Bringing lost ponds back to life: the art of ghost pond resurrection

Carl Sayer, Helene Burningham, Emily Alderton, Jan Axmacher, Peter Robinson, Helen Greaves and Andrew Hind

A 'ghost pond' is the site of a former pond that was deliberately filled in as land was repurposed for farming or other uses. In Britain, as in many parts of the world, infilling of both natural and human-made ponds has occurred at a rapid rate over the last century. It is likely that well over half of British ponds recorded in the late 19th century are no longer present (Rackham 1986; Wood *et al.* 2003) and sadly, especially in intensively farmed parts of the countryside, areas once speckled with life-giving ponds are now largely waterless, with a particularly rapid phase of destruction occurring during the postwar period. But are these lost ponds truly lost? Remarkably, we have found that seeds of wetland plants and stonewort oospores recovered from the sediments of ghost ponds are still viable, and can grow new plants, even after burial beneath intensively farmed fields for over 150 years (Alderton *et al.* 2017). Life persists under our fields and feet, ready to rise up again.

The presence of a viable seedbank fuels rapid wetland plant colonisation of restored ghost ponds and, similar to patterns observed following the restoration and management of existing, heavily overgrown ponds (Sayer *et al.* 2022), an extremely diverse and structurally complex flora can return within only a couple of years – sometimes including very rare species. In one ghost pond restored by the Norfolk Ponds Project (www.norfolkponds.org) on the Norfolk–Suffolk border, the formerly extinct Slimy-fruited Stonewort *Nitella capillaris* appeared just one year after it was rediscovered in Britain in a Suffolk pond (Hawkins 2019), having last been seen in the UK in 1959. Additionally, the Red Data Book species Tassel Stonewort *Tolypella intricata* was also found in this pond. Thus, a piece of cropped field can quickly be turned into a priority pond as dormant species of the old landscape are stirred by the return of water, light and warmth.

In this article, we outline the practicalities of a new and hugely promising approach in pond conservation: the restoration, or resurrection, of ghost ponds. We focus on farmland ghosts, but the principles outlined are broadly applicable to other settings as well.

Finding ghost ponds

Old maps are undoubtedly the best place to start when searching for ghost ponds. A review of different map editions back through time can immediately reveal the steady – and sometimes quite sudden – loss of ponds from the countryside. Online mapping resources are readily available, providing access to old maps and charts, and aerial photographs. The National Library of Scotland (https://maps.nls.uk), for example, includes large-scale (1:5,000 to 1:25,000) Ordnance Survey (OS) maps from the late 19th century through to the mid-20th century. OS mapping offers a robust basis for the interpretation of pond features in the landscape. Where available, however, enclosure (~1810) and tithe maps (~1840) are also useful for locating lost ponds. Despite their age, these older maps are often accurate in terms of locational information, but will not necessarily include pond features (i.e. absence of a pond does not mean that no pond was present) and so careful use and interpretation is required.

Aerial photographs (in some regions going back to the 1940s) are a useful complementary resource for uncovering ghost ponds. This imagery can capture features missed by OS mapping, which sometimes occurs where trees have encroached around ponds. The context provided by historical maps and/or aerial photography permits a chronological understanding of pond presence/absence, and more recent LiDAR (light detection and ranging) data can offer additional confidence in the identification of ghost ponds.

An illustration of pond loss from an area of mid-Norfolk, showing number of ponds present in the 1880s (top), in 1946 (middle) and in 2017 (bottom). Ghost ponds in 1946 and 2017 are marked as red empty polygons.

Map and/or photographic evidence is essential for accurately identifying ghost ponds, as not all




Ghost pond apparitions in the landscape taking the form of field puddles (top left), darker patches in the plough soil (top right), crop marks (bottom left) and areas in grasslands where the vegetation markedly differs from the norm (bottom right). Carl Sayer

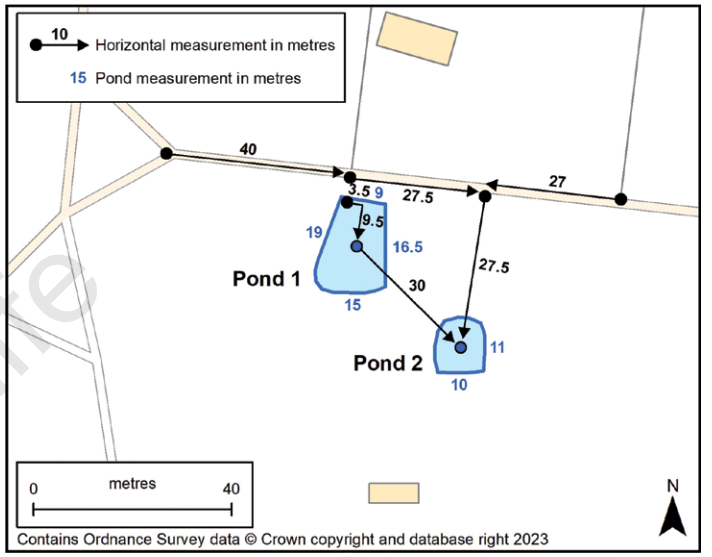
depressions or hollows in agricultural fields turn out to be lost bodies of water: collapsed field drains, small-scale quarries and natural hollows, for instance, can all take the form of pond apparitions and may falsely raise the hairs on the back of a ghost hunter's neck when in the field.

Having located a ghost pond through a mapping investigation, the next stage is to try and pinpoint it on the ground. In arable landscapes, ghost ponds are often visible as damp hollows or as winter puddles, especially following periods of heavy rain. Equally, ghost ponds can appear as darker patches of winter soil, or in spring and summer as crop marks (paler or darker areas) due to differing soil properties. In meadows, different grass species and sometimes disturbance indicators such as Stinging Nettle *Urtica dioica* can also mark the location of a former pond.

Where field evidence of a ghost pond is lacking, orientation relative to mapped landscape features (e.g. farm buildings, field boundaries, roads) can help to establish its location. Increased confidence can also be afforded by using Geographical Information System (GIS) software to view georeferenced historical maps and imagery alongside modern maps, aerial photographs and LiDAR data. In places where geospatial resources are limited, ground surveys employing differential

Global Positioning Systems (dGPS) or unpiloted aerial systems (UAS) can be useful in detecting subtle changes in elevation that might reveal the location of a ghost pond.

In all cases, it is important to recognise that ground features which might imply a former pond location may not exactly match those defined on historical maps. Where there is a clear mismatch between surface topography and mapped pond location, this could be due to inaccuracies in historical mapping or changes in surface topography since pond burial. For example, if a pond was filled in by scraping topsoil from the immediate surroundings into the pond, this would alter the size and shape of the depression around the original basin, and potentially laterally shift the centre of that depression. Activities such as ploughing could further change the shape of the depression. In the case of uncertainties, soil augering (the digging of vertical test pits) can be carried out to examine the soil profile of a suspected ghost pond in order to help confirm its location. A clear soil-profile boundary can usually be seen between infill material (often a heterogeneous mix of soil, subsoil, farm waste/rubble and woody debris) and the underlying, characteristic darker silt of a former pond. If you find the old pond sediment then you have found the pond.



Locating the centres of two neighbouring north Norfolk ghost ponds as marked on a tithe map based on a surviving minor road junction and field boundaries. The ghost ponds have been georeferenced into the Ordnance Survey (OS) National Grid. Horizontal distances are measured from current OS map features.

There will be many ponds that were dug and then filled in well before they could have been captured by mapping. Where such sites are suspected, small-scale soil stratigraphy investigations are essential. It is exciting to think that, hiding out in the fields, wetland plants that once grew in and around currently lost medieval, Anglo-Saxon, Roman and maybe even older ponds and wetlands could potentially be resurrected. More research is urgently required on the longevity of seed viability in ancient deposits, however.

Finally, local knowledge is invaluable to the ghost hunter. Many older landowners and farm workers will remember lost ponds, and may even have helped with the filling-in process. Information from locals can also inform on whether a pond was filled in with anything of concern, such as farm or household waste. Unfortunately, these waste-filled ghosts may be better left to lie.

Excavating a ghost pond

Ghost ponds should ideally be resurrected between August and October (but potentially the work can be undertaken earlier during a drought period), when the water table is low. This makes it easier to work with heavy machinery, and to inspect soil profiles without water flooding into the excavation. To avoid conflicts with farm work, pond resurrection should ideally be completed post-harvest, or during fallow field years. It is important to stay faithful to a ghost pond's history, and to excavate it, as far as possible, to its original dimensions, slope and shape.

The ideal kit for excavating a ghost pond is a 14-tonne 360° tracked excavator. For most small ghost ponds, at least two days of work should be budgeted for. Sometimes a small ghost pond can be successfully resurrected in a single day, but complications often arise, and enough time

Top A ghost pond resurrection, showing the first trench dug through the estimated centre revealing the darker historical sediment layer. Bottom left Two perpendicular trenches forming a cross. Bottom right A close-up of buried pond sediment showing freshwater mollusc and bivalve remains, as well as a pressed tree (likely *Salix* sp.) leaf. Carl Sayer

should be allowed to ensure a careful excavation. At least one person should be on the ground if possible, supervising the excavation. From the height of a digger cab, it is easy to miss key soil-profile features or changes in substrate.

Before beginning the excavation, it is important to mark where you think the centre of the ghost pond is based on a combination of mapping and field evidence. Next, it is a good idea to dig a small trench close to (but outside of) the suspected ghost pond site, so that the natural soil profile (especially clay depth) can be determined. This is helpful for understanding what you are seeing in the ghost pond excavation itself and can immediately tell you (if clay does not appear where it should) whether you are working in an in-filled pit.

To commence the excavation, dig a trench across the estimated centre of the ghost pond. Start to remove the soil gradually, until you encounter the distinctive darker layer of the buried pond. These sediments are easily recognised (compared to the overlying infill) by being very fine to the touch, such that, when you run the soil between your fingers, you can feel little or no mineral material. Other sure signs of old pond sediments include preserved freshwater snail and bivalve remains and pressed plant matter, especially leaves from terrestrial and aquatic plants.

The search for the historical pond layer often leads to much questioning of what you are doing. Are we in the right place? Have we gone deep enough? Did the pond even have any sediments? These are all common queries and points of discussion as you stare into the trench. A key lesson from much work undertaken by the Norfolk Ponds Project is not to rush – excavating a ghost invariably takes longer than creating a new pond. Dig slowly and carefully and observe the sediments that you are exposing at regular intervals. Sometimes the presence of certain objects and materials can indicate that you are still digging through the infill layer: common dumped items include broken bits of field drain, rubble, bailer twine, old bottles, tree stumps and often burnt woody material. This 'trash' layer can sometimes be deep (even 2–3m). At this point you need to be bold and keep on digging down. Many ghost ponds were probably infilled in stages, sometimes decades apart, so it is important to be wary of false pond beds, which take the form of a very thin layer of old sediment. Again, if in doubt keep on digging. Once you are sure that you have found the original pond sediment, the true bottom, continue a localised dig through it to gauge its depth, but do keep this material in a separate spoil heap. This layer can sometimes be more than 1m thick for the centre of old human-made farm ponds. The next stage is to dig a second trench, perpendicular to the first (forming a cross). Again, this should be extended outwards until the pond's former dimensions are revealed.

Top A completed excavation with much old seed-rich pond sediment (darker colour) exposed at the surface. Bottom A farmland ghost pond 11 months following resurrection showing much development of in-pond aquatic vegetation. Carl Sayer

Once the historical pond profile has been roughly established, digging can speed up. Working outwards from the trenches, the former pond can be re-excavated, following the old sediment profile as closely as possible. Any field drains found in or near the ghost pond should be removed or broken during the excavation process. This will ensure that water entering the pond does not come from arable field drainage (leading to nutrient enrichment), while also ensuring that the pond does not quickly drain away. Once digging is complete, return any removed pond sediment back into the excavation. Placing this around the edges and in areas where there is no exposed historical pond sediment is best. Aim to have the historic pond sediment exposed over as large an area as possible.

Disposing of spoil and pond buffers

In disposing of the spoil it is important that it is not placed in adjacent wet areas, or on top of any areas of archaeological or ecological importance such as agri-environment margins or wildflower-rich patches.

A resurrected ghost pond, if located in arable land, needs to be well buffered from farming activities and agro-chemical applications. A buffer zone of at least 10m width (and ideally wider) should therefore be installed around the pond. If a ghost pond is located within grazed land, it needs to be protected from livestock disturbance by good fencing – at least for the first few years. These aspects of ghost pond resurrection must be considered and agreed with the landowner from the outset.

Ghost pond colonisation and management

Newly excavated ghost ponds should be allowed to fill naturally with water through the winter, and both the pond and the disturbed land around it should be left to natural vegetation colonisation. Plants will appear quickly from exposed and still viable seeds and oospores, and in a warm winter stoneworts can sometimes emerge shortly after the excavation fills and are typically present by spring. After one year, while the pond edges and pond–field margin may be a little bare, the open waters of the resurrected pond will typically be full of different aquatic plants, especially stoneworts, pondweeds (Potamogetonaceae) and water-crowfoots (*Ranunculus* sect. *batrachium*). A few years on and it will not be possible to tell that any work was undertaken; the pond's ghostly past will be all but forgotten.

After several years, scrub can colonise the margins of a resurrected ghost pond, and to prevent it from becoming heavily terrestrialised, light scrub management, involving a few hours of coppicing trees and bushes, especially on the south and west sides of the pond, may be necessary. If the pond becomes heavily invaded by 'thuggish' plants like Greater Reedmace/Bulrush *Typha latifolia*, these can be reduced in area by using a digger. Another good way of managing the margins around a ghost pond is via low-level periodic conservation grazing. This both reduces the growth of trees and creates variation in pond-edge habitat.

Significance of ghost ponds

In recent decades there has rightly been a strong emphasis on pond creation to try and counteract major losses of British ponds (Williams *et al.* 2010). In combination with pond creation, we also stress the urgent need for restoration of existing degraded ponds (Sayer & Greaves, 2020) and the resurrection of ghost ponds (Alderton *et al.* 2017; Sayer *et al.* 2022). While successful pond creation relies on the dispersal of wetland plants through highly fragmented and degraded settings, ghost pond resurrection bypasses this problem owing to the historical seedbank. It equates to the opening of a time capsule, giving locally scarce or even presumed extinct wetland species a way back into the landscape. Finally, ghost ponds typically occupy patches of ground that are marginal for farming, and so bringing them back to life should result in minimal financial loss. Ghost pond resurrection could play a significant role in reversing some of the dramatic habitat and biodiversity losses caused by the disappearance of agricultural wetlands and so we urge conservationists to incorporate ghost pond restoration into evolving conservation strategies and agri-environment policy.

A ghost pond five years after resurrection showing major development of marginal vegetation. Carl Sayer

Acknowledgements

We thank all members of the Norfolk Ponds Project and many landowners for facilitating this work as well as Dominic Arnold ('Dom the Dig'), surely the best digger driver in Norfolk. Miles Irving is greatly thanked for assistance with the figures.

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Carl Sayer (e-mail: **c.sayer@ucl.ac.uk**) is a Professor in the Department of Geography at University College London (UCL) where he heads the Pond Restoration Research Group (PRRG). He is a co-founder and Director of the Norfolk Ponds Project (NPP). **Helene Burningham** and **Jan Axmacher** are Professors in Geography at UCL and members of the PRRG. **Emily Alderton** is a former PhD student in the PRRG and a self-employed ecologist. **Pete Robinson** is a GIS specialist, botanist and regular NPP volunteer. **Helen Greaves** works as a Research Assistant in the UCL PRRG and is a co-founder and Director of the NPP for which she is Strategic Lead. **Andrew Hind** is a Director of the NPP and a key part of the NPP pond restoration delivery team.