publication *Key to the earthworms of the UK and Ireland*. This work was carried out with the permission and cooperation of Emma and the Earthworm Society of Britain (ESB).

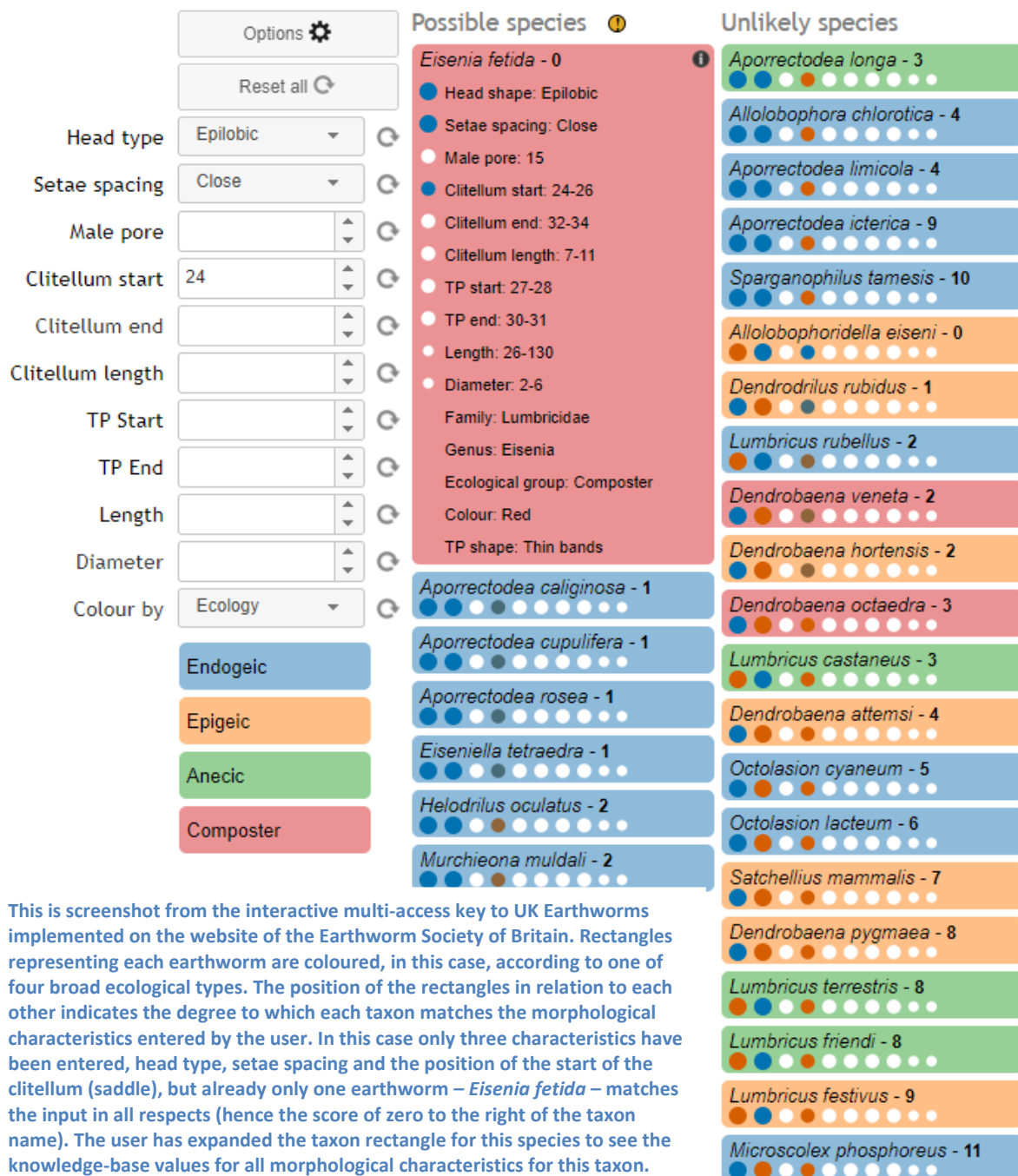
The multi-access key, pictured below, allows users to specify character states of an earthworm (e.g. a specimen), in any order they like. As they do so, rectangles representing the taxa dynamically change position on the screen to reflect the degree to which each matches the entered character states.

Differences between this and other multi-access keys include:

- The online browser-based delivery.
- The user-friendly interaction.
- The animation used to move the taxon rectangles in response to user input.
- The scoring/ranking system used to match the taxa against user input (rather than excluding taxa that don't 'match' completely)
- The ability to colour the taxon rectangles to reflect states for morphological characters in the knowledge-base (unrelated to specification of character states).

The multi-access key proved to be a very effective tool for the identification of UK earthworms and is now implemented on the website of the Earthworm Society of Britain (ESB):

<http://www.earthwormsoc.org.uk/fullscreen/earthwormkey>. The 'colour by' feature helped to demonstrate that this technology needn't focus exclusively on multi-access keys but that a taxonomic/morphological knowledge-base could be used to drive all kinds of tools, not only tools for identification but also tools to help people learn about the morphology of a group of organisms without necessarily having an identification problem at hand.



This is screenshot from the interactive multi-access key to UK Earthworms implemented on the website of the Earthworm Society of Britain. Rectangles representing each earthworm are coloured, in this case, according to one of four broad ecological types. The position of the rectangles in relation to each other indicates the degree to which each taxon matches the morphological characteristics entered by the user. In this case only three characteristics have been entered, head type, setae spacing and the position of the start of the clitellum (saddle), but already only one earthworm – *Eisenia fetida* – matches the input in all respects (hence the score of zero to the right of the taxon name). The user has expanded the taxon rectangle for this species to see the knowledge-base values for all morphological characteristics for this taxon.

We demonstrated the earthworm key and visualisation at the annual conference of the National Biodiversity Network (NBN) in York in 2015. It was well received and generated a lot of interest and ideas. Following the conference Sally Hyslop – then a trainee on the Natural History Museum’s ‘Identification Trainers for the Future’ project – approached us to see if we would be willing to work with her on a similar resource to groups of grasses. The upshot of that work was this resource: <http://www.tombio.uk/fullscreen/grassesv1>.

Key to Groups of British Grasses

Info ⓘ Reset ↺

Un-used characters:

show hide

Inflorescence

Spike ✕

Spikelet arrangement

select option

Spikelet shape

Triplet ✕

Glumes

Two glumes of equal length ✕

Floret number

select option

Awns

select option

Awn length

select option

Awn type

select option

Most likely	Least likely
Barleys	False Bromes
Couch or Lyme-grasses	Vernal-grasses
Wheat	Rye-grasses
Rye	Bent-grasses
Dog's-tails	Melick-grasses
Fox-tails	Soft-grasses
Cat's-tails and Timothy	True fescues
	Oats
	Quaking-grasses
	Hair-grasses
	Millet-grasses
	Bromes
	Cock's Feet
	Meadow-grasses



Dactylis glomerata
A panicle with spikelets clustered in groups at the ends of side branches
(by Sally Hyslop)

Screenshot of Sally Hyslop's Key to Groups of British Grasses produced in conjunction with Tomorrow's Biodiversity.

Sally wrote the knowledge-base for this tool and we produced a modified version of the software that we wrote for the earthworm key to create the key and visualisation.

7.6.2 Keys & visualisation project: the ID Framework

The Tomorrow's Biodiversity ID Framework is a set of tools for building online biological identification resources based around, but not limited to, multi-access keys.

Our original plan for the keys & visualisation project did not go beyond producing a small number of keys and visualisations to stimulate renewed interest in the approach within the biological recording community. But around the time that we produced the visualisation to groups of grasses other people approached us to experiment with various knowledge-bases and in each case we generated unique versions of the software because there wasn't a complete separation between the software logic and the taxonomic domain or a standard knowledge-representation format.

It soon became clear that we must either disappoint a lot of people, due to our limited resources, or change strategy and put our efforts into generalising the software. This would involve separating the representation of knowledge and the logic for the visualisations completely. The result would be software that anyone could take and, by adding their own knowledge-base (spreadsheet), create a completely new identification resource (without any need to alter the software). This was the genesis of the 'TomBio ID Framework' (which we also refer to as simply 'the framework').

The first edition of the framework was released in December 2016 and there have been sixteen incremental releases since then. The software is open source which means that anyone can take a



copy of it, or even contribute to the development themselves. The full release history can be viewed on the GitHub repository: <https://github.com/burkmarr/tombiovis/releases>.

The first release was accompanied by a 'demonstration release' of a knowledge-base on UK harvestmen that we worked on with Paul Richards – an associate of FSC and the author of the FSC's highly-regarded fold-out chart on harvestmen. The latest release of the framework (version 1.6.0) was released in November 2017 and, at the same time, we published the first full version of the harvestman knowledge-base. This harvestmen ID resource is hosted on its own website (a subdomain of the Tomorrow's Biodiversity website) here: <http://harvestmen.tombio.uk/>. This is currently the major showcase of the TomBio ID Framework and a very useful identification resource in its own right.

Home Species Comparisons Keys Info & help Links

Harvestmen of Britain and Ireland

An interactive guide from the Field Studies Council's Tomorrow's Biodiversity project

Filter names (use # for 'starts with')

- Nemastoma bimaculatum
- Mitostoma chrysomelas
- Nemastomella bacillifera
- Trogulus tricaratus
- Anelasmoecephalus cambridgei
- Sabacon viscayanum ramblaianum**
- Homalenotus quadridentatus
- Oligolophus tridens
- Oligolophus hansenii
- Paroligolophus agrestis
- Paroligolophus meadii
- Lacinius ephippiatus
- Odiellus spinosus
- Mitopus morio var morio
- Mitopus morio var ericaeus
- Phalangium opilio
- Opilio parietinus
- Opilio canestrinii
- Opilio saxatilis
- Megabunus diadema
- Platybunus triangularis

Images Knowledge-base Show text

Sabacon viscayanum ramblaianum

Field characters

Sabacon viscayanum ramblaianum is an enigmatic little harvestman which is easily recognised because of **highly unusual pedipalps** that are longer than the body, with the tarsus being the shortest segment. The tarsus and tibia of the pedipalps are **swollen and hairy**. There is no terminal claw on the pedipalp. The legs, palps and body are well furnished with dark spines/hairs which are quite unlike the tubercles of other harvestmen in the UK fauna. There is no trident and the ocularium is smooth and much wider than long. The body is marked with dark transverse bands on a brown ground colour. The male has a large, blunt projection (a 'boss') on the dorsal side of the first cheliceral segment.

Distribution and ecology

Sabacon viscayanum ramblaianum was not recorded in the UK until 1980 when it was found in South Wales. Now it is known from many locations in Wales, the Marches and a location in Devon - see the distribution map of the [Spider and Harvestman Recording Scheme](#). In Europe, the subspecies is known in the Pyrenees.

Sabacon viscayanum ramblaianum seems to require a moist environment and has most frequently be found in deep woodland leaf litter.

Very little is known about the phenology of this harvestman, but adults have been collected in late summer and autumn.

Synonyms

Screen shot from the Harvestmen of Britain & Ireland. This resource was created with the TomBio ID Framework. The screenshot shows the full details tool of the harvestmen resource.

The framework currently includes five visualisations (all driven by the same underlying knowledge-base): 3 multi-access keys (each offering a different way of visualising the information presented), a taxon comparison tool and a tool that presents 'full details' of a given taxon, e.g. a 'species description'.

One of the features of the framework is that people can engage with it on many different levels to create new ID resources. People can create their own resources by authoring new knowledge bases. Their resources can be hosted on a website they control or are associated with, or they can ask us to



host them on the Tomorrow's Biodiversity website. Some people build and test their knowledge-bases using a local version of the framework implemented on their own computers, whilst others send updates of their knowledge-bases to us and we implement them within the framework on private pages on our website so that the authors can test them. One or two other people engage with it at a much more detailed level, making 'pull requests' on GitHub to suggest software changes. Appendix B provides a rough idea of who has engaged with the framework at the level of new resource creation since its publication in December 2016. These are not all ongoing projects – some people have merely experimented with it, but some of them have every intention of creating a published resource. (Because this is an open-source project there may be people working with it that we don't know of.)

Development of the TomBio ID Framework will not cease at the end of the Tomorrow's Biodiversity project (see final section on legacy and recommendations for more details).

7.6.3 Keys & visualisation project: dissemination and education

There's no denying that using the ID Framework to create new identification resources, even at the most fundamental level of creating a new knowledge base, is not a simple matter. Even just using the resources created with the framework requires education – since multi-access keys and the other resources it can create are outside the experience of many biological recorders. Using a multi-access key effectively, for example, requires a completely different mindset from that required to use a dichotomous key. Therefore, supporting the framework with good documentation and training resources is vital. Our approach has been five-fold:

1. To supply comprehensive and up to date documentation for users and knowledge-base developers.
2. To provide help to users and knowledge-base developers within the software itself.
3. To create videos demonstrating the use of the framework and how to create new resources (knowledge-bases).
4. To promote the framework by giving presentations.
5. To offer a day-long workshop on building new knowledge-bases.

Basic user documentation is supplied as HTML files – one for each of the visualisations which comprise the framework and are accessible through the framework's user-interface when resources are published. For knowledge-base developers, there is a documentation folder in the framework (<https://github.com/burkmarr/tombiovis/tree/master/documentation>) that includes six documents:

1. Quickstart Guide (everything required for knowledge-base authors to get started).
2. Getting started (more detailed than the Quickstart Guide).
3. Building a knowledge-base (essential guide for knowledge-base developers).
4. Deploying your visualisations (how to make visualisations available to other people).
5. Character scoring (for those who want more detail on the framework's mechanism for scoring with multi-access keys).
6. Notes for coders (only for programmers who want to extend or modify the framework).

Every time we release a new version of the framework, we take pains to ensure that these documents reflect any changes made.



The framework allows knowledge-base authors to provide help to users of the resources they create. These facilities are flexible but can include, for example, the ability to display a pop-up 'tooltip' whenever the user passes the mouse pointer over the name of a morphological character. Such tooltips can contain both text and, optionally, images. More extensive help can be provided in a pop-up dialog when the user clicks on the character name.

There are also built-in knowledge-base 'integrity checks' that assist knowledge-base authors when creating and testing new knowledge bases.



First fix these knowledge-base problems...

Some problems were found with the knowledge-base. They should be easy enough to fix. Read on for more details and guidance.

When you've fixed one or more problems, use the *Save worksheets as CSV* button on the KB to regenerate the CSVs and then click the *Reload* button above.

The problems are colour-coded according to the schema shown below:

- These are serious problems that could cause the visualisation software to malfunction.
- These problems are not likely to cause the visualisation software to malfunction, but you might not see what you expect.
- These are for information only - it may be what you intended to do, but if not, you may as well sort them out. These will not cause the visualisation software to malfunction.

On the characters worksheet...

- There is no row on the *characters* worksheet for the character '**PalpClaws**' represented by a column (column 42) on the *taxa* worksheet. All columns on the *taxa* tab must be represented by a row in the *characters* worksheet regardless of whether or not they are used. Names are case sensitive. Note that rows will not be seen unless the **Group** column has a value.
- There is no column on the *taxa* worksheet for the character '**PalpClaw**' which is represented in the *characters* worksheet.
- " is an invalid spin control 'Param' value for '**OculariumArmatureRowTubercle**'. It must have the form 'n,n,n' (where n can be any valid numeric value, including decimal).
- For numeric, ordinal and ordinalCircular characters, you must specify a 'Strictness' value of between 0 and 10. There is an invalid 'Strictness' value for '**OculariumArmatureSize**'.

Richards, P. & Burkmar, R. (2017) *UK Harvestmen* (Version 1.0) [Knowledge-base] (for Tom.bio Framework for ID visualisations). Field Studies Council. Shrewsbury, England. Accessed Mon Jan 22 2018. <http://127.0.0.1:8887/vis-harvestmen.html>

A screenshot showing output from the TomBio ID Framework integrity checks that help knowledge-base developers trace and prevent problems in their knowledge-bases.

Built-in checks of this kind can save knowledge-base authors a lot of time and trouble in tracing problems in their knowledge-bases.

We have made extensive use of 'screencast' videos to provide help and education resources for the framework – both to users of the ID resources and to knowledge-base creators. Notably, there is a page on our website – <http://www.tombio.uk/framework> - which brings together a number of these videos and other resources to guide new knowledge-base developers through the process of setting up the right technical environment for creating and testing knowledge-bases and the main steps involved in creating them. All our framework videos are collected together on our [YouTube channel](#) under a [single playlist](#). The videos have, to date, been viewed a total of 450 times.

We are invited to present the framework at seminars and conferences and have, wherever possible, agreed to do this. Apart from raising awareness about the framework and the possibilities of multi-

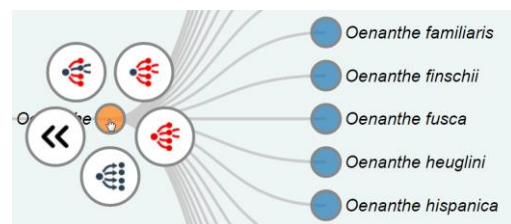
access keys and other online resources, the presentations sometimes raise enough interest to warrant the provision of a full one-day workshop where we take would-be knowledge-base creators and work through the whole process of installing the framework on their computers, setting up a development environment and running through the process of creating a new knowledge base. We ran three such workshops in 2017 – two at FSC Preston Montford and one at the offices of the West Wales Biodiversity Information Centre attracting a total of 19 people, several of whom have gone on to build their own knowledge bases.

7.6.4 Keys & visualisation project: other outputs and outcomes

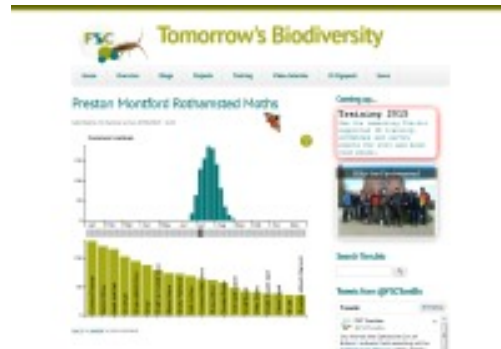
During the research and consultation phase of the project, when our interest in multi-access keys had been piqued, but before we had developed the ideas for our own products, we ran a couple of workshops in association with the Open University iSpot team on their multi-access key project known as iSpot Bayesian Keys (one at the end of 2013 and one at the start of 2014) which together attracted 17 attendances.

As part of the development of our own expertise in online visualisation tools, especially the Data Driven Documents (D3) Javascript library, we have developed number of 'incidental' visualisations including the following:

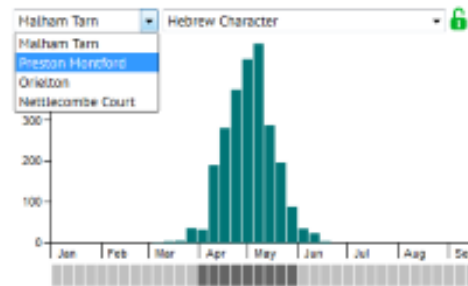
- [Taxonomy web services visualisation](#). A visualisation to explore taxonomies managed by both GBIF (Global Biodiversity Information Facility) and NBN (National Biodiversity Network). Search for organisms and build phylogenetic trees showing their positions within the taxonomies.
- [Sizes of British spiders](#). This is a visualisation of a small taxonomic knowledge base detailing the sizes of spiders in the British spider fauna. It demonstrates, in a small way, how morphological information on a taxonomic group can be explored in an interactive way. This visualisation also uses one of the D3 'layouts' - a circle pack - to illustrate taxonomic relationships between spiders in the British fauna.



- [Preston Montford Rothamsted Moths.](#)
Although this visualisation is driven by a knowledge base built from biological records rather than morphological characters, it does provide another example of an interactive tool that can be a useful aid to identification. It also demonstrates some of the excellent transitioning and animation capabilities of D3.



- [FSC Moths FSC Moths.](#) Another visualisation driven by a knowledge base built from biological records. This extension of the Preston Montford Rothamsted Moths visualisation adds the capability to switch knowledge bases to reflect the moths recorded at other FSC centres.



7.7 QGIS project

An increasing number of ecologists and biological recorders are using a GIS (Geographic Information System) package called QGIS to help them visualise, explore and analyse spatial data such as biological records. (QGIS originally stood for 'Quantum GIS' but the word 'Quantum' has officially been dropped and it is now simply known as QGIS – very often pronounced 'kewjiss'.) The QGIS exemplar project addressed itself to improving accessibility to GIS for presenting and analysing biological records and ecological data. It capitalised on existing expertise within the Tomorrow's Biodiversity team.

QGIS is a freely-available open-source Geographic Information System that runs on all major platforms including, Windows, macOS, Linux, Unix and even Android. It provides access to an extremely rich suite of GIS functionality that compares favourably to those offered by commercial products like MapInfo and ArcGIS. But whilst there are few, if any, financial or platform barriers to accessing this rich GIS environment, there remain significant barriers for UK ecologists and biological recorders including:

- it is a complex system that can overwhelm newcomers to GIS; and
- it is an international product which, although supporting the OS British National Grid *projection* (using eastings and northings), does not directly support the use of our unique *grid referencing system* (so, for example, the tetrad grid reference SJ41H means nothing to QGIS).

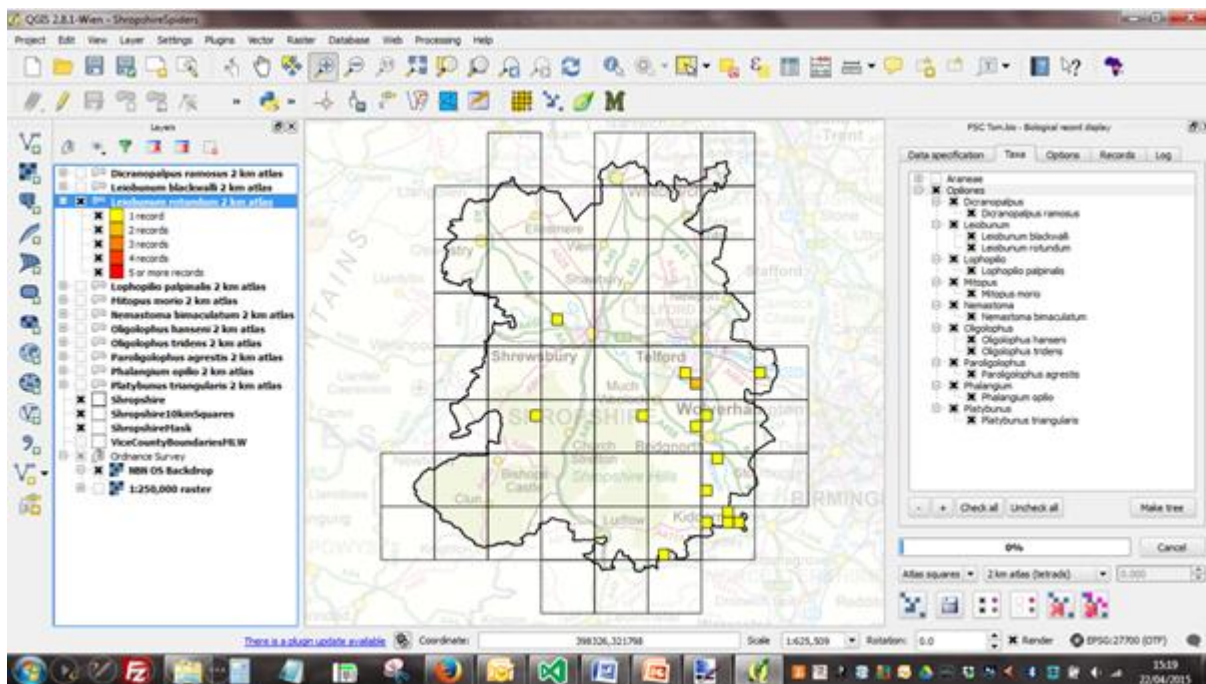
The QGIS project aimed to overcome these barriers by providing:

- a 'plugin' for QGIS that addresses some of the issues around complexity and adds direct support for OS grid references; and
- training & support for ecologists getting to grips with both QGIS itself and the TomBio plugin.

7.7.1 QGIS project: the TomBio QGIS plugin

We developed a plugin for QGIS called *FSC Tomorrow's Biodiversity tools for biological recorders* or, for short, *TomBio QGIS Plugin*. This plugin comprises a suite of four tools which are briefly outlined in appendix C.

The plugin itself is published in the official QGIS plugin repository. This means that it is discoverable and installable by any QGIS user from directly within the QGIS interface (via the 'plugin manager'). To date (January 2018) the plugin has been downloaded over 21,980 times and, from 24 reviews, has achieved a rating of 4.6 out of 5. The plugin embraces the open source paradigm and the software and source-code is available from GitHub (<https://github.com/burkmarr/QGIS-Biological-Recording-Tools>) – one of the world's most successful open-source code sharing platforms. The plugin is licensed under a GNU General Public License – a so called 'copyleft' license – meaning that anyone can freely distribute copies or even modified versions of the software.



A screenshot showing QGIS with the TomBio QGIS Plugin installed..

The project, especially the QGIS plugin, is promoted at events and conferences, for example at the 2015 NFBR conference, the 2016 BSBI recorder's conference and the BTO Yorkshire conference in 2017 we ran technical demonstrations (to audiences of over 100 people in all cases).

7.7.2 QGIS project: training courses and resources

Provision of training and support is a core feature of this project. Since the plugin was launched in November 2014 we have delivered the following QGIS courses:

- One-day introduction to QGIS and the TomBio plugin (7 times, 62 attendances)
- One-day introduction to QGIS only (5 times, 49 attendances)
- One-day introduction to the TomBio plugin only (4 times, 45 attendances)
- 3 ½ day residential course on QGIS and TomBio plugin (1 time, 11 attendances)
- 2 ½ day residential course on QGIS and TomBio plugin (2 times, 29 attendances)

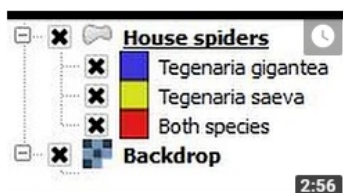
Demand for our QGIS courses is high and they often fill to capacity; the numbers in parentheses show the number of courses and the total attendances for that type of course. Most of these courses were delivered at FSC Preston Montford, but 7 of the various one-day courses were delivered at external sites including Chester Zoo, the Lancashire Wildlife Trust and Cumbria Wildlife Trust.

All the courses above were delivered by Tomorrow's Biodiversity project staff, but in 2016 we increased our capacity by working with an external specialist (Matt Davies) who has become an FSC Associate Tutor for QGIS to deliver 4 further 2 ½ day residentials at various FSC sites (Slapton Ley, Juniper Hall and Margam Park). These courses attracted a further 26 attendances.



Demonstrating the TomBio QGIS Plugin to an interested crowd at the NFBR conference in Sheffield in 2015.

Our QGIS courses are recognised within the sector as being outstanding value for money; for example, many of our day courses have been priced at £35, which has helped bring this specialist QGIS training to a wider audience. Our residential courses are a fraction of the price of other commercial QGIS training providers when the cost of accommodation is factored in.



QGIS How do I... Create a coincidence map

FSC Tomorrow's Biodiversity • 359 views • 2 years ago

A very quick demonstration of how to use the QGIS Tom.bio plugin to create a coincidence dot map for two species from records in a CSV file.

The link to one of our QGIS YouTube tutorial videos. This one was created in response to a query from a participant at one of our training courses, but answering with a publicly accessible video allowed others to benefit too.

We have also developed other means of delivering training, notably our YouTube video tutorials (published on the FSC Tomorrow's Biodiversity YouTube channel). We have published a total of 29 QGIS tutorial videos which together have been viewed over 33,000 times. Our highest viewed video (of all videos on our YouTube channel) is *QGIS OSGR tool: generating OS grid squares* (one of the TomBio plugin tools) which has been viewed over 8,700 times.

18 of our videos were created in direct response to user queries – we call these 'How do I...' videos. We've learned that answering a query with a publicly accessible resource in this way is a great way of leveraging maximum public benefit for time spent problem solving for partners. Our highest-viewed 'How do I...' video is *QGIS How do I... Create and rotate a user-defined grid* which was created in response to a query for a single user, but which has been viewed over 3,000 times. Another one, *QGIS How do I... Make a species richness map for an area in South America*, has been viewed over 900 times, demonstrating some of the international reach of the Tomorrow's Biodiversity QGIS project.

7.7.3 QGIS project: other outputs and outcomes

In 2017 the FSC Tomorrow's Biodiversity project was awarded the Chartered Institute of Ecology and Environmental Management (CIEEM) award for Best Practice in Knowledge Sharing for our work with QGIS and the TomBio plugin. We collected the award from Baroness Young at the CIEEM 2017 awards ceremony at the Drapers Hall in London.



Accepting our 2017 CIEEM award for Best Practice in Knowledge Sharing from Baroness Young at the Drapers Hall in London. From left to right, Charlie Bell, Dave Morgan, Sue Townsend, Rich Burkmar and Baroness Young.

Our nomination for the award was supported by John Handley who had benefitted from our QGIS training. Here's some of what he had to say:

"The courses are very well constructed and taught: structured to take into account the variety of experience of participants, from the novice to the expert. The tutor's experience means that the content of the courses is relevant to industry requirements; all examples provided enable participants to understand how this applies to their own situation and are clearly explained. [...] The TomBio plug-in means that I can take data geocoded with OS grid references and use it straightaway. This reduces the potential for mistakes and means that species can be displayed quickly and easily, this is particularly important when you are starting to use the software as long and complex processes can be very discouraging to a new user. [...] The importance of the Tomorrow's Biodiversity QGIS project is fundamental to me starting my exploration of QGIS and without it I would still be colouring maps in with a pencil crayon – no further forward than we were in the 1970s."

An unplanned benefit of our QGIS work was the on-line interactive atlases we created to facilitate the targeting of recording by local entomologists. These would not have been possible without the TomBio QGIS plugin which we use to produce the distribution maps from spreadsheets of records. The first of these was the Springtail 'progression atlas' which has been described earlier in this document. When this online atlas appeared, we were approached by other local entomologists to see if we could produce something similar for them. We now have 10 such local atlases on the website:

- Shropshire springtails
- Shropshire shieldbugs
- Shropshire orthoptera and allies
- Shropshire longhorns
- Shropshire psyllids
- Shropshire terrestrial heteroptera
- Shropshire psocoptera
- Shropshire auchenorrhyncha



- Shropshire earthworms
- South Lancashire earthworms

Links to these atlases can be found here: <http://www.tombio.uk/visualise#maps>. Providing these services to local entomologists has been an important element of our networking and has been of great benefit to both recorders and the project. In 2016 we published the code for these interactive maps as an open source project and we know of at least one organisation – Merseyside BioBank – that has taken the code is their own interactive website maps:

<http://www.activenaturalist.org.uk/meso/atlas/>. In this case, Ben Deed is using it to create an interactive atlas map for a Lancashire Springtails Atlas project. In his own words:

“Being able to provide a provisional atlas showing updates on the progress of our recording project is a key concern when thinking about feeding back on the hard work of the recorders supporting the project. It shows them that they are making meaningful contributions as well as allowing them to target their recording effort in the unknown spaces between squares. The Tomorrow’s Biodiversity atlas code allows us to present a clean and efficient interactive web map quickly and simply while being easy to update using the TomBio QGIS plugin. This helps me make the most of the limited time I have available to work on this technology and minimises the learning curve required to develop my own such web map.”

The legacy of our QGIS work and development is important to us. The future of FSC biodiversity project work has been secured for the next five years due to some continuation funding from Esmée Fairbairn (for 2018) and to the new five-year HLF-funded BioLinks project. We plan to continue work on the QGIS plugin and resources and support for the local interactive atlases into the next project. We are continuing to run the annual residential QGIS course at Preston Montford (which is a recognised module of the MMU/FSC Biological Recording post-graduate qualifications) and FSC’s relationship with QGIS Associate Tutor is set to continue into the future as long as there is sufficient demand for QGIS training.

7.8 Internet & communications project

This cross-cutting project facilitated all the others. Many of the other projects (and focal areas) required the support of a website and other internet communication tools such as social media. We created a new website, featuring a regularly updated blog, which acted as a central internet communications hub around which we used social media like Facebook, Twitter and YouTube. This allowed us to develop the *networks* and *signposting* focal areas as well as facilitating many others, notably *ID resources*.

7.8.1 Internet & communications project: website

During the early development phase of the Tomorrow’s Biodiversity project we developed a website on the NHM Scratchpad platform (tombio.myspecies.info). This was a cheap (free) way of getting a web presence up and running quickly and enabled us to explore the utility of the Scratchpad platform. It served us well for a couple of years, but the Scratchpad platform is quite tightly constrained in its capabilities - like a ‘cut down’ version of Drupal (on which it is built). Since our website had to enable us to experiment with, and host, novel facilities and tools, we concluded that



the Scratchpad platform was too constraining although we recognised its usefulness to communities actively engaged in taxonomic and systematics research.

Having made the decision that we needed another website, there were two options open to us: use the existing FSC website, architecture and branding or develop something separate. We took the second option, reasoning that because we wanted to experiment with new tools and facilities there could be a risk to the existing FSC website (and brand). It would be better to have a completely new website over which we have full control and freedom to innovate.

The Drupal content management system (CMS) is a widely used platform that is popular with natural history schemes and societies. For example, the National Forum for Biological Recording was moving to a new Drupal-based website at around the time we were looking to create ours. The BRC Indicia toolkit for building biological recording websites is particularly well suited for implementation on Drupal websites and although we did not, during this project, implement any Indicia functionality, this also influenced our choice. All these factors, combined with our own experience of Drupal through the Scratchpad platform, led us to favour building a new website based on the Drupal CMS.

Tomorrow's Biodiversity

Home Overview Blogs Training Films Visualise ID Signpost News

Plugin the gap...reflections on teaching QGIS for the FSC.
Guest blog by Matt Davies

Submitted by [Charlie Bell](#) on Wed, 01/03/2018 - 14:42

I like maps. I always have. I can thank both my father, a town planner, and the Scouts for nurturing my interest. With such a background, it's no surprise that that during my university degrees I developed an interest in GIS!

[Read more](#) | [Charlie Bell's blog](#)

Latest news...

TomBio ends soon, signup for BioLinks!
The Tomorrow's Biodiversity Project ends at the end of January 2018, but the FSC Biodiversity Projects baton will be passed to our brand new project - BioLinks. Keep up with the latest developments and news from BioLinks by signing up here: <http://www.tombio.uk/biolinks-signup>

If you wish to live and thrive...

Submitted by [Charlie Bell](#) on Wed, 11/29/2017 - 16:09

In 2017 Lesley Lancaster attended all three levels of Tom.bio spider ID courses: 'Learn to Love Spiders', 'Field ID of Spiders' and 'Spider ID With Microscopes'. Read her account of her 'spider journey' here!

[Read more](#) | [Char](#)

Tweets from @FSCTomBio

Tweets by @FSCTomBio

FSC Tom.bio
@FSCTomBio

The Tomorrow's Biodiversity Project ends at the end of January 2018, but the FSC will be passed to Links. Keep up

A screenshot from our website.

Over the first few months of 2015 – the start of the delivery phase of Tomorrow's Biodiversity – we created a new website, externally hosted by a company called Clook, with the domain www.tombio.uk. Charlie Bell had recently joined the project and one of her first jobs was to port much of the content of the old Scratchpad website to the new website. We chose a feely available theme called 'Skeleton' which gave the website a layout that was responsive to mobiles and other small format devices.



The website has, of course, evolved over the course of the project but it soon settled down into several distinct sections visible from the top menu. These are described very briefly in the bullets below (some of them are described more fully in later sections):

- **Home.** The homepage contains 'teasers' for recent content posted to the site which is often, but not exclusively, blog posts. Like many other pages on the website, the right-hand part of the page is used to display information that we wish to promote (the 'latest news' block) and also incorporates a feed from our Twitter account. All of this makes for a homepage with dynamic content, ensuring that it does not become stale.
- **Overview.** This section contains an overview of the project including outputs generated from the research and consultation of the development phase and links to pages with an overview of each of the exemplar projects.
- **Blogs.** This section contains a searchable archive of all the blogs posted to the website (see below).
- **Training.** This section contained upcoming courses and also a record of all past courses. Courses were implemented as individual 'nodes' using a Drupal content type specifically created for them. It meant that adding and updating courses was very simple.
- **Films.** This is where we posted links to some of our more important videos hosted on YouTube. Sometimes we linked directly to the videos hosted on YouTube. At other times, especially where we had a series of related videos, we created our own web pages and embedded the videos directly within these (e.g. <http://tombio.uk/NPMShabitats>).
- **Visualise.** This is the section of the website where we hosted all the products of the keys & visualisation project. There was a lot of content here so this section links to many different pages. Usually content is displayed within normal nodes of the CMS (e.g. www.tombio.uk/framework), but sometimes we implemented visualisation content outside of the normal Drupal environment (e.g. <http://www.tombio.uk/sites/vis-punched.html>) because the Javascript and CSS content of Drupal node pages can interfere with visualisation pages which are themselves highly dependent on Javascript and CSS.
- **ID Signpost.** A crowd-sourced interactive catalogue of ID resources.
- **News.** We gradually adopted a strategy of communicating news to our audience by using MailChimp (described below) so we didn't duplicate this functionality on the website. Instead we included a sign-up form for the MailChimp newsletter and included links to previous editions of the newsletter (created dynamically through Javascript).

The website has had over 120,000 pageviews since it came online.



7.8.2 Internet & communications project: blogs and guest blogs

Blogs proved to be a great way of showcasing training events and resources, highlighting issues in biological recording, and providing a means for people to engage with the project either by reading and following the blogs, or by writing guest blogs.

Over the lifetime of the project we have posted 53 blogs, of which 17 were guest authored for us by a wide variety of people from many parts of the biological recording community. The five most popular blogs from the website are listed below (numbers in parentheses are pageviews):

- Build Your Own LED Moth Trap - guest blog by Paul Palmer (3,088)
- OS OpenData for QGIS (1,955)
- Invertebrate specialists and alcohol problems (1,089)
- New online key to grass families - guest blog by Sally Hyslop (1,051)
- QGIS tips - building a map background (443)

It's very hard to determine what makes a popular blog but the five above all have something in common: they are all either tutorials or guides to a resource. Clearly the most popular blogs were those that helped people in a practical way.

Since blog posts are one of the best ways to keep a website dynamic, it pays to have a well-considered strategy for making regular blog posts. We had targets for posting regularly but we didn't always stick to them! It is too easy to underestimate the time and effort required to post regularly. One lesson we have learned from this is that guest blogs are great value! (Note that two of our top five blog posts were guest blogs.) Another is that it is probably better to blog 'short and often' than 'long and infrequently', although there is certainly also a place for longer blogs.

7.8.3 Internet & communications project: the ID Signpost

During the Tomorrow's Biodiversity consultation in 2014 there was a strong appetite for more 'signposting' of resources to enable UK biological recorders to quickly see what is available in respect of training, ID resources etc. People often referred to Richard Comont's blog where he has collated links to a huge number of online resources: <http://insectrambles.blogspot.co.uk/2012/12/web-id-resources.html>.

Richard Comont's monumental effort, which to a large degree inspired the ID Signpost, relies mostly on the work of a single person to keep it up-to-date. Platforms like Drupal can facilitate a crowd-sourcing approach to collating this kind of information - spreading the burden of maintenance and increasing reach and coverage.

The *ID Signpost* is an online searchable catalogue of UK biological identification resources. A key feature is that the records of ID resources are crowd-sourced. This means that it can be kept up-to-date more easily and have a much wider reach than if only a few people were able to edit it.



Everyone can use the ID Signpost, whether or not they have a website account. People who want to add catalogue entries need to register for a website account and then using the 'Request editor role' button to request permission to update the ID Signpost. Adding a resource is easy enough through a



simple form. For each new entry, a minimum of three pieces of information must be specified (those italicised below) and, optionally, a few more:

- *ID resource name*
- *Short description*
- Author(s)
- Free (checkbox to indicate whether or not the resource is freely available)
- Availability (checkboxes to indicate if the resource is available online, as a PDF, as a printed publication and/or as a computer app or program)
- Weblink (a URL to the resource, if online, or information about it)
- Additional weblinks (other useful URLs associated with the resource)
- Keywords (to add to those included in resource name, description and authors)
- *Major group(s)* (at least one must be specified)

The ID Signpost (642 matches)


Title	Description	Author(s)	Free	Availability	
Online key to Bee-flies (Bombyliidae) of North-west Europe	This online key to Bee-flies (Bombyliidae) of North-west Europe by Mark Van Veen contains a wide range of Bombyliidae sp	Mark van Veen	Yes	Online	View Edit
A field guide to the shallow-water echinoderms of the British Isles	Field guide & practical reference book on echinoderms likely to be encountered between the tides & underwater ar	Bernard E. Picton	No	Publication	View Edit
A field key to the British Brown Seaweeds	This AIDGAP identification key is designed to allow non-specialists to identify the majority of British macroscopic (lar	Hiscock	No	Publication	View Edit
A field key to the British Red Seaweeds	The larger seaweeds (marine ALGAE) are classified into four major groups according to the pigments (coloured compounds) t	Sue Hiscock	Yes	Online, PDF	View Edit


Keyword

Major group(s)
 unspecified
 habitat
 fungi
 fungi- lichens
 fungi- slime moulds
 plants
 plants - flowering plants
 plants - conifers

Free - Any - **Availability** - Any -

Click on the signpost icon for more information and details on how to add entries to the catalogue.



 Add new catalogue entry. (Not authorised? Click signpost icon to find out how to fix that.)

A screenshot of our website showing the ID Signpost tool.

To use the catalogue a user just specifies a keyword such as *shieldbugs* or *lichens* and then clicks the search button. Optionally resources can also be filtered based on whether or they are free and what media they are available on (e.g. 'online'). The tabulated search results show all entries that match the search criteria. For online resources, clicking on the title of the resource links straight to the resource.

The ID Signpost is the single most popular page on our website with 4,490 pageviews since it came online in July 2015. It currently has over 640 resources catalogued. 19 people are registered as users with the role of 'ID resource editor'. As a trial of using the Drupal platform to build an open crowd-sourced catalogue resource for the biological recording community, the ID Signpost has been a



technical success. But despite being the single most popular resource on our website, we believe that it has greater potential than the usage figures suggest. The figure of 19 people registered to add resources is disappointingly low.

One lesson to take forward from this is that resources like this require a lot of ongoing promotion to achieve the widest possible audience. The ID Signpost has not passed a tipping point where promotion is carried out by word of mouth. Quite why so few people registered to add resources is not clear. Even though the process to register is simple enough, it could be that the process of having to register for a website account and then apply for permission was too off-putting for many. A possible solution to this would be to allow people to submit resources without being registered, but instead of going straight onto the ID Signpost, these would have to be checked by a 'moderator' who would then be responsible for either okaying or declining them.

7.8.4 Internet & communications project: Facebook & Twitter

Social media has played a significant part in the success of the Tomorrow's Biodiversity project, especially in helping to promote and fill our courses and training events. Facebook and Twitter have been the two main ways we have engaged via social media. We have 428 'Likes' on the FSC Tomorrow's Biodiversity Facebook page (<https://www.facebook.com/fsctombio/>), with 432 people following the page. Our Twitter following stands at 1,173 followers (@FSCTomBio). Throughout the project we have sent over 1,700 tweets.

In general, we have been more active on Twitter than on Facebook and much of our Facebook page content derives from a link to our Twitter feed and, in some respects, has been used mainly as a vehicle for increasing the reach of our Twitter account. In retrospect, this is probably not the most effective way to use the Facebook page. Since Facebook does not have the 140 character limit of Twitter, it is a better forum for more extensive posts, but these, like website blog posts, can take time and effort to prepare. However, if website blog posts are frequent enough, Facebook could be used as a way to distil the headline content of these into an eye-catching post which links back to the original blog.

As well as our Tomorrow's Biodiversity Facebook community page, we also created a closed Facebook group for the Shropshire Spider Group (SSG) as part of the Spider project (<https://www.facebook.com/groups/shropshirespidergroup/>). The group has 98 members and has been reasonably successful in engaging local interest in the SSG, sometimes generating important spider records which may otherwise have been missed. One difficulty with using a Facebook group to support a local group is that, by their nature, there is nothing intrinsically *local* about a virtual group. Unless one takes a somewhat intrusive approach to moderating requests from people who want to join, there is no way to restrict such groups to local people. So many (if not most) of our 98 members don't live or work in Shropshire. We've learned that the best way to make a group like this feel 'local' is to include lots of content that is, by its nature, of mainly local interest. It takes a lot of time and attention to do this and we have probably fallen some way short of being really effective in this regard for the Shropshire Spider Group Facebook group.

We have also used other Facebook groups and forums to reach a wider audience. Some of the most useful to the project, in terms of increasing our reach were:

- FSC Biodiversity Fellows Group (<https://www.facebook.com/groups/bio.fell/>)



- National Forum for Biological Recording (<https://www.facebook.com/groups/NatForumBioRecording/>)
- Shropshire Invertebrate Group (<https://www.facebook.com/groups/643009322411173/>)

One of the legacies of the Tomorrow's Biodiversity project will be a ready-made social media audience for the new FSC BioLinks project and we will be doing all we can to transfer the attention of current Tomorrow's Biodiversity social media audiences to the social media of the new project as it gets underway.

7.8.5 Internet & communications project: YouTube videos

One of the strongest messages to come out of the Tomorrow's Biodiversity consultation was that there is a growing appetite, particularly amongst the younger audiences, to consume training and education resources from the internet in the form of videos rather than written material. So it was very important for us to establish a channel for hosting and disseminating short educational videos. We did this by creating a YouTube channel for the project: [FSC Tomorrow's Biodiversity](#). The channel has 177 subscribers and hosts 78 videos which have been viewed over 45,000 times. Clearly this has been one of the outstanding successes of our Internet & Communications project.



Our YouTube channel has been a very important way for us to provide training and resources for our QGIS project and the ID Framework. As described elsewhere in this report our 29 QGIS videos accounted for over 33,000 views and 16 videos for the Keys & Visualisations had over 1000 views. However, we used the channel for much more than this. Also mentioned elsewhere in this report were the 4 videos we produced to support the National Plant Monitoring Scheme which have been viewed a total of 714 times. We also filmed a series of five videos with Paul Palmer showing how to construct a cheap moth trap which have been viewed a total of 1,365 times. A series of seven short videos we made with Ian Wallace on identifying live invertebrates from kick samples have been viewed a total of 978 times (also described elsewhere in this report).

The consultation highlighted a lack of familiarity with biological sampling techniques as a barrier to people becoming involved in biological recording. Those new to biological recording can feel rather intimidated by frequent references to things like 'sweep netting', 'beating', 'kick sampling' and 'pooters', and may not know exactly what is involved, what equipment is needed and what species groups each technique is suitable for. In response we produced three short films, which demonstrated different invertebrate sampling techniques, and the equipment needed for each. The topics for these films were:

- Kick sampling in rivers and streams (4198 views).
- Making and using a spi-pot (675 views).
- Sampling springtails for the Shropshire springtail atlas (358 views).

As well as using these films ourselves in our teaching (e.g. the 'Making and using a spi-pot' film was used in our 'Field ID of Spiders and Harvestmen' courses, to guide participants through the process of making their own spi-pot), we have also been contacted by external associate tutors who have asked permission to use them in their own teaching (e.g. FSC Associate freshwater invertebrate tutor Adrian Chalkley asked to show the 'Kick sampling...' film in his courses).



Our videos are of two main kinds, filmed videos such as those for sampling techniques and computer screencasts for those such as the QGIS and ID Framework videos.

For the screencast videos we originally used a free version of the software *Screenpresso* to capture the screencast action and commentary and then edited these using *Windows Movie Maker*. The problem with this solution was that the editing process is quite cumbersome and the voice and video were recorded and edited as a single track. This really put the pressure on the do the whole video in a single take. More recently we moved to a subscription tool called *Screencast-o-matic* which we use for both capture and editing. The video and voice are captured on separate tracks and can be edited separately. Moreover, the screencasts can be scripted and recorded in sections which really eliminates the pressure of doing the whole thing in a single take and remembering all the steps. The editing tools are excellent allowing easy addition of text overlays and other effects, like highlighting and zooming it. Our decision to purchase and use this software really marked a step-change in the quality of our screencast videos. For comparison, look at the following two videos:

- This screencast was shot as a single take using the old tools: https://youtu.be/_DKxAJ1xsrQ
- This screencast was scripted, shot and edited with screencast-o-matic and includes overlays to highlight text: <https://youtu.be/tJ-2YTOumU>

Sound is one of the hardest features to get right, but it has a great effect on the overall quality of the videos. We invested in a Blue Yeti microphone for indoor recording (see below), but we didn't use it for most of the screencast videos (using a cheap headset instead) and, as a result, the sound of some of these isn't so good.

For filmed videos, we used two types of camera: a GoPro and a digital SLR. The GoPro camera was completely waterproof which allowed near-water and underwater filming. It was also highly portable, being easy to deploy, e.g. by mounting on poles, pond-nets, fenceposts etc. Disadvantages of the GoPro included a poor microphone and an inability to close-focus which proved to be serious limitations for us. We overcame these shortcomings by using, when necessary, a good quality digital SLR but, unlike the GoPro, this was heavy and bulky and not waterproof, reducing options for mounting and deployment.

The Yeti microphone was quite expensive but allows high quality sound to be recorded. A disadvantage is that it needs to be plugged into a laptop with audio recording software installed. It is also very large and bulky, ideally being placed on a desk. Whilst these limitations are not serious for screencasting and videos filmed indoors (e.g. the series on building a moth trap) it limits its usability outdoors.

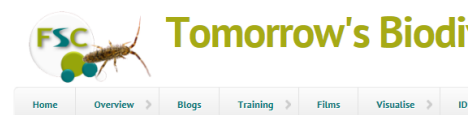
For filmed videos we used Audacity audio software, which is free and open-source, which is capable of multi-track recording and editing. It is however a complicated program and not easy to use. For editing filmed videos we used PowerDirector which, although including many useful features, is reasonably intuitive and easy to use. It was however, expensive.



7.8.6 Internet & communications project: MailChimp

Tomorrow's Biodiversity project newsletters were one of the ways we regularly communicated with our audience. They contained general project news, information and course details, and were sometimes sent specifically to promote certain training events. Relatively early on in the delivery phase of the project we made the decision to use the online mailing system MailChimp for our newsletters. MailChimp provided the following advantages over simply using email:

- Attractive, professional looking, customisable templates for building emails.
- An ability to create 'sub-sections' of the mailing list for certain targeted mailings.
- A system for tracking what percentage of people opened our emails and/or clicked on links within them.
- No issues with FSC servers being unable to cope with large numbers of outgoing emails or flagging us as spammers, as may happen with a simple email system.
- An automatic 'unsubscribe' function at the bottom of every email.
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 01/11/2017 - [FSC Tom bio news - Jan 2017](#)
 11/22/2016 - [FSC Tom bio news - 2017 courses](#)
 07/05/2016 - [FSC Tom bio news - July 2016](#)
 05/24/2016 - [Springtail Atlas Update - May 2016](#)
 03/22/2016 - [FSC Tom bio news - March 2016](#)
 02/10/2016 - [FSC Tom bio news - Feb 2016](#)
 11/24/2015 - [FSC Tom bio news - Nov 2015](#)
 09/02/2015 - [FSC Tom bio news - September 2015](#)

Sign-up form and links to previous MailChimp newsletters.

The last two points ensure that the project is compliant with data protection legislation on the storage and usage of personal details. We created sub-sets of recipients for the Shropshire Springtail Project and the Tom.bio ID Framework, as these are more specialist topics which have more relevance for a smaller group of people.

We have 898 people receiving our newsletters and we have sent a total of 28 newsletters via MailChimp during the project, with an average email open rate of 37.6%. Whilst this may not sound very high, this compares very favourably to an industry-wide average open rate of 18.11% (figures from MailChimp 09/01/18).

We were able to take advantage of Javascript code provided by MailChimp to embed sign-up forms into our website and also list recent issues of the newsletter.

7.9 Novel ID resources project

The Novel ID resources project was conceived as a way for FSC to keep abreast of developments in this area and to experiment and innovate itself. Since our own innovation concentrated on multi-access keys and related visualisations (see Keys & Visualisation project) we had little time to drive innovation in other areas ourselves, so this project was designed to be a vehicle for collaboration with others as opportunities arose. In the event, despite some early support for a few novel ID and resource projects, our involvement was limited. The projects we became involved in are described below.



7.9.1 Novel ID resources project: freshwater invertebrate ID films

Dr Ian Wallace is national recorder for caddisflies and previous curator for Invertebrate Zoology at Liverpool Museum. Ian approached us with the idea for some short video guides to freshwater invertebrates 'in the tray'. His rationale for this was that field guides, keys, and specialist photos and videos available online often offer very high quality, close-up images of such creatures – not at all representative of the sort of view you get in the field. He felt there was a need for some footage which gave an accurate representation of the sort of view you would get looking down into a sample tray.

When sampling freshwater invertebrates in the field, e.g. when pond dipping with children or doing Riverfly sampling, it is often the 'general impression' and the way an animal moves or holds itself that gives the first and best clue as to what taxonomic group it's in. We worked with Ian to produce a series of films, hosted on the Tomorrow's Biodiversity website, on the following groups:

- Heptageniidae
- Damselfly nymphs
- Gammarus
- Cased caddis
- Caseless caddis
- Flatworms
- Water mites

They have had a total of 978 views since they were published in the Autumn of 2016.

7.9.2 Novel ID resources project: three dimensional rotating images

TaxonAid is a project to examine the production and utility of three dimensional images of curated insect specimens to aid biological identification. We were approached by Dr Chris Hassall at Leeds University to see if we would be willing support a PhD student there – David Bodenham – who was working with the entomologist Roger Key to use a novel technique for capturing 3D images of specimen invertebrates so that they can be viewed as rotating images on over the internet. We supported the 'proof of concept' study using images of hoverflies (Syrphidae) of the tribe Eristalini. This concept proved successful and the images are available from the TaxonAid website:

<http://www.taxonaid.com/key/order-diptera/family-syrphidae/tribe-eristalini/>. This work was done over 2014 and 2015 but unfortunately it doesn't appear to have progressed since then. (Progression was dependent on the project finding more funding.)

7.9.3 Novel ID resources project: marine ID and recording resources

Tomorrow's Biodiversity also supported the production of a couple of marine identification and recording resources: 'Signs of Life', a project to produce a photographic guide to inshore benthic marine life led by Franki Perry, and Seasearch ID and protocol training videos, led by Paula Lightfoot. These two projects are the only projects supported by Tomorrow's Biodiversity that have an explicit marine content.

8 Delivery phase: additional outputs

Despite having defined 'exemplar projects' from the outset of the delivery phase, we wanted to remain open-minded about starting and/or supporting other projects as opportunities arose. Some

of the additional outputs of the Tomorrow's Biodiversity project which don't really fit into any particular exemplar projects are described below.

8.1 Introduction to Biological Recording courses

We identified a gap in training provision for a weekend-length introductory course to biological recording, aimed at the naturalist who wants to start turning their sightings into usable biological records. In response we developed a course called *Introduction to Biological Recording*. Through a mixture of formal and informal teaching and field sessions this course was designed to leave participants with an understanding of UK biological recording and a feeling that they were able to start contributing valuable records using the iRecord recording website.

Although we were willing to accept complete beginners, the course was really aimed at those with some experience as naturalists, who wanted to take the next steps into recording their observations. The course was designed as a two-night residential running from Friday evening to 4 pm on Sunday afternoon.

The first of these courses ran at Preston Montford, Shropshire in January 2016. This was extremely successful and was fully subscribed, with a waiting list. We also ran it in August 2016 at Malham FSC centre in North Yorkshire – although we had fewer attendees (six) it was also a successful and well-received course.

Unfortunately, the next course, planned for February 2017 at Preston Montford, had to be cancelled due to low bookings. This was very surprising given the fact the first course at Preston Montford had a waiting list. The reason for this was unclear, although factors such as time of year (winter) and location (i.e. maybe the location was too familiar to potential attendees) may have been important.



Isaac Johnston, a participant on our Introduction to Biological Recording course at Knepp, adorned with Elephant Hawkmoths as we emptied the moth trap.



Charlie inspecting the luxurious catering area of our class/dining room at Knepp.

In light of this we re-thought the course and its offer to attendees. For some time, we had been interested in the work being done by the Knepp estate in Sussex – often cited as one of the UK's most successful re-wilding projects. We thought that the Knepp estate could be a potential venue and host for FSC courses, so a relationship with them would potentially be mutually beneficial. We also suspected that the branding and corporate identity of the Knepp estate may have some useful learning which we could feed back to the FSC.

We made contact with the Knepp state ecologist and worked with her to run the *Introduction to Biological Recording at Knepp* course from their estate in August 2017. This included an additional session on the rewilding work being carried out there and its impact on the biodiversity of the site. We offered two accommodation options – camping or glamping – which added to the unique appeal of the course.

The course was very successful and the relationship with Knepp is one which we hope the FSC will take forward and develop further in the future.

8.2 Long duration aculeate courses

Another achievement of the Tomorrow's Biodiversity project was to reinvigorate the format of week-long residential courses run by FSC. In recent years long-duration courses have fallen out of favour due to the time commitment required from tutors and attendees, lack of capacity in centres to host a course for an entire week and the relatively high cost associated with a week-long course. However, feedback we received suggested that there was an appetite for a seven-day natural history

course, as an ‘immersive experience’ and an opportunity to allow attendees to really consolidate their learning over a full week of teaching and fieldwork.



Ian Cheesborough (centre in blue tee-shirt) with his students during the 2017 Solitary Wasps course based at FSC Orielton, Pembrokeshire (with thanks to Bex Cartwright for use of the photo).

We worked with entomologist Ian Cheeseborough to develop a seven-day solitary bee identification and ecology course, subsidised by Tomorrow’s Biodiversity, which first ran at Flatford Mill in Suffolk in summer 2016. This was fully booked – with a waiting list – and project officer Charlie Bell attended to assess the success of this long format. The feedback on this course was outstanding, with many attendees citing the longer duration as being a key factor in the amount of learning and enjoyment they got out of it.

In 2017 the week long solitary bee course ran again, but this time the course was self-supporting financially (i.e. not underwritten by Tomorrow’s Biodiversity). Running concurrently in an adjoining classroom we ran a new format event – a self-study solitary bee identification workshop. This offered people the chance to come together to identify their own solitary bee specimens in a supportive peer-to-peer environment. The classroom space and basic equipment were provided but attendees were encouraged to bring their own microscope. This self-study weekend was designed for those already experienced enough to self-study, with only occasional support and verification provided by the tutors of the concurrent week-long course. Many attendees from the previous year’s week-long taught course returned for this self-study workshop, and a close-knit network of hymenopterists is developing as a result.

In 2017 we supported a week-long Solitary Wasp Identification and Ecology course, also run by Ian Cheeseborough at FSC Orierton in Pembrokeshire, providing a similar subsidy to that we provided for solitary bee course in 2016 (in order to keep costs to participants down) . This was also over-subscribed.

Both the week-long solitary wasp and bee courses are running again in 2018, without any subsidy from Tomorrow's Biodiversity, now that their reputation has been established amongst the aculeate recording community. The week-long residential course is again recognised as a valid – and popular – course format.

8.3 Building a Pinned Reference Collection course

At the Shropshire Ento Day in December 2016 we handed out a short survey to attendees, asking what additional entomological skills and techniques, if any, they thought it would be valuable to offer training on. Although the Tomorrow's Biodiversity and the FSC in general have a track record of providing high quality training in species ID, we suspected that a barrier for those new to entomology might be a lack of familiarity and confidence in additional skills such as collecting, preserving, euthanising and pinning specimens, as well as maintaining collections.

The results of this survey confirmed our suspicions: preserving, setting and pinning specimens was consistently identified as an area where training could really help new recorders. Surprisingly, training and guidance on the legal and ethical issues surrounding collecting specimens was also requested.

In response to the survey results we developed the *Building a Pinned Reference Collection* one-day course which ran in 2017. This covered everything attendees would need to know to start building a pinned entomological reference collection. It included the legal and ethical issues surrounding collecting, the practical fieldwork skills required to collect specimens, and a classroom session to learn and practice the skills involved in preserving, setting and pinning invertebrates.



Pete Boardman demonstrates the use of a Malaise trap (above) and Ian Cheeseborough empties pitfall traps during our Building a Pinned Reference collection course.



The course was led by Shropshire based entomologists Pete Boardman and Ian Cheeseborough, with support from the FSC Tomorrow's Biodiversity project staff. Ten people attended.

8.4 Other specialist invertebrate courses

Towards the end of the first year of the delivery phase of the project we talked to Dave Grundy, one of the UK's foremost moth identification trainers, about a gap he recognised in training provision. Most moth identification courses concern themselves with the identification of live specimens which, in the clear majority of cases, is adequate for species-level ID. However, there is a significant number of species which can only be determined to genus (or to an aggregate) from live specimens and identification to species level requires dissection of dead specimens to examine the genitalia.

Although there are increasing numbers of people who are competent moth recorders of live specimens, Dave perceived a dwindling number of people with the skills required to identify these more cryptic species. People with these skills typically provide an identification service to the wider moth recording community, so these disappearing skills give rise to serious concern.

Tomorrow's Biodiversity worked with Dave to host a weekend residential course at FSC Preston Montford to teach people the necessary skills to be able to identify critical species by dissection, preparation and examination of their genitalia. The course covered the following skills:

- Preparing moth specimens for dissection.
- Dissecting moth genitalia, male and female, to enable possible identification.
- Preparing a microscope slide of genitalia ready for ID.
- Identifying genitalia of moths from microscope slides.
- Understanding how to develop these skills following the course.
- Understanding where to look up genitalia diagrams to enable ID.

Because of the intensive nature of the course – close attention to each student is required to teach the physical skills required in dissection – Dave was keen to limit the numbers on the course to just six. Running a residential course for such low numbers is a financial challenge to a field centre so Tomorrow's Biodiversity subsidised places on the course.

Over the course of the delivery stage of our project we have worked with Dave and Preston Montford Field Centre to host the course three times and each time it has been fully booked (indeed it is usually over-subscribed). In all, 18 people have been trained to a high standard thanks to this course. With each successive course, we have reduced the amount of subsidy paid by Tomorrow's Biodiversity and we are pleased that Preston Montford and Dave are running the course in 2018 as a completely self-financing initiative.



One of the course participants, Mike Shurmer, had this to say:

"I had been keen to learn how to use dissection skills to identify difficult moths for some time, so when Tomorrow's Biodiversity advertised the Moth Dissection Course, at an affordable price, I booked immediately. The course was brilliant, Dave Grundy is a superb teacher and the organisation by the Tomorrow's Biodiversity team was excellent. Following the course, I have processed several hundred smaller moths from many recorders, identifying new species for the county and many records of conservation interest. I am also now the County Micro-moth Recorder for Shropshire and the dissection skills I learnt have been transferable to other insect taxa. There is no question that Tomorrow's Biodiversity has had a hugely positive influence on my development as an entomologist."

In a similar vein we occasionally supported other specialist invertebrate identification courses including two courses on millipedes and centipedes at FSC Preston Montford, in association with Paul Richards, and a course on blowflies at FSC Bishop's Wood in association with Steven Falk. Together, these courses attracted an attendance of 24.

8.5 Invertebrate Challenge legacy events

2014 was the last year of another FSC biodiversity project – Invertebrate Challenge which was managed by Pete Boardman. As part of the legacy of this project, several events were organised for 2015 – the year after the project ended – and they were facilitated by the Tomorrow's Biodiversity project (during the first year of the delivery phase of this project).

The general format for these courses was a field day, during which field techniques were demonstrated and invertebrates collected, followed by a lab day that concentrated on ID. All of the tutors on these courses had been involved, in some way, with the Invertebrate Challenge day. There were, in all, 7 events:

- A crane fly field day (Pete Boardman).
- A crane fly identification day (Pete Boardman).
- A hoverfly field day (Nigel Jones).
- A hoverfly identification day (Nigel Jones).
- An aculeate hymenopteran field day (Ian Cheeseborough).
- An aculeate hymenoptera identification day (Ian Cheeseborough).
- A beetle field day (Don Stenhouse).

In all, these events attracted a total of 45 attendances. The format of two back-to-back non-residential day-long workshops, the first day in the field and second day in the lab, was a format which we successfully deployed on a number of other Tomorrow's Biodiversity events described in this report.

8.6 Shropshire Ento Day

Shropshire Ento Day first ran in 2008 under the auspices of the FSC biodiversity project Invertebrate Challenge. It is an annual one-day conference for entomologists from Shropshire and beyond, and includes a mix of presentations on various subjects. Attendees are free to bring displays, specimens,



photographs and posters to share with others attending. The Biodiversity Library (a legacy of the Invertebrate Challenge project) and invertebrate collections are available for attendees to peruse.

Tomorrow's Biodiversity staff have attended and/or presented at each of the last five Ento Days. We have used Ento Day to launch the Shropshire Springtail Atlas Project (at Ento Day 2015); to survey attendees on their perception of gaps in entomological training (Ento Day 2016, the results of which led to the development of the 'Building a pinned reference collection' course); and generally to promote the Tomorrow's Biodiversity project and its training events.

Ento Day is hosted by Preston Montford Field Centre who also provide a buffet lunch and afternoon tea and cake. For the last three years (2015 to 2017 inclusive) the event has been supported by Tomorrow's Biodiversity, both financially and in terms of organising and hosting. This has helped keep the cost to attendees at a very reasonable £5/head.

Shropshire Ento Day is now firmly established in the calendars of the local biological recording community with attendees coming from all over the West Midlands and, very often, much further afield. The last event saw approximately 70 people attend – maximum capacity for the venue.

9 Legacy & Recommendations

Over the course of the Tomorrow's Biodiversity project we have engaged with thousands of people, providing training in identification, survey and analytical skills to many hundreds of them.

Furthermore, we have developed and published tools and resources used by countless biological recorders in the UK and, in the case of the QGIS plugin, all over the world. The legacy of this depth of contact and influence is not measurable, but the report includes quotes from a few individuals that gives an inkling of it.

9.1 Legacy & recommendations: joined-up training provision

From the Field Studies Council's viewpoint, particularly within the Biodiversity Team, there are some clear lessons to take forward. Perhaps most significant in this respect, on the training side, have been the lessons and experience gained from the spider exemplar project. This approach to the provision of natural history training is very different to the way FSC and other providers have traditionally provided natural history training (with the exception of modules associated with larger programmes like the FSC/MMU Biological Recording post-graduate training). The usual approach to natural history training is to ask first 'what will put bums on seats'? There's nothing intrinsically wrong with that – a great deal of very useful training has been, and still is, provided in this way. First and foremost, courses must be viable, financially and otherwise, or else there will be no training provision at all! However, it is time to start thinking about training in a more joined up way, especially in terms of how individuals can progress through a series of courses, advancing their learning as they do so. The spider project was a great pilot of this idea and the concept and practice of developing integrated suites of training with paths for progression has been further developed as part of the FSC BioLinks project. Keiron Brown, FSC BioLinks Project Manager, puts it thus:



“In 2017 the Field Studies Council secured a £1.2 million grant from the Heritage Lottery Fund towards a 5 year project FSC BioLinks. The work of the Tomorrow's Biodiversity project was instrumental in designing the project plan and strongly influenced the direction the project will take. FSC BioLinks will build upon the structured training programme trialled by Tomorrow's Biodiversity for spiders. This will involve using the spider training structure as a template for the 8 focus species groups that FSC BioLinks will cover, delivering courses over 5 years and producing toolkit for developing structured species identification training programmes and sharing this with the biodiversity sector.”

We hope and expect that BioLinks will help spread the lessons we learned in the spider project, not just within FSC, but into training provided by the wider natural history community in the UK. BioLinks will run training courses and work with other training providers to develop these ideas even more over the next five years.

Our recommendations on providing joined-up natural history training are:

- Look beyond the immediate (and necessary) goal of filling courses; where do participants go next to progress? How could they be better prepared to benefit from your current provision?
- Consider what you can do to facilitate learning after (and possibly before) your courses.
- Consider where your training provision sits within the wider context of available training, both within and without your organisation and both locally and nationally.
- Don't take the process of making biological records for granted; often people leave ID courses with increased skills in biological identification, but little idea of how to make records, or who to connect with in order to do so.
- Make contact with the new five-year FSC BioLinks project; there are already outputs, ideas and tools from the BioLinks project that can help you (regardless of whether or not you are in one of the geographic hub areas or teaching one of the focus taxonomic groups of that project).

9.2 Legacy & recommendations: stronger partnerships

A common thread runs through many of Tomorrow's Biodiversity's most successful exemplar projects and other ventures; that of healthy and dynamic partnerships. Our partnerships with the Earthworm Society of Britain (ESB), Shropshire Spider Group (SSG) and the National Plant Monitoring Scheme (NPMS) were key to the success of several Tomorrow's Biodiversity exemplar projects. We hope that the continuation of these partnerships – either through the BioLinks project or via other channels – will be part of Tomorrow's Biodiversity's legacy to the recorders they serve and to FSC itself.

The best natural history training requires the conjunction of many elements which can include any of the following:



- A course leader (or leaders) that possess both the requisite taxonomic expertise *and* the ability to teach well.
- A well thought-through teaching plan.
- Accessible and inspiring field sites.
- Transport to field sites (where necessary).
- A comfortable and well-equipped classroom.
- Accessible refreshment facilities and toilets.
- Well-run accommodation and catering facilities staffed by hospitality specialists (for residential courses).
- After-course learning support.
- Marketing to ensure that the course attracts enough participants.
- Administration to handle bookings and, if necessary, payment.
- The necessary attention to health & safety.
- Liability insurance where necessary.

The list could be even longer. Good intentions are never enough on their own and it is rare that a single organisation, much less a single person, can provide all these different elements. That's not to say that natural history training which doesn't provide most of the above is without merit, but it *could* be so much better. Partnerships where each partner adds to the sum of these elements are mutually beneficial, more successful and stronger.

As a large environmental education charity with a national network of field centres, FSC can provide many of the elements in the list above, but not even the FSC can always supply them all. A well-established model for the provision of natural history training that FSC has used successfully for many years is that of building partnerships with Associate Tutors. Typically, Associate Tutors bring taxonomic expertise as well as teachings plans and, frequently, after-course support. But this is only one possible model and the partnership models we explored during Tomorrow's Biodiversity were all different from this and from each other.

Our partnerships with ESB, SSG and NPMS did have something common however: they all considered training provision within the wider context of what each organisation and the FSC is trying to achieve. They were never just about getting 'bums on seats', they were about moving participants of courses forward in their development and providing ongoing support and future opportunities to consolidate and advance their learning and to put it to use as biological recorders. Each of the partnerships had a very strong focus on facilitating the development of *active biological recorders* and in this they all met with considerable success. This is also true of the informal partnerships we worked very hard to build with local recording communities through activities such as our Open Lab Days, Shropshire Ento Day, the Shropshire Springtail Atlas and our support for external events organised and run by our local recording community.

Keiron Brown, FSC BioLinks Project Manager, said of Tomorrow's Biodiversity partnership working:



“Many of the relationships developed during Tomorrow’s Biodiversity have provided a legacy that FSC BioLinks will use to hit the ground running. This includes both organisational relationships (such as the Earthworm Society of Britain and Shropshire Spider Group) and individuals (as many of the participants of Tom.Bio contributed to the consultation phase of FSC BioLinks and have indicated their enthusiasm for participation in the project). Finally, both members of the Tom.Bio team successfully achieved full time positions on the FSC BioLinks project team and will provide continuity by helping the FSC to transition smoothly from one project to the next.”

Training providers should reflect on both successes and failures and, where necessary, adapt their provision by exploring new partnerships. After the initial success of our Introduction to Biological Recording course at FSC Preston Montford, we struggled attract people to subsequent courses and, indeed, we had to cancel one. On reflection we decided to boost the appeal of the rescheduled course by using a truly outstanding location that capitalised on the current interest in rewilding – namely the Knepp Estate in Sussex. This course was a success and has opened the possibility of future partnership working with Knepp. The important lesson here is that we were not dogmatic; even though FSC is best-known for hosting courses at its own inspiring locations, we considered that Knepp could give us extra ingredient we needed in this instance. So we pretty much flipped our normal partnership model; we relied on Knepp to provide classroom, field locations, accommodation etc, whilst we provided the biological recording and teaching expertise.

Our recommendations on partnership working for natural history training providers are:

- Critically examine your own provision (and that of any existing partnerships) in light of the list of elements above (or a similar list of your own creation) and see what’s missing.
- Explore the possibility of working with partners who can supply some of the missing elements.
- Favour partnerships where each partner adds to the sum of elements.
- Favour partnerships where all partners benefit from each other’s involvement.
- Favour working with partners who are imaginative and creative and think beyond the limits of their own immediate requirements.
- Don’t be dogmatic; don’t let the fact that you’ve always done it a certain way blind you to new opportunities.

9.3 Legacy & recommendations: specialist invertebrate courses

A legacy of Tomorrow’s Biodiversity is the enrichment of FSC’s natural history portfolio with a set of stronger and more sustainable specialist invertebrate courses. During the project we ran or facilitated invertebrate ID courses covering a wide range of taxa, including spiders, harvestmen, pseudoscorpions, earthworms, springtails, soil mites, aculeate hymenoptera, centipedes, millipedes, moths and blowflies. Some of these courses, e.g. centipedes & millipedes, were run under the traditional FSC Associate Tutor model and will continue to do so after Tomorrow’s Biodiversity ends.



We developed and ran other courses under new partnership models, e.g. arachnids (spiders, harvestmen & pseudoscorpions) with the Shropshire Spider Group and earthworms with the Earthworm Society of Britain (see elsewhere in this report), and these FSC partnerships will continue beyond Tomorrow's Biodiversity (e.g. through the BioLinks project).

But in this section we consider a set of specialist invertebrate ID courses which present particular difficulties for FSC as a training provider, especially in terms of financing and hosting:

- The Soil Mesofauna course (incorporating springtail and soil mite ID).
- The Moth Dissection course (for the ID of cryptic taxa).
- Ultra-long format aculeate ID courses (Solitary Bees and Solitary Wasp courses).

These courses all have several things in common:

- All require the provision of specialist equipment including high-quality microscopes.
- All are demanding courses, which include learning new practical skills, requiring a high level of one-to-one teaching.
- Teaching costs for these highly specialist courses are considerable.
- All are residential.

A significant consequence of these factors, particular the first two, is that capacity is capped at a low number: 10 for the Soil Mesofauna course, 8 for the aculeate courses and just 6 for the Moth Dissection course. Although the Soil Mesofauna course has the luxury of three tutors (so teaching ratios aren't such a problem) the limiting factor here is space and equipment. Each participant on this course requires both a dissection microscope and a good-quality compound microscope, plus lighting for both and plenty of desk space for equipment. The aculeate course numbers are limited both by the availability of equipment (high quality dissection microscopes & lighting) and the requirement for a high teacher/student ratio. Numbers on the Moth Dissection course are limited by the need for a high teacher/student ratio.

Capping numbers at such low levels, particularly for residential courses where accommodation and catering must be provided, can be problematic for FSC. The problem is exacerbated where tutor costs are high as they can be for specialist courses, particularly those for longer duration courses or where multiple tutors are required.

The biggest overheads for running residential courses are tutor fees & expenses and the costs associated with staffing for the provision of accommodation, catering etc. Importantly, these costs are similar regardless of the numbers of course attendees and it is the income from course fees which help to cover them. Therefore, it is *much* harder to make low-attendance courses cover their costs. It should also be noted that a course which just manages to cover its own immediate costs does nothing to sustain the future of the hosting organisation – in this case the FSC – on which the future of such courses depends. (The true cost of any course that depends on the infrastructure of an organisation like the FSC is greater than the immediate running costs of the course.)

Organisations that host residential courses, including the FSC, are familiar with these problems and ways of mitigating them, for example by scheduling courses to run at the same time at centres, thus dividing the overheads between them. It is important that all partners concerned with running



courses of these kinds are fully cognisant of the difficulties and correspondingly flexible in terms of the hosting arrangement to maximise the likelihood of the course covering its costs.

To mitigate the financial problems, Tomorrow's Biodiversity provided financial support (to the hosting FSC centres) for all the courses mentioned here, particularly in the early part of the delivery phase and when the courses were first becoming established. We normally did this in the form of a course fee subsidy, reducing the costs to participants and making up the difference with the hosting centre. However, in all cases, as the courses have become established, we have reduced the subsidies and increased the costs to participants to a level where the courses can realistically begin to cover their own costs. This has been possible because as the courses have become established and *their reputations have grown*, they have become able to carry a realistic course fee and still fill the available places. The 'seed funding' from Tomorrow's Biodiversity has allowed these courses the space and time to establish their reputations.

A key factor in growing the reputations of these courses – which all three had in common – is that the tutors actively marketed the courses using their own network of contacts, alongside the marketing efforts of the FSC and the Tomorrow's Biodiversity project. This is critical; marketing natural history courses is notoriously difficult, and specialist courses, by definition, have a narrower potential audience than most. But there is no doubt that tutors who actively market their own courses and 'build a following' invariably run better attended courses than those who rely solely on others, e.g. the hosting organisation, to do all the marketing.

Provision of equipment, particularly high-quality microscopes and associated lighting, can also be problematic. This has been an issue for the Soil Mesofauna course and the aculeate courses. We managed this problem during Tomorrow's Biodiversity by careful planning and flexibility when sourcing microscopes. For example, the tutor of the aculeate courses (Ian Cheeseborough) collected and transported microscopes from one FSC centre to another and for the Soil Mesofauna course the lead tutor (Matthew Shepherd of Natural England) supplies around half of the required microscopes by bringing Natural England kit with him to the course. Tomorrow's Biodiversity also purchased a number of microscopes to use on these courses. The key to making this work is careful planning and plenty of communication between the course hosts (e.g. a field centre), facilitators (e.g. Tomorrow's Biodiversity staff) and course tutors, well-before the course runs.



Our recommendations to partners involved in staging residential specialist invertebrate courses like those described here are:

- To be sustainable, partnerships must plan courses that will cover their costs at the very least.
- If project (or other) funding is available, consider subsidising course fees whilst the course is becoming established, but *aim to increase the fees* over time to a level where the course can realistically cover its own costs.
- Flexibility of all partners is vital for hosting partners to mitigate overheads.
- *All* members of partnerships should play an active role in marketing courses; the efforts of course tutors appear to have an extremely significant impact.
- Sufficient well-maintained specialist equipment, such as microscopes, can be hard to source; careful planning and communication between partners, may be required to secure the necessary equipment from several sources.
- Consider asking course participants to bring their own microscopes if they have them.

9.4 Legacy & recommendations: the TomBio ID Framework

We made substantial progress with the TomBio ID Framework, particularly over the last two years of the project, culminating in the release of the framework as a public open-source project and the publication of a new ID resource – Harvestmen of Britain and Ireland. The open source project is published on the GitHub repository and is itself a legacy of the Tomorrow's Biodiversity, but it is *not* 'legacy' in the software sense of that word – it is very much an ongoing developing project, thanks to continued support from Esmée Fairbairn who have funded development for another year in 2018.

The Esmée Fairbairn continuation funding in 2018 will enable us to create ID tools for the framework, married to new knowledge-bases, that are responsive to small format devices (useable in the field) and to develop a strong community of framework users actively engaged in the creation of new ID resources. We will be continuing to roll-out the one-day ID Framework knowledge-base creation workshops that we initiated during the Tomorrow's Biodiversity project. These workshops will likely be completely free to participants and hosting organisations.

Support for the ID Framework beyond 2018 will come through the BioLinks project. Keiron Brown, FSC BioLinks Project Manager, said of Tomorrow's Biodiversity digital work (including the ID Framework):

"The FSC BioLinks project will also take many aspects of the Tomorrow's Biodiversity digital work and continue to develop and expand these to benefit the biodiversity sector and volunteer biological recorders. The Tomorrow's Biodiversity project demonstrated to the FSC that digital work should be a core component of future biodiversity work and lead to the inclusion of a Digital Development Officer role being incorporated into the project plan for the full duration of the project."



Part of the legacy of the Tomorrow's Biodiversity ID Framework is simply a renewed awareness and interest in new ID resources, including multi-access keys, from within the biological recording community (even amongst many not actively engaging with the framework itself).

Our recommendations to those who want to stay in touch with developments in the ID Framework project are:

- Sign-up for the ID Framework MailChimp newsletter:
<http://www.tombio.uk/framework-signup>
- If you are aware of a number of people who are interested in exploring the idea of creating ID resources, contact us (see below) to talk about the possibility of organising a free one-day workshop.
- Explore the online tutorials: <http://www.tombio.uk/framework>
- Explore the Harvestman of Britain and Ireland resource: <http://harvestmen.tombio.uk/>
- If you have created ID resources using the ID Framework, but do not have access to a website to deploy them, contact us (see below), we are likely to be able to host them.
- If you have an idea for an ID resource and just want to talk it over, contact us (see below).
- Contact Rich Burkmar by email: richardb@field-studies-council.org

9.5 Legacy & recommendations: TomBio QGIS Plugin

The TomBio QGIS plugin is itself part of Tomorrow's Biodiversity's legacy since it is still out there as a publicly available plugin for QGIS and can still be downloaded and used within QGIS. Like the ID Framework, it will continue to be developed after the end of the Tomorrow's Biodiversity project, partly because it is a publicly available open-source project but also thanks to ongoing support from the FSC BioLinks project.

A new major version of QGIS – version 3 – is soon to be released (due end of February 2018). Most of what users of QGIS see will remain similar between version 2 and version 3. However there have been dramatic changes to QGIS *under the hood*, which affects developers of plugins like the TomBio QGIS Plugin. Plugins written for version 2 of QGIS (like the TomBio QGIS Plugin) will not work under version 3 until they are migrated by the developers.

It is likely that for some time after the initial release of version 3, many plugins that work on version 2 will not be available on version 3 whilst plugin developers catch up with the changes. During this transition period most serious QGIS users will run two versions on their computers – version 2 *and* version 3. Data can easily be swapped between them. However, in the interests of the long-term use and development of the TomBio QGIS Plugin, it will need to be migrated to version 3 of QGIS. Ongoing support for the TomBio QGIS Plugin through the BioLinks project will enable us to do that. We hope to have a QGIS version 3 compatible version of the TomBio QGIS Plugin available no later than the end of April 2018.

FSC will retain its interest in teaching QGIS skills to ecologists and biological recorders. The residential course which runs each February at FSC Preston Montford, in association with



Manchester Metropolitan University, will continue to run. Our partnership with Associate Tutor Matt Davies will also continue – he already has two residential courses planned at FSC centres in 2018.

Our recommendations to those who want to engage with FSC's QGIS training provision and developments with the TomBio QGIS Plugin:

- To keep abreast of what FSC QGIS courses are on offer, go to this site and search on the keyword 'QGIS': <http://www.field-studies-council.org/individuals-and-families/search-for-courses.aspx>
- To keep up to date with developments with the TomBio QGIS Plugin, check here for a 'current status' report: <https://github.com/burkmarr/QGIS-Biological-Recording-Tools/blob/master/README.md>
- Sign-up for the BioLink MailChimp newsletter: <http://www.tombio.uk/biolinks-signup>
- To report problems with, or ask for new features for, the TomBio QGIS Plugin either raise and issue here: <https://github.com/burkmarr/QGIS-Biological-Recording-Tools/issues> (preferred) or email us: richardb@field-studies-council.org
- If you have training or consultancy requirements that are not met by 'off the shelf' courses, contact Matt Davies: <http://www.maplango.com/>

9.6 Legacy & recommendations: digital communications strategy

The Tomorrow's Biodiversity website will continue under the current URL – www.tombio.uk – for at least another year (i.e. all of 2018). What happens after that will depend on decisions made during the early part of the BioLinks project, but we plan to ensure that all useful content and outputs from Tomorrow's Biodiversity (e.g. blogs, ID Signpost, visualisations etc) continue to be hosted and available beyond 2018.

What happens with our Twitter and Facebook Social Media accounts will again depend on the early development of the BioLinks project, but these accounts are unlikely to be very active beyond the end of the project. The YouTube channel (FSC Tomorrow's Biodiversity) hosts a great many video resources that will continue to be useful way beyond the end of the project, so this will be maintained.

We learned a lot about digital communications over the course of the Tomorrow's Biodiversity project and whilst we still have a lot to learn (and always will in such a rapidly changing environment) we can provide some recommendations to natural history projects or societies that wish to increase their reach and/or improve communications through digital media.



Our recommendations to natural history projects or societies that wish to increase their reach and/or improve communications through digital media:

- Keep website content, particularly the homepage, dynamic and fresh.
- A good way of providing regular fresh content (which can also feature on the homepage) is by blogging.
- Short frequent blogs may be better than longer infrequent ones (though don't shy away from longer blogs if you've something important to say).
- Invite guest blogs from project/group partners.
- Consider scheduling regular blog posts and do your utmost to stick to it.
- The most popular blogs are those which impart some practical knowhow or provide useful resources.
- A good strategy is to refer to website content, e.g. blogs, from social media posts.
- Videos proved to be an extremely effective way of reaching a wide audience.
- An effective strategy is to host videos on a YouTube channel, linking to them from your website, and embedding the more important YouTube videos in pages on your website.
- Carefully select which social media tools to engage with, and understand the reasons for your selection, but be prepared to change strategy in light of new knowledge, trends and the changing landscape of social media.
- Don't spread yourself too thinly over social media.
- Consider setting targets for regular engagement through your social media channels.
- Remember that inactive social media channels reflect badly on a project or organisation.

9.7 Legacy & recommendations: final words...

Tomorrow's Biodiversity has been a great success: it has opened new environmental education opportunities for FSC, e.g. QGIS training, 'learn to love' courses, specialist invertebrate courses, new partnerships and new ways of doing natural history training, as well as re-establishing FSC as an innovator of new biological identification technologies.

We have talked about a lot of partnerships throughout this document, but we have barely mentioned the one which has, above all others, been key to the success of Tomorrow's Biodiversity: that between the Field Studies Council and the Esmée Fairbairn Foundation. Right from the outset, Esmée has been an exceptionally imaginative, flexible and trusting partner. Funding a two-year research and consultation phase before a three-year delivery phase was a unique and bold move enabling us to deliver a relevant and imaginative project. Throughout the project, our relationship with Esmée has empowered us to steer the project in a way which has responded to our evolving ideas and experience to provide maximum value. The Esmée Fairbairn Foundation deserve a great deal of credit for the success of Tomorrow's Biodiversity.



Based on our successful partnership with Esmée Fairbairn, these are our recommendations to funders of long-duration (3 or more years) natural history and biodiversity projects who wish to maximise their success, impact and value:

- Develop a relationship, from the start, based *more* on trust and broad objectives and *less* on tightly defined and restrictive targets.
- Consider allowing time and space within the project, either at the start or perhaps in the middle, for reflection and adjusting of goals.
- Consider flexibility a strength, not a weakness.
- Use an open project reporting structure that is based *more* on communicating real successes & failures and discussing responses to these and *less* on ticking boxes.
- Place *more* emphasis on linking to, and building on, work that has come before and that which will follow after and *less* on eye-catching novelty.

We leave the last words in this report to the head of the Biodiversity Team at FSC, Sue Townsend, who has seen many projects come and go and has the sometimes unenviable task of ensuring that they form a coherent whole, informing and developing the wider biodiversity work of FSC.

“Tomorrow’s Biodiversity has increased the FSC strategic thinking in how best to engage further with the natural history community. There were some very strong messages on how important we are as network of connected field centres delivering support and encouragement through equipment, facilities and locations for discussion groups, workshops and courses. It also highlighted areas where we need to build more resilience though embracing more on-line learning, creating more digital solutions and maintaining the standards and reputations through our lab and equipment provision and staff awareness of the wider issues in the biodiversity sector.”

10 Acknowledgements

It would be impossible individually thank all the members of the UK Biological Recording and Natural History community who contributed to the success of Tomorrow’s Biodiversity – the total number must be well into 4 figures and includes:

- the people (and the schemes and societies they represented) who attended the consultation workshops;
- those who gave us one-to-one meetings or telephone conversations as part of the consultation;
- the schemes and societies that supported our training courses;
- the Associate Tutors and other experts who contributed their expertise to the training courses;
- those who participated in our training courses, workshops, lab days and other events; and



- those supported our project promotion by sharing, retweeting or linking to our digital communications.

Our thanks to all these people for being a key part of the success of Tomorrow's Biodiversity.

Elsewhere in this document we have described our admiration for the way Tomorrow's Biodiversity's funder, Esmée Fairbairn, partnered us on this project. None of it would have been possible without them.

Finally, we wish to express our deep gratitude to colleagues at the Field Studies Council who have played a vital part in the success of this project. Chief amongst these are head of the Biodiversity Team, Sue Townsend, for her loyalty, expertise, unwavering support and 'can do' attitude, and our Grants Officer Jennie Comerford who was instrumental in building and maintaining our partnership with Esmée Fairbairn. Without the support of a dedicated grants officer, it is unlikely that FSC would be so involved in the kind of natural history project work described in this report. Our sincerest thanks go to the Heads of Centres and all the learning centre staff who helped host our events (a special thanks to those at Preston Montford who have effectively been part of our team) and all our colleagues at FSC Head Office, including Marketing, Digital, Finance, HR, Front Office and the rest, who have gone out of their way to support our sometimes slightly different way of doing things!

11 Appendices

11.1 Appendix A: Advertisement for Learn to Love Spiders



FSC Preston Montford, Shrewsbury on Wednesday 29th April 2015

If you're interested in spiders but never felt ready for a beginner's *ID workshop*, then this day is for you!

It's a day for people who are fascinated by spiders but don't know where to start with them. It's a very gentle introduction to the world of spiders and the art telling one spider from another.

- Come and see different types of live British spiders
- Learn some of their names
- Learn how to tell a few of them apart
- Listen to some fascinating talks by local spider experts
- Find out what to do if you want to take your interest further



The day is free and places are limited, so book soon to avoid disappointment (please don't book unless you are *sure* that you will come). We will start at 10 am and finish at 3 pm. Bring your own packed lunch.

If you would like to come on the workshop, please send an email to Rich Burkmar: richardb@field-studies-council.org



A **Shropshire Spider Group** event supported by FSC Tomorrow's Biodiversity

Field Studies Council is a limited company (No.412621) and a charity (No.313364) registered in England and Wales and a charity registered in Scotland (SC039870).
Registered Office: Head Office, Preston Montford, Montford Bridge, Shrewsbury, Shropshire, SY4 1HW



11.2 Appendix B: engagement with the ID Framework

Who	What	URL	TomBio website link	Notes
Rich Burkmar & Paul Richards	Harvestmen of Britain & Ireland website	http://harvestmen.tombio.uk	Visualise > ID Visualisations > Harvestmen of Britain & Ireland	Rich Burkmar wrote the knowledge-base using much of Paul Richards material. Paul Richards supplied all the photographs.
Rich Burkmar & Emma Sherlock	UK Earthworms page on ESB website	http://www.earthwormsoc.org.uk/fullscreen/earthwormkey	Visualise > ID Visualisations > UK earthworms	Rich Burkmar derived the knowledge-base from Emma Sherlock's key.
Rich Burkmar & Nigel Cane-Honeysett	Linyphiid visualisation of Roberts' tables page on TomBio	http://www.tombio.uk/liny	Visualise > ID Visualisations > UK Linyphiids	Rich Burkmar created a knowledge-base from a spreadsheet created by Nigel Cane-Honeysett which itself was derived from tables published by Michael Roberts.
Paul Palmer	Spring moths knowledge-base and visualisation	https://kb-moths.tech-trends.co.uk/index.html	Not linked to from our website	Paul Palmer is a keen naturalist and a technologist. He established the knowledge-based and set up the website to run the framework with very little help. Paul has also contributed source code to the project.
Malcolm Greaves	<i>Scutellinia</i> fungi KB and visualisation	http://myfg.org.uk/tombiovis/tombiovis-1.3.2/scutellinia.html	Not linked to from our website	Malcolm produced this KB which he subsequently published on Mid Yorkshire Fungus Group website in August 2017.
Malcolm Greaves	Geoglossum (earthtongue) fungi KB	Not yet available	N/A	Malcom was in touch to say that he was working on this in early September.
Matt Parratt & Rich Burkmar	UK conifers (not in CMS)	http://www.tombio.uk/sites/vis-conifers.html	None (privately shared with Matt Parratt)	Ongoing work on knowledge-base by Matt Parratt. We expect this to become a major new resource.
Judith Allinson, Richard Pankhurst and Rich Burkmar	Vegetative key to grasses page on TomBio website	http://www.tombio.uk/sites/vis-punched.html	Visualise > ID Visualisations > Punched-card grasses key	This is a straight conversion from the original punched-card key produced by FSC in 1985. We are in communication with Judith about taking this forward to a new version. Has significant potential as a new resource.



Charlie Bell	KB on UK Springtails	Not yet available	N/A	Charlie is building a knowledge-base designed to be used alongside Hopkins key. Major potential for a new resource.
Sally Hyslop & Rich Burkmar	Groups of UK grasses page on TomBio	http://www.tombio.uk/grassesv1	Visualise > ID Visualisations > Groups of UK Grasses	Not using tombiovis (pre-dated the framework). Sarah Hyslop wrote the knowledge-base with support from Rich Burkmar.
Dave Earl & Rich Burkmar	KB on microspecies of bramble	http://www.tombio.uk/rubusvis	None (privately shared with Dave Earl)	Work is ongoing. Dave works on this mainly in the winter and sends updates to the KB to us. The knowledge-base is Dave's work.
Graham Wenmann	KB on larval stages of UK micromoths	None as yet	N/A	Graham has been working on this since early in 2017 in a development environment set up on his computer.
Martin Harvey & Rich Burkmar	Soldier Beetles	http://www.tombio.uk/soldierbeetles	None (privately shared with Martin Harvey)	Worked with Martin Harvey on a test project. This predates the framework does not use tombiovis.
Nick Stewart, Claudia Furguson-Smyth & Rich Burkmar	British and Irish Stoneworts	http://www.tombio.uk/chara-world	None (privately shared with Nick Stewart and Claudia Furguson-Smyth)	Worked on this to demonstrate to Nick Stewart and Claudia Furguson-Smyth.
David Hill	British Ferns	None as yet	N/A	Paid David is working on a knowledge-base for British Ferns.
Dave Slade	British Pug moths	http://www.tombio.uk/pugsvis	None (privately shared with Dave Slade)	Dave Slade developed the knowlege-base on and we hosted it.
Dave Slade	British Phyllonorycter moths	http://www.tombio.uk/micro1vis	None (privately shared with Dave Slade)	Dave Slade developed the knowlege-base on and we hosted it.
Michael Haft	Groups of freshwater animals	http://www.tombio.uk/invertsfa	None (privately shared with FBA)	We converted a spreadsheet supplied to us by FBA as a proof of concept.
Michael Haft	Stonefly larvae	http://www.tombio.uk/stonefliesfa	None (privately shared with FBA)	We converted a spreadsheet supplied to us by FBA as a proof of concept.

11.3 Appendix C: Description of the TomBio QGIS Plugin tools

The Tom.bio plugin for QGIS is designed to address two things to make working with biological records in QGIS much easier for UK users:

- Dealing with Ordnance Survey grid references.
- Dealing with data structured as biological records (who, what, where & when).

There are four main tools:

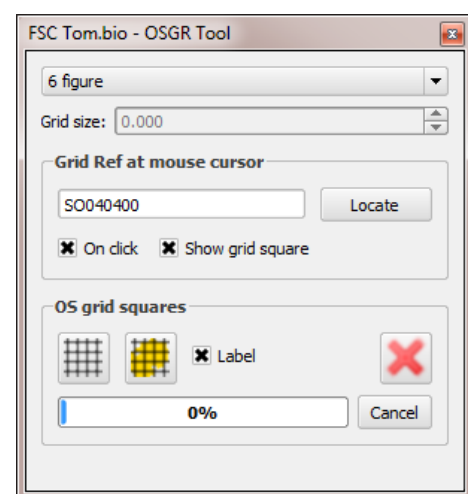
- The OSGR ToolTom.bio OSGR Tool
- The Biological Records ToolTom.bio Biological Records Tool
- The NBN ToolTom.bio NBN Tool
- The Map Mashup ToolTom.bio Map Mashup Tool



11.3.1 The OSGR Tool

QGIS is international in scope and not specifically geared up for the UK context. Although it handles the British-specific projections very well, it does not handle the unique OS grid referencing system that we have in the UK. This means that although it understands eastings and northings perfectly well, e.g. the location of the FSC Preston Montford bar which is easting 343292 and northing 314369, it doesn't understand the equivalent 10 figure grid reference, which is SJ4329214369.

But biological recorders and GIS users operating in the UK frequently need to deal with OS grid references, e.g. to centre a map on a given grid reference or to find the grid reference at a certain point and creating grids corresponding to OS grid squares. The QSGR Tool provides these functions to QGIS users.

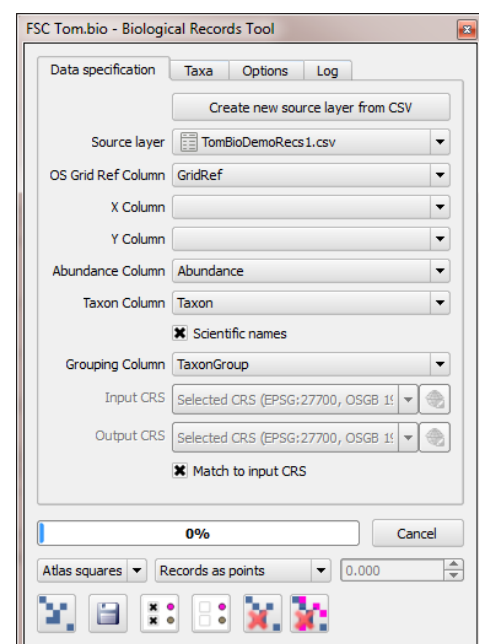


The other function of this tool is to generate grids aligned to the British National Grid at any specified precision. Grids can be created by dragging a box over the area of interest or by selecting a polygon which will act as a geographic filter for the grid (i.e. only generating squares that overlap the polygon).

11.3.2 The biological Records Tool

The Biological Records Tool reads spreadsheets of biological records and maps them in QGIS, either as points for individual records, or by aggregating records by OS grid squares. The aggregating feature can also be used on an existing point layer rather than a spreadsheet of records.

Records can be aggregated by grid square to create 'atlas' type maps. You can select any of the following aggregation levels from the aggregation drop-down:



- 10 m squares (8-figure grid ref)
- 100 m squares (6-figure grid ref)
- 1 km squares (monad grid ref)
- 2 km squares (tetrad grid ref)
- 5 km squares (quadrant grid ref)
- 10 km squares (hectad grid ref)

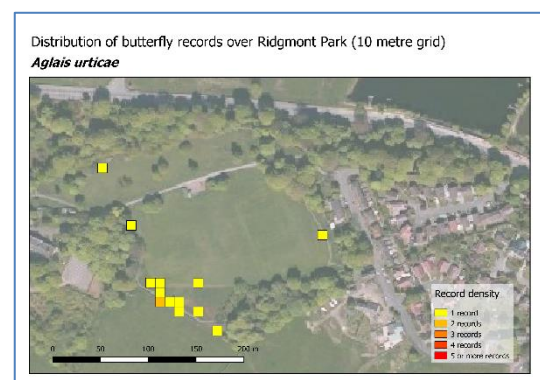
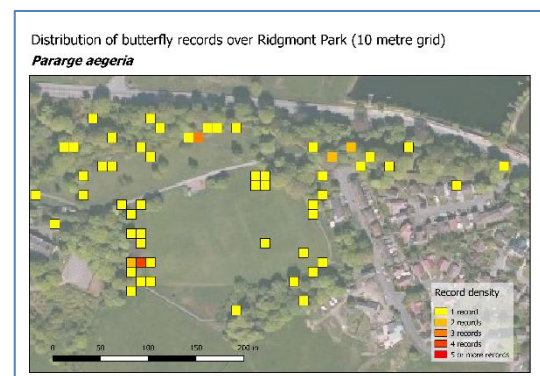
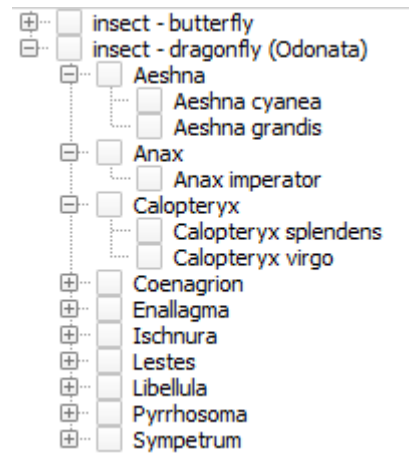
Non-standard grid sizes (e.g. 250 metres) can also be specified if required.

Specifying which column in a spreadsheet contains the names of taxa, instructs the tool to create a selectable list of taxa that appear in the spreadsheet and the user can then indicate which taxa to use to generate map layers. The tool can be used in batch mode so, for example, it can be instructed to create a separate map layer for each taxon – making it possible to create many, even hundreds, of map layers at the click of a button

A QGIS 'style file' can be specified and automatically applied to map layers as the tool creates them.

The Biological Records Tool gives you several ways of persisting the data in these temporary (memory) layers. You can create images, shapefiles or composer images for example. The full range is described below:

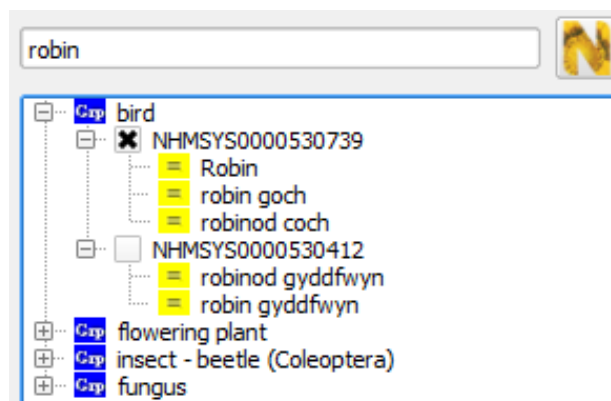
- **Image.** Option to generate a series of image files – one for temporary layer generated by the tool – each showing all displayed background layers (i.e. all open layers except those generated by the tool) and just one layer generated by the tool. The images are generated directly from the QGIS map view.
- **Shapefile.** Option to generate a permanent shapefile for each temporary layer generated by the tool.
- **GeoJSON.** Option to generate a permanent GeoJSON file for each temporary layer generated by the tool (good for display on websites).
- **Composer image.** Option to generate a series of image files – one for temporary layer generated by the tool – each showing all displayed background layers (i.e. all open layers except those generated by the tool) and just one layer generated by the tool. The image files are generated from a map composer.
- **Composer PDF.** Same as the previous option except that instead of producing image files, it produces PDFs.



11.3.3 The NBN Tool

The NBN Tool provides an interface from within QGIS to the NBN Gateway *via* the official NBN web services. It enables the incorporation of grid maps from the NBN as QGIS layers so that they can be used alongside the user's other data layers. It also provides a handy interface for downloading raw data from the NBN.

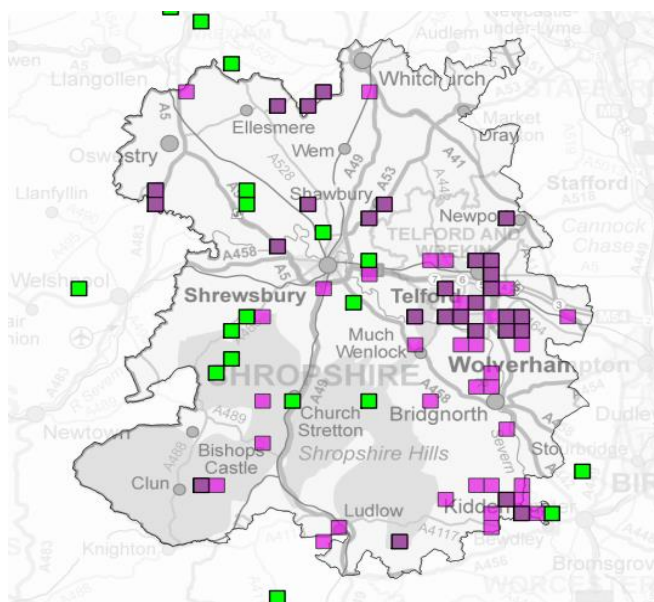
The simplest use of the NBN Tool is to add a layer to the map view showing a grid map for a particular species from the NBN Gateway. The data from the NBN are provided via a Web Mapping Service (WMS) – the NBN tool provides a short-hand method for specifying calls to the NBN WMS.



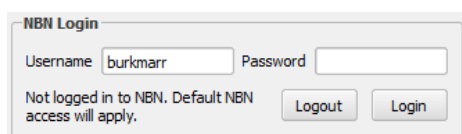
To download a grid map layer from the NBN for a taxon, the user first searches for the taxon for which the tool uses the NBN's 'taxon dictionary' web service. Then, by selecting the NBN key for the relevant species, the grid map layers can be displayed.

The tool facilitates the use of any filters provided by the NBN web services including polygon, grid reference, site, designation etc.

The second major feature of this tool is the facility to download raw records from the NBN based on a range of selection criteria (filters) and then create map layers from the raw data. To use the download feature you must be logged into the NBN.

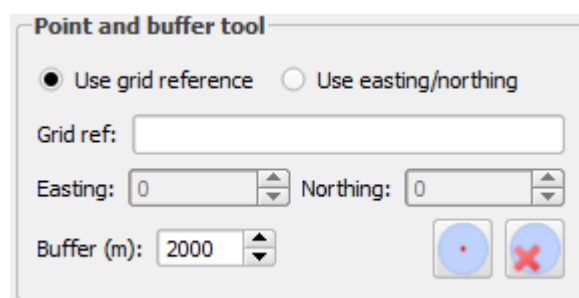


Distribution of the Nursery Web Spider (*Pisaura mirabilis*) in Shropshire at tetrad level. Green squares show a grid layer from the NBN and pink squares are generated from a local



The screenshot shows the NBN Login form with fields for Username (burkmarr) and Password. Below the fields, it says 'Not logged in to NBN. Default NBN access will apply.' and there are 'Logout' and 'Login' buttons.

The NBN Tool also provides a point and buffer facility. The primary purpose of this is to enable creation of a circle polygon to use as a geographic filter when downloading data. It generates a circle based on a centre point (specified by a grid reference or easting northing) and a buffer distance specified in metres. The polygon is created in a temporary layer but this can be saved to a permanent layer if desired and used for any other purpose.



The screenshot shows the 'Point and buffer tool' interface. It has two radio buttons: 'Use grid reference' (selected) and 'Use easting/northing'. Below these are input fields for 'Grid ref:', 'Easting: 0', and 'Northing: 0'. There is also a 'Buffer (m): 2000' field. At the bottom right, there are two circular buttons with a red dot and a red 'X'.

11.3.4 The Map Mashup Tool

There are a great many maps on the internet. They often show information that we would like to use as context to view biological records or other information within our GIS. Very often this is not possible – the raw data are not downloadable. However, raster images of maps from websites can sometimes be captured and registered in QGIS with a bit of effort and so long as we are using such maps in QGIS for our own learning and not contravening any copyright, this is okay.

Websites that produce many maps, all showing the same part of the earth and with the same projection, are amenable to being used with the Map Mashup Tool. This takes advantage of the fact that once a world file (i.e. raster registration file) is created for one such map – it can be used with any others covering the same area with the same projection.

For example, to grab a map from the BTO Map Store, you only copy it into the computer's buffer from the website and then click the 'paste from clipboard' button in the Map Mashup tool and the image will be georeferenced according to the world file and displayed as a raster layer in the GIS.

The image shows a distribution map of breeding skylark from the NBN map store, displayed in QGIS alongside vector data from the British Geological Survey showing the distribution of limestone and also the UK boundary.

