Climate Change in Herefordshire, and its impact on Biodiversity

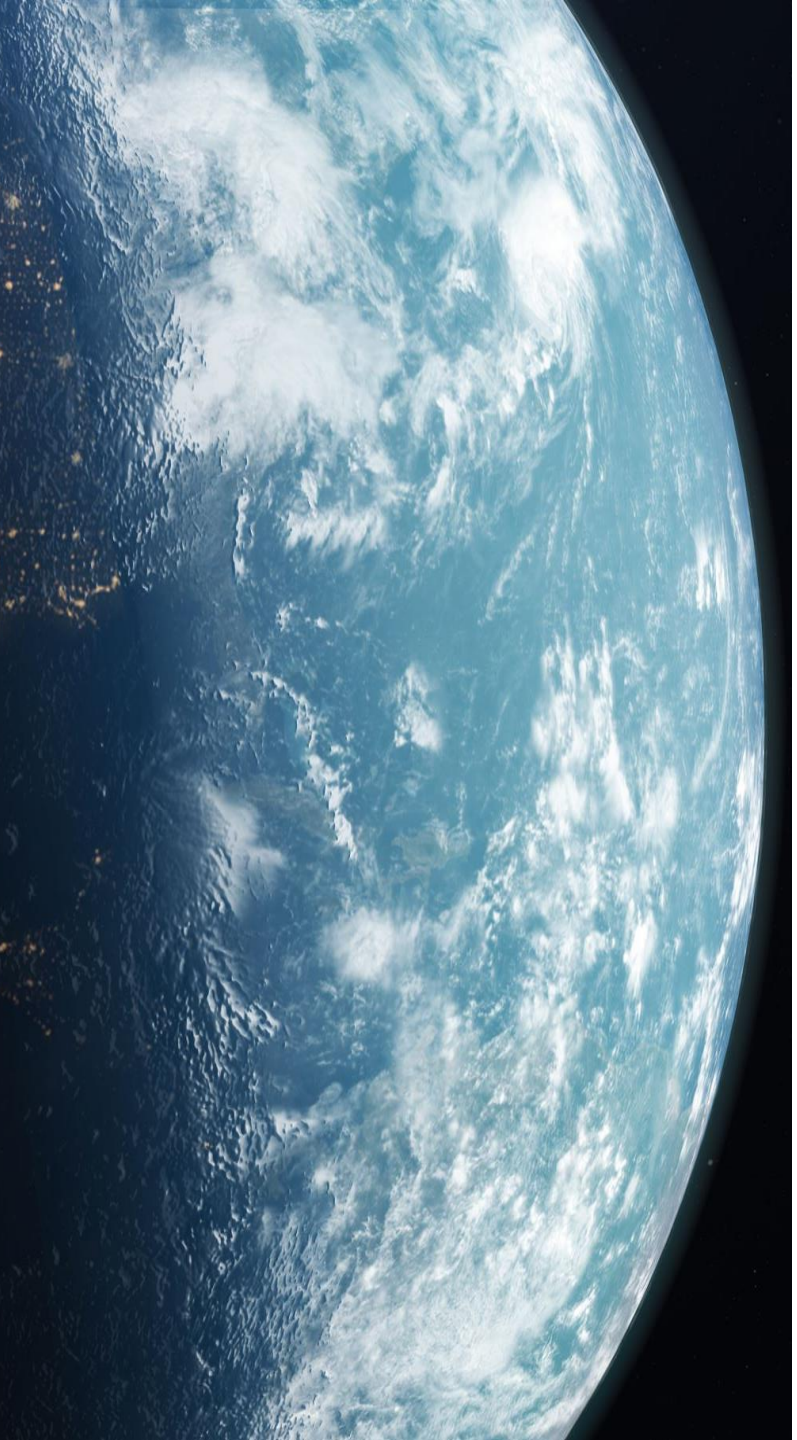
Rachel Jenkins

Climate change

- The climate has changed naturally before eg:
  - During time of dinosaurs (66-230 million years ago), the climate was several degrees warmer, allowing forests to grow in Antarctica
  - Eemian period 115,000-130,000 years ago. Temperatures warm enough for hippos and water buffalo to live in Britain
  - After previous ice ages, temperatures warmed at rate of 4-7C over 5000-10,000 years
  - Today we have more than 1C warming over last 160 years, mostly in last 50 years
  - Last ten years (2014-2023) have been the warmest years on record
  - 2023 was the hottest year on record

Herefordshire's ice age ponds

- These ponds are valuable geological time capsules, giving insight into how Herefordshire has changed over thousands of years.
- Pollen collected in core samples from deep pond sediment shows that after the ice retreated about 14,000 years ago, Herefordshire quickly warmed up and became covered in birch and juniper woodland.
- It then cooled again for a few thousand years before warming even more, as shown by the abundance of species such as oak, hazel and elm.



Natural changes to climate

- Natural cycles
  - **Milankovitch cycle**-caused by earth's tilt as it rotates round sun, changes very few 10,000-100,000 years
  - **El Nino Southern Oscillation**-pattern of changing water temperatures in Pacific Ocean, so in El Nino year, temp warms up and in EL Nina year, temp cools-effect lasts a few months or years
- Natural forcings
  - **Solar irradiance**-any increase in solar energy would make the entire atmosphere heat up but we can only see warming in bottom layer
  - **Volcanic eruptions**-volcanoes produce particles that cool Earth and CO2 that warms it. Overall effect is cooling not warming. Volcanoes produce 50 x less CO2 than humans.

Greenhouse gases

- Trap heat in atmosphere and stop it escaping,
  - acting as a warming blanket round the earth,
  - known as “the greenhouse effect”
  - Without natural greenhouse gases, earth would be 30C colder and uninhabitable.
  - But since Industrial Revolution, we have added in far more GHG, so heating the planet very fast
- Carbon dioxide
- Methane
- Nitrous oxide
- CFCs chloroflorocarbons

Evidence on CO_2 and CH_4 from Antarctic ice cores

Tight coupling of climate change and CO_2 levels over last 800,000 years

The recent rise in CO_2 is hugely anomalous compared with the natural shifts over time

Now seeing CO_2 levels not seen in 2 million years

CO_2 was stable over millennia but started to rise in early 1900s

Concentration of CO_2 now 40x higher than before industrial revolution

Isotopic data confirms the CO_2 has come from fossil fuel usage and deforestation.

Human causes of climate change

Burning fossil fuels-oil, gas, coal contain CO2 which has been locked away in ground for thousands of years.

Deforestation-forests remove and store CO2 from atmosphere,

so cutting them down means CO2 builds up quicker as no trees to absorb it,

and burning the tree releases more CO2

Agriculture

Animals produce CH4 which is 30x more powerful than CO2 as a GHG

Fertilisers contain N2O which is

10x worse than CH4 and 300 x worse than CO2

Cement responsible for 2% of all CO2 emissions.

Methane

- Atmospheric concentration of CH4 has more than doubled from pre-industrial level,
  - Due to increase in emissions from fossil fuels, ruminant animals and landfills, which in total now exceed wetlands and other sources
  - Concentration higher than in any period in last 800,000 years.

Agricultural emissions

CO_2 is only a small part of agricultural emissions which are dominated by N_2O , mostly from fertilisers spread on fields (synthetic and animal manure) , and CH_4 , largely produced by cows and sheep

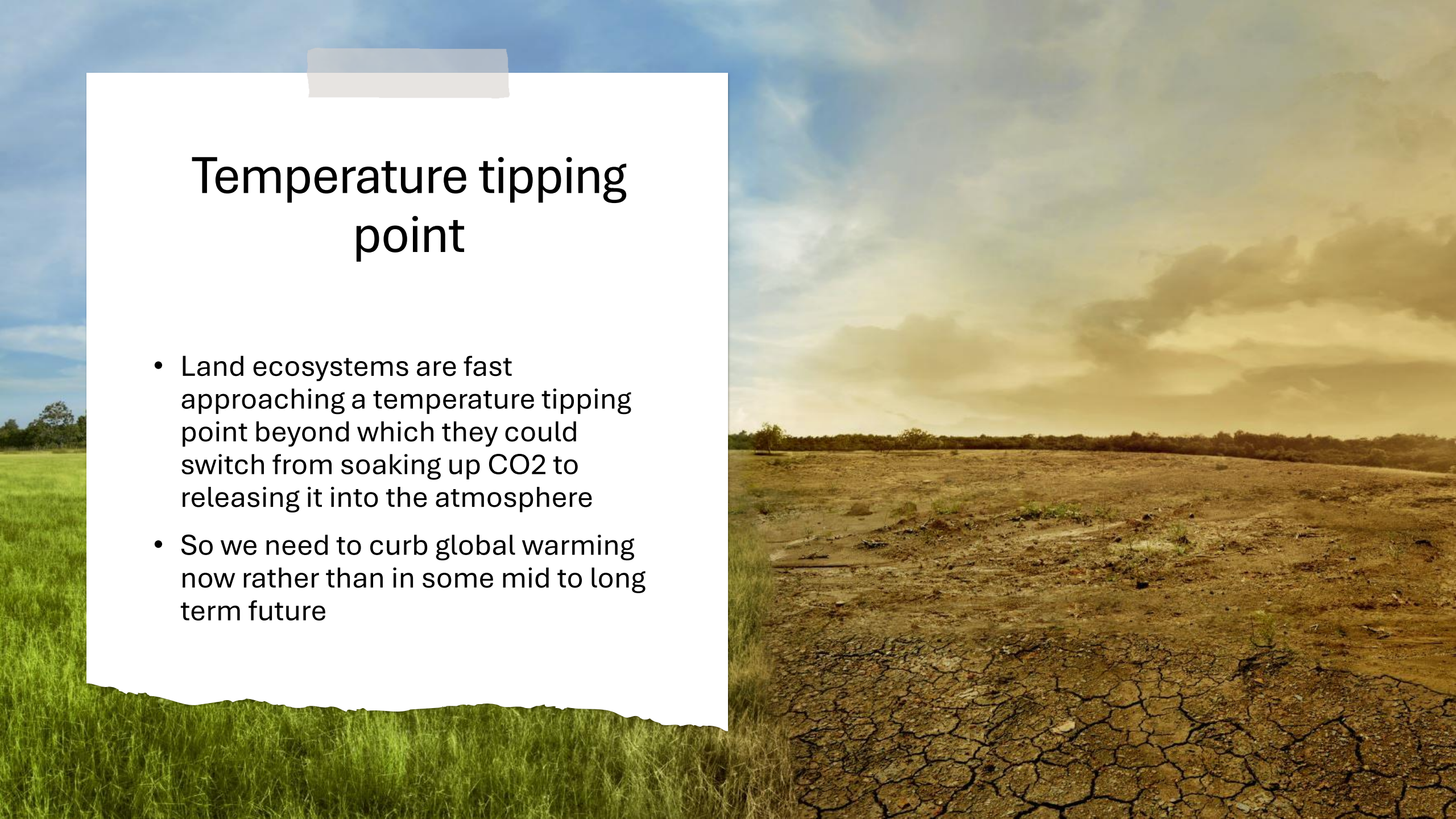
N_2O lasts in the atmosphere for a hundred years and subtracts from the carbon budget in the same way as CO_2

CH_4 lasts in the atmosphere for 10 years, so contributes to short term warming and needs to be factored into the carbon budget

Even if fossil fuels immediately phased out, we will still miss 1.5C and nearly miss 2C, from agricultural emissions alone.

Temperature tipping point

- Land ecosystems are fast approaching a temperature tipping point beyond which they could switch from soaking up CO_2 to releasing it into the atmosphere
- So we need to curb global warming now rather than in some mid to long term future



Climate change interacts with other factors to exacerbate pressures on wildlife

Habitat loss

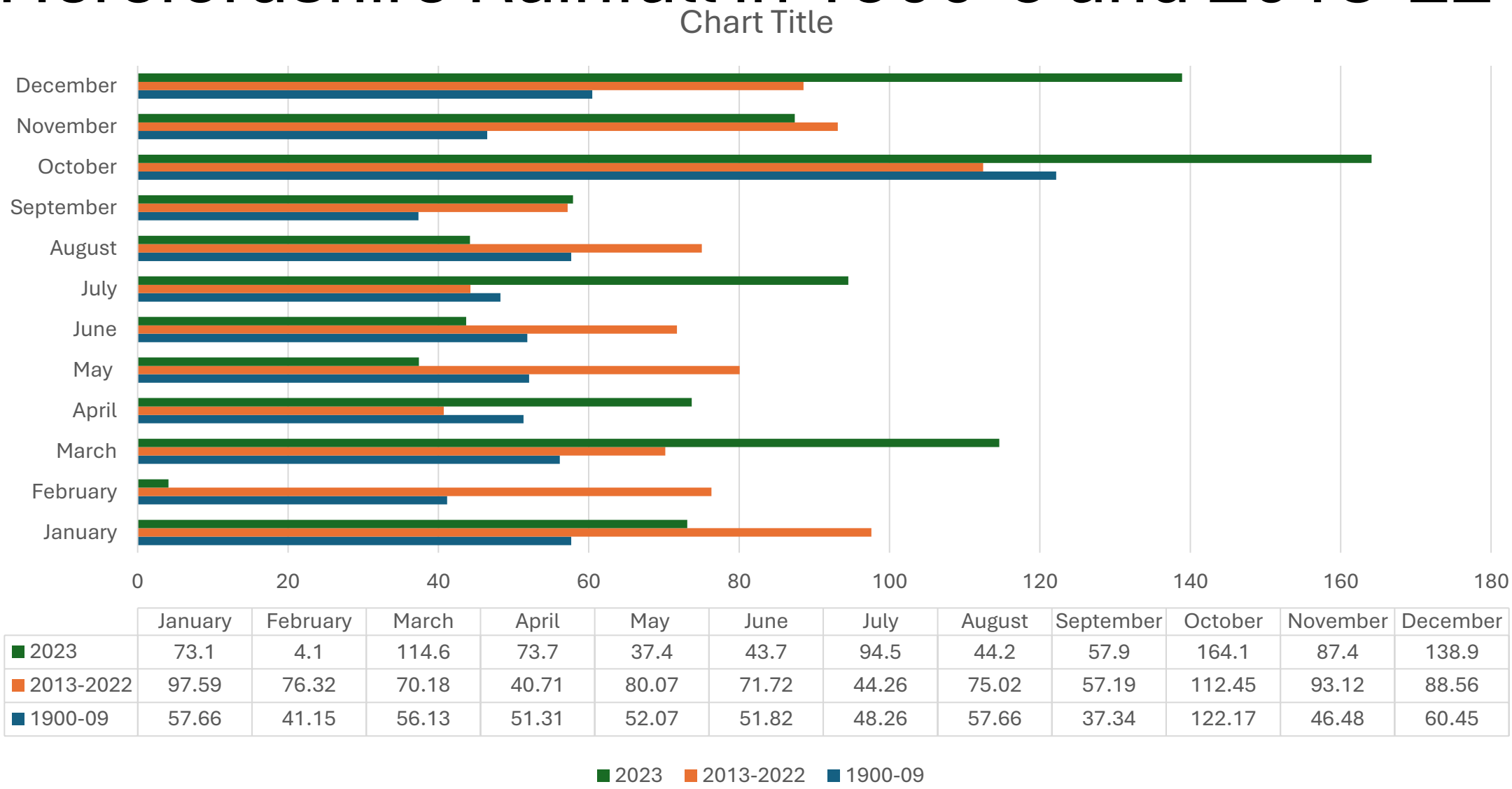
Changes in food availability

Pesticides, herbicides, fungicides and other chemicals

Disease

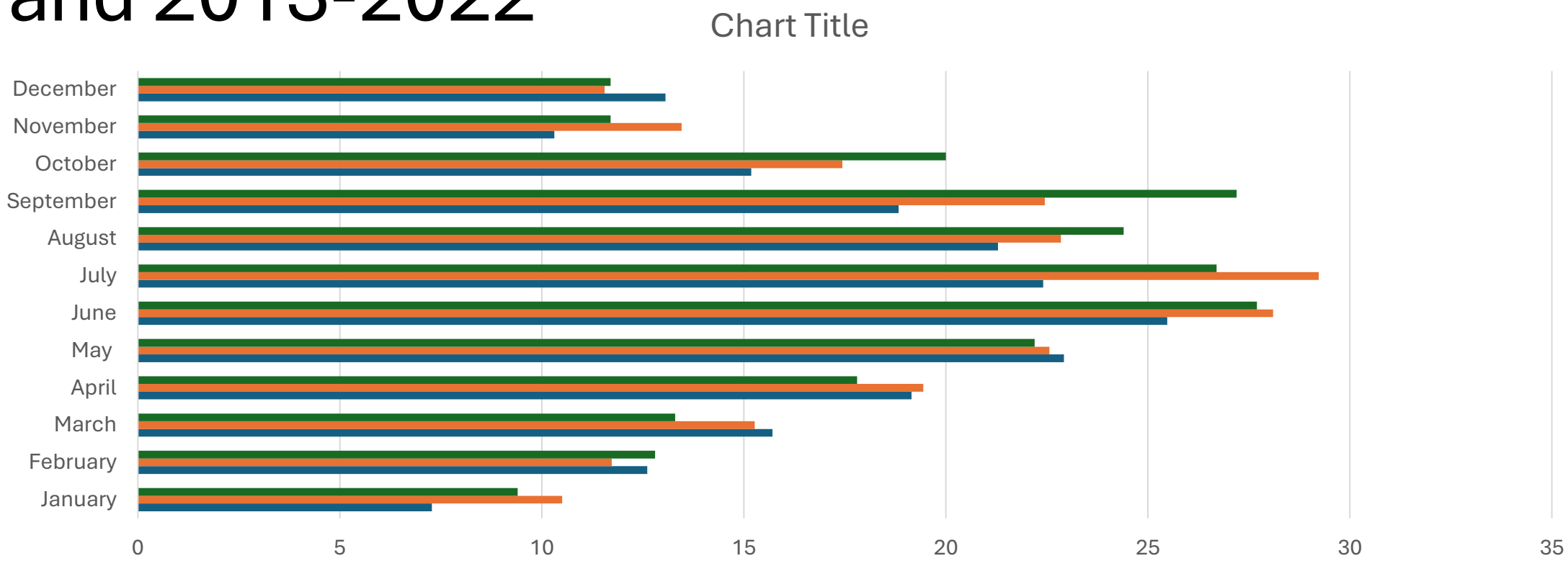
Competition with invasives

Herefordshire Rainfall in 1900-9 and 2013-22



	January	February	March	April	May	June	July	August	September	October	November	December
2023	73.1	4.1	114.6	73.7	37.4	43.7	94.5	44.2	57.9	164.1	87.4	138.9
2013-2022	97.59	76.32	70.18	40.71	80.07	71.72	44.26	75.02	57.19	112.45	93.12	88.56
1900-09	57.66	41.15	56.13	51.31	52.07	51.82	48.26	57.66	37.34	122.17	46.48	60.45

Herefordshire Temperature maxima 1900-9 and 2013-2022



	January	February	March	April	May	June	July	August	September	October	November	December
2023	9.4	12.8	13.3	17.8	22.2	27.7	26.7	24.4	27.2	20	11.7	11.7
2013-22	10.5	11.73	15.27	19.44	22.56	28.1	29.23	22.85	22.45	17.44	13.46	11.55
1900-9	7.28	12.61	15.71	19.15	22.92	25.48	22.41	21.29	18.83	15.18	10.31	13.06

Climate Change and UK 2015 Report Card , Living with Environmental Change Network

The Environmental Change Network is the UK's long-term ecosystem research network.

Climate change affects UK biodiversity

Many species occurring further north, and shifting to higher altitudes

CC increases invasive species including pests and pathogens

Evolutionary responses to CC in some species with short life cycles, but many with low genetic diversity or slow reproduction are unlikely to be able to adapt fast enough

Changes in composition of some plant, microbial and animal communities , consistent with different responses by different species to rising temperatures

2015 Report Card (cont.)

Species populations and habitats have been affected by year to year variations in rainfall and extreme weather events, particularly drought.

Some habitats are particularly sensitive to climate change, especially montane habitats (due to temp changes) , wetlands (due to water availability) and coastal habitats (due to sea level rise)

Warmer springs have caused life cycle events of many species to occur earlier in the season. Also some evidence of longer autumn resulting in a longer growing season

Regional differences are apparent reflecting different species climate, soils, land use and management

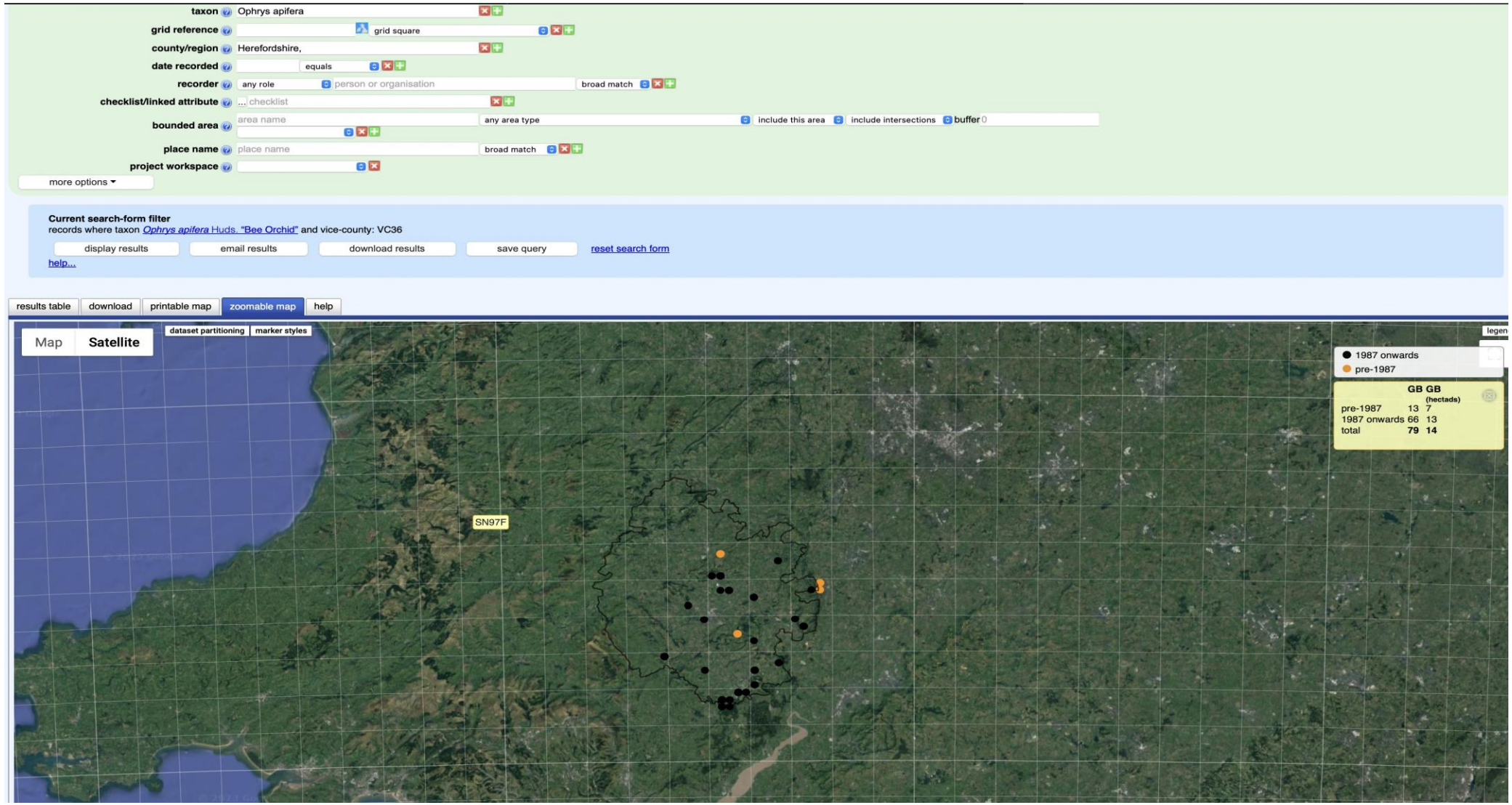
Land management decisions can influence impact of climate change on species and ecosystems

Climate change and plant habitats

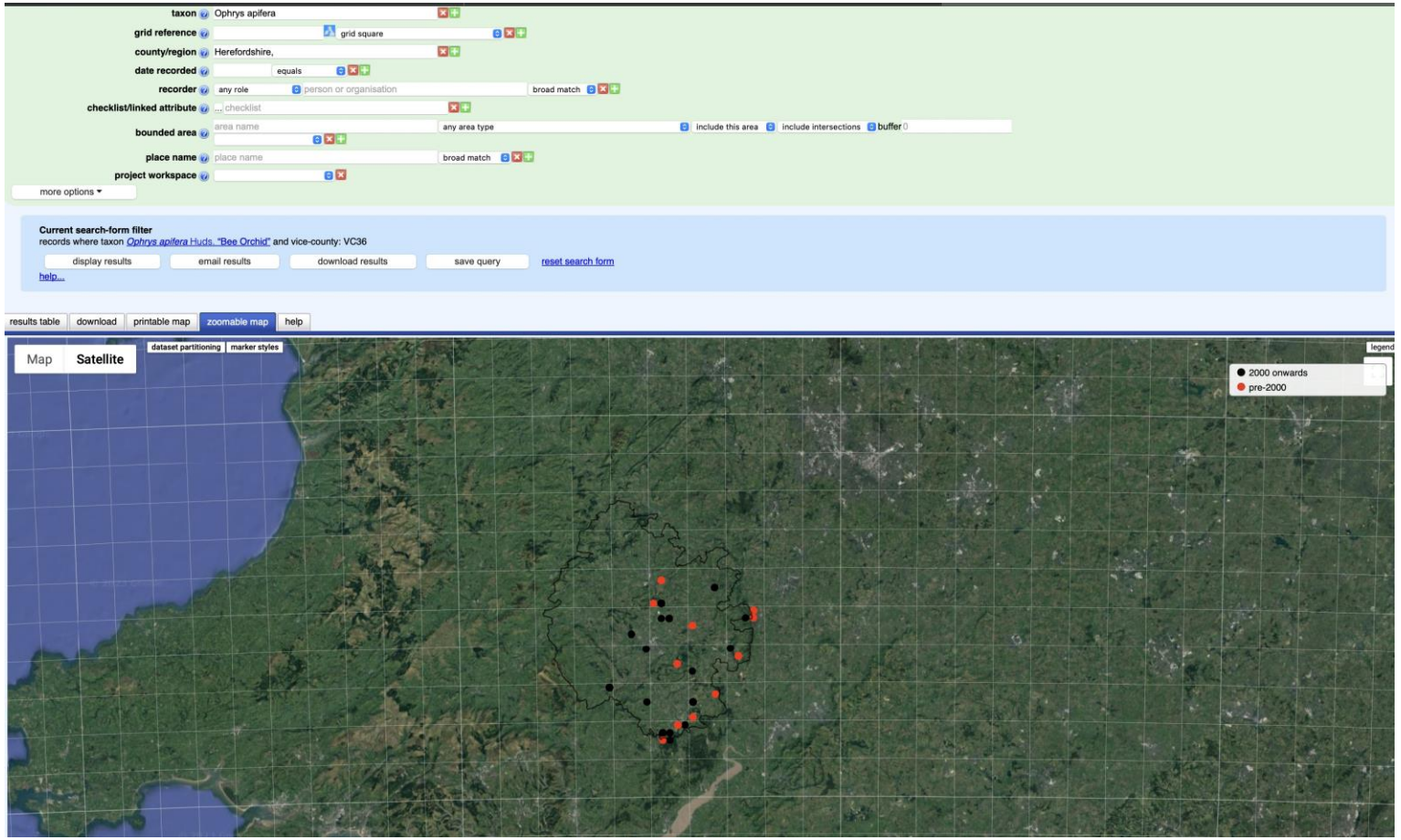
- Arctic and northern species have been declining for decades,
- Temperate and Mediterranean species have been increasing
- Bee orchid has now reached Scotland
- Pyramidal orchid has shifted its range 170km further north.
- Water reserves are critical to plants, and grassland suffers more than forests in drought periods
- Current flowering dates have advanced by 2-13 days over last 250 years

Bee orchid

Bee orchid pre and post 1987

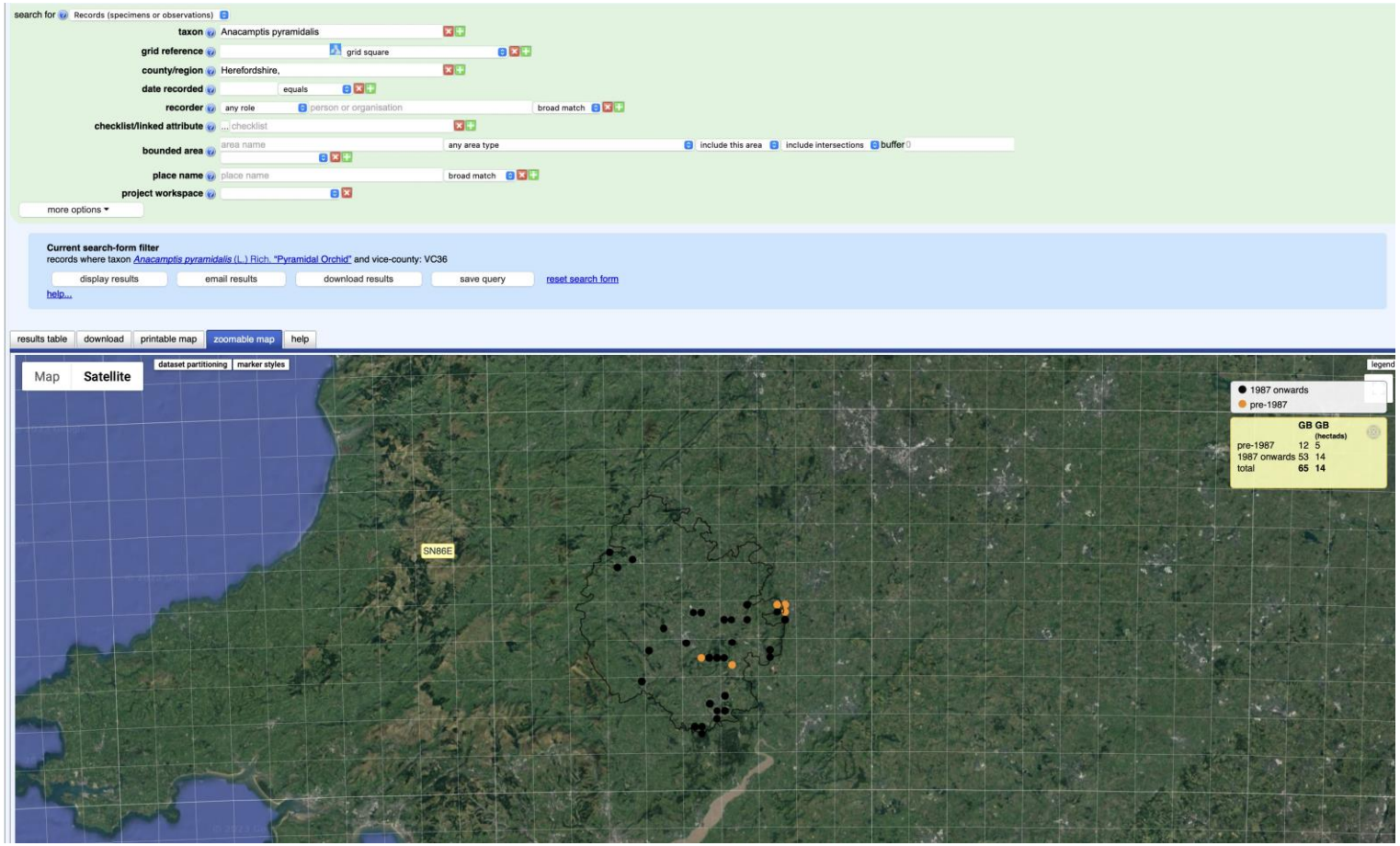


Bee orchid pre and post 2000

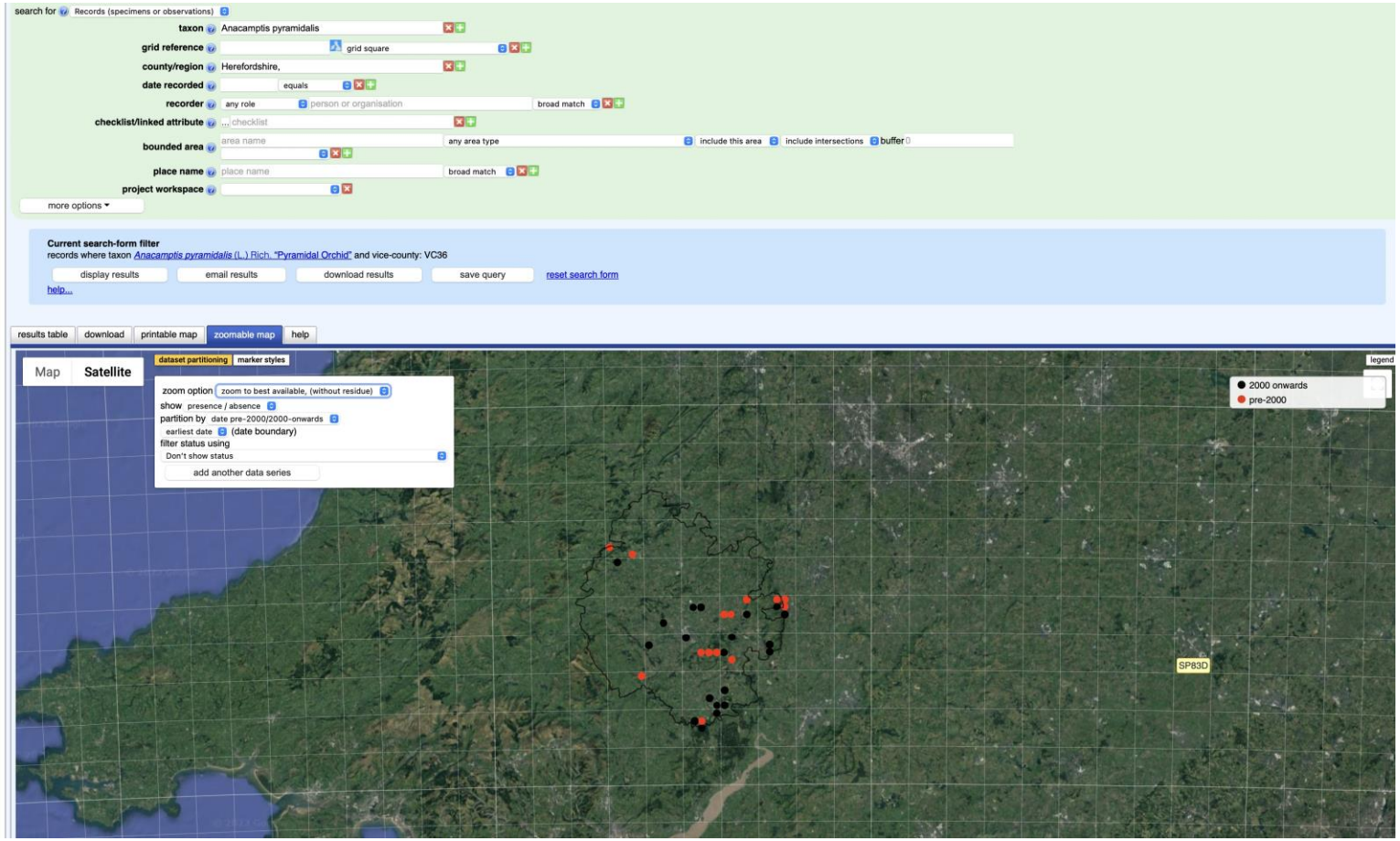


Pyramidal orchid

Pyramidal orchid pre and post 1987

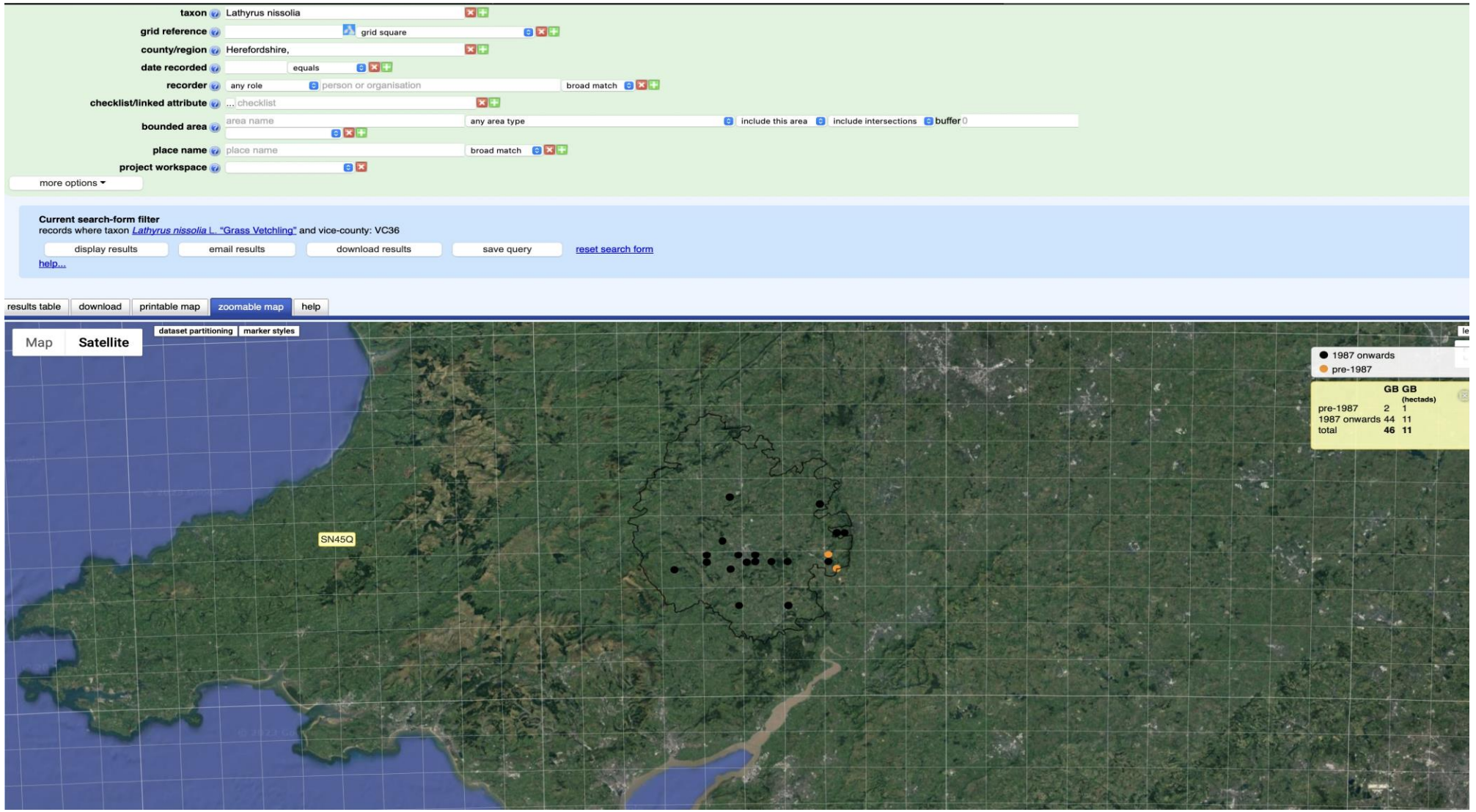


Pyramidal orchid pre and post 2000

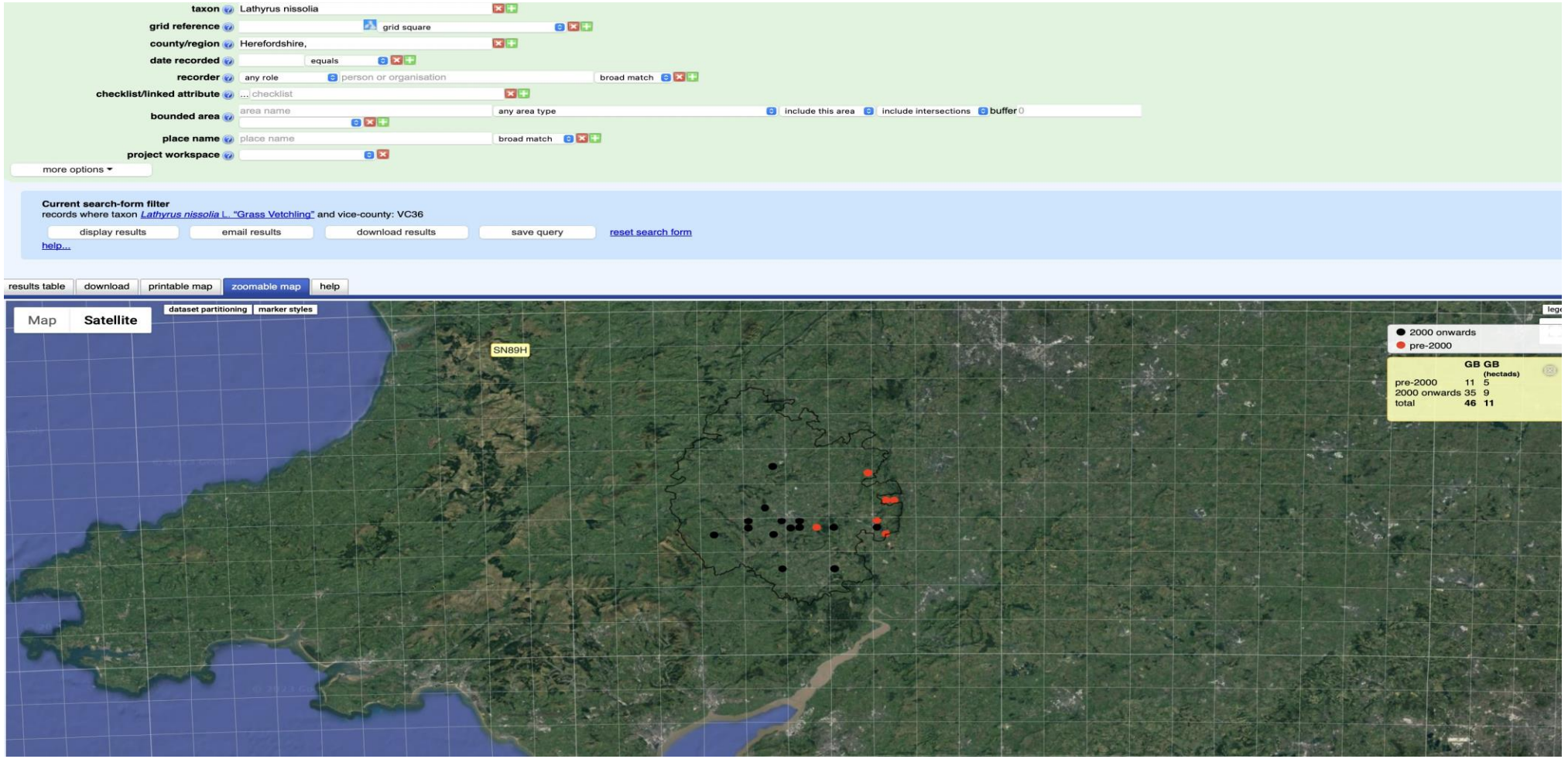


Grass vetchling

Grass Vetchling pre and post 1987

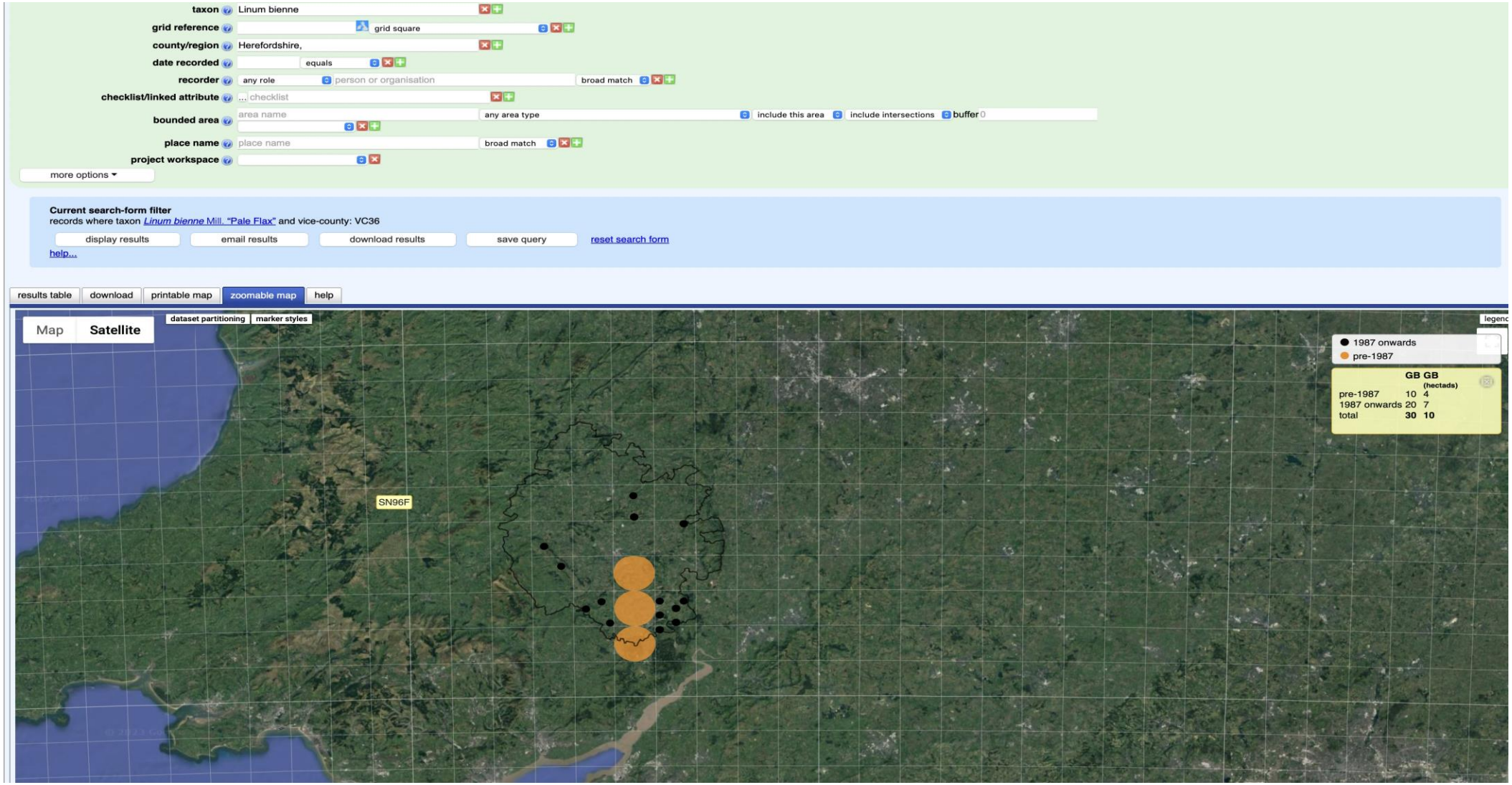


Grass vetchling pre and post 2000

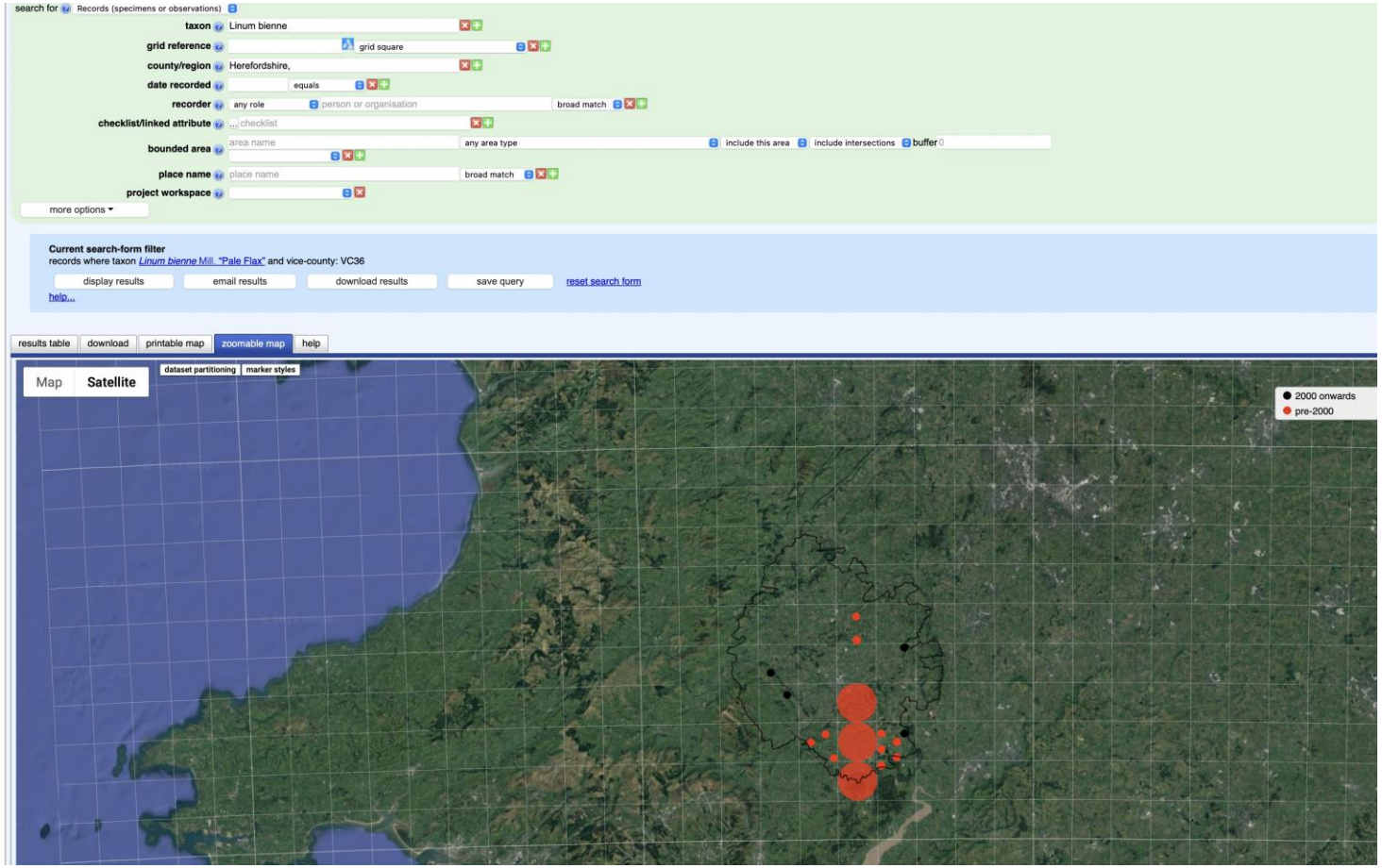


Pale flax

Pale Flax pre and post 1987



Pale Flax pre and post 2000



Alpine plants

- Global rise in temperature due to climate change has led to lowland species colonising upland areas and outcompeting the mountain plants, reducing the area they can grow in.
- Loss of snow cover due to climate change has removed plants' protection from freeze-thaws, which cause land slip and rock fall, destabilising the arctic-alpine habitat.
- Low-latitude arctic-alpine plant populations already situated at maximum local elevations are effectively on the elevator to extinction: we face their loss from our mountains because there is no higher ground left for them to retreat to as temperatures continue to rise.
- The declining mountain flora functions as a canary in the coal mine for escalating climate change and indicates broader threats to biodiversity in the coming decades.

Mountain Everlasting, currently showing snow-white leaf buds. The location shot shows the extent of the clonal patch, ringed by small pebbles. Philip Bauer record in 2011 the patch was 3m square. Stuart Hedley 2024 patch now about 60 x 45cm. At c 520m on the S-facing side.

Aquatic plant communities are influenced by warming

- Increase in algae and cyanobacteria in the water,
- leading to shading and decline in bottom growing species
- while duckweed and introduced species become more prominent.

Climate change and fungi

- With fungi, we see only the fruitbody. They are the equivalent to an apple on an apple tree but with the huge difference that we cannot see the body, the mycelium, which is underground.

- Fungal fruiting is unpredictable. They may come up in ones and twos, in hundreds or not at all. The only really very good year Jo Weightman has witnessed in Herefordshire was more than 20 years ago. Since then there have been average years and poor years. There have been local patches of generous fruiting amid a general desert. Years that have been poor in Herefordshire have seen exceptionally good fruiting in other counties.

- The last two years have been poor here, especially for mycorrhizal species, no doubt attributable to the prolonged summer drought. We do not know whether the mycelium underground has suffered.
- A mycelium can lie dormant for many years. Jo Weightman has known of a fungus that fruited in a huge ring (ie many years old) in the garden of a house owned by a fungus fanatic who had spent a lifetime there and never seen fruitbodies before.

Abortiporus biennis Kenchester 2013

- This wood-rotting fungus sometimes forms very attractive rosettes - and some people refer to it as the Blushing Rosette - but more often it grows as an amorphous mass of irregular maze-like pores exuding blobs of red-brown juice that eventually dry to leave brown stains of the pore surface.

Amanita Muscaria

Famous, enchanting and highly toxic. Fly agaric is the home of fairies and magical creatures and a lover of birch woodland, where it helps trees by transferring nutrients into their roots, but if eaten can cause hallucinations and psychotic reactions.

Climate change and trees

- Tree death during drought has been recorded at long term monitoring sites,
- Can lead to major changes in composition and structure of woodland
- Pests and diseases represent major threat to woodland
- Herbivores may increase in warmer winters
- Epiphytes eg mosses growing on trees may be affected

Leech Pool in Clifford in the Wye Valley.

Sallow trees which used to be on the margin of the pool are now about 8 metres from the shore;

The water level is now permanently higher than it used be

Dead veteran oak in a naturally fluctuating Ice Age Pond in Kenchester; this ancient oak has recently been killed by higher water levels.

Oak decline and climate in Herefordshire

- Oaks are sensitive to dry spring weather because this is when they are laying the earlywood sapwood that will conduct a large proportion of the water supply for the trees in that year. Sufficient moisture in spring means that trees can set up a good band of large lumen vessels in the early wood, but a shortage of moisture results in reduced earlywood formation and small vessels
- Oaks are not good at shutting off their stomata (pores that give off water vapour as a by product of photosynthesis. So even if water in short supply over the summer, the trees continue photosynthesising and giving off water vapour. This can lead to water deficits in trees and possibly even the formation of air bubbles in the sapwood
- If there is enough ground water and soil nutrients, the tree can photosynthesise more abundantly and build up reserves, as well as have sufficient resources to fight off pests and disease.
- Often damaging drought effects are only seen a few years after the drought.

The Woolhope Club Oak 1998 and 2019

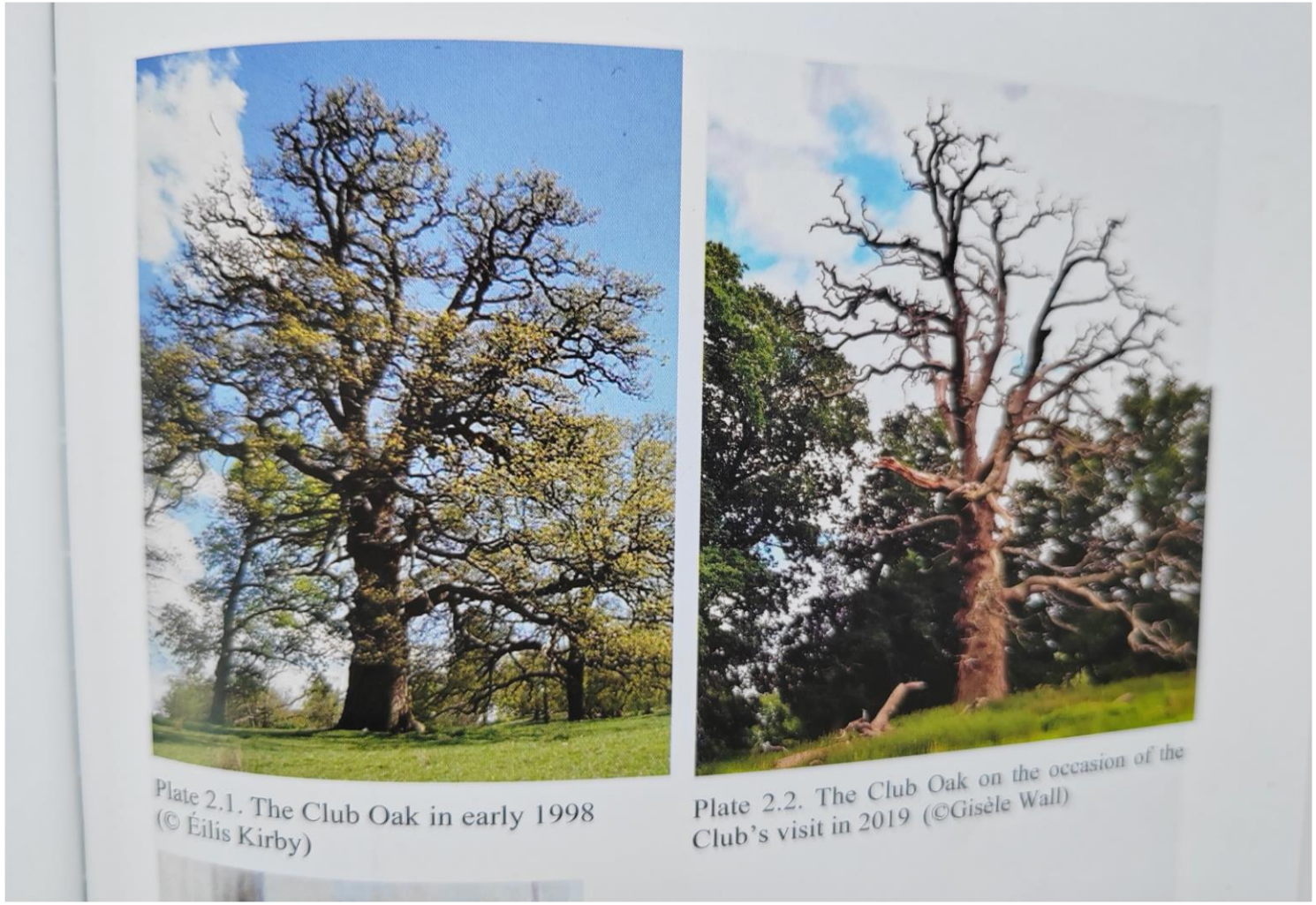


Plate 2.1. The Club Oak in early 1998 (© Éilis Kirby)

Plate 2.2. The Club Oak on the occasion of the Club's visit in 2019 (©Gisèle Wall)

WNFC facilitated research

- Research currently underway in Moccas deer park by Forest Research
  - to look at the interaction between Oaks, AOD, bacteria (Brenneria goodwinii, Rahnella Victoriana and Gibbbsiella quercecans, and the beetle (Agrilus bigutatus) which may be a vector for the bacteria.
  - Also examining role of soil microbes and enzymes, but not yet fungal mycorrhiza.

Climate change and Invertebrates

- Climate warming has resulted in many insects including butterflies , dragonflies, woodlice moving their ranges further north while some northern ones have declined.
- In the UK, long-term trends show that 80% of butterfly species have decreased in abundance or distribution, or both since the 1970s.
- 56% of species increased in one or both trends.
- UK butterflies have lost 6% of their total abundance at monitored sites and 42% of their distribution over the period 1976-2019

Climate change and Agapus undulatus at Blakemere pool

- Another example of climate change locally is Blakemere Pool where the newly found rare diving beetle *Agabus undulatus* is found
  - The beetle has survived since the Ice Age because this natural Ice Age pool had well-established emergent vegetation, dead leaves and shade , with no fish present .
- The pool was flooded by water from the River Wye in February 2020 after Storm Denise.
  - This resulted in fish colonising the pool including Three-spined Stickleback possibly for the first time.
  - The beetle has pelagic larva which are particularly prone to predation by fish such as sticklebacks.
- Fish presence now threatens the beetle with local extinction. There are no other known sites for this *Agabus undulatus* within 100 miles of this location.

Agapus undulatus at Blakemere

Climate change and moths

- Although there have been fluctuations in temperature and rainfall on a daily basis over the last centuries, only recently have significant changes in moth distribution and abundance been noticed.
- Now there is a general trend in most moth species to emerge earlier
- More species are managing to double brood
- Each species has its own criterion to survive and some are more robust than others.

Climate change and moths

Common Fan-foot Oakley Wood, despite its name, is uncommon and in decline in recent years

Dark -barred Twin- spot Carpet

- In serious decline

Clifden Nonpareil Westcott Moth

- Example of recent spectacular range expansion
- A scarce moth that survived in Kent until 1960s, then died out
- Returned in 2007 to south east and started to spread, at first slowly then rapidly
- Arrived in Herefordshire in 2017, continuing northward each year
- 2023 had 76 records in Herefordshire

Orange Moth

- In decline in recent years

Garden tiger

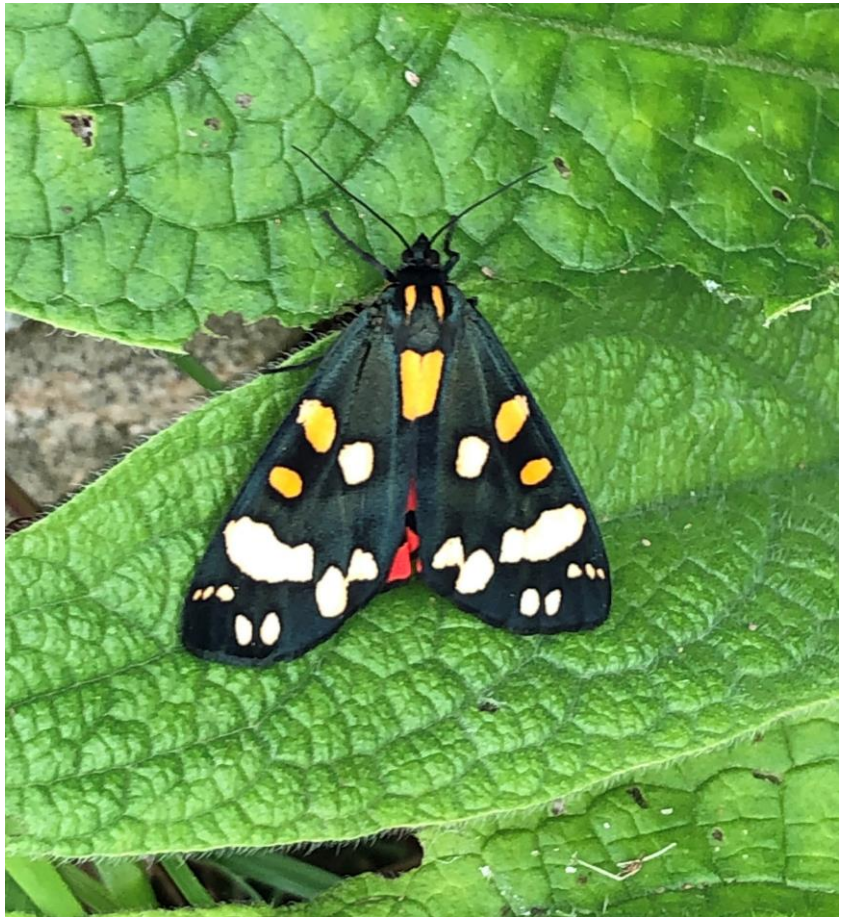
- the woolly bear caterpillars of our youth, romping over foot paths and roads)
- In decline because moth overwinters as a caterpillar

- and warmer winters encourage fungi, which attack the caterpillar

Argent and Sable West Sutherland

- This moth is in serious decline, and has not been seen in Herefordshire since 2000

- Scarlet Tiger is a recent arrival that is flourishing and replacing the Garden Tiger that is not coping so well with our warmer wetter winters



Climate change and amphibia

- Low water levels in spring has led to many ponds drying out before newts, frogs and toads have completed metamorphosis from tadpoles/larvae to adults
- Particular problem for our Great Crested Newt.
  - The GCN is relatively long lived and a degree of boom and bust caused by ponds drying out is built into its lifecycle.
  - But climate change makes the irregularities in weather more extreme, resulting in longer gaps between boom years, so adults have no chance to reproduce successfully.
  - Also some are now ready for breeding by November, although peak breeding still in April

- 1st spawning dates for frogs have varied across years but equate to more than a 5 day advance by every 1C increase in air temperature-study in Pennines.

- Reductions in frog and toad populations consistent with
  - low summer rainfall
  - lower soil moisture during drier summers
  - loss of suitable habitats, habitat fragmentation and road mortality

Climate change and reptiles

The adder is on the brink of extinction in many sites across Britain … and it is the uncontrolled release of millions of pheasants by shooting estates which is pushing it over the brink.

47 million non-native pheasants and 10 million partridges will be released each year into the countryside by estates and shoots across Britain.

Pheasants kill reptiles including adders on sight, pecking at adults and swallowing young snakes whole. Although the adders are venomous, they stand little chance in any encounter as their bites cannot penetrate the birds' feathers.

Last year the most comprehensive survey of adders was undertaken by ARG UK, which found the species could be extinct by 2032. It also found that more than 90% of surveyed sites had populations of 10 or fewer adult adders, which were vulnerable to local extinction.

Climate change and adders

The adder, Britain's only venomous snake, has for the first time been confirmed as being active in every month of the year.

Adders normally hibernate underground from October to March, a strategy designed to enable them to survive a cold winter, but with warmer weather have now been seen throughout the year.

They are declining as a result of increasing habitat loss, persecution, predation, disturbance and inbreeding. A shorter hibernation period and becoming more active in winter is likely to accelerate their demise, as snakes will be much more susceptible to any cold weather that follows a warm spell.

Following the record warm temperatures in February, adders have been seen in every calendar month. While the adder is well adapted to cold weather, occurring further north in the world than any other snake species, this is new behaviour and experts warn it is a clear sign of the impact climate change is having on wildlife

Climate change and birds

- Extreme weather events eg prolonged frozen spells and droughts can be catastrophic for bird populations
- Long term climatic changes can cause
  - Earlier breeding
  - Changes in timing of migration
  - Changes in breeding performance-clutch size and nesting success
  - Changes in population size
  - Changes in population distribution
  - Changes in selection differentials between components of a population

Timing of Migration

- Tendency for many summer migrants to arrive earlier
- Evidence for changes in autumn migration is mixed

Birds’ migration

- Many summer migrants now arrive earlier, especially short distance migrants
- Barnacle geese normally move south for winter feeding grounds, but now move less far
- Pied Flycatcher arriving earlier at breeding grounds, leading to mismatch between arrival and food availability to feed the nestlings.

Drought affects food supply

Bird populations such as Song Thrush, Blackbird, Ring Ouzel and Golden Plover that rely on invertebrates associated with wet conditions are negatively impacted by increasing summer temperatures and drought .

Rain and owls

- Owl feathers are normally silent because of the fingers at the end of the wings which keep the air currents close to the wing
- If the wing gets wet, the air currents are released into the air and make a noise, which affects ability to hunt and feed

Great tits-disjunction between predator and prey

- Great tits can shift their laying dates earlier in response to earlier warm weather , often in parallel with emergence of caterpillar prey
- But GTs cannot decrease incubation period whereas the caterpillars can halve their development time in sufficiently warm weather , and pupate earlier, leading to shortage of prey that GTs use to feed their young
- This disjunction between predator and prey has led to trend in selection differentials so that an increasingly greater proportion of adults in the following year come from early nesting individuals

Geographic range of British birds in response to climate change 1994-2009

- Average northern margin of the range of 80 species has expanded, at rate of 3.3km a year,
- with little change in trailing southern margin,
- so bird range has expanded rather than contracted, at least in the short term.
- Bird range has expanded more slowly than the shift in temperature isotherms which has moved north at rate of 108km over the 15 years , or 7.2km a year

Cetti’s Warbler

Normally resident in southern Europe and Morocco,

First bred in Kent in 1972,

Now there are several breeding pairs across southern UK.

First Herefordshire sighting was in 2002,

fourth in 2012,

and tenth in 2018.

Large waterbirds

- such as Great White Egret, Little Egret, Little Bittern and Spoonbills have expanded into Britain
- In Herefordshire GWE are regular sight at our gravel pits and along the Wye, with the 20th county record in 2018.

Northward shift

- Mediterranean species such as European bee-eater reaching UK due to milder winters
- Our smallest birds such as gold crests, wrens and long tailed tits are benefitting from milder winters.
- Redwing is red-listed in UK, and may disappear due to its northward shift in response to climate change
- Wildfowl which breed in the north and winter in the south now declining in UK eg Common Pochard now much rarer in Herefordshire

Climate change interacts with habitat loss and farming practice

- Sedge Warbler and Whitethroat populations affected by reduced survival in African winter grounds and desertification.
- Warmer winters in 1990s and 2000s increased the survival rates of many common resident bird species eg Wren.
- Bird ranges shifted northwards by 37km (1990-2008) but lagged behind changes in temperature.
- Southern species have increased more than Northern species
- 70% of wetland birds have shown a population decline since 2000 in both freshwater and estuarine sites.

- Breeding success of Tawny Owls reduced by impact of warmer wetter winters dampening the population cycles of voles.
- Wintering wildfowl and waders decline as milder winters reduce the distance they migrate.
- Willow tit is fastest declining resident bird in UK, declined by 94% (1970-2018)
- Willow warbler declined by 43%, Marsh tit by 75%, Starling by 88%, Song Thrush by 49%, Mistle Thrush by 57%, Spotted Flycatcher by 88%, Dipper by 23%, House Sparrow by 65% and Tree Sparrow by 96%

Relative impact on birds of climate versus land use

- BTO monitored 61 short distance migrants and 39 long distance migrants over 36 year period,
- found population trends more closely related to
  - climate change rather than land use in the breeding grounds
  - land use rather than climate change on non-breeding grounds.

Habitat available for birds

- This is the greatest threat at present, both here and in the tropics, driven by
  - drought and desertification in wintering grounds
  - conversion of natural habitats to human use.
  - Farming practices

UK wild bird indicators

- UK wild bird indicators are high level measures of the state of bird populations
- **The farmland indicator** continues to decline, despite agri-environment schemes and other conservation measures
  - In 2019, it stood at 45% of its 1970 value, with a decline of 5% in last 5 years.
  - Corn Bunting, Grey Partridge, Turtle Dove and Tree Sparrow all declined by 90% since 1970. Stockdove and Goldfinch have doubled .
  - Curlew now down to small numbers in Herefordshire
- **The woodland indicator** shows decline of 27% in the long term and 7% in the short term. Willow tits have declined dramatically since 1970
- **The wetland indicator** shows decline of 12% , with birds of wet grassland worst off (Lapwing, Redshank, Snipe,) while birds of slow or standing water show increase (Mallard and Tufted Duck)

Climate change and Mammals

Mammals that reply on hibernation are reducing their period of hibernation. Warmer winters mean that an animal's metabolic rate cannot remain suppressed effectively, which can reduce body condition, breeding success and survival rates.

Juveniles re more vulnerable than adults to extreme weather events eg drought, flooding and cold winters.

Direct links found between summer rainfall and survival of bat species , with higher rainfall associated with greater insect abundance, and drier springs and summers having a negative effect

Climate change and mammals

Herbivores (deer, rabbits, hares, many rodents) vulnerable to lack of plants

Insectivores (shrews, hedgehogs , moles and bats) are vulnerable to invertebrate availability . Insects most abundant during wet weather but persistent rainfall can “wash out) the insects

Omnivorous carnivores (badgers and foxes) are vulnerable to changes in herbivore prey, and to spring droughts making it impossible to dig up earthworms

Warm winters stop dormice, hedgehogs and bats from hibernating effectively.

Warm winters improve badger survival but cold-damp springs cause badger cub mortality

Bats

- Risks from landscape change, agricultural intensification, development, habitat fragmentation, pollution and factors affecting insect prey and factors affecting insect prey (pesticides, drainage, landscape change)
- Hibernation enhances over winter survival rate, but Climatic shifts will affect hibernation, breeding success and food availability
- Internal temperature of roosts may force bats to relocate
- A study in Oxfordshire found that protracted rain in spring/early summer washed out the insects

- Bats are expected to be particularly sensitive to climate change
  - because they are prone to dehydration due to high surface-to-volume ratios caused by their generally small body mass and their large wing and tail membranes
  - their slow reproductive strategy makes them more susceptible to extinction under rapid environmental changes.
- Understanding how bats are affected by and cope with climate change is key to informing more accurate conservation assessments and management strategies

Hedgehog

- 30 million in 1950s, 1.5 million in 1995 and probably less than one million now
- Risks from habitat loss, RTAs, molluscicide poisoning, predation by badgers
- Climate risks from warm winters disrupt hibernation, drier springs disrupt earthworm prey, and flooding of foraging grounds mean hedgehogs are facing a battle on all fronts. As well as having to navigate an increasingly disconnected landscape they are feeling the effects of climate change.
- Though hedgehogs hibernate, they do sometimes wake up during warmer winter periods to top up their energy reserves with a bite to eat. However, climate change is making our winters generally warmer and wetter, causing hedgehogs to wake up more often during a season where food is at its lowest. Without enough sustenance to replace the energy they use trying to forage during winter, hedgehogs may starve.
- The increasing number of devastating winter floods also have tragic consequences for hibernating hedgehogs – if they’re sleeping, they can’t escape.

Dormice

Main risks are habitat loss and fragmentation

Climate change may disrupt hibernation

Unpredictable summers affect food supply by

- waking up from hibernation during the winter months;
- causing changes in the timing of food availability at different times of the year; and
- influencing aspects of the hazel dormouse's lifecycle that might affect its reproductive success, such as reproductive timing.

Dormice

- Dormice hibernate for six months in nests below ground but milder winters mean they are increasingly emerging from hibernation when there is no food available. Between 40% and 70% of dormice die during the hibernation period.
- Now winters are becoming more mild and variable, there's a danger that dormice will wake up and they can only do that so many times before they run out of energy.
- Wetter springs and summers also stop dormice feeding because their fur is not waterproof [so they don't go out in rain], and they only produce on average four young per year – they don't have the breeding potential of mice and rats.
- If the decline continues at the same rate, in another 30 years dormouse populations will have fallen by 94% since 2000.

Badger

Badger populations highest in mild damp conditions that favour earthworm supply, so heavily dependent on weather patterns

Warmer winters have increased badger populations

Warmer springs encourage more foraging, and hence more RTAs

Prolonged drought limits access to earthworms so badgers shift to other prey eg bee nests.

Climate change affects Soil

- Soil processes such as nitrogen mineralisation, litter decomposition and soil respiration are sensitive to temperature and water content.
- Increases in atmospheric carbon dioxide increases plant photosynthesis and growth, including level of available biomass. This increases the abundance of fungi and abundance of animals
- Drought directly impacts soil fungi and bacteria. By reducing plant litter and root growth, it decreases abundance of most microbes in soil
- Extreme events like drought and wildfires lead to loss of carbon from vegetation and soils especially peatlands.
- Rainfall and flooding on soil results in soil compaction, increased run off of soil nutrients, and soil anaerobicity (lack of oxygen), leading to loss of soil's structural stability and of nutrients from the soil.

Species interactions

- Climate Change can
  - Increase plant growth
  - increase exudation of liquids from plant roots which affects the activity and composition of below ground organisms.
  - increase insect population which increases impact of the insects on the plant population
  - change timing of insect emergence which affects the species which feed on insects eg birds

Genetic diversity and potential for genetic adaptation

- CC driven changes in phenology, species distributions and population sizes are already altering the amount and distribution of genetic diversity which represents the raw material for natural selection.
- Genetic diversity is reduced in some species which results in inbreeding, reduced survival, and reduced opportunity for evolutionary adaptation to changing conditions
- THIS EXACERBATES EXTINCTION RISK

Pests

- Increases in temperature contribute to spread of bluetongue virus in the UK, carried by biting midge Culicoides imicola, a southern European species, spreading north . Deer suffer from it and act as wildlife reservoir.
- Increasing incidence of tick borne diseases notably Lyme disease carried by range of mammal species.

Competing demands of national targets/policy commitments on land use

land is a finite resource that our resilience in tis ‘ overpromised’ and is facing increasing and competing demands for energy, food, housing, major infrastructure, net zero, nature recovery, and improving he face of global shocks. The government has set a range of commitments that all require significant land use change:

Energy: Accelerate the transition from fossil fuels to renewables, such as increasing solar capacity from 14GW to 70GW by 2035.

Housing: Meet the government’s aspiration of 300,000 homes per year in England.

Biodiversity: Protect 30% of the UK’s land for nature by 2030. Restore or create more than 500,000ha of a range of wildlife-rich habitat in England by 2042.

Forestry: Increase tree canopy and woodland cover to 16.5% of England’s total land area by 2050 (increase of around 250,000 ha, equivalent to an area the size of Cheshire).

Food: Broadly maintain current levels of domestic food production in England.

Infrastructure: Significant public investment in strategic road and rail, UK-wide gigabit broadband roll-out, EV chargepoints, water resilience and flood defence.

Net Zero: Emissions in agriculture, forestry and other land use sectors could need to fall by 17-30% by 2030 and 24-30% by 2035, relative to 2019 levels.

Water: Restore 75% of our water bodies to good ecological status.

Government has also committed to publish a Land Use Framework (LUF) for England in 2023.

Need for land use change

- The Royal Society estimates that we would need an additional
  - 1.4 million hectares of additional land (equivalent to the area of Northern Ireland) by 2030 to meet current policy targets for net-zero and biodiversity (if current agricultural production, diets and food waste remain static).
  - 4.4 million hectares by 2050 (over twice the land area of Wales and 18% of total UK land area).
- Therefore we need trade offs : land use change (combined with dietary shift to less meat and dairy), exploring opportunities for multi-functional land use delivering multiple benefits at landscape scale eg see :

  - Climate Change Committee 6th Carbon Budget Report, 2020
  - National Food Strategy (Dimbleby Report) 2021 - see land use map attached
  - Defra UK Food Security Report 2021
  - Royal Society of Arts Land Use Study 2023
  - House of Lords Land Use in England Committee 2023

Land used for animal agriculture

- 71% of UK land is used for agriculture. The UK Food Security Report said that “what is most striking” is the amount of land used to rear lamb, beef and dairy cattle, both in terms of pasture and the land used to grow feed for these animals. It contended that this was a “very inefficient way to use our land” when calorie production was considered:
- 85% of farmland used to feed the UK (both here and overseas) is used to rear animals, but meat, dairy and eggs only provide 32% of the UK’s calories;
- the remaining 15% of total farmland used to grow plant crops for human consumption provides 68% of the UK’s calories.
- The UK Food Security Report said a reduction in meat consumption of 30% (along with less influential measures) would allow the UK to produce the “same amount of calories from 30% less land”. This is consistent with recommendations of the Climate Change Committee and others, but is politically controversial (e.g. PM’s recent ’snapping’ at non-existent Labour policy to introduce a ‘meat tax’).
- A more recent study for the RSPB and others, reported in the Financial Times online edition on 20/10/23 https://ig.ft.com/uk-land-use/, has reached similar conclusions and suggests that to get even close to net zero, 25% of UK farmland will have to shift to other land uses.

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What does this mean for Herefordshire ?

- Herefordshire is one of the least densely populated counties in England with around 80% of land used for agriculture and forestry, yet we have a similar problem of competing demands for finite land supply, for example:
  - Core Strategy Local Plan
  - Green/Blue Infrastructure Strategy
  - Climate Change Adaptation Strategy
  - Renewables Opportunity Mapping
  - Local Nature Recovery Strategy

- **Jamie Audsley: “It's not clear to me that anyone at county level is ‘joining the dots’ and making any sense of these competing demands in the spatial context”.**
-

What 30x30 means for Herefordshire

- a crucial promise: to protect and manage 30% of land and sea for nature by 2030.
- 6.5% of England is covered by protected area designations for nature (JNCC), but this figure refers to extent only and does not consider site condition/quality.
- Wildlife and Countryside Link 2022 progress report on in England states that 3.2% of England is effectively protected and managed for nature, based on the number of protected areas that are in favourable management condition.
- HoL ECCC's report (July'23) uses the higher JNCC figure of 6.5% as a starting point for assessing progress, thus leaving a gap of 23.5% of land in England to achieve 30x30, which equates to 1.5 x the size of Wales.
- But this does not consider management condition/quality of land protected, only extent.
- Defra evidence to HoL stated it plans to publish a map of what land counts towards 30x30 between now and 2030, but that is likely to be contentious because current intent is to include some/all of land under landscape designations (e.g. AoNBs and National Parks) which various studies have shown to be no better at protecting nature than wider countryside outside SSSIs.

What land counts towards 30 x 30?

- SSSIs
  - Environmental Improvement Plan 2023 includes a new target for all SSSIs to have an up-to-date condition assessment by January 2028, whereas only 22% of SSSIs have been monitored in last 6 years . Joint Nature Conservation Committee standard is to monitor 100% every 6 years),
  - and an interim target for 50% of SSSIs to have management actions in place to achieve favourable condition by January 2028, and to restore 75% of SSSIs to favourable condition by 2042.
  - Less than 50% of Herefordshire's SSSIs are in favourable condition.
- Local Wildlife Sites and ELMs
  - HoL ECCC recommends that Local Wildlife Sites and land within Environmental Land Management Schemes could be counted towards 30x30 only if they meet International Union for Conservation of Nature guidelines for protecting nature long-term.
- Wider countryside
  - Environmental Improvement Plan 2023 includes targets, In the wider countryside outside SSSIs, to restore or create more than 500,000 ha of wildlife-rich habitats by 2042; restore or create 140,000 ha of wildlife-rich habitats outside protected sites by 2028 compared to 2022 level.

What does Herefordshire need to do

- Herefordshire's land area is 218,000 ha, so our ‘fair share’ of 30x30 target could be 50,000 ha protected and managed for nature by 2030 , plus 12,000 ha protected sites and 500 ha Wildlife Trust reserves. There is some overlap between SSSIs/HWT reserves, so 50,000ha should be regarded as a minimum figure.
- Meeting the interim 2028 target for habitat restored or created outside SSSIs would require restoring/creating around 3,000 ha in Herefordshire - that’s not a huge ask if land within ELMs and Biodiversity Net Gain with specific nature recovery/conservation objectives can be included, but still leaves a big gap against the 30x30 target to be achieved by 2030 and/or 2042.

What contributes to Herefordshire's emissions?

- 22% of Herefordshire's territorial CO2 emissions are from agriculture (mainly livestock),
- 72% of Phosphate pollution in rivers Wye/Lugg is from agriculture
  - mainly livestock
  - around 30% of the 72% is from chickens - so cattle, sheep and pigs make a big impact too)

- Actions for carbon net zero, nature recovery and nutrient neutrality all depend on agriculture/land use change and that's why HWT are planning a project in the Wye/Lugg corridor to 'kick start' and showcase practical delivery of Local Nature Recovery Strategies and voluntary actions by famers to reduce CO2 emissions , recover nature and ecosystem function, and reduce nutrient runoff to water

- HWT will then need to scale up and extend the project across the county and integrate this with other competing land uses.

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