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NEW APPROACHES TO THE MANAGEMENT OF PONDS

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Pond management is one of the most popular practical conservation tasks, and throughout Britain thousands of ponds are regularly dredged, desilted and cleaned out. Yet remarkably little is known about the effects of management on ponds.

Over the last six years, Pond Action has undertaken a wide range of survey work on ponds in the course of a number of projects, including the Oxfordshire Pond Survey and the National Pond Survey. This article presents some of the first results of this work and suggests how, in the light of new information, many existing pond management techniques could be improved.

What is a pond?

The definition used here follows that of the Pond Conservation Group (1993): 'a small body of water, between $1m^2$ and 2ha in area, which usually holds water for at least four months of the year'.

Myths about ponds

Anyone who looks closely at the wildlife of ponds quickly realises that much of the published information about pond management seems to be at odds with his or her own experience. In fact, existing books and guides have perpetuated a series of myths and misconceptions about ponds, reflecting the general lack of available information about their ecology and management. The most significant of these are listed in Table 1.

Ponds – an ancient natural habitat

Much of the present misunderstanding about ponds stems from the belief that they are essentially artificial, man-made, habitats which must be managed to retain their conservation value.

Table 1 Common myths and misconceptions about pond management

1	Drying-out is disastrous for pond communities
2	Ponds should be at least 2m deep
3	All pond zones, from deep open water to shallow margins, should be created and maintained
4	The bigger the pond, the better
5	Ponds should not be shaded by trees
6	Ponds should be dredged to prevent them from being 'choked' with vegetation
7	Pond water-level fluctuations should be minimised
8	Livestock should be prevented from having access to ponds
9	Ponds are entirely self-contained systems, isolated 'islands' in a sea of dry land

It is true that, in Britain today, many ponds are man-made, especially in the lowlands. But natural geological and biological processes have been creating ponds for millions of years and the conditions provided by ponds have existed for as long as there has been water on the surface of the Earth. Human activity has simply added a number of new ways in which ponds can be formed.

It is important to appreciate that all ponds, however they were created, provide an essentially natural environment. This suggests that, if we want to manage ponds for wildlife, we should look at the structure of natural ponds, and the way they change and develop. Doing so casts new light on almost all aspects of pond conservation.

Features of natural ponds

Ponds created by natural processes are still common in some parts of Britain, especially in areas of extensive semi-natural habitat. The New Forest, for example, has river valleys with hundreds of pools formed by flushes, fallen trees, swales (banks of sediment left by rivers), abandoned river channels and surface undulations. Some of these pools may be filled by just a few centimetres of water but all of them, whether large or small, support plant and animal communities.

By looking at naturally created ponds both in the geological record and in the landscapes of Britain and Europe today, a number of conclusions can be drawn:

i natural ponds occur in all sizes and depths, from deep meander cut-off pools, to surface undulations which hold just a few centimetres of water for a few months of the year;

ii most ponds created by natural processes are small and shallow, usually less than half a metre deep;

iii many naturally formed ponds are quite short-

Many natural ponds are very small, shallow habitats. However, they still support thriving communities. Nearly 40 species of aquatic invertebrates (including the RDB2 snail *Lymnaea glabra*) were recorded from this tree-fall pool in the New Forest.

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lived, being created and filled in over a period of tens or hundreds of years;

iv some naturally formed ponds, such as bog pools and temporary ponds, can be very stable, changing little over thousands of years;

v ponds will always have been very common in areas where water is abundant or near to the surface: for example, in river valleys and areas with springs, flushes, fens, bogs or wet woodland;

vi the occurrence of ponds will often have been concentrated in time, with ponds especially abundant at the end of ice-ages or after periods of mountain-building (both of which have occurred many times during geological history);

vii ponds of all shapes, sizes, depths and degrees of permanence have the potential to provide valuable wildlife habitats;

viii man-made and natural ponds support plant and animal communities that are essentially the same in both pond types.

Pond succession

The process of pond succession, during which ponds progressively fill with sediment to become wetlands (and in the long term, perhaps, dry land), is often considered a problem by pond managers, who see the changes it brings as undesirable.

Looking at natural ponds, however, it is clear that, for most types of pond, succession is an entirely natural process. The changes associated with it, particularly the loss of open water and the gradual reduction of water depth, have been repeated constantly throughout geological time. So we might expect that all stages of the pond succession would be exploited by wildlife.

Studies of modern ponds suggest that this is, indeed, the case: newly created ponds, old silty ponds and ponds which have become marsh or wet woodland all have their own specific communities and value.

For example, new ponds often support plants and animals which are well adapted to colonise and survive in the bare open habitats that they offer. New ball-clay pits, turf ponds and gravel pits have all been shown to support aquatic invertebrates and/or plants which were not found at later stages of succession. These have included uncommon species, such as Lesser Water-plantain, *Baldellia ranunculoides*, damselflies such as the Scarce Blue-tailed Damselfly, *Ischnura pumilio*, and rare beetles such as *Helophorus longitarsus* (Barnes 1983; Kennison 1986; Foster 1991; Fox & Cham 1994).

As a pond fills with sediment and becomes progressively shallower, the community it supports will also gradually change. However, there is no evidence that the pond's conservation value will inevitably decline (Pond Action 1994a); rather it will support a different species assemblage which is likely to be just as valuable. Silty ponds, for example, support a wide variety of invertebrate animals, including the alderfly *Sialis lutaria* and water beetles such as *Haliplus laminatus*, and the Screech Beetle, *Hygrobia hermanni*. Finally, even when truly aquatic species are no longer present, the waterlogged soils will provide habitat for wetland plants and a variety of semi-terrestrial wetland animals, including snails such as *Oxyloma pfeifferi* and many flies and ground beetles. As will be noted in other

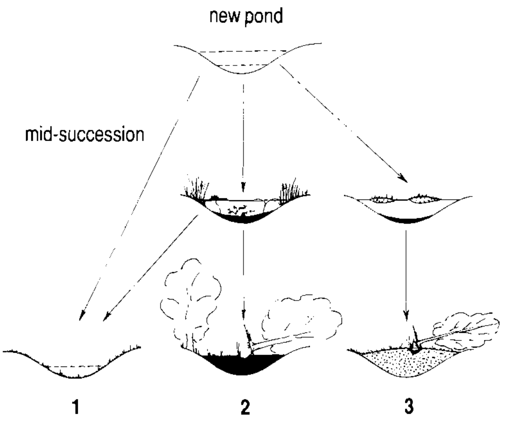

Figure 1: Pond succession. Pond succession can be a more complex process than is commonly realised and new ponds may take one of a number of successional routes.
1 Temporary ponds develop where water is shallow, and sediment inputs are low (e.g. grasslands, moorland, dune slacks). Because they can be very stable habitats temporary pond sites sometimes persist for long periods.
2 In the traditional route for pond succession the final stages may persist for long periods and tree-falls or other disturbance can recreate smaller pools in the water-logged soils.
3 In ponds with little wave action, floating rafts of vegetation may develop and become extensive. If nutrient status is low, these rafts can develop rich fen or bog communities.


N A Callow/Nature Photographers

The Screech Beetle, *Hygrobia hermanni*, is a species of muddy and silted ponds and ditches.

sections, even wet wooded hollows filled with leaves can have their own specific value.

In addition, the process of succession itself is often more complex than is commonly realised (see Figure 1). New pond basins may take a number of different successional routes, and on a regional basis this will add to the variety of pond habitats available for plants and animals.

Some wildlife managers are now beginning to exploit the process of succession. For example, in the Norfolk Broads new turf ponds are being specifically created and allowed to grow over, because their late successional stages are known to be associated with particularly rich fen plant communities, including species such as Grass-of-Parnassus, *Parnassia palustris*, Marsh Lousewort, *Pedicularis palustris*, and Marsh Helleborine, *Epipactis palustris* (Kennison 1986).

As the succession continues, the animal and plant species characteristic of earlier stages are not necessarily lost. In the first instance, some species persist into marsh and fen conditions, but in addition, as conditions become unsuitable, others may move on to alternative sites. The mobility of many freshwater plants and animals was noted by Darwin (1859), who realised that a surprisingly large number of freshwater species are either highly mobile or well adapted to passive dispersal. For example, most water beetles and bugs are active fliers, whilst, as Darwin himself proved, both plant seeds and small aquatic animals are frequently moved about on the feet of ducks and other waterbirds.

Darwin, and subsequently others, have suggested that the mobility of many freshwater species may be a specific adaptation to dispersal between small isolated waterbodies. The fact that natural ponds typically occur in concentrated groups, such as along river valleys or spring lines, must aid this process, because under natural conditions there would often be another suitable site (perhaps newly created) nearby.

Drying-out

One of the most significant myths of pond management is that drying-out is disastrous for pond wildlife, and much management effort goes into preventing this from happening.

Many ponds in natural situations (perhaps the majority) will always have been shallow, and

The alderfly *Sialis lutaria* is one of many aquatic invertebrates which live in silty or leafy ponds.


Cyril Nash/Pond Action

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Drying-out is not necessarily disastrous for ponds. This village pond in Ruscombe, Berkshire, dried out completely during the 1990 drought with no adverse effects on either plant or invertebrate communities.

both climatic vagaries and the processes of succession will ensure that occasional drying-up is part of the natural fluctuations of most sites.

It therefore seems likely that:

i the majority of species inhabiting shallow ponds should be well adapted to temporary drying-out;

ii although a few species may be unable to survive droughts, others will exploit the opportunities they create.

Three lines of evidence support this view.

First, the results of the Oxfordshire Pond Survey undertaken between 1988 and 1991 indicated that depth was the single most important environmental variable shaping the composition of pond invertebrate communities. Thus, shallow ponds, many of which dry out occasionally, support different invertebrate communities from those supported by permanent ponds. This survey also indicated that pond depth does not have a significant effect on pond conservation value, and that very shallow ponds are just as likely to support uncommon and rare invertebrate and plant species as deeper ponds (Pond Action 1994a).

Second, as has often been noted, a very wide variety of freshwater species is well adapted to survive periods of drought, and some species are particularly associated with intermittent drying. These include the Great Crested Newt, *Triturus cristatus*, damselflies such as the Scarce Emerald Damselfly, *Lestes dryas*, and Scarce Blue-tailed Damselfly, together with many snails (such as the Button Ramshorn, *Anisus leucostoma*) and beetles and caddis flies such as *Limnephilus vittatus* and *Trichostegia minor* (Macan 1977; Illies 1978; Wallace 1991; Swan & Oldham 1993; Fox & Cham 1994). The reason for this preference is not fully established but it is likely to be linked to the elimination of predatory fish, which are known considerably to reduce species diversity and abundance in ponds (e.g. Giles *et al.* 1990).

The final piece of evidence to suggest that temporary drying-out does little damage to pond communities comes from field studies of ponds which have dried out. For example, in a study of the water snails of 172 Cheshire ponds, McMillan (1959) found that no snail species were eliminated by intermittent drying-out. However, she did find that, in some ponds, snail species were lost as a result of pond management!

A more detailed study of a Berkshire pond during the 1990 drought gave similar results for other plant and animal groups (Pond Action 1991 and unpublished data). Ruscombe village pond dried out in 1990 for the first time in at least 15 years, leaving no surface water and a layer of mud which eventually formed a semi-solid crust. Surveys before, and one year after, the pond dried up showed no evidence of change or damage to plant or animal communities. All the 31 wetland plant species survived the drought, including aquatics, such as Curled Pondweed, *Potamogeton crispus*, Common Water-crowfoot, *Ranunculus aquatilis*, and White Water-lily, *Nymphaea alba*.

The pond's aquatic invertebrate community was also little affected. Standard surveys (Pond Action 1994b) recorded the same number of invertebrate species (50) before and after drying-out, suggesting that species richness had not suffered. Uncommon animals (including the Red Data Book [RDB] water beetle *Hydrochus elongatus* and the Great Crested Newt) were also present in similar, or greater, abundance. Neither was there any evidence of a change in invertebrate community composition: an index of sample similarity before and after the drought was similar to that of other samples taken from ponds in consecutive years (Pond Action, unpublished data).

Grass-poly is a nationally rare plant of temporary ponds and seasonally wet hollows.

Bob Gibbons

A word of warning, however: although it is very likely that many shallow ponds dry out with little or no damage, the drying-out caused by land drainage and abstraction is entirely different, mainly because drainage reduces water levels all the year round, making deep ponds permanently shallow and draining shallow ponds completely. The likelihood of permanently damaging wildlife communities under these circumstances is obviously considerable.

Temporary ponds

The myth that drying-out is inevitably disastrous for ponds has perhaps had its greatest effect on the way we think about temporary ponds. Temporary ponds are distinctive and predictable habitats in that they dry out, not at irregular intervals, but annually. Temporary ponds can also be extremely long-lived. Indeed, it is one of the paradoxes of freshwater ecology that these apparently ephemeral habitats may be the most stable of freshwater environments, filling in much more slowly than larger and deeper ponds and lakes (Gray 1988).

The reason why temporary ponds can persist for such long periods is that, unlike permanent waterbodies which progressively accumulate sediments and fill in over time, many temporary ponds accumulate little, if any, sediment. This is because, during the annual dry phase, organic matter in temporary pond basins is rapidly oxidised, so there is little opportunity for the pond to fill in.

Despite their persistence under natural conditions, temporary ponds are highly vulnerable to damage by man. Their small volumes make them particularly susceptible to water pollution, and their shallow depths and distinctive hydrological regime mean that they are easily damaged by land drainage.

It is likely that, prior to extensive land drainage, temporary ponds would have been much more common than they are now. Today, undamaged temporary ponds are at a premium and a large proportion of the specialised species associated with them are threatened or rare. These include two of the five freshwater invertebrates given special protection under Schedule 8 of the

Wildlife and Countryside Act 1981 (Fairy Shrimp, *Chirocephalus diaphanus*, and Tadpole Shrimp, *Triops cancriformis*), together with Natterjack Toad, *Bufo calamita*, and a number of very rare plants such as Grass-poly, *Lythrum hyssopifolia*, and Adder's-tongue Spearwort, *Ranunculus ophioglossifolius* (Whitten 1990).

Although most high-value temporary ponds now occur in semi-natural habitats, care always needs to be taken at sites in the wider countryside. For example, during recent surveys, temporary ponds located in agricultural fields and secondary-scrub woodland were found to support rare invertebrate species, including the RDB1 beetle *Haliplus furcatus* and the RDB2 snail *Lymnaea glabra*; (Collinson *et al.* 1993 Pond Action unpublished information). Similarly, in Cambridgeshire, temporary ponds in ancient hollows, now in arable fields, still retain Grass-poly and Fairy Shrimps (Preston 1989).

Management of shallow, temporary and silty ponds

From studies of shallow, temporary and late-succession ponds a number of general management recommendations can be made.

i Faced with the management of a very silty pond, two questions should always be asked: (a) which species will benefit (and which suffer) as a result of dredging?; and, bearing this in mind, (b) does the pond really need to be dredged? In many cases it will be better (and often cheaper!) to keep the pond as it is, protecting its current and future value, and mimic nature by creating a new pond if a suitable site is available nearby.

ii If a pond is already close to its mid-succession state, then gentle management may be appropriate to maintain it. However, where succession has continued and the pond has silted up, great care must be taken not to over-manage the site. Re-creating a mid-succession pond from a late-succession fen or wet woodland can largely eliminate the existing community, which may have developed over many years.

iii Panic pond-dredging is unlikely to be necessary in dry years, and can do positive harm. For example, the unauthorised dredging of a pond on Otmoor SSSI, Oxfordshire, in summer 1989 resulted in the loss of a number of plant species from the pond, including the nationally uncommon Frogbit, - *Hydrocharus morsus-ranae* (Pond Action in prep.).

iv Although temporary ponds can be important wildlife habitats, they often look uninteresting – especially during the dry phase, when the sites may appear to be no more than grassy or muddy hollows. Temporary ponds are therefore often regarded as prime candidates for 'improvement' to provide permanent water. Because of this it is clearly important to increase awareness of the value of temporary ponds, and essential that special care is taken to ensure that they are adequately surveyed if there is any threat from development or drainage.

v It is a widely repeated myth of pond management that new ponds should be at least two metres deep to be of value to wildlife. It should be clear from the above, however, that different depths of pond provide different habitat conditions. In many pond-creation schemes it would often be better to create two, or a series of, smaller ponds, including temporary and permanent pools, instead of one large pond. We have taken this approach at Pinkhill Meadow in Oxfordshire, where we are currently investigating the benefits of creating new pond complexes as part of a project jointly funded by the National Rivers Authority and Thames Water Utilities Limited (Pond Action 1993).

Trees and ponds

There is often uncertainty about how best to manage trees around ponds. Shaded ponds can appear dark and gloomy with few plants, and it is therefore usually assumed that they are poor wildlife habitats. This is an over-simplification.

The Oxfordshire Pond Survey shows that, as ponds become more shaded, the **number** of aquatic plant and invertebrate species does, indeed, drop. However, wooded ponds in this survey were just as likely to support uncommon species as more open sites (Pond Action 1994a).

This should not be surprising, since the association between trees and ponds is long-estab-

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A Brown Hawker egg-laying in rotten wood in a pond.

lished on a geological timescale, and in natural environments it would be expected that many ponds would have trees growing around them. It should also be expected that the conditions provided by decaying wood and leaves or wooded surrounds should be exploited by both aquatic plants and animals (Biggs *et al.* 1992).

Although few wetland plants tolerate very dense shade, a surprising number grow well in partial shade. These include emergents such as Yellow Iris, *Iris pseudacorus*, and Greater Tussock Sedge, *Carex paniculata*, and floating-leaved species such as the aquatic liverwort *Riccia fluitans*. Where water quality is good, more uncommon plants such as Water-violet, *Hottonia palustris*, and sometimes Fen Pondweed, *Potamogeton coloratus*, can be found.

Pond invertebrates can exploit woody debris and fallen leaves in a variety of ways. Tree trunks and branches that fall in to the water create habitat structure, providing one of the few firm substrates in some ponds. Wood can be colonised by epiphytic algae and fungi, which are the food of many invertebrates, and, as trunks and branches rot, dragonflies such as the Southern Hawker, *Aeshna cyanea*, and the Brown Hawker, *A. grandis*, often use them as egg-laying sites. Some aquatic fly and beetle larvae feed on decaying wood, whilst leeches and other pond invertebrates can attach their cocoons and eggs to woody substrates. Invertebrates also make use of the smaller debris: caddis flies, such as the common *Glyphotaelius pellucidus* and more local *Trichostegia minor*, use leafy or woody detritus, including tree bark, for case-building. Rotting leaves are also, themselves, a potential source of food for detritivores, including the freshwater shrimp *Gammarus pulex*, mosquito larvae such as *Aedes rusticus* and the larvae of the caddis fly *Limnephilus flavicornis*.

The submerged roots of bankside trees provide a habitat for the crawling water beetles, *Haliplus* species, and mayflies such as the Pond Olive Mayfly, *Cloeon dipterum*, whilst the muddy edges of shady ponds can be an important habitat for the larvae of a wide variety of dipteran families including owl-midges, craneflies, snail-killing flies and hoverflies.

Woodland near to, or surrounding, ponds is also valuable to aquatic species. Some aquatic invertebrates, such as the water beetles *Helophorus dorsalis* and the RDB2 species *Agabus striolatus*, are particularly characteristic of woodland pools (Friday 1988). Just as importantly, woodlands create the sheltered environment preferred by the adult stages of a number of aquatic and semi-aquatic insects. These include dragonflies (which frequently hawk in woodland glades and rides) and the more delicate-winged flies, which would desiccate in less shaded and humid environments (Stubbs & Chandler 1978). Among Britain's native amphibians, all except the Natterjack Toad prefer ponds surrounded by woodland, and in the Netherlands ponds with nearby wood or scrub have been shown to support significantly more species of amphibians than ponds surrounded by open country (Laan & Verboom 1990).

Managing trees

Clearly trees, leaves and woody debris may be of considerable importance to aquatic and wetland species, and management of tree-fringed ponds needs considerable care. Some general rules are:

i In areas where there are few shaded ponds, it is advisable to retain remaining examples wherever possible.

ii Where overgrown and shaded ponds are common, there is more likely to be an argument for carefully opening up portions of the canopy in some ponds. This can increase the cover of herbs and grasses, and provide additional habitats for aquatic and marginal invertebrate animals, such as hoverflies which feed on the flowers of terrestrial and wetland plant species such as Fool's Watercress, *Apium nodiflorum*, Celery-leaved Buttercup, *Ranunculus sceleratus*, and Hogweed, *Heracleum sphondylium*.

iii It is likely that the ponds which will benefit most from the removal of trees are those which have changed considerably in a short time: for example, ponds on heathlands or commons where trees have grown up because of a cessation of grazing. A good example is recent scrub clearance around ponds on a Buckinghamshire common, which resulted in hundreds of plants of the nationally rare Starfruit, *Damasonium alisma*, germinating from pond-edge mud.

iv Ideally, a survey of the pond should always be undertaken before any management work is considered, with emphasis on assessing the aquatic and marginal fauna. This is particularly important for ponds in semi-natural habitats.

v Where surveys are not feasible, then the main rule should be to avoid drastic changes. In particular:
 – avoid removing a large proportion of the leaf litter, branches or fallen trees from the pond;
 – prevent any attempts to clear-fell a continuous belt all around the pond to 'open it up'.

Retaining areas of wood or scrub next to the pond is important, not only because it makes sure that aquatic species have a continued supply of wood or leaf detritus, but because it ensures that bankside cover is retained for birds and amphibians to approach the pond in safety.

Plants in ponds

Although most pond guides stress the importance of plants, few manage to do this without also advising that ponds must not become 'choked' with vegetation. Our own, and others' observations suggest that it is generally better to have too many plants in a pond than too few.

Most pond guides treat plants purely as a food source or habitat for animals. This overlooks the fact that plants are also important in their own right. In fact, threats to wetland plants particularly from water pollution are now so widespread that about 70% of the British submerged and floating-leaved plants are, at best, only 'locally common' (Croft *et al.* 1991; Pond Action 1994c). It is increasingly clear that ponds provide an important refuge for these wetland plants. In Oxfordshire, for example, 118 wetland plant species (about 35% of the vascular wetland plants of Britain) were recorded from just 35 ponds, whilst preliminary analysis of 130 ponds in the National Pond Survey data set has recorded over 65% of our wetland flora. In addition, some of the rarest plants in Britain, such as Starfruit and Brown Galingale, *Cyperus fuscus*, are particularly associated with ponds. Seen in this light, removing plants from ponds can seem perverse.

There is no doubt that plants also provide a key habitat for pond animals: open water is an exposed and dangerous place for most species, and the great majority of animals live in the more complex and protected habitats associated with plants and/or sediments. For a large number of animals, plants not only provide a refuge, but are vital at one or more stages of their life cycle.

They provide sites for egg-laying and emergence, materials for case-building and a source of food, particularly for herbivorous invertebrates (such as many pond snails, fly larvae, caddis flies and mayflies) which graze the epiphytic algae and bacteria growing on plant leaves.

Invertebrates make use of all types of wetland plants, including tall emergents, low-growing grasses and herbs, and submerged and floating-leaved aquatics. They also use all parts of wetland plants, from roots buried in the sediment to the leaves and flowers.

Emergent plants are particularly valuable, in that they provide habitats both above and below water for semi-aquatic and aquatic species. For example, the spider *Marpissa radiata* places its egg sacs in the flower heads of Common Reed, *Phragmites australis*, and the pyralid moth *Calamotropha paludella* has larvae that mine the leaves of reedmaces, *Typha*. Even the roots of emergent plants are used by a variety of flies and leaf beetles, including larvae and pupae of the mosquito *Coquillettida richiardii* which live permanently below water and obtain their oxygen


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Ponds with 100% plant cover can still be very rich in wildlife. This pond on the Gower Peninsula, south Wales, supported over 40 plant species (including uncommon species such as Lesser Water Plantain and seven Nationally Notable species of water beetle.

by piercing the roots of plants. Among the larger animals, mammals, such as Water Vole, *Arvicola terrestris*, feed on the stems of grasses, especially Common Reed (Boyce 1991), whilst birds such as Coot, *Fulica atra*, and Moorhen, *Gallinula chloropus*, often nest among emergent plants and a variety of waterfowl feed on their seeds.

Within the water, the value of low-growing herbs and grasses is often forgotten. Marginal grasses, such as Creeping Bent, *Agrostis stolonifera*, and the floating sweet-grasses, *Glyceria*, are commonly regarded as weeds and pulled out when they begin to spread into the water. In fact, grasses growing in just a few centimetres of water are often excellent habitats for water beetles, whilst in deeper water floating sweet-grasses are among the most favoured habitats and egg-laying sites for Smooth Newts, *Triturus vulgaris*.

Floating-leaved plants are used by animals in a variety of ways. For example, aquatic springtails, *Sminthurides*, lay their eggs in duckweeds, *Lemna*, the larvae growing inside the individual leaves, while the Water-lily Leaf Beetle, *Pyrrhalta nymphaeae*, feeds on water-lilies both as a larva and as an adult, producing irregular trenches in the upper surface of the leaves.

Submerged aquatic plants are very valuable because they can grow in the deeper areas and therefore provide cover in what would otherwise be open water. They can also diversify the bottom sediment, with additional microhabitats created by the roots, rhizomes and plant detritus (Moss & Timms 1989). In some cases, submerged plant species are also associated with specific invertebrates (for example, the beetle *Haliplus obliquus*, which is associated with beds of stonewort, *Chara*).

The presence of a good diversity of plants is critical to encouraging a wide variety of animals at a pond, but other factors are important, too:

i different densities of plants are known to be important. For example, very dense stands of plants can provide invertebrates and amphibian tadpoles with a safe haven from fish, while Nummelin *et al.* (1984) showed that the nymphs of pond skaters, *Gerris*, inhabited areas of different vegetation density as they grew bigger.

ii invertebrate communities also change rapidly with water depth (Wissinger 1988); thus, the same plant stand will often support different invertebrate species in shallow and deeper water.

Paul Sterry/Nature Photographers

Plants are important sources of food and shelter for many invertebrates, such as this caddis fly larva which uses a covering of plant material to protect its body.

How much plant cover?

It is impossible to prescribe the 'ideal' amounts of plant cover for a pond. Different plant species and different amounts of cover inevitably support different animal communities.

However, in general, more plant cover is likely to be better than less. In the National Pond Survey, for example, it was clear that ponds with 100% vegetation cover often supported very rich invertebrate communities, and in Oxfordshire there was evidence that ponds with the greatest area of plant cover supported most plant species (Pond Action 1994a).

Plant management rules

On the basis of existing knowledge, a number of guidelines can be suggested for plant management:

i Be sure why the plant management is being done – are there going to be known benefits? Raking out most of a large stand of Common Reedmace, *Typha latifolia*, from a village pond may give better views of the pond and may be justifiable on the grounds of amenity. However, if the plants are likely to be replaced by nothing more than open water, the management is unlikely to benefit wildlife and should not be justified on conservation grounds.

ii If in doubt, it is better to leave the plants alone. In particular, plants are often removed from ponds when there is only 20-30% total cover. In terms of maintaining the 'health' of the pond this operation would usually be unnecessary, and in view of the importance of plants more likely to do harm than good.

iii When managing stands of vegetation (even single-species stands) it is important to retain any variations in plant density.

iv Since invertebrate communities change with water depth, as well as vegetation type, then, if vegetation must be removed, it would usually be better to remove a wedge of vegetation from deep to shallow water, rather than just raking out plants from, say, all the deep-water areas.

v Gentle management of very large single-species stands of plants may allow room for other plants to colonise and provide a greater diversity of habitats for invertebrates and amphibians, but care needs to be taken to ensure that large stands are not completely destroyed.

In particular, management should never aim to eliminate native plant species from a pond, since these plants may often support specific animal communities, both above and below water. Common Reedmace, for example, provides a habitat for a number of invertebrates, including the tiny Reedmace Bug, *Chilacis typhae*, which feeds in the flowerheads, and hoverflies such as *An-*

asimyia contracta as well as the three native species of *Parahelophilus*.

The danger of damage caused by over-management is a real one: there are several anecdotal reports of Ruddy Darter dragonflies, *Sympetrum sanguineum* (which is associated with the mud around reedmace roots), having been inadvertently eliminated from ponds as a result of management to 'control' plant stands.

vi Where appropriate, try to encourage creation or maintenance of complex structural plant mosaics. It is noticeable that the richest ponds often support varied mixed stands of floating-leaved, submerged and emergent species growing at a variety of densities and in a variety of water depths. This is much better than attempting to impose the dull and thin concentric fringes of vegetation specified in so many text books.

Water-level fluctuation: the drawdown zone

Another of the most persistent myths about ponds is that water levels should be stable and that fluctuation can be damaging. It is clear that ponds do need protection from land drainage and groundwater abstraction, which can lower water levels all the year round. However, this is quite different from the seasonal drawdown which is a normal characteristic of most waterbodies.

Surveys of ponds in a wide range of Britain's least disturbed semi-natural habitats show that water levels in most ponds fall by between 0.3m and 0.5m during the summer (Pond Action, unpublished information). This means that in many ponds the late-summer water depth is often half that of early spring.

The drawdown zone created by this water fluctuation is a key site for wildlife. It is particularly critical for the establishment of wetland plants, because the seeds of many emergents need exposure to air before they will germinate (ter Heerdt & Drost 1994). This is supported by the interim results from the National Pond survey, which suggest that over 85% of wetland plant species growing in ponds occur in the drawdown zone, and many are restricted to this area (Pond Action, unpublished data).

The mixtures of bare mud, sand and/or plants in the drawdown zone also provide an important habitat for a wide range of invertebrate animals. Some species use it during the wet phase; others when it is damp, or dry; and some species use both wet and dry phases, synchronising their life cycle with the seasonal change in water levels.

For example, the damp pond edge is used by many semi-terrestrial invertebrates, including snails, spiders, bugs and beetles such as the fast-running ground beetle *Elaphrus riparius* and the common shore bug *Saldula saltatoria*.

Some aquatic invertebrates also lay their eggs in the dry drawdown zone, perhaps because it is free from fish predation. These include dragonflies such as the Southern Hawker and the Brilliant Emerald, *Somatochlora metallica*, and caddis flies such as *Limnephilus rhombicus* (Fox 1991; Hickin 1967).

Finally, the drawdown zone can be a particularly important dipteran habitat, providing a prime site for the eggs, larvae and adults of generalist and specialist fly species alike, including species of hoverfly, soldier fly and cranefly (Stubbs & Chandler 1978; Stubbs & Falk 1983).

Management implications

Careful management of the drawdown area can contribute considerably to the conservation value of any pond.

Because of its marginal location the drawdown zone is very vulnerable to physical damage. The best advice is:

i Undertake any dredging or maintenance works necessary from a restricted number of points, and

ii ensure that the drawdown zone is neither removed to deepen the pond nor used as a dumping ground for pond dredgings.

The drawdown zone can also be used to positive effect in pond design, creating areas of shallow-angled (and preferably undulating) ground between likely summer and winter water levels to provide a rich habitat for plants, invertebrates and birds alike.

The effects of grazing animals

As Dolman (1993) recently noted in another *British Wildlife* article, ponds are often fenced against livestock to prevent trampling of the

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The Oxfordshire Pond Survey showed that ponds located in low-intensity grazed grassland supported a more diverse aquatic macroinvertebrate community than ponds in other land uses. The low-growing grasses at the water's edge are often particularly rich in water beetles and are a favoured habitat for Smooth Newts.

margins and fouling of the water. Yet for some plant and animal communities grazing is an essential factor in their conservation.

Grazing can have two beneficial effects. First, it prevents total domination of tall emergent species such as Common Reed or reedmaces which may exclude the rich communities of low-growing marginal plants. Secondly, grazing creates poached muddy margins, often a mixture of bare and vegetated ground with a complex micro-topography of tiny temporary pools and wet mud. This provides a host of habitats for terrestrial, semi-aquatic and aquatic invertebrates, including shore bugs, many flies, ground beetles and caddis.

As Dolman notes, a number of studies have shown that grazed ditches often have very rich invertebrate faunas. The results of the Oxfordshire Pond Survey suggest that this is also true of ponds: ponds located in grazed unimproved grasslands supported much higher-value communities than ponds from other types of land use. Furthermore, a surprising number of our rarest wetland plants are thought to rely on stock grazing and/or trampling around pond or lake margins to retain the open ground conditions that they need. They include: Creeping Marshwort, *Apium repens*, Strapwort, *Corrigiola litoralis*, Brown Galingale, *Cyperus fuscus*, Pennyroyal, *Mentha pulegium*, and Adder's-tongue Spearwort.

Management of grazed ponds

There is little doubt that over-grazing and trampling can sometimes be damaging to ponds, resulting in uniformly bare banks, and eliminating all emergent vegetation.

However, at low intensity it is likely that the gentle disturbance provided by grazing animals has a range of benefits. Indeed, on many higher-grade wildlife sites the conservation value of ponds depends on grazing.

Where grazing is already at a low intensity then little further change may be needed. Where stock densities are higher, additional measures to protect the pond may need to be taken. The usual recommendation of a fenced embayment into part of the pond tends to result in an 'all or nothing' regime of either bare mud or tall vegetation. Alternatives include movable electric fencing and location of fences very close to the water's edge to allow animals to poach and graze some of the wet edges more extensively, whilst still allowing taller plants and herbs to inhabit areas inside the fence. For new ponds it is often possible to design natural barriers to stock, such as steep banks, trenches or islands, which restrict access to some parts of the pond.

As a final point of caution, there may now be a more insidious problem associated with modern grazing systems. It has recently been noticed that traces of drugs (especially the pesticide Ivermectin) given to cattle are also present in their dung, and that this results in the mortality of invertebrates that come into contact with it. There is currently little information about the effects this may be having on pond wildlife, but it seems probable that they will be similar.

Ponds as islands

The idea that ponds are islands of water in a sea of dry land, self-contained and isolated from their surroundings, has appealed to a number of writers but is not consistent with the evidence.

It was one of the earliest achievements of freshwater ecologists to recognise that waterbodies reflect the qualities of their catchments, and ponds are no exception to this. There is no doubt that ponds are intimately connected to their surroundings. They are a sink for liquids and solids that drain in from the surroundings, and the animals and plants they support may be part of a larger population shared with neighbouring ponds and wetlands.

This link between ponds and the surrounding land has important practical implications. Where ponds are bordered by a relatively non-intensive land use (such as, semi-natural heathland or ancient woodland) they are often buffered from pollutants. Where land use is more intensive (for example on arable farmland or in urban areas) the amount of pollutants such as silt, nutrients, organic wastes and biocide sprays entering the pond can rapidly increase. Semi-natural land is also less likely to be drained, so that ponds in these areas are more likely to have a fairly natural hydrological regime.

The importance of land use for pond conservation has been clearly indicated by the results of the Oxfordshire Pond Survey, which showed that ponds surrounded by semi-natural habitats were generally of higher conservation value than those in more intensively managed areas (Pond Action 1994a).

As well as affecting water quality and quantity, the pond surrounds also provide a habitat for the large number of freshwater animals which use both water and land during their lifetime. Adult dragonflies and hoverflies all use the surrounds as areas in which to feed, returning to fresh water to breed. Water beetles may pupate in the near surrounds of ponds, and amphibians spend most of their lives on land.

Altering the type of surroundings can therefore considerably influence wildlife community types: ponds in woods, or on heaths and meadows, for example, will each have distinctive communities, and changing either the habitat type or its management can easily damage these.

Four principles for pond management

There is still too little reliable information about the effects of management on ponds to be able to make detailed prescriptions. However, most advice can be summed up in four principles.

i Make the most of existing habitats. It is very easy to eliminate valuable habitats simply because they are not aesthetically pleasing or because their value is not appreciated: poached muddy surrounds, shaded banks, bare sand, floating grasses and dense stands of emergent plants are all good examples of habitats which are undervalued. Some areas, like the drawdown zone, are mismanaged because their existence has not been adequately recognised.

ii Avoid making all ponds look the same. In any area (within a parish, a farm, or a nature reserve) retain examples of all stages of succession and a variety of depths. Avoid managing and maintaining all ponds at a mid-succession stage, the mythical idea of the 'ideal pond'. It would be better to retain an example of a silty, shaded pond and a 'new' or temporary pond than to try to make every pond a mix of everything.

iii Do not suddenly change the management regime of a pond or its surrounds (e.g. by drastic deepening or tree clearance). The risk is that the existing value of the community will be damaged with little conservation gain.

iv The intensity of land use surrounding a pond can have a vital effect on its conservation value. Protect ponds by creating or maintaining buffer zones wherever possible.

We would like your help

Pond Action is currently gathering information for a new guide to pond management and we would be very grateful for any good anecdotal examples of the effects of management on the quality or conservation value of ponds – triumphs, disasters, and cases which seem to support or refute the information given here would all be welcome. Permission will be sought before any examples are used in publication, and any used will be fully acknowledged.

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