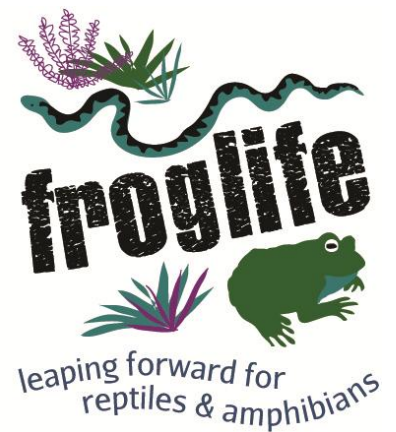


Ponds and carbon capture

Froglife Literature Review: January 2026

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1) Introduction

The UK Government Department for Energy Security and Net Zero update on Climate Change in June 2023 (UK Government, 2024a) include the following statements:

“Climate change is happening and is due to human activities; along with warming, many other changes are occurring such as melting polar ice, rising sea levels and more frequent floods, droughts and heatwaves”

“It is unequivocal that human influence has warmed the atmosphere, ocean, and land..... Each of the last 3 decades have been hotter than the previous one and the 7 warmest years on record have occurred between 2015 and 2021.”

The UK Government update outlines the effects in the UK:

“Some of the effects of changes to our climate include:

- *risk to water supplies*
- *localised flooding and flooding in coastal regions*
- *damage to marine ecosystems and associated failure of fisheries*
- *loss of biodiversity*
- *heat stress, affecting human health and habitability*
- *increased risk of wildfires*
- *food insecurity as conditions for growing crops change and habitable region of pests expands”*

.....“climate models project that [the UK] will see:

- *warmer and wetter winters*
- *hotter and drier summers*
- *more frequent and intense weather extremes”*

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In this scenario, action is needed to capture carbon and remove it from the atmosphere and, alongside this, improve biodiversity and support the UK Government in its commitment to “halt and reverse the loss of biodiversity by 2030 as well as signing up to the global ‘30x30’ initiative to conserve or protect at least 30 per cent of the world’s land and at least 30 per cent of the world’s ocean by 2030” (UK Government, 2024b)

This briefing note considers the role of natural ponds and other small freshwater bodies in the UK and their impact on the capture of organic carbon. This introduction considers initial investigations and evidence about the nature of 'blue carbon' in coastal ecosystems and carbon capture in lakes and rivers. The briefing then outlines the published literature regarding the role of small freshwater bodies, which have been lost in the UK at an alarming rate, as carbon sinks and sources. Jeffries (2011) identified the pond decline in the UK between the 19th century and the 1980s was as high as 75% with ponds estimated to have dropped from 800,000 to only 200,000. Surveys between 1990 and 1996 suggest that around two thousand new ponds were created in Britain each year but while pond creation increased in recent decades the value of new ponds for amphibians is not clear. Haines-Young *et al.* (2000) estimated 243,000 lowland ponds in England, Wales and Scotland in 1998 and suggested that between 1990 and 1998, 24,000 lowland ponds were lost, and 37,000 new ponds created, a net gain of 13,000 ponds. Data for 2007 (Williams *et al.* 2010) estimate 478,000 UK ponds with 18,000 ponds lost and 70,600 created between 1998 and 2007. A commonly used figure to illustrate the decline in small waterbodies is 500,000 ponds lost in the last one hundred years (Wildlife Trusts, 2024).

An ongoing debate surrounds the role of carbon dioxide and methane emissions from ponds and their impact on greenhouse gas (GHG) concentration and this briefing considers the evidence and current position (August 2025) regarding GHG emissions, carbon dioxide (CO₂), methane (CH₄) and nitrogen oxide (N₂O). Further information about the carbon capture role of aquaculture ponds, beaver ponds and stormwater collection is included to consider the question of whether ponds are operating as carbon ‘sources’ or ‘sinks’.

The term ‘blue carbon’ has been widely used to reflect sequestration of carbon in coastal ecosystems such as mangrove forests, marshes and seagrass meadows (McCreadie *et al.*, 2021). The contribution of these coastal habitats to long term carbon sequestration is high because of their efficiency in trapping suspended matter and its associated or organic carbon (McLeod *et al.* 2011). In freshwater environments, Ho *et al.* (2020) studied a range of rivers of different water quality and found that higher greenhouse gas emissions occurred where river water quality was poor, with heavily polluted water generating 10% more greenhouse gas emissions. Mendonça (2017) produced a global estimate of organic carbon burial in lakes and reservoirs, which retain approximately 20% of carbon dioxide emissions and so could be considered an contribution to carbon storage. Like rivers, GHG emissions and carbon sequestration in lakes was believed influenced by eutrophication. Anderson *et al.* (2013) found an increase in carbon burial and carbon sequestration in lakes in Minnesota where land cover change increased nutrient availability and productivity. A later review of global data from 516 lakes by



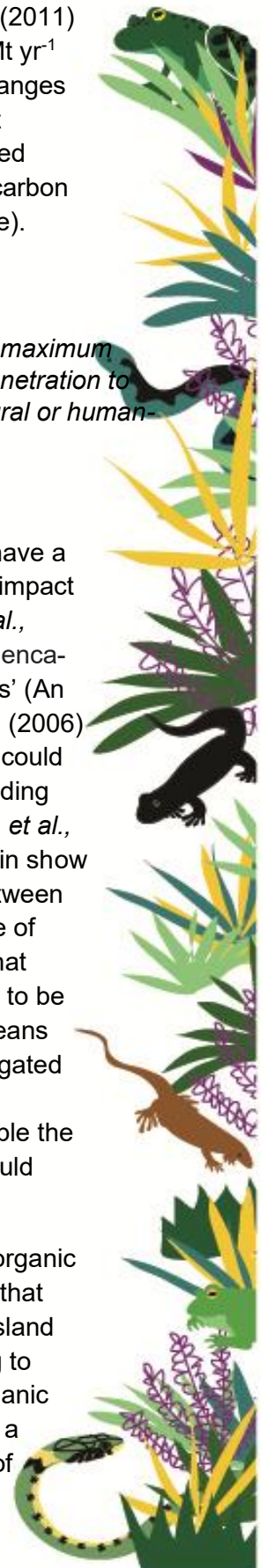
Anderson *et al.* (2020) found carbon burial rates had tripled in the last one hundred years and quadrupled in some biomes (tropical grasslands and forests). Kastowski *et al.* (2011) estimated permanent long-term carbon burial in European lake sediments of 1.25Mt yr⁻¹ and that lakes operate as minor carbon 'sinks'. Brothers *et al.* (2013) found that changes in aquatic ecosystem cycling had an influence on carbon sequestration, with a shift towards a turbid, phytoplankton dominated system resulting in the loss of submerged macrophytes and increased carbon sequestration (with approximately 80% of the carbon input permanently buried compared to 40% in a clearer macrophyte dominated lake). There is clearly a difference in the role of ponds and lakes and this study uses the 'functional' definition generated by Richardson *et al.* (2022):

"Ponds are small and shallow waterbodies with a maximum surface area of 5ha, a maximum depth of 5m, and < 30% coverage of emergent vegetation. Ponds will have light penetration to the sediments if water clarity permits and can be permanent or temporary and natural or human-made."

2) Pond carbon burial and carbon flux

Small ponds (generally with a maximum depth of 5 m and surface area of < 5 ha) have a significant impact as 'stepping stones' for flora and fauna, as buffers to reduce the impact of pollution and disease, as biodiversity reservoirs (Hassall *et al.*, 2011, Biggs *et al.*, 2017) and as nature based solutions for water management within catchments (Cuenca-Cambronero, 2023) but it appears they also have an important role as carbon 'sinks' (An environment that removes a greenhouse gas from the atmosphere). Downing *et al.* (2006) suggested that the global number of natural ponds with a surface area of 0.1–1 ha could exceed 277 million, covering a total area of 692,600 km², representing 91% of standing fresh waterbodies worldwide and 16% of their surface area. More recent work (Hill *et al.*, 2021) estimates 547 million to 3.19 billion ponds globally. Estimates for Great Britain show the importance of small ponds: Haines-Young (2000) estimated 400,000 ponds between 0.0025 ha and 5 ha area remaining in the UK, a loss of 50% from Rackham's figure of 800,000 in the late 19th century (Jeffries, 2011). Downing *et al.* (2008) estimated that small lakes and ponds bury significantly more carbon than was previously believed to be the case, suggesting farm ponds alone may bury more organic carbon than the oceans and 33% as much as the world's rivers carry into the sea. Holgerson (2024) investigated twenty-two experimental ponds where carbon sequestration came from primary production and found the ponds accumulated 67.1 gm⁻²yr⁻¹ of organic carbon, double the rate recorded for lakes. In 2014, Cereghino *et al.* estimated that a 500 m² pond could sequester 1000kg of carbon annually, as much as that generated by a car.

Jefferies *et al.* (2022) calculated that approximately 2.625 million metric tonnes of organic carbon was 'stored' in ponds in Great Britain and Downing *et al.* (2010) suggested that ponds hold more carbon than other terrestrial habitats such as woodland and grassland and bury carbon just as rapidly. Jefferies *et al.* (2022) reviewed information relating to organic carbon in pond sediments and estimated a general measure of 9.38 kg organic carbon in a 1m² x 20 cm block of surface sediment, which could be extrapolated to a figure for the UK of between 1.41 to 3.184 million tons (95% confidence intervals) of



carbon held in ponds. Gilbert *et al.* (2014) found carbon density was highest in sediments of ponds that dried out every year and the biggest density was in ponds with a diverse wetland flora. In their study ponds, 'carbon stock' was estimated at $4.18 \pm 2.12 \text{ kg m}^{-2}$ of carbon in the top 10 centimetres of settlement (Jefferies *et al.* (2022) estimated 9.38 kgm^{-2} of carbon in the top 20 cm). In Germany, Schmatz *et al.* (2025) found 33.1 kg m^{-2} TOC sequestered in a carp pond. Gilbert *et al.* (2014) found variation within individual ponds was less than between ponds and the extent of organic carbon in pond sediment varied between the four pond types in their study: naturally vegetated, arable field ponds, grass pasture field ponds, and dune slacks. The permanent, naturally vegetated ponds accumulated the highest percentage of organic carbon and were least affected by climatic variation. Gilbert *et al.* (2014), generated an annual value for sediment organic carbon and burial rates in ponds, observing a burial rate of approximately $149 \text{ g m}^{-2} \text{ yr}^{-1}$ of organic carbon which represents one of the highest rates of organic carbon (OC) burial reported across natural habitats (Taylor *et al.*, 2019). Taylor *et al.* (2019) derived separate organic carbon burial rates for small ponds and calculated an average rate of $142 \text{ g m}^{-2} \text{ yr}^{-1}$ but this varied depending on the pond's vegetation. These burial rates were 20 to 30 times higher than woodlands and grasslands and higher than those of other natural wetlands leading to a conclusion that ponds have the potential to offset carbon emissions. Hill *et al.* (2021) highlighted a lack of long-term studies on ponds and their influence on carbon and highlighted evidence that small water bodies can switch between being carbon sources and carbon sinks. Tundra ponds have been identified as net producers of carbon (Prèskienis, 2024), with CH_4 and CO_2 production varying depending on shoreline erosion; a result of recent changes to the environment based on climate change and global warming.

3) Ponds as sources of CO_2 and CH_4

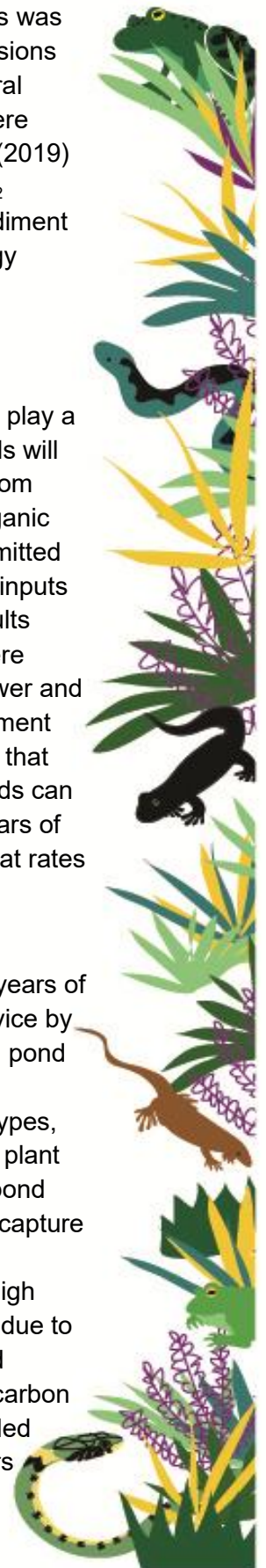
The question of methane emissions arises whenever ponds are proposed as net carbon sinks. Cambronerio *et al.* (2022) found ponds have the potential to act as both carbon sources and carbon sinks. Carbon burial rates in pond sediments were higher than other ecosystems and ponds store higher concentrations of greenhouse gas such as CH_4 and CO_2 per unit of surface than larger lakes (Cambronerio *et al.*, 2022). However, Holgerson and Raymond (2016) examined data from 427 lakes and ponds between 2.5 m^2 to 674 km^2 in surface area and found that ponds of less than 0.001 km^2 comprise only 8.6% of lakes and ponds by area but account for approximately 15% of CO_2 emissions and 40% of CH_4 emissions. They argued this was probably because of shallow waters, high sediment and edge to water volume ratios which increase CO_2 and CH_4 supersaturation in the water (Holgerson, 2015, Holgerson and Raymond, 2016). One study (Rosentreter *et al.*, 2021) undertook a metadata analysis of methane fluxes in a range of natural, impacted and human-made aquatic ecosystems. They found methane fluxes were variable within and between aquatic ecosystems and estimated that aquatic ecosystems contribute 41% (median) or 53% (mean) of total global methane emissions from anthropogenic and natural sources. Davidson *et al.* (2018) suggested a link between nutrients and global warming enhanced methane bubble release from experimental lake, with small shallow



waters identified as particular methane release hotspots. Peacock (2021) found that small artificial water bodies were sources of CO₂ and CH₄ to the atmosphere and that this was the case for ditches and ponds across different climate zones and land uses. Emissions from artificial water bodies were on average four times larger than those from natural water bodies for similar size. In Denmark, Audet *et al* (2020) found urban ponds were significant sources of GHG emissions, a finding replicated by Herrero Ortega *et al* (2019) in Germany. A further study by Ljung and Lin (2023) in Sweden estimated that CO₂ equivalent emissions from ponds were between 1.8 and 37.5 times higher than sediment accumulation of carbon and argued that using ponds as a carbon mitigation strategy should be done with caution.

Gilbert *et al* (2014) found that differences in pond types can explain variation in the deposition of organic carbon in sediments but further differences within pond types suggest that pond permanence, nutrient status, plant ecology and trophic status all play a role in carbon deposition. They argued that 'upscaling' from small numbers of ponds will not necessarily generate accurate information. Following a review of 110 studies from wetlands around the world, Villa and Banal (2017), found that carbon is held as organic matter which accumulates, and the carbon can then be dissolved or suspended, emitted as carbon dioxide or methane, or mineralized to form organic carbon. High carbon inputs can lead to a high carbon accumulation but also high gas emissions. However results from Taylor (2019) suggested the methane fluxes measured in ponds in the UK were equivalent to only 1.7% of the organic carbon burial rate. As ponds become shallower and move towards the latter stages of the successional sequence the exposure of sediment increases greenhouse gas emissions but, as they dry, ponds gain more vegetation that mitigates methane emission (Davidson *et al*, 2018). Although CO₂ flux rates in ponds can switch rapidly from 'sink' to 'source' as they dry (Gilbert *et al.* 2017), over the 20 years of their existence Gilbert *et al.* (2021) argued they are 'sinks', burying organic carbon at rates higher than other terrestrial habitats.

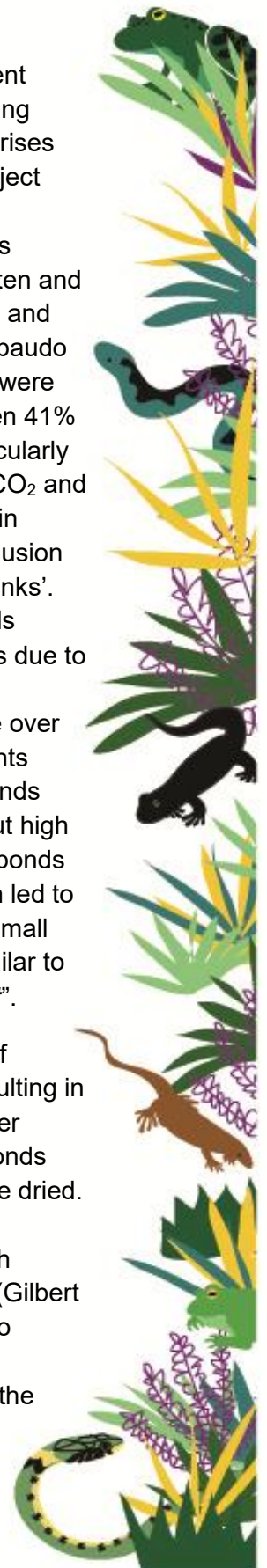
Taylor *et al.* (2019) found carbon burial rates varied over time, with young ponds sequestering carbon at a lower rate than mature ponds. Once between 19 and 25 years of age, sediment burial rates decreased but ponds provide a valuable ecosystem service by trapping sediments and elements (Rogers *et al.*, 2022). Rogers *et al.* (2022) found pond and substrate type have an important influence on the effectiveness of carbon sequestration. Organic carbon buried in substrates varies between different pond types, and also within individual ponds, linked to productivity, permanence, nutrient input, plant ecology and trophic status. Taylor *et al.*'s (2019) results show that the diversity of pond ecological communities is important when characterising differences in the carbon capture function of different ponds. Gilbert *et al.* (2021) argued high carbon burial can be attributed to high nutrient concentrations driving primary productivity, comparably high levels of soil particulate transfer from adjacent land, and high rates of preservation due to nearly continuous sediment anoxia. Their study of forty ponds in northeast England compared ponds with differing land use, vegetation, and drying regime. Sediment carbon varied between ponds and pond types but estimates of pond organic carbon provided measures higher than from soils in temperate grassland and woodland. The authors



identified that pond creation would be a useful and practical application to boost carbon sequestration (Gilbert *et al.*, 2021).

In the UK, unreliable summer rainfall (Fowler & Kilsby, 2002) often results in frequent drying and wetting over short periods of time, with annual rainfall variations disrupting measurement and modelling of pond ecosystem processes. A further uncertainty arises from acute rainfall or temperature changes linked to climate variability, that will subject ponds and their wildlife, to a level of unpredictability that could alter rates of sedimentation, carbon capture, GHG emissions and ultimately species' distributions (Jeffries, 2011). Further unpredictability seems to be linked to vegetation, with Kosten and Bodmer (2024) highlighting that CH₄ production by aquatic plants can be extensive and variable and that it should always be measured rather than using a proxy value. Ribaudo *et al.* (2024) also found that the presence of floating plants and hypoxic conditions were strongly linked to methane emissions. Rosentreter *et al.* (2021) argued that between 41% and 53% of methane emitted to the atmosphere comes from aquatic systems particularly eutrophic freshwater systems. Ray and Holgerson (2023) found higher release of CO₂ and CH₄ from temperate ponds during warm summer months and that CH₄ was the main component of gas emissions from ponds over an annual cycle, leading to the conclusion that the ponds in their study were net 'sources' of greenhouse gases rather than 'sinks'. Emissions varied on a weekly basis and were linked to 'mixing', with stratified ponds releasing higher levels of methane. Ray and Holgerson (2023) speculated this was due to lower levels of oxygen near sediments where micro-organisms tolerant of hypoxic conditions generate methane. Ponds show large variability in CO₂ and CH₄ release over space and time linked to physical features (mixing and depth) and dissolved nutrients (Ray *et al.* 2023). Ray and Holgerson (2023) considered temperate constructed ponds and found that they were a net source of greenhouse gases because of variable but high CH₄ emissions linked to stratification. Rabaey & Cotner (2024) found their studied ponds ranged from sinks to sources of CO₂ and were sources of CH₄ but that stratification led to greater annual fluxes than ponds with mixing. More extensive recent work on two small ponds (Holgerson *et al.* 2026) suggests that the annual release of C gases was similar to OC sediment burial and that '*some ponds may trap and bury more C than they emit*'.

Drying and sediment desiccation during periods of low rainfall impact the stability of carbon in sediment. Conditions can rapidly change from anoxic to oxygenated, resulting in aerobic microbial activity on the substrate surface, increasing rates of organic matter mineralization and CO₂ efflux (Fromin *et al.*, 2010). Raymond *et al.* (2013) found ponds acting as CO₂ sinks at the start of their study became net sources of CO₂ as the site dried. Gilbert *et al.* (2021) found that as poorly vegetated ponds become shallower, the exposure of sediment increases, promoting GHG emissions. In contrast, ponds with denser vegetation cover were found to emit smaller amounts of CO₂ as they dried (Gilbert *et al.* 2021). Sjø *et al.* (2024) found higher fluxes of methane in summer compared to winter, and that diel variation linked with mixing and stratification processes. They estimated likely carbon storage and argued carbon retention will 'markedly reduce the warming potential' of a new pond.



4) Other greenhouse gases (N₂O)

Emissions of N₂O from ponds are less well studied; however, Soued et al. (2016) suggested that pond emissions were negligible when compared to those from lakes (95%) and rivers (<5%), and equivalent to a maximum of 0.8 g m⁻² yr⁻¹ carbon. Mander et al. (2014) found that constructed wetlands can remove nitrogen providing the conditions are anaerobic and there is enough carbon in the system. Sovik et al. (2006) suggested that although constructed wetlands are increasing globally, they have a small area and may only represent a 'minor source' of N₂O and CH₄. Webb (2019) argued that while lake measurements are well researched, 67% of small artificial waterbodies, such as farm reservoirs, are acting as N₂O sinks. Webb's findings question assumptions that nitrogen-enriched and eutrophic surface waters within agricultural landscapes are strong sources of N₂O.

5) Beaver ponds

Beaver ponds, an increasing component of wild environments in the UK, have been reputed to be carbon sources because of high CO₂ and CH₄ release documented from shallow peatland ponds in North America (Roulet *et al.* 1997, Lazar *et al.*, 2014). He *et al.* (2023) established that, in peatland in Northern Canada, when American beaver pond water levels drop to 1.7 metres below the peat surface the pond switches from a carbon sink to a source. Gatti *et al.* (2018) examined carbon emissions from wetlands created by Eurasian beavers and found beaver ponds showed an increase in the aqueous concentration of methane and an increased accumulation of carbon into the sediment. Gatti *et al.* (2018) found:

- CO₂ dissolved in 'normal' streams is about a third of that in beaver ponds;
- dissolved organic carbon in beaver ponds is two times greater than in 'normal' streams;
- dissolved CH₄ in beaver ponds is twenty times greater than in 'normal' streams;
- carbon concentration of the sediments in beaver ponds is almost twice that in 'normal' streams;
- shoreline biomass along beaver ponds is four times greater than in 'normal' streams.

Beaver ponds with fine and deep sediment have also been found to increase storage of sediment nitrogen and increase denitrification (Murray, 2023). Puttock *et al.* (2018) investigated 13 beaver ponds at an enclosed site in south west England and found they held a total of 101.53 ± 16.24 t of sediment, equating to 71.40 ± 39.65 kg m⁻². The ponds also held 15.90 ± 2.50 t of carbon and 0.91 ± 0.15 t of nitrogen within the sediment suggesting beaver ponds help to mitigate soil erosion and diffuse pollution from agriculture as well as being probable net carbon sinks.



6) Constructed ponds

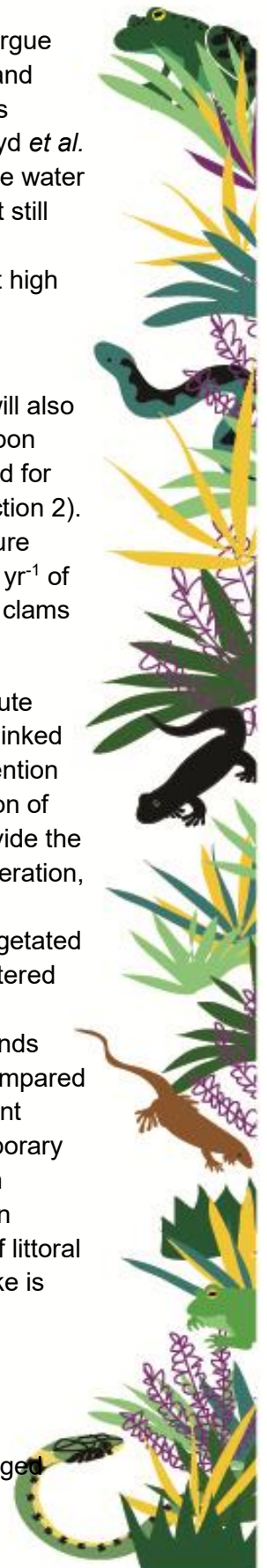
Mitsch *et al.*, 2013 studied carbon fluxes from existing constructed wetlands and argue that when balanced over time, carbon sequestration exceeds methane emissions and they can also be net 'sinks'. Aquaculture ponds may contribute to carbon emissions through management inputs to produce aquatic animals (Boyd *et al.* 2007) and Boyd *et al.* (2010) found that aquaculture ponds buried carbon at a lesser rate (70%) than large water bodies and agricultural water bodies because of a low input of external material but still acted as 'sinks'. As mentioned above, Ray and Holgerson (2023) found temperate constructed ponds were a net source of greenhouse gases because of variable but high CH₄ emissions linked to stratification.

Verdegem and Bosma, (2009) estimated figures of 8,750,000 ha freshwater and 2,333,000 ha brackish water aquaculture ponds worldwide so aquaculture ponds will also have a role in carbon sequestration. Annikuttan *et al.* (2016) found an average carbon burial rate of 1.02 Mg ha⁻¹yr⁻¹ (equivalent to 10.2g m⁻²yr⁻¹), higher than that reported for large lakes, small lakes, and inland seas, but lower than reports for ponds (see section 2). Boyd *et al.* (2010) estimated organic carbon concentration in sediment of aquaculture ponds ranged from 1.08% to 7.01% and that they sequester an estimated 16.6 MT yr⁻¹ of carbon globally. Lin *et al.* (2026) found that while aquaculture ponds in Taiwan with clams were carbon sources, ponds without clams acted as carbon sinks.

Stormwater management also has an important role in minimising the impact of acute climate events (Kavehei *et al.*, 2018). They considered urban design technologies linked to stormwater retention in Australia, investigating green roofs, rain gardens, bioretention basins, vegetated swales, and stormwater ponds through their 'life cycle': production of material, construction, operation and 'end of life'. Rain gardens were shown to provide the highest carbon sequestration, offsetting the carbon footprint of construction and operation, while retention basins offset 70%, green roofs 68%, vegetated swales 45%, and stormwater ponds only 8% of their carbon footprint. Moore & Hunt (2012) found vegetated shallow water areas of constructed stormwater wetlands in North Carolina, sequestered carbon at a rate of 84.4 g m⁻² yr⁻¹. Moore & Hunt (2012) highlighted that emergent vegetation is important for carbon accumulation in both natural and constructed ponds and stormwater wetlands, which supported higher rates of carbon accumulation compared to ponds. Merriman *et al.* (2017) studied storm water retention ponds in four different climates and found carbon accumulation occurred in shallow water areas and temporary inundation zones in temperate climate ponds but took place in all areas of ponds in tropical climates. They concluded vegetative production had a stronger influence on carbon accumulation rates than vegetation decomposition and the establishment of littoral zones and littoral shelves that enable vegetation growth and increase carbon uptake is important in the design of ponds (Merriman *et al.*, 2017).

7) Conclusion

Small ponds have a significant role in the conservation of biodiversity and flood management and act as reservoirs of food material for birds and bats. When managed



correctly they are vital components in the conservation of amphibians and reptile metapopulations as well as other wildlife and plant species (Lewis-Phillips 2019 & 2020). Taylor *et al.* (2019) argued that late succession, drying or newly dry ponds are often considered as species-poor, and as such are often targeted for restoration to enhance biodiversity but proposed a more effective strategy; to build new ponds near to existing pond sites, retaining the older late succession habitats. This strategy, creating 'pond clusters', part of a 'pondscape' would both support greater biodiversity (Williams *et al.*, 2010) and increase the potential for carbon burial. The construction of pond networks or 'pondscapes' are important for amphibians which move between ponds and may breed in, and recruit from, different ponds during different environmental conditions. The evidence reviewed in this briefing indicates there remains some debate about the role of small ponds which may operate as carbon sinks or sources depending on successional stage, plant and algal growth and stratification (Raymond *et al.*, 2013; Villa & Banal, 2017; Gilbert *et al.*, 2017; Taylor *et al.*, 2019; Cambronero *et al.* 2022, Holgerson & Raymond, 2016) and detailed long-term studies of pond carbon burial and emissions over their successional cycle will resolve these successional changes.

Using the figure of 500,000 ponds lost in the last 100 years (Wildlife Trusts, 2024), and the value of storage estimated by Jefferies *et al.* (2023) of 9.38 kg m⁻², the ratios of existing pond sizes generated by Jefferies *et al.* (2023) lead to an estimated amount of 2.73 million tonnes of additional carbon per year that could be sequestered had those 500,000 ponds been retained. Though these ponds will act as sinks and sources because of variation in GHG emissions, this figure for carbon sequestration supports the case for pond restoration and creation within a national 'pondscape' that will enhance biodiversity and flood management as well as having an influence on carbon sequestration. Batrons (2024) reviewed one hundred examples of ponds proposed as nature based solution (NBS) and found the emphasis was on creation of habitats for biodiversity, learning and inspiration, regulation of water quality and physical and psychological experiences rather than as measures to reduce greenhouse gas emissions or act as carbon sinks.

Many authors (Gatti *et al.*, 2018 (beaver ponds); Annikuttan *et al.*, 2016; Boyd *et al.*, 2010 (aquaculture ponds) suggest that constructed ponds have a positive response to carbon influenced climate change. Ponds have an emissions (source) impact in terms of the release of GHG (Holgerson and Raymond, 2016; Davidson *et al.*, 2018; Peacock, 2021; Rosentreter *et al.*, 2021) and water bodies in urban green spaces have been considered to be 'emission hotspots' (Herrero Ortega *et al.* 2019,). Others argue that the role of small ponds in carbon burial and storage is greater than the impact of emissions (Taylor *et al.*, 2019; Gilbert *et al.*, 2021; Rogers *et al.*, 2022; Jefferies *et al.*, 2023) and that overall natural ponds can be considered as carbon 'sinks'. The value of ponds as carbon sinks, especially if longer term sequestration of CO₂ outweighs methane emissions (Mitsch *et al.*, 2013) leads to arguments for pond creation as mitigation against global warming. Hamback *et al.* (2023) argue that the wetland CO₂ sink 'wins out' against the wetland methane 'source' argument with a net reducing effect on global warming. Recent research by Ljung and Lin (2023), Ray and Holgerson (2023) and (Ray *et al.* 2023) urge caution when it comes to arguing ponds can be considered a 'general' carbon sink



because of the wide variation in measurements and the use of estimates as proxies for actual measures of CO₂ and CH₄ release but a detailed study of two small ponds in the USA (Holgerson et al 2026) found carbon emissions were similar to sequestration and suggest that some ponds act as sinks rather than sources. Pilla *et al* (2020) argue for more research focusing on:

'(1) before-and-after measurements of C fluxes associated with climate change events and landscape changes, (2) quantification of C input from land, (3) improved assessment of spatial coverage and contributions of small inland waterbodies to C fluxes, and (4) integration of dried and drawdown areas to global C flux estimates.'

Future research will determine whether pond creation to improve biodiversity and resolve water storage issues may also be a practical and beneficial strategy for managing climate change.

Acknowledgments

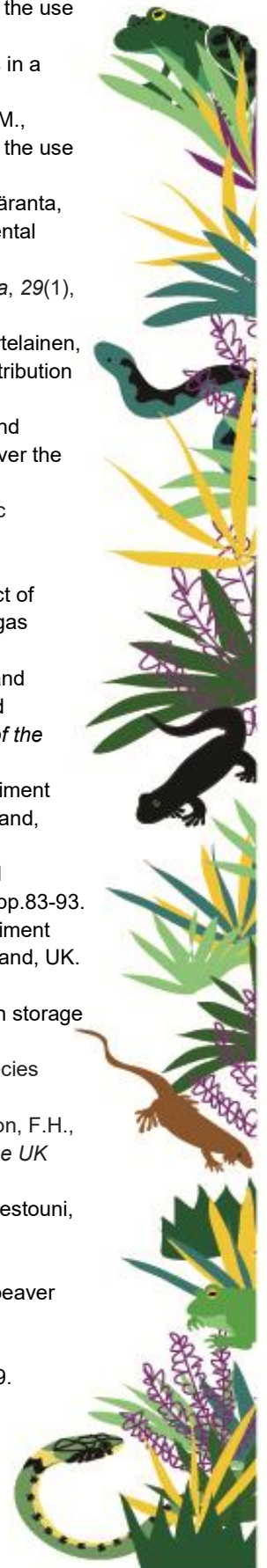
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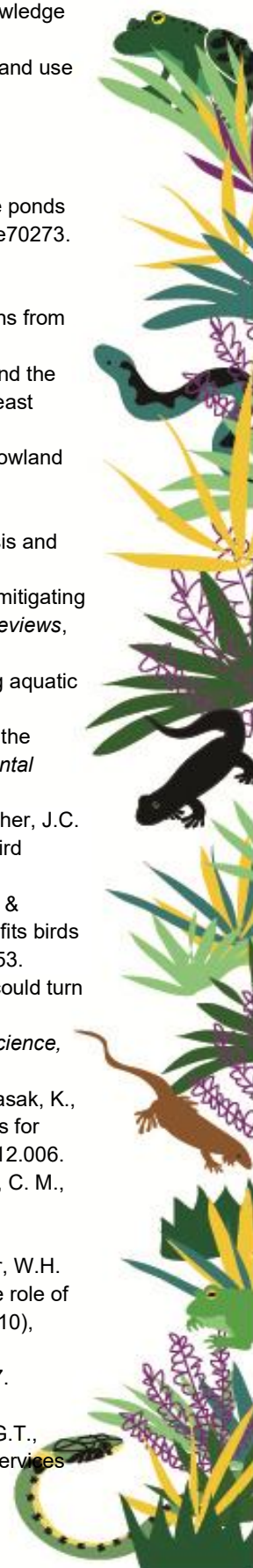
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