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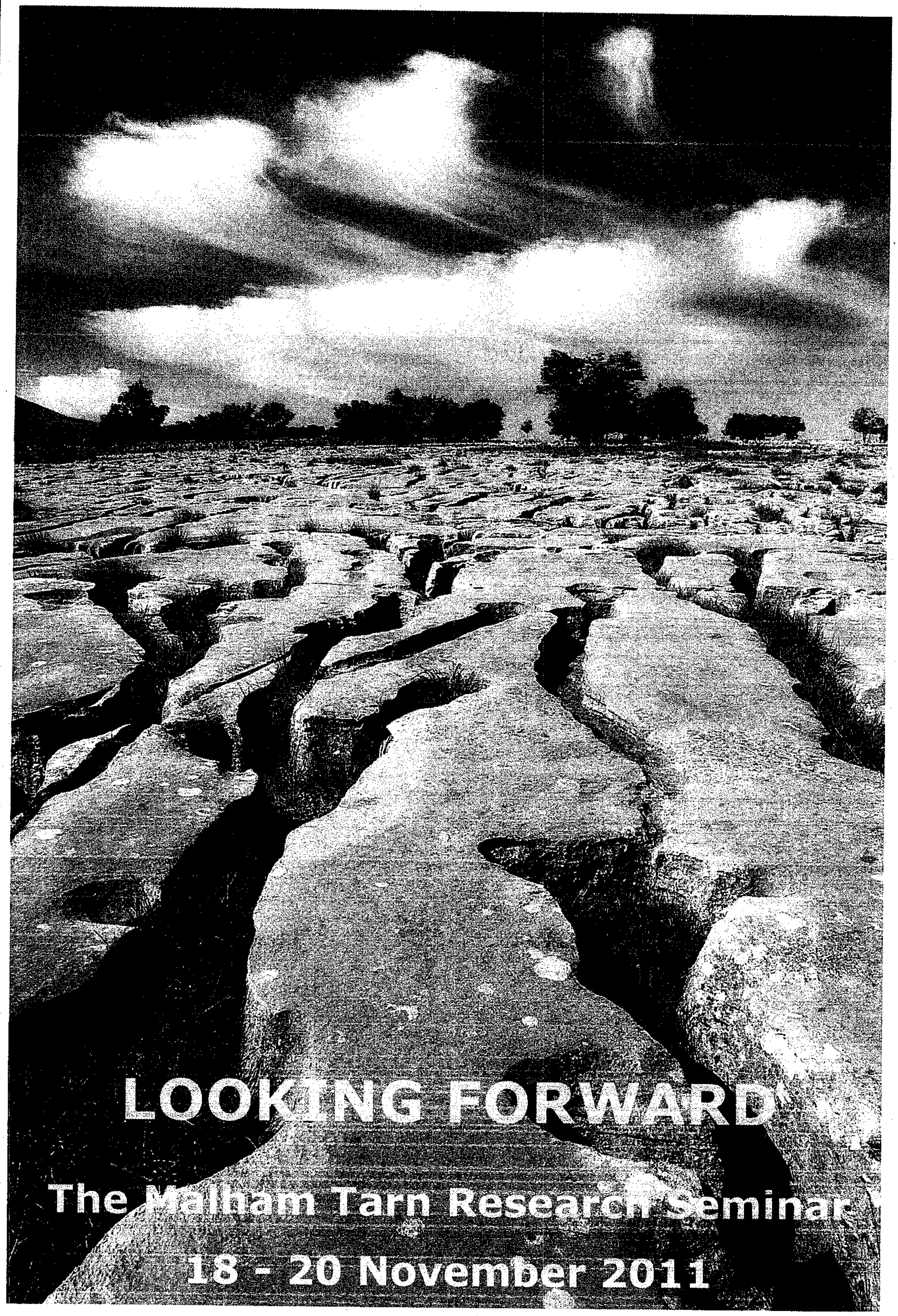

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Cover photograph: Limestone pavement at Southernscales. Photo by Robin Sutton.

FOREWORD

With 50 attendees and 14 colleagues making presentations, the Malham Tarn Research Seminar continues to be a major feature in the identity of the Field Study Centre. In 2011 subjects ranged over climate change, landscape history, limestone pavement microclimate, aquatic macro invertebrate recording and links between research and education to name but a few. This amply demonstrates the continuing research interest which the area engenders, underpinning decades of scientific importance and study.

A feature of the seminar was the attendance of some sixth form students from local schools, whose UCAS applications are bound to be strengthened by their experience. This is an aspect which it is hoped will be further embedded into future seminars, perhaps with some sessions aimed specifically at that age group.

The weekend was of particular interest to me, as a newly arrived Head of Centre, as it accelerated my personal knowledge of research activities in the environment of the Tarn. Knowledge which otherwise would have taken many months, even years to acquire.

The next Malham Tarn Research Seminar will be held from Friday 22nd to Sunday 24th November 2013. The theme is yet to be decided, but I hope all of you will feel able to contribute and I look forward to meeting you again.

In addition to thanking all the contributors and attendees, two people warrant particular gratitude. First, Rob Lucas who arranged to attend at short notice and ably chaired the proceedings as well as making a personal presentation and, second to Elizabeth Judson. Without her knowledge gained over a number of past seminars, the whole event would not have passed so smoothly if, indeed, at all.

Mike Cawthorn
June 2012

ACKNOWLEDGEMENTS

All contributors and attendees
Rob Lucas for chairing the sessions
Malham Tarn Field Centre Staff for looking after us so well
Robin Sutton for the cover photograph
Elizabeth Judson for compiling proceedings and co-ordinating the weekend

PROGRAMME

Friday 18th November

4.30-6.30pm	*ARRIVAL AND REGISTRATION*	
6.45pm	*Sherry followed by DINNER at 7.00pm*	
8pm	*Welcome*	Mike Cawthorn
8.10pm	**Insights into global climate change as recorded in Early Carboniferous sediments on the southern part of the Askrigg Block**	Marion Dunn
8.30pm	**Linking research and education – pipe dream or in the pipeline?**	Rob Lucas
9pm	*BAR*	

Saturday 19th November

9.00am	*Arrivals & Registration*	
9.15am	**Welcome and Introduction**	Mike Cawthorn / Rob Lucas
9.30am	**Palaeoecology and landscape history in upper Ribblesdale – an ongoing project**	Helen Shaw
9.55am	**Limestone Pavements: a refuge in a world of climate change.**	Peter York
10.25am	**Limestone pavement microclimate and / classification**	Cynthia Burek
10.50am	*COFFEE*	
11.15am	**Testing the response of peatlands to rapid climate change**	Graeme Swindles & Andrew Baird
11.40am	**Holocene perspective on the ecology of Moorland Burning in the Yorkshire Dales**	Sarah Edwards
12.05am	**National Trust: Management Plan and Peat Cliffs update.**	Martin Davies
12.30pm	**Long Term Monitoring of Malham Tarn: Cycles and Serendipity**	George Hinton
1.00pm	*LUNCH*	
2.00pm	**What has happened to the Fountains Fell Cetralias?**	Allan Pentecost
2.20pm	**Mapping the spread of the Dark Green Fritilary Butterfly in the Yorkshire Dales**	Terry Whitaker
2.45pm	**Wildlife in and around Dry Rigg Quarry and adjacent Swarth Moor SSSI**	Alastair Headley
3.15pm	*TEA*	
3.30pm	**Malham Tarn a marl lake recovering or degrading?**	Emma Wiik
3.55pm	**Dissolved Orthophosphate contribution of the mountain Limestone in the Malham Tarn catchment**	Allan Pentecost
4.45-5.30pm	**Discussion / Poster Displays**	
6.30pm	*Drinks Reception followed by DINNER at 6.45pm*	
8.00pm	**The Ecology of Shallow Lakes of the British Isles**	Carl Sayer
8.30pm	*Bar*	

Sunday 20th November

9.30am	***Site visits***
12.30pm	*LUNCH*
	DEPART

Insights into global climate change in Early Carboniferous sediments on the southern part of the Askrigg Block

Marion Dunn

This PhD project is at an early stage, and the main themes to be explored are summarised below.

The project is a study of Early Carboniferous cyclicity and climate change as recorded in selected Lower Carboniferous (Tournaisian-late Visean) platform carbonate sediments on the southern part of the Askrigg Block in the Settle and Ingleton districts of North Yorkshire.

Geographically, the Askrigg Block is a distinctive area of elevated limestone and gritstone moorland, much of it 400 m above sea level, which forms part of the watershed of the Pennine Hills of northern England, and straddles the three counties of Lancashire, North Yorkshire and Cumbria, UK (Dunham & Wilson, 1985; Arthurton *et al.,* 1988). Geologically the Askrigg Block is a tilt-block and consists of a rigid portion Lower Palaeozoic basement rocks overlain unconformably by Dinantian carbonates approximately 500 m thickness, which dip gently to the north-east. The Block is bounded by faulted margins to the west and south, an area of structural disturbance to the north, and on its eastern margin, its Dinantian sediments dip underneath younger Permo-Triassic strata (Dunham & Wilson, 1985; Arthurton *et al.,* 1988).

During the late Devonian and Carboniferous times, global palaeogeography was dominated by two supercontinents, Euramerica and Gondwana: Gondwana stretched from the equator to the palaeo-south Pole, and Euramerica, which included the British Isles (and the Askrigg Block) was situated to the north of Gondwana (Veevers & Powell, 1987; Scotese & Barrett, 1990; McKerrow *et al.*, 2000; Torsvik & Cocks, 2004).

During the latest Devonian to Late Permian interval, some areas of Gondwana close to the palaeo-South pole carried a complex of ice sheets, which varied in size (Caputo & Crowell, 1985; Veevers & Powell, 1987; Isbell *et al.*, 2003). Veevers & Powell (1987) report that high-frequency (fifth order) sedimentary cycles in the equatorial regions of Euramerica were coeval with the main phase Gondwanan glacioeustasy (III) starting in latest Brigantian or Early Namurian times, and other workers have suggested that these high-frequency sedimentary cycles are a proxy for glacioeustasy (Wright & Vanstone, 2001; Barnett *et al.*, 2002) as they were formed during small-scale rises and falls of relative sea-level due to repeated partial melting and re-freezing of the Gondwanan ice-sheets, during cycles of global warming and cooling.

The Askrigg Block carbonate sediments are important, as they form a distinctive part of the Euramerican equatorial sedimentary record, and have global significance as the high-frequency sedimentary cycles that they contain are likely to record a Gondwanan glacioeustatic influence. However, the onset and timing of phases of Gondwanan glacioeustasy is poorly constrained and the relationship of cyclic sedimentation on the Askrigg Block to phases of Gondwanan glacioeustasy requires clarification. This is identified as the first main theme which is being explored in this study.

Due to a variety of factors, the marine carbonate sediments on the Askrigg Block periodically became emergent (Schwarzacher, 1958; Waltham, 1971; Burgess & Mitchell, 1976; Dunham &

Wilson, 1985; Arthurton *et al.,* 1988; Dunn, 2004). Emergence allowed the sediments to be exposed to Carboniferous weather systems and to develop features recording the ambient Carboniferous climate (Dunn, 2004). The British Early Carboniferous climate record is generally patchy, and Askrigg Block sediments may therefore have the potential to reveal information about the evolution of the Early Carboniferous climate, in particular about the climatic zones that affected Euramerica close to the Carboniferous Equator (Witzke, 1990). An exploration of Early Carboniferous climate is identified as the second main theme in this study.

Geologists are obsessed by what is present in the rock record, and of recording and analysing it, and less mindful of what is absent, or is suspected to be absent. The gaps could be there for a variety of reasons: simple breaks in sedimentation on the sea floor; cessation of carbonate production and the formation of hardgrounds; regressions leading to the sub-aerial exposure and weathering of the sea-floor or rapid changes in water depth leading to marked facies changes and also gaps due to diagenetic modification such as stylolitisation. In terms of timespan, the gaps could be more significant than the sediments themselves: for example, based on a computer model of the gaps in Late Asbian/Early Brigantian carbonate sequences in the UK, Barnett *et al.*, (2002), concluded that these sediments were cyclic, primarily glacioeustatically-controlled and that the gaps (emergent surfaces) accounted for about 75% of the total duration of each cycle. This concurs with estimates made by Dunn (2004) in a study of high-frequency (fifth-order) carbonate sedimentary cycles on the Askrigg Block of Late Asbian/Early Brigantian age. This study intends to explore the nature of the gaps, as well as the sediments that are present, to see if they fit into a cyclic framework: for example, there is limited evidence of a climatic cyclicity recorded in Late Asbian/Early Brigantian carbonates in the UK which could be related to climatic changes induced by migration of the Inter-Tropical Convergence Zone caused by changes in global air circulation caused by glaciation (Falcon-Lang, 1999).

A number of laterally persistent, distinctive horizons occur within the Early Carboniferous carbonates on the southern part of the Askrigg Block. These are typically prominent algal, coral or macrofossil horizons which have been well-described in the literature (Garwood & Goodyear, 1924; Dunham & Wilson, 1985; Arthurton *et al.,* 1988), but whose context is still not well understood. Identical or very similar horizons are found in contemporaneous sediments on neighbouring UK carbonate platforms or further afield (Garwood & Goodyear, 1924; Dunham & Wilson, 1985; Arthurton *et al.*, 1988), suggesting a non-local origin for some of these horizons. The third, final and minor theme of this study will be to determine the environmental significance of these horizons to assess if they have been influenced primarily by local, regional or global events.

The project themes are summarised below:

- Exploration of the relationship between Early Carboniferous high-frequency sedimentary cyclic sedimentation on the Askrigg Block and periods of Gondwanan glacioeustasy;
- Exploration of the Early Carboniferous British climate using evidence from emergent profiles within Askrigg Block sediments;
- Determination of environmental significance of certain prominent algal and macrofossil horizons that are widespread across the Askrigg and assess if they have been influenced primarily by local, regional or global events.

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Linking Research and Education

Rob Lucas

Field Studies Council (FSC) is working at all academic levels throughout the UK. It is the UK's largest provider of fieldwork at A level. FSC's Vision for 2020 is 'Inspiring Environmental Understanding through First Hand Experience'.

One of the ways of inspiring A level students on the stepping stone to higher education is by building closer links between the scientific research undertaken by Universities and the field courses the students undertake with FSC.

One of the most profound changes over the last 30 years has been the increasing gap between A level and what is being discovered through current research. This is, in part, because the nature of research has changed, but more importantly it is because geography and science at A Level has not progressed at the same pace, driven largely by the demands of assessment models which do not encourage innovation or going beyond the specification.

Data collection on A level courses is still predominately gathered first hand. This is good for ensuring experience of the environment but can often mean working with small and time-limited data sets. At university the capturing of data in a digital format through remote devices has transformed much field based research. It can sometimes appear, when viewed from the outside, that research topics are becoming broader and more cross-disciplinary, not because this is good science but because you have to introduce other things to fill the time while the remote sensing does its stuff.

Prof Steve Jones in his review of the BBC's science reporting [1] noted that 'Science has long been a major element of our national culture and is of immense economic importance – a fact that the public, many politicians and parts of the media appear to be unaware of'. The UK is ranked second only to the USA on citations in scientific papers. Although medicine, molecular and cell biology and physics dominate the citations, ecology, evolution and the geosciences are well represented.

It is recognised at the highest levels [2] that "although scientists are a minority of the population, democratic citizenship in a modern society depends, amongst other things, on the ability of citizens to comprehend, criticize and use scientific ideas and claims."

It is also highlighted by Prof Steve Jones[1] that attempts to provide contrasting views on any subject being reported upon does not necessarily mean a balanced view is projected, a view supported strongly by Prof Brian Cox [3] especially regarding the blurring in the media of astronomy and astrology. This lack of clarity has contributed to a sense of unease and even mistrust in scientists by the general public who have little understanding of probability, certainty

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[1] Jones S, 2011, Review of impartiality and accuracy of BBC's science reporting

[2] House of Lords Science & Technology Committee, 2000, Third Report

[3] Cox B, 2010, Weldon Lecture BBC

and likelihood. The MMR vaccination scare being a good example of the media's desire for a good story fuelling an articulate minority's distrust of research.

We clearly need more scientists and need more of the public to think like scientists. This is not to belittle artists and their views and opinions but to avoid inappropriate comparisons being made – astrology might be a valid subject but its findings cannot be compared directly with astronomy and *vice versa.*

We also need to ensure that young scientists have direct practical experience of science both in and out of the classroom[4]. For example, it is becoming increasingly possible to carry out simple DNA mapping in a field laboratory. To have both an organism and its simple DNA code identified by a student whilst on a single field course is a powerful reminder of how basic science has moved on.

In its recent grants handbook [5] NERC sets out why researchers should engage with the public. This is in the philosophical context of its Charter and is endorsed in the RCUK Statement of Expectation on Economic and societal impact. At a more pragmatic level, NERC award holders have a responsibility to communicate their research to audiences outside the scientific community.

This duty of researchers to communicate is becoming more demanding – setting up an obscure website which no-one looks at is no longer acceptable in the age of multi-media, interaction and soundbite science. Projects such as the OPAL [6] have shown how communication and engagement can be taken to a higher level.

The Science and Technology Select Committee[4] urges the science community to work together in its provision of educational materials. FSC can really help with this. The barrier to effective communication is often that there is no one available to explain what it is that is going on in an informed but understandable manner. As skilled educators FSC's staff can help with this. In fulfilling this role we can also help inspire new scientists to better understand the environment.

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[4] Science & Technology Committee, September 2011, Practical experiments in school science lessons and science field trips

[5] NERC, November 2011, Research Grants Handbook

[6] OPAL, 2011, Open Air Laboratory

Limestone pavements - Microclimate matters

Peter York & Cynthia Burek

Limestone pavements are an exceptional geological phenomenon formed thousands of years ago by an unlikely combination of tearing rock layers and gentle percolation of acids. Though many school children may have been taught the theory of a limestone pavement's creation, many people do not know what goes on beneath the surface.

A microclimate is a very broad grouping to describe the climate active in a small finite space (Giger, 2009). In the case of a limestone pavement the microclimate is formed deep within narrow fissures called grikes. Though the microclimate fluctuates in line with changes outside the grike, these changes become less pronounced with depth (fig.1). The degree to which the microclimate is stabilised is influenced by a number of factors including grike width, location and orientation (Alexander, Burek & Gibbs, 2005). Ultimately the microclimate would become constant with enough depth; however studies to date have shown that even in mid-winter a grike never reached below 0°C at 1.5m below the surface (Burek & Legg, 1999). This stability has a marked influence on the species that are found in the grike when compared to those found in similar habitats at surface level. One such example is the rigid buckler fern of which 80% of the UK population is found in limestone pavement grikes (Ward & Evans, 1976). This habitat is however under threat from changes in management practice, damage and removal and like many other habitats may be influenced by climate change.

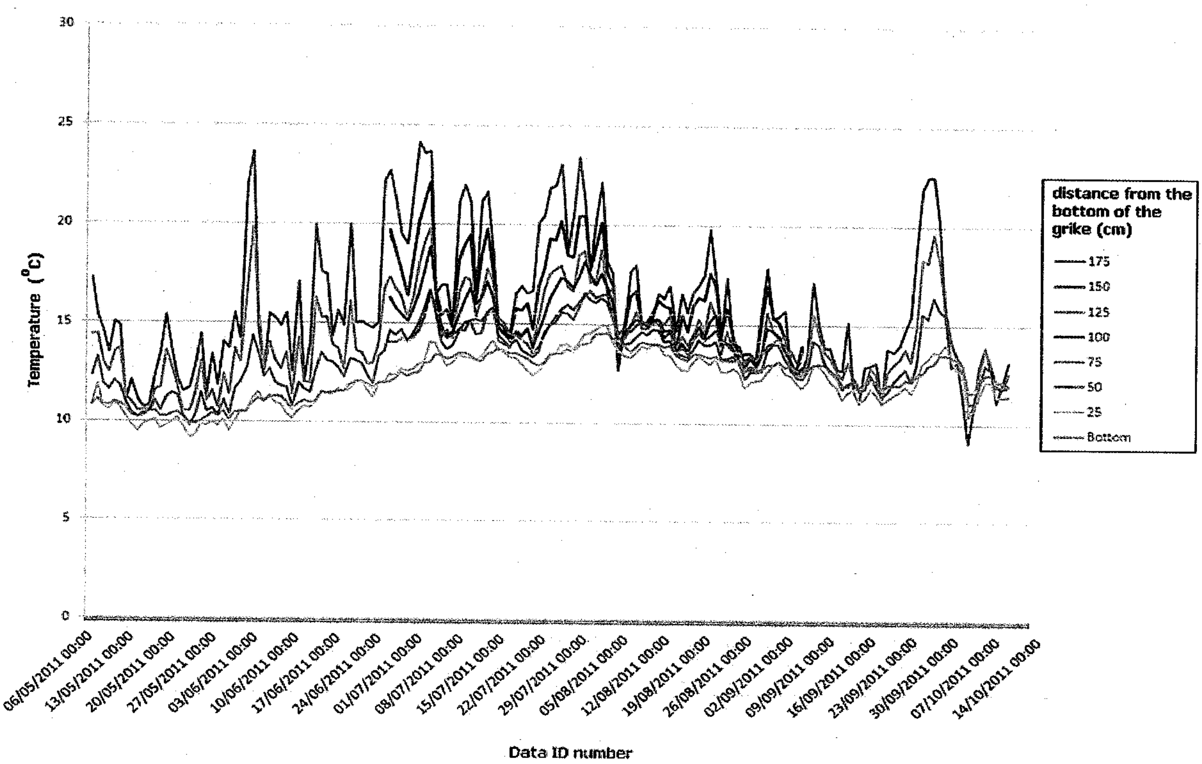


Figure.1 Graph showing the temperature at various depths in an East – West orientated grike on Holme park quarry for May to October 2011

Climate change is projected to cause a mean rise in temperature (fig. 2), dryer and hotter summers, wetter and warmer winters, and larger amounts of extreme weather conditions (Murphy, 2009).

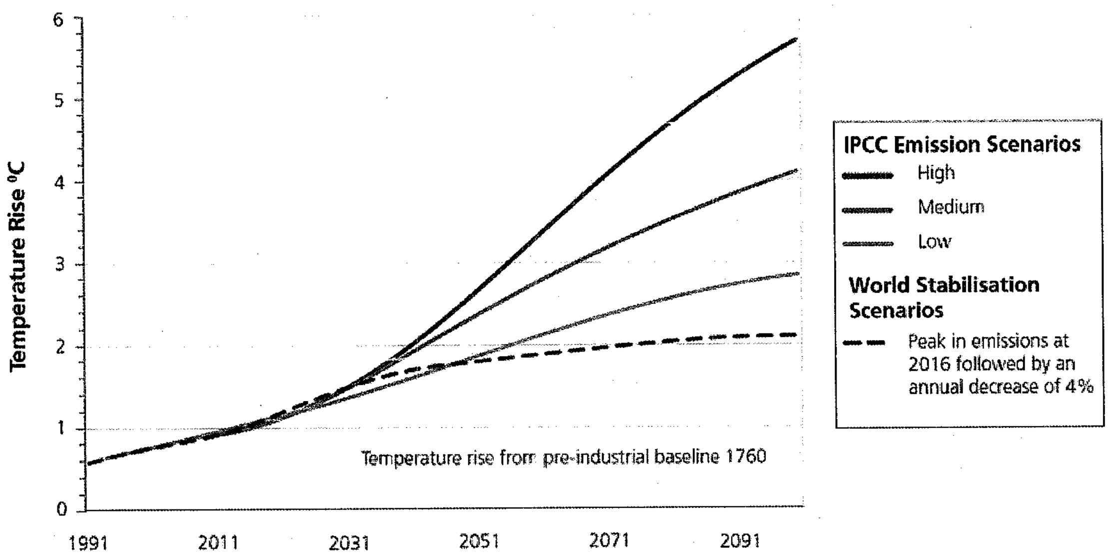


Figure.2 Graph showing projected global mean temperatures (Defra, 2009)

Such changes have a marked effect upon species ability to survive in their current latitudes and continue to interact with species whose behaviour is linked to climactic cues. If these projections are correct there is some uncertainty over the future of the grike microclimates and their associated species. Despite this little has been written in the life sciences about the effect of a change in climate on an associated microclimate, however from the research so far there are a number of plausible scenarios.

1. Climate change's effect, though extreme on the surface does not influence the grike microclimate as greatly. This provides a refuge for species whose ranges have progressed northward, perhaps off the top of the country.
2. Climate change affects the grike microclimate enough to make it inhospitable to relic species, or more suited to invasive species causing a change in the species composition of the grike.
3. Warmer winters brought on by climate change interrupt the annual convection of warmer air from within the grike out to the cold surface, causing a stagnation and build-up of CO_2 produced by invertebrates and plant decomposition.

It is because of the uncertain future of the grike microclimate and the possible effects of climate change on the grikes flora and fauna, the following research is being carried out.

With the technology now available, sampling large amounts of microclimate data has become cheaper, more reliable and less intensive work. This project takes advantage of a new line of self-contained sampling and logging devices to attempt to avoid the disruptions in data collection suffered by previous studies, and produce a continuous set of data spanning multiple years. With this data and a range of meshes (fig. 3) representing grikes it will be possible to create a computer based model to simulate what has been observed physically and extrapolate microclimate data to react to multiple scenarios. These scenarios will investigate the effect of changing the grike dimensions and external climate. This will produce greater understanding of a grikes form upon the microclimate found within, and provide projections of the grike microclimate in line with Defra's own projections for the future UK climate.

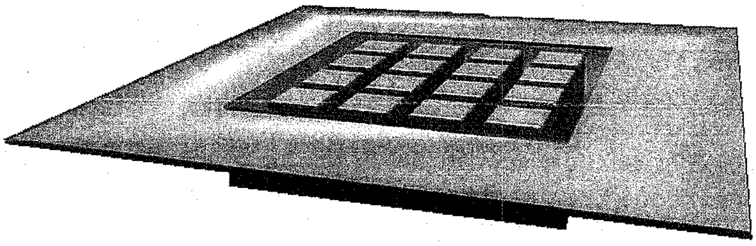
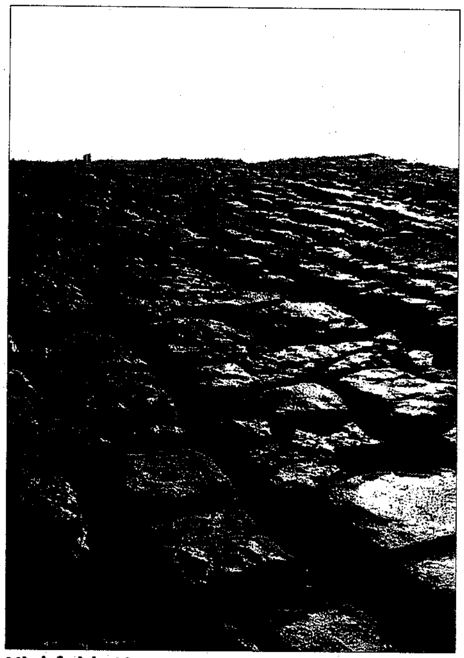


Figure.3 Mesh to be used to model the microclimate of grikes.

Invertebrates including molluscs, crustaceans and arthropods are the key fauna in the grike habitat (Burek & York, 2009). Further research will involve surveying invertebrates on a range of limestone pavements to better understand the roles played by grike form and external climate on the species found within grikes. This work hopes to draw together information from the many sources mentioned to answer once and for all "what is the future for UK limestone pavements and the species that rely on them for their survival?"



Highfolds Limestone Pavement

Ridged buckler fern (Dryopteris submontana)
Photo: Powell,2011

Acknowledgements
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How should we interpret palaeoclimate records from peatlands? The Malham Tarn Moss case study

Graeme T. Swindles and Andy Baird

Over the last two decades there has been a proliferation of Holocene climate studies based on palaeohydrological proxies from peatlands. However, the relationships between peatland water tables, climate and long term peatland development are poorly understood. As this is a rapidly developing area of Holocene climate science, a critical examination of the processes that influence peatland palaeo-water tables including autogenic (internal – e.g. peat growth and decay) and allogenic (external – e.g. climate) factors is now critical.

Here we use a novel combination of high-resolution multiproxy climate data from Malham Tarn Moss and an ecohydrological peatland development model to examine the relationship between rapid hydrological fluctuations in peatlands and climate forcing. Our analysis shows that although peatland water-tables do respond to climate, the peatland archive can be contaminated by complex internal responses that are non-linear. A degree of homeostasis can result from ecohydrological feedbacks inherent in peatland development which partially disconnects peatland water-table behaviour from external climatic influences.

Holocene Perspective on the Ecology of Moorland Burning in the Yorkshire Dales

Sarah Jayne Edwards

Introduction

This abstract forms an introduction to a current NERC and Yorkshire Dales National Park Authority (YDNPA) funded PhD research project.

Project Rationale

British moorlands are recognised as areas of high ecological value covered by several directives and conventions (Thompson *et al.,* 1995). It is common practice to use fire as a management technique in upland peatlands to control the growth of heather for land use practices. This significantly influences species dynamics, diversity and ecosystem function e.g. carbon storage. This project shall put current moorland burning issues into a long-term context.

It is known from charcoal fragments found in peat cores in the UK that fire has played an important role in influencing moorlands for millennia. Yet, little is understood about the relationship between fire, peatland development and vegetation. This project shall generate new palaeoecological datasets spanning the Holocene to understand the role of fire in determining ecosystem function and consider the implications of an altered future climate on fire risk.

At present in the Yorkshire Dales burning of moorland vegetation is widely practiced to stimulate heather regeneration. However, there are strong indications that such burning is having detrimental consequences on the protected upland habitat effecting the vegetation composition and structure, hydrology, water quality, and preservation of organic matter for carbon storage. With data suggesting intensification in burning since the 1970's, it is key to gain an understanding of the extent of the issue. With the added risk of wildfires (deliberate or not) and the increased forecasted risk from climate change, it is essential to fully comprehend ecosystems responses to burning.

Fig 1. Yorkshire Dales Moorlands/peatlands

Method and site selection

The study will focus on the Yorkshire Dales area, with field sites to be decided following a field trip in Spring 2012. Proxy records from peat will be used to reconstruct selected environmental parameters specifically burning intensity (charcoal), vegetation history (pollen) and surface wetness (testate amoebae). Charcoal records shall be used as the primary evidence for the reconstruction of fire in the palaeoenvironment (Innes and Simmons, 2000). This study intends to develop new methodologies to gain further understanding of the ecological impacts of using fire as a moorland management technique.

Documentary evidence including aerial photography and a variety of written documents (i.e. newspaper articles) of local and national sources shall be used to form a detailed chronology of the recent past (last 500 years), with a focus on past fires and changes in land management practices across the Yorkshire Dales.

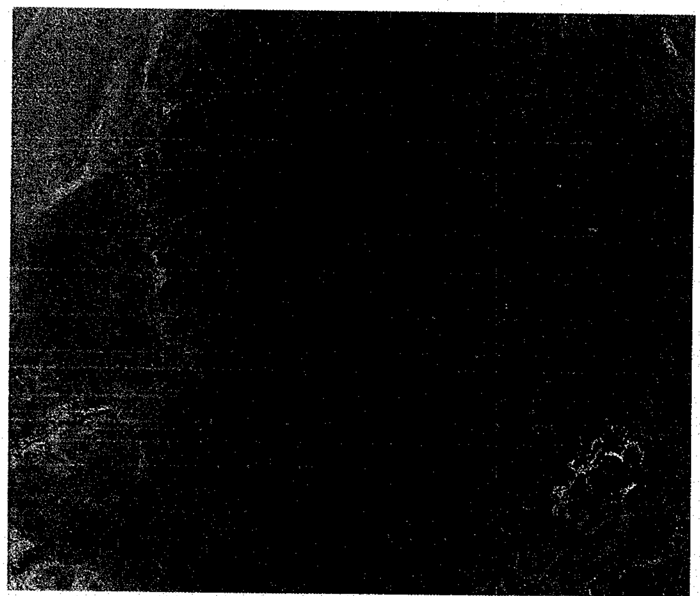

Fig. 2. Example aerial photograph of Oxnop Moor courtesy of Ed Turner

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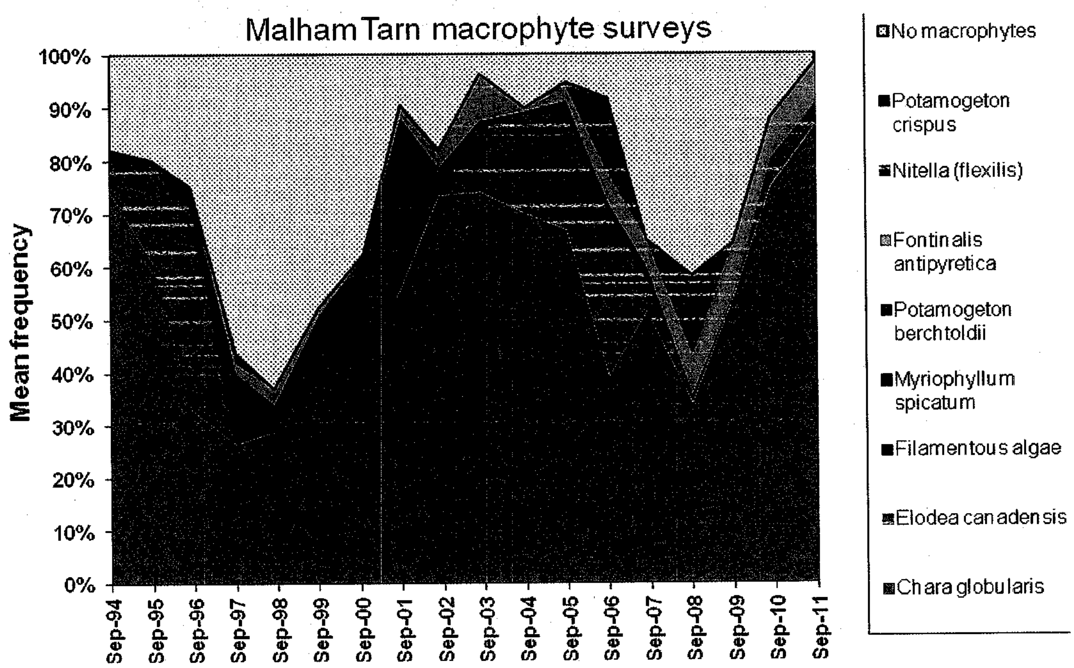
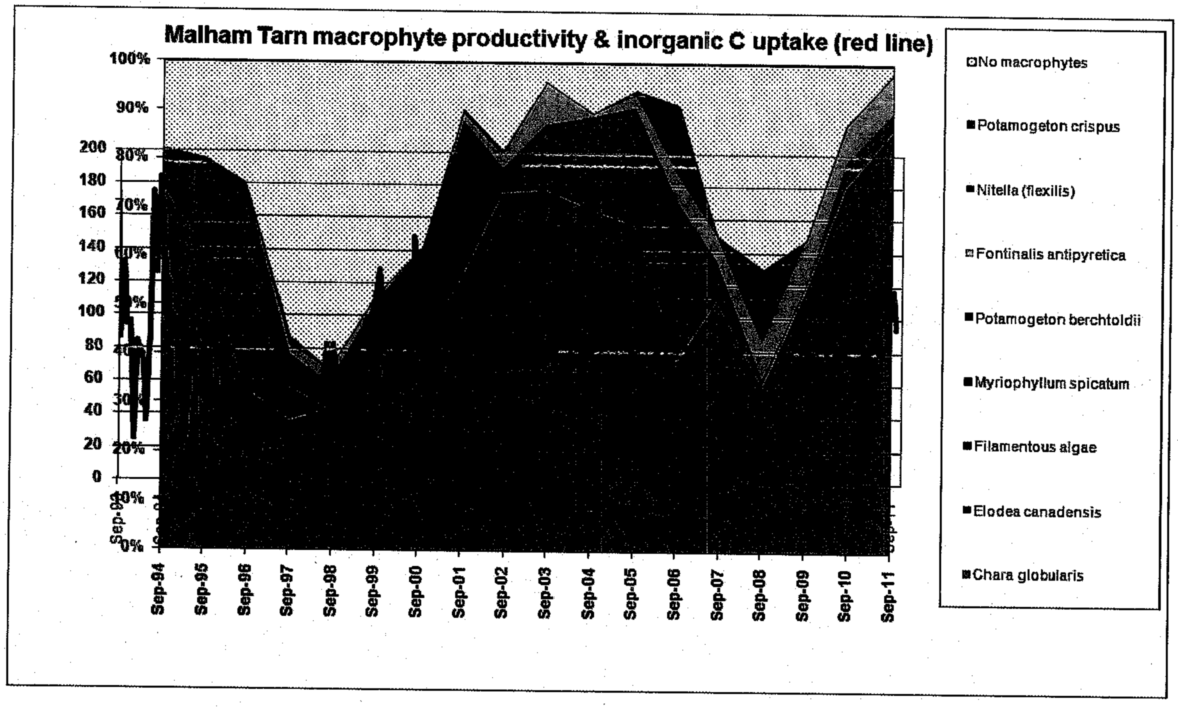
Malham Tarn: Long Term Tarn Monitoring Cycles

George C.F. Hinton

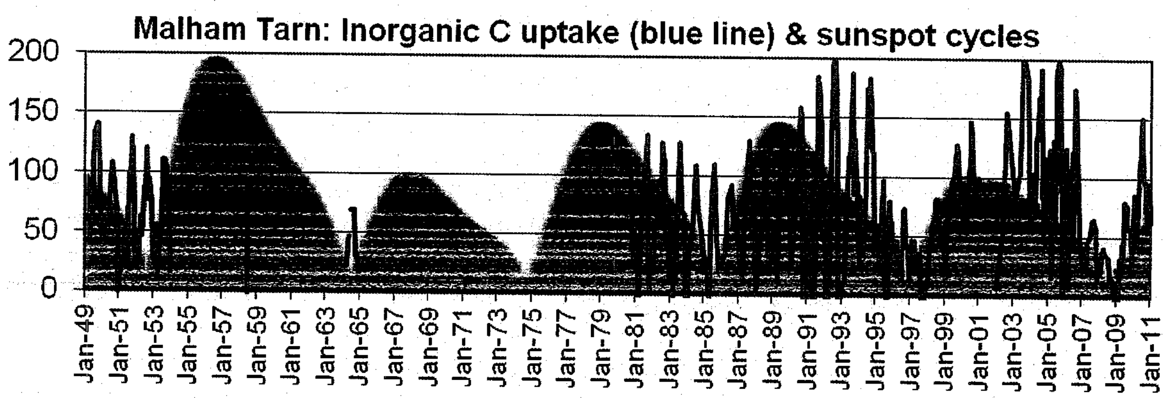
Malham Tarn is the highest marl lake in Britain and perhaps the best example of an upland charophyte (stonewort-dominated) lake and has been the subject of intermittent surveys since the 1930s. The current macrophyte monitoring work was prompted by concerns over catchment impacts and increased trophic status of the Tarn. Given the known sensitivity of charophytes to water quality, annual surveys were started in 1994 to provide semi-quantitative data on macrophyte cover and abundance. The methodology is based on cumulative presence or absence data for each species (from 10 grapnel drops) at each sampling station. Malham Tarn now has one of the longest, continuous macrophyte survey records, using a standardised methodology, of any lake in Britain. The present study provides evidence for the dynamic nature of the submerged macrophyte assemblage and its cyclical, long term changes in productivity.



Carbon uptake by plant biomass causes a seasonal drop in alkalinity peaking in July or August each year (based on calcium carbonate measured by Environment Agency). Uptake is determined approximately by the difference between the inflow and outflow alkalinity. The greater the productivity, the greater the carbonate removal into plant biomass and calcite formation. The reduced abundance and cover of macrophytes from 1996 to 1998 and 2006 to 2008 is reflected in a fall in inorganic carbon uptake (below 60 mg CaCO3/l). At peak productivity, inorganic carbon uptake can be as high as 200 mg CaCO3/l.



From 1980 to 2009, monitoring of inflow and outflow alkalinity by EA are almost continuous, although they have now suspended inflow monitoring in favour of a single Water Framework Directive sampling point. The regular nature of the productivity cycle suggests that it may be a long term phenomenon which could be traced back in time. Water quality monitoring data from EA confirm an earlier uptake minimum in 1986 and a maximum in around 1980. Research work by Pitty (covering 1964 to 1965) and Lund's pioneering work 1949 to 1953 on phytoplankton ecology provide more fragments of the long term cycle. My pre 2000 analysis suggested a weak match to the NAO (North Atlantic Oscillation). However, post 2000 data do not follow the NAO changes. The intermittent 62 year run of data show a striking alignment with solar sunspot cycles 18 to 24. In terms of synchronisation, inorganic C uptake peaks follow solar cycle peaks. Minima follow one year after solar minimum.



What has happened to the Fountains Fell *Cetrarias*?

Allan Pentecost

Three species of the lichen genus *Cetraria* have been recorded from Fountains Fell, close to Malham Tarn Field Centre: *C. aculeata, C. islandica* and *C.(Flavocetraria) nivalis*. All occur on the peat, often directly growing upon it, or among low vegetation, particularly bilberry (*Vaccinium myrtillus*) and bryophytes such as *Racomitrium lanuginosum*.

Cetraria aculeata is a small, widely distributed lichen found on poor but well-drained soils throughout the country. It is not abundant on Fountains Fell but its occurrence there is not surprising as there are many records from similar habitats in the Pennines and further afield.

Cetraria islandica (Iceland Moss) is an imposing lichen when well developed. It can produce carpets up to 10 cm in depth, usually among terrestrial bryophytes, but is only common in the some of the montane areas of Britain. It is a lichen with an interesting distribution pattern, being best developed in the Central Highlands of Scotland, but with outliers as far south as Norfolk (Ranwell Common). The pattern of distribution suggests a preference for regular low winter temperatures, at least for short periods, an indifference to high rainfall and avoidance of base-rich soils. It is rare, for example, in the mountains of Ireland, where winters are not normally severe. *Cetraria islandica* was first recorded in 1955 by C.A.Sinker from the summit plateau of Fountains Fell, but it has been known from other Pennine fells since the mid-19th Century. Its comparatively recent discovery near Malham is probably due to the opening of the Field Centre a few years earlier, bringing more intensive field studies to the area. Since 1955 the lichen has been seen fairly regularly on the Fell until recently and there are several herbarium specimens in existence, mostly Seaward's (Fig 1). The author has made occasional visits to Fountains Fell plateau since the late 1960's and noticed an apparent decline in its abundance. In 1969 it took no more than a few minutes to find colonies, and this continued to the 1980's. In 2010 it could not be found and in the summer of 2011 a more concerted effort was made and the author was rewarded with a few small thalli after a search of three hours near the old coal pits. The thalli were much reduced in size compared with those of the 1950's partly accounting for the difficulty in discovering them, suggesting that a significant change had taken place on the fell over the last few decades.

Little is known about the ecology of this lichen, despite its use as food by some quadrupeds in the Arctic. The apparent reduction in growth on Fountains Fell is matched on some other nearby fells, where searches were also conducted in 2011, several of which were negative and all but one yielding small thalli after prolonged searching (Table 1). The reason for this change is unknown but seems that intense sheep grazing has a negative influence (Gilbert, 2000). There is some sheep and cattle grazing on Fountains Fell, but it does not appear to be excessive and the flora as a whole appears to have changed little since the 1960's. National Trust staff suggested that grazing may even be less than it was a few years ago. There is plenty of evidence of red grouse feeding on the plateau. Their diet consists predominantly of young heather stems, but they may take other food. I can find no evidence that they eat lichens, but *C. islandica* contains significant amounts of a starch-like carbohydrate that might be palatable to birds. There is also the possibility of climate change influencing the growth and reproduction of this lichen. The recent slight rise in mean air temperature may have a negative influence, but this effect would spread right across the region, and there are much healthier colonies of *islandica* in parts of Cumbria and also on Plover Hill near Pen-y-Ghent. Finally it is possible that the recent rise in air-borne NOX is influencing growth. Only detailed mapping and careful monitoring of some sites over a number of years is likely to clarify the situation.

Lichens contain a suite of complex organic compounds, many of which are unique to the group. They can be used to characterise individual populations in some cases, particularly where there is no evidence of sexual reproduction, as is the case here. *C. islandica* for example always contains fumarprotocetraric acid sometimes accompanied by protocetraric and protolichesterinic acids. Thin layer chromatography was applied to acetone extracts of some collections of *islandica* from Fountains and other nearby fells (Table 2). The results indicate that at least two populations have colonised the area, one containing protolichesterinic acid and one without it, although all recent collections contained it. Another, similar acid also appeared in the chromatographs, possibly a pre- or postcursor to protolichesterinic acid although no reports of this were found in the literature. The distribution patterns of these chemotypes of *C. islandica* do not appear to have been investigated.

Semiquantitative sampling suggested similar quantities of fumarprotocetraric and protolichesterinic acids in all samples containing them.

Table 1 Locations and floral associates of some Dales *Cetraria islandica* samples

Location	Date	Collectors	NGR	Altitude m	Associated flora
Fountains Fell top	1955	C. Sinker [No. 106843]	-	-	*Vaccinium myrtillus*
Fountains Fell plateau	1977	MRD Seaward [no. 102093]	-	-	thin peat
Fountains Fell summit	1980	MRD Seaward [no. 103453]	34/867710	660	?
Fountains Fell plateau	1986	MRD Seaward [no. 105299]	34/8761	660	?
Fountains Fell	2011	AP	34/8670 7185	655	Eroding peat edge, *C. aculeata*, *V. myrtillus*
Birks Fell	2011	AP	34/9219 7560	600	*Calluna vulgaris*, *Juncus* spp, low ground
Crag Hill	2011	AP	34/6933 8345	675	*Racomitrium lanuginosum*
Gragereth	2011	AP	34/6895 7970	620	*Rubus chamaemorus*
Plover Hill	2011	AP	34/8439 7480	645	*Cladonia portentosa*,

Table 2. Lichen substances in the southern Dales *Cetraria islandica*

Location	Date collected	Fumarprotocetraric acid	Protocetraric acid	Proto-Lichesterinic acid	Fatty acid II [rf-G=0.54]	Other
Fountains Fell	1955	+	nd	-	+	
Fountains Fell	1977	+	nd	+	+	
Fountains Fell	1980	+	nd	+	+	
Fountains Fell	1986	+	nd	-	+	
Fountains Fell	2011	+	nd	+	+	
Birks Fell	2011	+	nd	+	+	
Crag Hill	2011	+	nd	+	+	
Gragereth	2011	+	nd	+	+	
Plover Hill	2011	+	nd	+	+	+purple pigment

Cetraria nivalis is the third species recorded from Fountains Fell. During the late 1950's several botanists reported seeing this lichen near the summit and recorded an apparent decline, possibly the result of collecting (Gilbert, 2000). This enigmatic sighting should provide a spur to further observations of lichens on the Pennine fells. *C. nivalis* is an arctic-alpine species known with certainty in Britain only from the high Scottish mountains. It has never been officially recorded from England, since no specimen has come to light. However, with its distinctive yellow-green upright growth, it is not readily mistaken for anything else. In Scandinavia this lichen is often common among the cloudberry, *Rubus chamaemorus*. On Fountains, and indeed on most of the Pennine fells above about 550 m, *R. chamaemorus* is often common making these unsubstantiated records all the more intriguing and it remains a lichen to look out for.

Acknowledgements

Thanks are extended to Mark Seaward for the generous loan of *C. islandica* specimens from his personal herbarium incorporating that of C.A. Sinker.

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Mapping changes of the Dark Green Fritillary (*Argynnis aglaja* L.) In Yorkshire VC 64 2000-2010

Terence M. Whitaker

Summary

The Dark Green Fritillary (DGF) was a very rare butterfly in West Yorkshire up to 2003. It was only known to be breeding on a single site and was recorded from less than 1% of the recorded tetrads in VC64 (Mid-west Yorkshire). Subsequently more reports were received every year and it is currently (2010), reported from over 12% of recorded tetrads and there are over twelve breeding locations known.

The observed increase in tetrads where DGF was reported is proven statistically to be unrelated to observer effort. This is a true population and range expansion eastward of the butterfly, which started in 2003-2004 and is considered to be the result of improved habitat quality following the 2001-2002 foot-and-mouth disease epidemic and the availability and active dispersal of females from a large population at Scar Close NNR. The progression of this change is illustrated using maps of distribution and abundance.

Introduction to the Dark Green Fritillary

The Dark Green Fritillary is a local, single brooded, large fritillary butterfly with adults flying from June to the end of August, the exact flight period depending on the weather of the season. It is encountered in biotopes with abundant violets, in a variety of situations from the early seral stages of woodland, to heathland, moorland and grasslands. Its main food plants are *Viola riviniana* and *V. palustris* but *V. hirta* is also used on calcareous sites. Adults are highly mobile and tend to occur at low densities over large areas in which there are small patches of suitable breeding habitat. On the best sites with a greater concentration of breeding habitat the adults can become more numerous and the colonies occupy more discrete areas (Asher *et al.* 2001).

For more details of its biology and life history see Clough (2005) and Thomas & Lewington (2010). In the few detailed mark and recapture studies the adults were found to move freely within each breeding area but most seemed to stay within their colony, moving less than 1km. In a very few cases the butterfly was observed to have moved up to 5km from known breeding areas (Warren, 1994, Whitaker 2006). Discrepancies in observed adult sex rations may indicate that a proportion of freshly emerged females emigrate (Whitaker unpublished data from Whitaker 2006).

The Past Status of the Butterfly

Populations of the Dark Green Fritillary have fluctuated during the past century but mainly its distributions and populations have declined. It was quite well distributed in Yorkshire until the 1850's but probably mainly on uplands. Set against the long-term distribution decline population levels of the Dark Green Fritillary have increased since the 1970s (Fox *et al.* 2006). Records in the decades to 2000 have mainly come from North York Moors National Park (NYMNP) and the Yorkshire Dales National Park (YDNP), near to the only sites where it was known as resident. Records from outside the National Parks included a scatter of reports and unconfirmed sightings of large fritillaries in the eastern Pennines in west central Yorkshire where the species has had a long history of solitary records and occasional colonisation (Clough 2005, Whitaker 2004). In the period 1995-2002 the Dark Green Fritillary was only recorded from 14 Yorkshire 10km squares (Whitaker 2004). Since 2000 many more records have been submitted and much more has been discovered about its behaviour and distribution in the West of Yorkshire (Clough 2005; Whitaker 2006, 2007).

Table 1
Relationship between the number of VC64 tetrads recorded & the tetrads where DGF was reported.

YEAR	**VC64 Tetrads**	**Recorded VC64 Tetrads with DGF**	**Tetrads with DGF as % of Tetrads Recorded in that Year**	**Tetrads with DGF as % of all Tetrads Recorded 2000-10**
2000	**227**	**2**	0.88	**0.21**
2001	**118**	**2**	1.69	**0.21**
2002	**336**	**3**	0.89	**0.32**
2003	**445**	**10**	2.25	**1.07**
2004	**471**	**19**	4.03	**2.03**
2005	**375**	**19**	5.07	**2.03**
2006	**361**	**29**	8.03	**3.1**
2007	**336**	**36**	10.72	**3.85**
2008	**266**	**35**	13.16	**3.74**
2009	**343**	**29**	8.45	**3.1**
2010	**329**	**40**	12.16	**4.28**

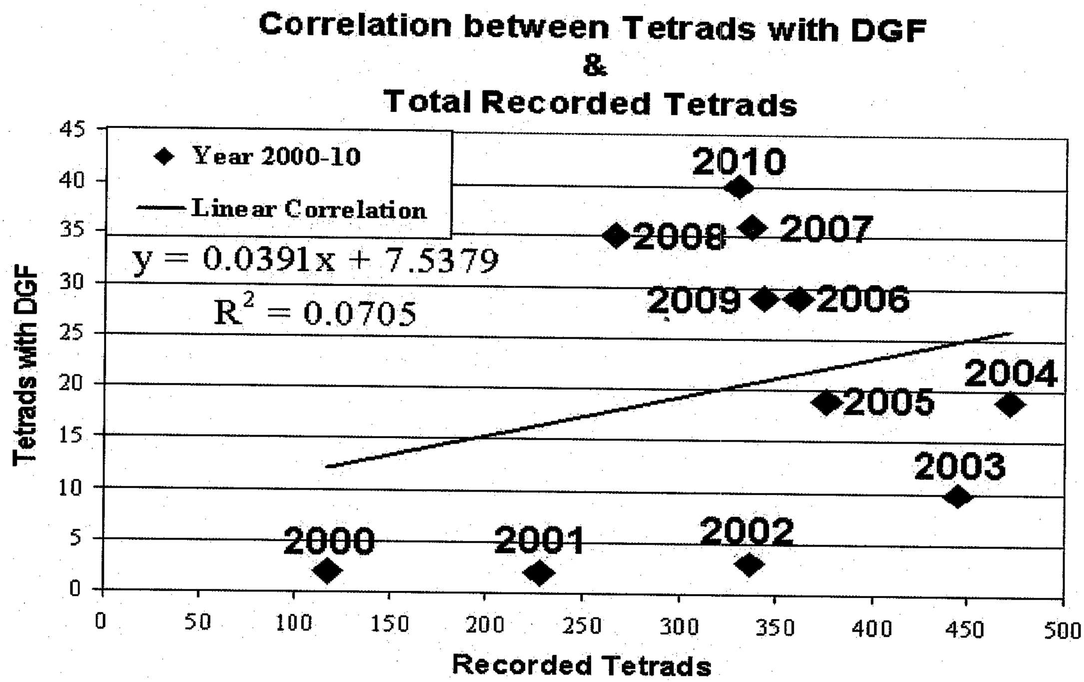
In the period up to 2004 there was a slight tendency for more observer effort in recording more tetrads to result in more DGF sites to be recorded. After 2004 more observer effort resulted in proportionally less DGF sites being reported.

Plotting a linear regression of these two variables over the period 2000 to 2010 the graph (Fig. 1) below is obtained. Between 2000 and 2004 a slightly positive linear regression accounts for 67% of the variance but afterwards, between 2005 and 2010, 39% of the variance is explained by an inverse linear relationship. Overall less than 0.07% of the variance is explained by the simple relationship.

This correlation between Recorded Tetrads & Tetrads with DGF was checked using Spearman's rank correlation coefficient and agreed with the conclusions below. A value of Rs of 0.124 & P = 0.717 indicating no significant correlation (significance at the 5% level would require an R value of < 0.591).

Conclusions supported by Table 1 & Figure 1
The observed increase in tetrads where DGF was reported is **NOT** related to observer effort. This is related to a true population and range expansion of the butterfly, which started in 2003-2004.

Figure 1. Correlation between tetrads with DGF & total recorded tetrads, 2000-2010.



The Progression of population and range expansion

In most years there are a number of records of solitary Dark Green Fritillary butterflies. These vagrants appear to represent the capacity for colonisation by the species and are more numerous in the warmer summers. The establishment of founder colonies gives rise to small numbers of records in the adjacent areas(Figs. 2 & 3).

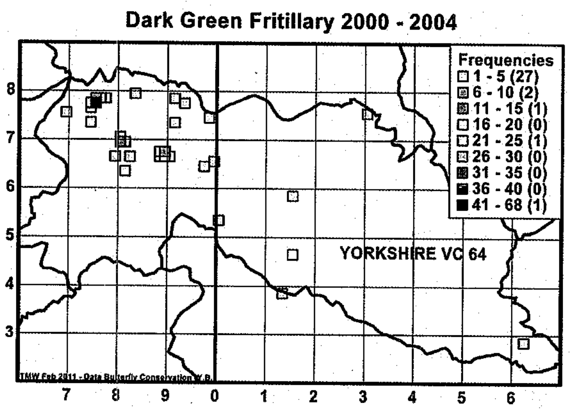


Figure 2.
Recorded frequencies of DGF 2000-2004

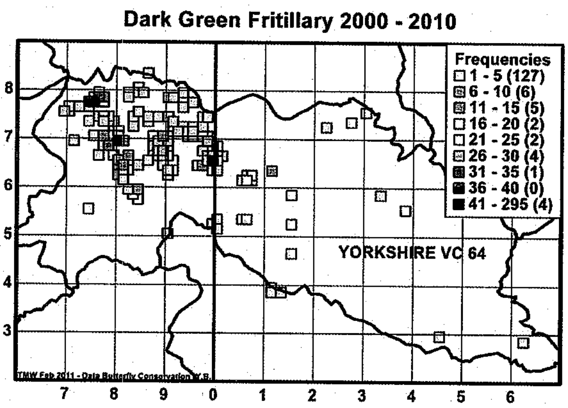
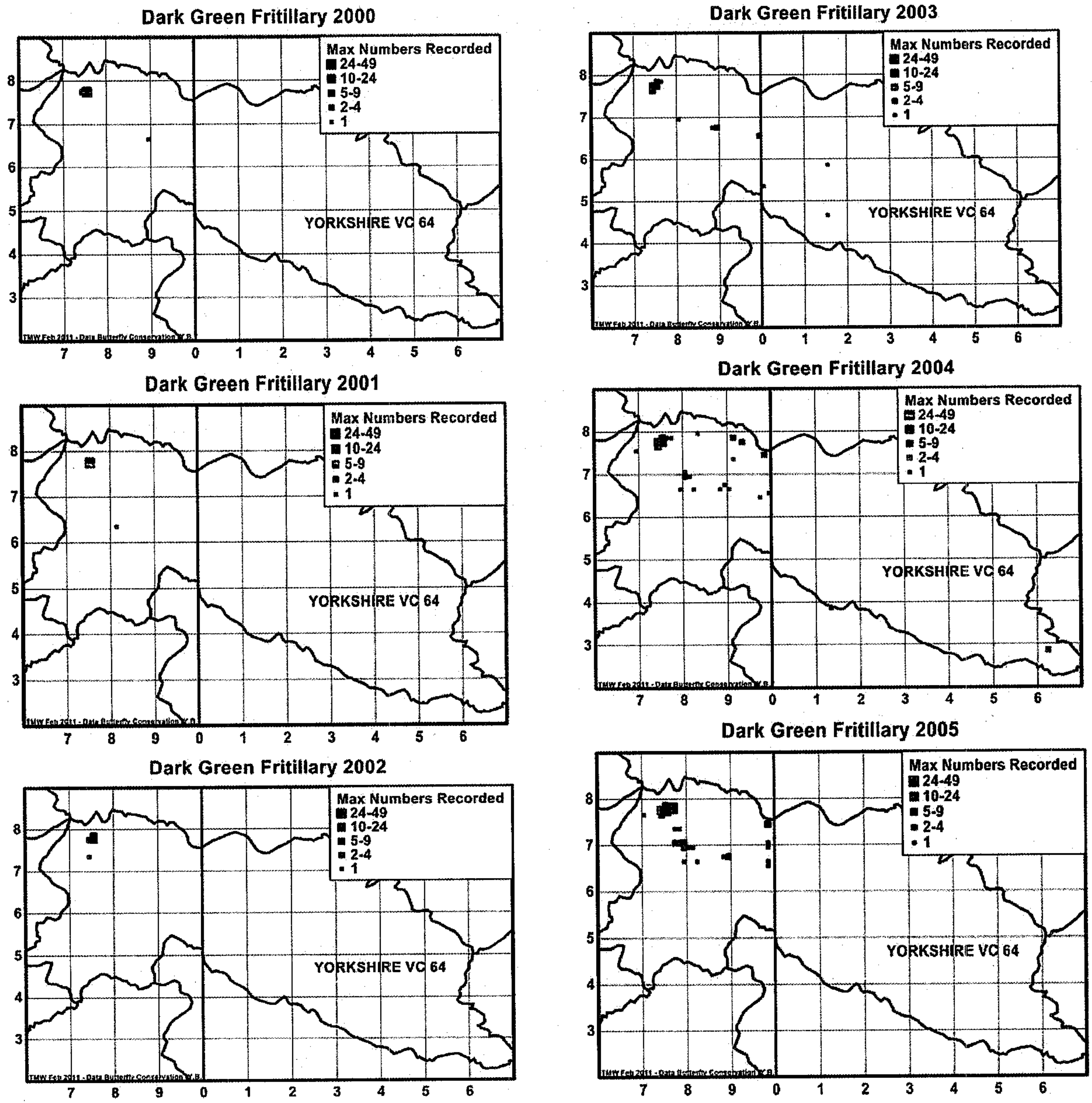


Figure 3.
Recorded frequencies of DGF 2000-2010

Figures 4-9. Dark Green Fritillary 2000-2005



Years 2000 to 2002

2001-2002 Foot and Mouth disease epidemic. Subsequently grazing intensity is reduced over much of the southeastern Dales. Only one location (Scar Close NNR) where DGF is regularly recorded.

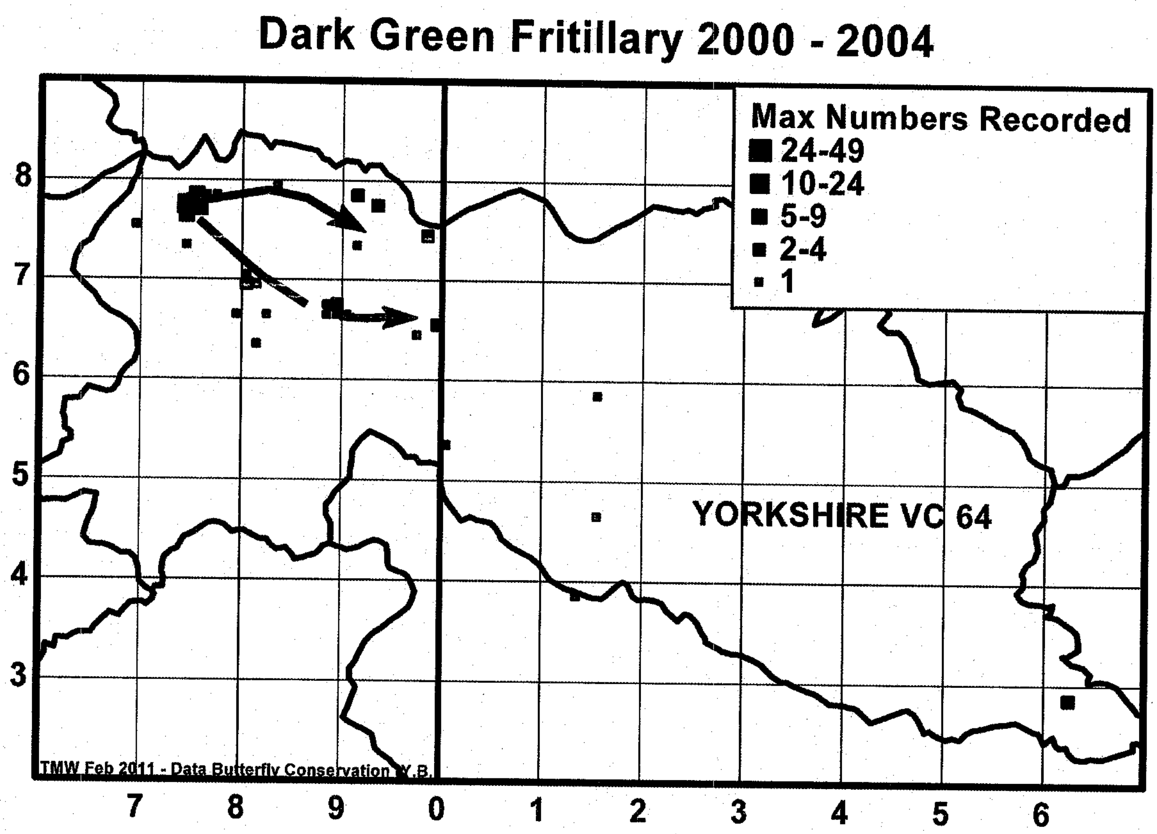
Year 2003

Records mainly from Scar Close NNR and nearby Ribblehead but a scatter of records from Swarth, Malham Tarn, and Grass & Bastow Woods. Is this the start of a southeasterly spread?

Years 2004 to 2005

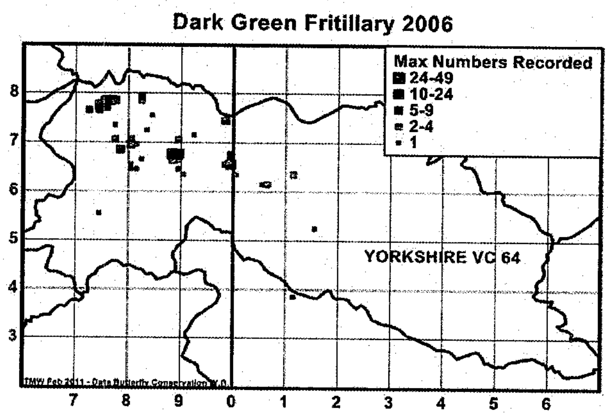
Records in new locations: Swarth Moor SSSI, Malham Tarn, Grass & Bastow Woods and Giggleswick Scar. A significant number of records from Upper Wharfedale-Langstrothdale; from Kettlewell to Greenfield Forest. Does this show an easterly spread from Scar Close NNR and Ribblehead through Greenfield Forest into Upper Wharfedale? Also from Scar Close NNR southeasterly to Giggleswick Scar, Swarth Moor, Malham and the Grassington Area?

Figure 10.



Progress of the Expansion

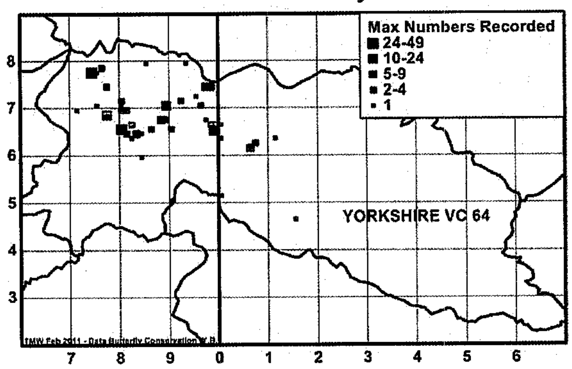
Figures 11-14. Dark Green Fritillary 2006-2009



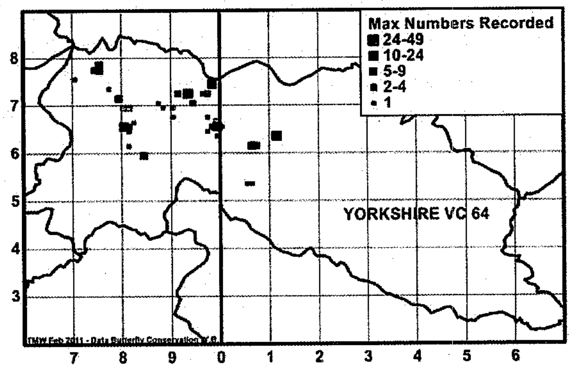
Year 2006

A year with an exceptionally warm and sunny flight period. Records from new locations, further East (Trollers Gill and Duckstreet) and also from Littondale and Gisburn Forest. Numbers increase and the population expands.

Dark Green Fritillary 2007



Dark Green Fritillary 2009



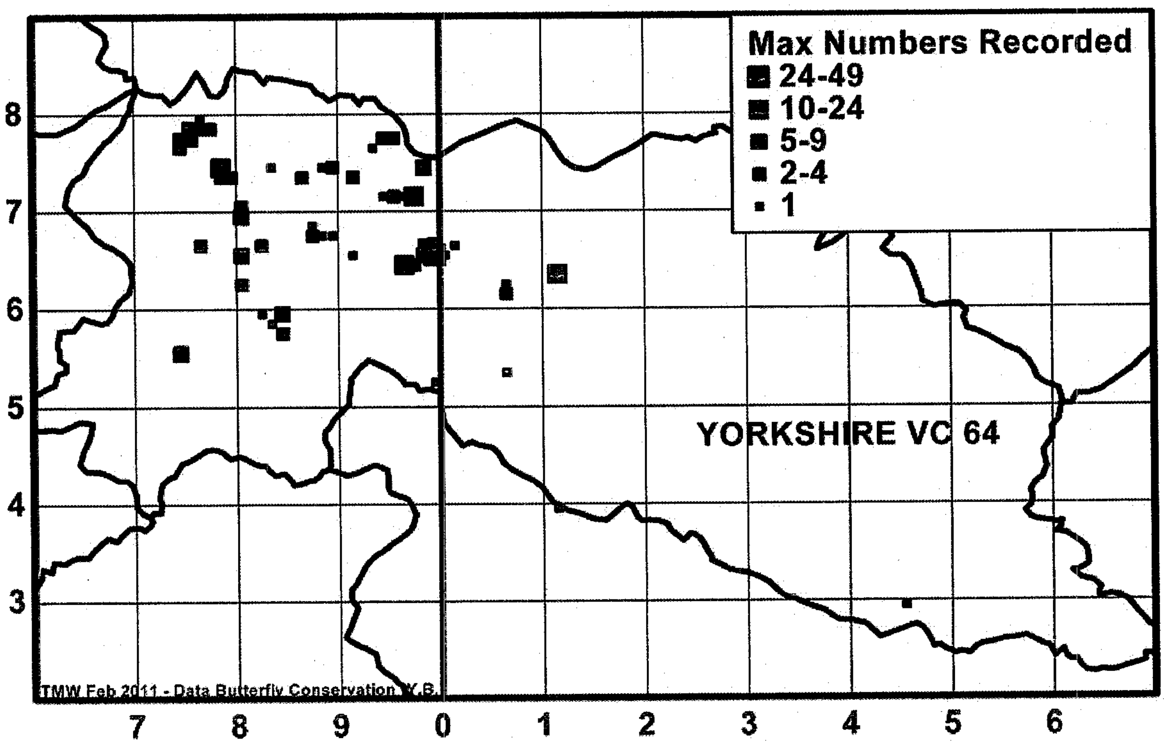
Year 2007

A year with a wet and changeable flight period. First records from Long Preston (Long Preston Moor). Larger numbers recorded from upper Wharfedale and Littondale (including Kettlewell, Grassington Area and Cowside Beck). Numbers increase & the population expands.

Years 2008 to 2010

The flight periods in 2008 to 2010 were average but changeable. Larger numbers recorded from around Ingleborough, Long Preston Moor, Gisburn Forest, Littondale, Upper Wharfedale, Grassington Area, Trollers Gill and Duckstreet. Despite poor summers, numbers continued to increase & the population continues to expand

Dark Green Fritillary 2010



What is driving the expansion?

Whitaker (2006) used mark release and recapture techniques (MMR) on Scar Close populations in both 2005 and 2006 to accurately estimate the male and female populations. From the start it was obvious that males & females behave very differently. A total of 1512 butterflies were marked (1332 male, 180 female).

Female emergence and maximum was approximately 14 days later than male; although wing wear rates (a measure of aging) were similar in the sexes. The number & proportion of females captured & recaptured was much smaller than males. In 2005 & 2006 for daily recaptures this was only 4.1% compared with 11.1% for the males but the instantaneous MRR estimates showed the mean proportion of females was 13.1% (Figs. 15 & 16)

Figure 15
Percent females captured

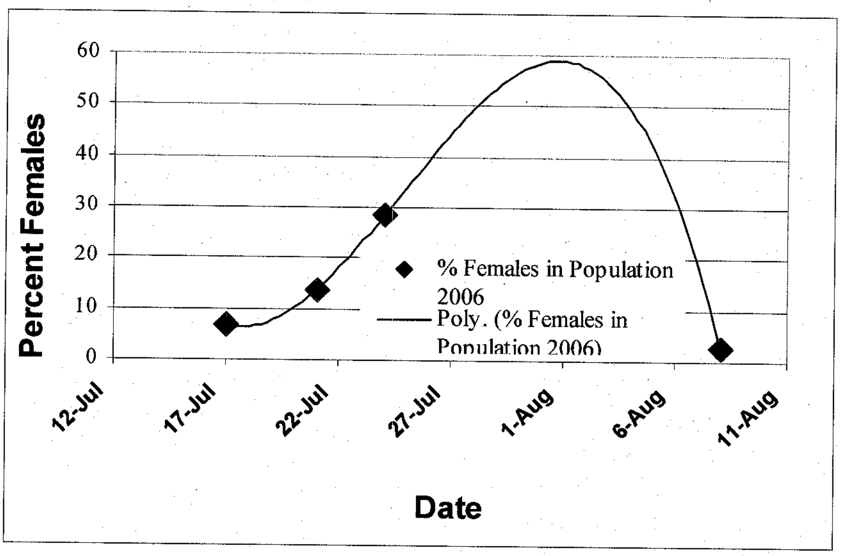
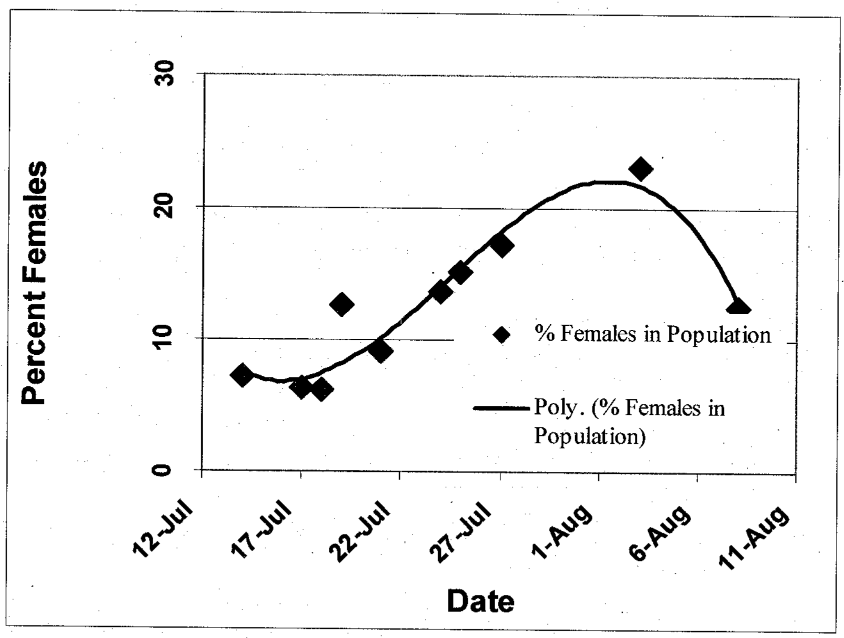


Figure 16
Percent female estimated from MMR recaptures



Discussion

It could be expected that the changing sex ratios are primarily a reflection of female recruitment into the population where most males have already emerged & are suffering progressive mortality. If the females emerge over a longer period within the annual flight period a similar survivorship of each sex would give differently shaped population abundance curves dependent on emergence rates and survivorship of each sex. Equality of numbers should occur once in the season & similar numbers of each sex would be seen to emerge during the flight season.

This does not happen. It appears that a large proportion of the females are dispersing from Scar Close NNR shortly after mating.

Conclusions

In the ten years 2000-2010 the abundance of the Dark Green Fritillary has changed from less than one percent to over twelve percent of recorded tetrads in VC64. It has spread eastward from a single site (Scar Close NNR) in Northwest Yorkshire to become established on several new sites in the Yorkshire Dales National Park and Pennine uplands, as Far East as Pateley Bridge.

This is surmised to be a result of improved habitat quality following changed grazing patterns resulting from the 2001-2002 foot-and-mouth disease epidemic (more extensive cattle and less sheep) and the active dispersal of newly mated females from a large population at Scar Close NNR.

Acknowledgments

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All the individuals who send butterfly records to Butterfly Conservation.

Butterfly Conservation (Yorkshire Branch) for access to that butterfly record data.

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Malham Tarn - a marl lake recovering or degrading?

Emma Wiik, Carl Sayer, Helen Bennion & Thomas Davidson (Environmental Change Research Centre, UCL); Stewart Clarke (Natural England)

Marl lakes are a fairly rare habitat in the UK, falling within category I of the UK's lake classification scheme as "base-rich lakes, with *Chara* spp., *Myriophyllum spicatum* and a diversity of *Potamogeton* species" (Duigan et al 2006). Currently, 203 lakes in the UK are classed as marl lakes, many of which and including Malham Tarn, are Sites of Special Scientific Interest (SSSI).

Charophytes (stoneworts) are macrophytic algae that are particularly common in high quality marl lakes and are known to accumulate a calcite coating during periods of high plant (and microalgal) productivity. This coating can also remain over winter. They tend to grow as dense stands, stabilising the sediment, and are generally associated with clear water and low overall primary productivity. As eutrophication progresses, charophytes tend to get replaced by other tall growing or floating-leaved macrophytes.

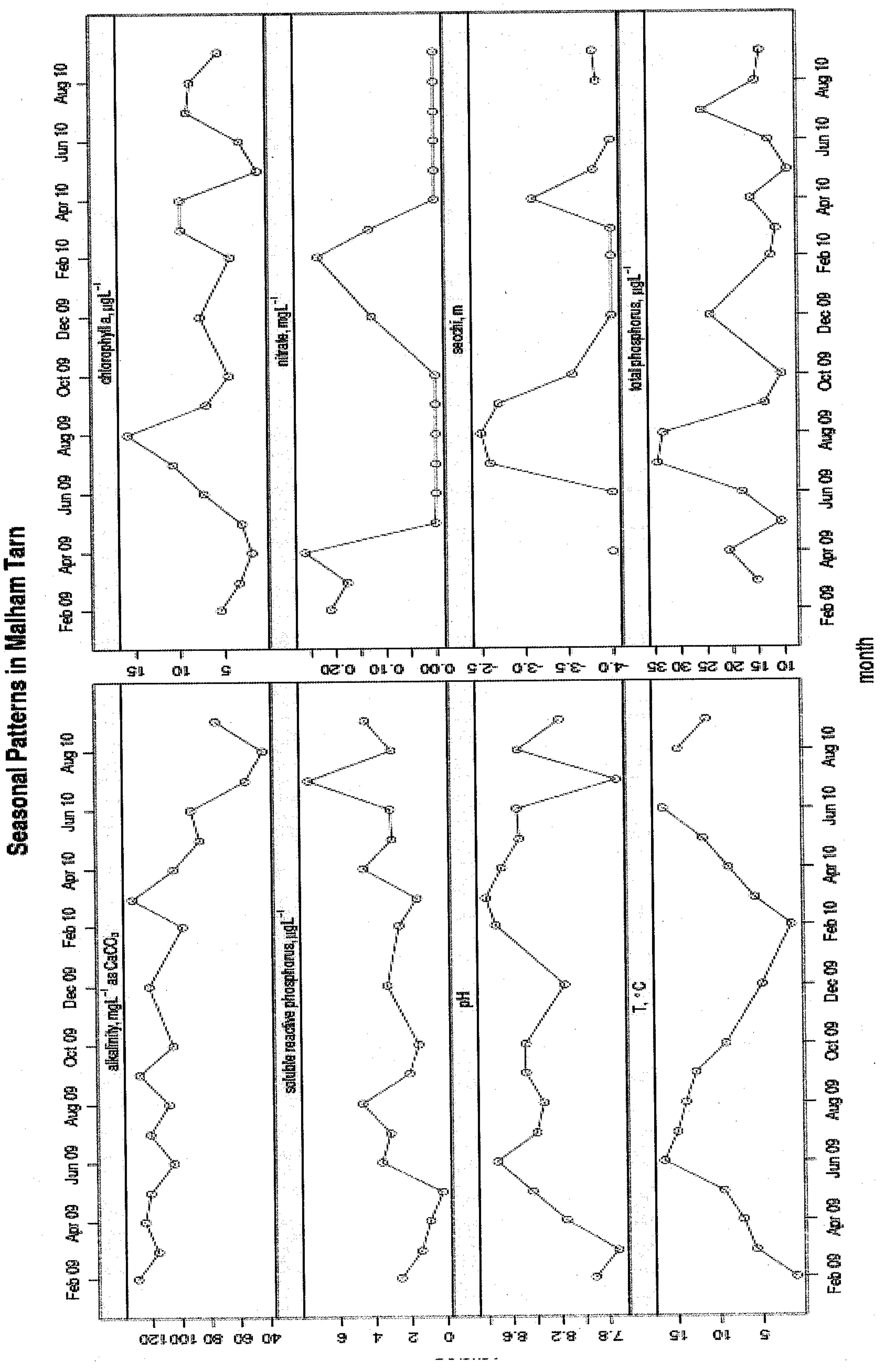
As part of a PhD, we have been researching three marl lakes (Cunswick Tarn in the Lake District, Hawes Water in Silverdale & Malham Tarn in the Yorkshire Dales). The project seeks to answer key questions regarding the sensitivity of marl lakes to nutrient enrichment: 1) How sensitive are they? 2) What ecological responses do they display? 3) If there is change, how rapid and dramatic is it?

Both Cunswick Tarn and Hawes Water are fairly deep (mean depths 3.2 and 4.2m, respectively). Cunswick Tarn is very eutrophic and Hawes Water is oligo-mesotrophic (mean total phosphorus over all seasons 56 and 20 μgL^{-1}, respectively). Multi-proxy analyses of sediment cores from both sites have been carried out. Cunswick Tarn has changed dramatically throughout the 20th and 21st centuries, undergoing a complete loss of a once diverse charophyte community, being at present dominated by water-lilies and the invasive *Elodea canadensis.* Large changes have also occurred in its invertebrate communities. Overall biodiversity seems reduced in comparison to the other marl lake sites. As is typical of eutrophication, there has been a transition to dominance by planktonic algae and cladocerans, which started in the 1950s. Currently, high productivity, and thus substantial accumulation of organic matter in the hypolimnion, has also led to very low oxygen concentrations below a depth of approximately 3m.

Hawes Water was assumed to be near pristine at the onset of the PhD, but palaeolimnological analyses have revealed surprisingly substantial changes despite its fairly low mean total phosphorus. Algal and higher plant communities, as well as invertebrate communities have changed. A deep-growing charophyte species *(Chara rudis)* has been lost from the lake, and currently, as in Cunswick Tarn, macrophytes are restricted to the shallower margins. Summer algal blooms have also become more frequent.

Sediment cores were collected from Malham Tarn, but radiometric dating of the cores did not prove possible, with several centuries of sediment compressed into a depth of less than 10cm. The Tarn is so windy that areas of continuous sedimentation are likely to be patchily distributed. Thus, regrettably, our research is limited to contemporary sampling as well as gathered historical ecological information.

Figure 1 Seasonal Patterns in Malham Tarn


Seasonal Patterns in Malham Tarn
alkalinity, mgL-1 as CaCO3
soluble reactive phosphorus, µgL-1
pH
T, °C
chlorophyll a, µgL-1
nitrate, mgL-1
secchi, m
total phosphorus, µgL-1
Feb 09
Apr 09
Jun 09
Aug 09
Oct 09
Dec 09
Feb 10
Apr 10
Jun 10
Aug 10
month

Malham Tarn is shallower (maximum and mean depths of 4.4 and 2.4m) than Hawes Water and Cunswick Tarn and consequently much less likely to suffer a reduction in the colonisation depth of charophytes. However, the lake is still showing symptoms of eutrophication. Recent macrophyte surveys indicate a rich growth of filamentous algae, locally smothering other plants by the inflow and outflow areas. The sediment at the inflow area is also very loose, suggesting substantial input of fine material from the catchment. Long-term inflow and outflow nutrient concentration data reveal increased nitrate concentrations since the early 1990's. In-lake nitrate concentrations go below detection during summer months (Fig.1), which suggests that the lake responds to increased nitrate concentrations by increased productivity. Historical macrophyte data reveal a loss of the eutrophication-sensitive *Potamogeton gramineus*, which is now found only in the outflow stream. Also *Potamogeton natans* has disappeared. Both *Potamogeton lucens* and *Myriophyllum spicatum* have become less abundant, while *Zannichellia palustris*, a species often associated with eutrophic conditions, has been found growing by the northwest and southeast shores. Sediment core studies of other UK shallow lakes have shown such changes, particularly declines in *M. spicatum* and broad-leaved pondweeds, to be characteristic of the early stages of nutrient enrichment (Davidson et al. 2005; Sayer et al. 2010). Algal blooms have become more common in summer, with less pellucid days than described in the 18th century when "on a still day, you may see the white chalky bottom, where it is 10 or 12 foot deep" (Fuller 1741).

Malham Tarn is a unique site, being the highest marl lake in the UK. It is a SSSI and also lies within a Natural Nature Reserve. A globally rare orb-like growth form of the alga *Aegagrophila linnaei* grows by the western shore, and is known to decline with eutrophication. In addition the Tarn's important population of white-clawed crayfish has undergone a steep decline in recent decades. All these factors, in addition to the natural beauty of the site itself, highlight the importance of protecting the Tarn from excess nutrients. If we could provide one take home message it would be this: Preventing eutrophication is much cheaper, and involves less effort, than reversing its effects on an ecosystem.

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Dissolved orthophosphate contribution of the Mountain Limestone in Malham Tarn Catchment

Allan Pentecost

There has been much interest in the nutrient content of water entering Malham Tarn owing to its key role in eutrophication (Talling & Hilton, 1982; Talling, 1987; Pentecost, 1992; Horan & Abis, 1993; Kaewsena, 1993; Johnes, 1996; Pentecost, 1998; Talling & Parker, 2002 a,b).

One source of dissolved orthophosphate phosphorus (P_i) in waterbodies is the weathering of rock within the catchment. Weathering rates, and thus release rates of P_i are mainly dependent upon macroclimate, rock type and soil characteristics. The Malham Tarn catchment is underlain primarily by hard limestones and enhanced locally by calcareous drift soils, so the weathering of limestone is likely to exert some influence over the P_i entering the mesotrophic marl lake Malham Tarn.

To provide a better understanding of the release of P_i by the limestone in the catchment, six limestone samples were removed from the catchment for analysis. Cobbles weighing 1-2 kg were broken open to reveal clean cores using limestone blocks to avoid contamination from steel hammers, then coarsely crushed. The crushings were passed through a pair of stainless steel sieves and the 1-5 mm fraction retained. These were washed twice with distilled water over 48h to remove surface dust then dried and equal amounts of the six samples mixed well to provide a composite sample. Twenty five grams of each composite sample plus 300 ml distilled water was added to each of four 1 litre borosilicate flasks, one of which acted as a control. The remaining three were fitted with gas-tight bungs and valves so that known volumes of carbon dioxide could be added to provide an atmosphere containing 1% CO_2 by volume. This atmosphere simulated the local soil atmosphere, since most of the limestone weathering occurs at the soil/rock interface. The flasks were incubated in the dark at 10-12°C for 12 days, by which time the specific conductivity of the contained water had risen to 400 µS cm^{-1} indicating limestone dissolution was close to equilibrium with the gas phase, and of a similar composition to that of the local limestone springwater. 100 ml water was removed from the flasks, passed through a 0.45 µm membrane filter and analysed for P_i using the phosphomolybdenum blue method followed by hexanol extraction. The results are shown in Table 1.

Table 1 Dissolved orthophosphate concentrations in water charged with CO_2 in contact with the limestone

Experiment no	Gas phase CO_2 %	P_i µg/l
1	1	5.9
2	1	5.2
3	1	6.3
4	1	5.8
Mean		**5.8**
Mean Total P at Tarn outflow from Talling (1987)		9.5

A sample of the limestone was also dissolved in N HCl so that the P content of the rock could be estimated. Dissolution was 1 hour at 15°C followed by filtration and analysis. The results for the five samples used in the experiments are shown in Table 2.

Table 2. Limestone P content based on N HCl dissolution

Sample no	Location	P content of limestone ppm
1	Great Close spring	16
2	Tarn E shore	17
3	Quarry car park	8
4	Road junction E of Capon Hall	20
5	Wall below Capon Hall	11
Mean		**14.2**

Discussion

Water in the main Tarn inflow contains approximately 250 ppm dissolved $CaCO_3$. Assuming the limestone P analysis of Table 2 is representative of the catchment limestone, the water would be expected to contain about 4 µg/l P_i. This is slightly lower than the average P_i reported from the CO_2 dissolution experiments and might indicate a source of P in the limestone that is released over a longer period of time.

According to Horan & Abis (1993) the retention time of Malham Tarn averages 3 months. The total volume of the Tarn is close to 1.47 x 10^6 m^3 (Talling & Hilton, 1982 gave 1.46; Pentecost & Coletta *unpublished* independently obtained 1.48). The amount of water running through the Tarn annually is therefore about 5.9 x 10^6 m^3. Using a figure of 5 µg/l for the P entering water from the limestone, it is evident that about 30 kg P could enter the Tarn annually from this source.

These figures mean little in isolation as they ignore other potential P sources and the transformation/capture of P within the catchment soils and vegetation such as nutrient spiralling. Rainwater contains P but levels vary widely geographically. In the Malham catchment, precipitation total P levels have been reported by Talling (1987, Table 2). For 1986-7 the mean was 32.9 µg/l, but it included several large outliers. Trimming at 5% brings the mean down 28.6 µg/l but there were no data for P_i. Peters (1977) found that 38-76% of the total P was in the dissolved form for some Canadian rainwater samples. If a conservative value of 50% is used for Malham then the rainwater P_i would average about 15 µg/l and is therefore significant when compared with limestone dissolution.

Talling (1987, Fig. 6) provides data for P levels in the main Tarn inflow over the period March 1985 to March 1987. During this time the average total P concentration was 9.5 µg/l with P_i 1.9 µg/l, much lower than the above estimates. This emphasises the importance of catchment processes, since limestone dissolution and precipitation alone provide in excess of 30 µg/l total P. The loss of P from the limestone therefore bears no direct relationship to the amount of P entering the Tarn but is significant in terms of catchment processes.

Location of P within the limestone

A larger set of limestone samples from the Malham area has demonstrated a strong ($p<0.01$) positive correlation between the acid-insoluble fraction of the rock and the P released by HCl. This suggests that most of the P in the limestone originates from this fraction. An X-ray study of this fraction revealed some particles containing P associated with Al and Si (Pentecost, 1990). Fe was high in the residue but there was no Fe associated with P, though the acid dissolution may have removed most of this if it was present, along with any apatite. It was also found that 28% of particles were 'organic' and these too could have contained some hydrolysable phosphorus.

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Aquatic Macroinvertebrate Recording on the Malham Tarn Estate

Sharon and Peter Flint

Introduction

The last major survey of macroinvertebrates on the Malham estate was undertaken by the Entomological Section of the Yorkshire Naturalist Union, over a period of 5 years (one week per year), from 1954 to 1958 (Flint *et al*, 1962). This work generated numerous records and included many aquatic species.

A range of methods were employed to collect specimens of both juvenile and adult insects. These included light traps, sweep nets and pond nets as well as hand searching of substrates. Since 2009, aquatic insects have been collected on an ad hoc basis, by us; and by students and ourselves during our taught course; from the tarn, dykes on Malham Fen, ponds on Malham Fen and from Gordale Beck. Some data from the Malham report of 1962 is presented along with data from the last 2-3 years, (Tables 1). Sampling locations are shown on figure 1.
Species additional to the Malham Report are listed in bold type.

Figure 1

Sample Point	Name
1	Large Pond, Fen
2	Large dyke, Fen
3	Small ponds, Fen
4, 5, 6	Tarn
7	Inlet Stream, Tarn
8	Outflow of Tarn
9	Large dyke, Fen
10	Gordale Beck

Table 1

Malham Report				2009-11									
Order	**Family**	**Species**	**Location**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Plecoptera	Taenyoptergidae	Brachyptera risi	GC										
	Nemouridae	Protonemura praecox	UGB, DB										
		P.meyeri	AS										
		A.sulcicollis	TSN,TSE, MB										
		Nemurella pictetii	TF										
		N.avicularis	TSN, TI,DB,										
		N.cambrica	TSN,TSE										
		N.erratica	GC,UGB, MB										
	Leutridae	Leuctra geniculata	TSN, TSS, inflow, MB							✓			
		L.inermis	AS										
		L.hippopus	WD										
		L.nigra	T										
		L.fusca	WD										
		L.moselyi	DB										
	Capniidae	Capnia bifrons	TSN, TSE, O, WS										
	Perlodidae	Perlodes microcephala	O, UGB, DB										
		Isoperla grammatica	AS										
	Perlidae	Dinocras cephalotes	O, WS										✓
	Chloroperlidae	Chloroperla torrentium	AS										✓
		C.tripunctata	TH										

Order	Family	Species	Location	1	2	3	4	5	6	7	8	9	10
Ephemeropte	Ephemeridae	Ephemera danica	UGB										✓
	Leptophlebiidae	Paraleptophlebia submarginata	UGB, CB										
		Habrophlebia fusca	SHF, TF, UGB										
	Ephemerellidae	Seratella ignita	UGB, MB										✓
	Caenidae	Caenis horaria	T										
		Caenis rivulorum											✓
	Baetidae	Baetis tenax	TH										
		B.rhodani	RS										✓
		Centroptilum luteolum	IFS										
		C. pennulatum	T, IFS, ESB										
		Cloeon simile	T, IFSESB										
	Siphlonuridae	Siphlonurus lacustris	CB										
		Ameletus inopinatus	MB										
	Ecdyonuridae	Rhithrogena semicolor	O										✓
		Heptagenia lateralis	O, CB										
		Ecdyonurus venosus	IFS,UGB, CB, MB										
		E.torrentis	UGB										✓
		E.dispar	TSN, TSE, UGB										
Odonata	Coenagrionidae	Pyrrhosoma nymphula	TM, FF	✓		✓							
		Enallagma cyathigerum	Tarn Chara beds										
		Lestes sponsa		✓									
	Aeshnidae	Aeshna juncea	TM, TF,TH, SHPP, FFT	✓									
	Libellulidae	Sympetrum scoticum	TM, SHPP										
		Libellula quadrimaculata		✓		✓							
Megaloptera	Sialidae	Sialis lutaria	TF, TM,UGB			✓		✓	✓				
Hemiptera Heteroptera	Veliidae	Velia caprai	TS, TSN										✓
	Gerridae	Gerris lateralis	ESB, TSN, TF										
		G.costai	TM, FF	✓									
	Nepidae	Nepa cinerea	GCM and TSW										
	Notonectidae	Notonecta glauca	SHPP	✓		✓							
	Corixidae	Micronecta poweri	Tarn				✓						
		Callicorixa praeusta	TF										
		Hesperocorixa sahlbergi	TF	✓		✓			✓				
		Arctocorisa carinata	FF										
		Sigara dorsalis	MW						✓				
		S.falleni							✓				
		S.nigrolineata	HM										
		S.limitata	TF.										
		Hesperocorixa castanea	SHPP										
		H.Linnaei				✓							

Order	Family	Species	Location	1	2	3	4	5	6	7	8	9	10
Coleoptera	Haliplidae	Brychius elevatus	TSN										
		Haliplus obliguus	TSN										
		H.ruficollis	TF,IFS,TSN										
		H.wehnckei	TSN,IFS						✔				
		H.flavicollis	TSW										
	Dytiscidae	Rhantus suturellus	SHPP,HM	✔		✔					✔		
		Oreodytes sanmarkii				✔							
		Agabus unguicularis		✔									
		A.bipustulatus	FF,SHPP,TF,GCM,HM,ML	✔		✔							
		A.congena	FF										
		A.guttatus	FF, T, MW										
		Hydroporus striola		✔									
		H. planus				✔							
		Hydrobius fuscipes		✔									
		H.erythrocephalus	TM,TF										
		H.obscurus	TF,TM,SHPP,HM										
		H.pubescens	ML,FF,TF,HM,TM										✔
		Ilybius quadriguttatus				✔							
		Potamonectes depressus elegans	TS,MW,FF	✔				✔					
		Oreodytes davisii	TS										
		O.septentrionis	FF										
		Platambus maculatus	TS,MW		✔			✔					
		Ilybius fuliginosus	SHPP,TF,IFS										
		Colymbetes fuscus	EB,TF										
		Dytiscus marginalis	SHPP	✔									
		Acilius sulcatus	MW	✔		✔							
	Gyrinidae	Gyrinus substriatus	TM	✔									
	Hydrophilidae	Helophorus rufipes	ML										
		Enochrus affinis				✔							
		Enochrus minutus	TF										
		Hydrobius fuscipes	TF										
		Anacaena globulus	TM,TF,FF										
	Elmidae	**Limnius volkmari**											✔

Future Work

Long term monitoring of juvenile and adult aquatic insects using a range of sampling methods and in each season of the year, is the most effective way of producing a comprehensive species list for a site. This work is very labour intensive and time consuming, but would produce species data, distributional and seasonal data. Such work could inform future management decisions.

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Caddis fly Recording on the Malham Estate

Sharon and Peter Flint

Introduction

The most comprehensive records of Caddisflies of the Malham area can be found in the Yorkshire Naturalists Report of 1962. Collecting was carried out from 1948 to 1958, by sweeping, direct searching of stones, vegetation and light trapping (Flint *et al*, 1962).

A total of 71 species of Caddis fly were recorded from the survey area (Figure 1.) including Gordale, Cowside and Darnbrook becks. Of these, 39 species were considered to belong to the tarn, only 15 could be considered common (Holmes, 1962). Malham has a third of the British species.

Species caught during 1948-58 are presented, along with records for juveniles, collected over the last two years and adults caught during a weekend of light trapping by the YNU. (Table 2).

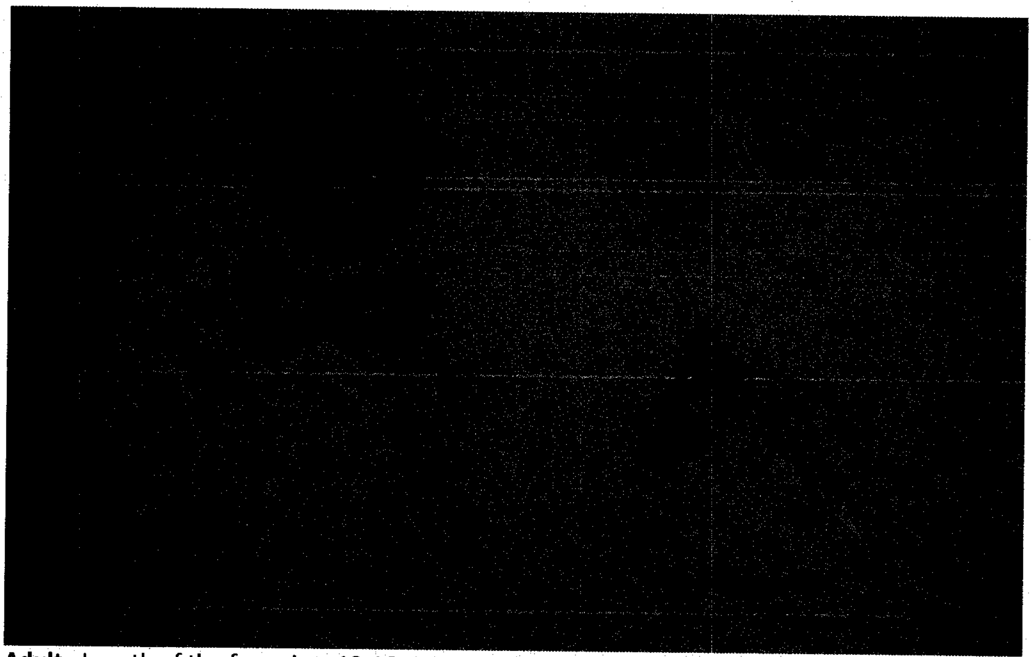
Table 2

Malham Report		2009-11												
Family	Species	1	2	3	4	5	6	7	8	9	10	11	12	Adult records July 2011
Phyganeidae	Phrygaenea bipunctata													
	Oligotrichia striata	✓		✓										
	Agrypnia varia													
	A.obsoleta					✓								
	Agrypnetes crassicornis													
Limnephilidae	Drusus annulatus													
	Limnephilus rhombicus													
	L.politus													
	L.stigma													
	L.lunatus		✓											✓
	L.luridus													
	L.elegans													
	L.griseus													
	L.affinis													
	L.incisus													
	L.centralis													
	L.sparsus													
	L.auricula													
	L.vittatus													
	L.extricatus													
	L.coenosus													
	Anabola nervosa		✓											
	Rhadicoleptus alpestris													
	Potamophylaxlatipennis													✓
	Potamophylax rotundipennis		✓											
	Halesus radiatus													
	H.digitatus													
	Melampophylaxmucoreus				✓	✓	✓	✓						

Family	Species	1	2	3	4	5	6	7	8	9	10	11	12	Adult records July 2011
	Stenophylaxpermistus													
	S.vibex													
	S.sequax													
	Mesophylaximpunctatus													
	Hydratophylaxinfumatus													
Phyganeidae	Phrygaenea bipunctata													
	Oligotrichia striata	✓		✓										
	Agrypnia varia													
	A.obsoleta					✓								
	Agrypnetes crassicornis													
Limnephilidae	Drusus annulatus													
	Limnephilus rhombicus													
	L.politus													
	L.stigma													
	L.lunatus		✓											✓
	L.luridus													
	L.elegans													
	L.griseus													
	L.affinis													
	L.incisus													
	L.centralis													
	L.sparsus													
	L.auricula													
	L.vittatus													
	L.extricatus													
	L.coenosus													
	Anabola nervosa		✓											
	Rhadicoleptus alpestris													
	Potamophylaxlatipennis													✓
	Potamophylax rotundipennis		✓											
	Halesus radiatus													
	H.digitatus													
	Melampophylaxmucoreus				✓	✓	✓	✓						
	Stenophylaxpermistus													
	S.vibex													
	S.sequax													
	Mesophylaximpunctatus													
	Hydratophylaxinfumatus													
Hydroptilidae	Agraylea multipunctata					✓	✓							✓
	A.pallidula													
	Hydroptila angulata													
	H.femoralis													
	H.forcipata													
	H.mchachlani													
	Oxyethira costalis													
	O.falcata													

Agrypnetes crassicornis (McLachlan). The Malham Sedge

The Malham Sedge has not been seen for the last 4 years. It is flightless and possibly not attracted to light traps



Adult: Length of the forewing, 12-16 mm. Head and appendages yellow-brown Antennae thick and somewhat serrate. Tibial spurs 1,2,2, (not consistent). Forewings long and narrow.

Larvae Carnivorous, lives in Chara beds. Short gill like process arises from anal proleg, unique in Phryganeid larvae. Case usually typical spiral arrangement of pieces of plants, but pieces of mollusc shells and lime encrustations may be included

Distribution: A Eurasian species, widely distributed in Finland, into Sweden and Estonia, with outlying population in Britain (Know only from Malham Tarn). Occurs over much of Russia, from Gulf of Finland to Transcaucasia and the region of the Aral sea. Extends to Mongolia where the population is said to be disjunct from those in central Asia and the Caucasus.

Future work

How should it be monitored ?
What sampling methods should be used ?
What is the size of its population ?
How does the population fluctuate
over time?

The first holistic limestone pavement classification – Where does Malham Cove fit in?

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Introduction

Limestone pavements are a unique habitat owing their existence to a unique series of natural processes which have taken place over a long period of time and cannot be replicated within the human timescale. This has led to their protection being undertaken often driven by legislation at the national (Wildlife and Countryside Act of 1981) and the European level (EU Habitats Directive). Perhaps soon there will be recognition of the habitat at the international level if the Burren is successful in its application for World Heritage Status.
In order to conserve the limestone pavements of the UK, they became the focus of a Habitat Action Plan, and a steering group was set up. This led to discussion about how to achieve the aforesaid protection. It became clear that a classification scheme was needed. It was argued that 'Geodiversity underpins biodiversity' (Burek 2001) and therefore a holistic approach was needed (Burek 2008).
The importance of a holistic classification for limestone pavement management was also identified (Willis, Burek and Alexander 2009). The commonly used classifications of the biologists, geologists and geomorphologists are not robust enough for successful management. Often the terms open, scrubby and wooded, are not precise enough to use for limestone pavement management (Burek & Conway 2000).
An additional problem at Malham Cove was tourist pressure where the aesthetic nature of the site has long been appreciated by the general public.

Methodology

In order to produce a holistic classification, 46 limestone pavements were randomly selected across North West England and North Wales as a first attempt at producing a workable classification (Willis 2011). This constituted about 10% of the available limestone pavement in the area (Willis 2011).
However first a new definition was devised for the study.
'A partially or wholly exposed area of limestone, fissured by natural erosion into a pattern of clints and grikes, with a distinctive and unique plant community which characterises the microclimates of the grikes.' (Willis 2011)
It was decided to use only geodiversity and biodiversity variables not microclimate data. Geodiversity being defined as 'Geodiversity: the natural range (diversity) of geological (rocks, minerals, fossils, geomorphological (landforms, processes) and soil features. It includes their assemblages, relationships, properties, interpretations and systems.' (Gray, 2004)
75 variables from these disciplines were selected, sought and tested to produce the classification. The broad categories were geodiversity, landscape scale features, biodiversity and human influence.

Table 1 shows the individual variables for the individual disciplines.

Table 1: Variables collected for the classification

Geodiversity	Geology	Geomorphology	Pedology	
	Age of limestone	Grike metrics: width, depth, orientation of grike	Soil colour	
	Thickness of beds	Clint metrics: width, length, perimeter of clints, clint-edge profiles	Texture	
	Dip of bedding plane	Runnel metrics: width, length, frequency and variety of geomorphological features present	Acidity – pH	
	Strike		Depth in grikes	
	Proximity to a major structural fault			
	Pavement slope			
	Mineral vein intrusion			
	Fossil presence and type			
Landscape scale features	Pavement topography	Local climate		
	Elevation	Frost exposure		
	Maritime influence	Precipitation		
	Aspect	Prevailing wind direction		
	Landscape	Wind speed		
Biodiversity	Alpha plant diversity	Plant species height	Vegetation cover over a set sample area	Faunal diversity
	Plant species presence per pavement area	Emergent height		Macro fauna present
	Abundance of rare species	Sward height		
	Presence of rare species			
Human influence	Grazing intensity	Human disturbance	Pavement disturbance	Archaeological remains present on site
	Observation of scars	Litter observed	Damage or removal of clint tops	
	Grazer presence	Trampling		
	Landowner/farmer interview	accessibility		

Line Intersect Sampling was undertaken to obtain the data.

Results

Using multivariate statistics produced an 8 group holistic classification. However the rationalisation with the data collected produced a robust 6 fold classification. Group 2 was made up of 2 damaged pavements and Group 5 was a single site, Colt Park Wood.
The other 6 groups comprised three high altitude groups:

- Group 1 was an open and midrange depth of grike group
- Group 6 was an open and deep grike group, species rich
- Group 7 was a shallow bedded group with low plant diversity

Malham Cove sits in Group 6.
The other three groups were at low altitude.

- Group 3 was a coastal and open group
- Groups 4 and 8 were wooded groups distinguished by their vegetation.

Key Variables

The multivariate analysis pulled out key factors establishing the classification.
The majority were geodiversity factors which is predictable as they form the context for the habitat. They were lithology, proximity to structural fault, altitude, distance from coast (proxy for moderating effect of coast on climate). The other important variable identified was human intervention in the form of grazing intensity. This significantly affects vegetation structure and composition.

Malham Cove

Malham Cove limestone pavements located in Group 6. This is a high altitude, flat open pavement group with thick beds and deep grikes. The group has unusually large, un-dissected clints. As far as the biodiversity goes Malham has great species richness and in the Ward and Evans data (1975) it scored mid-way between the other members of the group with Dale Head 71-90, Scar Close, Top Cow and Tennant Gill had the highest scores of 91+. Old Ing, the 6th member of this group, had the lowest index score of less than 71. Malham Cove is a heavily visited location (Fig 1) and human interference in the form of litter and trampling is noticeable and sad to see (Fig 2). Surprisingly rare limestone pavement specialist plant species have survived here, despite the many visitors. This is largely due to the deep narrow grikes and because the main pavement area is largely inaccessible to sheep due to its geomorphology.
With tourist management to reduce littering in particular, the limestone pavement is robust and engenders in visitors the sort of awe that makes them want to conserve the area for the future.

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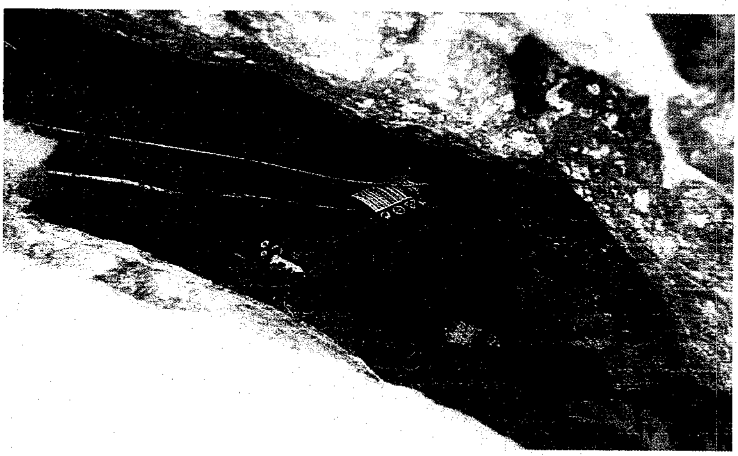
Figure 1 Malham Cove visitors
Figure 2 Litter on Malham Cove Limestone pavement



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HEAD OF CENTRE: Mike Cawthorn

September Summary			Mean for period 1961 -1990
Warmest Day	4 Sep	19.4 °C	
Average Maximum		13.9 °C	13.8 °C
Coldest Day	8 Sep	3.2 °C	
Average Minimum		7.7 °C	7.6 °C
Days with Air Frost		0 days	0 days
Wettest Day	14 Sep	19.4 mm	
Total Rain for Month		82.9 mm	138.8 mm
Days with > 1mm Rain		11 days	14.5 days
Sunniest Day	29 Sep	8.1 hours	
Total Sunshine		73.45 hours	100.8 hours

October Summary			Mean for period 1961 -1990
Warmest Day	4 Oct	16 °C	
Average Maximum		12.1 °C	10.6 °C
Coldest Day	9 Oct	2.9 °C	
Average Minimum		7.7 °C	5.2 °C
Days with Air Frost		0 days	1.2 days
Wettest Day	22 Oct	38.3 mm	
Total Rain for Month		239.7 mm	150.8 mm
Days with > 1mm Rain		22 days	16.4 days
Sunniest Day	1 Oct	0 hours	
Total Sunshine		0 hours	80.0 hours