Institution: University College London		
Unit of Assessment: 14 – Geography and Environmental Studies		
Title of case study: Restoring farmland ponds: delivering pond restoration, engaging the public and conservation sector with science-informed pond conservation, and changing English pond conservation policy		
Period when the underpinning research was undertaken: 2012-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Carl Sayer	Professor of Geography	1997-present
Jan Axmacher	Associate Professor in Landscape Ecology and Conservation	2005-present
Helen Bennion	Professor in Environmental Change	1995-present
Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact (indicative maximum 100 words)

In 2014, as a response to research undertaken by UCL's Pond Restoration Research Group (PRRG) identifying the actions necessary to restore pond biodiversity in UK lowland farmland, Sayer initiated the multi-partner Norfolk Ponds Project (NPP). Underpinned by PRRG science, the NPP has delivered over 200 successful pond restorations, as well as enabling tens of farmers to restore their own ponds, and educating conservation practitioners on pond restoration delivery. It directly inspired and supported the formation of similar projects in Suffolk and Gloucestershire and changed the strategic priorities of the National Trust's 'Riverlands' project. The NPP has raised public awareness of the importance of farmland pond restoration through considerable positive media attention reaching an audience of over 2 million. It has also influenced the Department of Environment, Food and Rural Affairs' (DEFRA) national environmental policy and Natural England's new English District Level Licensing (DLL) approach for Great Crested Newt (GCN) mitigation.

2. Underpinning research (indicative maximum 500 words)

Prof Carl Sayer formed the UCL Pond Restoration Research Group (PRRG) in 2012 to provide a scientific evidence base to inform UK pond conservation and restoration practices. It includes staff members (Carl Sayer, Jan Axmacher, Helen Bennion, Helene Burningham) and researchers with combined expertise in aquatic ecology, palaeoecology, landscape-scale conservation, aquatic ecological restoration and stakeholder engagement.

Since the 1950s many UK farmland ponds have been deliberately in-filled to reclaim land creating so-called "ghost ponds", while, due to a parallel cessation of traditional pond management, involving tree and sediment removal, remaining UK farmland ponds have become increasingly overgrown and shaded by trees (terrestrialisation). In 2012, a pioneering PRRG paper compared biological diversity across a set of farmland ponds managed by traditional tree and sediment removal with a set of overgrown tree-covered ponds in the surrounding area **[R1]** It showed that biological diversity was significantly higher in the managed ponds compared to the unmanaged highly-terrestrialised ponds. This was thought to be due to the development of dense and diverse aquatic plant communities in the managed ponds **[R1]**. Thus, a blueprint for a successful landscape-scale approach to farmland pond restoration and conservation – centred on tree and sediment removal – was established.

A further landmark paper arising from early PRRG research focused on the potential for restoring three ghost ponds deliberately in-filled by farmers between 1839-1883 and in the 1960s and 1970s **[R2]**. The ghost ponds were re-excavated and field surveys found them to support abundant and diverse aquatic plant communities after just six months. Parallel experimental work using on-site mesocosms (mini-ponds next to the restored ponds) and microcosms (tanks in a greenhouse setting) explained the rapidity of plant response, showing germination of at least eight aquatic plant species from long-lived seeds in the sediments of the ponds following as much as

150 years of enforced dormancy **[R2]**. Thus, ghost ponds are indeed, as the term suggests, never quite dead due to the presence of seed banks (effectively time capsules) viable on centennial time-scales underneath cropped fields.

More recent PRRG research has investigated the benefits of restoring farmland ponds for "terrestrial" species, demonstrating hitherto little understood aquatic-terrestrial linkages between ponds, farmland birds and pollinator communities. A year-round study of farmland bird use of recently restored ponds and typical highly-terrestrialised ponds showed bird abundance and species richness, as well as foraging and parental behaviour, to be significantly higher at restored ponds **[R3]**. Follow-up work showed that the mechanism underpinning this finding was an 18-fold (on average) higher abundance of emerging aquatic insects at restored open-canopy ponds in comparison to their unmanaged tree-covered counterparts **[R4]**. A study of pollinators, again comparing restored and overgrown terrestrialised farmland ponds, showed substantial benefits of pond restoration for wildflower resources and associated day-time pollinating insects **[R5]**. Thus, the research concluded that restoration of ponds in farmland may help to reverse well known and much publicised declines in bird and pollinator communities in UK farmland, the latter of which threatens crop production. Overall research undertaken by the PRRG at UCL provides a strong science evidence base to support the benefits of pond restoration and management in UK lowland farmland **[R6]**.

3. References to the research (indicative maximum of six references)

R1. Sayer, C.D., Andrews, K., **Shilland, E.,** Edmonds, N., Edmonds-Brown, R., **Patmore, I., Emson, D. & Axmacher, J.C.** (2012). The role of pond management for biodiversity conservation in an agricultural landscape. *Aquatic Conservation: Marine & Freshwater Ecosystems*, 22, 626-638. doi:10.1002/aqc.2254.

R2. Alderton, E., Sayer, C.D., Davies, R., Lambert, S.J. & **Axmacher, J.C**. (2017). Buried alive: Aquatic plants survive in 'ghost ponds' under agricultural fields. *Biological Conservation*, 212, 105-110. doi:10.1016/j.biocon.2017.06.004. Submitted to REF 2021

R3. Lewis-Phillips, J., Brooks, S., Sayer, C.D., McCrea, R., Siriwardena, G. & **Axmacher, J.C.** (2019). Pond management enhances the local abundance and species richness of farmland bird communities. *Agriculture, Ecosystems & Environment*, 273, 130-140. doi:10.1016/j.agee.2018.12.015. Submitted to REF2021

R4. Lewis-Phillips, J., Brooks, S.J., Sayer, C.D., Patmore, I.R., Hilton, G., Harrison, A., **Axmacher, J.C.** (2019). Ponds as insect chimneys: restoring overgrown farmland ponds benefits birds through elevated productivity of emerging aquatic insects. *Biological Conservation*, 241, 108253. doi:/10.1016/j.biocon.2019.108253. Submitted to REF 2021.

R5. Walton, R.E., Sayer, C.D., Bennion, H., & Axmacher, J.C. (in press 2020). Open-canopy ponds benefit diurnal pollinator communities in an agricultural landscape: implications for farmland pond management. *Insect Conservation & Diversity*. doi:/10.1111/icad.12452

R6. Sayer, C.D. & **Greaves, H.** (2020). Making an impact on UK farmland pond conservation. *Aquatic Conservation: Marine & Freshwater Ecosystems*, 30, 1821-1828. doi: 10.1002/aqc.3375. Emerged from **i**, **ii** and **iii** below.

All outputs were peer reviewed.

Funding

i. GBP3,650,000 (FEC) and GBP789,040 to UCL for NERC Consortium Grant (Co-Is Sayer; Bennion) on "*Hydroscape: Connectivity x stressor interaction in freshwater habitats*". NE/N006437/1, 2015-2020.

ii. GBP1,899 "Outreach Award" to UCL from the British Ecological Society (PI Greaves, Co-I Sayer) on "*Adopt a Pond (Pilot Project) – The Big Twin Pond Dig*", 2016-2019.

iii. GBP12,308 from NERC Impact Accelerator Award Phase III (PI Sayer) on "*Norfolk Ponds Partnership project"*, 2014-2015.

4. Details of the impact (indicative maximum 750 words)

Restoring ponds, raising awareness of the importance of pond conservation and inspiring conservation organizations to restore ponds

The Norfolk Ponds Project (NPP), initially established by Sayer and PhD candidate Greaves in 2014, is a partnership between UCL, local farmers, Norfolk County Council, Natural England, Anglian Water, Norfolk Farming & Wildlife Advisory Group (FWAG) and 5 NGOs. It has received funding support from UCL and its partner organisations. Drawing on PRRG research, the NPP was set up with two major aims: 1) to restore and conserve ponds in the county of Norfolk for the benefit of wildlife conservation, and; 2) to engage and educate farmers and the public, as well as conservation professionals and policy-makers, on the importance of pond management for biodiversity conservation.

Since 2014, the NPP team has restored (by major tree and sediment removal) over 200 highly terrestrialised farmland ponds in Norfolk with consequent direct improvements in the environment. Restorations are undertaken either as part of events combining all NPP partners or by a small dedicated NPP team, consisting of a chainsaw expert and digger operator. PRRG members Sayer and Greaves provide expert guidance, based on research findings, to inform the 'what and how' of all pond restorations. Studies of pond restorations delivered by the UCL PRRG show significant landscape-scale increases in aquatic diversity for a range of aquatic and terrestrial biological groups **[R1-R5]**. Further, a number of rare and threatened species have colonised NPP restored ponds, including the schedule 8 (under UK Wildlife & Countryside Act, 1981) species Holly-leaved Naiad *Najas marina* and Grass-poly *Lythrum hyssopifolia*, the latter of which had not been recorded in Norfolk for a century. NPP restorations have thus far resulted in 13 new Norfolk pond populations of the nationally rare schedule 5 (under UK Wildlife & Countryside Act, 1981) Great Crested Newt (GCN) *Triturus cristatus* and 17 new pond populations of the nationally threatened Crucian Carp *Carassius carassius*, a Norfolk Biodiversity Action Plan (BAP) species **[R6]**.

In addition to restoring ponds, the NPP has led to and informed (providing advice and know-how via events and visits to farms) pond restoration work in Norfolk, as well as more widely in Gloucestershire, Lancashire and Suffolk. For example, in May and September 2019, working for the NPP, the UCL PRRG ran two day-long events aimed at educating farmers and farm conservation advisors in Norfolk (total 42 participants) on the rationale and processes of farmland pond restoration. As a consequence, farmer members of the Upper Wensum Cluster Farm Group (Norfolk) were inspired to undertake 23 self-funded pond restorations in autumn 2019 with a further 20 undertaken in autumn 2020. Commenting on the 2019 work, the Farm Advisor for the Cluster, noted that the collaboration gave the farm cluster "a heightened academic understanding which motivated us to restore as many ponds in our landscape" **[A]**. She observed that: "This is an achievement considering that some farmers have highly conventional and intensive agricultural outlooks with little interest in pond restoration" **[A]**. UCL PRRG-run farmer events in Gloucestershire led to some 10 pond restorations being undertaken by the Seven Vale Guardians Cluster Farm Group and conservation NGO The Wildfowl & Wetlands Trust (WWT). As WWT's Wetland Science Manager states "the research work undertaken by UCL has been vital in advancing our understanding of UK pond loss and has been pivotal in identifying practical and sustainable solutions that can be communicated with landowners" **[B]**.

PRRG research changed the strategic priorities of the National Trust's GBP13,000,000 'Riverlands' catchment conservation project. The Project Manager for the Riverlands Upper Bure project in Norfolk explained that the PRRG's "essential research into the ecosystem wide benefits of ponds, and the success of ghost pond resurrection has helped the National Trust and Riverlands Program to see the benefits of ponds within our landscape scale project" **[C]**. As a consequence, The National Trust made the decision to include pond restoration in Riverlands and funded the NPP to deliver 50 pond restorations for the Upper Bure project. The Project Manager for the Riverlands Upper Bure project explains that the collaboration with the NPP: "has helped us establish new ways of approaching our targets for priority habitat restoration" and added that this links "well with the National Trust Strategy for healthy, beautiful, more natural environments as well as fulfilling Lawton's guiding principles" **[C]**. The collaboration has thus far delivered 22 Riverlands pond restorations, with further work planned for 2021 and 2022. Finally, in 2020, inspired by the NPP, the Suffolk Wildlife Trust (SWT) formed a Suffolk Ponds Project **[D]**. As SWT's Farmland Wildlife Adviser stated "The input and encouragement of UCL staff engaged with the Norfolk project has been instrumental in establishing this group in May 2020 and guiding our early thinking" **[D]**. In 2019 the NPP's positive influence on conservation organisations, and in particular the translation of UCL science to good conservation practice, was recognised by the

Chartered Institute of Ecology and Environmental Management (CIEEM) who awarded them their 'NGO Impact' award.

The PRRG has run outreach events (field workshops, open days, talks, seminars, webinars, agricultural shows, citizen science initiatives) which have educated farmers, conservation practitioners, policy-makers and the public on pond restoration and its under-valued importance in farmland conservation, engaging 3700 individuals **[R6]**. Before and after questionnaires indicate major positive advances in terms of understanding and practical know-how on pond restoration best practice **[Fig. 4 in R6]**. One Norfolk Farmer who attended NPP events commented: "I had looked into restoring ponds on my land through the countryside stewardship scheme before I heard about the Ghost Pond Project but I was put off by the cost and advice to leave the pond alone and just coppice trees along the bank to let light in" **[E]**. After attending NPP events he went on to restore ponds in 2013 as part of the Ghost Ponds Project **[R2]** and latterly in 2014 and 2015 by himself. He sees the restorations as part of his legacy: "knowing that you might leave a farm in a better condition than you started, well that's a fantastic thing to achieve" **[E]**.

Volunteers who participate in restorations benefit by learning new skills. The PRRG's "Great Twin Pond Dig - GTPD" (2016-19), funded by the British Ecological Society **(ii)**, twinned local people (20 participants in total) in Norfolk and Lancashire and involved them with before and after studies of farmland pond restoration, and asked them to adopt their local ponds. One volunteer explained that their group of 8 GTPD volunteers from Bodham, Norfolk "gained a tremendous amount of knowledge" **[F]**. The volunteer said participants "learn[t] new practical and scientific skills for the monitoring and observations required". The group has become self-sustaining: "Even though the project is now finished, the group continues to organise and undertake management through work parties at the restored ponds" **[F]**.

The importance and value of pond restoration has been transmitted to a large public audience of over 2 million in the UK, America and Japan via printed and online media and interviews with Sayer and Greaves on TV and radio **[G]**. Features in Farmers Guardian in April **[A/B]**, in print and online in New Scientist **[R2]** and The Conversation **[R2]** in 2017 reached an audience of 160,225 **[G]**. The NPP's 2019 "Big50" pond restoration project reached a global audience through coverage in The Telegraph, Mail Online, Japan Times, Japan News, Miami Herald, on BBC Look East and BBC Radio 4 'Farming Today' and by the Associated Press who featured the project in their "What Can Be Saved" conservation film series (19 November 2019 - viewed 36,772 times on YouTube) **[G]**. In February 2020, Sayer and Greaves explained the benefits of restoring farmland ponds **[R1-5]** in a 22 minute programme for the Radio 4 "On Your Farm" series (live listenership 720,000), as well as a 30 minute Radio 4 "Open Country" programme in October 2020 (listenership 1 million). In November 2020 Sayer was interviewed on the finding of the nationally rare wetland plant Grass-poly in a NPP restored pond on BBC News 24 and this story was also covered on BBC Breakfast **[G]**.

Raising the profile of pond restoration in the UK conservation and policy agenda and changing DEFRA and Natural England policy

In 2016 Natural England issued the report "Narrative for Conserving Freshwater and Wetland Habitats in England" **[H]**, which cited 3 PRRG papers, including **[R1]**. This important report outlines the evidence basis and philosophical framework for English freshwater and wetland habitat conservation, underpins key work-streams for protected sites, and sets out conservation ambitions and delivery mechanisms for important legislative drivers, including the UK's response to Biodiversity 2020, the EC Water Framework Directive and current and evolving agri-environment schemes (AES), including the current Countryside Stewardship scheme. In a section on 'Key Management Messages' the Narrative states that "in agricultural landscapes where there is less land available for pond creation, active management of the pond resource, involving partial scrub and sediment removal, can ensure that early successional ponds and the biodiversity they support remain part of the landscape". Inclusion of **[R1]** in the Narrative has helped to solidify the importance of farmland pond restoration in the delivery of effective landscape-scale conservation in England leading to inclusion in key environmental policy developments.

PRRG research has changed the new English District Level Licensing (DLL) policy approach for Great Crested Newt (GCN) mitigation. As a protected species GCN presence within and close to proposed development sites has to be mitigated for. As part of the UK Government's

25 Year Plan to Improve the Environment **[I]** a new DLL approach was highlighted as an innovative example of 'net gain' implementation, with districts empowered to use money from developers to create additional GCN habitat. As initially set up, creation of new ponds dominated the new DLL, with little consideration of the potential role of pond restoration **[I**, **pp. 142]**. However, as a result of PRRG evidence, in 2019, restoration and management were added as a key net gain pond option in the DLL. Natural England Habitat's Delivery Strategist for the DLL project, explained that: "Norfolk Ponds Project restoration works have proved extremely helpful in informing the habitat delivery elements of Natural England's GCN District Level Licensing project. In particular, you have illustrated that restoring ponds within the wider landscape has an important role to play alongside pond creation. Clearly the techniques you have used, and your careful decision making with regards to pond selection and restoration prescriptions, have added greatly to our knowledge base. We have used this to strengthen our pond specifications which are being used to deliver 400+ ponds across England this year" **[J]**.

PRRG research on pond restoration and resurrection **[R1/R2]** and the benefits of pond restoration for farmland birds **[R3/R4]** and pollinators **[R5]**, has been, and is currently being used, to influence agri-environment policy. For example, in 2016, the UK Government introduced the Wild Pollinator and Farm Wildlife Package to its Countryside Stewardship programme, which rewards landowners who adopt it. As a result of PRRG pond-pollinator research **[R5]**, the package now includes the edges of ponds. As the Standing Waters Senior Specialist for Natural England, stated: "The research evidence base you have produced has been fed into the development of agri-environment schemes and it continues to influence them, providing further justification for pond restoration to be funded. An example of this is the inclusion of pond buffers in the Wild Pollinator and Farm Wildlife Package, a decision that was informed by UCL's work" **[J]**. In 2020 Natural England invited Sayer and Greaves to produce pond conservation guidance (in collaboration with the Freshwater Habitats Trust) to inform DEFRA's forthcoming (2024) in-development Environmental Land Management (ELM) scheme. The guidance will inform participants and advisors concerned with ELM regarding pond creation, restoration and management and will shape the way that farmland pond conservation is undertaken in England for many years to come.

By demonstrating that restoration significantly enhances biodiversity in and around these waterbodies, UCL PRRG research has shown that the UK's formerly forgotten farmland ponds are critical to the nation's nature conservation strategy.

5. Sources to corroborate the impact (indicative maximum of 10 references)

A. Testimonial statement from Farm Advisor, Upper Wensum Cluster Farm Group
B. Testimonial statement from Wetland Science Manager, Wildfowl & Wetlands Trust (WWT)
C. Testimonial statement from Project Manager at National Trust
D. Testimonial statement from Farmland Wildlife Adviser, Suffolk Wildlife Trust
E. Interview with Norfolk Farmer https://bit.ly/3sHjXNZ
F. Testimonial statement from Great Twin Pond Dig Citizen Scientists
G. Press coverage including New Scientist, Conversation, BBC radio and TV programmes and evidence of global coverage.
H. Mainstone, C., Hall, R., & Diack, I. (2016). A narrative for conserving freshwater and wetland habitats in England. *Natural England Research Reports*, Number 064 https://bit.ly/3uHmt8D
I. DEFRA (2018) A Green Future: Our 25 Year Plan to Improve the Environment: https://bit.ly/3r54o1X
J. Natural England: Testimonial statements from Habitat Delivery Strategist for the District Level Licensing project and Standing Waters Senior Specialist quoted in **[R6]**.