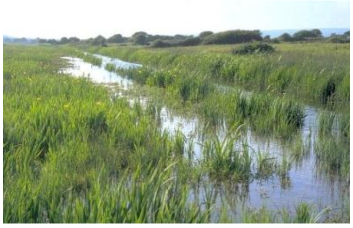
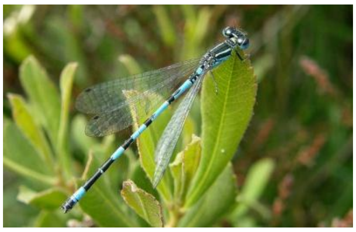
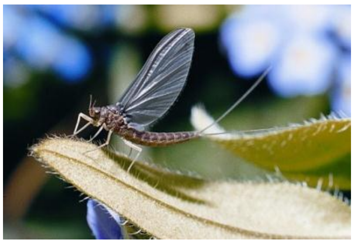





Freshwaters for the Future:

A Strategy for Freshwater Invertebrates

Freshwater, excluding ice, accounts for approximately 0.7% of all the water on the planet (Anon, 2010). It teems with wildlife and is vital to life on Earth, including human life. Rivers, streams, ditches, springs, seepages, ponds and lakes are all extremely important wildlife habitats, but with the development of agriculture, human settlements and industry, many freshwater habitats have been lost, damaged or polluted. This loss of freshwater habitats means that there is a great need to preserve what we have, restore what we have lost and create new freshwater habitats wherever possible.

Over 3,800 invertebrate species in the UK spend at least part of their lifecycle in freshwater (Davies & Edwards, 2011). These include well known freshwater invertebrates like dragonflies, mayflies, pond skaters and crayfish to lesser known worms and mites. They play a vital role in maintaining clean water; they help to break down and filter organic matter and provide a food source for fish, birds and mammals. Their presence is the standard indicator of the health of the habitat they live in. However, many of our freshwater invertebrates are declining in the face of pollution, invasive species, abstraction and development.

We believe that freshwater invertebrates and their habitats should be understood, respected, conserved and enhanced. This document details the 8 principles that society must choose to aspire to in order to save and sustain freshwater invertebrates and their habitats.

Aquatic invertebrates should be more widely understood, cherished and properly valued for the services they provide

Of all the ecosystems on the planet, freshwater supports the greatest concentration of biodiversity. Whilst freshwater habitats cover less than 1% of the planet's surface, they support up to 10% of known species (Strayer & Dudgeon, 2010). Freshwater life is very diverse and the emergence of insects from water contributes to healthy, functioning terrestrial ecosystems. The biology and ecology of freshwater bugs is intricate and amazing. Freshwater invertebrates are an important part of our culture and heritage – dragonflies inspire artists, crayfish excite children, and mayflies engage anglers. Freshwater ecosystems provide humans with a multitude of goods and services (Baron et al., 2002) and most of these are provided directly or indirectly by the species that live there (Covich et al., 2004; Hooper et al., 2005; Loreau, 2010). Yet freshwater ecosystems are among the most imperilled, with biodiversity losses occurring much faster in freshwater than terrestrial or marine environments (Ricciardi & Rasmussen, 1999; Dudgeon et al., 2006). Consequently, there are likely to be adverse effects on the delivery of services. A greater understanding of the relationships between freshwater biota and ecosystem services is particularly timely in achieving local and European legislative aims of restoring water bodies to 'good ecological status'.

> Learning about the variety and value of freshwater invertebrates incorporated in primary and secondary school education

> A review of the ecosystem services provided by aquatic invertebrates undertaken and results disseminated to decision makers

Reducing pollution and improving the cleanliness of water is essential to healthy aquatic ecosystems

Pollution continues to impact on water quality despite the introduction of legislation such as the Water Framework Directive in Europe. Almost half of sites monitored across Europe continue to suffer from chronic chemical pollution leading to long-term negative impacts on freshwater organisms (Malaj, et al., 2014). One in ten sites suffered acute pollution with potential lethal impacts for freshwater organisms. Sources of pollution include domestic and industrial sewage effluents, and run-off from agriculture and urban areas, with pesticides from farming posing the most immediate risk to freshwater ecosystems.

> A review of Priority Substances and the standards for pollutants in relation to the Water Framework Directive to ensure the correct substances are being monitored and that standards adequately protect sensitive invertebrates

The impact of neonicotinoid pesticides is particularly worrying. Diversity and overall abundance of freshwater invertebrates are significantly reduced in water chronically polluted with the pesticide imidacloprid (Van Dijk, et al., 2013). Continued exposure to low levels of neonicotinoids over several weeks affects the mobility and feeding activity of freshwater shrimps, while acute pollution events lasting less than a day were less harmful (Nyman, 2013). Mayflies, caddisflies and true-flies are particularly sensitive to these pesticides and even at low concentrations there is considerable risk of widespread impact on freshwater invertebrate populations as has been shown in countries and states that monitor neonicotinoid levels in freshwater habitats (Morrissey, et al., 2014).

It is not only neonicotinoid pesticides that have an impact on aquatic ecosystems. Metaldehydes, used to control slugs in gardens and agriculture, were found in 17% of waters used for drinking water supply in England in 2013 (Crabbe, 2014).

Compounds based on the synthetic pyrethroid Cypermethrin can be deadly in the aquatic environment. A small quantity of Cypermethrin entering a watercourse will kill aquatic invertebrates for many kilometres downstream. Whilst the sale of Cypermethrin as a sheep dip was banned after a campaign by Buglife and angling groups, it is still available for many other uses including for the treatment of sea lice infestations in marine fish farms, protection of crops and young trees, and for the control of fleas and other invertebrates in the home.

Neonicotinoid pesticides, metaldehydes and Cypermethrin monitored routinely in freshwaters

Robustness of the EU pesticide approval ‘test method’ must be improved and the impact of pesticides on the survival and reproductive capacity of a wide range of aquatic species must be established with statistically significant science prior to application for approval.

Pesticides and their impacts on freshwater invertebrates better researched and mitigated against

Eutrophication is a particular problem for standing water, and in particular reduces mayfly abundance, as has been the case in Lake Victoria over the last 75 years (Verschen, 2002). Pollution can affect not just presence and abundance of specific insect taxa but also their ability to perform services through altering their physical status. Furthermore, fine sediments caused by run-off from roads and agricultural areas, pose a major cause of river impairment with consequences for freshwater insect abundance, functional traits, biomass and species richness. With road run-off there is an added risk of hydrocarbons, de-icants, road salt, rubber residues and other substances entering the aquatic environment. Run-off from a new road was implicated in the national extinction of the Sussex diving beetle (Shardlow, 2012).

Comprehensive River Basin Management Plans functioning and effective in tackling diffuse and point source pollution

Agri-environment schemes delivering for clean water and reducing impacts of pesticides

The impact of road run-off on invertebrates investigated and measures put in place to reduce the risk

Investment by the water industry to reduce nutrient inputs from waste water treatment works and remove combined sewer overflows

There is growing evidence that pharmaceutical products which enter the freshwater environment can have a deleterious impact on the invertebrates living there.

The substances created as paracetamol breaks down are thought to be between 25 and 58 times more toxic than the paracetamol itself (Bedner & MacCrehan, 2006). Studies have shown that these substances cause deformations in zooplankton even at relatively low concentrations when they are exposed to the chemical over a long period of time.

Across the world over 35 million people are prescribed Prozac, also known as fluoxetine, to combat depression. 20-30% of the drug is, however, excreted unchanged from our bodies (Hartke and Mutschler 1993) and this residual chemical can pass through sewage treatment processes and be found in the effluent of wastewater treatment works, where it can accumulate in river sediments. Fluoxetine has been shown to influence the behaviour of aquatic molluscs, reducing their mobility and reproduction (Nentwig, 2007).

Triclosan is a synthetic anti-microbial agent which is found in a wide range of household products. From toothpaste to deodorants; antibacterial soaps to cleaning products, Triclosan has been in use for 30 years in health care however in recent times there has been an explosion in the use of this substance in domestic products. An American study found that Triclosan was one of the most frequently encountered chemicals in watercourses, particularly downstream of waste water treatment works (Kolpin, 2002). The antibacterial properties of Triclosan mean that it affects the very basis of the food chain in aquatic ecosystems. However, more worrying is that some studies have shown that Triclosan may bioaccumulate in higher organisms such as invertebrates and fish (Anon, 2009).

There are also growing concerns over microscopic pieces of plastic which are included in a range of substance including toothpaste and cosmetic products. These 'microplastics' accumulate in the sediment and have been shown to be consumed by various freshwater invertebrates including annelids, crustaceans, ostracods and gastropods (Wagner, et al., 2014).

The impact of pharmaceutical compounds and micro-plastics on aquatic invertebrates reviewed

Pharmaceutical compounds and microplastics monitored in watercourses and action taken to reduce pollution where required

Biosecurity, eradication and mitigation measures must be improved because of the extreme vulnerability of freshwater species and habitats to damage from invasive non-native species

Invasive Non-Native Species (INNS) are an increasing threat throughout the World. In Europe, many of these non-native species originate from the Ponto-Caspian region, with over a hundred species known to have spread from this area to date (Gallardo and Aldridge, 2013). The introduction of these invasive non-native species to new ecosystems leads to a reduction in species richness and abundance, with mayflies, caddisflies, freshwater shrimps and other crustaceans particularly vulnerable. A list of 100 of the World's worst invasive species features nine freshwater invertebrates, including the Chinese mitten crab (*Eriocheir sinensis*), the Fish-hook waterflea (*Cercopagis pengoi*) and Golden apple snail (*Pomacaea canaliculata*) (Lowe, et al., 2000). In Europe, crayfish species pose a particular threat with Signal crayfish (*Pacifastacus leniusculus*) and Red swamp crayfish (*Procambarus clarkii*) particularly problematic. An estimated annual cost of €454 million is incurred due to damage caused by and/or the control of these two crayfish species (Kettunen, et al., 2008). In the UK a list of 56 invasive non-native invertebrate species of most concern, produced by Buglife, features 24 freshwater species (Palmer and Macadam, 2014). The primary pathway for these freshwater species finding their way to the UK is in either ballast water or through aquaculture. A recent study has shown that south-east England is most at risk from invasion by invasive non-native freshwater invertebrates. It also shows that the presence of some species such as the Quagga mussel could enable other invasive species to establish more easily (Gallardo and Aldridge, 2013), for example, by providing a favourable substrate.

The forthcoming EU Invasive Alien Species Regulation must include key non-native aquatic invertebrate species for prevention and control in the UK

Add high risk invasive species, where appropriate, to Schedule 9 of the Wildlife and Countryside Act 1981 and to the list of species banned from sale under the Natural Environment and Rural Communities Act 2006

The UK Government must sign the Ballast Water Management Convention

Support the delivery of the recommendations made in the GB non-native species strategy review

Preventing the spread of invasive non-native species is key to limiting their establishment in new areas. Good biosecurity practices are essential to reduce and minimise the risk of spreading potentially invasive species. For aquatic ecosystems the GB Non-Native Species Secretariat (GBNNSS) promotes the Check, Clean, Dry message:

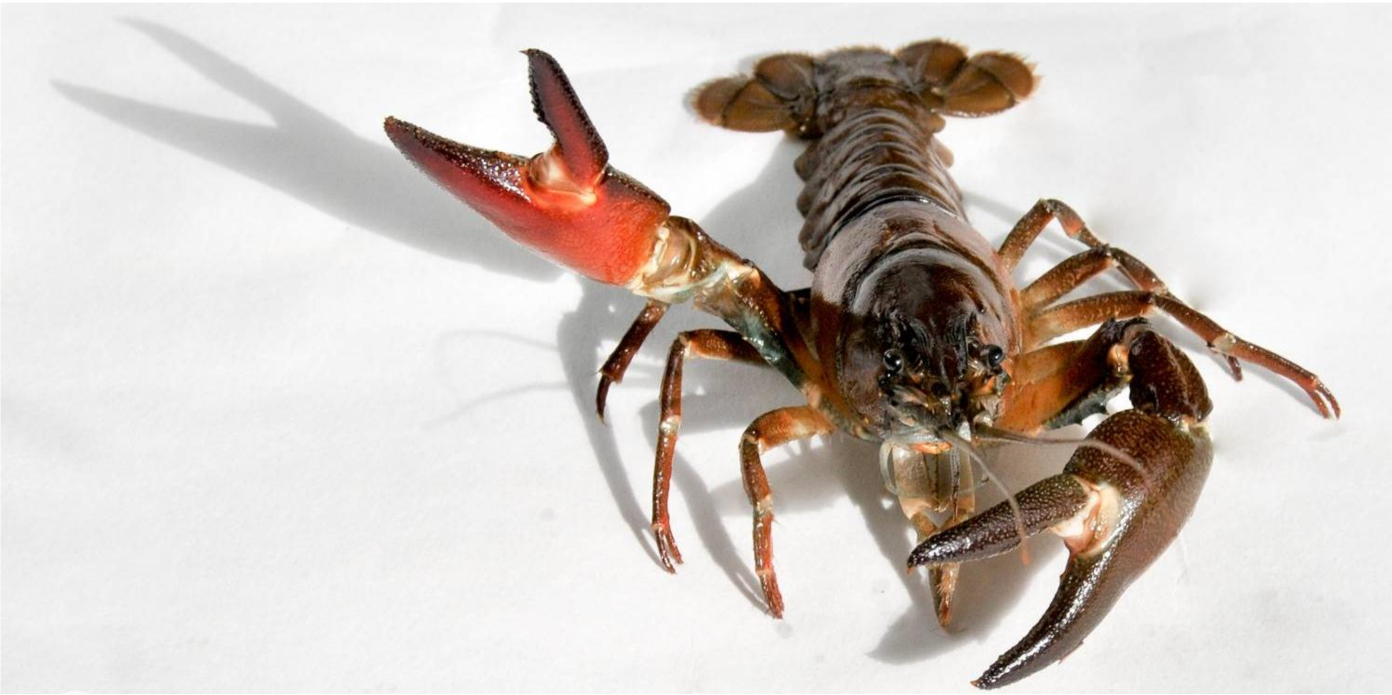
Check your equipment and clothing for live organisms - particular in areas that are damp or hard to inspect.

Clean and wash all equipment, footwear and clothes thoroughly. Use hot water where possible. If you do come across any organisms, leave them at the water body where you found them.

Dry all equipment and clothing - some species can live for many days in moist conditions. Make sure you don't transfer water elsewhere.

Raise public awareness of the threats from invasive non-native species through promotion of biosecurity measures in particular the 'Check, Clean, Dry' message

Review effectiveness of 'Check, Clean, Dry' campaign and adapt as necessary



Signal crayfish (*Pascifastacus leniusculus*) © NNSS

Where an invasive non-native species has become established it is often costly and time-consuming to control and eradicate. To ensure that control and eradication is as effective as possible it is essential that the current distribution and spread of the species is known. The GBNNSS provides a range of tools and resources for the identification of non-native species, including smartphone apps (http://naturelocator.org/aquainvaders.html) and a dedicated website (http://www.nonnativespecies.org//index.cfm?pageid=234).

The invasive North American Signal crayfish has been responsible for the widespread elimination of whole populations of the native White-clawed freshwater crayfish (which is listed on Annex II of the Habitats Directive) through predation, competition and transmission of crayfish plague. Since 2008, Buglife has spent an average of £60,000 per year on rescuing threatened populations of white-clawed crayfish and transferring them to secure 'Ark sites' isolated from Signal crayfish (Whitehouse, et al., 2009; Kindemba, et al., 2009). CABI estimated that the total cost incurred up to 2010 as a result of the invasion of American signal crayfish was £2.7 million in the UK (Williams, et al., 2010).

A review by Wildlife and Countryside Link has shown that over £650,000 is being spent on control and eradication projects for a range of invasive non-native species in England every year (Anon., 2014).

Harness the power of Citizen Science to report and map invasive non-native species

River Basin Management Plans should put more emphasis on monitoring, control and eradication of non-native species

Species Control Agreements and Orders under the Infrastructure Act 2015 and Wildlife and Natural Environment (Scotland) Act 2011 should be used to quickly eradicate newly arrived invasive non-native species

Research undertaken on the impact of invasive non-native species on native aquatic invertebrates

Climate change is an urgent threat to aquatic ecosystems and actions to make them more resilient must be implemented now

Climate change is one of the major long term threats to biodiversity. Most recent predictions (Anon, 2011) are that temperatures will rise as a result of climate change and there will be changes to precipitation patterns - these will inevitably have an impact on invertebrate populations. Freshwater invertebrates are particularly at risk, firstly because warmer water holds less of the dissolved oxygen that they need to survive, and secondly because changes to rainfall, evapotranspiration and flow rates will profoundly affect habitat continuity and availability. Indeed with the majority of species having relatively short life cycles and good powers of mobility they are likely to be one of the first groups to show the impact of a changing climate. Cold-loving species will retreat northwards and uphill, while warm-loving species will increase their range in the UK. An analysis of European caddisfly species traits found that the biggest potential impact from climate change was likely in Southern Europe with up to 30% of the fauna in the Iberic-Macaronesian region being potentially endangered by climate change (Hering, et al., 2009). In the UK a 3^{o}C rise in temperature was found to result in a 10-43% reduction in macroinvertebrate abundance in upland circumneutral streams and lead to the local extinction of Gold-ringed dragonfly (*Cordulegaster boltonii*), biting midges *Ceratopogonidae* and a caddisfly *Rhyacophila munda (*Durance & Ormerod, 2007). Surveys have also shown that the Upland summer mayfly (*Ameletus inopinatus*) - a predominately montane species restricted to cold water streams - has disappeared from lower altitudes and seems to be being pushed further and further upstream as water temperatures rise (Kitchen et al., 2010). European research using climate change models has shown that the geographical range of this species is likely to contract, with remaining populations of *A. inopinatus* in 2080 restricted to the Alps, Scandinavia and parts of the Scottish Highlands such as the Cairngorms (Taubmann, et al., 2011).

Adopt a catchment approach through River Basin Management Planning to address the impacts of climate change

Climate change predictions (Anon, 2011) suggest that the UK will be subjected to an increase in the frequency and severity of extreme weather events. The result will be increased incidences of drought and flooding.

Demands on freshwaters for water supplies are high. These demands are particularly focussed during times of drought. The effect on aquatic habitats is often exacerbated by abstraction for water supply and irrigation of crops. Leakage from the water supply network further adds to demands on freshwater.

Review abstraction licences for both surface water and groundwater in the vicinity of sensitive sites in light of climate change predictions

Promote water efficiency measures to domestic and industrial water users, monitor results and refine until water use comes down

Aim for a 50% reduction in leakage from their water supply networks by 2025

Water transfer proposals must be properly evaluated for their effects on freshwater ecosystems including the native and non-native invertebrate fauna

Increased severity and intensity of flooding is another anticipated impact of a changing climate. In recent years there have been several instances of widespread flooding in the UK. The immediate response by decision makers is to instigate a programme of dredging in the hope that this will increase the speed with which water drains and thereby reduce flooding. These decisions are often taken contrary to scientific advice and can lead to devastating impacts on the aquatic environment, particularly for fragile habitats such as exposed riverine sediments and ditches.

A more sustainable approach to flood management is to slow the movement of rain water throughout the catchment. This can include the inclusion of Sustainable Urban Drainage Systems (SUDS) such as attenuation ponds, swales and soakaways to capture rain water as it runs of paved areas, or green roofs and rain gardens that help to slow the flow of rain water from roofs. Due to their multiple benefits the USA, Canada Germany, Switzerland and most recently France now all have policies advocating the use of green roofs.

Natural flood management promoted as part of a sustainable flood management strategy

Planning policy should require the inclusion of green roofs and other sustainable green infrastructure, such as sustainable urban drainage systems in all new developments

River restoration schemes seek to improve the river environment by making changes to the river channel to protect the banks and create a diverse flow regime in the watercourse. Some schemes involve planting deciduous trees to provide shade along the watercourse and therefore prevent the water from becoming too warm. Whilst this is likely to benefit some invertebrate species, there are others that require open conditions and the provision of shade may inadvertently cause their decline. Similarly, leaves falling from these trees will provide an input of organic material to the watercourse. In headwaters this may be a particular problem for species more suited to less organic material being present. Fencing of riverbanks and the provision of buffer strips is traditionally seen a good for the river environment however it can lead to stabilisation of naturally mobile habitats such as gravel bars and sandy banks (known as exposed riverine sediments) and the loss of the specialist invertebrates that live there.

Scientific assessment of impact of river restoration schemes on invertebrates and their key micro-habitats

The needs of rare and threatened invertebrates integrated into catchment management and river restoration schemes

Efforts to conserve aquatic habitats have focussed on rivers and lakes, but most invertebrate biodiversity lives in small, marginal and dynamic waterbodies, these are much more fragile and require improved protection from damage

Over 50% of wetlands in North America, Europe, Australia and New Zealand have been lost through conversion to other land uses (Millennium Ecosystem Assessment, 2005). Whilst this assessment includes some coastal wetlands, it is clear that there has been a significant loss of freshwater habitats over the last 100 years.

Projects should be developed and funded to focus on the conservation of fragile freshwater habitats

Continued investment in hydro-power electricity generation is predicted to result in a 21% decrease in the number of remaining free-flowing rivers around the world. The majority of these developments are focused on the Amazon in South America, the Ganges in India and the Yangtze in China (Zarfl et al., 2014). River drainage and flood protection schemes involving the straightening and widening of watercourses also causes a reduction in habitat diversity, on the banks as well as in the water habitat, and changes in environmental conditions such as water depth and temperature. Mono Lake, California, is a case in point as the diversion of water to supply Los Angeles reduced water levels in the lake with detrimental effects on the ecology, including the once abundant brine fly *Ephydra hians* (Wiens, et al., 1993).

Urban development also impacts on freshwater invertebrates. The steady increase in the intensity and distribution of lights next to rivers may have a negative impact on riverfly populations and the ecological functioning of the waterbodies. The adults of many species, particularly caddisflies, are attracted to light and bankside lights may lure them away from their natural waterside habitat (Bruce-White & Shardlow, 2011). Light shining on lakes can inhibit nocturnal turnover, increasing the risk of anoxia (Moore, et al., 2000).

Asphalt roads can act as an ecological trap for mayflies which are attracted to the horizontally polarised light reflected from their surface (Kriska et al., 1998). Solar panels are known to cause the same phenomenon (Horváth and Kriska, 2008) and the proliferation of this renewable energy source in recent years is a cause for concern. Fortunately, there are relatively simple mitigation measures that can be undertaken to reduce the attractiveness of these panels (Horváth et al., 2010).

A further impact of urban development is the placing of bridges over watercourses. Observations have shown that on approaching a bridge, up to 86 percent of Long-tailed mayflies (*Palingenia longicauda*) turn back rather than go under the bridge to continue upstream (Málnás, et al., 2011). This is particularly problematic as it disrupts the compensatory upstream mating flight of the mayfly, thus restricting the range of the mayfly in the river. Conversely the caddisfly *Brachycentrus subnubilus*, is attracted to bridges where the females lay their eggs en-masse (Loxdale, et al., 2013).

Infrastructure and Urban developments must take in to account their impact on aquatic invertebrates: the Design Manual for Roads and Bridges should include information on mitigating against effects on invertebrates

Expand the protected areas network to adequately represent the most important sites for aquatic invertebrates

Take a catchment-based approach to the conservation and enhancement of freshwater invertebrate populations

Habitats such as exposed riverine sediments, ditches, springs and seepages, headwaters, fishless lakes, ephemeral pond and pools, bog pools and subterranean and groundwater systems often have important invertebrate assemblages. They are however also often poorly studied and misunderstood. The EU Water Framework Directive focuses on larger waterbodies, and as a result many fragile freshwater habitats are overlooked and undervalued.

Extend implementation of the Water Framework Directive to cover small water bodies

Develop agri-environment options that protect and enhance fragile habitats such as temporary ponds and seepages

CASE STUDY

The Pond Mud snail (*Omphiscola glabra*) is typically found in soft, nutrient poor waters with few other aquatic animals or plants. These include freshwater marshes, small ditches, temporary/seasonal pools or seepages.

These water-bodies are challenging habitats, which in the past were regarded as inferior wildlife habitats and were typically converted into productive agricultural land or improved visually for landscape reasons. Historically, this species is thought to have been widespread across acidic lowland areas of England, Wales and central Scotland, however, in the last 25 years, numbers have declined significantly.

The main reasons for the decline of the Pond mud snail are the loss or degradation of temporary ponds through infilling, pollution from agricultural run-off, overgrazing, scrub encroachment, and the enlargement of small ponds to create permanent waterbodies.

The small, temporary ponds that this species prefer are rarely protected and are seen as being difficult to manage and inferior. These ephemeral habitats are, however extremely important and support various scarce species that, like the Pond mud snail are specially adapted to survive periodic drought.

Transitional habitats such as saline lagoons and coastal grazing marshes are similarly often overlooked. These habitats are under pressure from climate change and rising sea levels, as well a ‘coastal squeeze’ where development and agriculture impact upon these sites. It is important to maintain the transition zone between fresh and saline water, which supports a specialised invertebrate fauna.

The EU Habitats Directive provides for some of these fragile habitats such as Saline lagoons and Tufa-depositing springs. These Annex I habitats should be maintained or restored in ‘favourable conservation status’ and protected through a network of Special Areas of Conservation.

An assessment undertaken of the status of Annex 1 habitats (Saline Lagoons, Oligotrophic, Dystrophic, Mesotrophic & naturally Eutrophic lakes, Bog woodland, Alkaline & Calcareous fens, Petrifying springs, Raised bogs, blanket bogs & transitional mires, Turloughs, *Ranunculus* rivers and Chalkstreams)to determine their status and conservation action required

Clear and resourced plan to ensure that there is the right habitat in the right places for the conservation of saline lagoon and brackish water specialist species for the next 50 years

The use of peat in horticulture destroys wildlife, it is a disgrace and must halt

The UK has about 10 to 15% of the total global area of blanket bog, making it one of the most important international locations for this habitat (Maddock, 2008). In addition, there are also internationally important areas of lowland raised bogs in northern England, Wales, Northern Ireland and Scotland.

The peat in these bogs has formed over thousands of years and can reach depths exceeding five metres. The water chemistry is nutrient-poor and acidic and the habitat is dominated by acid-loving plant communities, especially *Sphagnum* mosses. These conditions lead to peatlands being home to a unique assemblage of invertebrates, which includes the Large heath butterfly (*Coenonympha tullia*), the Six-spotted pot-beetle (*Cryptocephalus sexpunctata*), the Bog bush cricket (*Metrioptera brachyptera*) and the Bog sun-jumper spider (*Heliophanus dampfi*).

There has been a dramatic decline in the area of peatland habitat in the past 100 years. The area of lowland raised bog in the UK retaining a largely undisturbed surface is estimated to have diminished by around 94% from an original 95,000 to 6,000 hectares (Maddock, 2008). Much of this peat has been extracted for sale as compost for horticulture, however agricultural intensification and afforestation also contribute to the loss of these habitats.

Recent voluntary approaches to move the horticulture industry away to peat alternatives have failed to make the step change that is required to protect this fragile habitat. A change in buying habits of gardeners, horticulturists and local authorities is required. A tax on the production of peat products could lead to producers sourcing their peat from outside the UK, and therefore damaging this fragile habitat in other countries. A levy on the sale of peat products however could lead users to source alternatives to peat and raise funds to ensure continued investment in research on alternatives and the restoration of degraded bogs (Anon, 2010c).

New regulation introduced to label all products containing peat with a clear declaration of the percentage peat content and its source

A consumer levy should be placed on peat products at point of sale and increased annually until bulk trade ceases

Funds received from the Peat Levy should be used to research alternatives to peat in horticulture and to restore degraded bogs.

Local authorities and other public bodies must stop using peat immediately

Freshwater invertebrate populations tell us how healthy our environment is and they must be properly monitored and understood

In contrast to many other invertebrate groups, the distribution of freshwater invertebrate species is relatively well known. This is due largely to routine monitoring undertaken by the statutory environment agencies (EA, SEPA, NRW and NIEA). Invertebrates have been used to determine quality of freshwaters for over half a century. Nevertheless there are still gaps in our knowledge. The majority of statutory sampling is concerned with flowing water or larger standing waters meaning that smaller habitats such as ponds, headwaters, springs and ditches are poorly covered. In addition, this sampling is entirely focused on the aquatic life stages of the invertebrates and therefore our understanding of changes to aquatic insect emergence is often lacking. In the past this monitoring has been limited to family level identification of the invertebrates collected. Recently there has been a move toward more species level identification which will lead to this information being useful for a wider range of purposes. It is however important that this information is made more widely available.

Freshwater invertebrate data collected by the statutory agencies made publicly available on the National Biodiversity Network

In many areas monitoring by the statutory agencies has been reduced to the minimum required by legislation which means that some watercourses may only be monitored once in every six years. To address this the Riverfly Partnership have developed a simple monitoring method which can be used on any watercourse by trained members of the public (Anon., 2007). The Riverfly Monitoring Initiative has trained over 3000 volunteers to monitor around 800 sites, the majority of which are in England (www.riverflies.org). This initiative has led to the successful detection of a number of pollution incidents and subsequent enforcement action from the Environment Agency.

The Riverfly Monitoring Initiative fully rolled out to the rest of the UK

The Freshwater Habitats Trust has recently launched a similar citizen science initiative called PondNet (http://www.freshwaterhabitats.org.uk/projects/pondnet/) which aims to gather information about information on the condition of ponds and the species which inhabit them. This three year initiative will result in a network of ponds across England and Wales being monitored on a regular basis.

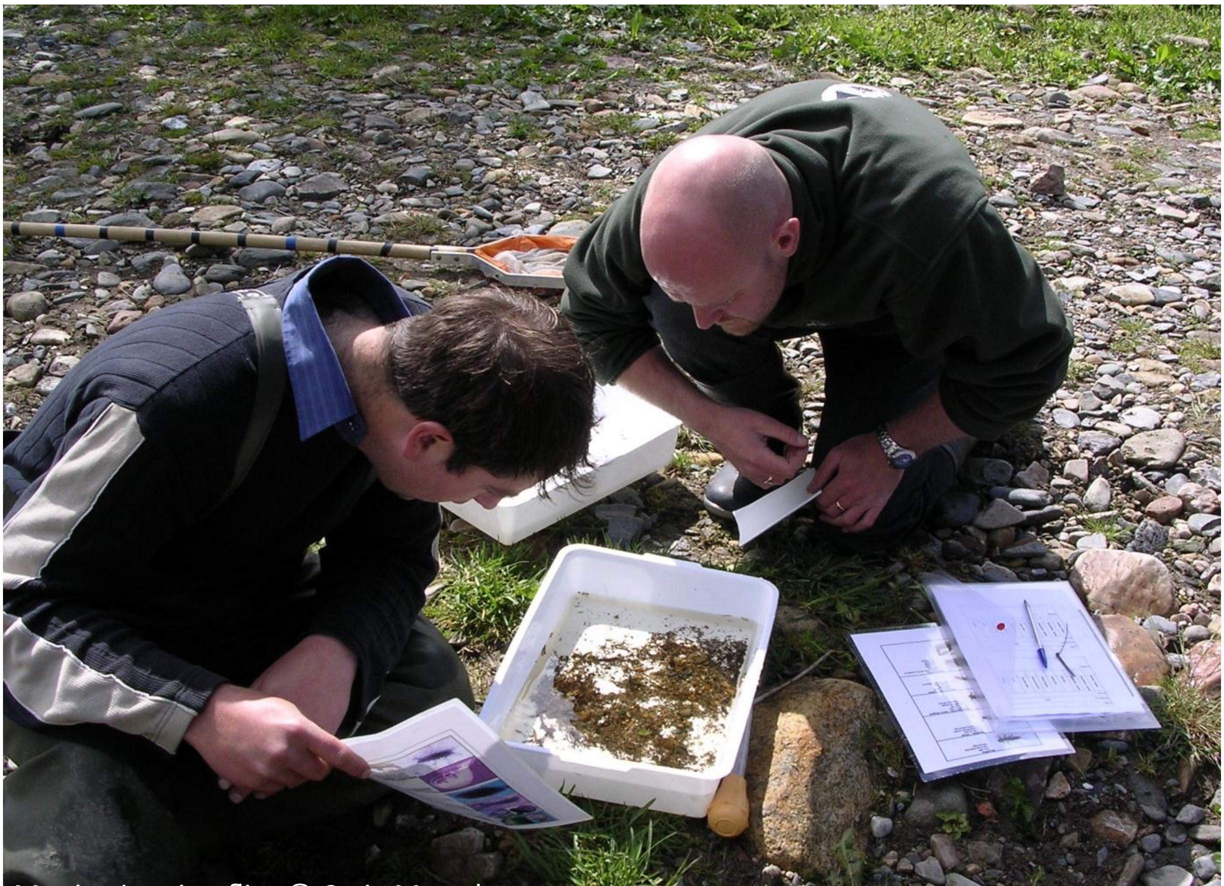
The PondNet programme extended to cover the rest of the UK

Develop citizen science surveys for other freshwater habitats (e.g. ditches, canals, river margins)

The study and recording of nature in the UK has a long history. The Biological Records Centre currently supports volunteer-led recording schemes for a range of freshwater invertebrate groups (table 1). These recording schemes and societies encourage recording, collate records, publish atlases and identification guides, and targets study on species. The data collected by the recording schemes is also invaluable when undertaking status reviews.

These recording schemes often rely on a very small number of volunteers to provide data on the distribution of the species they focus. The advent of digital photography, accessible identification keys (such as those published by the Field Studies Council) and websites such as iSpot (www.ispotnature.org) and iRecord (www.brc.ac.uk/irecord) mean that more and more people are interested in studying invertebrates. However, as co-ordination of the recording schemes is typically undertaken by volunteers there can be significant capacity issues.

Recording Schemes supported to develop volunteers



Monitoring riverflies © Craig Macadam

Cladocera (Water fleas)	Culicidae (Mosquitoes)
Coleoptera (Water beetles)	Dixidae (Meniscus midges)
Hypogean Crustacea (Cave amphipods)	Ephemeroptera (Mayflies)
Crustacea (Amphipods)	Hemiptera (Water bugs)
Ceratopogonidae (Biting midges	Non-marine molluscs
Chironomidae (Non-biting midges)	Megaloptera (Alderflies)
Odonata (Damselflies and Dragonflies)	Trichoptera (Caddisflies)
Plecoptera (Stoneflies)	Tricladida (Freshwater flatworms)

Table 1 – UK recording schemes for freshwater taxa

We know that pollution, climate change and non-native species are major factors leading to declines in freshwater invertebrates. However, there remain significant gaps in knowledge and understanding about how they interact with other factors such as habitat loss, eutrophication, etc., and the effects on the freshwater environment. Similarly, there is a need to determine what habitats and habitat features are crucial for maintain and restoring freshwater invertebrate populations.

An analysis undertaken to identify gaps in our knowledge and understanding of freshwater invertebrates, their ecology and reasons for their decline

Increased research efforts informed by gap analysis and findings translated into policy messages and practical action on the ground

Some freshwater species are now so vulnerable that specific, targeted conservation action and legislative changes are required to save them from extinction

Global freshwater biodiversity is reported to have declined by 76% since 1970 (WWF, 2014). Whilst this analysis did not include invertebrates there is no reason to suggest that similar declines have not occurred with invertebrates. Indeed, a survey of trout anglers reported a perceived 66% reduction in the number of freshwater insects emerging from chalk streams in southern England since the 1970s (Frake and Hayes, 2001). In a recent assessment of red lists from around the world 15% of dragonflies and damselflies (Odonata) were found to be at threat of extinction (Collen, et al., 2012). 32% of the world's 590 crayfish species are threatened with extinction (Richman, et al., 2015) and 27.8% of freshwater shrimp species are at risk of extinction (De Grave, et al., 2015).

Recent status reviews in the UK show that 35 water beetle species, 6 species of dragonflies/damselflies 5 species of mayfly and 2 species of stonefly are threatened with extinction. 5 species of water beetle, 3 species of dragonfly/damselfly, 2 species of mayfly and 1 species of stonefly are now considered extinct in the UK (Daguet, et al., 2008; Foster, 2010; Macadam, 2015; Macadam, in press).

Declines in rare and endangered freshwater species must be reversed through targeted funding and conservation action

UK Legislation should effectively conserve and protect freshwater invertebrates and their habitats - all Critically Endangered species protected from threats to their future

The most important areas for aquatic invertebrates should be identified and recognised in River Basin Management Plans

The Freshwater pearl mussel (*Margaritifera margaritifera*) is one of the most critically endangered molluscs in the world. Up to a half of the world's remaining breeding population are thought to be found in the Scotland (Skinner, et al., 2003). We therefore have an international responsibility to safeguard the future for this species. Over the last 100 years Freshwater pearl mussels have been lost from over one third of rivers where they once occurred (Cosgrove, 2000). Of the remaining populations, a third have been unable to reproduce due to deterioration in the freshwater ecosystem. All but one of the remaining colonies in England and Wales are considered small and vulnerable (Anon, 2010b) and despite full legal protection, they continue to be threatened.

The UK's international obligations to conserve and enhance populations of species listed on the Habitats Directive annexes (such as Freshwater pearl mussel, White-clawed crayfish and Southern damselfly) are adequately resourced and supported by Governments

A national network of White-clawed crayfish Ark Sites developed

CASE STUDY: Crayfish Ark Sites

The White-clawed crayfish (*Austropotamobius pallipes*) is the only species of crayfish native to the UK and has declined dramatically throughout much of its range since the 1970s, in particular due to introductions of invasive non-native crayfish species and associated pathogens. Habitat degradation, pollution and changes to water quality have also contributed to the species' decline.

The South West Crayfish Partnership (SWCP) - a collaboration between Buglife, Avon Wildlife Trust, Bristol Conservation & Science Foundation and the Environment Agency - was established in 2008 in response to the severe decline of native White-clawed crayfish in South West England and has recently completed the largest strategic programme of re-homing at risk populations of White-clawed crayfish to new safe sites. Since 2008 the Partnership has:

- translocated more than 4,000 White-clawed crayfish from 8 threatened populations to 14 new Ark sites across the region
- implemented a survey and monitoring programme of wild crayfish populations
- engaged landowners and managers through surveys and monitoring work
- established a captive breeding population (breeding over 1300 crayfish) and public exhibit of White-clawed crayfish at Bristol Zoological Gardens
- run an education programme highlighting the threats to White-clawed crayfish and promoting measures for their conservation amongst the public, landowners and key stakeholder groups such as anglers.
- hosted a national crayfish conservation conference in 2010.
- undertaken outreach to over 1600 school children and over 2 million other members of the public

However, the region's White-clawed crayfish wild populations remain under threat of extinction. A strategy has been developed in order to agree priorities for the partnership and our wider stakeholder groups for the next five years. Whilst the need for establishing further Ark sites remains, it is a challenge to find suitable sites. And so this strategy focuses more on the monitoring and conservation of wild populations, and the monitoring and consolidation of our Ark site populations. Where opportunities for new Ark sites arise we hope that the Partnership is able to act opportunistically to utilise sites for the conservation of threatened crayfish populations. We will also continue to maintain and develop the captive breeding and education programmes.


White-clawed crayfish © John Mason

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Buglife would like to thank the Dulverton Trust for their support with preparation of this manifesto

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