

One Hell of a Plant to Save the Planet

A Green House Gas by Ciara Shannon

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This gas by Ciara Shannon considers the multiple carbon opportunities of bracken including its potential as an alternative to peat, its carbon storage, its role as a feedstock for bioethanol and it being a marker of ancient woodlands and where to replace it for new woodlands.



Loughrigg Fell, Cumbria. Photo by Tarn House

“To place it in perspective as succinctly as possible, bracken is one hell of a plant”. I.A. Evans (1987)

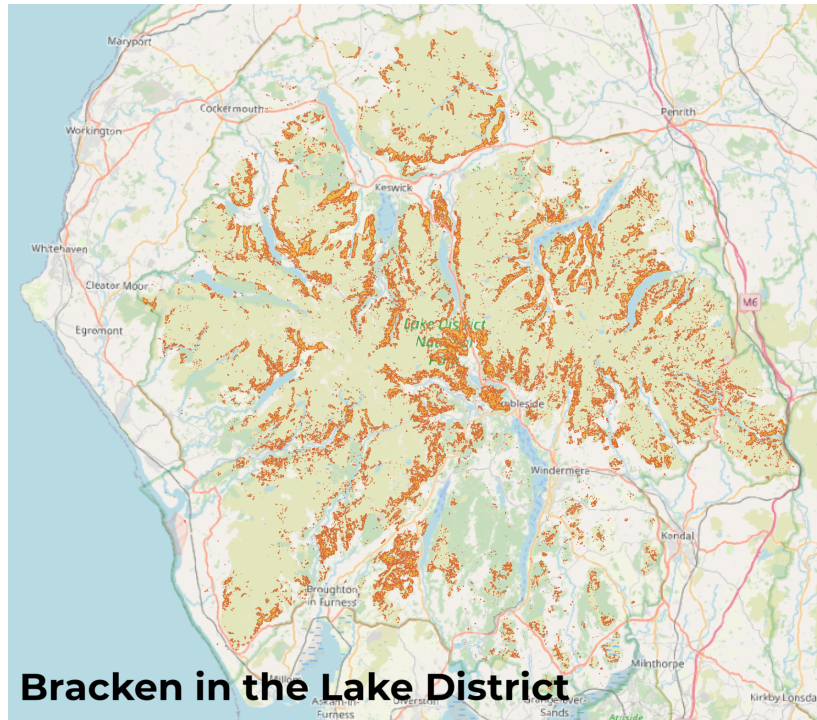
I’d not considered bracken (*Pteridium aquilinum*) much until recently, beyond chasing my dog away from bouncing around in the stuff and thinking of it as fern’s less glamorous relation.

In writing this, I’ve been intrigued by the power of its ropey rhizomes, curious to its carbon saving opportunity and wondered about the old saying: ‘Copper under heather, silver under gorse, gold under bracken’. I also gladly welcome your opinion on this ‘gas’, especially if you know about bracken’s brazenly brilliant ways.

Fossil record shows that bracken has been a species of deciduous woodland for the last 55 million years. Its opportunistic biology is such, that its spread has happened both in response to deforestation and to the way it can outcompete the growth of other plants - inhibiting seed germination. It is commonly found in woodland and upland areas and prefers acidic, well-drained soil. Its proliferation spreads via its underground rhizomes that run amok, ‘allelopathically’ (chemically interfering) with the growth of other plants, presenting a real threat to woodlands and biodiversity. It is also a ‘Pteridophyte’, reproducing by spores rather than seeds and it contains different poisonous agents such as cyanogen glycosides and carcinogens such as ptaquiloside.

Vast swathes of heather on many a moorland is besieged by its grip that causes immense problems to land managers, livestock farmers, and foresters. It has a direct impact on the productivity of land as it can shade out and completely replace other, useful, vegetation that are important to biodiversity and good for cattle and sheep grazing. Bracken currently covers some 1.6%ⁱ or ~1.5 million hectares of Britain and it seems that whatever you do to control it, it grows back. A bit like a cockroach - fire does not kill it either. In fact, it makes it stronger.

Here in the Lake District, bracken covers about 6%ⁱⁱ or some 35,000 acres and from my window, it appears to cloak the fells everywhere with its winter die-back that has turned the landscape a coppery brown. Underneath though is new growth peeping through and its young fronds will soon unfurl into a blanket of green.



Map data: Habitat classification by University of Exeter, SWEEP

Traditionally, bracken has had many uses - from animal bedding, compost, thatch, fuel and burnt bracken ash was often used in glass, soap making and dyes. Today, there are only a few commercial uses for bracken, and this is likely due to the high cost of harvesting it because of the physical difficulties in accessing it from a very steep hill.

Harvesting and controlling bracken on steep slopes is extremely challenging, costly and time-consuming. Changes in land management practices mean that there are now fewer cattle and sheep in upland areas to trample it down. Other ways to control it include to cut/roll/ flail bracken at least twice in the first year (in May/June and again in July/August) and the years following. There is also aerial spraying with Asulam (also known as Asulox) which is extremely toxic, as is glyphosate.



Brielmaier cutters, demonstrated in Cumbria in 2015, can tackle steep slopes. The cutters can cost £20-30,000 and some of the machines can also mulch. Other machines are needed to rake the material where it can be baled. Photo credit: Roland Priebe.

Carbon Saving Opportunities

What interests me most about bracken though are its magnificent carbon saving opportunities. From replacing some of it with woodland - especially as bracken is a good indicator of former woodland; to its use as a second-generation feedstock for bioethanol and as an alternative to peat. However, despite all its promise, I've been surprised that there is not much literature on bracken's carbon store and sequestration potential.

What is known is that the carbon stored in bracken in the top 15 cm of soil is relatively low when compared to other ecosystems and habitats. According to research done by the University of Cumbria and the Lake District National Park Authority (2013), bracken stores carbon in the top 15 cm of soil at ~79 tonnesⁱⁱⁱ of carbon per hectare in the Lake District (55 t C ha⁻¹ to 77.1 t C ha⁻¹ under bracken, and 2 t C ha⁻¹ in vegetation). This equals to ~ 2.8 million tonnes of CO₂e for the park's 6%^{iv} share. For comparison, 84 million tonnes of CO₂e are stored in the Lake District's peat soils and 12.6 million tonnes of CO₂e in its woodland.

To illustrate this point further, see the below table on carbon storage and sequestration by habitat from Natural England (2021).^v However, Natural England doesn't mention bracken specifically and doesn't cite figures at all for the annual sequestration potential. Though given the carbon stored in the bracken itself is relatively low, it's probably a small-scale sequestration.

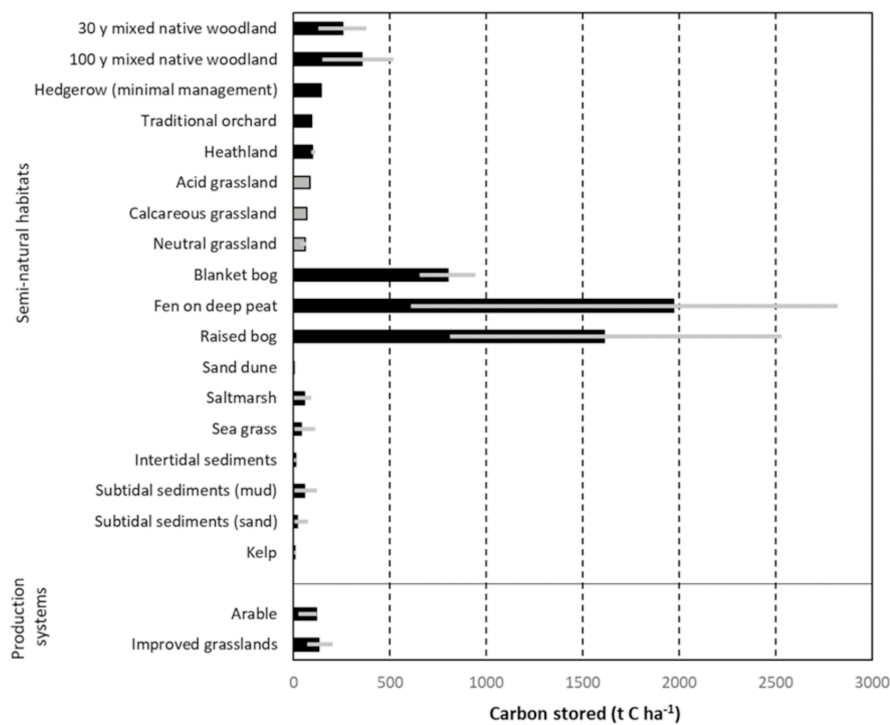


Chart Source: Carbon Storage and Sequestration by Habitat, Natural England (2021)

An Indicator of Deep and Fertile Soils for Woodlands

But what about carbon stored below 15 cm of soil? This could be important information as bracken is well known to be an indicator of deep and fertile soils which would mean bracken's deeper soils would contain more carbon than is currently known. All of this should be researched more to better understand the carbon cost of leaving it in the ground as a land gobbling monoculture or removing it for more commercial net zero opportunities or tree planting.

Guy Shrubsole from the Lost Rainforest of Britain project also sees our bracken 'problem' as an opportunity and he thinks bracken may be telling us something important about how we use our land, and how we should be sparing more of it for nature. Far from being a harbinger of doom, he sees bracken as being a good guide as to where to let native woodland return. In other words, bracken offers us 'guidance' to put 'the right tree in the right place'. Guidance that should be used when deciding where to plant trees as part of the government's commitment to increase woodland creation across the UK to 30,000 hectares per year by 2025.

Ghost Woods

Interestingly, Guy Shrubsole cites the ecologist Ian Rotherham, who thinks bracken is a sign of lost woods - 'ghost woods' or 'shadow woods' – that show us not only where woodland once existed, but it is possible these old woods don't entirely disappear. Indeed, some bracken stands may contain old woodland seedbanks that are lying in wait to spring back into life. Breaking up bracken and generating wood pastures/ savannah-type environments could perhaps help these old seedbanks rejuvenate.

Trees are one the few plant groups that can reduce bracken's domination and in general, turning bracken into woodland can be done through a mix of planting, natural regeneration and reintroducing disturbance, say with pigs/ wild boar, to break up bracken stands and allow seedbanks to rejuvenate and prepare the ground for saplings.

Advanced Cellulosic Biofuels Possibilities for Sustainable Transport and Aviation Biofuel

While planting more woodlands is of course a good solution, bracken's quickest planetary saving potential, lies in it being a feedstock for bioethanol and maximising the production of its C5 and C6 sugars (and therefore its yield of bioethanol). This can be done through fermentation, distillation, and other technological processes such as gasification, pyrolysis, enzymes, (to name some). All of which are competing for tech prominence but also add a fair whack to increasing the capital cost of production.

Tech and money issues aside, one outstanding advantage in using bracken for bioethanol is that it neither competes directly with food production, nor indirectly for land use, and thus it avoids the "food and energy" dilemma.

It is encouraging to see that a commercial biomass to biofuel facility is being built in Nottingham which, once completed, will enable the technology to be rolled out across the UK. But it is a beast of a machine that will require an annual supply of 40,000 tonnes of feedstock. Where an average bracken yield is ~30 tonnes per hectare, this requires harvesting areas of up to 1,500 hectares to run one unit.^{vi}

According to the International Energy Agency (IEA) World Energy Outlook (WEO), biofuel demand is expected to increase by nearly 1.5 million barrels of oil equivalent per day (mboe/d) by 2030 as highlighted in the Stated Policies Scenario (STEPS).^{vii} In September last year, the UK mandated the introduction of E10 fuel which contains up to 10% of sustainable bioethanol and the Climate Change Committee's Land Use Report (2020) recommends expanding the planting of UK energy crops to around 23,000 hectares each year to meet net zero by 2050.

The Transport Opportunity

Bioethanol prices are linked to the price of oil and the resurgence in oil prices coupled with the expansion of the use of biofuels in the heavy transport and aviation sectors are driving price increases for ethanol and for Road Transport Fuel Certificates (RTFCs), making them more economically viable. Last year, the UK Department of Transport added bracken to the UK Road Transport Fuel Obligation list of acceptable feedstocks, both as a lignocellulosic material, and as a waste material given its invasive nature.^{viii} Meaning every litre of biofuel produced from bracken will qualify for **double** Renewable Transport Fuel Certificates.

Given such a high 'weighting', could it be that bracken, the bane of many hill and upland farmers, might be able reap a positive reward as an advanced biofuel that could be used for aviation and heavy transport?

With the new biofuel certificate values, biofuel projects using bracken as a feedstock could be a promising option for the UK as it ticks several boxes in offering farmers an option to control the spread of bracken, earn an income from unproductive land, reduce the risk of fire, while enabling emissions to be reduced.

Bracken has been used as a biofuel for centuries, probably due to its low moisture content and its high calorific value that when cut and dried is 21 GJ/t (Callaghan et al., 1981), compared to 19 GJ/t for straw (Christian and Riche, 1999).^{ix}

An Alternative to Peat

Mixed with sheep's wool, it can also be an effective peat-free potting compost good for fruiting and flowering. Sheep's wool replaces the peat element by increasing water retention and acting as a source of slow-release nitrogen. Bracken, being ericaceous, is also one of the few viable substitutes that can be used instead of peat to grow plants, such as rhododendrons, camellias or blueberries. Several companies commercially produce 'wool and bracken' composts - not only is this a sustainable, environmentally friendly, peat-free alternative, but it can help the wool market as it continues to decline.

Biomass Pellets

Another use is that bracken has been used to produce biomass pellets which when converted into "brackettes", claimed to burn longer and more fiercely than oak and they sold for around £6.99 for 10

kilos.^x But, Brackenburn the company that processed the brackettes, has since ceased trading. Why this company didn't progress is not known, it simply could be that the company didn't factor in all the costs for harvesting the bracken. If there is potential to commercialise bracken biomass pellets, could bracken pellets also be burnt in UK power stations instead of having to import them? In 2018, 7.8 million tonnes of wood pellets were imported to the UK and 82% of these wood pellets imported were from the United States and Canada. Importing such a vast amount, does not equal a sustainable use of biomass given all the emissions associated with its transportation or potential impacts on land use in cutting up the wood.^{xi}

While opportunities abound, for any of these opportunities to succeed they must be properly sustainable. Meaning that the emissions saved must outweigh any potential carbon service provided by the bracken. To better understand this, it would be good to see some detailed life cycle assessment (LCA) done that focuses on energy and GHGs balances, including bracken's carbon storage and sequestration below 15 cm of soil.

There also needs to be greater policy incentives that foster commercialisation. Without such support, there is a real risk that bracken will continue to run amok and many of the technologies that could turn bracken into a carbon saving will not be developed properly and this would be a missed carbon opportunity.

Some Research References

- Carbon storage and sequestration by habitat, Natural England (2021).
- Managing land for carbon: a guide for farmers, land managers and advisors. Lake District National Park, University of Cumbria (2013).
- Biomass in a low carbon economy, the Climate Change Committee (2018).

Endnotes

ⁱ Source: https://academic.oup.com/aob/article/85/suppl_2/37/194573

ⁱⁱ Source: <https://www.lakedistrict.gov.uk/caringfor/farming/farming-and-carbon>

ⁱⁱⁱ Source: Managing land for carbon: a guide for farmers, land managers and advisors. Lake District National Park, University of Cumbria (2013)
https://www.lakedistrict.gov.uk/__data/assets/pdf_file/0035/109898/Managing-land-for-carbon-booklet.pdf

^{iv} Source: <https://lostrainforestssofbritain.org/2022/02/03/using-bracken-maps-as-a-guide-for-regenerating-rainforest/>

^v Source: <https://www.lakedistrict.gov.uk/caringfor/farming/farming-and-carbon>

^{vi} Source: <https://waste-management-world.com/artikel/the-waste-to-energy-revolution/>

^{vii} Source: <https://biofuels-news.com/news/drive-to-greater-biofuel-usage-hampered-by-high-costs-and-lack-of-feedstock-availability-weo-report-reveals/>

^{viii} Source: <https://www.gov.uk/government/publications/renewable-transport-fuel-obligation-rtfo-guidance-2021/list-of-feedstocks-including-wastes-and-residues-year-2021--2>

^{ix} Source: https://orgprints.org/id/eprint/8312/1/Donnelly_Potential_historical_bracken.pdf

^x Source: <https://www.labmate-online.com/news/news-and-views/5/breaking-news/could-a-british-fern-be-the-next-big-biofuel-source/37419>

^{xi} Another interesting project is a biomass biochar project in Ireland that will convert waste farm biomass, such as reeds and bracken and it will be interesting to see if this project can be commercialised at scale.