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# Restoring Ghost Pingos

## What are pingos?

There are many old ponds scattered throughout the East Anglia landscape; most were made by humans. However in the Breckland and Fen edge there are some truly ancient ponds and depressions which originated at the end of the last Ice Age, over 10,000 years ago. These pond features likely formed in two ways: (1) former frost mounds, often called pingos, and (2) solution hollows, known as dolines. They are often found in areas where chalk bedrock lies close to the surface.

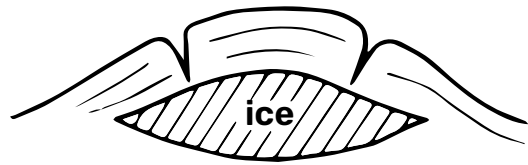
10,000 years ago, the landscape was a periglacial one (i.e. close to but not covered by an ice sheet). Ground water froze into swollen pockets of ice in the winter and then melted in summer, in a cyclical process, that gradually formed an enlarged hollow at the ground surface. As the climate warmed, the ice melted permanently, leaving a wet depression – a pingo. Pingos almost always occur in low-lying areas such as valley floors, and can readily be seen in maps, aerial photos, and elevation data.





## Development of a pingo depression

1



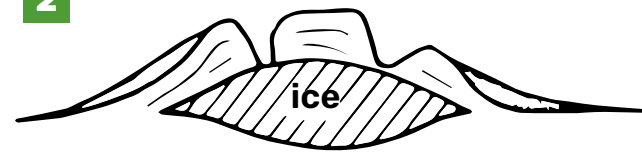
Ice lens within frozen ground

3



Melting ice in ramparted depression

2



Soil slumping off mound as ice lens develops



Pond

Pingos usually exist in dense clusters and often have raised edges known as ramparts. You can see good examples at Thompson Common, Norfolk where there is a pingo trail allowing visitor access. Pingos lost to de-watering and ploughing can also be seen emerging from wasting peat in the Fen edge region where they appear as blotches in the plough-soil.

Dolines can have a similar appearance in the landscape but were formed when underground cavities within chalk bedrock collapsed, causing a circular or oval-shaped pit to appear at the ground surface. Dolines mostly occur in plateau areas of the Breckland where they are far more solitary or loosely scattered than pingos. They are not as easy to identify, though some have been mapped by the British Geological Survey. Although technically incorrect, the term pingo is used to describe all of the ponds in East Anglia which formed in Ice-Age depressions.

Below: A doline depression near Peddars Way, Sturston, Norfolk; Right: A Thompson Common pingo pond



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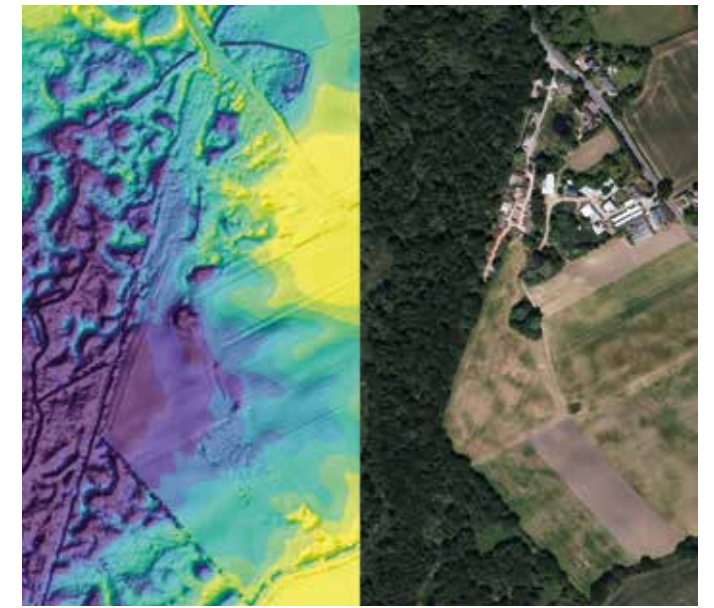
## Pingos and biodiversity

The pingo ponds of the East Anglian Breckland are among the best for wildlife found in Britain. As well as being visually stunning, Brecks pingos are exceptionally rich in plant and animal species. Many ponds contain abundant stands of water violet and sometimes the beautiful bladderwort. They harbour several rare species including Ice Age relict water beetle species found nowhere else in Britain, the scarce pond mud snail, and a host of threatened plants, including fen pondweed, tubular water-dropwort, fibrous tussock-sedge, and the delicate fringed heartwort, an aquatic liverwort. Pingo biodiversity can be threatened by pollution from surrounding farmland and a lack of appropriate management which can result in heavy tree-shading and consequently the elimination of wetland plants and the insect life depending on them.

The rare fen pondweed



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Above: Satellite image and aerial photos of ghost pingo

© Helene Birmingham

## How to locate a ghost pingo?

Ghost pingos can be identified via a variety of means. Some infilled pingo ponds will have been mapped and can be relatively easily located by comparing recent and historic maps. The webpages of the National Library of Scotland provide a great means of finding ghost ponds from old Ordnance Survey maps: [maps.nls.uk/os](https://maps.nls.uk/os)

Many pingo ponds had already been modified before the first maps were produced meaning that there is often no record of their presence. However, the presence of pond sediments beneath the ground surface will often create subtle differences in the vegetation above allowing ghost pingos to be found. Careful interpretation of satellite imagery, high resolution aerial photography and elevation data underpin geoscience detective work aimed at finding ghost pingos in the landscape. Additionally, local knowledge is valuable when it comes to locating ghost pingos and it is a good idea to talk to older farm workers/managers who may remember pond in-filling in the past.

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## Why should we restore ghost pingos?

Over recent centuries, agricultural practices have modified the landscape to remove depressions and drain wetted areas. Many Brecks Ice Age depressions have been ploughed, scraped, infilled and drained, leaving behind, what we generically call, "ghost pingos". Research by University College London (UCL) and the Norfolk Ponds Project shows that former pond muds that lie buried in agricultural fields contain viable seeds and spores (so-called seedbanks) of many wetland plant species that previously thrived in ghost ponds, some of which are locally or nationally rare. Remarkably, it has been shown that these seedbanks can preserve seeds in a living state for hundreds of years. Ghost pingo project studies of 15 lost pingos restored on land adjoining the Norfolk Wildlife Trust Thompson Common Site of Special Scientific Interest (SSSI) has revealed an astonishingly rapid colonisation of wetland plants and amphibians. The resurrected pingo ponds are now home to great crested newt, grass snake, common toad, common frog, smooth newt, nine-spined stickleback, and a rich variety of native water plants that are uncommon or even absent from the SSSI. Ghost pingos, once returned to the land of the living, can be an important asset for wetland restoration and biodiversity enhancement at the whole-landscape scale.

Ghost pingos require sensitive handling when it comes to restoration. They often contain layers of sediment dating back over 10,000 years, which include fossils that tell the story of local environmental change. They may also contain archaeological remains, since ponds and hollows were attractive places for our prehistoric ancestors to set up camp.

Ghost Pingo Project researchers can advise on whether or not you are likely to have ghost pingos on your land. They will consider a range of factors including geology, topography, hydrology, and soil type. They can also advise and assist with the excavation of ghost pingos to help maximise biodiversity gains and safeguard geological and archaeological interest – contact details are provided at the end of this guidance.

*Right: During and less than two years after ghost pingo restoration; Excavating a prehistoric burnt mound*

## The importance of ghost pingo resurrection

Pingo ponds are perhaps the most important and biodiverse pond type in Britain and there are huge advantages to restoring lost pingos within, and around, existing protected wetland areas. By making high quality pingo areas larger, many declining species may be able to build up stronger local populations. Ghost pingo resurrection does not take long, but biodiversity responses are fast. We urge landowners and conservation bodies to include ghost pingo resurrection in their future plans. The ghost pingos project team will always be keen to assist.



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## How to restore a ghost pingo

### Finding a ghost pingo on the ground

Having identified potential ghost pingo features from maps and other geospatial evidence, it is important to explore the site itself on the ground. In grassland environments, a ghost pingo is often evident as a slight depression and/or as a wetter patch where the grass is greener, with this especially the case in late summer as the wider vegetation yellows. In winter a grassland ghost pingo may often be demarcated by an area of surface water flooding or waterlogging. In arable land ghost pingos may also show up as puddles in winter or as darker patches of soil; in spring and summer they may appear as crop marks where part of a crop has matured earlier (or later). When the location of a ghost pingo remains unclear, hand augering can help to reveal its location, especially where pond deposits, which are notably different to the overlying soil and infill, are found (see below).

### Excavating a ghost pond

Ghost pingos should ideally be resurrected between August-October 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. The ideal kit for excavating a ghost pingo is a 14 tonne 360° tracked excavator. For most small features, 1-2 days of work per pingo should be budgeted for, but for larger ghost pingos more time may be required. The excavation requires gradual removal of layers of soil, and should be supervised on the ground as it is very easy to miss key soil profile features from the height of a digger cab, leading to mistakes. **There is only one chance to get it right**, so take your time and ideally seek expert advice from the start of your project.



*Signature of a ghost pingo in late summer grassland*



*Signature of a ghost pingo in a barley crop*

Prior to digging it is a good idea to mark where you think the centre of the ghost pingo was using a flag. Sometimes it is also useful to dig a trench well away from the suspected ghost pingo site to determine the approximate vertical position of natural subsoil layers, relative to the land surface. This information can help with understanding what you are seeing in the main excavation and can tell you (for example if a certain subsoil layer does not appear where it should) that you are working in the right place within an in-filled ghost pingo depression.



**1** To start the ghost pingo excavation, dig a trench across the estimated centre of the ghost pond



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**2** Start to remove the soil gradually, grading down with the untoothed lip of the digger bucket, layer by layer, until you find the distinctive darker sediment layer of the buried pond.



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**3** Old pond sediments may be highly organic and sometimes peaty and are very fine to the touch, compared with typically coarse and gritty overlying infill materials; when you run the soil between your fingers, you will feel little to no mineral matter.

Other sure signs of old pingo muds include preserved freshwater snail and mussel shells as well as compressed, often layered, terrestrial and aquatic plant material. Before you reach the old pond layer it is important to dig slowly and carefully and to observe the sediments that you are exposing at regular intervals. It is all too easy to dig out the seedbank layer, especially if it is thin, and this is a bad mistake to make. Take your time, as you only get **one chance to get it right**.

The search for the historic pingo layer can often lead to 'head-scratching' moments. Are we in the right place? Have we gone deep enough? Sometimes the presence of certain objects and materials can indicate that you are still digging through the infill layer.

**4** Common infill materials and items include rubble, broken bits of field drain, bailer twine (as in photo), old bottles, intact and broken drainpipes and tree stumps.



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**3**

*Above: Sure signs of old pingo muds include preserved freshwater snail and mussel shells as well as compressed, often layered, terrestrial and aquatic plant material*

*Below: A dumper truck moves excavated old pond sediments to a separate pile*

This infill layer can sometimes be quite deep, at 1-2 m below surface. If you see any of the aforementioned materials and if you are sure you are not looking at pond sediment, keep on digging. **Be bold**, but be patient and use all the clues available to you. A hand auger and a spade are helpful tools to have at hand. Both can be used to quickly go down deeper within the trench to look for old pond sediments during a pause in the digging. Equally, if you suspect that the estimated ghost pingo centre is incorrect (as often happens), test pits can quickly be excavated with the digger to look for buried pingo sediments so that the main trench can be correctly re-positioned. Again take your time.

**5** Once you are sure that you have found the original pond sediment, continue a localised dig to gauge its depth, but do keep this material in a separate spoil heap. This layer can sometimes be 0.5-1 m thick at the centre of ghost pingos, but typically thins out to the sides of the depression and hence can easily be missed. Then, following the old pond layer, extend your trench outwards, if required, so that it covers the full extent of the lost pingo.



**5**

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**6** 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. Once the historic pond profile has been roughly established, digging can speed up. Working outwards from the trenches, the former pingo can be re-excavated, following the old sediment profile as closely as possible.

*Below and right: Different types of drain that are often encountered*



Do dig out some of the old pond sediment (again keeping it separate for later) but don't dig it all out and always keep it exposed at the surface of the excavation. A clever approach to excavation is to keep one step ahead of the digger with the hand auger so that the depth of the old pingo mud layer is known in advance of the digger bucket. By keeping the digger driver informed of what is coming up they are able to keep on digging and there is less stopping, starting and checking required.

**7** Any field drains found in or near to a ghost pond should be removed or broken during the excavation process. This will ensure that water entering the excavation does not come from surrounding arable field drainage (leading to nutrient-enrichment), whilst ensuring that the pond does not quickly drain away and lose its water. It is generally a good idea to ensure that a field containing ghost pingos does not have any functioning drainage infrastructure in it so that a pingo wetland complex holds water in a more natural way. When excavating a pingo do aim to leave behind plenty of very shallow water (less than 10 cm deep) and wet ground because this is important for many



pond species – suitable water's edge slopes are less than 1:5 (12°) and preferably less than this.

**8** Once the excavation is complete, return any removed pingo sediment back into the depression and spread it out. Placing this sediment into areas where there is no exposed historic pond sediment is ideal and you should aim to have the historic pond sediment exposed over as large an area as possible.





## Disposing of spoil

In disposing of the spoil from a ghost pingo excavation it is important that it is not dumped in adjacent wet areas, or on top of any areas of archaeological or ecological importance such as agri-environment margins, species-rich grassland or existing wetland areas. Before disposing of spoil please refer to 'Waste exemption: U10 spreading waste to benefit agricultural land.'



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## Plant colonisation

ALWAYS leave an excavated pingo pond to natural plant recolonisation. Never be tempted to add plants or seeds to the finished excavation or developing pond.

## What to expect following restoration

Water should fill ghost pond excavations in winter. It can be expected that spring may see some development of algae in the pond, but by early

summer the water should soon become clear. If a good seedbank is present plant colonisation can be rapid (often in under six months), often including rushes, pondweeds and especially stoneworts, but also many other species, such that a remarkable 20-30 wetland plants may be present by the end of summer. Many pingos may be dry by late summer in a drought year, but some sites can hold water, particularly if they have a good connection to groundwater.

*If a good seedbank is present, 20-30 wetland plants may be present by the end of summer, including stoneworts (above).*



## Pond margins and management

A resurrected ghost pingo needs to be well buffered from farming activities and agro-chemical applications, and it is ideal that a field where ghost pingos are resurrected is no longer farmed.

Where resurrected ghost pingos are located in grassland that needs to be grazed by cattle and horses, it is important that they are fenced off from the pingo for at least 3 years so that they are not damaged by poaching. This allows a thick emergent vegetation to develop which stabilises the newly excavated edges of the pond and also allows newly colonised plants to set seed.

In time, after around 5-10 years, if appropriate grazing is not part of a field's management regime, scrub may have developed around a resurrected pingo and at this point it is important to undertake scrub management.

These aspects of ghost pingo resurrection must be considered and agreed with the landowner from the outset.



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## Archaeological considerations

Wetland areas were clearly attractive to humans in prehistory, so features and materials of archaeological interest are often encountered during ghost pingo excavations. These includes mounds and scatters of heat-crackled flint indicative of prehistoric industry and domestic life, as well as flint tools, animal bones and ancient wood pieces. The Norfolk Historic Environment Service's Specialist Advice Team can provide advice on identifying and managing archaeological assets and may refer artefacts to the county Finds Liaison Team for identification. There are equivalent services in Suffolk. Members of the Norfolk Geodiversity Partnership can also advise about these Ice Age landforms and on the sediments and palaeo-environmental evidence they contain.

*Left: A prehistoric burnt mound exposed on the margin of a backfilled pingo pond*



© Tim Holt-Wilson



# Where to go for further information

This leaflet is a guide to straightforward pingo restoration, but we urge landowners to seek advice at any time, especially if complications or questions arise.

See the Norfolk Ponds Project web pages for further information on pond restoration, including an extensive Guide to the Restoration, Creation and Management of Ponds: [norfolkponds.org](http://norfolkponds.org)

UCL Pond Restoration Research Group: [ucl.ac.uk/geography/research/research-centres/pond-restoration-research-group](http://ucl.ac.uk/geography/research/research-centres/pond-restoration-research-group)

Norfolk Geodiversity Partnership: [sites.google.com/site/norfolkgeodiversity/home](https://sites.google.com/site/norfolkgeodiversity/home)

Norfolk Wildlife Trust: [norfolkwildlifetrust.org.uk](http://norfolkwildlifetrust.org.uk)

Norfolk Historic Environment Service Specialist Advice Team: **01362 869278**, email [HEP@norfolk.gov.uk](mailto:HEP@norfolk.gov.uk)

Suffolk County Council Archaeological Service: **01284 741230**, email [archaeology@suffolk.gov.uk](mailto:archaeology@suffolk.gov.uk)

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