HISTORY, ORIGINS AND IMPORTANCE OF TEMPORARY PONDS

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Introduction

In Europe, temporary ponds are a naturally common and widespread habitat occurring, often in abundance, in all biogeographical regions from the boreal snow-melt pools of northern Scandinavia to the seasonally inundated coastal dune pools of southern Spain (Nilsson & Soderstrom 1988; Serrano & Serrano 1991; Collinson et al. 1995; Zintz & Poschlod 1996; Williams 1997). Ecological studies in Europe and elsewhere also emphasise that temporary ponds are a biologically important habitat type, renowned both for their specialised assemblages and the considerable numbers of rare and endemic species they support (Bratton 1990; Baskin 1994; Kalettka 1996; King et al. 1996). They are, however, a habitat currently under considerable threat. Most temporary ponds are inherently shallow and the majority are destroyed even by limited soil drainage for agriculture or urban development (Serrano & Serrano 1991). Their low water volumes mean that they are highly susceptible to pollution (Williams et al. 1998). Lack of awareness is also a major issue. Even within protected landscapes, temporary ponds have often gone unrecognised by conservationists alongside better-studied permanent freshwater ecosystems such as lakes, rivers and permanent ponds. Among the public there is little recognition that temporary ponds exist at all - most are thought to be merely permanent ponds that have dried up and are now "lost". As a result, not only has the conservation of temporary ponds received little attention, but these waterbodies have often been unthinkingly destroyed either by infilling or by deepening to create permanent ponds (Bratton 1990). More recently, there has been additional concern that such threats will be compounded by climate change, to which temporary ponds, with their delicately balanced hydrological regimes, are likely to be exceptionally susceptible (Bailey-Watts et al. 2000).

A major difficulty in attempting to address such issues is lack of information. Studies of temporary ponds lag at least 50 years behind those of better known waterbody types and, in Northern Europe in particular, there have been few descriptions of the habitat or its role in the landscape. The aim of this article is to begin to redress the balance by describing some of the

fundamentals of temporary pond biogeography in Europe. In doing so, it is hoped that our contribution will also provide a background to the important ecological and conservation findings about European temporary ponds that are discussed in the following articles.

Definitions of temporary ponds

Temporary ponds can be described simply, if rather simplistically, as "lentic waterbodies with a recurrent dry phase". Within this definition, however, there is a wide range of waterbody types from, at one extreme, tiny puddles that might only hold water for a few days after rain, to more permanent waterbodies that may only dry up for a few weeks in most years. Like all other freshwater habitats, temporary ponds also merge imperceptibly into other freshwater ecosystems. As the length of the hydroperiod increases, they grade into semi-permanent ponds that dry only in drought years, and then into permanent ponds. As their size increases, temporary ponds also merge seamlessly into temporary lakes and marshes such as the Coto Donana's playas and marismas in southern Spain. Examples of some of the many different names given to temporary pond types worldwide are listed in Table 1.

Table 1. Examples of names used for temporary ponds worldwide

Term	Area where term is used	Notes
Turlochs	Ireland	In limestone areas such as the Burren
Billabongs	Australia	Floodplain pools, almost all temporary
Gnammas	Western Australia	Temporary ponds on granite outcrops
Vernal pools	North America	Filled in spring
Autumnal pools	North America	Filled in autumn
Playas	Africa, Europe	Broad, shallow, temporary ponds or lakes characteristic of arid areas
Rain pools	Africa, Australia	Small, temporary pools often in rocky outcrops
Tinajas	North America	Desert rock-pool complexes
Dayas	North Africa	Temporary ponds on sandy soils
Vleis	South Africa	Temporary ponds on clay layers or rock outcrops
Seasonal ponds	Ubiquitous	
Ephemeral ponds	Ubiquitous	

Formation and persistence of temporary ponds

A paradox often noted about temporary ponds is that although apparently ephemeral they are, in reality, amongst the most long-lived of aquatic habitats (Gray 1988). In Britain, many temporary pingos (ancient periglacial ponds) are thought to be in excess of 8,000 years old. In California some temporary ponds are known to date back at least 50,000 years and have, therefore, outlived the silting up of many major lake basins in the United States (Martin 1990). The reason that some temporary ponds can persist for such long periods relates to the dry phase. Thus, whereas in a permanent pond or lake, organic sediments accumulate at the bottom of the waterbody and build up every year, in a temporary pond most organic matter that accumulates in the wet phase oxidises during the dry stage so that, year-on-year, there is often no net gain in sediment depth. There are exceptions of course. Where temporary ponds are located on flood plains they will inevitably receive, in floodwater, inorganic silts and sands that do not break down quickly. Similarly, in dense woodland the large amounts of refractory leaf matter that is deposited may take a long time to degrade, allowing temporary ponds to gradually fill in. The fact remains, however, that such in-filling is usually a much slower process than it is for permanent ponds.

As a result, only the earliest years in the life of any natural pond basin are likely to conform to the classic permanent pond that we know so well. As soon as the sediment base in the pond reaches the surface, and sediment accumulation slows down, the waterbody will become first a semi-permanent pond and then eventually a temporary pond that, in semi-natural areas at least, will often remain stable for hundreds or thousands of years.

Temporary ponds in the landscape

A distinctive characteristic of temporary ponds is that they can form almost anywhere. All that is needed is water, a depression in the ground and, for a surface-fed pool, some silt to stop the water draining away immediately. Their ease of formation and temporal persistence as habitats means that they are found in many different ecosystem types. Examples in natural landscapes include dune-slack pools, pingos, oxbows, abandoned channels and tree-fall pools, or indeed anywhere in the uplands and lowlands where there are surface irregularities. Man-made depressions also frequently become temporary pools. As noted above, any created permanent pond will naturally develop into a temporary pond in time, and many of man's accidental depressions - vehicle ruts, depressions between old ridge and furrow, quarry bottoms - all form perfectly good temporary ponds.

Abundance of temporary ponds

When one begins to look for temporary ponds in the landscape they are found everywhere! So it is perhaps surprising that for many years temporary ponds have been a more or less invisible habitat in Britain, not least to ecologists. Ratcliffe's 1997 two-volume Nature Conservation Review, for example, aimed to identify the major semi-natural habitats in the UK, but only mentions temporary ponds to state that they are "not an important waterbody type in Britain" because there is so much rainfall that only very tiny pools ever dry up in summer. More recent research from the UK Countryside Survey suggests that the reality is rather different. The Countryside Survey provides stratified random survey data from 1-km grid squares spread across the UK countryside (Barr et al. 1993). Since the 1980s the survey has been repeated at intervals between six and ten years by the Centre for Ecology and Hydrology (CEH) under contract to the Department of the Environment Transport and the Regions (DETR). In 1990 and earlier Countryside Surveys no temporary ponds were recognised although some pond sites were noted as "dried up" or "lost" (Barr, personal communication). In 1996, however, a more detailed "thematic" Countryside Survey was undertaken that aimed particularly to look at pond quality in lowland Britain. As part of this work, temporary ponds were identified as a specific waterbody type for the first time (Biggs et al. 1996). Data from the new survey showed that almost 40% of all ponds in the lowland countryside were temporary: more than 82,000 temporary ponds in total, and about one temporary pond for every square mile (c. 0.7 per 1 km^2) of lowland countryside.

The 1996 thematic Countryside Survey clearly showed that temporary ponds are common in the agricultural lowlands of Britain, but in semi-natural areas evidence suggests that the number of ponds can be far greater. In the mid 1990s we "ground-truthed" areas of the New Forest in spring, taking random 200 m^2 survey squares and calculating the areas of each type of wetland in those squares. The results showed that, at that time of year, seasonal ponds were the most abundant of all the waterbody types in the Forest, with an average of over 100 discrete seasonal pools per 1 km^2 - two orders of magnitude more than is typical of the wider countryside.

Bialowieza Forest in Poland: lessons from a natural landscape

In recent years there has been increasing realisation that even Britain's most semi-natural areas, like the New Forest, have often been extensively drained and modified hydrologically (Tubbs 1986). To investigate the occurrence of temporary ponds in a more truly pristine landscape the authors visited Bialowieza Forest in eastern Poland to look at one of the last vestiges of lowland primeval forest remaining in Europe.

Bialowieza comprises an area of low, rolling, sandy topography, similar in many ways to the New Forest and, indeed, typical of much of the Northern European plain. Bialowieza is dominated by a mosaic of three major woodland types, all of which support temporary ponds in abundance. Pine *Pinus sylvestris* and spruce *Picea abies* with relatively acid and often *Sphagnum-rich* temporary pools dominate the highest ground. The mid-ground is colonised by mixed oak *Quercus rober,* hornbeam *Carpinus betulus* and small-leaved lime *Tilia cordata* woodland with more neutral temporary pools. In both woodland types many of the pools appeared to have been created, maintained and enlarged by the action of wild boar *Sus scrofa,* which are common in the forest and which constantly make pools by rooting around in damp ground.

The temporary ponds in the third woodland type, alder *Alnus glutinosa* forest, are very different. Here the pools are large and flat-bottomed temporary waterbodies, often a hectare or more in area. Investigation shows that these alder pools typically form a series of progressively dropping terraces with small trickles between them. The topographic map for the area also shows that these pools form linear features that eventually drain into Bialowieza's few rivers. The clear impression is that these terraced temporary pond systems replace what, in most modified European landscapes, would be small stream- or ditch-drained valleys.

Confirmation of the important hydrological function that temporary ponds play in natural landscapes such as Bialowieza came from more detailed study of an area where settlement and farmland has cut into the forest, bisecting an alder woodland valley. Walking along a transect through this area, over a distance of a kilometre, shows a rapid transformation from the natural wooded valley which is full of terraced temporary ponds (Fig. la), to pasture lands where water is drained first into a series of six or eight parallel drainage ditches and then into a single moderately fast flowing narrow stream channel running along the valley base (Fig. lb).

This case study from Bialowieza is instructive for two main reasons. First it shows how easy it is to eradicate temporary ponds from natural landscapes. The land around Bialowieza Forest is still farmed at very low intensity: application of fertilisers and pesticides is minimal, many farms still use horses, and drainage techniques are rudimentary with little under-drainage. Yet even these limited landscape changes transformed a seasonally wet landscape full of temporary ponds into an essentially dry area with very little remaining temporary water. Further west towards Warsaw, where intensive agriculture increasingly dominates, even these few temporary pools all but disappear.

The second observation from Bialowieza relates to the area's hydrology. It is clear that in areas of woodland clearance, even very limited drainage has





FIG. 1. (a) *(left):* A terraced temporary pond in alder woodland of Bialowieza Forest, Poland, (b) *(below):* The effect of draining temporary pools. This stream at the edge of Bialowieza Forest has been created by draining the temporary ponds which would otherwise fill the valley.

managed to replace an essentially still-water system possessing a high water-storage capacity, with a running-water system that drains water straight off the land into the nearest river. Looking at this stream in isolation it would be impossible to guess that naturally it should be a series of temporary pools.

Conclusions and recommendations

From examples in both Britain and mainland Europe, it seems clear that temporary ponds would naturally be a very common habitat in many landscape types. Temporary ponds still persist even in intensively-managed landscapes, but their numbers are probably a mere fraction of what they would naturally have been in the past. Historically, it is likely that temporary ponds have been progressively lost from the European landscape during at least the last two or three millennia. As with many other habitats, this process probably intensified during the 19th and 20th centuries, when the advent of under-drainage and intensive cultivation removed many of the last remaining wet corners where temporary ponds could survive. This is, however, largely speculation, because among the many other unusual characteristics of temporary ponds is the fact that their history essentially has gone unremarked and undocumented through the centuries.

Now that we are beginning to understand more about the value and importance of temporary ponds, both as landscape features and as habitats, there is an increasing imperative for retaining and protecting these vulnerable waterbodies. To aid this, it is possible to suggest at least two simple steps that will begin to help restore temporary ponds in the landscape.

The first is to consider the incorporation of temporary ponds into landscape restoration schemes. Temporary ponds would naturally occur in most landscape types, so regardless of whether it is a heathland or a river restoration, it is always worth at least considering the appropriateness of putting temporary ponds back as part of the natural mosaic of the ecosystem being managed.

Second, there would seem to be considerable value in thinking more imaginatively about temporary ponds as functional habitats: waterbodies that would naturally buffer runoff from catchments and that can store water and release it slowly. With the loss of so many temporary ponds from the landscape of Europe we have almost certainly lost not only the distinctive communities associated with these waterbodies, but also their natural hydrological functions. Major flood events in Britain in winter 2000-2001 have highlighted the need for introducing methods of holding water back on the land rather than draining it rapidly into flooding streams and rivers. Examples like the terraced temporary ponds in Bialoweiza provide natural analogues which could bring future benefits in catchment management.

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