Burren Invertebrate Conference

9-11 August 2022

Conference Report

Áine O Connor and Brian Nelson

Front cover photograph: Burren Green *Calamia tridens*, **Brian Nelson**

Citation: O Connor, Á. and Nelson, B. (2022) Burren Invertebrate Conference, 9-11 August 2022, Conference Report. National Parks and Wildlife Service, DHLGH, Dublin.

An Roinn Tithíochta,
Rialtais Áitiúil agus Oidhreachta
Department of Housing,
Local Government and Heritage

An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service

Contents

1 The event

The Burren Invertebrate Conference took place over three sunny days in August 2022. It comprised talk sessions on the mornings of Tuesday 9 and Wednesday 10 August, and field outings on both afternoons and on Thursday 11 August. The talk sessions were hybrid, presented to attending delegates at the excellent Michael Cusack Centre, Carron (http://michaelcusack.ie/) and were also available online. A report on each talk is provided in Appendix I. Recordings of the talks are accessible at https://www.npws.ie/research-projects/animal-species/invertebrates.

Participants at the Burren Invertebrate Conference, Day 2 Field Trip. *Photo Áine O Connor*

2 The organisers and facilitators

The Burren Invertebrate Conference was organised by the National Parks and Wildlife Service of the Department of Housing, Local Government and Heritage. The organising committee comprised the following staff of the Burren National Park and the Scientific Unit: Helen Carty, Emma Glanville, Maria Long, Enda Mooney, Brian Nelson, Áine O Connor.

We would like to acknowledge the help of the following in making the conference possible and successful

- Michael Cusack Centre, particularly Tim and Agnes
- MyWebinar, particularly James and Fergal

3 The purpose

The Burren is well known, famous even, in Ireland and beyond for its geology (the karst landscape), its flora and its cultural history (both its archaeology and ongoing farming practices), but very little mention is made in text or talk of its invertebrate fauna. This is despite the Burren invertebrate fauna being highly diverse, comprising rare and specialist species and highly unusual species assemblages. As much of the rest of the Irish landscape becomes ever more intensively used resulting in declines in both invertebrate species richness and abundance, the relative importance of the Burren landscape for invertebrates increases year-on-year. The first aim of this conference, therefore, was to exchange knowledge on and celebrate the importance of the invertebrates of the Burren.

Like its flora, the Burren invertebrate fauna has been shaped by land management. Consequently, the second conference aim was to discuss how the management of the Burren landscape supports its invertebrates. Further, the conference explored, through examination of evidence from elsewhere, whether other actions could be taken to further support and enhance Burren invertebrate communities.

Forester moth *Adscita statices*. *Photo Áine O Connor*

4 The programme

The following tables present the conference programme, both talk sessions and field outings.

Day 1 - Tuesday 9 August 2022

09.50-13.20	Day 1 Talks **INVERTEBRATE DIVERSITY**	
09.50	Introduction and welcome	Áine O Connor
10.00	*Overview of the Burren invertebrates*	Brian Nelson
10.30	*The butterflies of the Burren*	Jesmond Harding
10.55	*Selected moths of the Burren - a strange brew*	Dave Allen
11.20	Coffee break	
11.50	*Invertebrate communities at Ballyogan and Slieve Carran*	Adam Mantell
12.15	*The Burren as an internationally unique site for water beetles*	Garth Foster
12.40	*Hoverflies*	Tom Gittings
13.05-13.20	Closing comments day 1	
14.30-17.00	Day 1 Field Trip to the Burren National Park to see characteristic Burren habitats	

Day 2 Wednesday 10 August 2022

09.50-13.30	Day 2 Talks **Managing for Invertebrates**	
09.50	Introduction and summary of Day 1	Áine O Connor
10.00	*The role of the traditional Sunday roast on invertebrate conservation in calcareous grasslands*	Ashley Lyons
10.30	*Delivering conservation through a results-based agri-environmental programme - lessons from the Burren*	Brendan Dunford
10.55	*Pollinators and management on Burren farmland*	Dara Stanley
11.20	Coffee break	
11.50	*Ants and management*	Tim King
12.20	*Management for butterflies*	Nigel Bourn
12.45	*Land snails and land management in the Burren*	Maria Long
13.10-13.30	Discussion and closing comments	
14.30-17.00	Day 2 Field Trip - a walk from the Michael Cusack Centre to discuss the Burren Programme and land management	

Day 3 - Thursday 11 August 2022

09.50-12.00	Day 3 Field Trip 1 – Burren National Park, Cooloorta
12.00-14.00	Day 3 Field Trip 2 – Burren Programme Farm near Slieve Carran

Spot the entomologists. Burren National Park, Day 1 Field Trip. *Photo Maria Long*

5 Key findings and recommendations

5.1 Headline facts and figures

The following are some of the key points raised by presenters and other participants during discussions and field trips

Invertebrates

- The Burren invertebrate fauna, like its flora, is internationally renowned and, arguably, of greater conservation importance than the flora. The Burren has the most diverse and species-rich invertebrate fauna in Ireland.
- The study of Burren invertebrates is less than 100 years old, having begun in earnest around 1950.
- Butterflies, moths, some Hemiptera, dragonflies and ground-, rove- and water beetles are some of the better-studied Burren invertebrate groups.
- The Burren is home to 31 species of butterfly, a higher species-richness than elsewhere in Ireland and reflective of other groups.
- 21 of the 24 (87.5%) resident Irish dragonflies are recorded from the Burren wetlands.
- 967 (62%) of Ireland's 1,567 species of moth are found in the Burren. 513 of these are micro-moths, or 55% of the Irish fauna, and 422 (73%) are macro-moths.
- Two-thirds, or 113 of the *c.* 180 hoverfly species known from Ireland occur in the Burren.
- The Burren is also a bumblebee hotspot, with significant populations of threatened species such as Shrill Carder Bee *Bombus sylvarum,* Red-tailed Cuckoo Bumblebee *B. rupestris* and Red-shanked Carder Bee *B. ruderarius.*
- Approximately two-thirds of Ireland's terrestrial and freshwater snail fauna occurs in the Burren.
- A 2018 survey of two sites, Slieve Carran and Ballyogan, recorded approximately 1,000 species of invertebrate across many different groups and included 12 species new to Ireland.
- There are many notable species in the Burren, from across invertebrate groups. These include Robust Spreadwing *Lestes dryas*, Irish Damselfly *Coenagrion lunulatum* (Odonata); *Rhopalopyx vitripennis*, *Limnoporus rufoscutellatus* (Hemiptera); *Agonum lugens*, *Ochthebius nilssoni* (Coleoptera); *Bombus sylvarum* (Hymenoptera); Pearl-bordered Fritillary *Boloria euphrosyne*, Burren Green *Calamia tridens*, Irish Annulet *Odontognophos dumetata* (Lepidoptera); *Sarcophaga discifera*, *Doros profuges*, *Cheilosia ahenea* (Diptera); *Tanymastix stagnalis* (Anostraca); *Microniphargus leruthi* (Amphipoda); Heath Snail *Helicella itala*, Round-mouthed Snail *Pomatias elegans* (Mollusca).
- Many of the 250 or so invertebrate species that occur in Ireland but not in Great Britain have their distributions centred on the Burren, for example Burren Green, Irish Annulet, *Tanymastix stagnalis*, *Sarcophaga discifera*, *Agonum lugens.*
- It is also home to some of the only endemic Irish invertebrates, for example the subterranean amphipods *Niphargus wexfordensis* and *N. irlandicus*.
- The water beetle *Ochthebius nilssoni* has one of the strangest global distributions of any Burren invertebrate being found in Sweden, Italy and Ireland. It is globally rare and five out of its eight known sites are lakes in the Burren (it is also found in Lough Carra Co. Mayo).
- 50% of all Irish red listed and near threatened invertebrate species are found in the Burren (124 species).
- Ten Irish red listed water beetle species have their distributions centred on the Burren.
- As for plants, but perhaps even more-marked in invertebrates, the Burren is somewhere that northern, Arctic and Alpine species co-occur with Mediterranean and continental European invertebrate species.

- The Marsh Fritillary *Euphydryas aurinia,* the only Annex II listed insect found in Ireland, is found at landscape scale in the Burren which provides stable habitat conditions.
- To quote Dave Allen, the invertebrate species particular to the Burren are 'a strange brew', with little commonality – no simple set of environmental conditions explains the fauna.

Shrill Carder Bee *Bombus sylvarum* (left), Pearl-bordered Fritillary *Boloria euphrosyne* (right). *Photos Brian Nelson*

Invertebrate habitats

- The species richness of grassland and wetland invertebrates is particularly notable in the Burren.
- The Burren's high quality, natural and semi-natural habitats and, particularly, its transitional zones and habitat mosaics, are very important for butterfly and moth species.
- Hoverfly specialities of the Burren are mainly species associated with calcareous grassland and limestone pavement habitats, as well as ant nests.
- Permanent wetland habitats, as opposed to turloughs, are very important for hoverflies. So too is Hazel *Corylus avellana* scrub.
- Turloughs, marl lakes and other wetland habitats are very important for water beetles.
- The threatened water beetle fauna is a cluster of species, rather than a distinct community, that has come together in the Burren because of a range of different conditions it provides. Some key water beetle habitat requirements found in the Burren are low-lying, exposure, mineral shorelines, deep water, good oxygenation, base-richness, sparse vegetation, oligotrophic, liable to dry out completely in midsummer, fish-free, undisturbed, disturbed and pioneer.
- Species-rich and flower-rich grassland, limestone pavement, heath and scrub habitat mosaics in the Burren are very important for invertebrates.
- Grasslands, heath and pavement are even more invertebrate species-rich where they are found in mosaics with wet habitats such as lakes, bog, fen, pools, springs and seepages.
- The abundance of bare rock and the heat-storage benefit it provides may contribute to the very high invertebrate diversity in the Burren.
- The interface/transition between scrub and calcareous grassland and rock is extremely important as it provide the combination of warmth and shelter necessary for many invertebrate species.
- Edges and transitions are important for invertebrates both at a micro-scale, *e.g*. where ant-hills or calcareous grassland plants abut and spill across limestone pavement, and at landscape-scale, *e.g*. stone walls, scrub and woodland in mosaic with more open habitats.
- The close juxtaposition of many different habitats and niches in the Burren provides the environmental requirements for each stage of invertebrate life cycles, thus supporting high diversity in small areas.

- Ants increase heterogeneity at field-scale and are incredibly important for other invertebrates and for ecosystems in general. Ants have symbiotic relationships with Brown Hairstreak and Holly Blue, hoverflies such as *Microdon mutabilis, Chrysotoxum festivum, Xanthogramma citrofasciatum* and, possibly, *Doros profuges.*
- The Yellow Meadow Ant *Lasius flavus* builds large semi-permanent structures that are used by a wide range of other organisms. These structures extend below ground far beyond the ant hill.
- Ants are not fed upon by many invertebrates, but are the prey of the spider *Dipoena tristis*. Another spider, *Evansia merens,* lives in the middle of ant colonies.
- The significant areas of lowland karst in the south and east Burren are even more important for invertebrates than the, perhaps, better known exposed uplands of the north and west because of the higher habitat heterogeneity and greater shelter.
- The south and east Burren includes many wetlands, which also contribute to the very high invertebrate diversity.
- Even very small areas of wetland significantly increase invertebrate diversity at a site. Wetlands such as fens and flushes are not just important to invertebrate groups that breed in them, but also as feeding and roosting habitat, for example, for moths and butterflies.

Management for invertebrates

- Continuation of traditional extensive grazing is absolutely vital for the invertebrates of the Burren.
- Small-scale and landscape-scale mosaics (high heterogeneity) are both important and should be considered in management.
- Appropriate management at field-scale is sufficient for some invertebrates, such as bumblebees.
- For others, *e.g*. grassland hoverflies and butterflies, species-richness and composition are significantly influenced by surrounding land use; they need a diversity of features within the landscape.
- Isolation within the landscape (distance to other habitat patches and colonies/populations) negatively impacts upon some invertebrates, *e.g*. butterflies.
- In terms of wetland hoverflies, however, small, isolated and disturbed wetlands can have high biodiversity value – even sites surrounded by relatively intensive land use can have high hoverfly richness.
- Across Europe, land abandonment and intensification are the main threats to invertebrates, leading to destruction, modification and fragmentation of their habitats, particularly calcareous grasslands.
- If the Burren is over- or under-farmed, it loses its biodiversity value.
- In the 1980s and 1990s, the Burren was suffering from both intensification, leading to loss of grassland species and water pollution, and abandonment leading to scrub-encroachment.
- Payments for nature and environmental services such as high biodiversity, clean water and landscape features has worked in the Burren, which has an award-winning, long-running results-based agri-environmental scheme.
- The Burren Programme covers 72,000 ha *c*. 30,000 ha of which is Annex I habitats in SACs, and around 1,000 farm families. Approximately 70% of the area and 321 farm families are currently in the programme.
- The Burren Programme also supports *c*. 20 local jobs beyond farming.
- Developing and demonstrating locally-targeted, integrated solutions and plans together (farmers, advisors and project staff) is key to the success of the Burren Programme. A pocket, heat and heart approach!

A mention of Burren plants!

- The Burren is home to over 70% of Ireland's native flora, with plants from the Arctic, Alpine and Mediterranean regions.
- The botanical diversity contributes to high phytophagous insect diversity.
- Scrub in the Burren has distinct vascular plant, bryophyte and lichen communities, that are different to those in the woodland and grassland.

Brendan Dunford explaining Burren Programme management to delegates. *Photo Tim King*

5.2 Recording

Despite the increased knowledge of the Burren's invertebrate fauna in recent decades, there are still large knowledge gaps and a need for increased recording. For some groups, including water mites, soil fauna and many families of Hymenoptera and Diptera, the records are so few that any recording is to be welcomed. For others, such as moths, there is a need for a more targeted approach to improve the spatial and temporal coverage. For all, more frequent recording would allow better interpretation of trends in populations and ranges. Specific targets highlighted during the conference included

- Moths
    - Micro-moths, especially cryptic species and leaf mines – it is likely that the Burren has an even higher proportion of the Irish micro-moths than of macro-moth species
    - Combine light trapping with searches of food plants for larvae and leaf mines
    - Nepticulid *Stigmella dryadella* on Mountain Avens *Dryas octopetala*
    - On Mountain Everlasting *Antennaria dioica* in the Burren and elsewhere, Irish Plume *Platyptilia tesseradactyla* and *Scrobipalpa murinella*
    - On bramble, *Stigmella auromarginella* and *Stigmella splendidissimella.*
    - Species associated with shrub species especially Purging Buckthorn *Rhamnus cathartica* and Juniper *Juniperus communis*
    - Species feeding on Bearberry *Arctostaphylos uva-ursi*
- Sedentary or relict species in old or ancient woodland.

- Hoverflies
  - Intensive hoverfly survey of limestone pavement and other dry habitats – targeting species such as *Cheilosia psilophthalma* and ant-associated species
  - Targeted survey for *Xylota tarda* on Aspen in Dromore Wood (only Irish record is for here from 1978).
- Solitary bees – to determine whether they are under-recorded, or naturally under-represented in the Burren.
- Great Yellow Bumblebee *Bombus distinguendus* – does it still occur in the Burren?
- Ants
  - Sampling by pit-fall trapping, soil sampling or vacuum sampling
  - Survey of associated soil fauna
  - Survey of associated above ground fauna, from beetles to hoverflies to moths and butterflies to solitary bees to grasshoppers, *etc*.
  - Searches for more ant predators and inquilines
  - Preferentially sample old grasslands with abundant large-ant-hills
  - Jet-black Ant *Lasius fuliginosus* crawling up trees.
- Subterranean fauna – probably a genuine ice age survivor, with a number of interesting and likely endemic species.
- Water mites.
- Survey other marl lakes for *Ochthebius nilssoni.*
- Mollusc survey generally, and targeting of *Vertigo* spp.

It was evident throughout the event that dedicated specialist recorders have significant expert knowledge of the biology and ecology of their target species groups. Further work is needed to encourage and assist such experts to document and share that knowledge. In particular, enhanced links between the expert recorder and academic communities would benefit younger generations of naturalists and provide invaluable assistance with research studies. Further efforts are needed to support collaboration, training and mentoring between the two communities and with conservation managers, including through events such as this conference and training such as that organised by the National Biodiversity Data Centre (NBDC) and Botanical Society of Britain and Ireland (BSBI).

Worming along. Burren National Park, Day 1 Field Trip. *Photo Maria Long*

5.3 Research

As for recording, there is almost an endless series of research questions on Burren invertebrates, including

- Identify species that have not been recorded but are likely to occur in the Burren, develop summary statistics and promote targeted research and recording, *e.g*. based on occurrence of food plants or habitats.
- In-depth study of species with disjunct distributions - why some species that occur in the Burren are not found elsewhere in Ireland, or in Great Britain *etc*.
- Absences – why are species found in the Burren that are absent from Britain, and, why are species that are common and widespread in Great Britain quite rare or absent in Ireland?
- Ants – their associations with other invertebrate and plant species, and how they shape Burren ecosystems, *e.g*. soil structure, chemistry and temperature, plant germination and rooting.
- Solitary bees – habitat use and availability.
- Great Yellow Bumblebee *Bombus distinguendus* – why did its population crash in the Burren and can it be restored?
- The invertebrate fauna of grikes.
- The invertebrates of Hazel scrub and woodland.
- The effects of long-term cycles of scrub clearance and re-growth on the scrub and woodland invertebrate fauna in the Burren.
- Why species associated with shade and woodland in Great Britain and elsewhere occur in more open habitats in the Burren? Is it Ireland's impoverished fauna having wider ecological niches? Is it the Burren's climate or other environmental factors?
- Similarly, why species associated with base-poor habitats elsewhere are frequently found in base-rich habitats in Ireland, and *vice versa*, *e.g*. the hoverflies *Melanogaster aerosa* and *M. hirtella.*
- Autecological studies of moth (and other invertebrate) species, *e.g*. species' food plants, why moth species' distributions are concentrated on the Burren when their food plants are far more widespread (*e.g*. species associated with Purging Buckthorn *Rhamnus cathartica* and Mountain Everlasting *Antennaria dioica*), bramble micro-species and their moths, other ecological requirements. The wide gap between the knowledge of butterfly food plant, habitat requirements, behaviour *etc*. and those of moth species was highlighted during the conference.
- DNA studies of species, across invertebrate groups, with disjunct distributions. Work has been done on water beetles such as *Ochthebius nilssoni* and study of other disjunct invertebrates would reveal commonalities and differences.
- The effects of drought on isolated wetlands in the high Burren.
- Winter-grazing and invertebrates
    - Does the removal of vegetation at that time of year remove over-wintering habitat for invertebrates?
    - Does it affect dung fauna?
- The importance of grazing for wetland species.
- The relationships between Burren Programme field scores (5-10) and all invertebrate groups.
- Variation in species composition and functional traits in pollinators and other invertebrate groups with management and habitat diversity at field and landscape scales.
- Development of lists of characteristic invertebrates for natural and semi-natural Burren habitats.
- Development of habitat fidelity scores, similar to the Pantheon scheme used in England, and incorporating information on rarity and scarcity, that could be used to assess invertebrate habitat and assemblage quality in Ireland.

- The development of new results-based scores for the ecological requirements of invertebrates and/or simple invertebrate metrics that can be incorporated into existing scores.
- Ground water losses of nutrients from more intensively managed land (*i.e*. areas with inputs of chemical fertiliser, slurry, farmyard manure and/or higher stocking levels), pathways to and impacts on Burren wetlands.
- A special publication on the Burren invertebrate fauna.

Waiting for Irish Annulet *Odontognophos dumetata* (it didn't show!). *Photo Áine O Connor*

5.4 Management

A series of key management principles and actions were highlighted during the conference

- Continuation of traditional grazing is absolutely vital for the invertebrates of the Burren, and is dependent on sustained, long-term funding of the Burren Programme, with its experienced and highly-skilled project team and established relationships with farmers, advisers and the Burren community.
- Invertebrates move. Individual species may require the resources provided by multiple habitats at any one time and their habitat requirements may change with life-stage.
- An absence of plants does not mean an absence of invertebrates. Rock and bare soil are important for providing heat and nesting, pupating and over-wintering sites.
- In vegetated habitats, the plant species composition is important for some invertebrates, *e.g*. moths and butterflies, but not for others, *e.g*. wetland hoverflies.
- Habitat heterogeneity is the key, both at field and landscape scales.
- Heterogeneity includes structural variation, but also variation in soil properties, microclimate, water and vegetation, as well as the availability of scattered small patches of bare ground.
- To preserve distinct species compositions, have heterogeneous low-intensity grazing, conserve the range of semi-natural habitats and all successional stages.
- To preserve rare species, habitat heterogeneity is the key.

- Light to moderate grazing levels are best. Cattle are generally preferable to sheep. Sheep grazing, where used, should be very extensive (very low stocking levels).
- Prioritise grassland management in areas of old grassland as indicated by ant-hills.
- The timing of management is important for pollinators. Pollinators need flower heads throughout summer (mid-April to August) to provide nectar. Flowers are also particularly important in September-October to allow pollinators such as bumblebees to build up their reserves to over-winter.
- Taller herbaceous vegetation is important for groups such as snails and spiders.
- Appropriate management at field-scale may be sufficient for some groups, such as bumblebees, however appropriate management at landscape-scale is necessary for other groups such as butterflies and hoverflies.
- While extensive, dense Hazel scrub is not desirable for invertebrates, scattered patchy scrub of varied sizes and ages is very important in the Burren in providing
    - Shelter and sun-traps – the Burren is a windy and wet place; many species occur along the scrub–grassland interface, especially where it is south-facing
    - Over-wintering habitat - invertebrates need secure resting places, protected from grazing and trampling, often associated with scrub and the transition between scrub and open habitats
    - Other invertebrate needs, which vary over their complex life-cycles, *e.g*. pupation sites, mating habitat, larval food, flower resources for adults
    - Habitat heterogeneity - provides niches for certain food plants and prey.
- Scrub should not be viewed in isolation but rather seen as a natural, dynamic part of grassland, wetland and woodland habitats.
- Allow space for scrub – and sunny edges in general – and look at means for incorporating the value of these into existing agri-environment schemes for fields and landscapes where the main objective is maintenance of semi-natural grassland and other open habitats (heath, limestone pavement, *etc*.).
- Scrub encroachment is an on-going issue, and while invertebrates need scrub margin habitat, scrub control is very important to stop the expansion of extensive, continuous, dense Hazel scrub.
- Ponies can be good for grassland restoration where there is scrub encroachment.
- Investigate mechanical options for harvesting extensive scrub.
- Before clearing large areas of scrub, survey for specialist invertebrates, plants and lichens.
- When clearing scrub, always leave patches to create structural variety, shelter, *etc*.
- Open, sparse woodland with high structural diversity is important for invertebrates.
- Landscapes have inbuilt heterogeneity of habitats, and targeted management can deliver even more variety and benefit invertebrates.
- Reintroduce grazing to wetlands, and consider cutting *Cladium mariscus* swamp especially where it forms mono-dominant stands.
- Periodic disturbance of small areas can be important for creating bare soil and resetting succession.
- Avoid uniform management that creates uniform fields and landscapes and sharp edges. Do not be too tidy. Create habitat mosaics that include scrub and trees within open habitats.
- Management of Aspen at Dromore wood for *Xylota tarda.*
- Look for opportunities to reinstate hay making and associated traditional management practices.

- Prevent further intensification of land use and look for opportunities to restore areas of more intensive agricultural land to semi-natural and natural habitats.
- Consider the potential for losses of nutrients to groundwater from more intensively managed land, which may impact on lake, turlough and other wetland invertebrates.
- Early intervention and on-going control of invasive species especially Cotoneaster, Red Valarian and Buddleja, which have been known to damage limestone pavements; and also Montbretia where it is displacing native herbs from roadside verges and fields, and Fuchsia, where it is replacing Hawthorn in hedgerows *etc*.
- Use leaflet drops, social- and traditional-media to discourage cultivation of invasive species in the Burren, and to encourage the maintenance and restoration of semi-natural and natural habitats in gardens and community spaces.
- Stop fly-tipping because it risks introducing non-native species, particularly where it includes garden cuttings.
- Incorporate invertebrates and their habitat needs into results-based payment scores, through creation of separate scores or bonus payments, or modification of existing scores.
- Monitoring measures success – and allows adaptation and improvement. Invertebrate monitoring should be used in management of the Burren.
- Provide opportunities for specialist invertebrate surveyors to feedback directly to site managers on their results from contracted and grant-funded work.
- Support more events that bring invertebrate recorders, academics and land managers together to share knowledge and create networks.
- Produce more plain-English (clear, succinct) publications aimed at practical management for invertebrates.
- Incorporate information on invertebrates into visitor and education signs, guides *etc*.

Tim King exploring an ant-hill. *Photos Maria Long*

6 Conclusions

1. The Burren is a wonderful place (particularly when the sun is shining), with a diverse, fascinating and important invertebrate fauna.
2. Traditional farming is critical to the survival of much of the Burren invertebrate fauna, and the Burren Programme is critical to the continuation of the essential traditional farming practices.
3. Bringing together those interested in invertebrates is important, in particular to make progress in unique and important systems such as the Burren.
4. Invertebrates are understudied and undervalued in general. Despite the rare and unusual invertebrates found here, this is also true of the Burren.
5. There is a need for significantly more invertebrate recording, both in groups that are relatively well-known and those that are less studied and more cryptic.
6. Increased spatial and temporal resolution in recording will allow interrogation of trends and provide significantly greater understanding of species' ecology.
7. Specialist recorders have expert knowledge that would benefit both the academic and conservation management communities and efforts are needed to support further collaboration.
8. Significantly more invertebrate research is needed, in the Burren, and in Ireland more generally.
9. From a conservation perspective, accommodating invertebrates in site management is challenging as with such a diverse group, habitat requirements *etc*. are very diverse and may be conflicting.
10. Planning and working at site level, however, and using a suite of simple principles, should make it relatively straight forward to incorporate invertebrate needs into programmes that are more focussed on plant communities or vertebrates.

Transparent Burnet *Zygaena purpuralis*. *Photo Brian Nelson*

Appendix I

Below is a report of each talk, in the order in which it was delivered at the conference. References and other relevant sources are given at the end of each account.

Day I (i) Brian Nelson, *Overview of the Burren Invertebrates*

Brian began by describing where and what is the Burren. He explained that the literature is focussed on flora – commonly described as unique and internationally renowned. Little reference is made to invertebrates. The Burren has a unique fauna that is internationally renowned – and in his view fauna trumps the flora. An important thing to remember is that an absence of plants does not mean an absence of insects.

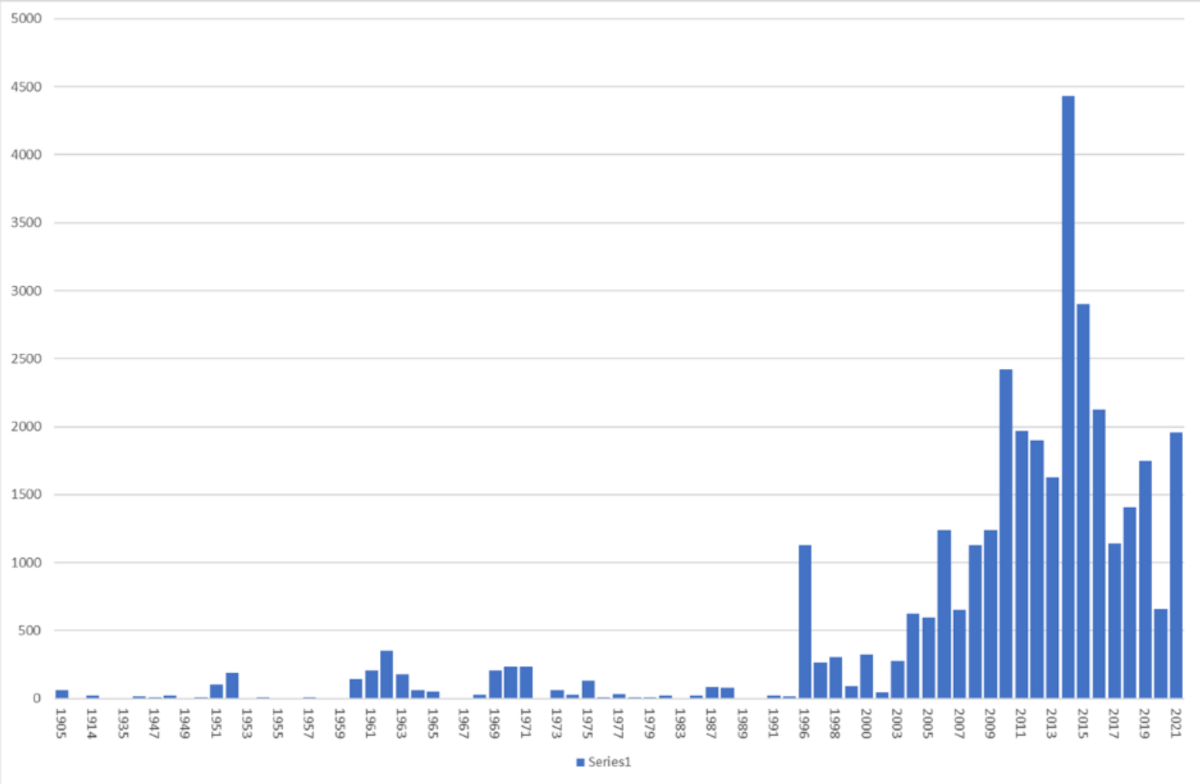
There is no fixed boundary for the Burren. While the sea offers a clear boundary to the north and west, the east and south is more tricky to delineate. Brian offered his map using the M18 and railway line as eastern boundary. Karst is the key feature – 60% of the Burren is limestone pavement. Much of that area is at or above 200 m, but the significant area of lowlands in the south and east contain important wetlands.

Who, what and why – discovery and recording of invertebrates.

- Plant records for the Burren date from the 1600s onwards.
- There are virtually no insect records for the Burren from before 1900. There was a brief visit as part of a field club meeting based in Galway in July 1895 (*Irish Naturalist* Vol. 4 No. 9), attended by most of the active Irish entomologists including J.N. Halbert – apparently his only trip to the Burren. The one day spent in the Burren was clearly a wet day so was not ideal for looking for insects. The group went by boat to Ballyvaughan and walked west towards Black Head, and very few insects were seen.
- 1922 saw the first Irish record of Pearl-bordered Fritillary *Boloria euphrosyne* found at Clooncoose by two botanists. It wasn't seen again for many decades.
- A.W. Stelfox spent a week in Co. Clare based mainly around Lahinch, in July 1924, during which he certainly visited Clooncoose. Stelfox was an expert malacologist and hymenopterist but strangely did not record *Bombus sylvarum* which occurs at Clooncoose.
- The lack of railways into the Burren may explain the low numbers of invertebrate records from the early 20th century entomologists. Other areas such as Killarney and Connemara attracted much more interest, leaving the Burren very much an unrecorded area.
- Surprisingly, the Burren Green, which can be disturbed during the day, was not discovered until 1949. It was first collected by Stuart Wright, an entomologist who was attending a botanical trip. He spent the winter showing it to entomologists in Great Britain before it was confirmed in 1950 by E.W. Classey. It is a common species of calcareous grassland in Europe but not known from Great Britain or elsewhere in Ireland.
- This discovery heralded an era of visiting naturalists and some research-focussed study of the Burren insects
- In 1951 there was a big moth trapping outing – mainly recorders come from Great Britain.

Burren fauna studies and recording since 1950 have included

- Hemiptera-Auchenorhyncha of Burren grasslands Mike Morris
- Hemiptera-Heteroptera Ivor Lansbury, Berend Aukema
- Flies – Owain Richards, Peter Chandler, Martin Speight, Tom Gittings
- Moths – many
- Butterflies – many
- Dragonflies – Norman Moore, Bob Merritt
- Water beetles – Dave Bilton, Garth Foster, Derek Lott
- Ground and rove beetles – Roy Anderson, Jervis Good, Mark Telfer
- Studies of turlough and turlough fauna – Julian Reynolds, Áine O Connor, Eugenie Regan
- Groundwater fauna – Joerg Arnscheidt, Marcin Penk, Lee Knight



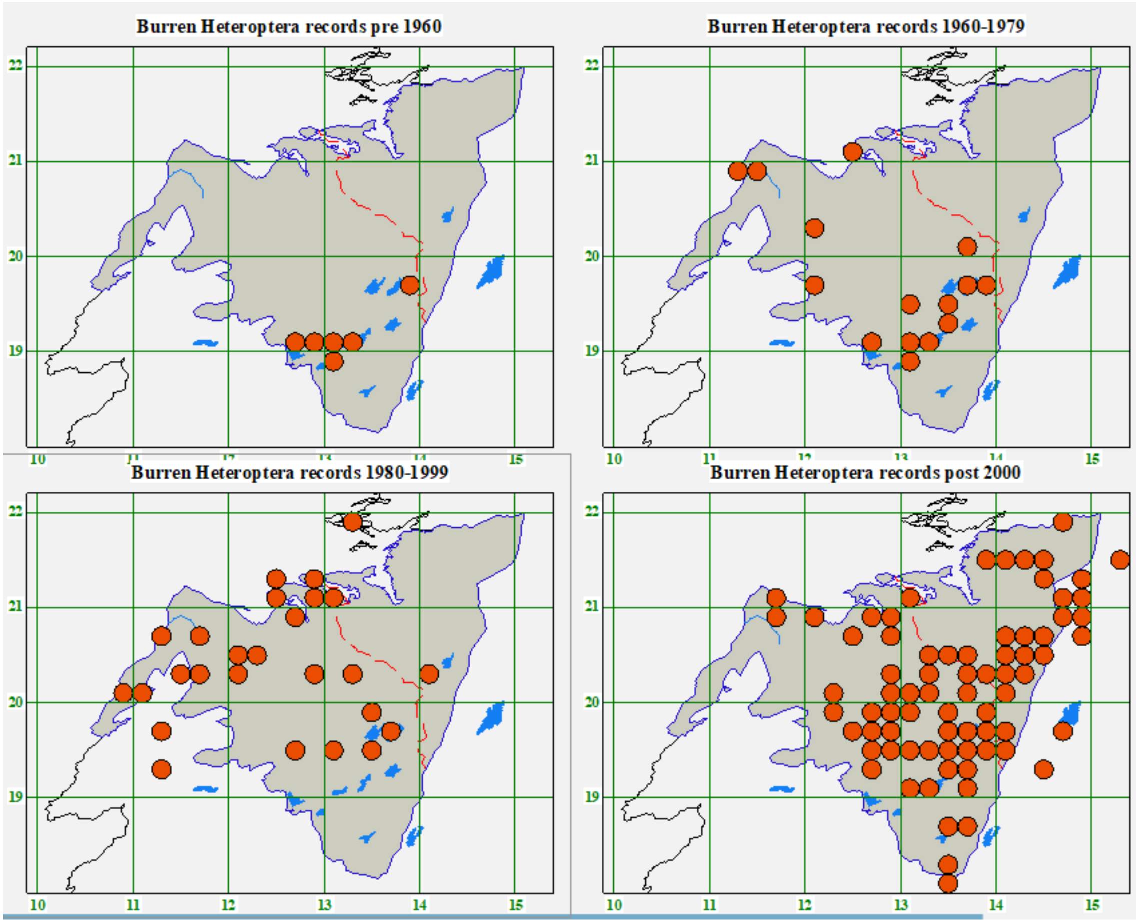
Moth recording in the Burren

Current state of knowledge
Illustrated using data for three groups

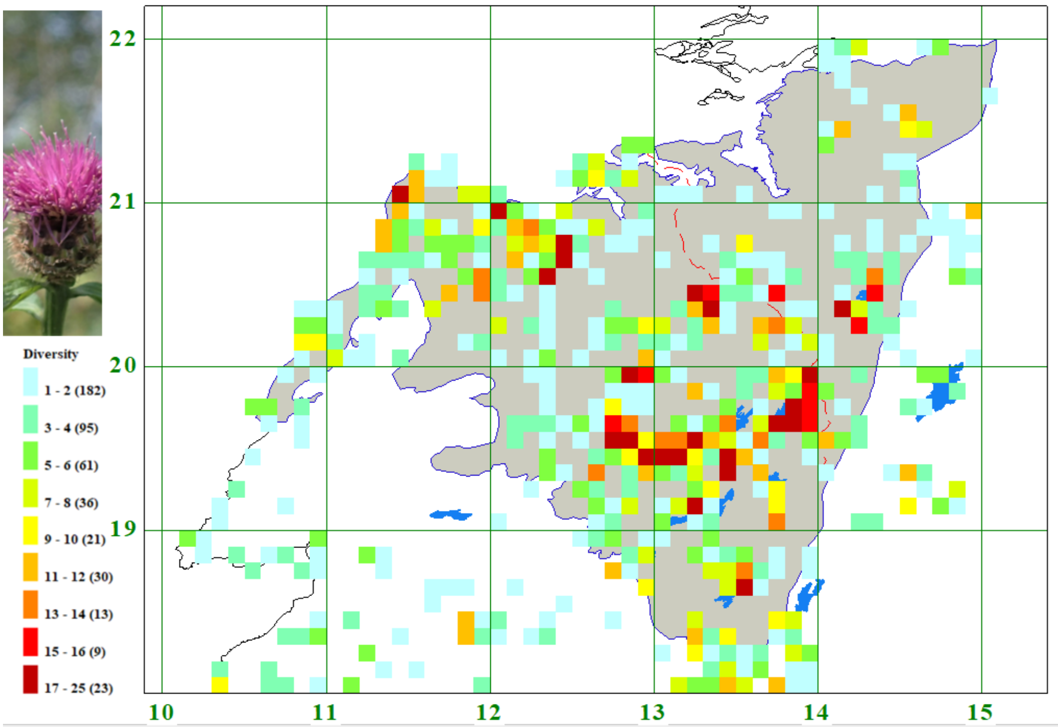
1. Graph of numbers of **moth** records per year (see above). Increases in 1950s after discovery of Burren Green. 1960s and into 1970s, moth recorders travelling from Great Britain, but it's really only since the 1990s that Irish-based moth recorders have been working in the Burren and there was a huge jump in recording effort from about 1996 onwards. This means the data are too recent to show trends.
2. Maps of **Heteroptera** records in four time periods (see below) showing increased recording particularly since 2000. Illustrates how recording was, particularly 1980-1999, concentrated on the western and upland areas of the Burren, but since 2000 has been more on the eastern side which is more diverse and interesting.
3. Butterfly – illustrated by mapping diversity at 1 km x 1 km scale in categories ranging from 1-2 species to 17-25 species (see below). The highest diversity in the south-east, lowland again, but also around Ballyvaughan and Fanore. The map illustrates butterfly recorder behaviour, as well as actual species-richness.

Notable species

- **Lepidoptera** Pearl-bordered Fritillary *Boloria euphrosyne* 1922, Burren Green *Calamia tridens* 1949, Irish Annulet *Odontognophos dumetata* 1991 (neither moth species occurs in Great Britain) Wood White *Leptidea sinapis* (2000 when second species recognised in Ireland and *sinapis* found to be restricted to karst areas)
- **Odonata** Robust Spreadwing *Lestes dryas* 1978 (Norman Moore identified it. It is found in turloughs because it's life-cycle matches their hydrological cycle), Irish Damselfly *Coenagrion lunulatum* 2011
- **Diptera** *Sarcophaga discifera* 1961, *Doros profuges* 1962, *Cheilosia ahenea* 1972
- **Coleoptera** *Agonum lugens* 1985, *Ochthebius nilssoni* 2006
- **Hemiptera** *Rhopalopyx vitripennis* 1961, *Limnoporus rufoscutellatus* 1965
- **Other invertebrates** *Tanymastix stagnalis* 1975, *Microniphargus leruthi* 2009



Heteroptera recording in the Burren



Butterfly recording and pattern of species diversity in the Burren

Red listed species 50% of all Irish red listed and near threatened species are found in the Burren
Red lists have been prepared for eight invertebrate groups, with 249 species assessed as threatened. 124, or almost half, of these occur in the Burren. These species cover all groups from terrestrial and pollinators to wetland species. Stoneflies are not well represented in the Burren because of the low number of rivers, however mayflies are well represented with three Red Listed species, one of which is known only from the Burren.

Red-listed group	No of Red-listed and Near Threatened species	Number in the Burren region	% of total
Bees	42	23	55
Butterflies	10	8	80
Dragonflies	5	3	60
Macro-moths	66	32	48
Mayflies	8	3	38
Molluscs	51	31	61
Stoneflies	2	0	0
Water Beetles	65	24	37
OVERALL	249	124	*c.* 50%

Ireland-only species
About 250 invertebrate species are known from Ireland but not from Great Britain, about 60 for which we have good data. Examples include Burren Green, Irish Annulet, Irish Damselfly, *Tanymastix stagnalis*, *Ochthebius nilssoni*, *Agonum lugens.* These Ireland-only invertebrates are very much concentrated on the Burren, in comparison to Ireland-only vascular plants, which are concentrated on Kerry and other parts of western Ireland including Connemara. The species richness of grassland and wetland invertebrates is particularly notable in the Burren.

Species' ranges
Botanical texts highlight that the Burren is remarkable for its combination of northern and southern species. This same pattern is found and even more marked in invertebrates. The Burren Green occurs from Spain to southern Finland, with the Burren at the -western edge of its range but in the middle of its latitudinal global range. Irish Damselfly is a more northern species, and the Burren is its southern limit in Ireland and closer to its southern European limit. Irish Annulet is a southern species, the Burren being at its northern range limit. The chydorid cladoceran *Eurycercus glacialis* is a northern species, with the Burren at the south of its range. The Burren fauna is a strange mixture of species from Arctic and Mediterranean.

Gaps and questions
- Do our definitions of and management prescriptions for habitats take account of invertebrates?
- Is the importance of scrub recognised? While accepting that dense Hazel scrub is not desirable for invertebrates, the Burren is a windy and wet place so scrub may be very important for simply providing shelter – particularly patchy, sparse scrub (notable in eastern Burren). Scrub may also be important in terms of invertebrate life cycles which are more complex than those of plants. Invertebrates over-winter and so need secure resting places, protected from grazing and trampling, often associated with scrub and the transition between scrub and open habitats. Patchy scrub results in habitat heterogeneity and provides niches for certain food plants and prey.
- Need habitat heterogeneity to support different life-stages- one species may require two or three different habitats to complete its life cycle. Invertebrates, particularly insects, move about.
- Bare ground is an important habitat feature for invertebrates - many insects need heat and access to soil. The abundance of bare rock and the heat benefit it provides may be one of the main reasons why invertebrate diversity is so high in the Burren. In Ireland, with its naturally cool climate and changeable weather our temperate climate means heat can be a limiting factor

for insects. Many species are restricted to the coast in Ireland and are only found inland in areas such as the Burren. For example Grayling *Hipparchia semele*

- Many invertebrates need access to soil as that may be where they over-winter or pupate
- Every group needs more recording
- Is winter-grazing best for invertebrates? Does the removal of vegetation at that time of year risk removing over-wintering habitat for invertebrates?
- Do the wetlands need to be grazed?
- What time would be best time to graze wetlands?
- Grazing – dung fauna (could this be limited if there is no summer grazing?), structure of vegetation, retention of overwintering areas, grazing of wetlands, life-cycles
- Is there enough dung available in summer?
- Subterranean fauna – this is a group found deep in groundwater that is probably a genuine ice age survivor. It is only recently have people begun to recognise and look at this group and there are four known very interesting species of subterranean amphipod, three of which are probably endemic Irish species. Needs more work
- Turloughs drainage and enrichment – how are these pressures affecting turlough fauna?
- Marl lakes – how is enrichment affecting their fauna?
- Poorly recorded groups such as water mites need more work. The fact that mites are under recorded highlights the irony that Halbert, who was a mite specialist, had such a brief and unproductive visit.
- Habitat heterogeneity is important – including having bare ground (heat)

The Burren is home to

- a strange mixture of species from Arctic and Mediterranean. That applies to invertebrates as much as plants
- most if not all species are native. No need for elaborate theories of ice age refuges
- the region supports the most diverse and species rich fauna in Ireland
- a high proportion of threatened and red-listed species are found in the Burren. But only one European protected species is present
- a majority of the species that are confined to Ireland within Britain and Ireland
- some of the only genuine endemics

And

- There is still more to be found
- Invertebrates occur in all Burren habitats – wider ecological range than plants
- Robust ecosystem little affected by introduced species; should be a zero tolerance of these
- Climate change – some arrivals in recent years
- There's a need for zero tolerance for non-native species such as Cotoneaster and Red Valerian – control at early stage of colonisation best to avoid well documented problems seen on calcareous sites.

Brown Hairstreak *Thecla betulae*. *Photo Brian Nelson*

Overview of the Burren Invertebrates selected bibliography

Allen, D., O'Donnell, M., Nelson, B., Tyner, A., Bond, K.G.M., Bryant, T., Crory, A., Mellon, C., O'Boyle, J., O'Donnell, E., Rolston, T., Sheppard, R., Strickland, P., Fitzpatrick, U., & Regan, E. (2016) Ireland Red List No. 9: Macro-moths (Lepidoptera). National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Aukema, B., Hermes, D.J., Nelson, B. and O'Connor, J.P. (2007) Eleven land and water bugs new to the Irish list (Insecta: Heteroptera) *Irish Naturalists' Journal* **28**, 327–333.

Bilton, D.T. (1988) A survey of aquatic Coleoptera in Central Ireland and the Burren. *Bulletin of the Irish Biogeographical Society* **11**, 77-94.

Bilton, D.T. & Lott, D.A. (1991). Further records of aquatic Coleoptera from Ireland. *Irish Naturalists' Journal*, **23**(10), 389-397.

Bond, K.G.M. & O'Connor, J.P. (2012) Additions, deletions and corrections to an annotated checklist of the Irish butterflies and moths (Lepidoptera) with a concise checklist of Irish species and *Elachista biatomella* (Stainton, 1848) new to Ireland. *Bulletin of the Irish Biogeographical Society* **36,** 60-179.

Bradley, J.D. & Pelham-Clinton, E.C. (1967). The Lepidoptera of the Burren, Co. Clare, W. Ireland. *Entomologist's Gazette* **18**, 115-153.

Byrne, A., Moorkens, E.A., Anderson, R., Killeen, I.J. & Regan, E.C. (2009) Ireland Red List No. 2 – Non-Marine Molluscs. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Cabot, D. & Goodwillie, R. (2018) *The Burren*. Collins New Naturalist Library, 138. Harper Collins, London.

Classey, E.W. (1950) *Luceria (Calamia) virens* in Britain. *Entomologist's Gazette* **1**, 185.

Classey, E.W. & Robinson, H.W. (1951) Burren – 1950. *Entomologist's Gazette* **2**, 87-94.

D'Arcy, G. (2016) *The Breathing Burren.* Collins Press, Cork.

D'Arcy, G. & Hayward, J. (1991) *The Natural History of the Burren.* Immel, London.

Forder, P. (1993) *Odontognophos dumetata* Treitschke (Lepidoptera: Geometridae) new to the British Isles with description of a new form, *hibernica* Forder ssp. nov. *Entomologist's Record and Journal of Variation* **105**: 201–202.

Foster, G.N., Bilton, D.T. & Nelson, B.H. (2016) *Atlas of the Predaceous Water Beetles (Hydradephaga) of Britain and Ireland*. Biological Records Centre, Wallingford and Field Studies Council, Telford.

Foster, G.N., Bilton, D.T., Hammond, M. & Nelson, B.H. (2018). *Atlas of the Hydrophiloid Beetles of Britain and Ireland*. Biological Records Centre, Wallingford and Field Studies Council, Telford.

Foster, G.N., Bilton, D.T., Hammond, M. & Nelson, B.H. (2020) *Atlas of Water Beetles of Britain and Ireland – smaller families of Polyphaga*. Biological Records Centre, Wallingford and Field Studies Council, Telford.

Foster, G.N., Nelson, B.H., Bilton, D.T., Lott, D.A., Merritt, R., Weyl, R.S. & Eyre, M.D. **(**1992) A classification and evaluation of Irish water beetle assemblages. *Aquatic Conservation: Marine and Freshwater Ecosystems* **2**, 185–208.

Foster, G. N., Nelson, B.H. & O Connor, Á. (2009) Ireland Red List No. 1 – Water beetles. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Grainger, J.N.R. (1976) Further records for the fairy shrimp *Tanymastix stagnalis* (L.). *Irish Naturalists' Journal* **18**: 326.

Grainger, J.N.R. (1991) The biology of *Tanymastix stagnalis* (L.) and its survival in large and small temporary water bodies in Ireland. *Hydrobiologia* **212**: 77–82.

Kelly-Quinn, M. & Regan, E.C. (2012) Ireland Red List No. 7: Mayflies (Ephemeroptera). National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Knight, L.R. & Penk, M.R. (2010) Groundwater Crustacea of Ireland: survey of the stygobitic Malacostraca in caves and springs. *Biology and Environment* **110**: 211-235.

Lansbury, I. (1965) Notes on the Hemiptera, Coleoptera, Diptera and other invertebrates of the Burren, Co. Clare and Inishmore, Aran Islands. *Proceedings of the Royal Irish Academy* **64B**: 89-115.

Moore, N.W. (1980). *Lestes dryas* Kirby—a declining species of dragonfly (Odonata) in need of conservation: notes on its status and habitat in England and Ireland. *Biological Conservation*, **17**(2), 143-148.

Morris, M.G. (1967) Weevils (Coleoptera: Curculionoidea) and other insects collected in north west Clare, with special reference to the Burren region. *Proceedings of the Royal Irish Academy* **65B**: 349-371.

Morris, M.G. (1974) Auchenorhyncha (Hemiptera) of the Burren, with special reference to species-associations of the grasslands. *Proceedings of the Royal Irish Academy* **74B**: 7-30.

Morris, M.G. (1985) *Bagous brevis* Gyllenhal new to Ireland from the Burren, Co. Clare, with a brief review of the Irish Bagoini (Coleoptera: Curculionidae). *Irish Naturalists' Journal* **21,** 400-403.

Nelson, B. & Doherty, L. (2021) Addition of two species of *Pilophorus* (Hemiptera: Miridae) to the Irish list of true bugs. *Irish Naturalists' Journal* **38**, 72-73.

Nelson, B., Hughes, M. & Bond, K. (2011) The distribution of *Leptidea sinapis* (Linnaeus, 1758) and *L. reali* Reissinger, 1989 (Lepidoptera: Pieridae) in Ireland. *Entomologist's Gazette* **62**, 213–233.

Nelson, B., O Connor, Á., Foster, G.N., Doddy, P. & Roden, C. (2019) A review of *Ochthebius nilssoni* Hebauer (Coleoptera: Hydraenidae) in western Ireland including a first report from Lough Carra. *Irish Naturalists' Journal* **36** (2): 117-122.

Nelson, B., Ronayne, C. & Thompson, R. (2011) *Ireland Red List No.6: Damselflies & Dragonflies (Odonata)*. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Nelson, B. & Thompson, R. (2004) *The Natural History of Ireland's Dragonflies*. MAGNI Publication No 013. NMGNI, Belfast.

Nelson, E.C. & Walsh, W (1991) *The Burren: a Companion to the Wildflowers of an Irish Limestone Wilderness.* Boethius Press, Aberystwyth and Kilkenny.

O'Callaghan, E., Foster, G.N., Bilton, D.T. & Reynolds, J.D. (2009) *Ochthebius nilssoni* Hebauer new for Ireland (Hydraenidae, Coleoptera). *Irish Naturalists' Journal* **30**, 19-23.

Platts, E.A. (1977) The land winkle *Pomatias elegans* (Müller) confirmed as an Irish species. *Irish Naturalists' Journal* **19**, 10-12.

Praeger, R.L. (1950) *Natural History of Ireland*. Collins, London.

Randle, Z., Evans-Hill, L.J., Parsons, M.S., Tyner, A., Bourn, N.A.D., Davis, T., Dennis, E.B., O'Donnell, M., Prescott, T., Tordoff, G.M. and Fox, R. (2019) *Atlas of Britain & Ireland's Larger Moths*. Pisces Publications, Newbury, Berkshire for Butterfly Conservation and MothsIreland.

Regan, E.C., Nelson, B., Aldwell, B., Bertrand, C., Bond, K., Harding, J., Nash, D., Nixon, D., Wilson, C.J. (2010) *Ireland Red List No. 4 – Butterflies*. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Ireland.

Reynolds, J., Murphy, M., & O Connor, Á. (2004). Early season cladoceran diversity. *Archives des Sciences* **57**, 97-104.

Reynolds, J. D. (2000). Invertebrate communities of turloughs (temporary lakes) in southeast Galway, Ireland. *Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen*, **27**(3), 1679-1684.

Richards, O.W. (1961). The fauna of an area of limestone pavement on the Burren, Co. Clare. *Proceedings of the Royal Irish Academy* **62B**: 1-7.

Skeffington, M.S., Moran, J., O Connor, Á., Regan, E., Coxon, C.E., Scott, N.E. & Gormally, M. (2006) Turloughs–Ireland's unique wetland habitat. *Biological Conservation*, **133**(3), 265-290.

Speight, M.C.D. (1978) *Cheilosia laskai* sp.n. (Diptera, Syrphidae) from western Ireland. *Irish Naturalists' Journal* **19**, 217–222.

Speight, M.C.D., Chandler, P.J. & Nash, R. (1975). Irish Syrphidae (Diptera): notes on the species and an account of their known distribution. *Proceedings of the Royal Irish Academy. Section B: Biological, geological, and chemical science* (pp. 1-80). Royal Irish Academy.

Woodrow, W., Nelson, B., Allen, D., Glanville, E., Hughes, M., Mclaughlin, V., Mellon, C. & Waring, P. (2018) The distribution and ecology of *Gnophos dumetata* Treitschke, 1827 (Lepidoptera: Geometridae) in the Burren of western Ireland. *Entomologist's Gazette*, **69**, 1-14.

Wright, W.S. (1951) Moth new to British and Irish lists in Co. Clare. *Irish Naturalists' Journal* **10**, 135.

Young, R. (1975) *Tanymastix stagnalis* (L.) new to Britain and Ireland. *Irish Naturalists' Journal* **18**, 203.

Trouble makers. Brian Nelson and Áine O Connor. *Photo Maria Long*

Day I (ii) Jesmond Harding, *Butterflies of the Burren Overview*

The Burren is home to 31 species of butterfly, a higher species richness than elsewhere in Ireland, which is reflective of other groups.

- All 3 Endangered species (Regan *et al*., 2010) occur in the Burren: Small Blue *Cupido minimus*, Pearl-bordered Fritillary *Boloria euphrosyne*, Wall Brown *Lasiommata megera.*
- The Burren is the national stronghold for two Vulnerable species: Marsh Fritillary *Euphydryas aurinia* and Dark Green Fritillary *Speyeria aglaja*.
- It is also the Irish stronghold for three Near Threatened species: Dingy Skipper *Erynnis tages*, Wood White *Leptidea sinapis*, Small Heath *Coenonympha pamphilus*.
- Two of Ireland's butterflies occur in the Burren as sub-species: Dingy Skipper *Erynnis tages baynesi* and Grayling *Hipparchia semele clarensis*.

The Burren has extensive areas of suitably-managed, high quality, unspoilt habitats that provide ideal breeding sites for many butterfly and moth species, with transitional zones and habitat mosaics being particularly important.

The eastern Burren has high butterfly abundance and diversity, which is probably related to it being much more sheltered than the western Burren, and the extensive habitat mosaics, particularly where scrub interfaces with calcareous grassland and rock, which provide the necessary combination of warmth and shelter. Winterage areas of the western and upland Burren are more exposed and wind-swept and butterfly populations are generally smaller, and lower than might be expected given the occurrence of the necessary food plants.

- **Dingy Skipper** *Erynnis tages – baynesi* form (first described in 1956) found in the Burren is a different colour (ground colour blackish-brown and lighter colour can be almost white) that blends very well with limestone. Rests a lot on limestone pavement. Breeds on Common Bird's-foot Trefoil *Lotus corniculatus*, mainly where growing amongst grasses and other plants, rather than straggling across bare rock.
- **Wood White** *Leptidea sinapis* – floppy, low, gentle flight distinguishes it from other whites on the wing. Double broods in most years (not in 2012), like in Surrey, because it is warm enough. The first brood flies from early May to mid-June, the second is much smaller from the end of July to mid-August. Quite common in open scrub areas with limestone. Food plants are Meadow Vetchling *Lathyrus pratensis*, Tufted Vetch *Vicia cracca* (particularly for second brood) and also been found laying eggs on Bitter Vetch *Lathyrus linifolius*. It is doing well in the Burren. Breeds right up against the scrub – where food plant is growing next to the scrub. So does not lay eggs in the open, rather in the transitional zones between grassland and scrub. It is not widespread elsewhere in Ireland, likely because of the lack the combination of succulent, rain-fed, food plants and hot tangles of vegetation for the larvae to develop.
- **Brimstone** *Gonepteryx rhamni* – scattered distribution in Ireland is linked to its food plants, Purging Buckthorn *Rhamnus cathartica* and Alder Buckthorn *Frangula alnus*, which are both more common in the Burren than elsewhere. Purging Buckthorn is especially common. Brimstone is the longest-lived adult butterfly, and breeds in spring having over-wintered.
- **Green Hairstreak** *Callophrys rubi* – is rare in the Burren, Jesmond has only seen it in Ballinderren, but Rinroe marsh looks like a potential site. Likes wetter habitats and a lot of moisture around its food plants include Cross-leaved Heath *Erica tetralix*. Generally rare in Burren, but does occur in the south east.
- **Brown Hairstreak** *Thecla betulae* – a scrub specialist. Needs scrub that is not cut. Food plant is Blackthorn *Prunus spinosa*, which is common across country, but the butterfly is only really found in Burren and in one or two areas to the north and east. Generally doing well in the Burren. Easier to see in Burren than in Great Britain where males are found high in the canopy, but as Burren doesn't have many tall trees, they fly lower and are much more visible here. Also come down to feed on the honey dew produced by aphids. Eggs are also easy to find.
- **Purple Hairstreak** *Favonius quercus* – oak is not that plentiful in Burren, because of shallow soils, so species is restricted but does occur at Ballyeighter, Rockforest Pinewood and Garryland. Is restricted across Ireland.
- **Small Copper** *Lycaena phlaeas* – really common in the Burren, larval food plants are Common Sorrel *Rumex acetosa* and Sheep's Sorrel *Rumex acetosella*.
- **Small Blue** *Cupido minimus* – one of our species of serious conservation concern. Scattered distribution in the Burren. Ballyryan district has a good population scattered over fairly large

area. Small population in the Burren National Park. Has just one food plant, Kidney Vetch *Anthyllis vulneraria*, which is vulnerable to over-grazing. Small Blue disappears quickly when the food plant is heavily grazed. It is a species that has been lost from some areas so it needs to be monitored and action taken to prevent/reverse over-grazing of its food plant.

- **Common Blue** *Polyommatus icarus* – two, probably three broods in the Burren. Specimens found in the lowland are notably larger (broader wingspan) than those in upland areas. Size differences might be linked to food plant quality.
- **Holly Blue** *Celastrina argiolus* – found anywhere there is Holly *Ilex aquifolium*, but also breeds on other food plants like Alder Buckthorn *Frangula alnus*. Pretty common in some parts of the Burren, particularly wooded areas like Garryland.
- **Red Admiral** *Vanessa atalanta* – migrant. Frequent in the Burren. Nettle *Urtica dioica* is its food plant.
- **Small Tortoiseshell** *Aglais urticae* – very common throughout most of the country and the Burren is no exception, although they do require shelter and is not found in exposed parts of the Burren.
- **Peacock** *Aglais io* – While research shows a general preference for shelter and it is common in sheltered parts of the Burren, the adult can be found on hill tops. The reasons for this are unknown. In the Burren, however it does not breed in these locations.
- **Pearl-bordered Fritillary** *Boloria euphrosyne* – it is the 100 year anniversary of its discovery in the Burren. Found by Fogarty and Philips in June 2022 a few weeks before the civil war broke out. It is found only in the Burren in Ireland, despite its food plant Common Dog Violet *Viola riviniana* being common across the country. This is probably because it has similar requirements to Wood White – the two are found in very similar habitat, although different food plants. Both require a succulent food plant, well nourished by rain, well-watered, but the larva of the Pearl-bordered Fritillary cannot tolerate damp conditions, which would kill it. The Burren provides the double advantage of heavy rainfall and porosity of limestone – regularly wet but drains away quickly. Pearl-bordered Fritillary is very fussy in its breeding needs – likes wet and dry, violets growing right up against scrub with a mixture of direct sun and shade.
- **Dark Green Fritillary** *Speyeria aglaja* – very common in the Burren and is found in communal roosts in large numbers. Hundreds of adults congregate to roost at night in summer. It is a superb aerial acrobat and can fly into strong winds.
- **Silver-washed Fritillary** *Argynnis paphia* – found in woodland in the Burren. Likes mature scrub (tall stands of Hazel *Corylus avellana* that are open). Shadier conditions than other fritillary species. Seems to be doing quite well. Populations fluctuate between years. Garryland wood a good place for it.
- **Marsh Fritillary** *Euphydryas aurinia* – our only legally protected and Annex II insect species. It is found on a landscape scale in some areas of the Burren – it is not restricted to discrete sites or reliant on metapopulations, but is rather found across a large range, so the management appears to work very well for it.
- **Wall Brown** *Lasiommata megera* – is not doing at all well in Ireland – disappearing from vast areas of the country. It has declined significantly since the mid-1980s because of the switch from hay to silage, but is still widespread in the Burren. It may also be impacted by climate change, owing to earlier, more vigorous grass growth resulting in lower temperatures at soil level at a critical time, meaning the larvae cannot develop. Also, there is a general absence of dead plant material, which is critical for larvae to bask on and heat up. So it is the early, spring generation that is impacted, rather than the summer generation: the critical period is February and March. Enrichment of soil may also contribute, owing to more vigorous, early growth. Stone walls are important for Wall Brown in the Burren, in providing both warmth and shade; shade means the larvae do not desiccate as they would in open grassland.
- **Grayling** *Hipparchia semele* – the Burren *clarensis* form is abundant at Cooloorta and Mullaghmore. This species is not doing well elsewhere in Ireland, *e.g*. a survey of the entire Dublin coast two years ago found it at only a single location, Howth. It was previously found along much of the Dublin coast.
- **Small Heath** *Coenonympha pamphilus* – a common and widespread species that is now declining seriously across Ireland, it is still doing well in the Burren. When a common, widespread species begins to show decline it should ring every alarm bell, as it indicates widespread landscape degradation. A very important indicator. Is not a habitat specialist, but is becoming one owing to landscape changes. Although still often viewed as a common species,

it is becoming one of conservation concern owing to widespread environmental degradation at landscape-scale.

The reason why all of these butterflies are in the Burren is the habitats

- Rich fen and flush as at Clooncoose, butterflies need different parts of the landscape for different purposes – *e.g*. roosting, rather than breeding.
- Mosaic of marsh, wet grassland, scrub, exposed calcareous rock as at Fahee North, a small site with 25 or 26 butterfly species.
- Scrub with dry calcareous grassland in flower-rich clearings, a habitat that is common across the Burren and used by Dingy Skipper, Pearl-bordered Fritillary, Wood White, Peacock, Meadow Brown *Maniola jurtina*.
- Calcareous grassland containing food plants and habitat transitions. Wild Thyme is a very good nectar plant for butterflies – large and small species (Dark Green Fritillary, Small Copper, Transparent Burnet Moth *Zygaena purpuralis*). The edge habitats such as where thyme spills onto rock, creates a warm microclimate for the Transparent Burnet. Habitat transitions/edges where calcareous grassland meets scrub are very important breeding sites for species such as Pearl-Bordered Fritillary and Wood White.
- Exposed upland dry calcareous grassland and exposed calcareous rock – although exposed, does have butterflies including breeding Marsh Fritillary colonies in these areas if there are tufts of grass for larvae to shelter and over-winter. Common Blue and Forester Moth *Adscita statices* can also be found in this habitat.
- Exposed calcareous rock, dry calcareous grassland, heath, scrub – very warm habitat that have large populations of lots of species including species such as Dark Green Fritillary which is in trouble elsewhere.

Lough Fingall Complex is probably the best site for butterflies with 28 species, owing to the range of habitats present: Alpine/Boreal heaths, semi-natural dry grasslands and scrubland facies, calcareous fens, limestone pavement. The transitions and gradations between habitats, for example between turloughs, lakes and limestone pavement (itself highly variable in structure, with associated vegetation of heath, calcareous grassland and scrub) provides a range of physical conditions that favour many common and uncommon species. Light to moderate cattle grazing maintains suitable the conditions. Lough Fingall Complex has huge populations of Grayling and Wall Brown.

The importance of close observation must be emphasised– taking the invertebrate eye-view, a scaled-down view. Jesmond has bred all the Irish species and found it very informative, *e.g*. Small Tortoiseshell – before laying eggs, it checks the food plant. It has four functional legs, and its front two legs not used in locomotion. It drums leaves with front two legs checking nitrogen content before laying eggs.

There is always something new to discover and to interest you. For example, Brown Hairstreak pupae sing to ants – a white noise with rattle. This attracts ants to lick secretions off the surface of the pupa. Jesmond has noticed that you do not find Brown Hairstreak in areas with close grazed sward, where ant-hills have been destroyed – adults are always found in areas with ant-hills, so there appears to be a symbiosis. Ants have been found tending Holly Blue larvae in Ireland.

https://butterflyconservation.ie/wp/2022/09/13/the-importance-of-scrub-and-grassland-mosaics-for-the-butterflies-and-moths-of-the-burren/

Harding, J. (2021) The Irish Butterfly Book. Privately published, Maynooth.

Regan, E.C., Nelson, B., Aldwell, B., Bertrand, C., Bond, K., Harding, J., Nash, D., Nixon, D., & Wilson, C.J. (2010) Ireland Red List No. 4 – Butterflies. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Ireland. https://www.npws.ie/sites/default/files/publications/pdf/RL_2010_Butterflies.pdf

Day I (iii) Dave Allen, *Selected moths of the Burren - a strange brew*

Ireland has *c*. 1,567 species of moth, 967 of these occur in the Burren – or 61.7%. 940 of the Irish species are micro-moths, 513 of these occur in the Burren (54.6%). 422 of the 582 macro-moth species occur in the Burren (72.5%). This highlights gaps in recording, as undoubtedly the reality is that the Burren has an even higher proportion of the Irish micro-moths than of macro-moth species.

There is a huge bias in moth recording in the Burren, various reasons for this

- Recorder expertise
  - moth recorders usually specialise in macros (most commonly) or micros, some people do both. Fewer recorders do all species.
  - In particular, there are some groups of micro-moths that very few work on – one of the reasons why Dave has delved into the world of leaf miners – a handful of people in Ireland do leaf miners.
  - Dissection is needed for many micro-moths – and at the moment in Ireland, there is only one expert undertaking this regularly. There is a high risk, therefore, that in the not-too-distant future there will be no one doing moth dissection and determinations will be left as 'either/or' – which could cover as multiple species in some cases such as Nepticulids
- Recorder effort – the where, when and why – and how
  - When people come to the Burren - timing
  - Why they come - typically to target certain species
  - Where they go – moth recorders go to known sites to see their target species, and there is a real eastern bias in the Burren in terms of moth recording (*e.g*. Cooloorta, Lough Bunny)
  - risk of equipment theft – generators have been stolen
  - British moth recorders often stay with their trap, but pack up about 3 a.m. and therefore miss quite a few species. Some macro moths in particular only fly later in the night
  - Methods – have changed over time – many of the older records are from methods that are no longer used like sugaring and pupal digging – putting stuff in a box and waiting to see what comes out later. The bias now is for light traps, with some beating. Light traps show what flies past the light, which does not necessarily mean the species is breeding on the site where you are trapping. To find out what is breeding on a site, you have to combine light trapping with searches of food plants for larvae and leaf mines. These much more detailed surveys are essential if you want to tie the survey into the management of the site or fully understand the moth fauna of the site.

The Burren has been a magnet for visiting experts since the late 1940s, including

- Pelham-Clinton
- J.D. Bradley
- Col. Maitland Emmet and J.R. Langmaid

All names that are well known to moth recorders, and also our resident expert

- K.G.M. Bond

Two well known Burren moth specialities, both have extensive European distributions but are absent from Britain

- Irish Annulet *Odontognophos dumetata* – Discovered 1991 – very restricted, even in the Burren region
- Burren Green *Calamia tridens* – Discovered 1949

There are loads of discussion species Dave could have chosen to focus on, including

- Royal Mantle *Catarhoe cuculata* – feeds on Bedstraws *Galium* spp. – very Burren-centric Irish distribution
- Dew Moth *Setina irrorella* – Lichen/algae feeder on rock – again very Burren centric
- Brown Scallop *Philereme vetulata* – Purging Buckthorn *Rhamnus cathartica* – wider distribution
- Dark Umber *Philereme transversata* - Purging Buckthorn *Rhamnus cathartica*
- Tissue *Triphosa dubitata* – Purging Buckthorn *Rhamnus cathartica* – found right across Ireland – but the concentration of the species is in the Burren – staggering numbers of larvae on *Rhamnus* in Burren compared with elsewhere

- *Paracrania chrysolepidella* – one of the eriocraniid leaf miners of Hazel *Corylus avellana*, so why is it rare in Ireland and Great Britain? Something is going on with micro nutrients or climate, *etc*.
- Heath Rivulet *Perizoma minorata* – Eyebrights *Euphrasia* spp., again very Burren centric
- *Stigmella spinosissimae* – leaf mine on Burnet Rose *Rosa spinosissima* – it is so uncommon there are hardly any images of it
- Least Minor *Photedes captiuncula* – *Carex flacca* feeder
- *Agonopterix capreolella* – feeds on Burnet Saxifrage *Pimpinella saxifraga*
- Mere's Pug *Eupithecia intricata hibernica etc*.

This list is just a sample of Burren-centric moths. But the focus of Dave's talk was not on these, but rather on a random suite of species that have strange northern and southern distributions, first examining the distribution of their food plants.

Mountain Everlasting *Antennaria dioica*
This has an assemblage of species that feed on it in the Burren, including three critical species

- Irish Plume *Platyptilia tesseradactyla* – not found in Britain, is found in parts of Europe. In Ireland, outside of the Burren, is found in west Fermanagh (re-found this year – netted in day time). Historic records by Greer in Tyrone are questionable – plant may have been transplanted there with moth.
- *Coleophora pappiferella* – need to dissect adults and finding their cases which can be a nightmare. It is found in the Burren, the same site in Fermanagh and one site in Galway. It has a very restricted distribution in Great Britain. But is it really restricted, or are people not looking for it, not knowing what to look for, not recognising what they have found or not dissecting it when they find it?
- *Scrobipalpa murinella* – same distribution – west Fermanagh and one old record from the Burren. Incredibly rare in Ireland and Great Britain, but also highly cryptic and again adults need dissection

But if you compare the distribution of these three species to that of the food plant, *Antennaria dioica*, it doesn't make sense – the plant is much more widespread. So there is something else going on – climatic, possibly altitude, but also lack of proper determination/recording. Bare rock/limestone probably has an influence, both in terms of chemical signature and as a heat source, but this is speculative- there is almost no research done on micro-moths in comparison to butterflies, so their autecology not so well known.

Mountain Avens *Dryas octopetala*
This is a classic Burren plant, but mainly a montane species in Great Britain where it has a restricted distribution. Only in Ireland is the plant found close to sea level. There is a nepticulid *Stigmella dryadella* that leaf mines it. The only Irish records for this moth are from the Burren and all the original records are by one of the famous recorders, J.D. Bradley. Is it under-recorded or rare? It is hard to locate? Could be in other Irish localities?

Bramble
It seems unlikely that such a ubiquitous species would harbour rare moths, but bramble is highly complex with highly complex genetics. Trace minerals may also have a role to play. There is one incredibly common bramble feeder *Stigmella aurella* that can be found throughout Ireland, but there are two others known primarily from the Burren in Ireland

- *Stigmella auromarginella* Classic mine – looks similar to *Stigmella aurella* mines but should have an amber corridor around frass line in the mine and a nice reddish line outside that. Adults need to be dissected and determined by examination of genitalia. Very rare in Great Britain
- *Stigmella splendidissimella* – slimmer mine with line of largely unbroken frass. Adults can be determined without dissection. Almost certainly under-recorded in Ireland, as is much more widespread in Great Britain

Both need to be bred through to adulthood to be determined. Larvae can also be identified to species but there is only a short window to find the larvae – which may only occupy the mine for 3-4 days during the summer.

Scarce Crimson & Gold *Pyrausta sanguinalis* - easier to understand its distribution

- Common on the Burren; rare in the east and north (restricted to dune systems in these area)
- Extinct in Great Britain

- ‘Extirpated by golf’ – most of its prime sites were turned into golf courses
- Limestone karst in the Burren – akin to continental habitat preference

Burren moth species conundrums

- Presence of food plant not the only factor in distribution
- Some species occupy niches more akin to Continental Europe rather than Great Britain
- Others have montane distributions elsewhere
- Some are largely distributed in limestone country in Great Britain such as Least Minor *Photedes captiuncula*
- The distributions of some buckthorn feeders are largely reflective of the host plant distribution in Ireland (*e.g*. Brown Scallop *Philereme vetulata*, Dark Umber *Philereme transversata*, Tissue *Triphosa dubitata* and *Stigmella catharticella*) but others (Irish Annulet and *Bucculatrix frangutella*) are not so and are restricted to the Burren, although *Bucculatrix frangutella* likely to be under-recorded.

Conclusions

- A lot more work needed on selected cryptic and mining species to find out their true distribution in Ireland
- Unclear how this strange brew of moths have all ended up in this unique place – but they all fly, so it may be that simple
- For every theory there appears to be an exception
- Surely still more to discover, *e.g*. Bright Wave *Idaea ochrata* (there is a disputed record of two specimens from Dromore Wood in 2006. In Great Britain it is an immigrant with a remnant population on coastal shingle in the south-east, but in Europe it largely occupies karst habitats - just like some of the other Burren specialties such as *Pyrausta sanguinalis*).

Dave Allen in Action, Burren National Park, Day 1 Field Trip. *Photo Maria Long*

Day I (iv) Adam Mantell, *Invertebrate surveying in the Burren 2018*

It was very hot when Adam and Roy Anderson undertook the survey in 2018, particularly towards the end of the summer. They looked at two sites: Slieve Carran and Ballyogan Loughs in one of the more in-depth invertebrate surveys in the Burren in recent times (Mantell and Anderson, 2020).

Slieve Carran is largely a limestone pavement site, with some damp areas restricted to small seepages and wet areas along the edge of the limestone scarp. A block of improved/semi-improved grassland in the centre is excluded from the SAC. Mixed with the extensive areas of limestone pavement are Hazel *Corylus avellana* scrub, closed canopy Hazel woodland, steep slopes, spring-lines and different heath and grassland communities. Scrub is an important feature of this site. There is quite a lot of Hazel woodland, that has closed canopy and is dark underneath with a limited ground flora. This is pretty much all Hazel, with occasional Ash *Fraxinus excelsior* trees poking above Hazel canopy.

Ballyogan is to the south-east of the Burren and is a much smaller site but has much greater habitat diversity, including marl lakes and extensive *Cladium* fen, which has been cut-over in the past. There are also small areas of limestone pavement and basins filled in with peat – including some acid loving plants. Ballyogan has lots of hedgerows, limestone pavement and species-rich grassland.

The project involved intensive survey, using multiple fieldwork techniques including

- Pitfall traps (10/site)
- Flight intercept traps (3 at Slieve Carran because it has more woodland, 1 at Ballyogan)
- Malaise traps (1/per site)
- Hand searching
    - Sweep nets/butterfly nets
    - Turning stones
    - Sieving grass/moss
    - Pond-netting

The purpose of the survey was to pull together site-lists, and look at what was special or, in some cases, unique to the site. There were three visits to each site, one each in June, July and August. There was exceptionally hot dry drought conditions, which resulted in the soil drying and cracking and pushing the pitfall traps out of the ground and led to springs drying up. It also caused the preservative in some of the traps to evaporate, so that invertebrates began to decompose, which attracted huge numbers of Diptera and carrion beetles.

Headline results

- Recorded approximately 1,000 species of invertebrates during the survey across many different groups. Determinations were by Adam, Roy Anderson and Peter Chandler. Peter dealt with the huge numbers of Diptera trapped.
- Many of the species recorded are more or less confined to the Burren and south-Galway limestone areas
- 12 species new to Ireland were recorded, mostly Diptera
- Open grassland/scrub supported the most notable species and again, the areas where scrub meets grassland are particularly important. Wetland habitats were also important: even the limited amount of wetland found at Slieve Carran.
- Woodland habitats have quite an impoverished fauna, which is odd given that Hazel scrub has been a feature of the Burren for hundreds and hundreds of years, possibly millennia but maybe it is linked to the cycles of scrub clearance and re-growth. Many saproxylic species are sedentary or relict species and may have been eradicated by periods of clearance. Woodland fauna is certainly less interesting than the open habitat and wetland fauna.

Moth highlights

- Small Eggar *Eriogaster lanestris*
- Scarce Crimson and Gold *Pyrausta sanguinalis*
- *Anania funebris*
- Dew Moth *Setina irrorella*
- Transparent Burnet *Zyygaena purpuralis*
- Shuttle-shaped Dart *Agrotis puta* – recorded by vising moth recorders from Great Britain. Generally considered a migrant and assumed this record was also a migrant, but worth keeping an eye out for potential small, resident populations. The species is very common in south

Wales. It highlights one of the interesting things about Irish entomology: sometimes, species that are common and widespread in Great Britain are quite rare or absent from Ireland for reasons that are not always obvious
- Irish Plume *Platyptilia tesseradactyla*
- Thyme Plume *Merrifieldia leucodactyla*
- Approximately 10 species with very clear ant associations.

Spiders
- Raft spider *Dolomedes fimbriatus*
- *Mecynargus morulus* (montane)
- *Dipoena tristis* – Related to the False Widow Spider, it has an ant association – hangs around at ground level and makes a web to capture ants. Ants are not generally fed upon by many other invertebrates because of their feisty and aggressive nature.
- *Micrommata virescens*
- *Evansia merens* – clear ant association – lives under stones in the middle of ant colonies. Unsure whether it feeds on ants, but is certainly able to evade detection by ants and live among them
- *Zelotes apricorum*

Diptera – sampled a lot of these
- *Paragus constrictus*
- *Sacrocophaga discifera* – more or less confined to the Burren
- *Microdon mutabilis* – another ant associated species, living under stones, distinctive hunched look and flight pattern (lazy circles around margin of limestone pavement)
- *Cheilosia ahenea* – another Burren speciality – was common on the limestone pavement, sunning itself to warm up
- *Pherbellia rozkosnyi* (Sciomyzid)

Beetles
- *Pterostichus atterimus* – extinct in Great Britain now. Found in its classic habitat of cutover fen
- *Bagous lutosus* – clings onto horsetail stems in water and very difficult to find
- *Ilyobates propinquus*
- *Stenus fornicatus*
- *Tachyusa umbratica*

Other things
- Dark Bush Cricket *Pholidoptera griseoaptera* – just two specimens
- Moss Carder Bee *Bombus muscorum* – Adam's impression is these are few and far between in the Burren and are more abundant in the dunes in the south-east of Ireland. The latter are also more diverse in terms of bumblebees
- Shrill Carder Bee *Bombus sylvarum* – as for Moss Carder Bee
- Irish Damselfly *Coenagrion lunulatum* – found a new colony

The stand out groups in terms of numbers of species were Diptera, Coleoptera and spiders, which was not surprising.

There was not much overlap in the fauna of the two sites, so for example only 36 beetle species were common to both sites, out of a total of 277 species recorded in the survey. So the sites are starkly different, despite both being part of the Burren.

They examined the invertebrate fauna of the two sites using the invertebrate analytical tool Pantheon, which was developed for use in England and identifies the numbers of species associated with different biotopes and habitats. 88 marshland species were found at Ballyogan, but only 18 at Slieve Carran. 123 peatland species at Ballyogan and 28 at Slieve Carran, which was higher than expected for Slieve Carran given how little peat is present. 67 shaded woodland floor species were found at Ballyogan, where there was very limited scrub/woodland, and only 18 at Slieve Carran, where there was extensive Hazel woodland; so something odd going on there, perhaps linked to the cycles of woodland clearance.

Table of the number of species recorded at each site (and combined) by taxonomic group (reproduced from Mantell and Anderson (2020), table 3)

Taxonomic Group	Ballyogan	Slieve Carran	Both	Combined
Arachnida, Araneae (Spiders)	79	59	32	106
Arachnida, Opiliones (Harvestmen)	3	9	2	10
Arachnida, Pseudoscorpiones (False scorpions)	1	1	1	1
Arynchobdellida (Leeches)	1	0	0	1
Chilopoda (Centipedes)	0	2	0	2
Coleoptera (Beetles)	181	132	36	277
Crustacea, Isopoda (Woodlice & relatives)	5	6	3	8
Dermaptera (Earwigs)	1	0	0	1
Diplopoda (Millipedes)	4	7	4	7
Diptera (Two-winged flies)	203	180	90	293
Hemiptera (True bugs & relatives)	43	27	8	62
Hymenoptera, Aculeata (Bees, ants & wasps)	15	17	20	19
Lepidoptera (Butterflies & moths)	71	101	34	138
Mollusca (Snails & slugs)	23	29	7	45
Odonata (Damselflies & dragonflies)	13	2	2	13
Orthoptera (Grasshoppers & crickets)	5	4	3	6
TOTAL	648	576	234	990

Habitat management and future challenges

- Continuation of traditional grazing is absolutely vital for these sites
- There was some evidence of fly-tipping, which was concerning because it included garden cuttings so there's a possibility of introducing non-native species
- Scrub encroachment is likely to be an on-going issue. The invertebrates need lots of scrub margin habitat, but we do not want extensive, continuous, dense Hazel woodland and so on-going scrub control will be important
- Diverse land ownership
- Agricultural intensification – hopes that the Burren is large enough and so stony that this will not become a major issue, but seeing bright green blobs appearing is some of these beautiful habitats is rather a shame.

Questions/comments

Maria Long – there is a pseudo-woodland situation in grikes in limestone pavement where small tree species and woodland snail species occur – could that contribute to Ballyogan's rich woodland fauna?
Adam Mantell – it could be a factor, and Slieve Carran despite the large areas of woodland, may be too dry. In Ireland, species Pantheon associates with woodland may be more widespread because of the prevalence of damp conditions – so it may be humidity.

Mantell, A. & Anderson, R. (2020) Important Invertebrate Area Surveys: Ballyogan and Slieve Carran, Co. Clare. Irish Wildlife Manuals, No. 127. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage, Ireland https://www.npws.ie/sites/default/files/publications/pdf/IWM127.pdf

Day I (v) Garth Foster, *The Burren as an internationally unique site for water beetles – the important things*

The Balfour~Browne Club is an international study group for water beetles that has visited the Burren.

There is a need to look much more widely at why some of the species are in the Burren and Ireland, and why some are not found in Great Britain or elsewhere.
Approximately ten Irish red listed water beetle species are centred on the Burren (out of a total of 49 red listed water beetles, Foster *et al*., 2009)

- Lipped Diver *Agabus labiatus* – important in the Burren. The adult is quite short-lived. The larvae, unlike other *Agabus* spp., live in open water where they prey on Cladocera. It is found in two quite distinct habitats in Great Britain: one is very acid water, the other is habitats that dry up completely and the key link is the absence of fish. Fish cannot survive if the habitat is too acid or where it dries out.
- The Two-Lined Diver *Graptodytes bilineatus* – weird distribution: south coast of England, islands in Wales, Jersey, then the Burren.
- Sallow Scavenger Beetle *Berosus luridus* – most hydrophilids are vegetation feeders, but this and *Berosus signaticollis* are predators and active swimmers. Both are limited to the Burren
- Spotted Scavenger Beetle *Berosus signaticollis* – see above. This species was first found in Ireland by David Bilton who recognised it as part of the important moss-edge dwelling beetle fauna of turloughs.
- The Wrinkled Brow *Helophorus strigifrons* – found in shaded sedge litter.
- Sculptured Moss Beetle *Ochthebius exsculptus* – in Great Britain and the rest of Europe is found in exposed, calcareous rivers, in Ireland choses to be in a few calcareous lakes.
- Ciaróginbán *Ochthebius nilssoni* – only about 1.5 mm long.
- Turlough Long-Claw *Dryops similaris* – exposed calcareous habitats, both natural and artificial.
- Short Sloth Weevil *Bagous brevis* – are very slothful and difficult to find because they are so inert although they can gallop away when they think you are not looking. Associated with particular plants.
- Miry Sloth Weevil *Bagous lutosus* – see above.

If you try to have one-liners to explain these species, some things are repeated, some not

- *Agabus labiatus* predictable impermanence, relict
- *Graptodytes bilineatus* exposed, non-brackish coastal, ponds
- *Berosus luridus* peaty but base-rich
- *Berosus signaticollis* exposed, mineral substrate, pioneer
- *Helophorus strigifrons* marshes, sedge litter, relict
- *Ochthebius exsculptus* lime-rich, silt, pristine running water!
- *Ochthebius nilssoni* lime-rich, Krustenstein, deep
- *Dryops similaris* base-rich, semi-natural, pioneer
- *Bagous brevis* Lesser Spearwort *Ranunculus flammula*, relict
- *Bagous lutosus* pond-weeds (*Potamogeton*), base-rich, temporary, relict

So this is in no way a community, rather a cluster of species that has come together in the Burren. Quite rare to find even three of these species together in one site. And none of the species is confined to the Burren, also occurring in other limestone-rich areas of Ireland.

If you were to describe the characteristics of Burren sites based on their water beetle fauna – what draws them together, their commonalities

- lowland, mainly coastal
- from exposed mineral shoreline to deep water with wave action and good oxygenation – generally shade-intolerant apart from one or two species (*e.g*. *Helophorus strigifrons*)
- base-rich, but that doesn't necessarily mean vegetation-rich - probably oligotrophic with low phosphate level restricting plant growth, providing a degree of necessary exposure, for example for species that live deep in the water – will not be shaded out
- liable to dry out completely in midsummer, fish-free
- from undisturbed history to pioneer/man-made

Ochthebius nilssoni
One of the strangest distributions of any Burren invertebrate

- Sweden, Italy and Ireland – the most extreme example of a disjunct distribution in water beetles – and presumably lots of other insects
- DNA shows there is a *c*. 14,000 year gap between Sweden and Italy, but Sweden and Ireland are about the same (*c*. 1,000 years) – so perhaps the Alps are a cut off?
- It is associated with karsts mainly in Krustenstein in deep water (cyanobacteria-dominated layered community with *Schizothrix fasciculata* (see Doddy 2019). Like most *Ochthebius* spp, *O. nilssoni* is algivorous and its gut is full of krustenstein, but it is absent from many other major wet limestone biodiversity hotspots.
- It is sometimes abundant but sometimes infuriatingly elusive and absent, and is small enough to be overlooked.
- We think this is one of the most important species in Ireland.
- It was first found in Sweden in 1985 – a lake in the north (Vatn Skärträsket, a deep lake on an esker, hard-bottomed with very little vegetation – exposed surfaces deep into the water. It is not found in other Swedish water bodies – which have been extensively searched.
- It was discovered in Lough Briskeen, Galway in 2006 by Eoin O'Callaghan.
- Garth originally identified it as the similar to *O. nanus* Stephens, a species occurring in England and which would have been new for Ireland.
- Manfred Jäch (Vienna Museum) was the first to suggest checking for *O. nilssoni* Hebauer, known only from Lake Skärträsket in northern Sweden – and it was quite a shock to discover we had this species known only from Sweden and not in Britain.
- In the same year, 2006, it was found by Manfred Kahlen in Tagliamento valley, Italy – a wide river valley with think, creamy marl.
- Garth has been to the Italian river site (Tagliamento) three times and hasn't found it.
- And in preparing for this talk, Garth discovered old record from Lake Garda, Italy.
- In Ireland is in five lakes in the Burren (Cooloorta, Knockaunroe, Briskeen, Bunny and Gealain), and also in Lough Carra – a Burren outlier.
- We need to check Ballyogan and other marl lakes for it.
- When Garth took Prof Anders Nilsson to see this species that is named after him, water levels were low and sites were teeming with it.
- Can be in quite deep water (up to 0.75 m or more).

When *Ochthebius nilssoni* was found, Garth considered other potential sites – all of which have since been checked

- Anglesey limestone pavement fens (resident water beetler did not find – so pretty certain it is not there).
- Lismore lochs – island in the Hebrides – almost entirely limestone, and has its own, beautiful, calcareous loch fauna – was thoroughly checked and does not have *Ochthebius nilssoni.*
- Breckland into Broadland palsa or pingo fens – massive amount of work has been done on these, they do have exposed, oligotrophic surfaces and the species does not occur.
- The Alvar, Øland – a Balfour~Browne club meeting was held there to explore the huge area of karst on Swedish islands – not found.
- Les Landes pingos – south of Bordeaux – pingos associated with peri-glacial activity from the Pyrenees – not there either.
- It does occur in the Tagliamento Valley – was known as a good water beetle site.
- Slovenian turloughs – have been checked and do have their own fauna, but not *Ochthebius nilssoni.*
- Turlough-like sites on Welsh mainland have also been checked, and it is not there.

> *A beetle may or may not be inferior to a man – the matter awaits demonstration; but if he were inferior to a man by 10,000 fathoms, the fact remains that there is probably a beetle view of things of which a man is entirely ignorant*
>
> G K Chesterton 1901

Admirably sums-up the state of knowledge of most of our beetle species

Finally, a quotation from Audrey Molloy's ***One Beetle, Two Beetles***

> "*Aithníonn ciaróg ciaróg eile*. …It loses something in translation, but it literally means one beetle recognises another beetle. … Maybe… one beetle, two beetles….that's my best shot at it. Anyway, that's enough about beetles ….."

Doddy, P., Roden, C.M. & Gammell, M.P. (2019a) Microbialite crusts in Irish limestone lakes reflect lake nutrient status. *Biology and Environment: Proceedings of the Royal Irish Academy* **119** (1), 1–11.

Doddy, P., Roden, C.M. & Gammell, M.P. (2019b) Nutrient-pollution degrades microbialites in Lough Carra, an Irish marl lake. *Aquatic Microbial Ecology* **83**, 203–209.

Foster, G.N., Nelson, B.H. & O Connor, Á. (2009) Ireland Red List No. 1 – Water beetles. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland. https://www.npws.ie/sites/default/files/publications/pdf/RL1.pdf

https://www.latissimus.org/?page_id=24

https://loughcarra.org/marl-crust-krustenstein/

Questions/comments

Brian Nelson – the key difference between sites that have *Ochthebius nilssoni* and those that do not is the presence/absence of krustenstein. Garth and Adam have emphasised that the Burren is not just dry habitats. It is very important for water beetles and other wetland invertebrates too.

Áine O Connor – does *Cladium mariscus* swamp present a threat to the species that require more open, exposed habitats/niches? She is concerned such swamp is expanding because of lack of grazing of wetter areas in the Burren and presents a threat to stoneworts (charophyte species).

Brian – *Cladium* fen in the Norfolk Broads is very different to *Cladium* fen in Ireland, the former open and species-rich (both plants and invertebrates), the latter is mono-dominate – a bit like the Hazel scrub - dominated by tall *Cladium* and virtually impossible to sample for invertebrates. If Irish sites were grazed and cut as in the Norfolk Broads it might be different.

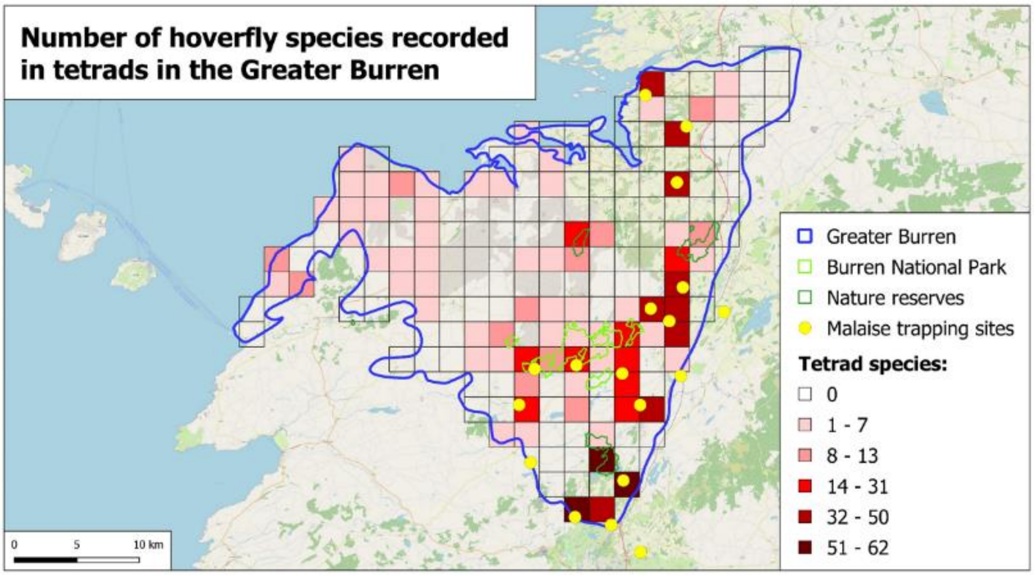
NOT Garth Foster (who would never wear this hat). *Photo Maria Long*

Day I (vi) Tom Gittings, *Hoverflies of the Greater Burren*

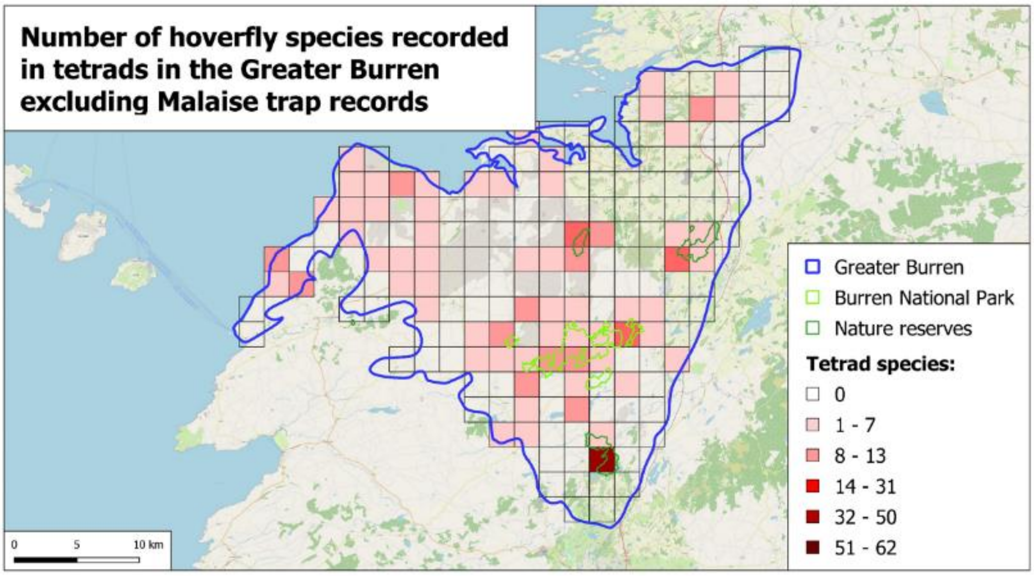
The title slide showed Coolreash Lough, which is on the eastern side of the Burren National Park, a site with permanent wetland habitats – which are very important for hoverflies in the Burren (permanent wetlands rather than turloughs that dry fully). The dry Burren habitats, limestone pavements, calcareous grassland, Hazel *Corylus avellana* scrub, have their own important hoverfly assemblages.

The overall level of Hoverfly recording in the Burren

Tom presented tetrad maps based on a database he prepared for NPWS in 2020 but that do not contain the records for Ballyogan and Slieve Carran. Tetrads with the highest number of species recorded (32-62 species) are all in the eastern Burren. Map also illustrates Malaise trapping sites. All of the tetrads with high numbers of hoverfly species are where Tom carried out Malaise trapping.



When he removes the data from the Malaise traps, only Dromore wood still has high species-richness.



Overall, the maps show quite widespread recording, but a general lack of concentrated, intensive effort. All of Tom's Malaise trapping effort was on wetland sites, so there has been no intensive survey of limestone pavement and other dry habitats.

Despite the lack of intensive survey effort, there is a respectable number of hoverfly species recorded from the Burren. Of the *c.* 180 species known from Ireland, two thirds or 113 have been recorded from the Greater Burren. Habitat associations, based on *Syrph the Net database*, shows the Irish hoverfly fauna is mainly forest and wetland fauna and not surprisingly in the Burren shows greater representation of wetland than forest fauna. The wetland fauna includes fen carr, so he separated out the fauna of open wetlands. And not surprisingly, nearly all of the Irish limestone pavement fauna has been recorded in the Burren.

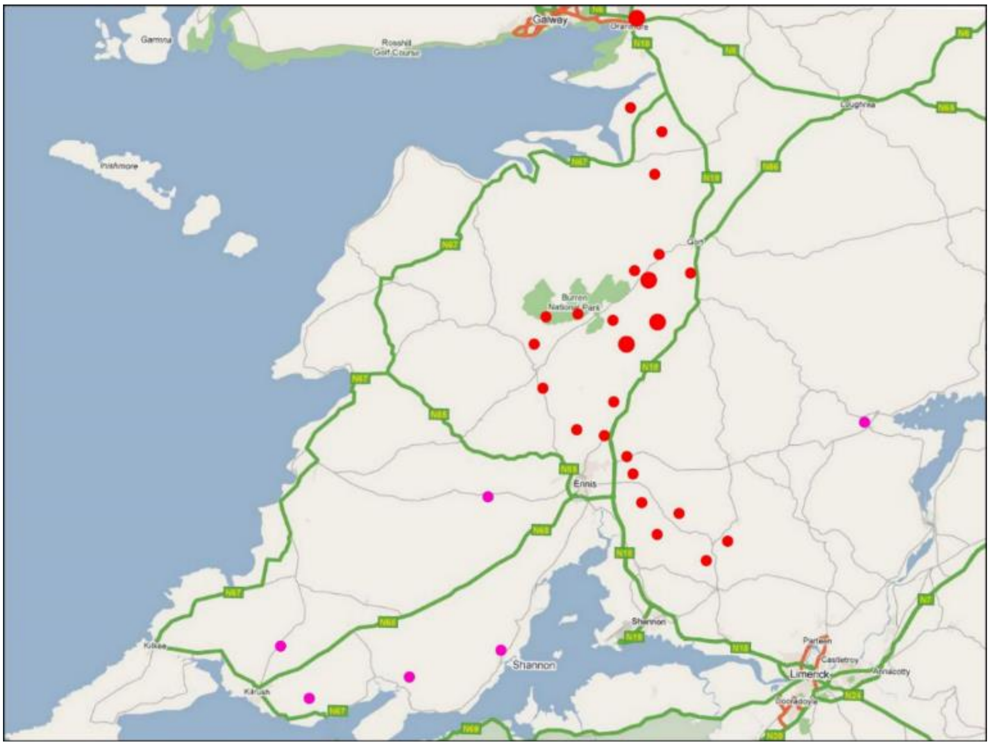
	Recorded in the Greater Burren	Not recorded in the Greater Burren
All species	113	69
Forest species	80	52
Wetland species	69	30
Open wetland species	43	10
Limestone pavement complex	46	4

Habitat associations based on Speight, M.C.D., Castella, E. & Sarthou, J.-P. (2020) StN 2020, *Syrph the Net on CD, Issue 12* (eds M.C.D. Speight, E. Castella, J.-P. Sarthou & C. Vanappelghem), Syrph the Net Publications, Dublin.

The Wetland Hoverfly Fauna

This research was carried out under the BioChange Project, which was funded by the EPA. Surveys of wetland biodiversity were conducted using various invertebrate groups. Methods included the use of Malaise traps (a tent-like structure that captures flying insects – very effective at catching large numbers). 31 sites were surveyed across Co. Clare, not just in the Burren – 21 were isolated, small (1-10 ha) calcareous fens (small red circles), four large (25-100+ ha) calcareous fens (large red circles), six non-calcareous (pink circles). 14 within Brian's definition of the Greater Burren.

Tom looked at how the number hoverfly and other species recorded was related to the catch volume of the Malaise trap, because Malaise traps are very variable in terms of their effectiveness and highly influenced by where they are placed in terms of shelter, flight lines *etc*. There is a bit of an art in placement of Malaise traps that makes it difficult to know how representative they are across sites and Tom was aiming to standardise the results across sites. He found a strong logarithmic correlation between numbers of species and catch volume, and that he could use catch volume to standardise the data by looking at the deviation of individual site from the regression lines. The three sites with the lowest trap catch volume were those that were 'high Burren', small wetlands surrounded by large areas of exposed limestone *e.g*. Rinnamona Lough. He surveyed in 2007 and thinks these results were likely influenced by a drought in 2006 leading to these three sites drying out.



His standard trapping method was three Malaise per site, but in some of the larger sites, he increased the trap number to six and covered a larger area of the site and a wider range of habitats. More traps did record a greater numbers of species, rather the increase was simply what would have been predicted based on the increase in the catch volume, which shows that the hoverfly fauna is very well mixed on these sites, without localised populations or colonies.

Two interesting wetland hoverfly species recorded during this research were *Melanogaster aerosa* and *M. hirtella*. *M. hirtella* is a more widespread and common species in Ireland, *M. aerosa* has a much more restricted distribution. In the literature, *M. aerosa* is described as a species of acid fen and *M. hirtella* as a species of calcareous, base-rich fen, but Tom found exactly the opposite – high numbers of *M. aerosa* in calcareous fen and virtually no/low numbers of *M. hirtella*, and in the acid fens, he recorded only *M. hirtella*. The pattern was so unusual that hoverfly experts were questioning his determinations and he had to send specimens for confirmation – but they were also the first European *Melanogaster* species recorded in Ireland. Clearly they are behaving very differently in Ireland than elsewhere in Europe. Tom has recorded both species in good numbers in Pollardstown fen.

Broad conclusions from the BioChange hoverfly work

- Small, isolated and disturbed wetlands can have high biodiversity value – even sites surrounded by relatively intensive land use can have high hoverfly richness
- No effect of habitat isolation detected
- Habitat/vegetation composition does not affect the assemblages in calcareous wetlands (*Phragmites* vs *Cladium* vs *Schoenus* vs mixed – all similar fauna) – so it is one hoverfly assemblage that occurs across the wetlands

Hoverfly specialities of the Burren

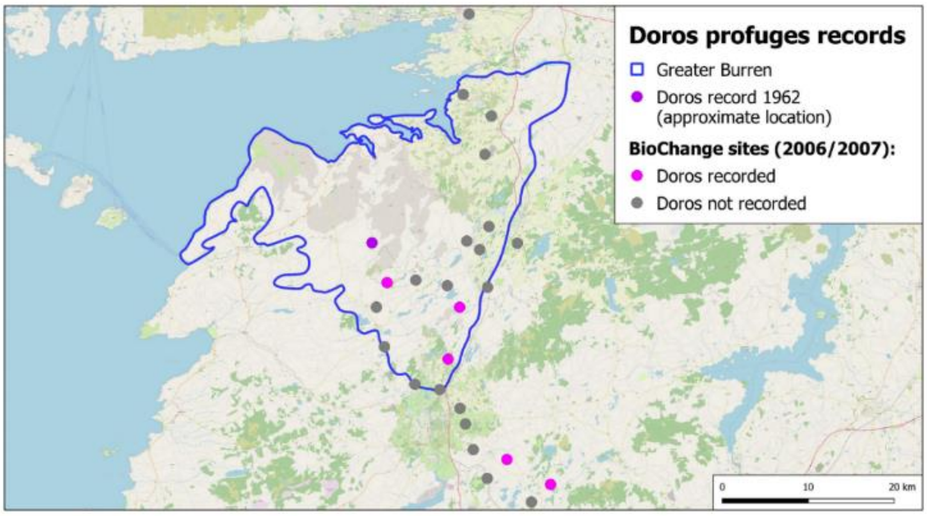
Mainly species associated with calcareous grassland and limestone pavement habitats. Three species whose larvae develop in ant nests

- *Chrysotoxum festivum* – not just confined to Burren, easily recognised in field
- *Xanthogramma citrofasciatum*– not just confined to Burren, easily recognised in field
- *Microdon mutabilis* – associated with dry grassland habitat and there are very large populations in the Burren. The Burren may be a hotspot in terms of this species' distribution, perhaps at European as well as Irish scale. Need the larvae or pupae to identify – cannot separate adults. Part of species pair with *M. myrmicae*. Tom is not aware of any records *M. myrmicae* for the Greater Burren, but it has been recorded by students of John Breen in a wetland east of the motorway near Ennis.

Small black species that cannot be identified in the field

- *Cheilosia ahenea* – can be abundant on limestone pavement habitats in the Burren
- *Cheilosia psilophthalma* – one of the four records for this species is in the Burren and little is known about its ecology in Ireland. More survey of limestone pavement may result in more records for this species.
- *Paragus constrictus* – a true Burren species, it does not occur elsewhere in Ireland and as far as Tom knows is not known from Great Britain either. Can be very abundant on limestone pavement in the Burren

- *Xylota tarda* – a woodland hoverfly associated with over-mature Aspen trees. The only Irish record is from Dromore Wood in 1978. Worth targeting to see if still present and managing for if present
- *Doros profuges* – probably the most charismatic of the Burren hoverflies. It is very elusive – known as the Phantom Hoverfly. It is quite widespread in Europe, but in sites where it occurs it tends to be only seen once and then not again for many years. Thought to be a species associated with ant nests, possibly *Lasius fuliginosus*, although the evidence for that is sketchy. It is associated with a mixture of scrub and grassland habitats. First recorded in Ireland in the Burren in 1962 from vicinity of Carran (purple circle) and then, despite people looking for it, it was not found again for another 50 years when Tom found it at five of his BioChange sites (pink circles, three in the Greater Burren: Rinnamona Lough, Ballyogan Lough, Loughaunore). Tom recorded it in about 20% of the calcareous sites he surveyed. Only single specimens taken at each sites by Malaise Trap. So it may be more widespread, but Malaise trapping is a very labour intensive way to find it.



Questions/comments

With Malaise trapping, most of the catch volume is made up of parasitic wasps and small Diptera, with hoverfiles only a minor component. Malaise traps are a very effective method for catching hoverflies, but if you are concentrating on hoverflies, you will have a large by-catch.

Scally, L., Waldren, S., Atalah, J., Brown, M., Byrne, C., Crowe, T., Cunningham, C., Davies, A., Eschmann, C., Fitch, J., Fitzgerald, H., Galley, C., Gittings, T., Grennan, J., Guiry, M., Higgins, T., Harrison, S., Irvine, K., Kavanagh, R., Kelly, D.L., Kelly-Quinn, M., Long, M., McCarthy, T.K., Milbau, A., O'Callaghan, E., O' Halloran, J., O'Mahony, L., Osborne, B., O'Toole, C., Parnell, J.A.N., Rodríguez Tuñón, A., Stengel, D., and Stout J (2011) Biodiversity and Environmental Change an Integrated Study Encompassing a Range of Scales, Taxa and Habitats. (2005-CD-B2-M1). Technical Project Report. EPA STRIVE Programme 2007–2013. Environmental Protection Agency, Wexford.

Waldren, S., Scally, L., Atalah, J., Brown, M., Byrne, C., Crowe, T., Cunningham, C., Davies, A., Eschmann, C., Fitch, J., Fitzgerald, H., Galley, C., Gittings, T., Grennan, J., Guiry, M., Higgins, T., Harrison, S., Irvine, K., Kavanagh, R., Kelly-Quinn, D.L., Long, M.P., McCarthy, T.K., Milbau, A., O'Callaghan, E., O'Halloran, J., O'Mahony, L., Osborne, B., O'Toole, C., Parnell, J.A.N., Rodríguez Tuñón, A., Stengel, D. & Stout, J. (2011) Biochange. Biodiversity and Environmental Change: An Integrated Study Encompassing a Range of Scales, Taxa and Habitats. Synthesis Report. STRIVE Report Series No. 68. Environmental Protection Agency, Wexford.

Surveying in the Burren National Park, Day 1 Field Trip. *Photos Maria Long*

Day II (vii) Ashley Lyons, *The Role of the Traditional Sunday Roast on Invertebrate Conservation in Calcareous Grasslands or The Impacts of Contrasting Grazing Management on Invertebrate Conservation Calcareous Grasslands*

Ashley presented the results of four studies, first introducing the importance of calcareous grassland across Europe

Calcareous grassland is exceptionally diverse in terms of both plants and invertebrates, and holds the world record for the most plant species in a square metre. It is Europe's most species-rich and diverse habitat. It requires careful management, which is not something calcareous grassland sites have always had. Since the second World War, across Europe large areas of calcareous grassland have been lost and there has been dramatic loss of plant species richness owing to agricultural intensification. And this decline was recognised through the protection of the habitat under EU Habitats Directive Annex I Habitat (6210: Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia)).

How much calcareous grassland is there?

Location	Area	No. of Sites
Europe	595,973 ha	
Ireland	3,335 ha	33
Germany	31,079 ha	924
United Kingdom	33,419 ha*	62
Upland Britain	60-75%	

* figures do not include Northern Ireland.

It is important to note that the large area of calcareous grassland in Germany is scattered across many different sites.

Outlook in Great Britain

The habitat faced decline due to intensive grazing and there was a 37% loss overall between 1960 and 2013. Then some changes, notably

- Foot and mouth disease, 2001 – 4.9 million sheep culled
- Common Agricultural Policy reform, 2003 changed payments from a headage basis to an area based system

Resulted in a reduction in grazing intensity and a shift from heavy sheep grazing to light cattle grazing. But the impacts on biota were unknown, so they began a number of studies to address this knowledge gap.

***Study 1 Impacts of contrasting conservation grazing management on plants and carabid beetles in upland calcareous grasslands* (Lyons *et al.*, 2017)**

Three grazing treatments

1. Low-intensity sheep grazing
2. Low-intensity cattle grazing (comparable to 1.)
3. No grazing

Investigating three questions

- Does plant or carabid beetle species richness differ across treatments?
- Does plant or carabid beetle species composition differ?
- Can plant species composition be used to indicate carabid beetle species composition? (because plants are often more readily recorded than carabids)

Three locations across northern England, three replicates of each grazing treatment at each location and three sampling plots at each replicate. Sampling plots had five pitfall traps that ran for the length of the season, paired with 2 m X 2 m vegetation quadrat that ran through the season.

<u>Results</u>

In terms of plant species-richness, it was comparable in the sheep and cattle grazed treatments, and reduced in the un-grazed plots.

Carabid species-richness was comparable across all treatments.

The interesting thing is when we look at the composition of the communities

- Two distinct plant communities, one for un-grazed areas, the second for grazed areas (cattle and sheep)
- Same pattern in carabids – two distinct assemblages associated with grazed and un-grazed areas.

While there was some correlation between the plant and carabid communities (Correlation in a symmetric Procrustes rotation = 0.42, p = 0.015), it was too low to be able to infer carabid species composition from plant data.

Next they looked at which species were associated with the different treatments. A total of 102 plant species and 23 carabid species were recorded, of which nine plants and three beetles were associated species

Grazing Treatment	No. of Plant Indicator Species	No. of Carabid Indicator Species
Cattle	7	1
Sheep	1	2
Ungrazed	1	0

And when you look at what species these were, it tells you something

Species	Indicator Value	Associated Grazing	Vegetative Pattern	Clonality
Carex panicea	0.54 **	Cattle	Patch forming	Rhizome far creeping
Carex flacca	0.50 ***	Cattle	Patch forming	Rhizome far creeping
Danthonia decumbens	0.46 **	Cattle	Patch forming	Tussock forming graminoid
Thymus polytrichus	0.50 ***	Cattle	Patch forming	Extensively creeping and rooting at nodes
Anthoxanthum odoratum	0.57 **	Sheep	Patch forming	Tussock forming graminoid
Stachys officinalis	0.44 *	No Grazing	Patch forming	Little or no vegetative spread

Cattle grazed areas are dominated by plants that spread by rhizomes into bare patches created when cattle uproot a patch of vegetation or dung. The associated species for sheep grazed areas was, unsurprisingly, a tussock-forming grass. And un-grazed areas, there was no space created to allow vegetative spread.

And the carabid associated species included two that are known to be in decline, so grazing was found to create space for threatened carabids and support their conservation.

Species	Indicator Value	Associated Grazing	Conservation Status
Carabus violaceaus	0.64 **	Sheep	Declining
Synchus vivalis	0.65 **	Sheep	N/A
Carabus arvensis	0.74 ***	Cattle	Declining

To summarise results

- Does plant or carabid beetle species richness differ among treatments? Plants yes/carabids no
- Does plant or carabid beetle species composition differ? Yes – there are two distinct assemblages, one in un-grazed areas, the other in grazed areas, and also in plants
- Can plant species composition be used to indicate carabid beetle species composition? No

Study 2 Spider assemblage responses to vegetation structure under contrasting grazing management in upland calcareous grasslands **(Lyons *et al*., 2018a)**

Four grazing treatments

1. Light sheep grazing
2. Heavy sheep grazing – because it still occurs in these landscapes
3. Light cattle grazing
4. No grazing

We know from study 1 that plant species richness is affected by grazing, but here looked at effects on vegetation structural complexity, which we know from practical experience does vary with grazing regime. Heavy grazing can produce uniform sward with little structure. Light grazing produces structurally complex sward.

Vegetation structure is important for spiders

- Increased structural complexity favours web builders
  - Anchorage points
  - Foraging niches
  - Prey availability
  - Cover
- Open habitats favour
  - Shade intolerant species
  - Good dispersers

The study investigated the four questions

- Does vegetation structural complexity differ?
- Does spider species richness differ?
- Does spider guild proportion differ? (the way in which the spiders hunt)
- Does spider assemblage differ?

They used a similar sampling design, with measurements of vertical height at 5 cm intervals along a pin to give data on vegetation structure. The number of contacts was recorded with moss, graminoids, forbs, woody plants and thatch, and the total number contacts was used as the measures of structural complexity.

And they split the spiders into five guilds

1. Ground hunters
2. Sheet web weavers
3. Space web weavers
4. Ambush hunter
5. Other hunters

<u>Results</u>

- Vegetation structure was as expected, high intensity grazing led to low structural complexity, no grazing to very high structural complexity and light grazing to intermediate structure.
- Despite spiders being much more speciose than carabid beetles, there was no significant difference in spider species richness across grazing treatments.
- There were interesting variations in spider guild across treatments
  - The lowest proportion of sheet web weavers was found in the heavy sheep grazed treatments
  - There was a much lower proportion of ground hunters in the high intensity sheep grazed treatments, where the guild seems to be replaced by 'other hunters'
- Three different types of spider assemblages were distinguished: high intensity sheep grazed, un-grazed, low intensity sheep and cattle shared assemblage.
- In terms of associated species, those for un-grazed areas were species that like moist stable environments that are not very often disturbed, often with leaf litter. The associated species for light grazed treatments were grassland species that like some dampness and tolerate some level of disturbance. The species found in high intensity grazing were ubiquitous, good dispersers, some shade intolerant species but in general an assemblage likely to be found in any grassland.

Species	**Guild**	**Habitat Preferences**	**Indicator Value**
Ungrazed			
Monocephalus fuscipes	SW	Litter in woodland but also in grassland	0.62^{***}
Robertus lividus	SP	Leaf litter	0.60^{**}
Palliduphantes pallidus	SW	Litter and under stones	0.56^{**}
Pocadicnemis pumila	SW	Grassland, moorland (damp conditions)	0.53^{***}
Saaristoa abnormis	SW	Leaf litter	0.51^{**}
Palliduphantes ericaeus	SW	Amongst plant stems, litter: humid	0.50^{**}
Bathyphantes parvulus	SW	Grasslands, also marshes and fens	0.46^{*}
Walckenaeria acuminata	SW	Damp substrates, any habitat on the ground	0.44^{*}
Micrargus apertus	SW	Litter	0.33^{*}

Species	Guild	Habitat Preferences	Indicator Value
Centromerus dilutus	SW	Detritus	0.32*
Cattle			
Gongylidiellum vivum	SW	Grassland, damp situations	0.44*
Pardosa pullata	GH	Grassland with tussocks	0.44*
Silometopus elegans	SW	Grass, wet or marshy places	0.38*
Light Sheep			
Hahnia nava	SW	Moss and other low vegetation and amongst stones	0.63***
Agyneta cauta	SW	Litter, detritus, occasionally moss on damp sites	0.46*
Peponocranium ludicrum	SW	Unimproved grassland, close to the ground.	0.44*
Species	Guild	Habitat Preferences	Indicator Value
Heavy Sheep			
Erigone atra	O	Low vegetation – ubiquitous	0.77***
Bathyphantes gracilis	SW	Grasslands – ubiquitous	0.69***
Oedothorax retusus	O	Grassland and agricultural fields	0.65**
Dicymbium tibiale	SW	Under stones	0.63**
Oedothorax gibbosus	O	Moist/disturbed habitats	0.56**
Oedothorax fuscus	O	Short grassland	0.55**
Xysticus cristatus	AM	Disturbed grasslands, shade intolerant	0.47*
Erigone dentipalpis	O	Low vegetation – ubiquitous	0.45*
Tiso vagans	SW	Grassland - aeronaut	0.43*
Oedothorax agrestis	O	Saturated habitats	0.33*

<u>Spiders of conservation interest</u>

One Endangered species, *Jacksonella falconeri*, was found across all treatments. A second Endangered species, *Porrhomma egeria*, was found only in un-grazed areas and according to the literature is a cave dweller, so perhaps an association with limestone pavement where the species emerges into completely undisturbed grassland.

Species	Conservation Status	Ungrazed	Cattle	Light Sheep	Heavy Sheep
Jacksonella falconeri	EN				
Porrhomma egeria	EN				
Agyneta subtilis	VU				
Allomengea scopigera	VU				
Maro minutus	VU				
Trichopternoides thorelli	VU				
Walckenaeria dysderoides	VU				
Walckenaeria incisa	VU				
Walckenaeria monoceros	VU				
Walckenaeria obtusa	VU				

To summarise results

- Does vegetation structural complexity differ? Yes
- Does spider species richness differ? No
- Does spider guild proportion differ? Yes – particularly for high intensity sheep grazing
- Does spider assemblage differ? Yes – probably explained by guild

***Study 3 Spider diversity of habitats associated with the upland calcareous grassland matrix* (Lyons *et al*., 2018b)**

These grasslands are naturally heterogeneous, with areas of limestone pavement, areas of glacial till with acid grassland or heathland. So this was particularly looking at the importance of these less calcareous habitats that are not the target of conservation. This study looked only at low intensity sheep grazing, which is found where there is good development of heather, and three habitat treatments (could not sample limestone pavement with pitfall traps)

1. Calcareous grassland
2. Acid grassland
3. Heath

Asking the following questions

- Do spider assemblages differ?
- Does spider guild proportion differ?
- Do non-target habitats support species of conservation interest?

Did not consider species richness as it did not tell us anything in the other studies.

A similar experimental set up, this time with within site replication across different habitat types

- 3 regions in Northern England
- 3 replicate plots of each habitat type in each region
- 5 pitfall traps per replicate plot
- May – September 2014

<u>Results</u>

- Two distinct assemblages: a distinct one in heather patches (heath) and a shared grassland (calcareous and acid) assemblage.
- The proportion of sheet web weavers varied across habitats, being lowest in acid grassland and highest in heath.
- A lower proportion of ground hunters was found in heathland than in the grasslands
- Similar species of conservation importance were found as in Study 2, but very interestingly found *Porrhomma egeria* again, this time in the heath. Grazing intensity is so low in the study area that the sheep do not really bother with the heath, so that the heath is largely undisturbed. In Study 2 it was found only in un-grazed areas. So it may be a species of undisturbed habitat rather than caves.

Species	**Conservation Status**	**Acid Grassland**	**Calcareous Grassland**	**Heath**
Jacksonella falconeri	EN			
Porrhomma egeria	EN			
Agyneta subtilis	VU			
Allomengea scopigera	VU			
Trichopternoides thorelli	VU			
Walckenaeria dysderoides	VU			
Walckenaeria incisa	VU			
Walckenaeria monoceros	VU			

Summary of results

- Do spider species assemblages differ? Yes
- Does spider guild proportion differ? Yes
- Do non-target habitats support species of conservation interest? Yes

Management recommendations

Taking the information from all of the studies, what are the management recommendations? (Lyons *et al*., 2018c)

It depends on what conservation bodies want

- If you want distinct species compositions
    - have heterogeneous low-intensity grazing and, in terms of the Sunday roast, sometimes have beef, sometimes lamb and sometimes nut roast.
    - Conserve calcareous grassland and heath, and perhaps promote succession from acid grassland to heath
- But, if you also want to preserve rare species
    - some rare species are found only in acid grassland, so patches of it should be maintained

Outlook in Germany

Although Germany has a similar extent of calcareous grassland to Great Britain, it is dispersed across many more sites many of which are less than 1 ha in extent. There was a 60% loss of calcareous grassland area in Germany in the 20th century, but this was largely due to lack of grazing, caused in part by the UK and German Sunday roast preferences. In the 1950s, the UK guaranteed wool prices, which meant British farmers got lots of money for their sheep. At the same time, sheep prices dropped in Germany. Sheep farming was no longer competitive in Germany and the national sheep flock fell from 30 million to below 1 million by the 1960s. Land that had been under sheep farming was then either abandoned because there were no grazing animals, or intensified for arable farming. Abandoned land experienced succession - first scrub encroachment, and then reversion to beech forest. All of this led to fragmentation and a decrease in the size of the remaining calcareous grassland, which was compounded by increases in infrastructure and by urbanisation. Fragmentation and small sites also increased the administrative burden and together with the lack of resources, particularly grazing animals, led to further losses. Pork is the preferred Sunday roast in Germany, which meant little demand for lamb or beef to drive an increase in grazing. The sheep flock increased to *c*. 2.7 million in 2002, but declined again and has been *c*. 1.5 million for the last six or seven years.

Study 4, How do butterflies respond to habitat size, connectivity and landscape context? **(Loos *et al*., 2021)**

Questions

- Which environmental variables influence local patterns of diversity?
- Which spatial scale of landscape composition impacts local patterns of butterfly diversity?

(also looked at other taxonomic groups)

Sampling design

- Three patch sizes
    - Small <1 ha
    - Medium 1-3 ha
    - Large >3 ha (up to 5.5 ha)
- Metrics of connectivity – how far the patches are from each other or other species rich grasslands
- Four categories of succession from open to tree covered
- The percentage of arable land around the patches in increments of 250 m
- Landscape context - Which spatial scale of landscape composition influences local patterns of butterfly diversity? – scaled up from 250 m increments to 3 km

<u>Results</u>

- Species composition is more variable within small fragments – small fragments differed from each other
- Small and large fragments differed most for species composition – small fragments differed more from large fragments than from each other (but not quite significantly so)
- Butterfly species composition is significantly related to per cent of arable land at 250 m radius and to the successional stage of the grassland, rather than how far apart those grassland were or to their size
- Increased per cent cover of arable land resulted in fewer grassland specialist species.

<u>Management in Germany</u>

Must consider

- Lack of resources means conservation efforts have to be targeted.
- Grazing is not economically viable on small patches.
- Successional stage influences specialist species and composition.
- Patches with less arable land within 250 m have more specialist species and distinct communities.

<u>Management recommendations for Germany are therefore</u>

- Choose large areas, if you have to choose
- Choose large areas that have a lower proportion of arable land within 250 m
- Think about successional processes – choose areas that are still open and if you have the resources, being scrub control.

Questions/comments

Tom Gittings - question about dunging. Ashley commented about grass-fed cattle producing very different dung in terms of structure *etc*.

Jesmond Harding - attended a conference where a statistic was given that in Protected Areas in Western Germany there was a 75% decline in insect biomass in the 27 years to 2017 – what is going wrong?

Ashley said arable farming would be her best guess, because it covers such extensive areas surrounding the protected areas and it is probably the result of factors such as bare soil/soil disturbance, nitrogen fertiliser and pesticide use.

Loos *et al*. (2021) Local and landscape responses of biodiversity in calcareous grasslands. *Biodiversity and Conservation*, **30**, 2415-2432.

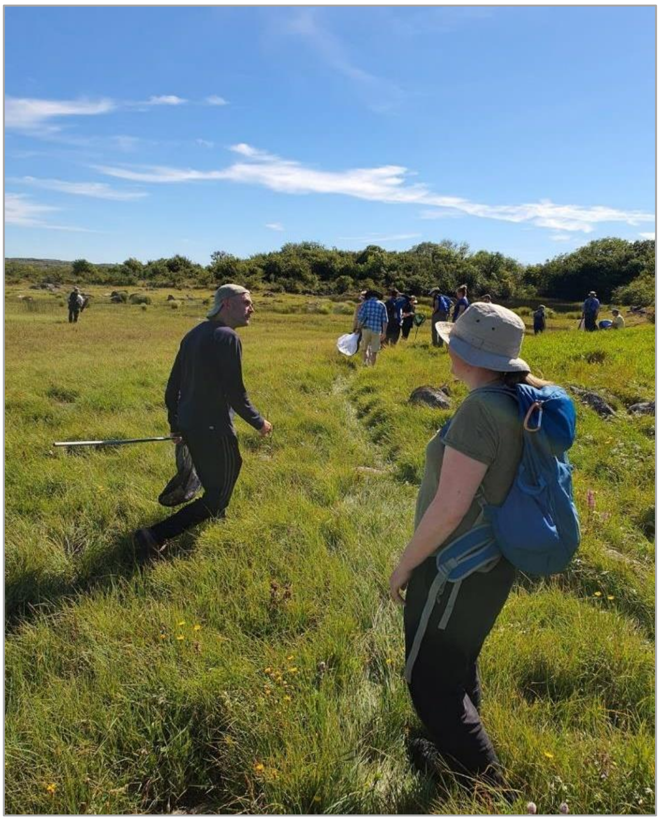
Lyons A., Ashton P.A., Powell I., Oxbrough A. (2017) Impacts of contrasting conservation grazing management on plants and carabid beetles in upland calcareous grasslands. *Agriculture, Ecosystems and Environment*, **244**, 22-31.

Lyons A., Ashton P.A., Powell I., Oxbrough A. (2018a) Epigeal spider assemblage responses to vegetation structure under contrasting grazing management in upland calcareous grasslands. *Insect Conservation and Diversity*, **21**, 383-395.

Lyons A., Ashton P.A., Powell I., Oxbrough A. (2018b) Habitat associations of epigeal spiders in upland calcareous grassland landscapes: the importance for conservation. *Biodiversity and Conservation*, **27**, 1201-1219.

Lyons A., Oxbrough A. and Ashton P. (2018c) Managing biodiversity in upland calcareous grassland landscapes: a case study of spiders and ground beetles. Edge Hill University, Lancashire, UK. Pages 1-32. ISBN: 978-1-900230-62-9 https://www.edgehill.ac.uk/document/managing-biodiversity-in-upland-calcareous-grassland-landscapes

Ashley Lyons speaking at the Michael Cusack Centre. *Photo Maria Long*


Jesmond Harding, Ashley Lyons and others in a turlough in the Burren National Park. *Photo Maria Long*

Day II (viii) Brendan Dunford, *Delivering conservation through a results-based agri-environmental programme – lessons from the Burren*

Brendan spoke about the conservation work he and lots of others have been involved in over the last 20 years. The Burren Programme's definition of the Burren (fertile rock) covers 72,000 ha and *c*. 95% of that is privately owned by somewhere around 1,000 farm families. There is a small amount of commonage and *c*. 2,500 ha in the National Park and nature reserves. About 30,000 ha constitutes Annex I habitats in SACs. The Burren was described as a 'botanical metropolis' by Webb and Scannell (1983), hosting over 70% of Ireland's native flora, with plants from the Arctic, Alpine and Mediterranean regions. And as we heard yesterday, the Burren also has an amazing invertebrate fauna.

The Burren has wonderful biodiversity and is also a farmed landscape, with a wonderful history of farming and archaeological legacy –of *c*. 6,000 years of human activity. The Burren holds fascination for many groups from farmers to botanists, invertebrate ecologists, archaeologists and geologists and it can make management challenging to accommodate the various demands and expectations of these groups. Even within groups expectations can vary.

If the Burren is over- or under-farmed, it starts to lose its biodiversity value, and its environment and heritage suffers. Like in other landscapes, the balance is being lost to abandonment and intensification. With too much farming, as happened in the 1980s and 1990s, you lose a lot of species, water pollution occurs, particularly associated with silage feeders. The other extreme is abandonment and scrub-encroachment, which happens because farming it is challenging and not economically viable, work is available elsewhere and part-time farmers concentrate on green land and slatted houses. As well as threatening biodiversity, intensification and abandonment threaten archaeology, tourism and recreation. So for many years now, a large team of people has been working to keep and restore the balance in the Burren. Undergrazing was the big threat over large areas.

The first responses to the threats of intensification and abandonment were designation, of archaeological sites and, particularly, SACs (1990s). These were important in preventing reclamation and destruction of important limestone pavement, but unfortunately these are still happening outwith the SACs. Designations really caused a bitter division between farmers and the national authorities, with farmers feeling that their freedom to farm was being taken from them. Ireland then did respond with the carrot of national agri-environmental schemes, which were an important source of income but very much top-down. Initially Burren farmers were told no more out-wintering – stopping 6,000 years of tradition. But then the rules were changed, but to the other extreme and only winter grazing was allowed and a cow on a field in summer could lead to a fine of €2,000-3,000. These national schemes were, therefore, not working for biodiversity in the Burren.

Then about 20 years ago, a new, inclusive, Burren targeted scheme was developed. Producing food is deep in psyche of all farmers, but with the new scheme farmers were being asked not only to produce food, but also to deliver all these other important environmental services such as high biodiversity, clean water, landscape features. This was a large mind-shift and cultural shift, so it was not easy and has been gradual over many different phases

- 1999-2001 – Brendan's PhD study on farming in the Burren
- 2005–2010 Burren LIFE project with NPWS
- 2010-2015 Burren Farming for Conservation
- 2015-now – the Burren Programme
- 2022 – working on development of new ACRES co-operation project (a national scheme, that is a continuation of the Burren scheme but with big differences)

Based on the Burren experience, what works

1. **Pocket**: very important – pay farmers to deliver clearly defined Ecosystem Services.
2. **Head**: Support farmers on *how* best to deliver Ecosystem Services, how to farm for nature, to suit plants, invertebrates, climate, *e.g*. when to graze, what breeds.
3. **Heart**: Persuade farmers that this is really *worth doing,* it is their legacy.

We need to get farmers on board, currently the relationship is not always good between the environmental and farming communities at a national level, but in the Burren the relationship is generally very good which helps the programme operate more effectively.

Pocket – 3 economic opportunities

1. Results-based payments

About 20 years ago, they developed a field scoring system on which they could base payments to farmers. This is paying for 'Ecosystem Services' using result-based payments model. If a field is overstocked and overgrazed and is delivering no ecosystem services, it receives a score of 0/10 and no payment. If a field is under-grazed and lacking diversity it receives a score of 4/10 and no payment. Payments are made on fields scoring from 5-10, with a maximum score of 10/10 receiving a payment of €315/ha. The Average Annual 'Biodiversity' Payment is €3,400. 'Paying for results' means that the farmer is free to decide how to manage the land.

The three main advantages of this approach are

1. The farmer has the total freedom to farm – they are not told how to farm, but rather what results or product they will be paid for
2. Detailed data are gathered on the condition of each field, each year and can track the impact of the programme
3. It delivers value for money

The project doesn't expect or want every field to receive a 10/10 because that would make the Burren uniform. They aim is to keep the Burren complex and variable using this scoring system.

Scores are assigned by farm advisors and the project team checks the score on about 20-30% of fields each year. The score card is simple. There area based bands for payments

Per ha payment	Score 10	Score 9	Score 8	Score 7	Score 6	Score 5	4	3	2	1	0
0-10 ha	€315	€240	€192	€168	€144	€120	-	-	-	-	-
>10-40 ha	€180	€135	€96	€84	€72	€60	-	-	-	-	-
>40-80 ha	€90	€68	€48	€42	€36	€30	-	-	-	-	-
>80-120 ha	€45	€34	€24	€21	€18	€15	-	-	-	-	-
>120 ha	€23	€17	€12	€11	€9	€8	-	-	-	-	-

The project pays out *c*. €1million/year to 321 farmers (In 2021 €1,098,969, an average of €3,424/farmer, ranging from €82 to €10,000 to one farmer with *c*. 400 ha of immaculately managed habitat).

2. Paying for practical actions

The scheme also pays for practical conservation support actions, designed to help improve the field scores, *e.g*. a field may receive a low score because of poor water management and pollution risk and a support action may be installation of water troughs. Other support actions include targeted removal of scrub that is encroaching on open habitats, and repair of stone walls to aid stock management. The farmer nominates the conservation tasks to suit his/her farm and boost the field score. The farmer also co-funds works. How it works, for example, with scrub removal, a planner marks the area(s) out on the farm plan map and provides a description of the works needed, and the farmer employs a contractor to do it. The programme pays 75% of the cost after the work is completed. Average Plan Value of *c*. €3,600

Task Type	Claimed €	% of total	Extent	Additional Info
Scrub Removal - Areas	€704,413.23	45.10%	136.18ha	54.62ha cut using brushcutter
Scrub Removal - Bands	€129,999.74	8.32%	21.86ha	10.26ha brushcutter, 8.88ha chainsaw
Scrub Removal - Paths	€139,419.36	8.93%	17.58ha	87,344m length equivalent
Scrub Removal - Burning / Chipping.	€25,329.05	1.62%	15 tasks	6 chipping tasks, 9 burning tasks

Wall Repair	€ 137,551.88	8.81%	41,799.5m	31,037m internal & 10,762m external
Water Installation	€ 131,584.35	8.42%	610 units	219 troughs, 280 pipe rolls, 30 storage tanks, 13 pumps, 13 harvesters
Access Tracks	€ 98,351.74	6.30%	33,520m	14,508m new, 19,012m upgraded
Fencing	€ 56,616.71	3.62%	36,718m	32,990m post and wire
Gates	€ 59,685.57	3.82%	271 units	108 Burren gates, 163 standard gates
Feed Equipment	€ 19,692.36	1.26%	270 units	194 feed bins, 5 silos, 71 troughs
Habitat Restoration	€ 29,111.77	1.86%	105 tasks	84 bracken control tasks
Livestock Handling Facilities	€ 22,680.31	1.45%	15 units	7 Cattle pens, 6 Crushes
Other (incl. Stone-facing, PPE)	€ 7,458.47	0.48%	18 units	18 sets of chainsaw safety gear
Total Allocation	€ 1,561,894.52	--	--	--

3. Creating new opportunities for farmers and the local community
These are both economic and social opportunities. The Programme is estimated to support *c*. 20 local jobs. These cover jobs in areas such as scrub clearance, wall repair, making Burren gates, producing troughs, leading walks (education and recreation services).

Head
4. Training
The team does a lot of in the field and local classroom training with farmers. Ideally such environmental training, advice and ongoing support is provided at a local level. The project team produce videos for farmers, *e.g*. most recently on grazing Purple Moor Grass *Molinia caerulea*, which is a big problem, how it has to be done in June/July. Sent the video out by WhatsApp.

5. Developing and demonstrating solutions together
Co-creation - and on-farm demonstration - of innovative environmental solutions. 95% of farms now in the programme do not feed silage on the winterages, instead using a tailored food ration. This is partly because such fields scored zero, but also because of the alternative feeding solution – an Irish produced tailored ration which was a solution proposed and tested by farmers. The ration is scattered across the ground and encourages livestock to graze throughout a site. Horses have proven to be excellent grazers in some sites. Old technologies around water harvesting have also been used successfully, and modernised with solar and wind, thanks to farmer knowledge.

6. Peer-to-peer learning
Farmers showing other farmers what they have done and how it works. This has been used throughout the Burren schemes and has now been taken to national level as part of Farming for Nature. Methods used have included farm visits, webinars, podcasts, short films, on-line forums, best practice guides. There is a new project called the horse's mouth, where they fund farmers to visit other farmers to share knowledge. In the countryside, it is not just the message, it is the messenger as well – the messenger must have credibility.

Heart
Heart is often neglected, but is essential. One of the reasons so many agri-environmental schemes haven't worked is probably because people have not bought into them, and see them as 'soft money'.

7. Investing in the future guardians of the land – place-based learning
For over 20 years, through the BurrenBeo trust, a charitable organisation, they have invested in the future guardians of the land – the farmers sons and daughters and other local people – through programmes such as 'áitbheo'. Thousands of Burren children have come through that programme and graduated as 'Burren Experts'. There is a new programme now called 'Heritage Keepers'. The idea of these is using critical thinking and having fun, to foster a sense of informed pride and stewardship of your place.

8. Building an engaged community – monthly walks and talks
It is a great way to share information on ecology and archaeology, *etc*.

9. Burren winterage festival – celebrating farming heritage
Highlight the importance of the grazing animal and the farming traditions.

Does it work?
The Burren Programme can track the impact of their work. In 2010, the average score across all fields and farms was 6.8 and that has increased every year, except the year of change over between CAP programmes, and is now *c*. 7.75. Within that, some farmers have dropped scores, some have stayed the same and some improved, including some very significant recoveries from intensified fields damaged by silage feeding to species-rich grassland, and overall the trend is upwards. So this demonstrates that the Burren is in better condition than it was 12 years ago. Approximately 70% of the is Burren under management at the moment. A value has been put on the impact of the scheme of at least €33 million in terms of landscape and biodiversity improvements since 2010.

The Burren approach was adopted across many parts of the country in 2016 with the development of targeted, results-based EIPs (European Innovation Partnerships) under CAP, such as the Hen Harrier and Pearl Mussel Projects. From 2016-22, these local projects were worth €70m, during a 'testing' phase with *c.* 2,000 participant farmers). This was a big success, with the result that under the new CAP (2023-28) results-based schemes , with a budget of €750m, will be rolled out to *c*. 20,000 farmers in eight 'Co-operation Projects' across much of the high nature value farmland in Ireland. There are always challenges when you scale up, however and there are concerns about the structure of this project.

Conclusions – lessons learned

- Farmers and landowners are a powerful (and under-used) – and potentially willing – resource in helping to tackle our climate and biodiversity crises, particularly in HNV areas.
- To mobilise this resource, at scale, we need to take a pocket, head and heart approach and provide supports which are
  - Locally targeted – in terms of design, stakeholder engagement, project management *etc*. – greater impact/ownership
  - Integrated – *e.g*. give farmers a single whole-farm sustainability plan (Biodiversity, Carbon, Water, Cultural heritage…) It is a confusing space – for all, *e.g*. should scrub/trees be cut down to make space for nature or kept for carbon?
  - Result-based - money earned should reflect both effort and outcomes, always incentivising improvement.
  - Farmer-friendly – ensure freedom to farm, adapt and innovate; minimal paperwork, positive language, celebratory. Respect farmer values.

Webb, D.A. & Scannell, M.J.P. (1983) *Flora of Connemara and the Burren.* Royal Dublin Society, Dublin and Cambridge University Press, Cambridge.

http://burrenprogramme.com/
https://burrenbeo.com/
www.burrenwinterage.com
www.farmingfornature.ie

Brendan Dunford speaking at the Michael Cusack Centre. *Photo Maria Long*

Day II (ix) Dara Stanley, *Pollinators and management on Burren farmland*

The work Dara presented was from on Michelle Larkin's PhD research, and Michelle was helped by Brendan, and his team, particularly Sharon with experimental set-up *etc*.

The Burren is a hotspot for diversity, with 70% of the native flora, a large proportion of which is in the semi-natural grasslands. The literature indicates that a high diversity of plants, especially flowering plants, means more pollinators. It is clear from Jesmond, Dave and Tom's talks that the Burren is a hotspot for hoverflies, moths and butterflies. In this research, they focussed on the following pollinators

- Bees – bumblebees and solitary bees
- Hoverflies
- Butterflies

The first research study looked at field vs landscape-scale

They looked at the variation in pollinators across grasslands, based on the scores assigned to them by the Burren Programme. In particular, they looked at the Conservation Value scores, which are based on plant diversity and score from D for improved fields, to A for highly diverse semi-natural grassland. Pollinators move and may be influenced by habitats beyond a field, so they asked two questions

1. How does the conservation value score of a field from a results-based agri-environmental programme affect pollinator diversity?
2. How does the composition of the surrounding landscape affect pollinator diversity?

Michelle, with Sharon's help, selected 23 sites all around the Burren varying in conservation value score from A to D. Half of these were within high intensity landscapes (within a 2 km radius there was more than 65% intensive land-use. Half were in a low intensity landscape (more than 65% low intensity land-use within a 2 km radius)

The survey took place in 2017 and two sampling methods were used: pan traps and transect walks. Almost across the board, more species were recorded using the transect walks, but there was value in using both methods

- Transects
  - 377 bumblebees (11 species)
  - 46 solitary bees (4 species)
  - 135 butterflies (17 species)
  - 314 hoverflies (32 species)
- Pan Traps
  - 53 bumblebees (6 species)
  - 41 solitary bees (6 species)
  - 152 hoverflies (21 species)

The exception being solitary bees, where both abundance and diversity was low.

- Plants
  - 80 species were recorded across 24 families
  - 46 species were observed to receive visits from insects

<u>Bumblebees</u>

- Higher bumblebee species-richness was recorded in fields with higher conservation value (D scoring fields significantly different to others, A and B highest). So field-scale agri-environmental management is important for bumblebees.
- Landscape context – high and low intensity surrounding land-use were not so important for bumblebees. Species richness was higher in fields surrounded by low intensity land-use, but not significantly so. This may be a result of the mobility of bumblebees, that can fly over longer distances.

<u>Hoverflies</u>

- Very different results
- No difference across conservation value scores,
- but landscape was important with significantly higher species-richness in low intensity landscapes. Hoverflies need more than just species-rich grassland – they need a diversity of features within a landscape, such as scrub *etc*., to provide larval habitat *etc*.

Butterflies

- Community composition – did not vary with conservation value
- Did find significantly different communities between high- and low-intensity landscapes, and similar to hoverflies, butterflies need heterogeneity with scrub and shelter particularly important.

Solitary bees

- Interestingly, only found eight species, which is only 10% of the Irish fauna
- *Lasioglossum calceatum* was the most commonly encountered species
- By contrast, Dara recorded nine species in the south-east of Ireland on intensively managed silage fields
- This could be because they only sampled twice, they only sampled species-rich grassland, it was an unusual year, and it may not be a true reflection of solitary bee diversity in the Burren. But it could also indicate that the karst landscape is not suitable for solitary bees. It is a harsh landscape – exposed, wet, windy. Also, a lot of our solitary bees are ground-nesters, and perhaps it is more difficult for them to find next sites because the dominance of rock in the Burren
- These questions show that there is a need for a lot more study of solitary bees.

Summary

- Local and landscape management has implications for pollinators
- Bumblebees respond to management at field scale – benefit from high floral diversity
- Landscape scale is more important for hoverflies and butterflies – a diversity of habitats particularly important

The conclusions of this study were that field-scale management works very well for bumblebees, but the other pollinator groups need landscape-scale management.

The second research looked at interactions between pollinators and plants

They created plant-pollinator networks based on the number of visits of pollinators to plants, collected using transect walks. They found much more complex plant-pollinator interactions in A fields than in D fields and could identify key plant species for different groups

- Bumblebees
  - Common Knapweed *Centaurea nigra* – all nine species visited it and 17% of bumblebee visits were to Common Knapweed
- Solitary bees
  - Rough Hawkbit *Leontodon hispidus* (3 out of the 4 solitary bee species recorded, 34% of all visits)
  - Meadow Buttercup *Ranunculus acris* (2 out of the 4 solitary bee species recorded, 24% of all visits)
- Butterflies
  - Autumn Hawkbit *Scorzoneroides autumnalis* (5 out of the 8 butterfly species recorded, 14% of total visits)
  - Common Knapweed *Centaurea nigra* (5 out of the 8 butterfly species recorded, 23% of visits) had the highest species strength for butterflies with
  - an additional five plant species needed to cover all 8 species
- Hoverflies
  - Creeping Buttercup *Ranunculus repens*. had the highest species strength (13 out of the total 28 hoverfly species recorded, 25% of visits)
  - An additional 8 species were required to include the remaining 15 hoverfly species
  - Most hoverfly and solitary bee species have relatively short tongues so need to feed on open flowers

Shrill Carder Bee *Bombus sylvarum*

- One of the rarest bumblebee species in Ireland
- Endangered on Irish Red List (Fitzpatrick *et al*., 2006)
- The Burren is now its stronghold, not just in Ireland, but Ireland and Great Britain
- Not a huge amount is known about the species, so Michelle wanted to carry out basic ecological research, by comparing its habitat requirements with three more common species: *Bombus lucorum, Bombus pascuorum and Bombus lapidarius,* across a range of different habitats:

calcareous grassland, Hazel *Corylus avellana* scrub, limestone pavement, mosaic, semi-improved grassland

- Did not find significant differences in the abundance of the more common species across these Burren habitats, showing they are using a wide range of habitats
- *Bombus sylvarum* – found more in calcareous grassland than in other habitats, probably explaining the importance of the Burren for this species
- *Bombus sylvarum* – foraged on a range of species, the most important being Common Knapweed *Centaurea nigra* and Devil's-bit Scabious *Succisa pratensis*
- It is late to emerge, and forages into September or October
- So the timing of management is important for bumblebees, in particular we need to think about the provision of flowers in September-October. These are important for new reproductive to allow them to build up their reserves to get them through the winter.

Conclusions

- The Burren has lots of flowers, and therefore is a pollinator hotspot – certainly for bumblebees, hoverflies and butterflies
- But the jury is still out on Solitary bees – under-recorded or under-represented? – more work needed
- Local field-scale management is really benefiting some groups, but other pollinator groups need both field-scale and landscape scale management
- Some plants are key – but this does not mean pollinators are reliant on one or two plants - they do need a diversity of plants
- Rare species, particularly *Bombus sylvarum* - the Burren is a hotspot

Great Yellow Bumblebee *Bombus distinguendus*

- Belmullet is its remaining stronghold in Ireland
- but the flowers in forages on and the type of grassland it uses are well represented in the Burren
- and it was known from the Burren until about ten years ago
- It is a bit of a mystery why it is no longer in the Burren - perhaps disease or competition with honeybees, but it is a mystery that needs work
- And is a species to look out for.

Questions/comments

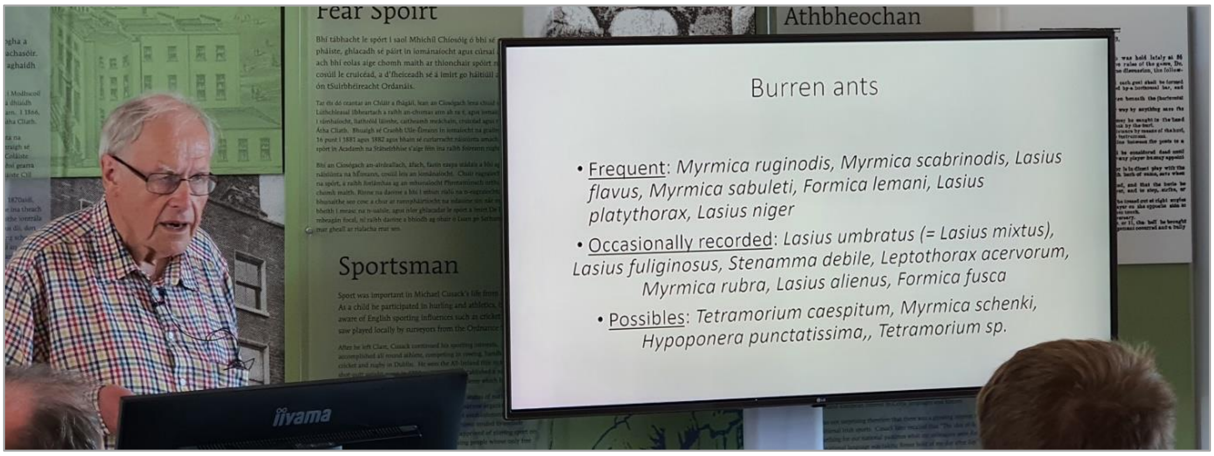
Neal Jeuken – keeping hives means releasing large numbers of honeybees into the landscape, do they impact on native pollinators?
Dara – the vast majority of honeybee colonies are managed, but there is some evidence of some feral populations in Ireland. There is some evidence that very high densities of honeybees changes the behaviour of native pollinators, and also of disease transfer from honeybees to bumblebees, but overall, the data are insufficient in this area.

Brian Nelson - it would be interesting to examine the variation in terms of pollinator species composition, functional traits or guilds.

@darastanley
www.stanleyecologylab.org

Fitzpatrick, U., Murray, T.E., Byrne, A., Paxton, R.J. and Brown, M.J.F. (2006) Regional red list of Irish Bees. Report to National Parks and Wildlife Service (Ireland) and Environment and Heritage Service (N. Ireland).

Larkin, M., and Stanley, D. A. (2021). Impacts of management at a local and landscape scale on pollinators in semi-natural grasslands. *Journal of Applied Ecology*, **58**, 2505–2514. https://doi.org/10.1111/1365-2664.13990



Day II (x) Tim King, *Ants and management*

Tim began by saying that he believes that ants are so important in management that someone like Brendan ought to give every farmer a Euro (€) an ant-hill, while realising this may be a somewhat extreme point of view. There are about 13 or 16 species of ants found on the Burren, depending on where you place the boundary

- Frequent: *Myrmica ruginodis, Myrmica scabrinodis, Lasius flavus, Myrmica sabuleti, Formica lemani, Lasius platythorax, Lasius niger*
- Occasionally recorded: *Lasius umbratus* (= *Lasius mixtus*), *Lasius fuliginosus, Stenamma debile, Leptothorax acervorum, Myrmica rubra, Lasius alienus, Formica fusca*
- Possibles: *Tetramorium caespitum, Myrmica schenki, Hypoponera punctatissima, Tetramorium* sp.

There are considerable problems with our knowledge of ants in the Burren

- Under-sampling. Hardly anyone has sampled the Burren properly by pit-fall trapping, soil sampling or vacuum sampling.
- Ant specialists are prone to split, so for example *Lasius niger* was split in 1991 into *Lasius niger* and *Lasius platythorax*, which is probably far more abundant than *Lasius niger* – on the Burren at least. When you have *Lasius flavus*, you do not know if you have one of the species that was formerly associated with it. Tim is a lumper and is more interested in what these organisms do, than what they are called.

He is speaking about most of the biodiversity on the Burren, which is in the soil. It is not those charismatic organisms that are found above the soil, but rather below ground. The more important and more diverse organisms are stuck in the soil.

Burren ant habitats

- Xerothermous rocky: *Formica lemani, Myrmica sabuleti, Lasius alienus, Myrmica schencki*
- Grassland: *Lasius flavus, Myrmica scabrinodis, Lasius niger, Lasius umbratus*
- Heathland: *Tetramorium caespitum*
- Scrubby: *Lasius platythorax, Lasius fuliginosus, Lasius umbratus, Leptothorax acervorum*. These may all occur in Hazel *Corylus avellana* scrub, but how to find them?, especially as Lasius *fuliginosus* is a hyper-parasite – in invades *Lasius umbratus* which itself invades *Lasius niger*, and the change might take 20 years. So how do you happen to find it amongst all the species?
- Pine & Hazel woodland: *Myrmica ruginodis, Stennama debile*
- Marshes: *Myrmica ruginodis*
- Stone walls: *Leptothorax acervorum*

Burren soil invertebrates are under-sampled

- Soil is a black box
- Motor on which all charismatic species depend
- Recycling of nutrients, aeration and renewal of soil, providing plant nutrients, food for all animals
- Earthworms, ants, springtails, mites, aphids, nematodes, flatworms, mycorrhizal and other fungi, bacteria (decomposers, ammonium oxidisers, nitrogen fixers)
- Lots of important soil invertebrates have not been mentioned at this conference

There is a huge amount of work to do on below ground organisms in the Burren.

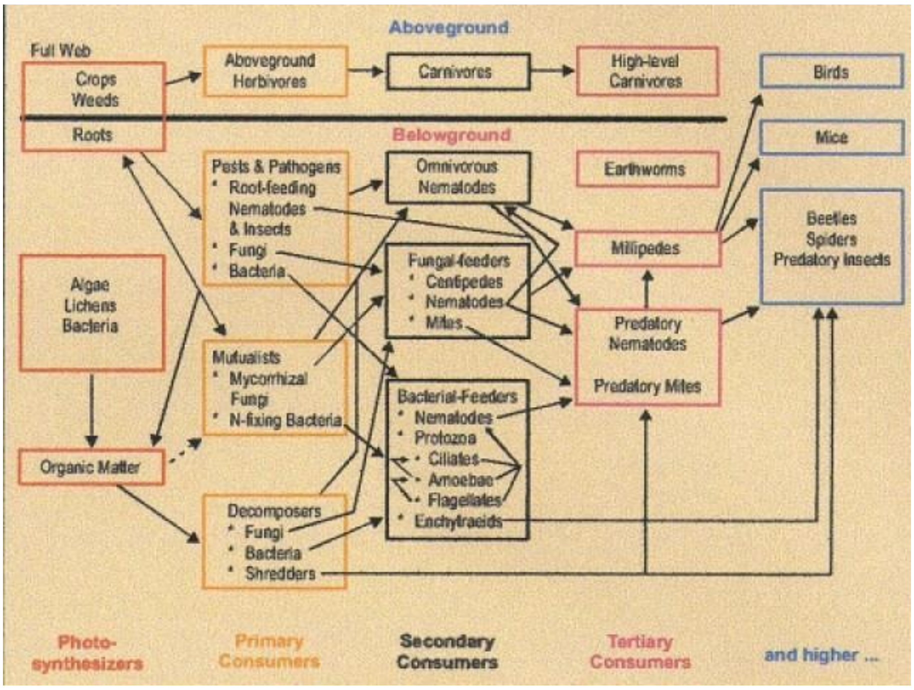


Diagram summarising the importance of soil organisms (below the horizontal bar) arranged by trophic level

Lasius flavus

Tim emphasised the importance and complexity of the yellow meadow ant, ***Lasius flavus*****,** and covered some of the invertebrates which, like this subterranean ant, are hidden from view at this conference.

Burren grasslands consist of two habitats, ant-hills and the surrounding grasslands. Ant-hills are a distinct habitat. When you sample terrestrial invertebrates, whether you have sampled from an ant-hill or not is important, and should be recorded on museum labels.

- *Lasius flavus* is different to the organisms we have discussed – it builds things, semi-permanent structures. It is in the same category as corals or beavers in building great big structures that are used by a wide range of other organisms and so *Lasius flavus* has probably had a major effect on Burren biodiversity over a very long period, *c.* 6,000 years. *Lasius flavus* is the main mound-builder in European grasslands
- Its warm ant-hills increase the rate at which the young broods develop
- Its worker ants are 3-4 mm long, yellow and subterranean with small eyes
- The larger queens burrow into bare soil where they can establish a new colony (this behaviour was observed during the conference field trip on Day 1 9 August
- Up to 100,000 workers occur in a large mound, but not all of the ants are in the mounds, they also dominate the soil beneath the surface between the mounds
- The workers carry soil particles onto the surface, especially at night after rain, so are hardly ever seen – they are subterranean
- These ants are engineers, farmers & conservationists.
- They produce **HETEROGENEITY** – the mounds create structure, they have height and sides with different aspects, lots of bare soil. There is also **HETEROGENEITY AMONGST ANT-HILLS** themselves: abandoned and occupied ant-hills, ones of different sizes, on different slopes. Ordinary grassland is boring: grassland with ant-hill is really interesting. A study by John Breen in the Burren indicates that there is an increase in plant diversity on ant-hills. There should be an accompanying increase in invertebrate diversity as well. So one indicator of good grasslands that should be conserved is ant-hills.

Why is this species special?

- Keystone species – particularly numerous and if you took its ant-hills out of the environment, you would lose lots of different plant and animal species
- Considerably affect flora and fauna

- Affects grassland between ant-hills (Allogenic) Engineer
- Mounds long-lived
- Grassland heterogeneity
- Largest biomass for an ant species worldwide, up to 165 kg/ha fresh-weight.
- In a dense population, it hauls up to 7 tonnes/ha of mineral soil to the surface each year.

Ecological services

- Increases species richness in flora and fauna
- Considerably increase grassland microclimate diversity and soil moisture and nutrient diversity
- Maintaining bare soil in grasslands, providing seed germination microsites and animal microhabitats (important for oviposition for grasshoppers, sites for solitary bees and other organisms that need bare soils)
- Transporting mineral soil from depth to surface, counteracting leaching, increasing soil depth
- Creating aeration and drainage channels beneath the surrounding grassland (rather like earthworms and particularly important in acidic soils where earthworms tend not to be abundant)
- Refuge for low-growing characteristic grassland plant species when surrounding grassland is under-grazed – there are certain winter annuals which only occur on ant-hills, *e.g*. Thyme-leaved Sandwort *Arenaria serpyllifolia*, Wall Speedwell *Veronica arvensis*, Rue-leaved Saxifrage *Saxifraga tridactylites* – Tim has identified about 40 different species that in many sites are confined to ant-hills (King 1977a, 2020)– and would not occur if the ant-hills were not there
- Recycling of nutrients from plants to soil by harvesting aphid honeydew from plants. There is a very consistent pattern that potassium ion content of ant-hills is roughly three-times that of surrounding grassland and this may well be the result of honeydew harvesting by ants.

The ants build higher and rapidly when surrounded by tall grasses, *e.g*. *Brachypodium* spp., resulting in a characteristic shape when the height exceeds the radius. In situations where grazing has been removed, they may act as reserves of grassland species, refugia from which such species can re-colonise once grazing has resumed.

Space & Time

- Ant-hills were very abundant in British grazed pastures 1450-1780, during the period of maximum sheep grazing – and a legend tells that you could walk right across Rutland or Northamptonshire by stepping on ant-hills all the way. It was likely to have been similar in the Burren. In the Burren, it is probable that ants counteracted the leaching effect and slowed down the loss of soil into the grykes by transporting soil back onto the clints and surface
- British farmers realised that ants limited sheep productivity, because ant-hills create bare and droughted soil and sheep and ants are in competition with one another for photosynthate. As a result, a massive, nation-wide eradication campaign was implemented. County agricultural accounts between 1780-1813 all have a chapter on how to eradicate ant-hills. And ant-hills have been reduced ever since
- Reduced by ploughing pastures in Napoleonic Wars, agricultural depressions, First & Second World Wars, rabbit myxomatosis (1954)
- Now ant-hills indicate old grasslands
- New campaign, spear-headed by Tim, to get ant-hills back
- More or less invisible even to many biologists.

History of Burren ant-hills?

- Could have survived glaciation on nunataks or migrated from Britain before land bridge submerged
- Would have declined during woody phase up to 5,500 years before present
- Expanded on subsequent grasslands, counteracting erosion by humans and cattle
- Probably rife until the potato famines and declined later cf. Great Britain counties
- Range limited by appearance of bare clints and invasion of scrub and woodland
- Still counteracts erosion in grikes and replenishes upper soil
- Mounds may provide deep soil patches for shrub and woodland invasion, as in boreal regions where ant-hills provide the only deep soil on limestone and the main places that shrubs can establish. A Burrenbeo Trust You-tube (Sharon Parr) shows Hazel is established on an ant-hill.

Burial

- Sand dunes in the grassland
- Smothers rosette species
- Favours species capable of growing rapidly through heaped soil – 10 cm, *e.g*. Wild Thyme *Thymus drucei*
- Creates bare soil suitable for establishment of winter annual plants
- Ant-hills create higher temperatures and reduced soil organic matter produce dry soil in mid summer
- Get lots of small ant-hills to start with, that are easily over-looked
- The Porton Ranges is the main ant site in Great Britain and has about 3 million ant-hills in *c*. 7 square miles. Bushy Park, London, old grassland established in 1490 is another good site.

Distinct vegetation

- A lot of grassland is ex-ant-hill. There is a distinct succession associated with occupied and abandoned ant-hills.
- More species capable of growing through heaped soil
- More short-lived species
- More mosses which colonise bare soil
- Fewer rosette herbs
- Creeping mosses on the north side

Studies

- When ant-hills are occupied, they continue to increase in volume (probably for hundreds of years), but when abandoned, their volume decreases. Tim measured ant-hills at the same site from 1970-2015
- From 24 different sites, data show that ant-hills are small at the start, grow rapidly and ultimately reach a maximum size where the rate of erosion equals the rate of accumulation.

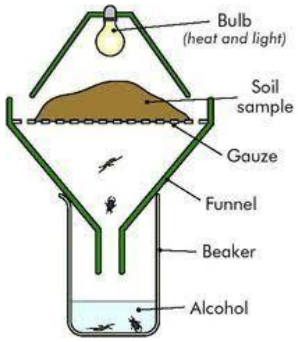
Value to other animals

- Food source for choughs
- Oviposition for grasshoppers, butterflies, moths
- Numerous ant-associated aphids, inquilines, parasites, caterpillars
- Many mammals
- South side microclimate important for invertebrates requiring warmer conditions
- Early spring grazing for sheep, deer, cattle
- Grazing, by rabbits, sheep, deer *etc*., as well as mowing, causes damage to ant-hills, the removal of vegetation and creation of bare soil patches. Similar damage can be caused by digging by badger, fox and dog. The bare friable soil is then colonised by both social and solitary bees and wasps, which are then attacked by mice, field mice, voles and shrews
- The mite *Antennophorus grandis* parasitizes *Lasius flavus*, wraps forelimbs around the ant's neck and when ants exchange fluids, stick their heads up and slurp some
- The blind white woodlouse *Platyarthrus hoffmannseggii* associated with *Lasius flavus* and *Lasius niger*
- Staphylinid beetle *Claviger testaceus* is often associated with *Lasius flavus* ant-hills
- Hoverflies, *Microdon* spp. including *M. devius* – four species that never fly far from the mounds
- Largest biomass and diversity is aphids, mites and springtails.

Aphids

- 22 specialised species; small cornicles, hairy bottoms
- Most of the intake of energy comes from eating aphid honeydew. The aphids live on the roots of the surrounding plants
- The aphids live in groups on the roots
- Aphids are collected by the ants in winter, moved to the mounds (over-winter in lumps in mound), and then replaced on the roots in spring
- High proportion are single clones
- Very large numbers of aphids.

Tim has sampled soil fauna on and around the mounds at Richmond Park NNR, with a soil auger, producing soil cores c. 15 cm deep. Invertebrates were extracted using a Tullgren funnel. Organisms <2 mm fall down through a gauze. Leave for *c*. five days.



Tullgren funnels in action

Ant-hill

- 73% of the ants (reproductive centre)
- 6% of aphids
- 5% of springtails
- 3% of mites

Surrounding grasslands

- 27% of the ants – 5,500 worker ants per square metre. During the day they are foraging, moving between mound and the aphids on roots of plants
- 94% of aphids – 2,740/m^2, clumped distribution
- 95% of springtails – 7,390/m^2
- 97% of mites – 21,130 /m^2

Ants are working as primary consumers – feeding on honeydew produced by aphids and passing it onto their larvae in the mounds. Ultimately, some of the larvae become new queens. But ant larvae don't just feed on honeydew, they also feed on aphids (particularly nymphs), mites and springtails collected by worker ants. Work by John Breen and others shows in summer (August) worker ants occupy the second trophic level, when they are feeding up the queens. At this time, the queens have hatched and sit beneath the tops of the mounds where they are fed by the workers on these other soil invertebrates (putting on 2.5 times their weight).

Conclusions

- Burren soils are seething with invertebrate life; soil organisms should be studied in more detail
- *Lasius flavus* is one of the most numerous and influential invertebrates, creating a distinct plant and invertebrate community
- Its mounds create grassland heterogeneity (aspects, slopes)
- Amongst the mounds there is heterogeneity in age, size, activity, abandonment
- In areas lacking grazing, the mounds maintain a bank of plant and invertebrate species characteristic of an earlier stage of succession
- *Lasius flavus* counteracts erosion but the mounds may increase the rate of scrub invasion
- This ant affects the grassland between the mounds
- It competes for photosynthate with above ground herbivores
- It may affect the balance of plant species in the nearby grassland
- *Lasius flavus* has probably played a major role in the Burren in grazed situations in the past and will do so in future

Management

- Most ant species have short-lived small mobile colonies; they are adaptable and do not require special measures

- Watch out for the jet black ant *Lasius fuliginosus* crawling up trees in lines to milk aphids; hyperparasite very rarely recorded on the Burren
- Wider range of sampling techniques desirable to find extra ant species *e.g*. pitfall trapping
- In view of the presence of *Myrmica sabuleti*, consider the possibility of introduction of the large blue butterfly?
- Maintain the optimal balance of the main habitats; woodland, scrub, grassland and *Lasius flavus* mounds
- Ask local farmers what they think about ant-hills; they are likely to know a lot
- Abundant large-ant-hills likely to indicate old grasslands. Grasslands usually accumulate plant and invertebrate species with age. Such sites need to be preferentially sampled and conserved (*e.g*. remove invading shrubs)
- Ant-hills are resilient to damage by grazing mammals
- National Park managers, farmers and conservationists need to be alerted to the value of ant-hills in maintaining floral and faunal biodiversity
- Ant-hills should be incorporated in management plans, and nature trails for the public
- Ant-hill sites lacking grazing need to have mammal grazing introduced
- In areas, such as parks, churchyards and gardens, in Burren villages which boast ant-hills mowing should be replaced by scything or strimming around the mounds
- Youngsters should be encouraged to investigate ant-hills to increase their appreciation

Tim has successfully translocated ant-hills at Richmond Park and advocates it as a management measure.

Shade gradually reduces the number of queens and drones produced by the colony. Ants react to shade by building taller at first, but can't keep pace and eventually the colony dies out. Under Hazel scrub, you are likely to find the remnants of ant-hills.

The yellow meadow ants have no particular preference for substrate: they can even build on sand dunes and in coastal areas where they are inundated in salt water for about half of the tidal cycle. Their mounds are Incredibly resilient to damage by grazing animals. Do not show any preferences in terms of pH *etc*.

Bargett, R.D. & Wardle, D.A. (2010). *Aboveground-Belowground Linkages*. Oxford University Press. ISBN 978-0-19-954688-6.

Boots, B., Keith A.M., Niechoj, R., Breen, J., Schmidt, O. & Clipson, N. (2012). Unique soil microbial assemblages associated with grassland ant species with different nesting and foraging strategies. *Pedobiologia*, **55** (1), 33-40.

Breen, J. & O'Brien, A. (1995). Species Richness in Oldfield Limestone Grassland. pp. 204-9, *In*: Jeffrey, D.W., Jones, M. & MacAdam J.H. (eds) *Irish grasslands -their biology and management*. Royal Irish Academy, Dublin.

King, T.J. (1977a). The plant ecology of ant-hills in calcareous grasslands. I. Patterns of species in relation to ant-hills in southern England. *Journal of Ecology*, **65**, 237-256.

King T.J. (1977). The plant ecology of ant-hills in calcareous grasslands. II. Succession on the mounds. *Journal of Ecology*, **65**, 257-278.

King, T.J. (1977). The plant ecology of ant-hills in calcareous grasslands. III. Factors affecting the population sizes of selected species on ant-hills. *Journal of Ecology*, **65**, 279-315.

King, T.J. (1981). Ant-hill vegetation of acidic grasslands in the Gower peninsula, South Wales. *New Phytologist*, **88**, 559-571.

King T J (2006). The value of ant-hills in grasslands. *British Wildlife,* **17** (6), 392-397.

King, T.J. (2020). The persistence of *Lasius flavus* ant-hills and their influence on biodiversity on grasslands. *British Journal of Entomology and Natural History,* **33**, 215-221.

King, T.J. (2021). Ant-hill heterogeneity and grassland management. *Ecological Solutions and Evidence*, **2**, 2020;00:e12037. https://doi.org/10.1002/2688-8319.12037.

King T.J. & Balfour, J. (2020). A technique for the translocation of ant colonies and termite mounds to protect species and improve restoration efforts. *Conservation Science and Practice*, **2**, https://doi.org/10.1111/csp2.154.

Long, M.P. (2011). *Plant and snail communities in three habitat types in a limestone landscape in the west of Ireland, and the effects of exclusion of large grazing animals.* Doctoral thesis, Trinity College Dublin.

Niechoj, R. (2011). *Irish Ants (Hymenoptera, Formicidae): Distribution, Conservation and Functional Relationships.* Doctoral Thesis, University of Limerick.

Parr, S. (2022). Appreciating Hazel in the Burren. YouTube. Burrenbeo Trust

Vlaskova, B., Raabova, J., Kyncl, T., Dostal, P., Kovarova, M., Kovar, P. & Herben, T. (2009) Ants accelerate succession from mountain grassland toward spruce forest. *Journal of Vegetation Science*, **20** (4), 577-587.

Day II (xi) Nigel Bourn, *Grassland management for butterflies*

Acknowledgements
Work by Sam Ellis and Jenny Plackett, as well as Nigel's own studies, informed his talk.

Importance of grassland and threats

Across Europe, grasslands hold the majority of butterfly species: 280 species are found on grassland, 153 in woodland and scrub, 25 on heath bog and fen, and 31 on other habitats. Nigel sometimes says he works on grasslands and woodlands, because those are the habitats where most of the butterfly species are found.

The key current threat to butterflies across Europe is abandonment, particularly in the upland. And this has been happening for many years. Agricultural intensification is the other major threat, as illustrated by figures on the destruction, modification and fragmentation of habitats in England

- 97% loss of flower-rich grassland
- 80% loss of chalk and limestone grassland
- 50% loss of ancient broad-leaved woodland
- 40% loss of lowland heathland

Basic principles of grassland management for butterflies

We need to maintain pastoral systems that maintain open grassland habitats, including

- Livestock grazing, which we've spoken a lot about,
- Hay-cutting – should not be forgotten about. Hay cutting systems have been decimated across Europe.

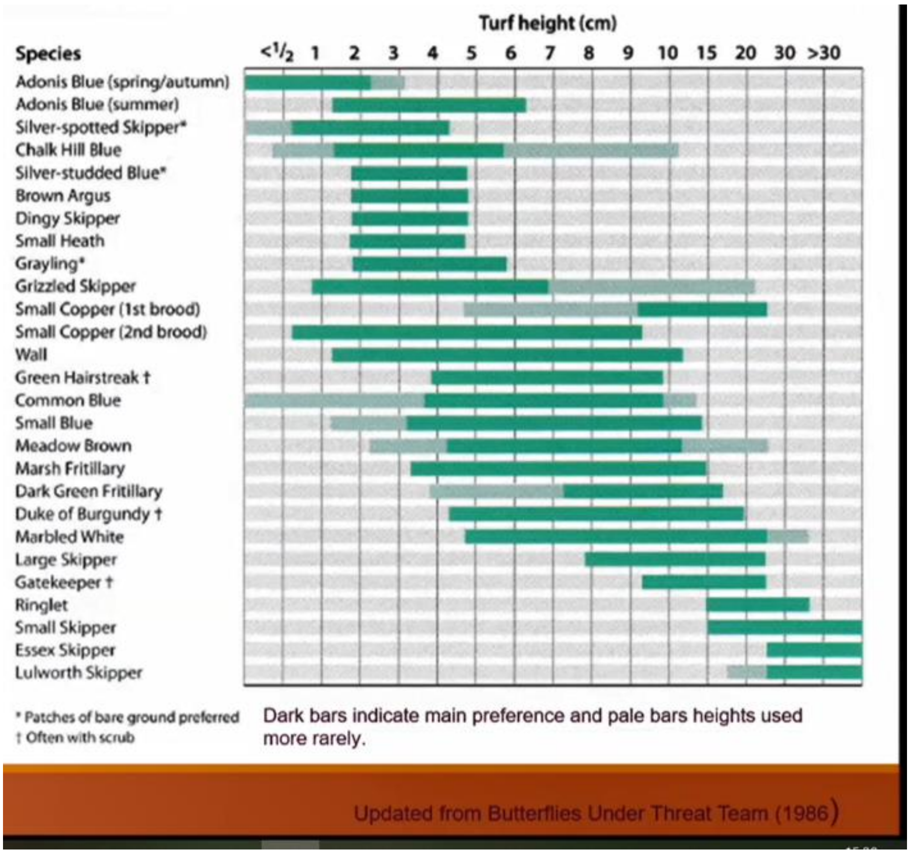
About ten years ago, Butterfly Conservation worked with Natural England on an agri-environment scheme and developed three key solutions for farmland management for butterflies: the Farmland Butterfly Initiative. This was working on seven priority species. The came up with the FBI-Big Three

1. Structural variety in grassland sward
    a. Description – Varied sward, ranging from bare ground, short, medium and tall vegetation. Scattered small patches of bare ground which provide water micro-climates for adults/larvae and where food-plants can germinate.
    b. Management needed to achieve feature – Moderate/light grazing. No summer sheep grazing or, if present, must be very extensive sheep. Bare ground patches may be provided by hoof impact of cattle grazing, sheep tracks, pulse grazing, scrub-clearance *etc*.
2. Summer nectar
    a. Description – Abundant flower-heads throughout summer (mid-April to August)
    b. Management needed to achieve feature – Moderate/light cattle grazing. No or very extensive summer sheep grazing.
3. Scrub (depending on species/habitat)
    a. Description – Scattered scrub on grassland and/or scrub patches of varied sizes and ages
    b. Management needed to achieve feature – Retain some scrub if required. Manage on rotation to create a range of patch sizes and ages. Amount required varies with species.

These principles will maintain the butterflies on your grassland – clearly heterogeneity of management is important.

Principle – variety of turf height

As has been emphasised throughout the conference, heterogeneity is important, as can be illustrated by the turf-heights favoured by most British grassland species for successful breeding, from the Adonis Blue *Polyommatus bellargus* which prefers very tightly grazed chalk grassland to the Lulworth Skipper *Thymelicus acteon*, which prefer un-grazed grasslands.



Principle – variety of grazing
Grassland heterogeneity and variability can be delivered in different ways

- Livestock type – cattle give a more varied sward than sheep, ponies are good for restoration (scrub encroachment)
- Grazing intensity (livestock units)
- Timing or seasonality
- Grazing system (*e.g*. extensive, rotational, pulse graze, transhumance)

Overgrazing – reduces the heterogeneity, leads to a loss of structural diversity, larval host-plants may still be present but in not in suitable growth form, limited nectar sources.
Under-grazing – eventually results in woodland, leads to closed grassland with fewer germination sites, more coarse grasses, scrub invasion.

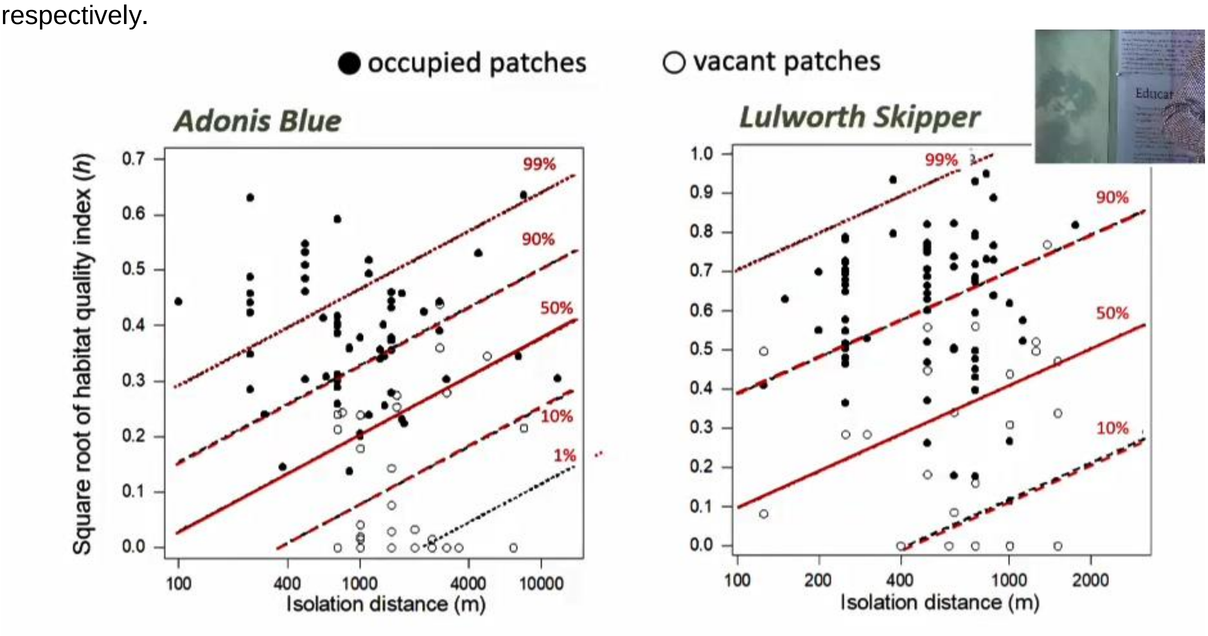
Principle – variety of disturbance.
Localised mechanical disturbance can be used. Nigel worked on a £2 million pound project to remove Cotoneaster from calcareous grassland at Portland in Dorset and advised that the problems of the spread of Cotoneaster in the Burren should be tackled now. If it is not dealt with at the earliest possible time it can be very costly and challenging. At Portland, they used the opportunity to created scrapes for Silver-studded Blue. Exposing bare ground re-set succession and increased the availability of its food plants Bird's-foot trefoil (*Lotus corniculatus*) Rockroses (*Helianthemum* sp.) and other low growing shoots.

Principle – avoid uniform management
Listen to the farmers and use their experience and knowledge. It is especially important in hay meadows: vary cutting dates. A mosaic of small-scale cutting mimics traditional management before mechanisation.

Principle – mosaic with scrub
Mosaics are really crucial. Different resources are provided by different habitats. For some species, scrub edge is very important – they breed along scrub or woodland edges. Grasslands are important for nectar. So individual species require the resources provided by multiple habitats and habitat variability supports more species.

Moving to landscape-scale conservation
Landscapes provide that habitat diversity: grasslands with swards of different height, scrub/woodland edges along grassland and more dense woodland. So considering landscape-scale diversity is important.

Landscape-scale conservation is now a common approach in the UK. A very influential publication was Lawton (2010) Making space for nature: review of England's Wildlife Sites and Ecological Networks', that spoke about bigger, better, more joined up management, which Butterfly Conservation followed up with a report on lessons from butterflies (Ellis *et al*., 2012). Nigel illustrated the theory underpinning Butterfly Conservation's landscape-scale conservation using Adonis Blue *Polyommatus bellargus*, which feeds on Horseshoe Vetch *Hippocrepis comosa* and requires very short, close-grazed vegetation to lay its eggs on, and Lulworth Skipper, which feeds on *Brachypodium pinnatum* requires tall vegetation, up to 20 or 30 cm tall (Thomas, *et al*., 2001). The two species occur in the same area, but in very different habitats/patches, with very different management. The graph illustrates that there is a much higher chance that habitat patches will be occupied the higher their quality, and also the shorter the distance to other patches and populations. It illustrates metapopulation dynamics, and also that higher quality habitats produce farm more individuals. The same pattern was seen in other species (Thomas *et al*., 2001). Habitat quality was the best predictor for each species, with habitat predictive association (GKG) values of 85% for Adonis Blue and 74% for Lulworth Skipper, followed by patch isolation, 51% and 39% respectively, while patch area was not a good predictor at 12% and 8% respectively.



Conservation case study and lessons learned

Case study: Marsh Fritillary and Dartmoor Fernworthy-Long Lane network.
This conservation project has been running since 2005. It was first part of 'the two moors project' (Exmoor and Dartmoor) followed by the 'all the moors project' which also included Bodmin Moor. Marsh Fritillary occurs in damp, botanically diverse, Purple Moor Grass *Molinia caerulea* – Soft-rush *Juncus effusus* pasture (tussock-forming grasses and rushes), feeding on Devil's-bit Scabious *Succisa pratensis*. The grassland is managed by grazing and scrub control. At Dartmoor there are four valleys with important grasslands and Marsh Fritillary *Euphydryas aurinia*, and while the moors are protected, these valleys are not and have suffered all of the usual impacts of intensification and abandonment. The Fernworthy-Long Lane system is one of these four valleys. The main management requirement is to create the conditions required by the Marsh Fritillary for breeding, specifically the larval food-plant in the right growth form. The management required to deliver this are

- Appropriate grazing with hardy ponies or cattle
- Occasional burning on rotation as a restoration tool or where grazing is not feasible
- Scrub control
- Good connectivity to adjacent breeding patches to enable butterfly to move between sites

The project started in 2005, with Butterfly Conservation working very closely with Natural England. 15 farmers participated, with 20 habitat patches in the Fernworthy-Long Lane system. Measures undertaken included

- Provided habitat management advice across the whole valley
- Provided support with entry Stewardship Agreements for half the farms
- Cash for fencing (provided almost 5 km of fencing)
- Re-introduced Dartmoor ponies
- Opened up flight routes to connect habitat patches
- Scrub clearance (targeted)
- Strimming of soft rush
- Organised volunteer work parties (particularly in later years of the project)
- Enabled over 90 ha of grazing to be restored
- Managed a further 10 ha

In 2005, the Marsh Fritillary had contracted to just six patches in four sites in the valley. 15 patches were occupied in 2015 and the habitat resource was increased by 46.1 ha. The expansion of the butterfly was by natural colonisation following appropriate management. In 2021, the situation was stable with 15 patches occupied and

- The connectivity had improved: the mean distance between a habitat patch and the nearest occupied patch reduced from 542 m to 360 m
- Patch occupancy increased from 30% in 2005 to 70% in 2021
- There was 95% occupancy in the peak year of 2010
- The species is doing better on Dartmoor than in the UK overall. On Dartmoor it as increased by 386% since 2005, compared to a UK decline of 27%

The work now is heavily dependent on volunteers helping farmers.

Lessons learned from Two Moors Study

1. Sustained effort is essential – requires long-term funding
2. Skilled advisors are crucial
    a. Advice was provided to 290 farmers across Dartmoor and Exmoor
    b. To build strong relations with landowners, which are very important
    c. To deliver habitat management advice – management was delivered across 1,500 ha of habitat
    d. To manage contractors (like reducing paperwork, makes it more appealing to farmers)
    e. To provide training – 5 training workshops held annually
    f. To recruit and manage volunteers – 20 volunteer work parties were held annually
3. Networking between landowners is absolutely essential
4. Action now is cheaper than later, *e.g*. Cotoneaster project Portland cost £2 million and still a problem, scrub expands and becomes woodland
5. Monitoring measures success – and allows adaptation and improvement
6. Other species and habitats benefit too from the improvement in butterfly habitat quality
7. Maintaining project outcomes is important
    a. Working with local communities, inspiring the public, and training landowners and volunteers helps secure the project legacy
8. Partnerships are essential

Summary and conclusions

1. Importance and threats
    - Grasslands across Europe and biodiversity hotspots
    - Under- and over-management (abandonment and intensification) are the major threats
2. Principles of management
    - Heterogeneity – in both sward and habitat
    - Delivered through – stock type, systems (timing and intensity)
3. Moving to landscape-scale
    - Landscapes have inbuilt heterogeneity of habitats, and targeted management can deliver more
    - This is also the key to climate adaptation
4. Case study and lessons learned

- These principles are being used to deliver but can only work with appropriate financial and expert support, over a long time
- Partnership is not a fad – it is essential

Ellis, S., Bourn, N. A. D. and Bulman, C. R. (2012) Landscape-scale conservation for butterflies and moths: lessons from the UK Butterfly Conservation, Wareham, Dorset. https://butterfly-conservation.org/sites/default/files/landscape-scale-conservation-for-butterflies-and-moths-low-resolution.pdf

Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J., & Wynne, G.R. (2010) Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra

Thomas, J.A., Bourn, N.A.D., Clarke, R.T., Stewart, K.E., Simcox, D.J., Pearman, G.S., Curtis, R. and Goodger, B. (2001) The quality and isolation of habitat patches both determine where butterflies persist in fragmented landscapes. *Proceedings of the Royal Society, London B*, **268**: 1791-1796.

UK Government (2018) *A green future: our 25 year plan to improve the environment*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf

Nigel Bourn speaking at the Michael Cusack Centre. *Photo Maria Long*


Everyone's searching for something! Day 2 Field Trip. *Photos Maria Long*

Day II (xii) Maria Long, *Land snails and land management in the Burren*

The focus of Maria's talk was the research (2006-2011) on the effects of land management on plant and mollusc communities in the Burren. During and after this project, she also worked on molluscan projects with national experts, including a national monitoring programme for *Vertigo angustior*, *V. geyeri* and V. *moulinsiana* with Evelyn Moorkens and Ian Killeen, and a survey of four rare molluscs – *V. geyeri, V. moulinsiana, Oxyloma sarsii* and *Omphiscola glabra* – with Roy Anderson. She then led the national survey of the three *Vertigo* species in 2014-2017. Maria also identified land snails from archaeological samples from Poulnabrone portal tomb. Molluscs are much more widely used outside of Ireland in archaeological and palaeoecological work to infer past habitats and land-uses. They are particularly important in calcareous habitats where snail shells are well-preserved but plant pollen grains and macrofossils degrade.

Overview

- There are roughly 150 species of native non-marine molluscs in Ireland, and around 27 introduced species
- The focus of the talk is on land-snails – no slugs and no freshwater molluscs covered
- Approximately two-thirds of Ireland's snail fauna occurs in the Burren.

Non-marine mollusc Red List (Byrne *et al*., 2009)

- When published, two native species were assessed as Regionally Extinct
- Since then, one has been re-found: *Omphiscola glabra*, at a single, un-designated site. The population is small and in a precarious position, but still hanging on. So *Omphiscola glabra* has now moved to Critically Endangered
- 6 species were assessed as Critically Endangered, including a Burren speciality the Round-mouthed Snail *Pomatias elegans.* It is known only from one site, a patch of limestone pavement near Finavarra (the flaggy shore) and Lough Murree (Platts *et al*., 2003)
- 14 species were assessed as Endangered, including the Wall Whorl Snail *Vertigo pusilla*. Maria has found two specimens of this species, both (long-) dead shells, one from one of her PhD sites and a second from Poulnabrone, indicating the species was present in the Burren, and may still occur
- 26 species assessed as Vulnerable
- 10 native species were considered to be 'populations of significant international worth'
- Some of these are almost endemic, or limited mainly to Britain and Ireland (*e.g*. *Ashfordia granulata* [very common in urban areas and gardens], *Leiostyla anglica*)
- 6 non-marine mollusc species are protected under the Habitats Directive, more than Irish arthropods
- Species declines are primarily driven by <u>habitat loss</u> and <u>habitat change</u>
- Heath Snail – a big obvious snail in the Burren, one of our largest snails and xeric – so does not mind hot, sunny weather. It was widespread in Ireland, found in semi-natural grasslands, but has declined by over 60% since 1980 with its range reduced to the Burren and coastal sites, and some remaining patches of semi-natural grassland elsewhere.

Snails are variable and surprising

- Hairy snails
- Spiky snails
- Garlic snails – emits strong smell when disturbed
- Many are very tiny in size – most of us only see the largest species such as *Cornu aspersum* which are common in gardens
- Subtle differences distinguish species from one another, often comparative features such 'rounder than' so it requires time and practice, patience and verified specimens that can be laid out and compared.

PhD study investigated what effect would the cessation of grazing have on biodiversity?

- The main grazers on the Burren are cattle (+ feral goats)
- Used fenced exclosures to exclude grazers and monitor the responses among plants and snails
- 3 habitats
    - Woodland – primarily Hazel *Corylus avellana*, with structure, a closed canopy and distinct woodland flora beneath

    - Scrub – again Hazel, but patchy, difficult to move through, heterogeneous
    - Grassland (unimproved)
- Study sites were spread across the north Burren in Counties Clare and Galway, with four replicates of each treatment, so 12 sites in total
- At each site, a fenced 20 m x 20 m plot was erected, with five 2 m x 2 m vegetation quadrats and adjacent snail quadrats inside. Nearby to the fenced plots, were identical unfenced plots marked by metal pins in the ground
- 288 mollusc quadrats sampled over three years (full sampling in years 1 and 3, sub-sampling in year 2)
- Snail sampling was by clearing the vegetation down to the soil surface and taking it and any leaf litter, and also beating of any tall/woody vegetation
- Processing samples was very laborious and involved drying in mesh bags, followed by further drying on newspaper, with multiple changes of newspaper required. Samples are then sieved and searched for snail shells

Results
- ~ 3,500 specimens, of which on average
    - 1/4 adult
    - 1/2 immature so didn't have all of their features developed
    - 1/4 dead, often faded, lacking colour or shell architecture
- Majority of specimens <1mm in size
- 30 species
- Top 3 species
    - Glossy Pillar Snail *Cochlicopa lubrica* (13%)
    - Hairy Snail *Trochulus hispidus* (12%)
    - Rayed Glass Snail *Nesovitrea hammonis* (9%)
- Rare or notable species – Red List
    - *Leiostyla anglica* (VU) - 37 specimens, mainly woodland, but not at all limited to woodland. Seen as an indicator of old woodland in Great Britain, but not so in Ireland
    - *Helicella itala* (VU) - 12 specimens in scrub + grassland
    - *Acicula fusca* (VU)) – multiple specimens, <1 mm
    - *Vertigo pusilla* (EN) – 1 dead specimen, woodland
- Can be difficult to tell whether specimen was dead when collected – damaged shells and worn shells infer long dead
- Two species that are typically understood to be found in wetter habitats that were found during the research are
    - *Vertigo substriata:* - generally restricted to marshes, damp woods
    - *Carychium minimum:* - common in wet places such as fens, marshes, moist woods
- A few possible reasons for the occurrence of species in what may seem atypical habitats
    - Ireland has much fewer snails compared to say Great Britain and so may have wider ecological niches
    - A lot of literature and ecological understanding comes from England, Great Britain and/or continental Europe
    - Distinct possibility that the west of Ireland is wetter and the species are not confined to woodland: sufficient moisture/humidity occurs in more open habitats
- Grazing exclusion from four grassland sites resulted in
    - Increase in number of snail individuals and number of snail species across most sites
    - Litter increased by 62% on average across grassland exclosures (notoriously difficult to measure, but no inter-operator variation – Maria did all measurements). Farmers were surprised by the productivity – that so much litter built up so quickly
    - Plant species declined strongly, with a shift in relative covers of forbs (decreased) and grasses (increased). This change was further reflected in decreases in diversity in both forbs and grasses.

Overall results
- Plants
    - Grassland - No grazing is very bad news for plant species richness. Some plants were lost very rapidly – within the first growing season and not seen again thereafter, *e.g.*

    Yellow-rattle *Rhinanthus minor*, eyebrights *Euphrasia* spp., Red Bartsia *Odontites vernus*. Dominance of graminoids – a small number of species came to dominate
  - Scrub – mixed picture, a re-survey is overdue – will always be mixed picture because scrub as a habitat is so heterogeneous
  - Woodland – 3 years is a short period in woodland life history.
    - During the course of the PhD, short-term (3 years), no grazing = increased diversity (particularly in herb layer)
    - But 12 years later, plant species richness was significantly lower inside the ungrazed fenced plots (Dougherty, 2018).
- Molluscs
  - Grassland: large increase in volume of litter = increase in good mollusc habitat = increase in snails (increased moisture and food material)
  - no grazing ≈ good news for snail biodiversity (nothing black and white – need a mix, not too tidy, uniform)
  - Effects in woodlands and scrub may be more subtle – no strong trends in snails yet.

Annex II species in the Burren

- No *Vertigo geyeri* records for the Burren, which is a bit of a mystery as it likes strongly calcareous mineral rich flushes
- One record for *Vertigo moulinsiana* from near Mullaghmore – Evelyn Moorkens reconfirmed an old record in 2006
- *Vertigo angustior* – go to the beach! Lots of it at Fanore, Doonbeg, on the Aran Islands. So populations exist and some are doing very well

PhD findings on **scrub**

- Distinct vascular plant, bryophyte and lichen communities in the scrub, that are different to those in the woodland and grassland
- Mollusc communities were not so distinct – there was overlap
- Scrub has importance and value that we must be mindful of in our management
- There is definitely a value in having scrub in and associated with grasslands because it increases diversity
- But it is important not to underestimate the subtlety of management needed to achieve the right balance, because Blackthorn or Bracken or other species can expand so rapidly
- Can be very difficult to communicate the above nuances

Byrne, A., Moorkens, E.A., Anderson, R., Killeen, I.J. & Regan, E.C. (2009) Ireland Red List No. 2 – Non-Marine Molluscs. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland. https://www.npws.ie/sites/default/files/publications/pdf/RL2.pdf

Dougherty, Maura (2018) Examining the long-term effects of grazing cessation on vegetation in woodland habitats in the Burren, Co. Clare. MSc Thesis, Environmental Science, TCD.

Long, M.P. & Brophy, J.T. (2019) Monitoring of sites and habitat for three Annex II species of whorl snail (*Vertigo*). *Irish Wildlife Manuals*, No. 104. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland.

Long, M.P., Moorkens, E.A. and Kelly, D.L. (2018) The importance of sieve mesh size in invertebrate surveys – an example using land snails: Are snails 0.5-1mm in size worth including? *Irish Naturalists' Journal* **36** (1), 1-8.

Long, M.P. (2014) Analysis of Terrestrial Mollusca. *In:* Lynch, A. (ed.) *Poulnabrone: An Early Neolithic Portal Tomb in Ireland. Archaeological Monograph Series: 9.* National Monuments Section, Department of the Arts, Heritage and the Gaeltacht, Ireland.

Platts, E., Bailey, S., McGrath, D. and McGeough, G. (2003) A survey of the land winkle *Pomatias elegans* (Müller, 1774) in the Burren, Co. Clare. *Biology and Environment: Proceedings of the Royal Academy*, **103B**, 197-201.

http://www.habitas.org.uk/molluscireland/

PhD thesis download: http://www.tara.tcd.ie/handle/2262/77573

Roy Anderson searching for snails. *Photo Maria Long*