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## Nature-based Solutions

# Flood-plain Meadows: An Entirely Sustainable Nature-based Solution that is Centuries Old

Figure 1. Flood-plain meadows support a vibrant plant community with up to 40 species of plants/m<sup>2</sup>, including rare and uncommon species such as snakeshead fritillary (*Fritillaria meleagris*), narrow-leaved water-dropwort (*Oenanthe silaifolia*) and great burnet (*Sanguisorba officinalis*). Photo credit: Mike Dodd.



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3000 ha in England and Wales. Their loss has had wide-ranging consequences, exacerbating the impacts of climate change and removing substantial carbon reserves and an important buffer for rivers against diffuse agricultural pollution. This article explains why flood-plain meadows are a particularly elegant nature-

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Widespread in river valleys, species-rich flood-plain meadows were overwhelmingly converted to intensive agriculture or urban development during the 20th century, leaving just

based solution to the climate and biodiversity crises, and details how we can work together to restore them as a core component of an effective nature recovery network that also sustains productive regenerative agriculture.

### Flood-plain meadows and the Partnership

Flood-plains of high nature value that support habitats such as species-rich hay meadows are a vital element of UK natural capital. Unmodified, they support a healthy freshwater environment and provide many goods and services, helping to mitigate flood risk and drought, store carbon, reduce sediment and nutrient loadings in rivers, conserve biodiversity and cultural heritage, support pollinating insects and provide inspirational places for people.

Flood-plain meadows were highly prized for centuries because river

sediments deposited during floods provided natural fertiliser and stimulating early grass growth. The diverse grasses and herbs rendered the hay of particularly high nutritional quality, vital as winter feed for livestock on which transport, agriculture and local communities were dependent.

The Floodplain Meadows Partnership (FMP; Rothero *et al.* 2021) was established in 2006 by the Open University in association with statutory agencies and non-governmental organisations. The FMP focuses on turning research into best practice management advice, influencing policy and raising awareness through advocacy. Key environmental issues are investigated through long-term experiments and observation. The resulting information is disseminated through training, workshops, publications and conferences. The Partnership promotes the recovery of at least 70,000 ha of species-rich flood-plain meadow for multiple benefits; its website details restoration, creation and management techniques.

### A rare habitat

Once occurring at a landscape scale, the meadow foxtail/great burnet (*Alopecurus pratensis/Sanguisorba officinalis*) flood-plain-meadow plant community (National Vegetation Classification MG4; Rodwell 1992) is now extremely rare and mostly found in small sites of <10 ha. Stands are largely restricted to lowland river flood-plains in England, where little more than 1500 ha remains (Holmes *et al.* 2005), with less than 10 ha recorded in Wales (Figure 2).

Where summer water tables are higher, for example on groundwater-fed systems, MG4 is replaced by crested dog's tail/marsh marigold (*Cynosurus cristatus/Caltha palustris*) grassland (MG8). Many sites support a mosaic of other wet grassland plant communities.

As dynamic semi-natural systems, species-rich flood-plain meadows lose their biological diversity through application of agrochemicals, lack of cutting and/or prolonged waterlogging caused by neglect of surface drainage infrastructure. All remaining examples of ancient flood-plain meadows and successfully restored sites should therefore be conserved and managed to ensure they are in the best possible condition and can provide sources of seed for the future.

### Unintended consequences of loss

Extensively altered by river engineering and land drainage, at least 42% all flood-plains in England have been separated from their river (Maltby *et al.* 2011), no longer able to store, clean and distribute water across the landscape. The impacts are becoming increasingly apparent as climate change bites – with winter rainfall and flooding predicted to increase, and reduced summer rainfall leading to drought. A step change in the way flood-plains are managed is urgently needed to help society adapt and become more resilient to climatic extremes. Just 14% of English rivers currently meet the criteria for good ecological status (Bevan 2020), primarily because of physical alterations and diffuse pollution from agriculture. Nearly 70% of flood-plain land is intensively managed (Heritage and Entwistle 2017) whereas semi-natural habitats such as flower-rich meadows

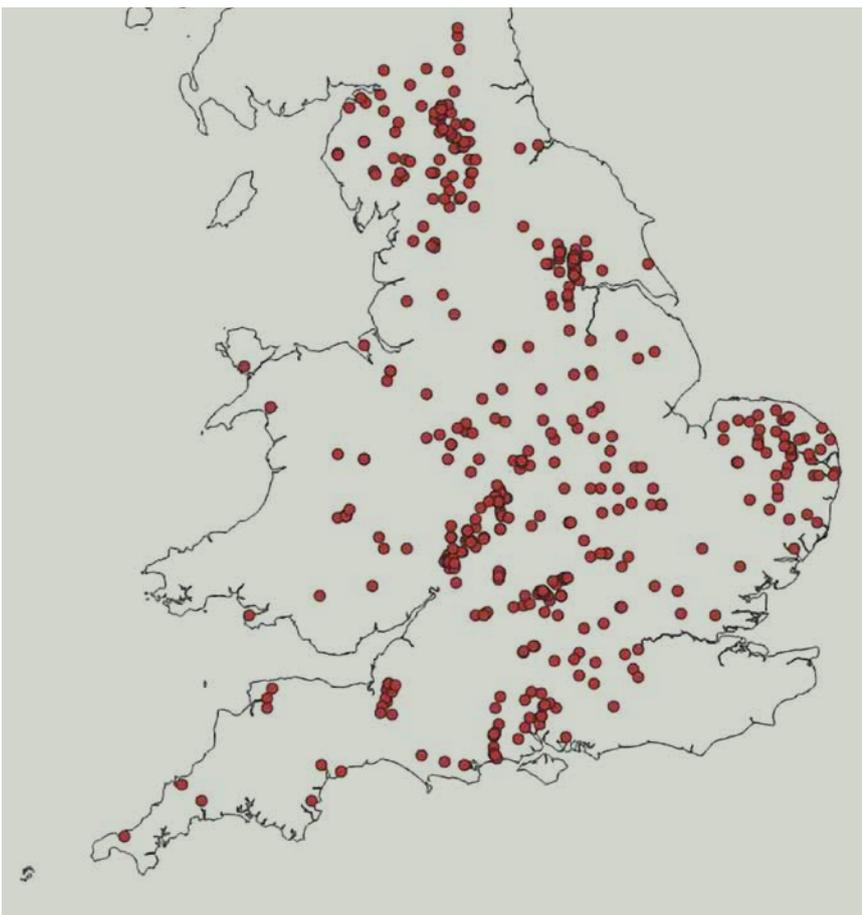


Figure 2. Known flood-plain meadows in England and Wales.

and wet woodland occupy a mere 11%. The loss of these protective flood-plain habitats makes the Government's 25-year Environment Plan target for 75% of waters to be close to their natural state extremely difficult to achieve.

### The benefits of flood-plain meadows today

Flood-plain meadows, developed during an age when soil fertility was difficult to build and maintain, were considered to be the most valuable agricultural land. Some might argue that, despite their beauty, diversity and intrinsic value, they are essentially an historical anachronism with little role to play in modern day socio-economics. However, there is growing recognition of the contribution flood-plain meadows can make to both the climate and biodiversity crises, and increasing evidence for the many benefits they provide. A review concluded that the overall benefits provided by seasonally inundated flood-plain meadows are greater than those provided by land in intensive agriculture (Lawson *et al.* 2018).

### Carbon storage

Regular replenishment during floods ensures flood-plain soils are constantly accreting and maintain their fertility, in stark contrast to the widespread compaction and erosion found in most lowland agricultural landscapes. Three to five times more carbon is stored in soils than in vegetation such as trees (Anderson 2021). The deep rooting strategies of meadow plants (Figure 3) enhance the ability of flood-plain soils to sequester and securely store significant quantities of carbon throughout the soil profile.

Organic carbon within the top 10 cm of soil at North Meadow in Wiltshire was recorded as 109 tC·ha<sup>-1</sup> (Lawson *et al.* 2018), a much higher value than reported for neutral grasslands in Gregg *et al.* (2021). Recently published research (Yang *et al.* 2019) showed that higher species richness increases the sequestration rate in grasslands. Carbon sequestration in a newly restored flood-plain meadow occurs more rapidly and over a much larger scale than is likely to be achieved through tree planting (Figure 4) and the land can continue to be farmed, which

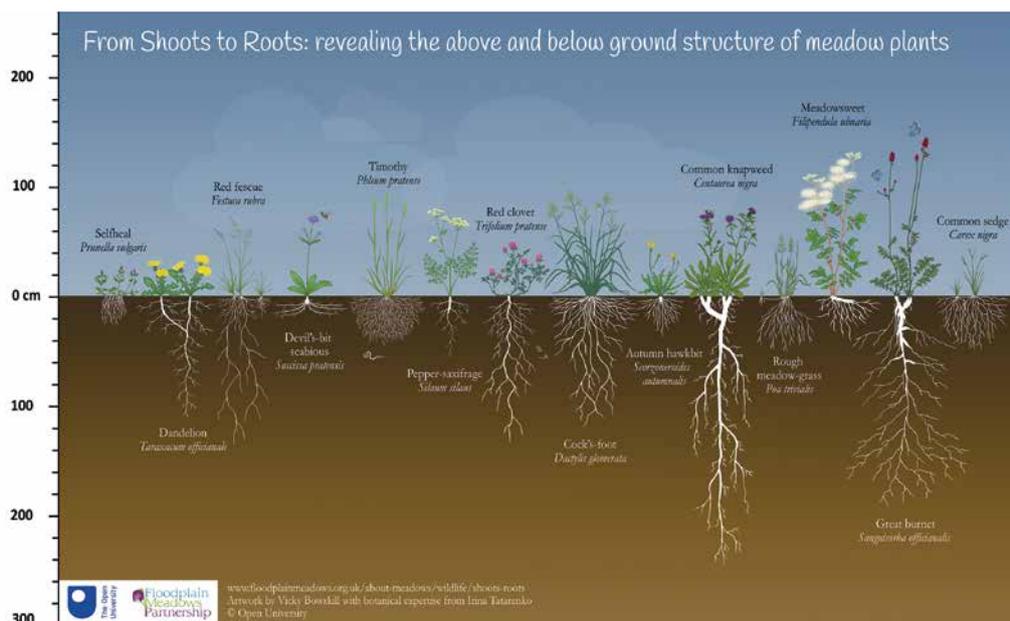


Figure 3. Rooting depth of meadow plant species reflects the depth of carbon distribution down the soil profile. Reproduced from Bowskill and Tatarenko (2020) under CC BY-NC-SA 2.0 UK. © Open University.

many landowners would prefer. Newly planted trees can actually liberate carbon through soil disturbance and may not begin to sequester net carbon for 10–30 years (Anderson 2021). These facts are at odds with the current widespread focus on tree planting rather than grassland restoration.

### Natural flood management and aquifer recharge

The increased likelihood of extreme events makes it vital that the ability of flood-plains to slow, store and filter floodwater is restored so they can play a critical role in natural flood management. The enormous potential

for river and flood-plain meadow restoration as nature-based solutions to both floods and drought is recognised in the *Working with Natural Processes* documents (Environment Agency 2021), but rarely utilised. Flood-plain soils tend to be highly permeable, often with underlying deposits of sand and gravel, allowing water to replenish the aquifers below and support low summer river flows, buffering rivers against drought. Conversely, because seasonally inundated flood-plain soils are very vulnerable to compaction when wet, and to erosion when left bare over winter, arable crops such as maize are particularly damaging in flood-plains.

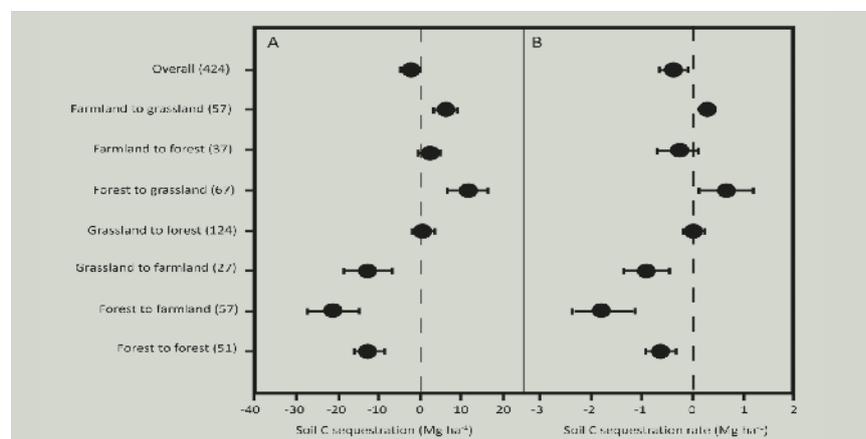


Figure 4. The effects of land-use change on soil carbon sequestration (A) and soil carbon sequestration rate (B) from a meta-analysis of independent studies, which considered change over a range of timescales, in many cases for >30 years. Circles with error bars denote overall mean values and 95% confidence intervals, with numbers of observations in parentheses. Reproduced from Deng *et al.* (2016) under CC BY 4.0 with permission from Elsevier.

“ Restoring flood-plain meadows, for example by replacing arable crops, can directly reduce inputs of pollution in the form of suspended sediment and excess nutrients that arise from intensive agriculture. ”

### Water quality benefits

Widespread diffuse pollution from intensive agriculture results in many rivers having artificially high levels of suspended sediment and excess nutrients. Restoring flood-plain meadows, for example by replacing arable crops, can directly reduce inputs of both. Up to 40 t of sediment per hectare were deposited after the 2007 summer floods on 10 UK flood-plain meadow sites across five catchments. The deposition of nutrients on flood-plain meadows across England was also significant, varying from 2 to 270 kg·ha<sup>-1</sup> for potassium and 1–32 kg·ha<sup>-1</sup> of phosphorus (Rothero *et al.* 2016).

The ability of flood-plain meadows to trap sediments and export nutrients such as phosphorus through the annual hay cut is vitally important to the restoration of good ecological status to rivers. A single hectare of meadow can export 5 kg of elemental phosphorus from a river system every year, highlighting their potential as a nature-based solution to eutrophication (Rothero *et al.* 2016).

### Sustainable agriculture

Restoration of species-rich flood-plain meadows at a landscape scale could help in the drive to achieve net zero, support the green economy and provide jobs by extending a naturally regenerative agricultural system that requires no chemical inputs yet recovers well after floods and remains productive during droughts. The animals that graze such meadows and consume the hay require less imported feed, have better nutrition and therefore produce healthier meat for human consumption (Shellswell 2017).

### Biodiversity

The biodiversity of flood-plain meadows has been well documented (Rothero *et al.* 2016; Figure 1). They support a wide range of flowering plants and invertebrates, providing vital nectar for significant populations of pollinating insects. They are important for small mammals, wading birds, amphibians and reptiles, and their abundant natural predators may help to combat the threat of new pest species as the climate warms.

### Other values

Flood-plain meadows are iconic landscapes of significant historic, cultural and aesthetic importance, often close to towns and cities (Figure 5). Well used and much loved, they are a vital resource for improving physical and mental health and well-being through quiet recreation and contact with nature. This was highlighted during the current pandemic and in the Partnership's recent arts and crafts competition, a particularly powerful



Figure 5. Oxford meadows in flood. Photo credit: Mike Dodd.

way for engaging with local communities. View some of the diverse entries at <https://tinyurl.com/y5zdpzt>.

### Working together to promote, co-design and co-fund restoration schemes

Flood-plains occupy around 5% of the UK (652,000 ha), offering huge opportunities for conservation professionals to restore a functioning mosaic of wetland habitats. Flood-plain meadows are cost-effective to restore using green hay and low cost to maintain, providing productive grassland that protects and enhances soil and buffers watercourses. A substantial increase in extent is needed as part of the UK's strategy to restore resilient landscapes.

Many organisations and individuals have a part to play. Wide-ranging policy mechanisms and funding opportunities include:

- reduction of greenhouse gas emissions and natural disasters
- reduction of diffuse pollution
- more sustainable, regenerative agriculture: working towards net zero
- nature recovery network and providing Biodiversity Net Gain through development.

**“ Working effectively together, and through strategic plans such as Local Nature Recovery Strategies, is vital to ensure the right habitats are restored or created in the best places. ”**

Species-rich flood-plain meadows can help to achieve all these objectives at the same time. The new Environmental Land Management Scheme will provide the main source of funding for habitat restoration. The extent to which this will support multiple farmers in discrete landscapes like flood-plains is not yet clear. Groups of farmers with flood-plain land should be encouraged to take up appropriate Sustainable Farming Initiative measures, Local Nature Recovery options, and long-term land use change through the Landscape Recovery scheme. Farmer facilitation groups can help focus restoration on discrete areas and specific habitats; where backed by funding and a long-term commitment, an increase in flood-plain meadows could bring about sustainable and measurable change.

Working effectively together, and through strategic plans such as Local Nature Recovery Strategies (LNRS), is

vital to ensure the right habitats are restored or created in the best places. Achieving the optimum balance will require careful planning to avoid conflicts between, for example, food production, government tree planting targets and the drive to establish more riparian woodland.

Biodiversity off-setting, carbon and nutrient trading are new and largely unregulated markets. The data used are not comprehensive, partly because of the lack of empirical evidence of values for different habitats and current schemes do not adequately reflect the long-term contribution that flood-plain meadows can make (Figure 6).

### What you can do to help

All conservation professionals can look for opportunities to restore functional flood-plain habitats, identifying rivers and their flood-plains as a core component of LNRS or restoring them as Biodiversity Net Gain associated with development. Working with farming cluster groups and catchment management partnerships is another very effective way of developing projects that deliver change.

The FMP is keen to work with partners on local projects and liaise with farmer



Figure 6. The restoration of flood-plain meadows at a landscape scale is far more effective than using thin riparian strips (Sawatzky and Fahrig 2019). Photo credit: Emma Rothero.

groups and land managers working in flood-plains. Local groups are supported with guidance and training, helping them investigate flood-plain history and undertake long-term monitoring, management and restoration using a range of methods. Local advice can be provided through FMP Ambassadors, a network of experienced practitioners and volunteers available to support projects and share advice in their local area (see *Where to find out more*).

## Conclusions

Land use in flood-plains needs to be optimised so they can once again slow, store and filter the flow of water from the land. Functioning flood-plain meadows are a cost-effective nature-based solution that can help reduce flood risk and diffuse pollution, halt and reverse the loss of biodiversity, store carbon securely at volume and significantly benefit local communities. As flood-plains occupy just 5% of the UK's land area, targeted investment in restoration would give integrated outcomes and massive financial savings and gains for society as a whole. We know what to do, where and how to do it: now we need to ensure the various targets, strategies and funding mechanisms to enable our skilled professionals and land managers to restore and re-create this amazing and supremely pragmatic land use at a landscape scale.

## Where to find out more

The FMP website ([www.floodplainmeadows.org.uk](http://www.floodplainmeadows.org.uk)) gives access to the handbook, research outputs, newsletters and details of the Ambassador scheme.

YouTube recordings from the 2021 conference are available at: [www.youtube.com/watch?v=UPHWdNC AAWI&list=PLQdkll7Mtm 6N9hZWGuGZ xnmTNTMVw24UN &index=1](https://www.youtube.com/watch?v=UPHWdNC AAWI&list=PLQdkll7Mtm 6N9hZWGuGZ xnmTNTMVw24UN &index=1)

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