On the distribution, ecology and management of non-native reptiles and amphibians in the London Area. Part 1. Distribution and predator/prey impacts

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Abstract

This is a review of fifty-one non-native species, subspecies, intergrades or hybrids of amphibians and reptiles recorded as living wild in the London Area. Of these fifty-one taxa, referred to here as 'types', around twenty-one are amphibians of which fourteen have bred successfully and thirty are reptiles of which just two have been proven to breed. Other types may have bred unrecorded. A rapid increase in the number of types of terrapin in the wild has been observed since trade restrictions on red-eared terrapin importation in 1997. Many new species, mostly North American, but including those from Africa and Australia, can

now be found in the wild. The traditional split of Water Frogs into two species and a hybrid has now diversified to include many more types that may interbreed when mixed. The distribution and spread of Water Frogs over the last two hundred years in this part of south-east England is described for the first time. Brief descriptions and identification notes are provided and zoogeographic and historical aspects of colonization are considered. Part 1 refers to distribution and aspects of impacts from the species' role in the food chain of the communities where they have colonized. The trade in herpetofauna and nature conservation and welfare issues are considered. Aspects of disease impacts and philosophical considerations are described in Part 2.

Introduction

There are at least fifty-one species, subspecies, intergrades or hybrids (referred to here as 'types') of amphibian and reptile recorded as living in the wild in the London Area. It includes those that are or have been self-maintaining through breeding for at least one generation (sixteen types). It also includes three types that are being recorded in the wild on a more frequent basis, that are tropical species often released in summer and are unlikely to survive a winter period. There are in addition to the fifty-one types, a larger number of species recorded once or twice that have escaped, often for a few days or weeks, to be recaught or to die outdoors, for which records have not been particularly sought as they are so numerous, although some examples are given. Of the fifty-one types, around twenty-one are amphibians, of which fourteen have bred successfully, and thirty are of reptiles of which just two have been proven to breed. At least four of the types (and possibly up to a further four suspected but not recorded) are native to the UK but have originated from mainland Europe.

The 'London Area' is the centre of abandonment of non-native herpetofauna in the United Kingdom. The London Area as described here includes the London Natural History Society recording area and a hinterland representing an edge-area outside of up to ten kilometres or so. In recent decades the number of such species seen has overtaken the twelve species that are considered unequivocally to be, native to the British Isles (not counting marine turtles) and the London Area in recent times (Langton 1991). We also refer to the smaller Greater London area that represents the more urban land, almost all of which falls inside the M25 motorway (Figure 1).

Of the fifty-one types of herpetofauna (shortened here to herp or herps), relatively few have become established or have spread to any degree, although some have been subject to removal activities. Removal has been either to prevent breeding and the potential of further spread and harm to other wild species (nature conservation), or potential damage to economic interest (e.g., fishery), or to reduce perceived harm to the animal in an unsuitable location for its well-being and survival (welfare).

Records have been received by the current recorder (TESL) from our Society's members since the mid 1980s. Until that period the number of records of introduced species reported in *The London Naturalist* from time to time has been relatively few, generally increasing through the twentieth century after about 1935 and with the greater increase in importation of animals from Continental Europe as pets in the 1950s. In addition to a recent appeal to members for records we have included those made available by the London, Essex and Hertfordshire Amphibian and Reptile Trust (LEHART) and those of the County Amphibian and Reptile Groups (ARGs), many of which to some extent gather records as a part of their established function to carry out conservation work. Several ARGs were established and coordinated with help from the Fauna and Flora Preservation Society (now Fauna and Flora International) in the 1980s and steadily built up via the Herpetofauna Groups of Britain and Ireland (HGBI) in the 1990s and early 2000s by the UK herpetofauna conservation charity Froglife. In addition, some of the county or area-based biological record centres were able to provide some records. A large volume of information was provided by Herpetofauna Consultants International (HCI Ltd) from its library and archives.

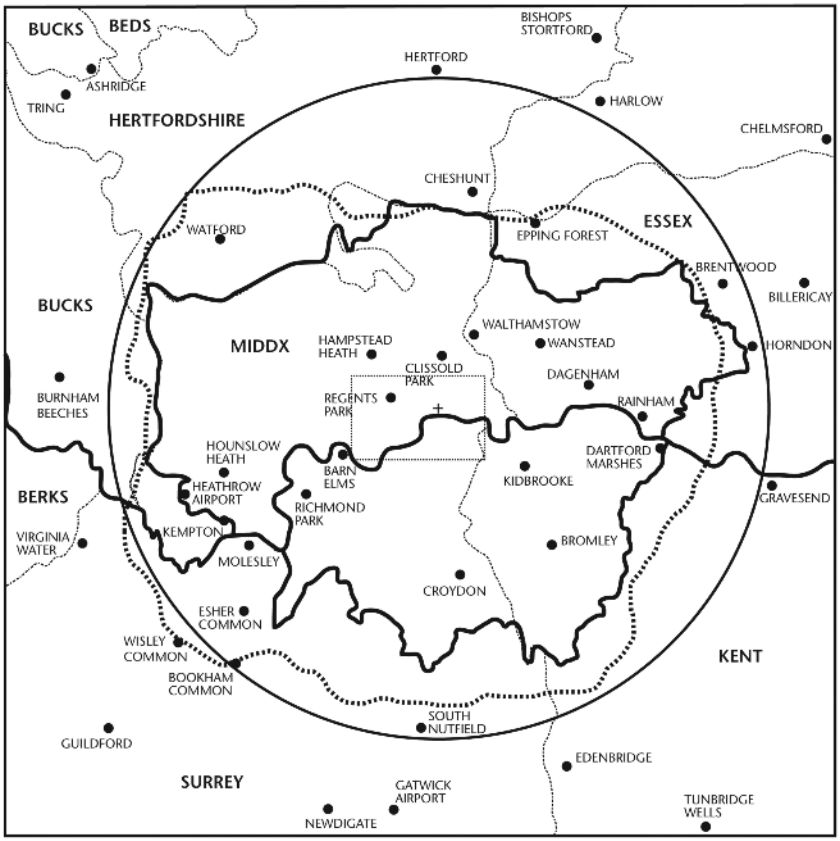


FIGURE 1. Study area 80 × 80 km showing the outer edge of Greater London boroughs (solid regular line), the London Natural History Society recording boundary (Solid circle), the M25 motorway (dashed line), with many of the locations that are cited within the text. The bold line running west to east is the River Thames.

Many published research papers, reports and university student studies were also consulted and searched for records. In total, around 1,200 records have been collated of which about 200 have been generated by our members and 620 by your LNHS recorder from various sources. Around eighty additional records have been provided by LEHART and 280 from six county record centres and from local ARG records. With the species accounts, the number of records inside and outside the LNHS area within the London Area are stated when the number of records exceed a total of around ten records.

With regard to taxonomic nomenclature, there has been substantial disruption to scientific naming in recent years which is unhelpful with respect to continuity of general reference for non-specialists, and with reference to published legal documents including international law. This is particularly the case when names change more than once over a short period, for example with alpine newt. Although some names are widely accepted, we have kept with previously familiar scientific names but also given new names that have become more generally accepted in recent years or partially accepted by taxonomic convention.

Past interest and research

In the past, Fitter (1949, 1959, 1960) and Yalden (1965, 1967) in particular made initial efforts to document non-native amphibian and reptile reports for the LNHS area, before but mostly between 1940 and the 1970. The first local atlas of distribution that included non-native herpetofauna covering at least a part of the LNHS recording area was for Essex (Plant 1983) and there have been more recent contributions, for Kent (Philp 1998), for Surrey (Wycherley and Anstis 2001) and for Hertfordshire (Clark 2001). Trevor Weeks conducted a survey of feral terrapins for his National Terrapin Survey in the mid 1990s (Weeks 1995, 1997) and a final checklist in 1999, covering the whole of the UK. This showed just how extensive the abandonment of terrapins was becoming. The report identified over 200 UK sightings of which around fifty (twenty-five per cent) were from the London Area, making London the densest area for terrapin abandonment in the UK.

With Water Frogs, Surrey ARG members, and particularly Julia Wycherley, can be singled out for contributing significantly by collating reports by local recorders from the south-central and south-west of the study area in Surrey. In Middlesex and elsewhere Doug Napier has carried out extensive fieldwork to recheck sites for continued Water Frog occupancy. Apart from this there have been only a few volunteer and university student studies nationally. This is possibly a reflection of a perception, that existed until fairly recently, that the release of amphibians and reptiles could not potentially impact significantly on agriculture or human health to any great extent, or cause harm to native wildlife and so it has not been a priority area. Other workers have studied individual sites and those persons are listed in the acknowledgements. It is not exactly clear how comprehensive our coverage has been; however it is likely that most individuals or populations persisting for any duration would have been noticed over the years, at least post 1900. However, those species not breeding or present only for a few years (such as populations centred on a single pond) may have been overlooked.

History of recorded introductions

The Changing Wild Life of Britain (Edlin 1952)appears to be the earliest review of non-native fauna in Britain and followed Malcolm Smith's (1951) New Naturalist series volume *The British Amphibians and Reptiles* that included non-natives. Previously, Cooke (1893) had summarized the stories, snippets and other evidence pertaining to Water Frogs from journals such as the *Zoologist* and other published texts. The first full attempt at documenting all introduced animal species in the British Isles was *The Ark in our midst* (Fitter 1959). This was extended by *The Naturalised Animals of the British Isles* (Lever 1977) that has been recently updated (Lever 2009) and with a world-wide review (Lever 2003). Frazer (1964) and the New Naturalist series subsequent updates have provided further information on non-natives but were not comprehensive reviews. In a European context, Langton and Burton (1997) listed over thirteen species of amphibians and reptiles introduced outside their range in Europe. The first extensive European herpetofauna distribution atlas was produced by the European Herpetological Society (Gasc et al. 1997) but in many countries national atlases now provide additional information. Other information collated for this study relates to the London Area (Figure 2) and south-east England in general. This includes:

- Reports published within *The London Naturalist* over the last hundred years or so
- A range of articles published in Victorian/nineteenth-century journals
- County reports for Essex, Kent, Surrey, Buckinghamshire and Hertfordshire
- A monograph on Water Frog dispersal in Kent (Philp 1998)

- Student dissertations on aspects of Water Frogs, terrapins and palaeo-archaeology
- Reports on activities of biological supply companies at Newdigate and South Nutfield in Surrey
- Technical reports prepared by a range of national charities, voluntary bodies and individuals
- Papers published in *British Wildlife* magazine
- Government-funded research reports
- Publications in scientific journals.

Historically, it is thought that fish breeding and fish transport in Asia began around 5,000 years ago in China and that more recently the Romans and others imported wild and domesticated animals to England, to establish them for human food and/or for in rituals/entertainment. It is almost impossible to think that children did not carry small animals as pets on such journeys during Iron and Bronze Age travel too. Whether they survived, or were released or escaped in sufficient numbers to colonize is not known. What is known from archaeological investigation so far is that all of the generally accepted UK native herpetofauna

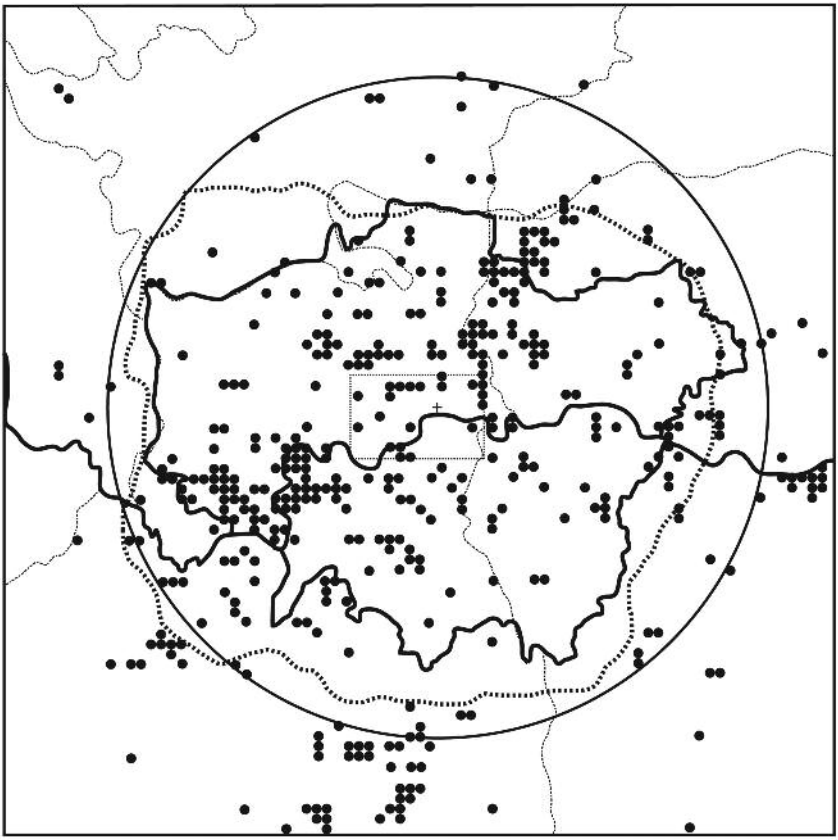


FIGURE 2. One-kilometre distribution records for all non-native reptile and amphibian records in the London Area over the period 1830 to 2011.

species in modern times are represented in the fossil/sub-fossil UK fauna after the last Ice Age, when they might be expected to have colonized naturally. They recolonized the land mass that is now Britain across areas that would then become eroded and flooded by sea level rise.

Development of London's pet trade

In the last century, although the human population of Greater London reduced from an estimated 8.6 to around 6.7 million between 1940 and the 1980s, there was growth on the outskirts of modern London with numerous new garden cities, new towns and other housing developments. At some point around the late 1950s, as British economic conditions improved, parents were more able to buy glass aquaria or 'tanks' or to have wood or plastic containers for children to keep pets at home than before, and garden pond building became more frequent. As access to wild areas in and around London to collect reptiles and amphibians was shrinking and books written for the American pet hobby market on home-keeping became available, demand for pet amphibians and reptiles in urban areas extended beyond the traditional sale of grass snake, sand lizard and slow-worm, to batches of animals sent from all over Europe to Britain in large quantities. Shops with extensive ranges such as the Harrods pet department and the (recently closed) Palmers Pet shop near Regent's Park offered a range of species collected in the wild. *Exchange and Mart* magazine became a main national advertiser to the public in the 1970s.

John A. Burton recalls from his youth in the mid 1950s (pers. comm.) 'The increase in European trade and imports of wildlife were on a massive scale. Despite researching it, there is relatively little documentation of this, with few records of either the species or the volume. It was not until Mike Lambert and I started writing about the tortoise trade in the 1970s, and Tim Inskipp wrote about the bird trade, that there seems to be much awareness of its impacts. Cage birds such as waxbills from Africa were sold for as little as 5/- a pair (equivalent today to about £6) and wall lizard from Italy for as little as 1/- each (£1.20). Tanks containing a squirming mass of lizards were a common sight in London pet shops, and among the frequent wall lizards there were undoubtedly a range of other species mixed in. I, like most other people (including most naturalists) were not aware that this was likely to cause any problems, and as a ten-year-old bought green lizards and several wall lizards, which rarely survived for more than a few months. This trade is apparent from the books of Alfred Leutscher, one of my mentors in the 1950s and '60s, and a senior member of staff at the Natural History Museum (Leutscher 1952).'

The sale of hatchling terrapins from North America saw noticeable growth in the 1950s, often together with a small plastic bowl to keep them in.

Today, Greater London holds about 3.2 million or twelve per cent of the UK's twenty-six million households. The numbers of mainly exotic pet reptiles and amphibians being kept is becoming easier to estimate. The Pet Food Manufacturers Association produces figures each year (web-based data) showing for example that in 2010 almost half of UK households had a pet, with on average one in five households having a dog or cat. While indoor tropical or cold-water fish remain highly popular, at around ten per cent or one in ten households, reptiles and amphibians appear to have increased to around one in twenty-five households (2.4 per cent), close to that of rabbits and indoor birds. This is made up from tortoises and terrapins (0.9 per cent), snakes (0.4 per cent), lizards (0.5 per cent) and amphibians (0.6 per cent). Very roughly, at present around 80,000 London households hold up to around 150,000 captive reptiles and amphibians. The UK level of exploitation can be compared with the USA where keeping of herps appears to be nearly twice as prevalent. In 1998 an estimated 3.9 million households (four per cent of total) held an estimated nine million reptiles and amphibians (Franke and Telecky 2001). Japan, another island with large populated cities, is reported to have 80,000 reptile keepers in fifty million

households in 2006, roughly half the ratio of the UK. European figures however, appear to be unavailable.

There was thought to be a near doubling in UK herp keeping from 1996 to 1998, partly a response to the improving economy and disposable incomes, the availability of cheaper cages and equipment and the position of reptiles as a substitute to the diminishing sale of wild-caught birds. There has been a second noticeable increase since 2005. There has been stimulation of trade by the entertainment industry promoting of reptiles and dinosaur imagery that has been taken up by the toy manufacturing industry increasing the desirability of them to children. Use of exotic pets in advertising such as showing lizards in glass tanks, combined with their image within nature programmes as beautiful and mysterious has produced interest that has transferred to making personal possession of them more common. One recent TV advert (for HSBC) has even shown a family moving home and abandoning their snake in their garden as they leave and then getting a new one for their new home. WA (author) as a teacher has evidence that some parents may choose the hypoallergenic nature of reptiles and amphibians — no fur or feathers — as a reason for buying their children pet reptiles, together with the misapprehension that they need less care than mammals and birds.

Background

Archaeological and taxonomic considerations

There are a few issues concerning the origins of the current British herpetofauna that remain unresolved and some details remain sketchy. One has been the subject of debate since the 1840s. The reconstruction of the historic herpetofauna of Britain since the last post-glacial period has not been published but there are a number of papers addressing those species that were present during the Holocene period and there are numerous sites where excavation of stratified deposits in caves and at other locations together with radiocarbon dating have revealed evidence of past faunal assemblages.

Information from dozens of archaeological sites around Britain that contain amphibian bones deposited since the last Ice Age, consistently reflect occupation by those species that are presently extant. For herpetofauna, the exception is a claim based upon two relatively recent heavily human occupied coastal sites from the Middle to Late Saxon period. These are for frog bone material from up to three frog species (Gleed-Owen 2000). There has been disagreement between experts in the field and the identity of the material remains uncertain and in need of independent scrutiny.

Generally, UK vertebrate bone deposits reveal a consistent assemblage of species, together with a proportion that have become extinct in Britain but that today inhabit the slightly warmer habitats of 'mainland' northern Europe. The London Area, like the rest of England, was colonized after the last glaciation by a range of species, that moved north with increasing temperature after the last Ice Age. This was at a time when eastern England was contiguous with Germany and southern Scandinavia and prior to the English Channel forming, with the gradual shrinkage and submergence of the Doggerland island around 8,000 years ago. The amphibian and reptile species found previously, yet now no longer present, include those that have had fragmented distributions in northern Europe as a result of climate, such as the European pond terrapin *Emys orbicularis* that is recorded in the sub-fossil record in Denmark (with Aesculapian snake) around 7,000 years ago. Generally the length and intensity of spring and summer temperatures dictates their ability to breed and feed.

Climatic and zoogeographic considerations

It is important in a description of London's non-native herpetofauna to consider the conditions required for the survival of these species. Climate change awareness has recently become a dominant factor in environmental protection.

Changing weather patterns bring alterations that can have huge evolutionary significance. Probably the first analysis of temperature as a limiting factor in distribution of herpetofauna is that of Sweden's amphibian and reptile fauna (Gilsen and Kauri 1959). Sweden is a country with similar species to England, albeit somewhat richer by virtue of a more Continental climate, as a function of it being part of the larger European land mass. As in Britain, species richness reduces towards the Arctic. In Sweden there are also similar historic trends in the loss of species over the last centuries, the nature of the surrounding North and Baltic Seas effectively giving south Sweden a degree of island-isolation from the south. Isolation and edge-of-range effects on species, in combination with land alteration by humans and human translocation of fauna and flora, mean that cautious interpretation is required. Further information on changing climate in Britain and movement of amphibians by humans is given in Appendix 1.

Wildlife trade

An early reference to importation of wild-caught non-native herps as pets to London and Britain can be found in *A natural history of Jersey* (Le Sueur 1976). The impending importation of reptiles is recorded in the 1760s with Jean Simon, a general merchant in Jersey writing to his son in England 'regarding the lizards — as it is no longer hot they are out very little, but if there is a boat going from here to London I will collect some for you'. Presumably these were green lizard or wall lizard. The pet trade that developed was prohibited by the Jersey government in 1947. This followed increasing intensity of collectors visiting Jersey. It reached an unsustainable level and controls were one of the earliest actions to prevent over exploitation of wild animals taken for the pet trade. Around that time, concerns regarding the uncontrolled taking and selling of wild animals were being more widely discussed in Britain.

Since around 1970, nature conservation awareness has grown in Europe, with national legislation being put in force. Over the same period and more recently in most countries, measures have further increased as a result of the European Economic Community Directives and Regulations. International Conventions, such as the Convention on International Trade in Endangered Species (CITES), have raised concerns regarding over-exploitation.

Legislation relating to restrictions in the trading of wild-collected animals had generally reduced much of the large-scale exploitation between 1970 and 1990. However, since then changes appear to have allowed the opening up of trade so that more species are available and in increasing volumes. Unfortunately, trade forces of a kind found in any commercial process have resulted in illegal trade, rule-bending and pro-trade techniques that apply to many kinds of restricted goods. Around the world domestic 'consumption' of animals for food, as live animals for trade and as components of souvenirs or potions, creates a problem that is as bad if not worse than the gradual loss of rare animals; the wide-scale depletion of commoner or more widespread animals.

There is also a growing debate about how to address the spread of non-native species and a range of views have been expressed. Considerations of these includes, but goes beyond, issues relating to reptiles and amphibians and are not dealt with to any degree here.

Species accounts — reptiles

European lizards and snakes

*c.*10 records inside, <10 records outside LNHS area.

WALL LIZARD *Podarcis muralis* (Figure 3)

Wall lizards were sold widely not only as pets but for school/laboratory use until the 1970s. They have also arrived accidentally within imported goods and escaped or were released. They seem dependent on the warm microclimate provided by

FIGURE 3. Wall lizard basking in the London Borough of Greenwich. *Photo: John Webb*

stone and rubble features, including old sunny walls with gapped rather than sealed mortar joints. Here they find safe retreat and egg-laying sites. Heat absorption by rock acts like a storage radiator and extends their daily activity period; they can be active throughout the year on sunny days on the south coast. Wall lizards have persisted for several years, or even decades at release sites but have not spread to any significant extent due to the lack of the particular warm conditions that they require. Colonization to distances of around 2,000 metres may be possible in areas with contiguous habitat and favourable microclimate such as on the Poole/Bournemouth cliffs in Dorset, where they have spread. This has possibly led to localized reduction in native sand lizards (BBC 2009). Many of the UK populations appear visually to resemble the subspecies *Podarcis muralis maculiventris, nigriventris* or *bruegemanni* originating from north-west Italy.

A national wall lizard project listing UK colonies past and present is run by the Surrey Amphibian and Reptile Group (SARG) and was summarized in print (Lever 2009). This has identified over thirty locations with small wall lizard populations and it estimates the UK numbers at over 20,000 animals. This number of locations reflects the unlawful (since 1981) release and spread of older releases of this non-native lizard along the south coastal cliffs and slopes of England by hobbyists. There is no evidence that this species will colonize London or spread over England widely even with future releases under current weather/temperature patterns although it can persist and spread locally if suitable conditions are created and maintained in gardened areas.

Our Society's members have commented on colonies in the LNHS area for some time. At the Beam Brook Nursery site in Newdigate, Surrey, wall lizards were established in the wild from the 1950s (Fitter 1959) and were present until around 1977, with individuals seen until the late 1980s. The first specific account of wall lizard in London was by Stiles (1979) in *The London Naturalist,* who recorded a population centred on an embankment and two railway bridges at Oldfield Road near Hampton Station in Richmond. They were reported in 1957 as already well established and were apparently reduced by repointing work on the bridges in 1973 although they were still present after twenty-one years in 1979 and could well have lasted thirty years or so. It is possibly the population in London, location unspecified, that is referred to by Edlin (1952).

There have, apparently, been wall lizards at the urban green spaces at Birdbrook/Kidbrooke in Greenwich since the 1970s, originating from animals bought locally at Well Hall pet shop. The colonization includes the release on the Birdbrook site of twenty-nine wall lizards obtained in 1978 by Charles Snell, a portrait artist, owning a garden backing onto the site (Snell 1981). They are

reported to have bred on the Birdbrook site with a young lizard being found in 1980 from breeding in 1979. It was apparently not until the 1980s that they were found 800 yards away (on Kidbrooke Green). Snell has reported that three sand lizards *Lacerta agilis* found on Birdbrook had escaped from his garden (pers. comm. to TESL). This continuous occupation by wall lizards over what is now around forty years may be the longest yet recorded in London. The population at one point was thought to have reached 1,000 individuals, but the sites have changed and been reduced by development over the years and recent reports put numbers at around 200 adults.

Other than a few sporadic records from inner London boroughs from time to time, there are no other known established populations of wall lizard other than the Richmond and Greenwich colonies within Greater London although some small ones could exist. At the edge of the LNHS area there is however a population at the former biological supply base (Xenopus Ltd) site in South Nutfield (see later) in what is now a private garden. Here around 300 adults are believed to be derived from lizards obtained from Bologna in Italy by a trade supplier. Also within the LNHS area is a small population at Banstead, close to garden centre boundaries, thought to be around sixty strong and to have been present since around 2007.

In the mid 1960s, just outside the LNHS boundary, around a hundred wall lizards that were reported as surplus from a pet shop in Slough were released by Tony Phelps at East Burnham Common (Berkshire) in an area that is now a part of Burnham Beeches National Nature Reserve. There is no evidence that they survived for long. Wall lizards were released at Box Hill in the 1960s too and no doubt many other places at that time when they were available at low prices and where they died out unrecorded within a few years.

GREEN LIZARD *Lacerta viridis/bilineata* and SAND LIZARD *Lacerta agilis exigua* (non-native subspecies).

Despite the frequency of green lizard *Lacerta viridis* and western green lizard *Lacerta bilineata* in the pet trade, there are few records of survival in the wild although a population of *bilineata* is now established over a small area on coastal cliffs in Dorset. Here a population is thought to date from unlawful releases in the 1990s, though it was not widely reported until 2004. Within the LNHS area a green lizard was rescued by M. Offer and other LNHS members in 1961, when it was being stoned by children by the river in Kingston-on-Thames. It was probably an escaped or released pet. Fitter (1949) wrote of 'large green lizard' records in the wild from Godstone that were also reported to Malcolm Smith but not verified, and an introduction at Frensham, all of which do not seem to have been further reported. Sand lizards from Russia, *Lacerta agilis exigua,* were released at Noak Bridge in Essex in small numbers during the mid 1990s but did not remain and some of them may have been recaught (TESL, pers. obs.).

In general, non- native lizards from mainland Europe do not appear to establish well in the London Area. This is perhaps not just due to poor climate. The urban 'heat island effect' would be expected to favour the establishment of oviparous / poikilothermic species and while they can survive from year to year and some can breed, they do not appear to flourish. London's dominant 'cold' clay soils and limited 'dry' stone wall habitat creates constraints as much as our climate does. Lizards might otherwise expand along corridors such as railway lines, road verges and canals in the manner of our native lizards. Domestic cat and brown rat predation can reduce lizards to extinction, and collection and persecution of them by humans are other factors. One or two wall lizard colonies hang on, and there are occasional reports of individuals being sighted but nothing to suggest general persistence. The variability in common lizard coloration from dark grey and green, red, yellow, and black-coloured individuals can lead to the misapprehension that a non-native species has been seen. In short, it is considered unlikely that

non-native lizard species will spread extensively in our area. Isolated populations may however continue to exist as long as they are 'gardened' by lizard enthusiasts.

Native species should obviously not be kept close to non-native lizards in captivity if they are to be released into the wild. There is, apparently, some circumstantial evidence that introduced wall lizard has caused the disappearance of native sand lizard *Lacerta agilis agilis* in Germany. On Boscombe Cliffs in Dorset there has been monitoring of the spread of wall lizard and western green lizard (Mole 2010). A new virus is reported to have been identified in wall lizard (BBC 2009). One theory is that it may be responsible for recent sand lizard decline and their removal may be required. Preliminary veterinary investigations are being considered (D. Bird, pers. comm.).

Tesselated or dice snake *Natrix tesselata*, viperine snake *Natrix maura* and non-native grass snake *Natrix natrix* subspecies

Although the native grass snake was sold frequently as a pet until around 1980, non-native subspecies and the other semi-aquatic dice snake and viperine snake were also imported from mainland Europe for sale and were equally frequently released or escaped. Numbers of records are low, perhaps reflecting that anyone seeing them might assume them all to be native grass snakes. There are records of dice snake from Epping Forest by Malenoir from the 1960s (Malenoir 1963) and a single record of two viperine snakes at Joydens Wood in 1953 (Edwards 1953). There are records from the last fifteen years of dice snake and Italian grass snake *Natrix natrix persa* from Beam Brook Nurseries. There is no evidence of these species breeding, but interbreeding of grass snake subspecies might not be detected. Populations of non-native grass snakes or hybrid populations have been suspected in several places in the UK where striped or other unusually coloured grass snakes have been found. This year (2011) tests have detected a breeding population of the genetically distinct Romanian grass snake (although still regarded as being the subspecies *helvetica* like our native grass snake) in the Aire Valley in West Yorkshire.

Aesculapian snake *Elaphe longissima* [*Zamenis longissimus*] (Figure 4)

This large egg-laying ratsnake occurs in at least twenty-six countries in Europe with a small population in northern Iran (Gasc et al. 1997). It has been lost from one country, Denmark, where it was apparently quite common in the 1700s north

Figure 4. Adult Aesculapian snake at the canal location in London Borough of Camden. *Photo: Will Atkins*

of its main current range. In Denmark, relict populations are thought to have become finally extinct around 1863. Several other isolated populations are still found around the edges of its main range and are thought to be remnants of a former, much wider distribution, dating back to when the climate was warmer although human introduction could be a contributing factor.

Today, populations occur closest to Britain in north-west France. In western Europe there are several clearly introduced populations. In Britain a single site has been reported since the 1970s at the Welsh Mountain Zoo in Colwyn Bay, north Wales where a population of low hundreds of snakes has built up since the 1960s (Lever 2009) both within and some distance from the zoo. There they play an integral part in the local food chain and are also taken by many captive animals in enclosures. A second feral population has been extant since the mid 1980s along a canal embankment habitat in Camden, north London. This was first reported to TESL in 1998 by Ester Wenman, then head keeper of reptiles at London Zoo. Aesculapian snakes had apparently colonized the area during an experiment reported by the British Herpetological Society Legal Officer, Peter Curry, who was working there and keeping this species at the Inner London Education Authority Centre for Life Studies at the time that it was closed down around 1986. One account was that eight snakes had been released 'on the quiet' around the time of closure to try to form a population, several of which were recaptured, but some remained at large. Those caught initially were being euthanased but the view was then taken to leave the others 'to take their chances' where they were. Ten years later, in an aviary close to the embankment, fragments of juvenile Aesculapian snakes were found in a laughing thrush *Garrulax* sp. aviary, suggesting that the snakes had bred. Hatchling Aesculapians range from 120–370 mm body length. Breeding was not perhaps that unexpected in retrospect due to the hot dry summers of the late 1980s and mid 1990s when egg incubation could have been successful, especially since the snakes seek artificial warmth-producing sites such as manure and compost heaps in a similar manner to grass snake. In addition to the suspected 1995 breeding, a young snake was found in June 1999 at 250 mm total body length; suggesting a hatchling from the previous autumn (1998). Several newly born snakes were found in the basement of a building around thirty metres from the embankment in 2010 and breeding in that year was also shown in 2011 with a young 2010 cohort snake being located. To date this is the only example of a non-native snake species breeding successfully and forming populations in the wild in London and the UK as a whole.

Further observations

Detailed observations of adult snakes and including the young from 1995/1998 have been made at the location (by WA) between July 2007 and Sept 2010 and since then, in 2011 along 1.1 km of canal bank. To date around thirty different adults have been identified using the snakes' unique head-scale patterns and photography. Over this period the first and last season records for any year were 26 April (2010) and 30 September (2007). The air temperature during sightings were; lowest 19°C and highest 24°C. Of the thirty records, there was only one in April, in May seven records, June eleven, July four, August three, and in September four, suggesting a restricted active season peaking in June of only around five months in the cooler climate of northern Europe. Several mature snakes were found three years running in the same patch of habitat/bush at set times of year, although they may range more extensively at other times and a few individuals were seen at distances of up to 300 metres from original positions. Most were observations of older snakes in low bushes, inactive and basking in partial or full sunshine. Several observations were made of snakes partly hidden in semi-shade along the ecotone between denser scrub and wooded slopes and the more-exposed grassland.

Almost all observations were of snakes on the southern — i.e. north-facing side of the canal, often in moderately dense secondary woodland of hawthorn, birch,

oak and horse chestnut originating from formal planting with bramble and bare patch understory. This use of wooded habitat corresponds with that reported as favoured in its natural range. Lack of observations on northern, i.e. south-facing bank is possibly observer bias due to difficult access and denser vegetation on that side of the canal. Almost all snakes when located were inactive and basking. So far no clear mating, hunting or feeding behaviour has been seen. One female was seen on leaf mould in June exploring, perhaps prospecting for an egg-laying site, and in July 2011 a female which had recently laid eggs was seen. There is a large heap of leaf mould next to the old Education Centre building and several rotting tree stumps along banks of the canal and manure heaps/compost heaps in the vicinity. No signs such as eggs or old eggshells have been found or reported. One adult was known to have crossed the main canal, presumably by swimming rather than using a footbridge. One adult was also seen at twilight during a guided bat walk. Reduction in snake sightings in high summer was thought perhaps to be due to snakes becoming more arboreal to compensate for canopy closure in wooded areas, or simply because high stands of bramble, nettle and hawthorn scrub make observations more difficult. There is evidence now that some have dispersed to be found in a new parkland area across a busy main road and around 500 metres away from the initial release area.

In the recent study, snakes were mainly of mature animals ranging from 700–1,500 mm in length; however lack of scope to place survey refuges may well have led to underestimate of juvenile snakes, which are often found sheltering under artificial sun-warmed materials. With respect to diet, one snake dropping was analysed and found to contain mouse hairs. Lizards, which are reported to form part of the juvenile diet, are not present on the canal, but common frog (breeding in the Zoo's Cotton terrace and wildlife pond) and nestling mammals may be available for hatchlings to eat. One snake was found in an empty bird's nest in June, but there was no direct evidence it had fed on eggs/nestlings. Snakes were observed by keepers (pers. comm. to WA), to be attacked by magpies regularly. A small rodent was seen to be taken from a snake by a magpie outside the Education Centre (zoo volunteer, pers. comm. to WA). Young brown rats may be a source of food for snakes in zoo and canal situations. A healed wound showed damage to the neck of one snake, possibly caused by a fox, cat, brown rat, or corvid, or by the action of grounds maintenance machinery.

Public awareness of the snakes has been allowed to spread through internet sites that encourage collecting and keeping reptiles as well as by mention in publications. The population is likely to be limited through collection, persecution, inbreeding, lack of egg-laying sites, or extreme events such as fire and isolation. The small population with its apparent current expansion warrants further study.

Non-European lizards and snakes

With LNHS recording of released and escaped pets and laboratory animals in the last century, the number of records was relatively low. Yalden (1965) produced a short list of species arriving from overseas having hidden in commercial goods such as typewriters and being detected without the animals getting into the wild. Today hardly a week goes by without a small amphibian being found in a bunch of grapes or lettuce in a supermarket; just about any small animals can appear anywhere at any time although most fail to reach the wild. Animals find their way back from foreign lands in suitcases too. Most are the smallest and commoner species. There seems little point in documenting the large number of reported escaped species. These now struggle to achieve a line in local newspapers, which earlier they often did. There are any number of snakes and lizard escaping, mostly inside houses but in summer months leaving through open doors and windows into gardens. Some are found in cars in garages, others in public parks, and most slowly starve if they are not located. The internet is a rich source of information, showing how casual the appearance of non-natives has become. As one web blogger indicated 'I don't think it is surprising that there are so many alien herps knocking

around in Essex. Essex is a bit like Miami — it was once (and still is to a degree) the reptile importing centre of the UK. Having grown up there it always amazed me how many importers and animal dealers (including fish, birds, etc.) there were in eastern London and out into Essex, especially along the arterial road to Southend. It's not surprising with so much availability of species that there are so many escapees/ releases in the county over the years. I was once told of a whole shipment of *phelsumas* (geckos) that broke when it arrived at a shop, resulting in day geckos wandering around Benfleet for quite a few months in the early 1990s.'

There has been an almost brutalization of the public into seeing small exotic animals as a desirable yet often disposable commodity (see for example *Essex Jungle,* Channel 5 TV, May 2011). This has moved on to a point where proliferation of them as a short-term novelty is considered acceptable and effectively, with the formation of selective breeding of colour morphs into a true 'fancy' with all the quirkiness of budgerigar and miniature dog breeds, based on unusualness and rarity (Bartlett 1987). This is despite the behavioural and physiological needs of particularly reptiles being far more subtle than many or most other species.

Some of the more regular escapes and abandonments are of iguanas. People like iguanas, perhaps because they look to some extent like dinosaurs, but they are not suited to Britain, and it is very hard to give them enough room in a house even when a whole room is devoted to them. They can reach over 1.5 metres in length and are not easy to keep as they mature. Many are abandoned or given up to specialist rescue centres including those run by the RSPCA which receives an annual average of one call a day relating to iguanas. They need a lot of room as well as heating. They are usually imported from Central America and Mexico at around six months old, and are attractive, with vivid colours. Adult male iguanas can also be aggressive. Males have a strong mating drive, which becomes apparent from the age of two years, and they may periodically try to mate with female humans, this includes powerful and painful biting and scratching. The RSPCA uses specialist rescue centres for iguanas, but there is not always enough capacity and they are often euthanased. Owners may abandon iguanas in open spaces if rescue centres cannot take them, but this leaves the iguanas to die from hypothermia and starvation, since they are not adapted to our climate.

Tortoises

Tortoises of the genus *Testudo*, mainly spur-thighed tortoise *Testudo graeca* and Hermann's tortoise *T. hermanni,* but also Horsfield's tortoise *T. horsfieldii,* were imported in hundreds from the late Victorian period (RSPCA 1979) and probably in quantities of several thousand each year. By 1938 over 250,000 were imported per year, many of them juveniles. They seem to have been the first widely sold non-native reptile pet and symbolized garden ownership and people at home during the day with the time to move them in and out according to the weather. Tortoise keeping was promoted from 1964 by the Blue Peter children's TV programme and demand escalated as a middle-class trend with an average of 200,000 tortoises recorded as imported per year in the 1960s and 1970s. This was an inhumane trade with high mortality at every stage and almost all dying within a few months (RSPCA 1979). It continued on a large scale until the ban on mass trade of European tortoises in 1984. CITES figures show that in the period leading up to the ban, between 1980 and 1984, 150,000 European tortoises were brought into the UK with many being crudely crated and dead on arrival. Many released in gardens escaped to uncertain fates. WA remembers seeing escaped tortoises on several occasions along the old railway line at Parkland Walk in Crouch End, Haringey in the 1980s. There are an estimated 15,000 tortoise keepers in the UK today of which perhaps 2,000 are based in Greater London. This means that on average tortoises are spaced about a kilometre apart from each other and probably around 500 metres apart in urban areas. A distribution map of them would effectively be the same as that of urban housing although many sadly are confined to glass tanks rather than larger secure and

heated outdoor enclosures. A proportion, perhaps ten per cent, are free-roaming within gardens so effectively 'wild' albeit mostly unable to escape. From the mid 1980s a range of other species began to replace the European tortoises, with, for example, imports of box turtles *Terrapene* spp. from the USA reaching around 4,000 per year (Warwick 1987).

Tortoises struggle in the UK climate and require careful management. As one web blogger put it recently 'I cannot think it appropriate to keep a reptile which loves warmth, hates the rain (which drums on its shell), will not breed (unless kept in an indoor vivarium), hibernates from November to April and does not relish food for some time after waking or before returning into torpor. The way Gilbert White's "Timothy" would prop his body up against the garden wall to absorb as much of the weakening autumn sunshine as he could seems to say it all and suggests a creature that should be somewhere else.' Equally, a comment in the European herp field guide (Arnold et al. 1978) seems apposite 'unless they receive a great deal of care they live a travesty of their natural existence. The average semi-moribund captive tortoise bears no comparison with the alert, vigorous, herb scented beasts that plough through the undergrowth of southern Europe.'

Terrapins and freshwater turtles

The word 'terrapin' is a general one in British English language for freshwater chelonians with a hard external shell. This is unlike North America where the word 'turtle' covers all shelled reptiles, and the vernacular terms slider and cooter are used instead or in addition or for particular groupings of species as well as in species common names. In North America and elsewhere, compared with Europe the variety of species is much larger. In the UK, the word 'turtle' tends to be mainly used in reference to marine chelonians, with 'softshell turtle' a reference to species with a soft surface that feels and looks like rubber. The term 'freshwater terrapins and turtles' covers the two principal non-marine groups.

The terrapin trade, like the tortoise trade, has seen restrictions since the original mass importations. Initially the predominant species in trade and released into the wild in London and the UK was largely the red-eared terrapin *Trachemys scripta elegans*. Following import restrictions within the European Union in 1997 a wider and growing range of look-alike or substitute species have replaced them, originating from around the world, including species from Australia, Africa, Asia and the Americas. Today in the London Area we have identified at least twenty-two different types of terrapin, mostly species or subspecies but some intergrades and hybrids that are the result of breeding in captivity and illegal abandonment by the public. Table 1 lists the types that have been identified largely from photographs, reliable accounts and recaptured individuals. There are at least a further seven types including several subspecies and possibly many more that are present elsewhere in the UK and with probable or possible reports and sightings within the London Area but as yet no absolute confirmed record. The range and variety of terrapins released to the wild since the late 1990s is not picked up in the recent non-native species review by Lever (2009).

Figure 5 shows the distribution of all freshwater terrapin and turtle sightings in the London Area since records began around 1910, almost all of which are post 1980. This covers over 300 records over this period describing over 2,000 individual terrapins over the last thirty years.

The distribution of terrapin records is relatively even across the area and generally reflects the available aquatic freshwater habitat; ponds, lakes, other larger water bodies and the canals, streams and rivers of London. Locations reported include many Borough Council-managed parks and gardens, those larger open spaces managed by the Corporation of London, Royal Parks, English Heritage, and several nature reserves and wetlands centres run by charities such as The Royal Society for the Protection of Birds, The London Wildlife Trust and The Wildfowl and Wetlands Trust. Examples of those within the LNHS recording area to date are listed below. Those actively birdwatching are invited to include

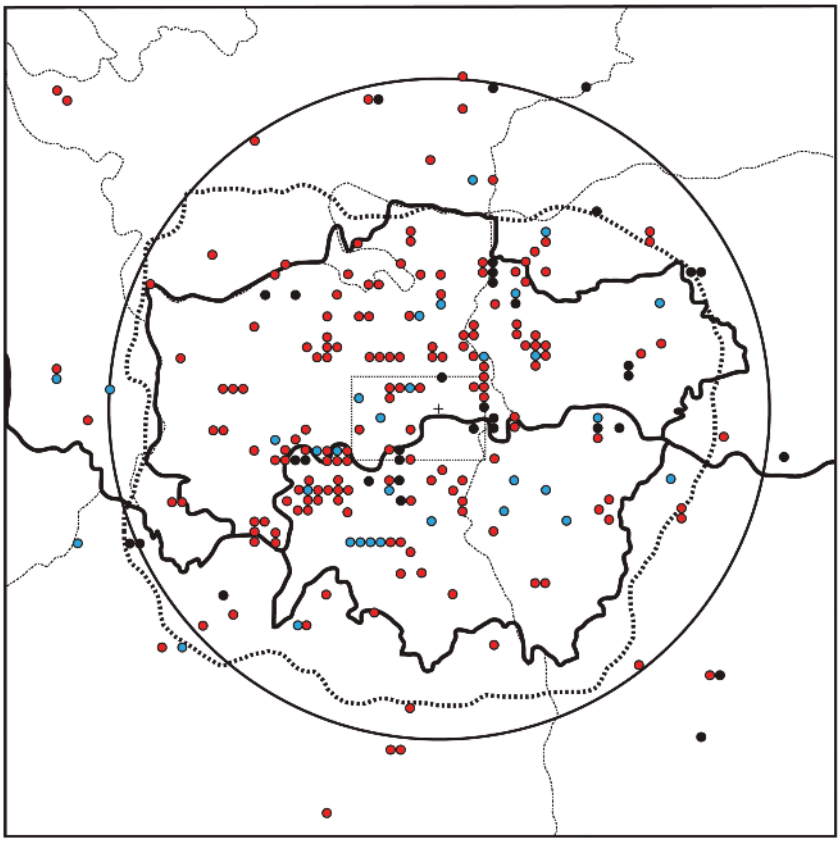


FIGURE 5. One-kilometre distribution records for freshwater terrapins/turtles in the London Area to 2011.

Red dots = 'red-eared type', Black dots = at least one non 'red-ear type', Blue dots = 'red eared type' and at least one other terrapin type.

the reporting of terrapins in their regular and one-off recording excursions and to encourage their friends to report them too, to the LNHS recorder for herpetofauna.

Examples of park, reservoir, river and nature reserve locations with terrapin records within LNHS recording area are listed below. Many of the canal systems have multiple records over long distances:

Middlesex, Hertfordshire and Buckinghamshire: King George V Reservoir, William Girling Reservoir, Brent Reservoir, Hampstead Heath, Chiswick House, New River Walk, Lots Ait, Boston Manor Park, Middlesex Filter Beds, Canons Park, Gladstone Park, Fryent Country Park, Roundwood Park, Alexandra Park, Tottenham Cemetery, Camley Street Natural Park, Meanwhile Gardens, Regent's Park, Waterlow Park, Grand Union Canal, Gillespie Park, Finsbury Park, Carville Hall Park, Gunnersbury Park, Holland Park, Horsenden Hill, Kensington Gardens, St James's Park, Chelsea Physic Garden, Osterley Park, Bedfont Lakes, Grovelands Park, Watford Town Centre, Black Park. **Essex:** Epping Forest, Wanstead Flats, Highams Park, Clissold Park, Walthamstow Reservoirs, City of London Cemetery, Victoria Park, Canary Wharf, East India

Dock, Old River Lee. **Surrey:** Morden Hill Common, Mitcham Common, Lonsdale Road LNR, Rectory Park, Wandsworth Common, Bushy Park, Hampton Court, Syon Park, Ruskin Park, River Hogsmill, Battersea Park, Wandsworth Common, Chertsey Lake, River Wandle, River Quaggy, Tooting Common, Kew Gardens, Chislehurst Common, Richmond Park, Clapham Common, Epsom Common, London Wetland Centre Barnes, Cannon Hill Common, Sydenham Wells Park, Bushy Park, Mercers Park, Putney Heath, Wimbledon Common, Ham Common, Crystal Palace, Tooting Common, Kelsey Park, Ruskin Park, Bookham Common, Beddington Gravel Pit. **Kent:** Keston Ponds, Southmere Lake, Foots Cray Meadows, Greenwich Ecology Park, Canada Water, Dulwich Park, Lesnes Abbey Wood.

The number of terrapins at any one location reported ranged from one to 180 individuals. Sightings of two to ten terrapins were most frequent. The maximum number of terrapin types (species, subspecies or intergrades/ hybrids) present was six (Clissold Park, Hackney) and only twelve sites had four or five types recorded together and all of these where trapping revealed numbers rather than distant observation.

TABLE 1. Species of freshwater terrapin/turtle that have been reliably recorded within the London Area.

Red-eared terrapin	*Trachemys scripta elegans*
Yellow-bellied slider	*Trachemys scripta scripta*
RET/YBS hybrid	*Trachemys scripta elegans* × *Trachemys scripta scripta*
Other slider intergrades	*Trachemys* sp./ssp. × *Trachemys* sp./ssp.
Cumberland slider	*Trachemys scripta troostii*
Painted terrapin spp.	*Chrysemys picta*
American red-bellied cooter	*Pseudemys rubriventris* (see text)
Hieroglyphic river cooter	*Pseudemys concinna hieroglyphica*
Cooter/slider hybrids	*Trachemys* sp. × *Pseudemys* sp.
Diamondback terrapin	*Malaclemys terrapin*
Common snapping turtle	*Chelydra serpentina*
False map turtle group	*Graptemys pseudogeographica* group
Black knobbed map turtle	*Graptemys nigrinoda*
Ouachita map turtle	*Graptemys ouachitensis*
Common musk turtle	*Sternotherus odoratus*
European pond terrapin	*Emys orbicularis*
Spanish terrapin	*Mauremys leprosa*
Chinese softshell turtle	*Pelodiscus sinensis*
Spiney softshell turtle	*Apalone spinifera*
Unidentified softshell turtle	*Apalone*/*Pelodiscus* sp. (not Chinese or spiney)
Snake-necked turtle	*Chelodina*/*Macrochelodina* spp.
African helmeted turtle	*Pelomedusa subrufa*

TABLE 2. Other species of freshwater terrapin/turtle with wild sightings or captures elsewhere in the UK and probable or possible reports and sightings but no confirmed record within the London Area. Some of these species stay almost permanently hidden from view.

Eastern river cooter	*Pseudemys concinna*
Florida red-bellied turtle	*Pseudemys nelsoni*
Peninsular cooter	*Pseudemys peninsularis*
Razorback musk turtle	*Sternotherus carinatus*
Alligator snapping turtle	*Macrochelys temminckii*

The following accounts and descriptions will hopefully assist those interested in recording and reporting these species. Please report any further sightings to the LNHS recorder for amphibians and reptiles.

RED-EARED TERRAPIN (RET) *Trachemys scripta elegans* (Figure 6)

See Frontispiece.

100s of records inside, *c.*10 records outside LNHS area.

FIGURE 6. Red-eared terrapin on land at Sheepwash Pond, Barnet in 2006. *Photo: Liz Barrett*

Also called red-eared slider, this is the most frequently released and reported species and it represented most of the pet terrapin trade until around 1997 when lookalike species were substituted. It has a noticeable red bar or ear behind its eye that can be variable in size, shape and colour. It can be confused with the rarer Cumberland slider that also can have an orange/red two-tone eye bar. Hybrids and intergrades may or may not retain some kind of 'ear' marking. Together these are referred to as 'red-eared type' terrapins, to take account of the difficulty in distinguishing them. Upon close inspection and with good photographs most are currently 'pure' red-eared terrapins. When young, like many terrapins, red-eared terrapins have a more carnivorous diet and feed on fish fry, amphibian spawn, tadpoles and adults and invertebrates. Some aquatic plant material is also taken but when adult they become mainly herbivorous although they will continue to take carrion. In one London park terrapins began feeding on bread that was being thrown for ducks.

Occupying freshwater wetland habitats, and originating from central and southern USA, it is a species that has become established around the world as a result of captive breeding and ranching and its subsequent mass sale and abandonment. This species has been wrongly accused in the press of attacking ducklings and other small wildlife (e.g., Yapp 2004, Lloyd 2005) often when other predatory species such as northern pike *Esox lucius* or the introduced wels catfish *Silurus glanis* are more likely to be responsible (e.g., Anon. 2005*a*). In consuming quite large amounts of vegetation, however, the species may alter smaller pond ecosystems. At Sheepwash Pond in Barnet it was loss of condition in the previously varied aquatic plant community that in part instigated the concern for terrapin removal (local volunteers, pers. comm.) although it was not proven that the terrapins had played a role in significant change to vegetation.

YELLOW-BELLIED SLIDER (YBS) *Trachemys scripta scripta* (Figure 7)

See Frontispiece.

The yellow-bellied slider is very is closely related to the red-eared terrapin but with no red ear mark. There is a diagnostic yellow-coloured 'S'-shape marking running from behind the eye down to the lower side of the neck. Its origin is the south-east USA. Diet is the same as red-eared terrapin.

FIGURE 7. Yellow-bellied slider with some cooter characteristics. This individual may be the result of cross-breeding in the wild or captivity prior to sale as a pet and its abandonment. *Photo: Liz Barrett*

RED-EARED × YELLOW-BELLIED intergrade *Trachemys scripta elegans* × *Trachemys scripta scripta* (Figure 8)

FIGURE 8. This red-ear × yellow-bellied intergrade shows the yellow 'S' shape of yellow-bellied slider and the red 'ear' of a red-eared terrapin. *Photo: Roman Muryn*

Other intergrades/hybrids *Trachemys scripta troostii* × *Trachemys scripta scripta* (Figure 9)

FIGURE 9. This male *Trachemys* is probably an intergrade and appears biased towards a Cumberland terrapin *Trachemys scripta troostii*. *Photo: Tom Langton*

CUMBERLAND SLIDER *Trachemys scripta troostii*

A semi-aquatic species found originally in east-north-eastern Tennessee and the extreme south-western corner of Virginia. Also released elsewhere in south-east USA and found in trade but mainly as intergrades. This species prefers quiet ponds, lakes, and streams with lots of aquatic vegetation and muddy bottoms. It is primarily carnivorous as a juvenile and omnivorous as an adult.

PAINTED TERRAPIN *Chrysemys picta* (Figure 10)

FIGURE 10. Painted terrapins can have very vivid red markings on their shell and neck. *Photo: Roman Muryn*

This is the most widespread native terrapin in North America, occurring in slow-moving fresh waters, across the entire continent from southern Canada to northern Mexico. Its diet includes water plants, algae, small invertebrates and fish fry.

COOTER; *Pseudemys* type, including RIVER COOTER *Pseudemys concinna* (Figure 11), the NORTHERN or AMERICAN RED-BELLIED COOTER *Pseudemys rubriventris*, FLORIDA RED-BELLIED COOTER *Pseudemys nelsoni* and HIEROGLYPHIC RIVER COOTER *Pseudemys concinna hieroglyphica.*

FIGURE 11. River cooter *Pseudemys concinna*. *Photo: Roman Muryn*

The cooter carapace is not highly domed. It can have brown or yellowish markings, and the pleural (side) scutes can have C-shaped marks. Older males may become very dark obscuring earlier pattern. Hatchlings have a central keel

which disappears with age. There are a range of cooter subspecies throughout the USA where they occupy rivers, lakes and a range of wetlands and coastal areas and there are several declining types. Often largely herbivorous, they are opportunistic and have tooth-like cusps in the upper jaw for crushing leaves and fibrous aquatic and terrestrial plants. They will eat fallen fruit as well as forage for small fish.

DIAMONDBACK TERRAPIN *Malaclemys terrapin*

The diamondback is native to the brackish coastal swamps of the eastern and southern United States, from Cape Cod south to Massachusetts to the southern tip of Florida. It reaches around the Gulf Coast to Texas. Diet includes molluscs, crustaceans and small fish. This is a rarer species that commands higher value in trade.

COMMON SNAPPING TURTLE *Chelydra serpentina* (Figures 12 and 13)

FIGURE 12. Snapping turtle in captivity at a rescue centre under veterinary care. Some of the short fine lines on the carapace (shell) are parasitic worms. The green tint on the nose is caused by the disinfectant bath this turtle was being treated in. *Photo: Tom Langton*

FIGURE 13. A common snapping turtle swimming, viewed from underneath showing reduced plastron and thick limbs and neck. *Photo: Roman Muryn*

Snapping turtles are large freshwater species, distributed from southeastern Canada to the Rocky Mountains. They are widely introduced outside their range in the USA and south from Mexico to Ecuador. They have powerful beak-like jaws and a dexterous elongated retractable neck. Locally in the USA they are

frequently and probably increasingly hunted for use to make turtle stew/soup. They are dangerous to handle due to a very powerful bite and sharp-edged jaws. These turtles can live to approaching fifty years in captivity, while the lifespan of wild individuals is around thirty years.

Snappers live in shallow ponds, lakes and streams with tolerance of brackish conditions. They occasionally bask on trees and logs in the water but in the UK are seldom seen basking. In shallow waters, they may sit on a muddy bottom stretching their long necks to the surface to breathe, with the forward-pointing nostrils functioning as snorkels.

Snapping turtles are omnivores, consuming both plant and animal matter, and are important aquatic scavengers; but they are also active hunters that prey on anything they can swallow, including crayfish, fish, frogs and reptiles. This also includes juvenile and adults of the smaller terrapin species, and invertebrates, birds and small mammals. There is some indication that in some cases, once reaching around five years of age the species behaviour shifts and they become more predatory, killing and leaving prey for future consumption on the bottom of a water body and in this way may possibly influence small closed water-body communities more significantly.

The alligator snapping turtle *Macrochelys temminckii* is a large turtle not dissimilar in appearance to the common snapping turtle with a big head, up to 80 kg (176 lb) in weight and sometimes more. It is reported to be much rarer and occasionally the media will run scare stories about one being present or possibly present and to be taking large prey. There are unproven rumours of swans and small dogs being taken. There are media reports of possible wild alligator snapping turtles, including a BBC report in 2005 in the River Lea 'Boat trip fuels "river croc" tale', when a Canada goose was reported to have been dragged under water. The species appears to fetch a high price tag and in Essex is reported by one rescue centre to attract the persons who might also keep a dangerous dog as a status symbol. Although there is circumstantial evidence that alligator snappers have been released in Greater London and the LNHS/London Area in general we have not yet documented an authenticated record. They have however been removed from water bodies elsewhere in the UK in recent times.

Map terrapins *Graptemys* spp. (Figures 14–17)

False map turtle	*Graptemys pseudogeographica pseudogeographica*
Mississippi map turtle	*Graptemys pseudogeographica khonii*
Ouachita map turtle	*Graptemys ouachitensis*
Black knobbed map turtle	*Graptemys nigrinoda*

Figure 14. Unidentified *Graptemys* sp. at a Hampstead Heath pond, May 2011. This illustrates how shadow and light contrast can make exact identification at a distance very difficult. *Photo: City of London Hampstead Heath*

Graptemys is a genus of small aquatic freshwater turtles that are hard to identify without a close-up photograph or them being in the hand. Females can get up to female cooter size. They make up a small but significant component of terrapins being found in the London Area. They occur throughout the eastern half of the USA and in southern Canada and can have features resembling those of other species of aquatic turtle but are distinguished by a keel sometimes with serrations or knobs that runs the length of the centre of their carapace. They are sometimes also called sawback turtles although this name is less well used. The name map turtle is due to some having map-like fine line markings on the carapace although these are not always obvious. Map turtles are omnivorous and consume invertebrates as well as vegetation.

FIGURE 15. False map turtle *Graptemys pseudogeographica pseudogeographica* with two hockey stick-shaped marks on the top of its head. *Photo: Jo Jeynes*

FIGURE 16. Mississippi map turtle *Graptemys pseudogeographica khonii* with crescent-shaped mark going under its eye. *Photo: Roman Muryn*

FIGURE 17. This capture resembles an Ouachita map turtle *Graptemys ouachitensis* with two bold face marks above and below the mouth. *Photo: Tom Langton*

The Ouachita map turtle, as with other map turtles, might be expected to survive better in the UK than others, it having a more northerly natural range. A further species, the black knobbed map turtle *Graptemys nigrinoda*, has been reported by trappers but is not currently thought to be commonly in trade. Sizes have been recorded as up to 100 mm in males and 190 mm in females. This species has been observed to consume beetles and dragonflies but diet includes a lot of vegetation, and animal food is reported to include freshwater sponges, bryozoans, and molluscs.

COMMON MUSK TURTLE *Sternotherus odoratus*

Widespread across North America, these small terrapins are carnivorous and have long necks assisting hunting of crayfish, clams, snails, insects, fish and carrion. Also called stinkpots as when threatened they can secrete a foul-smelling, yellowish fluid from musk glands under the edge of the carapace. This species likes to bask in shallow water, or amid floating vegetation, with the centre of its carapace exposed to the sun. Highly aquatic, these turtles rarely leave the water and hence are probably under recorded as they should survive in the UK climate.

EUROPEAN POND TERRAPIN *Emys orbicularis* (Figure 18)

*c.*10 records inside and 2 records outside LNHS area.

FIGURE 18. European pond (tortoise) terrapin. *Photo: Roman Muryn*

European pond terrapins are distributed across southern and central Europe, west Asia and North Africa and there are many subspecies. In the early post-glacial period, the pond turtle had a wider distribution, being found in the UK and southern Sweden. The species is considered semi-aquatic, and they can range on land up to 4,000 metres from water. As a common animal in trade until the 1970s there have been numerous attempts to establish this species in northern Europe and frequent garden escapes. Released animals may survive for some time but other than close to their natural range (including in the UK), any eggs laid outdoors do not get high enough incubation temperatures to hatch. Pond terrapins have been imported since Victorian times and two of the early releases in the London Area were at Shere and Frensham in Surrey (Fitter 1949, 1959). Yalden (1965) reported them as a common pet and subject to numerous attempts at introduction. Lever (2009) felt that nine terrapins caught in north Surrey in 1948 could be descendants of those released at Frensham before 1911, but there is no evidence for this and lack of UK outdoor breeding records suggests that this is unlikely. Lever's suggestion that with climate change it may become widely established depends on whether the climate gets hotter or colder. There is no evidence that the species is widely released any more nor that it survives very long once released. Its nearest natural breeding site in France is around 200 km south of Paris. Omnivorous, like other turtles its diet may become more herbivorous with age.

SPANISH TERRAPIN *Mauremys leprosa*

Colours range from orange-brown to olive. Young can have small orange or yellow markings on scales. Their plastron is yellow with a dark patch sometimes with a light line running down the middle. Their head and neck have a light striped pattern. They feed on small fish, amphibians, tadpoles and insects and sometimes on plants. Apparently tolerant of polluted water. There is a record of two individuals from a small pond at the Middlesex University site at Cat Hill.

SOFTSHELL TURTLES *Pelodiscus, Apalone* and *Trionyx* spp. (Figures 19 and 20)

FIGURE 19. Softshell turtle captured at Sheepwash Pond, Barnet. *Photo: Liz Barrett*

FIGURE 20. Softshell turtle recently caught from a lake north of Harlow.
Photo: Tom Langton

Apalone are North American softshell turtles and those appearing in trade and abandoned include *A. ferox* Florida softshell, *A. mutica* smooth softshell and *A. spinifera* spiny softshell, that were previously assigned to the North American species of the genus *Trionyx,* that still refers to some of the softshell species found in Asia. They are mainly piscivorous. The Chinese or Asiatic softshell turtle *Pelodiscus sinensis*, formerly known as *Trionyx sinensis,* has a natural range across China, Korea, north Vietnam, Japan, and Russia and is bred in captivity in massive numbers in China. Like the common snapper they often rest part-submerged in silt in shallow water, snorkel breathing and ambushing passing crustaceans, molluscs, insects, fish, and amphibians. Chinese softshells, like snapping turtles, replaced red-eared terrapins in the pet market and are substantially better adapted to cold climates. They probably represent a higher ecological impact; softshells are a very cryptic species and significantly more carnivorous than the red-eared terrapin.

AFRICAN HELMETED TURTLE *Pelomedusa subrufa* (Figure 21)

FIGURE 21. African helmeted turtle caught at Hampstead Heath, Camden.
Photo: City of London Hampstead Heath

This is a fairly widespread semi-aquatic African species living in rivers, lakes, marshes and temporary pools. Omnivorous, they will eat insects, small crustaceans, fish, earthworms, snails and carrion. They are reported to feed in groups at the water's edge by dragging and drowning small vertebrates. Due to its tropical environmental needs it is incapable of surviving a British winter.

SNAKE-NECKED TURTLE *Chelodina*/*Macrochelodina* spp.

Turtles that are native to Australia, New Guinea and the Indonesian archipelago with oval-shaped carapaces. They are side-necked turtles tucking their head around the side of their body when threatened rather than backwards into their shell. They are fish feeders and remarkably six individuals were reported as caught using a basket trap from one location in Harlow in 2011.

Basic freshwater terrapin and turtle identification in the London Area

Terrapins/turtles have very good eyesight and are naturally skittish. Most disappear into the water very quickly when you get within thirty metres or so. A good pair of binoculars is all but essential for viewing from the bank, or better still a good telescope or camera with telephoto lens. If water is clear, polarizing sunglasses may help when looking for them submerged under the water from the bank or from a boat. They are inquisitive and sitting patiently often is rewarded with their cautious reappearance. Most of the shelled animals seen in the UK will be American so the guides recommended are American.

The best starting book is *Turtles of the United States and Canada* (Ernst et al., currently 2009 edition) but it is quite expensive. The National Audubon Society's *Field Guide to North American Reptiles and Amphibians* is a good cheaper option. Also useful and cheap are the *Golden Field Guides — Reptiles of North America*. Be aware that the Latin names of some species have been reclassified recently. Note that terrapins from eggs incubated at too high temperatures and fed incorrectly can have malformed shell shapes and be hard to identify easily.

SLIDERS *'red-ear type'*

The terrapins or sliders with 'ears' or red patches behind the eye tend to be red-eared sliders *Trachemys scripta elegans* or Cumberland sliders *Trachemys scripta troostii.* Cumberlands are rare and the ear is often pinkish or yellow-orange-to-red and often darkening from front to back. They have a dome-shaped shell that is dark greenish through to dark brown or black. Sometimes a pale stripe is present through each scute.

SLIDERS *'yellow-bellied type'*

The yellow-bellied slider *Trachemys scripta scripta* is closely related to the red-eared but with no red ear mark and you need to look for an S-shaped marking running from behind the eye down to the lower side of the neck. ***Remember S for Slider.*** When these intergrade with red-eared or Cumberland the red 'ear' is usually lost but you can get a colourless patch in that area. With practice you may be able to recognize 'pure' yellow-bellied with the help of a good picture for later verification. Sliders interbreed/hybridize with cooters (below) and you can get a cooter and slider combination of markings on these animals. They have a dome-shaped shell that is dark greenish through to dark brown or black. Often there is a pale stripe through each side scute. Sliders also have what can be described as yellow 'pyjamas' on their hind legs, much more so than cooters.

COOTERS *'cooter type'*

Only the river cooter *Pseudemys concinna* has a yellow line along the bottom side of the neck that forks around the back of the mouth, sometimes crossing the mouth. ***Remember C for river Cooter.*** It seems to be one of the terrapins most likely to be encountered and is able to survive a UK winter. Northern red-bellied cooter *Pseudemys rubriventris* and Florida red-bellied cooter *Pseudemys nelsoni* do not have this mark but may also be rarely encountered and have reddish markings on the shell. At a distance the markings of cooters and sliders and the various crosses are all but impossible to determine and sometimes the underside needs examination. If the red ear mark or the S-shaped marking is missing it is possibly a cooter of some kind. There can be a pale red stripe or reticulations on the upper shell.

MAP TURTLES *'map turtle type'*

Several species of smaller terrapin with a shell that angles from a central ridge like a shallow tent, sometimes with raised backward-pointing knobs and a serrated shell edge. Very large females lose the characteristic tent shape. Males show the body ridge character much more. The head can have yellow stripes with small rounded or other shaped yellow or whitish patches and lines.

OTHERS CATEGORY *'terrapin other species'*

There is a range of occasional and rarer sightings of other species with similar dome-shaped shells. These include diamondback terrapin *Malaclemys terrapin* with very pale or white legs with spots, European pond turtle *Emys orbicularis,* very dark shell with yellowish spots, Spanish terrapin *Mauremys leprosa.* The last two are similar to the sliders but generally smaller with much paler leg markings. Painted turtles *Chrysemys picta* are sometimes seen; these are often small with vivid red marks on their limbs and shell. Rarely snake-necked turtles *Chelodina* and *Macrochelodina* spp. and African helmeted turtles *Pelomedusa subrufa* are released and presumably survive into early winter. Once you have got to grips with the sliders, cooters and others described above and think it is not one of them, you may need to look at the traits of the other options below which are more aquatic and hardly ever seen, being more readily encountered through the use of basket trapping.

SNAPPING TURTLES *'snapping turtle type'*

Adults are massive bulky turtles but are generally timid and secretive. Much of the shell (upper carapace and lower plastron) is reduced compared with the sliders and cooters, and with large thick head, neck, limbs and tail. They have a large hooked upper beak. They do not often sunbathe and they tend to walk under water rather than swim.

MUSK AND MUD TURTLES

These are very small and hardly ever seen, at less than 120 mm in length. Species may include the common musk turtle or stinkpot *Sternotherus odoratus* and the razorback musk turtle *Sternotherus carinatus* and the eastern or common mud turtle *Kinosternon subrubrum*.

SOFTSHELLS *'softshell type'*

These are usually greenish or brown and with a flat rubbery looking carapace can be up to 50 cm in diameter. The nose is pointed and there are two prominent raised eyes. The most likely candidate for seeing in the wild is the eastern softshell *Apalone spinifer.* They are most likely to be seen in the very shallowest of water with their noses sticking out.

Figures 22 a–e have been prepared to assist those seeking to identify terrapins and turtles in the field at least to the taxonomic rank of genera. We have tried to show key diagnostic features, shapes and coloration and together with photographs should help observers gain a degree of accuracy. Identification can be tricky or impossible at long distance, and even on close examination terrapins are quite variable and can overlap in terms of size, pattern and colour. They are often coated in mud, and with algae on their shell. For identification purposes it is worth taking pictures from as many angles as you can, if possible including those from the front to show the head, side of neck, shell colour, pattern above and below the neck, and the underside (plastron).

Figures 22 a–e show types of freshwater terrapin/turtle recorded as abandoned in ponds, lakes and canals in the London Area, with typical silhouettes of body shape.

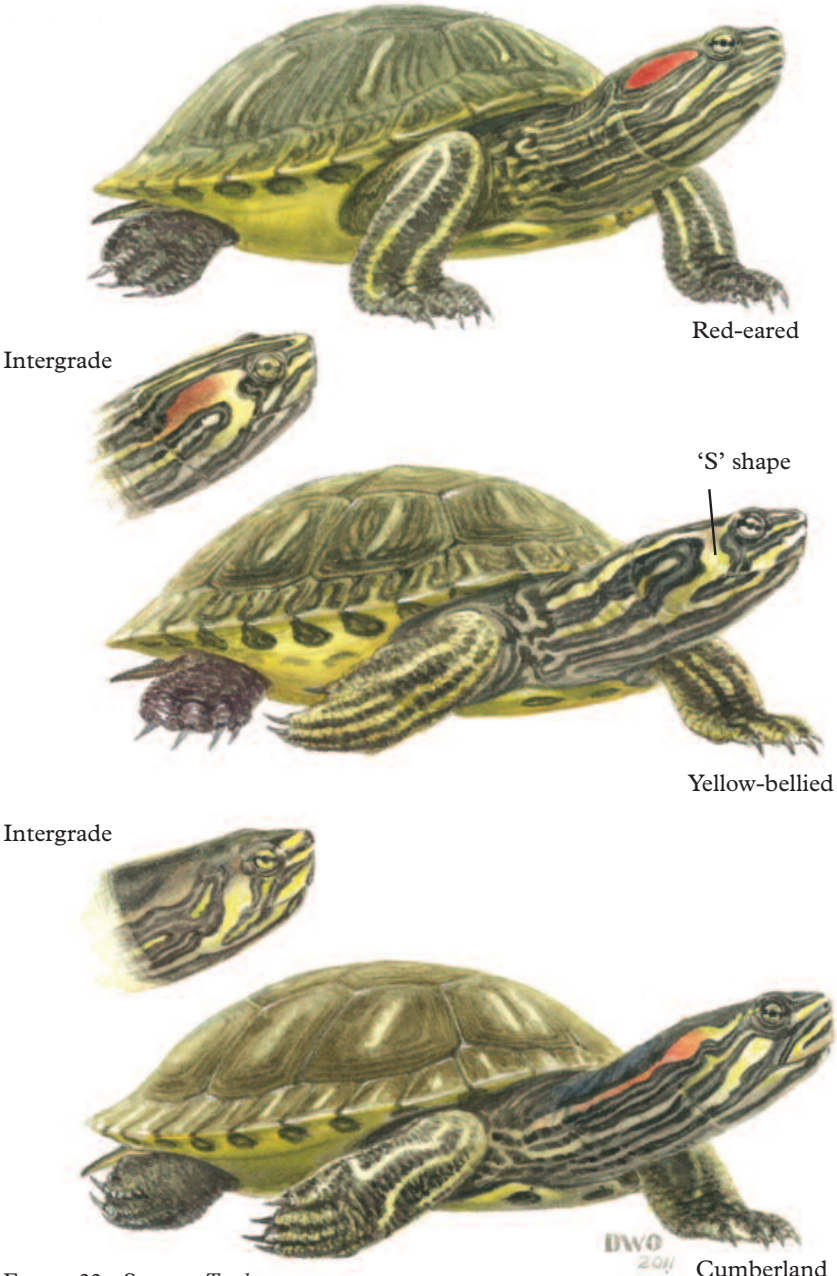


FIGURE 22a. SLIDERS *Trachemys* spp.

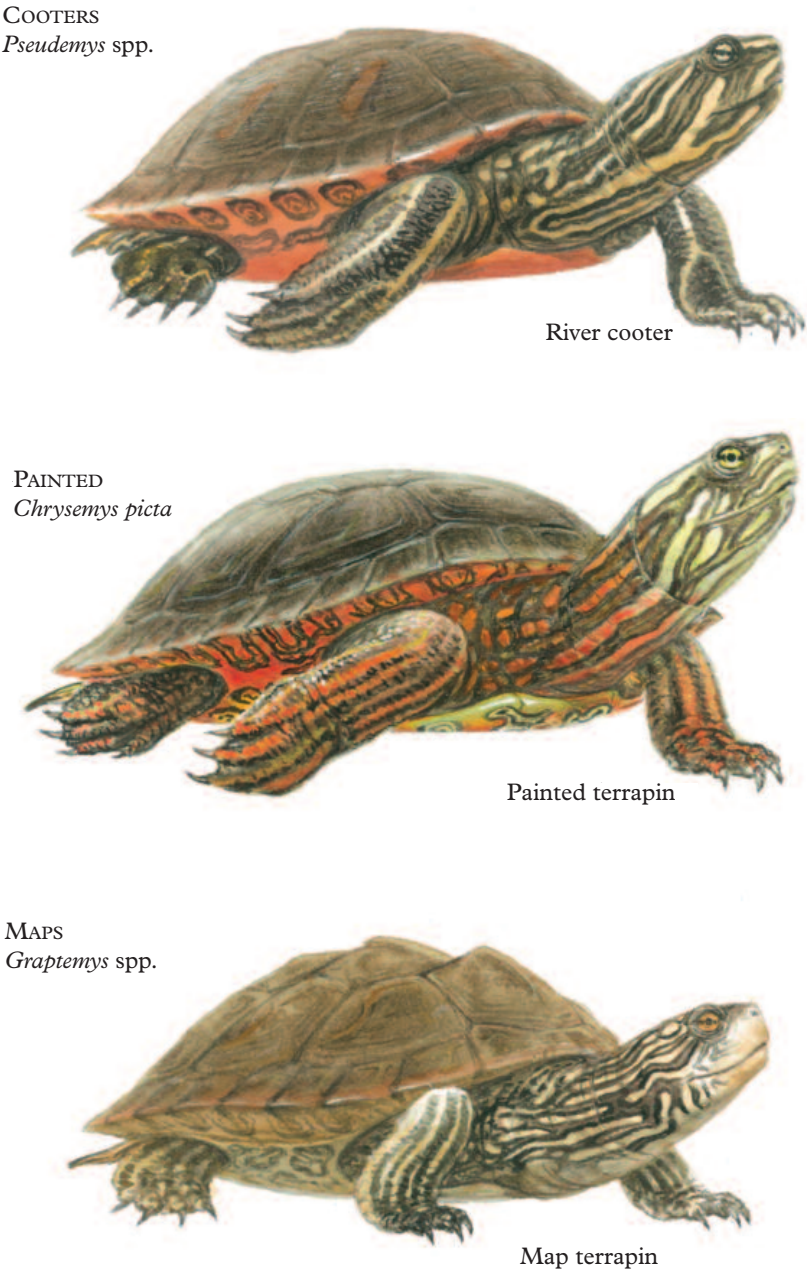

COOTERS
Pseudemys spp.
River cooter
PAINTED
Chrysemys picta
Painted terrapin
MAPS
Graptemys spp.
Map terrapin

FIGURE 22b.

DIAMONDBACK
Malaclemys terrapin

Diamondback terrapin

EUROPEAN
Emys/*Malaclemys*

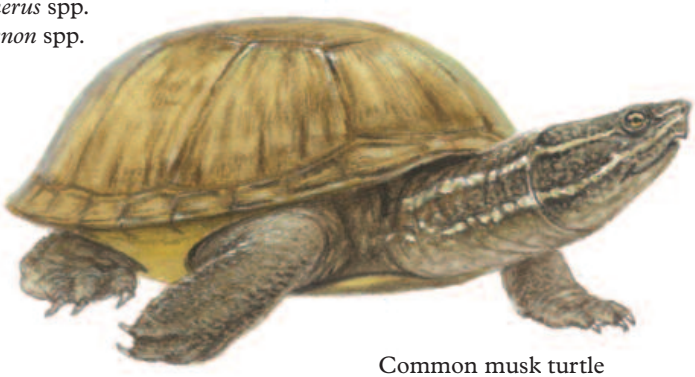
European pond terrapin

SNAPPERS
Chelydra/*Malaclemys*

Common snapping turtle

FIGURE 22c.

MUSKS/MUDS
Sternotherus spp.
Kinosternon spp.



Common musk turtle

SOFTSHELLS
Pelodiscus, Apalone, Trionyx

Florida softshell

FIGURE 22d.

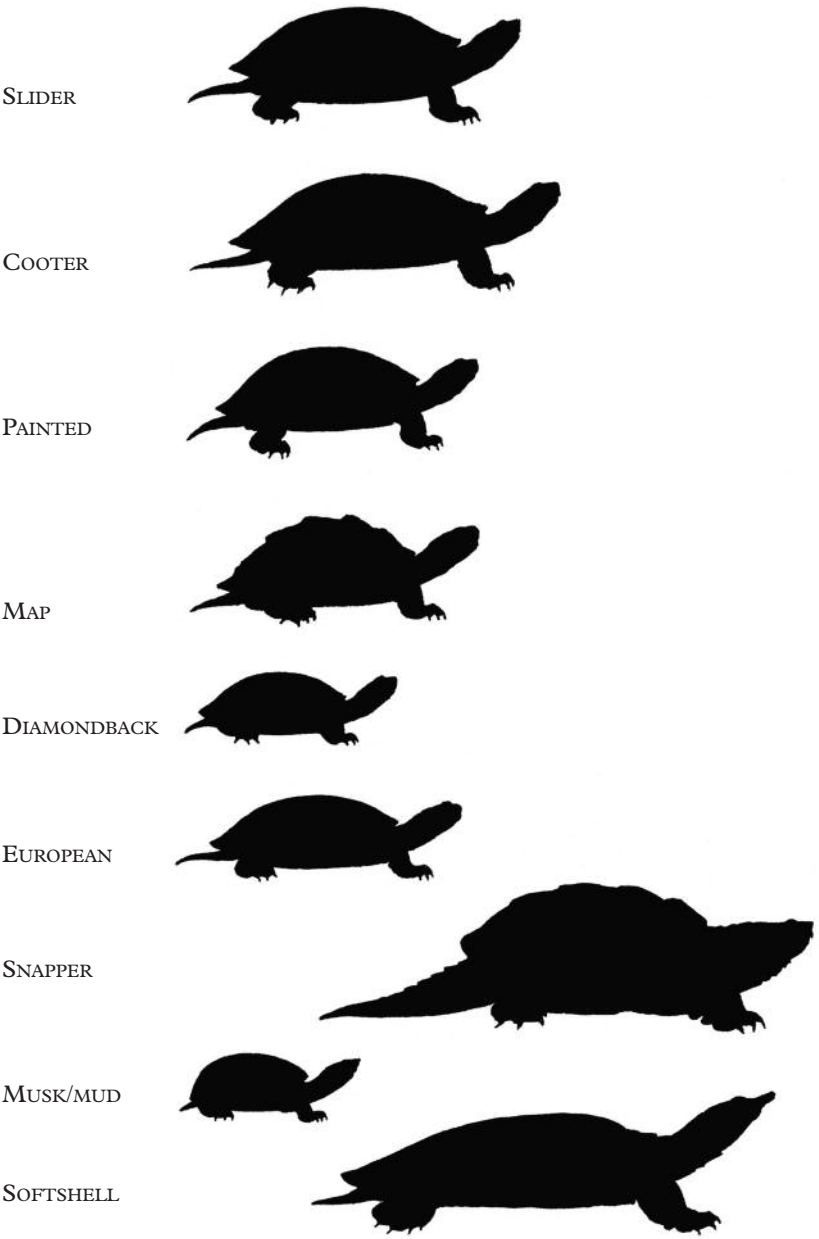

Slider
Cooter
Painted
Map
Diamondback
European
Snapper
Musk/mud
Softshell

Figure 22e.

Species accounts — amphibians

Water Frogs *Rana* spp. (The genus *Pelophylax* has now become widely accepted)

The species/hybrids recorded or reported in the London Area, with their natural ranges are:

Levant green frog	*Rana bedriagae* Camerano 1882 (Turkey south to Egypt)
Iberian Water Frog	*Rana perezi* Seoane 1885 (Iberia, southern France)
Marsh frog	*Rana ridibunda* Pallas 1771 (east France to western China — may include other species)
Graf's hybrid frog	*Rana* kl. *grafi*, a cross of marsh frog and Iberian Water Frog
Italian pool frog	*Rana bergeri* Günther 1986 (Italy)
Pool frog	*Rana lessonae* Camerano 1882 (France, east to the Volga River)
Edible frog	*Rana* kl. *esculenta* (Linnaeus 1758) hybrid of pool and marsh frog.

Species/hybrids not recorded but possibly present include:

Greek/Balkan marsh frog	*Rana balcanica* (Albania and Greece)
Karpathos frog	*Rana cerigensis* Beerli, Hotz, Tunner, Heppich and Uzzell 1994 (Karpathos and Rhodos)
Cretan Water Frog	*Rana cretensis* Beerli, Hotz, Tunner, Heppich and Uzzell 1994 (Crete)
Epirus Water Frog	*Rana epeirotica* Schneider, Sofianidou, and Kyriakoupoulou-Slavounou 1984 (western Greece, south Albania)
Sahara frog	*Rana saharica* Boulenger in Hartert 1913 (North Africa)
Albanian Water Frog	*Rana shqiperica* Hotz, Uzzell, Tunner, and Heppich 1987 (southern former Yugoslavia area and Albania).
Italian edible frog	*Rana* kl. *hispanica* (Italy and Sicily)

There are other similar species from elsewhere in Asia that could also occur.

Problems with precise identification

Water Frogs are also collectively known as Green Frogs, while other generally more terrestrial, smaller and usually brownish coloured ranid frogs are often known collectively as Brown Frogs. We have used the term Water Frog here for reference to the more aquatic and larger Green Frogs that are all closely related. The taxonomy and consequent identification of different species of Water Frog is complex and more details on this with notes on other aspects of biology can be found in Appendix 2. These are the most common form of European frog and are all similar and closely related. They are arguably the most successful as they are active and capable of feeding in (and under) water as well as on land and the larger species can even predate smaller frogs. They are highly variable in pattern and colour. Most are widely distributed, other than in parts of northern Europe and with regional variations that are complicated by human transfers and hybridization. Until the early 1970s it was not widely realized that the edible frog was a hybrid of pool frog and marsh frog. Edible frogs are usually self-sterile but

capable of reproducing with either parent species to produce more edible frogs. To complicate matters, some populations of edible frog appear to be self-sustaining, consisting of fertile hybrids. Because of these complexities researchers have often avoided their precise identification. In populations that may have up to three types present, their varied coloration and patterning also gives rise to confusion in identifying what taxa (species, subspecies and hybrid) are present in any given location and genetic tests may be needed to identify individuals. For these reasons, as with some of the interbreeding terrapins, this paper is more cautious than previous works on what exactly was/is present at each location and refers to 'types' rather than positive identification of exact species or hybrids. In a few cases previous identification from known origins along with details of characteristic body size and pattern may have been accurate but new information suggests much greater complexity now exists.

There are around twenty-five taxa of Water Frog in Europe. There have been considerable developments in the identification of them in Europe in recent decades following debate and recent detailed studies to try to separate them. Most distribution maps are incomplete because until recently pool and edible frogs were mostly recorded as one (Gasc et al. 1997). The pool frog occurs in mountain areas up to 1,000 metres in altitude but it is now very rare across its range as a single species. It is an ephemeral species unable to compete with marsh frog and its hybrid. The original separation of the species, as shown by Smith (1951) suggested that in northern Europe pool frog might be a more western European-originating species and marsh frog a more eastern European-originating species, both having met in the middle when redistributing into northern Europe after the last Ice Age and prior to the last major phase of sea level rise that cut Britain off from mainland Europe. The situation is still uncertain and it may be that the species were more sympatric and shared ranges (although pool frog occurs further west than marsh frog), but with greater niche partitioning before human disturbance increasingly promoted hybridization. The exact current distribution of edible frog is not fully established but molecular techniques should now allow closer examination.

Distribution and historical aspects

The distribution of Water Frog records in the London Area over the last 180 years is shown in Figure 23. There have been over 110 occupied 1-kilometre squares in the LNHS recording area and nearly sixty 1-kilometre squares with one or more Water Frog record in the recording hinterland.

There are approximately fifty documented releases or escapes of Water Frogs in the London Area and approaching eighty implied from individual records of isolated occurrence and many more are suspected. Records indicate four main core areas of Water Frog distribution, identified within clusters of one-kilometre square records with known or presumed breeding waters and associated wetlands. These are: the Heathrow/River Crane cluster, the Newdigate and Gatwick to South Nutfield cluster, the North Kent Marshes cluster and the Ockendon to Rainham cluster. In addition to these are seven smaller one-kilometre distribution groupings with between six and ten occupied one-kilometre squares and around thirty-four more isolated localities of up to three adjacent one-kilometre squares, representing one or more separate release(s)/escape(s). The date/s of first and subsequent records are indicated for many sites, as is the general direction of movement from natural spread or further transfer by humans since the first release or escape (Figure 24).

Although no detailed research appears to have been conducted, it is hard to see how the sale of live frogs for human food in wicker baskets in Europe has not occurred since at least Roman times. Importation of Water Frogs into Britain does not appear to have been researched in detail but the first known documented account is from the 1830s (Smith 1951). In terms of origin, there is a noticeable start to the recording of Water Frogs from the 1840s when there is frequent mention in published literature and good evidence of regular importation as well

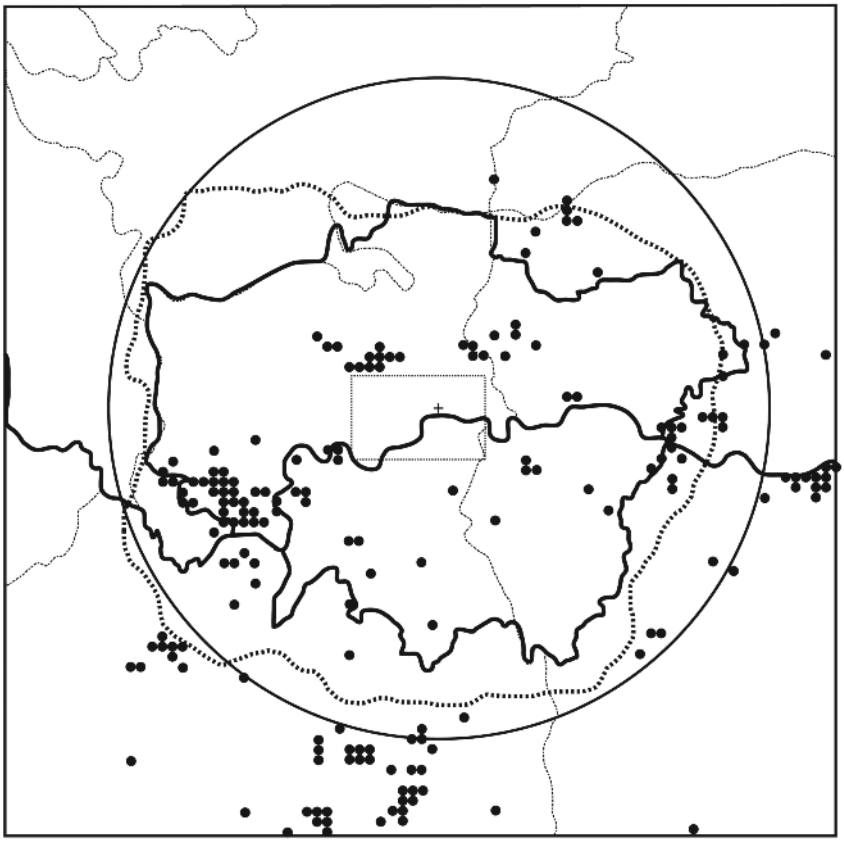


FIGURE 23. One-kilometre distribution records for Water Frog records in the London Area, 1830–2010.

as attempts to establish them. This period followed the end of difficult climatic conditions in northern Europe; the 'Little Ice Age' had ended. With warmer weather, a new era of importing plants and animals with better chance of survival outdoors must have seemed possible again to a nation that had experienced long periods of poor weather. In London, large water bodies were being increasingly engineered as public water supplies, such as the Brent Reservoir in the 1830s, and these will have attracted considerable public interest and new habitat for the release of animals. Water Frog release at Epping Forest is recorded in the 1840s and release or 'acclimatization' was increasing.

There is at least one London Area release in the 1870s with an unclear London location, but in general, after the well-recorded imports earlier in the century, records over the period 1850–1900 are few, possibly because the novelty value in releasing them had gone or perhaps because reporting them was less newsworthy. In 1900 and 1904 came the documented releases at Chilworth and Ockham in Surrey (Dalgleish 1904). Water Frog was recorded at Hampstead Heath in the period up to 1914 (see later) but it is not clear if they were derived from those present sixty years or so earlier or from subsequent release. Recorded releases also occurred at Ham Common and Ham gravel pits and at Teddington gravel pits

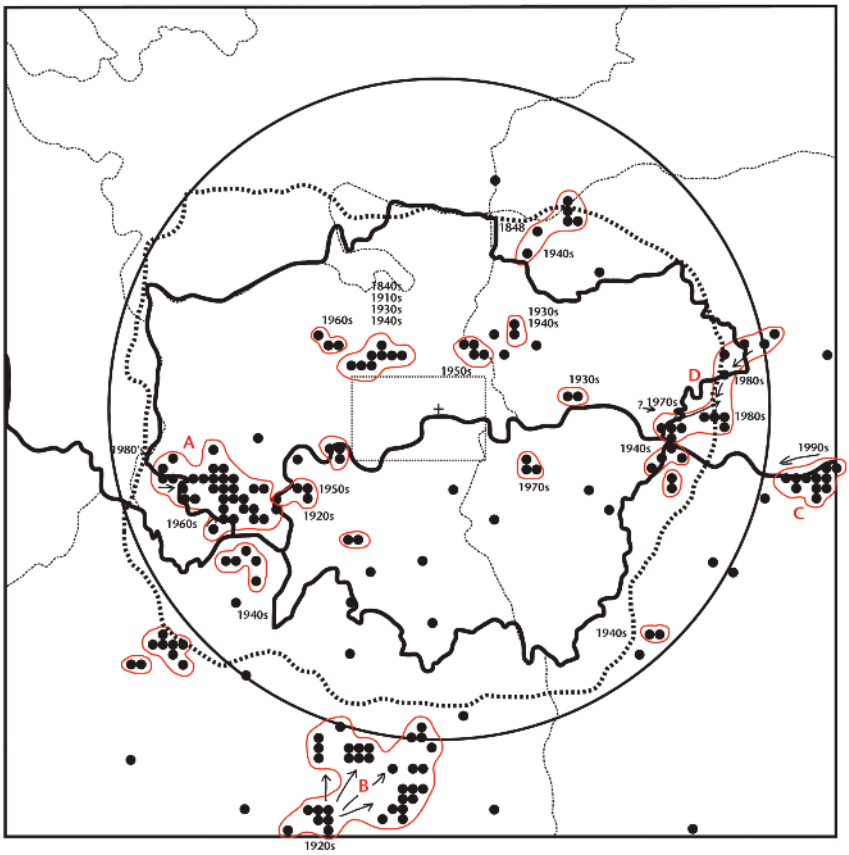


FIGURE 24. Location of main Water Frog clusters of occupation, sub-clusters and isolated locations as indicated by one-kilometre square occupation, with dates of first records and any perceived general direction of natural spread or transfer by humans since the first record of release or escape. Where: A is the Heathrow/River Crane cluster, B is the Newdigate and Gatwick to South Nutfield cluster, C is the North Kent Marshes cluster, and D is the Ockendon to Rainham cluster.

around 1929 (Fitter 1959). These were followed in 1937 by a release of marsh frog type at Barking Creek in east London. All these releases are reported to have been sourced from Romney Marsh in Kent. At Barking the release was apparently an attempt to bring biological control to mosquitoes by a local company (Fitter 1959).

The approximate number of recorded Water Frog releases/escapes that have been identified, starting from 1830 and over subsequent periods in the London Area are as follows: between 1830 and 1870 (8), between 1900 and 1940 (10), between 1940 and 1980 (28) and between 1980 and 2010 (31).

It is not clear if the apparent rate of increase is real or possibly a function of better communications in recent decades. The highest number is after the Wildlife and Countryside Act (1981) made it an offence (punishable by an unlimited fine or indeterminate prison sentence) to release non-native species into the UK, even if populations of the species are already present, suggesting that a lack of interest in enforcement has prevailed. These eighty or so release/escape events

determined by this research suggest that on average over the last seventy years, Water Frogs have been/are released or escaping at a new location at a rate of around one per year, somewhere in the London Area.

Water Frog history in the London Area

The detection of fossil/sub-fossil evidence for Water Frogs in Britain since Roman times starts conveniently in London in the early 1980s with archaeological excavations at St Clare Street near Aldgate. This is the site of an old Roman cemetery that was positioned at the then edge of Roman London and about 600 metres from the River Thames. A rectangular pit, 1.3 square metres was found, thought to be around 2.5 metres deep when dug. It was excavated and the area dated at around AD 200. At its base, the pit had traces of the sides of a wooden container (0.75 metre square) with intact and broken pottery and within or amongst them a quantity of animal bones from 315 individual animals (Ellis 1985, Hibberd 1991). Barry Clarke, an experienced herpetologist at the Natural History Museum, helped identify the numerous amphibian bones that were mostly (n=232) those of common frog *Rana temporaria*, i.e., our native species belonging to the Brown Frog group of European frogs. A single Water Frog was identified from the group at the time as marsh frog *Rana ridibunda*. Some bones were also provisionally assigned to a single moor frog *Rana arvalis*, a species no longer present in Britain. The wide range of other animals — mice, voles, shrews, lizards, newts and even grey heron, suggested either a species-rich fauna was present, falling into a pit left open for a few weeks during spring, or a collection of animals placed there by adults for some kind of ritual purpose or by children playing. If of pitfall origin, it seems just possible that the heron tried to feed on trapped amphibians and also became trapped. However burial of collected animals seems more likely for a number of reasons including that the shrews and mice might otherwise have attacked and eaten each other and the amphibians resulting in bones that were incomplete or showing bite marks. Whatever the cause of deposition, it gives some evidence for placing a Water Frog at least at one location in London although the exact type was not determined.

Next, in the 1980s came the discovery of Water Frog bones amongst kitchen waste deposited in a medieval well in the garden of London Greyfriars, just two kilometres west of St Clare Street, dating to around the years 1480 to 1500 (Armitage and West 1985). As at St Clare Street a wide range of small wildlife species are present such as mice, voles, shrews and small birds. Kitchen waste included bones of cattle, sheep, pigs, chicken, fish and birds. Using frog pelvic (ilia) bones, this paper distinguished between common frog and Water Frog bones, assuming them to have been pitfall trapped in the well, rather than having been eaten and thrown away as kitchen waste. The identification to pool and edible frog however was made on the basis that this was the most likely Water Frog type to be present in England at the time (Barry Clarke, pers. comm.). Because head bones were not involved, in hindsight marsh frog cannot be ruled out.

However, all that can be currently gleaned from the St Clare and Greyfriars finds regarding Water Frog occurrence is that any combination of pool, edible or marsh frog (but also possibly others from further afield) could have been present in London in Roman times and around 1500, origin unclear, either native or introduced, like European rabbit *Oryctolagus cuniculus* as food. Finds of frog skulls or wet bones that could hold genetic traces are needed for better determination of species.

Thomas Pennant's *British Zoology* (1776) refers to both edible and common frog (as Linnaeus had before him) and in the context of them being eaten by humans although they were also used for dissection by anatomy classes. He refers to large numbers being on sale in baskets at Paris markets. Presumably by inclusion in the British fauna, their presence in the wild in Britain is implied but it is not apparently supported by reports from the local naturalists in London or

East Anglia of the time. George Shaw's *General Zoology* Vol. II lists 'Rana Esculenta' as 'the Green frog' and 'Rana Ridibunda' the 'Laughing frog' as two distinct species (Shaw 1802), the former with western Europe including England where it is 'rare', and the latter associated with Russia, although clearly by then well-established west of the Rhine. Like Pennant however, Shaw's account also does not tell us where they may have been observed. Further information on Water Frog translocation and status in the UK is given at Appendix 3.

Water Frogs and Hampstead Heath

Over the last hundred years, Hampstead Heath has provided an interesting reference on Water Frogs as it shows both the frequency of release and lack of persistence over a long period. The first record of one of the authors (TESL) at this location was made at the Viaduct Pond in 1967. The pond was in a rather treed and overgrown state, yet frog numbers were high enough to see and hear them jumping with loud splashes from the edge. The frogs, however, seemed to decline and were then no longer seen after a desilting operation in the mid 1970s.

Exactly when Water Frogs were first present at the Viaduct Pond is not known but they may have been there some time since its construction in the mid 1800s along with the older large ponds that must have rapidly increased amphibian numbers in the area. The location of an escape in the 1930s (Fitter 1949) is not clear but that they were present from 1940 is established. The Hampstead Scientific Society (1913) published an account of natural history of the Heath and this included a reference to 'Edible frogs' at a pond in the garden of Meadow Cottage at Parliament Hill, that had been recently levelled. Its position is close to the small pond that remains today in a private property close to Brookfield Mansions. Parliament Hill is a low spot that used to inundate rapidly in high rainfall. There is also an intriguing link in Henry Mayhew's detailed account of London in 1851 (Quennell 1984) when Mayhew interviewed two animal collectors selling on the streets of central London. Both referred to collecting frogs to sell for human consumption. Frogs were collected by at least one of them from the Hampstead and Highgate ponds areas and there are clearly two types and sizes:

'The snails and frogs I sell to Frenchmen. I don't know what part they eat of the frog, but I do know they buy them. The frogs is 6d and 1s per dozen. [presumably there is twice the meat on a Water Frog as a common frog] They like the yellow bellied ones, the others they're afraid is toads. I've had an order for as many as six dozen, but that was the French hotel in Leicester-square; but I have sold three dozen a week to one man, a Frenchman as keeps a cigar shop. Many people swallow young frogs they're reckoned very good things to clear the insides.'

The yellow underside is a reference to common frog belly coloration that is usually yellow/yellow-orange in females although males are often whitish. This may have been a 'lay' check to avoid being sold toads although the larger 'edible' frogs were presumably easier to distinguish. Considerable French immigration to London around and after 1600 presumably established modern frog eating in London if it did not occur before, but for which there is little medieval evidence other than 'medicinal' use, although this is a valid area for student research. There are other accounts of 'French' people collecting frogs for 'the pot' in another urban area; Birmingham around the mid nineteenth century.

Water Frogs have also been recorded more or less continuously on Hampstead Heath from the 1930s to the 1970s where they last remained in the Viaduct Pond. In the 1950s/1960s the LNHS field excursions to Hampstead Heath were often specifically to hear and see the frogs in summer. The thought that they may have been present continuously for 130 years (1830s to 1970s) reflects the frequency of their release rather than their ability to persist. Richard Fitter's (1959) observation that no Water Frog population has survived more than a few decades,

points to factors that suggest that up to at least the 1970s, the UK may have had factors preventing their colonization, including obviously inbreeding and inadequate climate for sufficient tadpole development. Today however, in places where habitat appears optimal and large scale, Water Frog populations seem to be robustly established and likely to persist.

Descriptions of Water Frogs in London by individual cluster:

The Heathrow/River Crane cluster

The origin of Water Frogs in the largest of the LNHS clusters is known to be multiple since the 1960s. The earliest source in this cluster was from the import of most probably a marsh frog type or Italian pool frog *Rana bergeri* or a hybrid, collected from Corsica during a holiday and established in a garden pond in Sunbury on Thames in 1964 by Alan Sauvarin of the Thames Valley Naturalists. These bred so well that he also kept them in tanks, only to find them swallowing each other, and observed an ability for one slightly larger to consume another. Alan told TESL that at first he used to search for them in his covered aquaria, not believing that this was possible. Froglets from his pond were however released nearby at Kempton where they spread into the reservoirs and other ponds in the vicinity and were soon moving into the racecourse and towards the Thames. They were however released too late to explain the origin of Water Frogs at Walton, Hersham and Molesley in 1961 just south of the Thames and a few kilometres away. In 1994 Alan Sauvarin found that domestic cat numbers were so high that they had killed off the entire adult population in his garden. Water Frogs located around that time at the Kempton Reservoirs appeared to be relatively small and of mixed appearance but were calling like marsh frogs (TESL, pers. obs. 1995), and it was suspected that possibly more than one type had been released in the area and interbred over the years.

The other major source in the general vicinity has been the Air Transport Cargo area of Heathrow Airport that sits in the south-west part of the Heathrow secured area and adjoining the Northumberland and Longford Rivers that drain into the River Crane. Notably, during 1988 and 1989, two shipments that were not packaged properly, each of around 1,500 Water Frogs (both probably being Levant Water Frogs *Rana bedriagae,* one from Egypt and one from Turkey), opened and released frogs into the inside of the aircraft. On releasing the external aircraft doors, many dozens if not hundreds of Water Frogs and probably other species, dropped onto the tarmac of the world's busiest airport and rapidly dispersed (Bob Quest, pers. comm.). More escaped from the boxes as they were unloaded and carried away. Many were rescued due to the proximity of the City of London Animal Reception (formerly Quarantine) Centre and the Heathrow office of the RSPCA. Those that were not killed or injured by aeroplanes or service traffic dispersed into the nearby watercourses and individuals that were found for a few days afterwards tended to be taken there by ground crew for release. Some of the frogs moved into the Perry Oaks Sewage Farm area to the west where they bred until the area was destroyed in the building of Terminal 5. Those recorded by King (1981) on the River Crane could have been earlier, similar but lower-scale escapes of a similar kind from incoming aircraft. It is also quite likely that Water Frogs were released elsewhere in the River Crane/Hounslow Heath area where they remain today. Spread has occurred for distances of around 7,000 metres in any direction from any known release point.

Hounslow Council became aware of Water Frogs following local residents complaining about the noise of males calling around the month of June along the Duke of Northumberland and Crane Rivers in the Twickenham and Whitton areas of Hounslow in the 1980s. Some welcomed and others hated the sound — reactions that echo those around Europe in places where they are native or introduced. During the 1984 London Pond Survey, TESL was surveying amphibians in one of the Hounslow Heath ponds with numerous Water Frogs

around its edges and out of a hedge came a Council worker who had been hiding and watching for 'frog catchers'. In previous days, rescued Vietnamese refugee 'boat people' who were temporarily housed nearby had apparently ventured out. Seeing the large frogs and being subject to 'British' food they had set about catching them with sharpened bamboos borrowed from an allotment. The previous day, one batch of frogs had been observed being carried away, impaled on a stick and the authorities had been alerted. Doug Napier, then working at Hounslow Council subsequently took on the job of researching Water Frog distribution in the area and extended it more recently into a dissertation (Napier 2006) further adding to the many records for this area.

The Newdigate and Gatwick to South Nutfield cluster

Despite the Water Frog releases elsewhere in Surrey at the time, what is thought to be the main source of the current Water Frog community within the Newdigate area began to develop at Beam Brook Nurseries at some point after it started in 1903. Here there were small animal-holding enclosures including a range of ponds that became increasingly open to escape at some point before 1940 but possibly from an early point following its establishment. Escapes and releases were the result of the international animal import businesses with interests there, including Gerrard and Haig and Griffin and George (Medical Research Council 1968). The 'melting pot' of Water Frog types was topped up with a wide variety (amongst several other non-native herp species) until large-scale trading ceased around the late 1960s but probably also after that date by incidental releases of small numbers. Amphibians were collected in low numbers for sale until at least the late 1990s and several colonies of Water Frog have been established elsewhere as a result. Recent reinforcement of Water Frog has occurred as a result of their numbers growing in the large adjoining Newdigate brickpits, abandoned in the 1970s/80s and where numbers were high in the 1990s and they can be found today (TESL, pers. obs.). Julia Wycherley identified five different types in the mid 2000s: *Rana bergeri*, *Rana* kl. *esculenta*, *Rana lessonae*, *Rana perezi* and *Rana ridibunda* (Wycherley 2003*a*, *b*) based upon analysis of male advertisement call patterns and genetic (RAPD) analysis.

FIGURE 25. Edible frog type from the Nutfield area. *Photo: Will Atkins*

Local ponds appear to have been colonized through frog dispersal along the Beam Brook stream, but it was in a period following the hot summers of the late 1980s, around the period 1990–1994, that dispersal appeared to be increasing, with records found further afield from the Beam Brook source (TESL, pers. obs.,

FIGURE 26. Edible frog type at Marbles Pond, Burgh Heath, Surrey. Described as one of the darkest colour variations encountered — mainly dark brown with a bright green vertebral stripe. *Photo: Doug Napier*

FIGURE 27. Male marsh frog type calling at RSPB Rainham Marshes. *Photo: Mark Webb*

Joslin and Wycherley 1994). A second source had been deliberately established at and around South Nutfield, centred on the Xenopus Ltd Biological Suppliers site which was founded from Newdigate animals. The Water Frog distribution is fragmented in this cluster and spread is likely to have been mediated by human transfer as well as natural dispersal along rivers. The Gatwick area distribution may well be from a human release/s in the 1980s. Maximum possible natural dispersal in this cluster has not been shown to exceed ten kilometres in any one direction although movements along the River Wey and associated canals and the Upper Mole, could in theory have allowed their movement for further distances, but this has not been demonstrated.

The North Kent Marshes cluster

Marsh frogs *Rana ridibunda* from Hungary were introduced to Walland Marsh in Kent in 1935, via the well-recorded garden releases/escapes of E. P. Smith. The female marsh frog is capable of growing up to around 180 mm maximum snout–vent length (some books suggest 200 mm can be achieved) compared with the pool and edible frogs that reach up to around 90–120 mm. Hence marsh frog is by far the largest and most dominant Water Frog type.

On the south Kent coast by 1940 the release had spread to occupy over 50 sq. km and by 1950 around 150 sq. km (Philp 1998). By the early 1970s there were records from the North Kent Marshes at Sittingbourne and Sheppey, apparently moved there from the Walland/Romney area by birdwatchers (E. G. Philp, pers. comm. to TESL) on the basis of them being 'good food' for birds. They were also transferred by humans west to Lewes Brooks in Sussex. The marsh frog is established widely over central south Kent and has spread in a linear fashion along

the River East Stour and the River Great Stour between Ashford and Canterbury. Again movement may have been assisted by human transfers.

From the 1980s there has been gradual spread across Sheppey, and westwards close into Gravesend in more recent years, with considerable numbers recorded on marshland located between Higham Bight and Gravesend. There is some suspicion that other Water Frog types have mixed in with them, possibly from the south Essex coast animals (see below). The block of urbanization at Gravesend seems to stop the westwards advance on the south side of the river. There are older (1950s) records of long-extinct Water Frog releases in the Dartford Creek and marshes area. These have been added to recently with records from west of Littlebrook Power Station. These could have originated from frogs crossing where the Mar Dyke enters the Thames and the crossing distance is only 600 metres or so or possibly those moving or carried along the Thames from the east.

The Ockendon to Rainham cluster

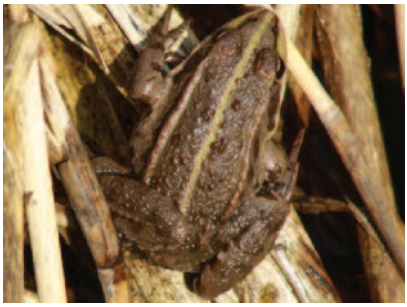
The origin of Water Frogs along the Essex coast has been described for us by Ray Cranfield who has been active in the area with his son Jon for many years now. Apparently they were first released a little way beyond our study area, behind the railway station by the coast at Old Leigh-on-Sea in the early to mid 1970s. The Hadleigh population (it is believed) was introduced into the borrow dykes behind the golf driving range at Leigh in the 1990s by a local person who collected tadpoles from Camber Sands in Kent. By the end of that decade the marsh frog type frogs had moved along the borrow dyke to Benfleet and dispersed into the drainage ditches of the Hadleigh and Benfleet Downs. The population has spread northwards towards Hadleigh and they are now found in fishing lakes (Colony Lakes) quite close to the car park of Hadleigh Country Park. On release they are reported to have rapidly moved west into what is now Hadleigh Marshes and Hadleigh Castle Country Park near Benfleet, occupying quite an extensive area. Water Frog tadpoles taken from the Hadleigh area were then moved into London by East End enthusiasts; one known batch was raised in a Dagenham garden. Although not documented, the Water Frogs at Dagenham that were present in the 1980s (TESL, pers. obs. 1984) are probably derived from this or another garden escape or releases in the local area around the late 1970s. Releases were also made subsequently, possibly during the early 1990s at Davy Down in South Ockendon where they were recorded in 2004. Tadpoles were collected from another Essex Country Park (location unknown, probably Hadleigh Country Park) and a South Ockenden resident decided to release the frogs across lakes and ponds located in the Mar Dyke catchment, although multiple sources of colonization of that water body from local fish farm/pet-keeping sources are possible and even quite likely. The Mar Dyke is fed by tributaries that extend to the west of Basildon near Horndon at the edge of the LNHS area. Other Water Frogs (type unknown) are reported to have been released around South Ockendon more recently. The spread of the marsh frog from South Ockendon downstream to Rainham seems likely where they may have met with the slightly older eastwards spreading Water Frog population there in the 1990s and also up to fishing lakes near the A127. They are also present further east along the coast. Marsh frog juveniles are still sold in pet shops in Essex (being sold in 2009 and 2010) in Rayleigh near Leigh-on-Sea (also in the Colchester area), despite their unsuitability as house pets and likelihood of breeding and escape when put in garden ponds.

Water Frog has extended into what is now the RSPB reserve at Rainham Marshes and the timing suggests the Mar Dyke source may have been the main one there. Howard Vaughan has been birding there since the mid 1980s and does not remember any arriving from Dagenham before then, although a combination from both areas is possible. Water Frogs that show characteristics of marsh frog *Rana ridibunda* but also that look like other Water Frog species/hybrids are now prolific across the site and can be found in every ditch, west up to the edge of the

silt lagoons. They have apparently never been heard on 'the silts' or in the ditch system at the far west end of Rainham Marshes South. The Rainham frogs are highly variable in size and pattern with colours ranging from turquoise blue through baize green, to dark chocolate brown and including individuals reported to look like xanthistic specimens with yellow skin and red eyes (Figure 28, a–m). Many are plain looking but a percentage has a pale green lateral dorsal stripe while others are very blotchy in appearance. There are a number of large dominant adult female individuals at Rainham, reported sometimes to sit very upright, possibly watching for prey or competitors.

a) Green/gold with green stripe, dark blotches and banded/blotches legs.

b) Brown with green stripe and with few clear markings.



c) Brown with pale stripe and low density dark brown blotches.

d) Pale green with yellow-green stripe.

e) Variable olive green with dark brown blotches and banded/blotched legs.

f) Turquoise with dark brown blotches and banded legs.

FIGURE 28, a–m. Water Frog pattern and colour variability from RSPB Rainham Marshes.

g) Green with few mid-green blotches.

h) Beige/off-white with brown freckles and blotches.

i) Pale brown with green blotches.

j) Light blue with blue stripe and dark olive-brown variable markings.

k) Yellow with variable brown dot-like markings.

l) Olive grey-green with dark olive-grey markings.

m) Olive-green with bright green stripe and dark brown markings.

Photos: Howard Vaughan, Mike Hughes, Daniel Woollard, Pete Merchant, Freddie Roll, Roman Muryn and Anon.

The past and present distribution of Water Frogs in London as illustrated in Figure 23 indicates that perhaps not surprisingly, in urban and city edge habitats their colonization and survival is not that secure. The distribution is limited, not just because they are at the edge of their climatic range but because habitats are relatively small and fragmented and the frogs suffer the same isolation pressures as other native wildlife. Inbreeding is likely to be a factor with initially small founder numbers. The Rainham population looks to be expansive and the north Kent area to the south-east also appears quite robust. It is clear however that many if not most Water Frog populations in the past have lasted under thirty years and often less. The three smaller north London Water Frog sub-clusters at and around Epping, Hampstead Heath and Walthamstow have survived for some time but seem limited in terms of future dispersal due to their urban surrounds and low density of suitable breeding ponds. They seem likely not to last that long under current circumstances even with a degree of restocking from local garden populations. Equally, in the Surrey countryside, with limited pond conservation work being undertaken, it will be interesting to see if Water Frog distribution consolidates or depletes over the next few decades. Certainly Doug Napier's field research suggests that occupied sites can relatively quickly lose their Water Frogs.

Other European amphibians

EUROPEAN GREEN TREE FROG *Hyla arborea* (Figure 29)
11 records inside, 2 records outside LNHS area.

FIGURE 29. Juvenile tree frog basking on leaf. *Photo: Tom Langton*

Tree frogs have been a common trade species in the past, many have escaped or been released but few have established breeding colonies. Inside the LNHS area one small maintained colony at the Birdbrook/Kidbrooke sites has held on in small numbers. The colony has apparently both been collected from and topped up since its origination from the garden of Charles Snell, after breeding there in

1980 (Snell 1981). Outside the LNHS area, tree frog breeding has been reported in Essex from specimens reported to be of Turkish origin. These bred in the garden of Antony Millwood in Basildon with a range of other amphibians and could even be a different species. Tree frog clearly struggles to survive outdoors, no doubt as with other species due to thermal limitation in tadpole development as well as lack of suitable habitat. Colonies are kept around the UK in sunny garden ponds and one colony in a secluded pond in the New Forest appeared to have hung on for more than a few years before being collected by dealers or hobbyists. Outside the London Area numerous attempts have been made to introduce this species since the 1840s and all have failed (Lever 2009). Although the species was probably present with the European pond terrapin after the last Ice Age there is no evidence of its survival after the main period of climate deterioration. Modern understanding of distribution shows its current range to be further south and east in Continental Europe. Another species, *Hyla meridionalis,* is also likely to have been released occasionally in the past.

PARSLEY FROG *Pelodytes punctatus* and PAINTED FROG *Discoglussus pictus*

Two parsley frogs were seen at Birdbrook (Birdbrook Nature Reserve) in 1993 and a single adult female painted frog was found at Oak Hill Farm Pond, Epping Forest in 1999 by WA and CH. There is no evidence of breeding and these are likely to be escaped/released pets.

MIDWIFE TOAD *Alytes obstetricans*

12 records inside, 5 records outside LNHS area.

Introduced to Bedford in the late-Victorian period, midwife toad is widespread in mainland Europe. Although populations have bred and persisted locally in the UK for several generations, other than in Bedford there has been no extensive colonization from source areas. There are a number of records from the Epping Forest area by the Essex Field Club but these do not appear to have resulted in populations forming or spreading. There has been a newer urban population with males calling, breeding and dispersing at least to adjoining gardens (1992–1996) in Wandsworth but its current status is not known. Outside the LNHS boundary, midwife toad has been reported in three small colonies in High Wycombe since 2006 and possibly before then, and there are rumours of an older population in that area. They have been present on National Trust property in Ashridge, Buckinghamshire where they may now no longer be present as a pond has been removed, but they had been there from 1970 until quite recently (NT Website). These five older locations were not reported in Lever (2009).

YELLOW-BELLIED TOAD *Bombina variegata* and FIRE-BELLIED TOAD *Bombina bombina*

Yellow-bellied toad *Bombina variegata* were reported to be introduced after 1977 and to be breeding at Birdbrook Road in the 1970s. There are not surprisingly scattered records in gardens and other urban water bodies of this widely traded species but no sign of significant establishment and persistence. The fire-bellied toad *Bombina bombina* apparently achieved breeding status at Beam Brook Nursery but failed to establish elsewhere despite several attempts to move it. A more recent introduction of fire-bellied toad from Turkey has apparently established in the Kingswood area of Basildon (Ray Cranfield, pers. comm.). Everything points to conditions in the UK being borderline for its survival. It does occur at more northerly latitudes in countries where summers are hotter.

Urodeles: newts and salamanders

Alpine newt	*Triturus alpestris* [*Mesotriton alpestris*/ *Ichthyosaura alpestris*]
Alpine/smooth newt hybrids	*Triturus alpestris* × *vulgaris* hybrid
Southern banded newt	*Ommatotriton vittatus*
Marbled newt	*Triturus marmoratus*
Italian crested newt	*Triturus carnifex*
Crested newt hybrids	*Triturus carnifex*/*cristatus*/*dobrogicus* hybrids

ALPINE NEWT *Triturus alpestris* [*Mesotriton alpestris*/ *Ichthyosaura alpestris*]

Within Greater London, Alpine newt breeds at the Birdbrook/Kidbrooke sites and in a garden pond in Beckenham. Just outside the LNHS Area, the Beam Brook Nurseries site is thought to have had alpine newts present and breeding for many decades and individuals from there were taken for release at the Xenopus Ltd site in South Nutfield in the 1980s and survived for a few years. Alpine/smooth newt hybrids have been reported from Beam Brook Nurseries in the 1980s (Gillett 1988).

The Essex Amphibian and Reptile Group report finding alpine newt populations in garden ponds at Rochford, Southend and Basildon where in addition they were present at Willow Park, an Essex Wildlife Trust nature reserve, in 2002. They were released on Chorleywood Common in Hertfordshire around 1970 and have remained there in several ponds after forty years. They have been sustained in the wild near to another urban area; Edinburgh, at Golden Acre Quarry where TESL was brought in to check what had been described as a great crested newt *Triturus cristatus* pond, to identify alpine newt instead, as tadpoles had been previously misidentified. The pond had received protection and a road had been moved to avoid a pond held within a stone quarry. Alpine newt had been released by a genetics researcher at Edinburgh University in the late 1950s when they were surplus to experimental use. This species has been recently identified as a carrier of chytrid fungus in Britain. The DEFRA non-native species secretariat web pages indicate the pathogen has been identified together with this species in a number of locations.

SOUTHERN BANDED NEWT *Triturus vittatus* [*Ommatotriton vittatus*]

One record only exists for a dead adult at the Kidbrooke site, located in 1997.

MARBLED NEWT *Triturus marmoratus*

Inside the LNHS boundary there are a few records from Birdbrook NR and an adjoining garden pond. Outside they are reported at Beam Brook Nurseries but breeding records do not seem to have been confirmed at any site although this seems quite possible.

ITALIAN CRESTED NEWT *Triturus carnifex* and *Triturus cristatus* group *carnifex*/*cristatus*/*dobrogicus* intergrades/hybrids

There are four morphotypes of the crested newt superspecies where previously subspecies of *Triturus cristatus cristatus* have been described.

Inside the LNHS area, *T. carnifex* was established for around five years at the Xenopus Ltd site at South Nutfield and there are other small isolated mainly

garden sites elsewhere in the UK. Outside the LNHS area, the release of non-native members of the *cristatus* group has resulted in hybrids being found at Beam Brook Nurseries in Surrey where all four types are likely to have been mixed. Initial considerations were that the main crosses were *cristatus* × *carnifex* but *cristatus* × *dobrogicus* and *carnifex* × *dobrogicus* was also considered possible from the 'look' of a few of the animals. However, as with Water Frogs, these closely related species may have resulted in animals with mixed genes in previously undescribed ratios. In 1998 the ecological consultancy HCI Ltd funded research into morphological variation at the site (Brede et al. 2000). With police involvement to halt trade that was found to be ongoing, an evaluation of the extent of hybridization in the surrounding countryside was conducted. The study concluded little sign of spread of non-native characters in surrounding populations and that local GCN appeared to be dominant and possibly resistant to replacement by hybrids which was fortunate. However, genetic studies would be useful to see if the local native species surrounding the site remain completely unmodified.

Non-European amphibians

African clawed frog *Xenopus laevis*

Sometimes also called African clawed toad, this is an aquatic species up to 150 mm. From the 1930s it was used in human pregnancy testing and biology teaching. This and other similar species from sub-Saharan Africa also entered the pet trade from the 1960s. Inside the LNHS recording area the species was apparently breeding at and around the Xenopus Ltd site in South Nutfield in the 1980s. Elsewhere it has appeared as breeding in the wild in England and Wales, but it does not appear to spread to any great extent from points of establishment although it may be under-recorded. Located in 2003 with American bullfrog at the site near Edenbridge in Kent, a cohort of tadpoles were thought to have been fully eradicated with use of pond draining, netting and rotenone treatment, but a few adults were caught afterwards and checking continues. The origin there was linked to a biological supply company nearby that bred *Xenopus* for sale around the UK. The Nature Conservancy Council funded trials some time ago that suggested that *Xenopus laevis*, in small containers in captivity will predate native amphibian species larvae but did not seem to prey on sticklebacks *Gasterosteus* sp. that were offered (Tinsley and Simmonds 1987).

Xenopus laevis has been linked to the sudden appearance of the fungal disease chytridiomycosis, the cause of reported amphibian deaths and population declines in several continents in recent decades. One theory is that the amphibian chytrid *Batrachochytrium dendrobatidis* was introduced from Africa in this species around the world (Weldon et al. 2004). In this study, around 700 preserved specimens of three species of *Xenopus* were examined, these having been collected from 1879 to 1999 in southern Africa. Toe webbing was examined for signs of disease. Chytridiomycosis was found in a *Xenopus laevis* frog from 1938, and the overall prevalence was about three per cent of specimens examined. However, despite very strong circumstantial evidence, the origin, exact nature and cause of recent outbreaks remains largely unclear. Chytridiomycosis was an endemic infection in southern Africa for twenty-three years before being found in other continents. Possible spread of the disease around the UK is considered in the disease section (see later). Oddly, we have had no records of the axolotl *Ambystoma mexicanum* in the wild, despite it similarly being commonly kept in schools and as domestic pets for at least two decades.

AMERICAN BULLFROG *Rana catesbeiana* [*Lithobates catesbeianus*]
(Figures 30–32)
1 record inside, 1 record outside LNHS area.

FIGURE 30. American bullfrog adult. *Photo: Kevin Morgan/HCI*

FIGURE 31. American bullfrog tadpole. *Photo: Kevin Morgan/HCI*

FIGURE 32. Bullfrog removal exercise in 1999. *Photo: Kevin Morgan/HCI*

American bullfrog reaches a snout-vent length of up to around 200 mm. It is a dominant amphibian species from North America, also with large tadpoles up to 170 mm in length. The bullfrog call is short repeated bursts of cow-like mooing. It has been spread west over the USA and in many countries, in part due to demand for its leg muscles for human food. It has escaped and been released following attempts to set up commercial breeding farms around the world. The south-west USA has a small southern bullfrog or pig frog *Rana grylio*, that is also taken for food, sold and released outside its range but to a much lesser extent. In Europe, free-ranging American bullfrog populations are located in Belgium, France, Germany, Greece and Italy (Ficetola et al. 2007). Bullfrog tadpoles seem to appear to deter predatory fish such as pike, it is thought by being distasteful to them.

From the mid 1970s, bullfrog tadpoles have been on sale to the public in London, sold at cold water and tropical fish shops, aquatic centres and pet shops. As a result there is no doubt that many tadpoles, froglets and juveniles have been released into gardens and larger ponds and wetland areas. The importation of bullfrog tadpoles has been partly an incidental occurrence, with tadpoles being included in pet trade shipments of American-bred goldfish. One supplier explained that these were added as a free 'bonus' from the suppliers with ordered fish. Bullfrog tadpoles are also sent in batches on their own. Bullfrogs are a pest in goldfish farms in North America where they compete for food and are culled (Langton 2002). During 2000, and following publicity, the charity Froglife

received enquiries with over half the reports from south-east England: Kent (43), Surrey (11), Greater London (7) and Sussex (10). Scrutiny suggested several were misidentifications. None of the locations were reported to have bullfrog breeding although at eight sites (including five in open habitat and nature reserve settings) follow-up visits seemed a priority. No tadpoles or froglets were detected at the time, but three adult bullfrogs were removed. DEFRA went as far as issuing a statement saying that the public were advised against purchasing them. Further records were obtained following a ridiculous *Evening Standard* 'page a day' hunt for frogs by two London newspaper reporters dressed in safari suits and pith helmets and with a decorated car (Smith and Hayes 1995 *a–d*). Although the publicity had some value, the trivializing of the issue and 'Killer frog' theme was arguably counter-productive to mainstream conservation interests.

There is nevertheless a surprising lack of reporting of large adult bullfrogs calling and breeding over the years, suggesting that conditions in garden ponds are less than ideal for them. This may be due to the late winter (February/March) period in London being too mild and the frogs waking early but being unable to survive early spring through lack of warmth and food. Equally, as with Water Frogs, our summers are often too short and cold for tadpole development. A Declining Amphibians Population Taskforce (DAPTF) worker had indicated that it was unlikely that bullfrogs would become established in the UK (Baker 1995), due to insufficient levels and duration of warmth in the UK for the species to spawn and hatch. Others published concerns that it was an invasive species that was likely to breed in the wild in conditions in England (Cunningham and Langton 1997).

There have since been two incidences of breeding in the London Area. The first was in 1999 a little way outside the LNHS area and around five kilometres south of Edenbridge on the Sussex/Kent border (Banks et al. 2000, Froglife 2000). The other was at a location that adjoins a golf course within the LNHS recording area, near Horndon in Essex in 2008/2009 (Ray Cranfield, pers. comm.). There are also a few other sites in southern England where breeding is known or suspected. At Horndon the origin of the frogs is not exactly known but the proximity of the Mar Dyke river system and ditches, which the local fisheries use to fill their ponds is a potential dispersal route used by Water Frogs and possibly also American bullfrog. At Horndon, bullfrogs were known to have bred in the smaller pond around 2006 but males were calling from two larger lakes where breeding was not observed. Non-breeding American bullfrog records in Essex from wild situations have also been mentioned more recently from Havering, Thurrock, Chelmsford and Southend.

Near Edenbridge in 1999, there were two secluded and warm shallow ponds, closely adjoining each other and one discharging into the other and managed for fly fishing on open farmland. The Environment Agency and the charity Froglife, together with the landowner, located numerous bullfrog tadpoles and froglets leaving the water with residual tails in large numbers. Further details are given in Appendix 4. In urgent response specialist contractors immediately undertook a range of activities to remove bullfrogs in 1999 and 2000, checking initially twenty-three water bodies, farmland ponds and small lakes nearby. In some of these locations they were found to have spread and efforts were made to remove them from those places before they bred. Post-mortem examination of random samples of bullfrogs that were captured and euthanased revealed that the young bullfrogs were eating native species of mammal, amphibian and dragonfly.

The most efficient control method proved to be shooting but because of welfare and health and safety considerations at the location, these methods were not used as part of the approved project control methods. Catching by hand using nets and torches was the most efficient approved method. Electrofishing and the use of crayfish traps were not found to be efficient because the animals were present at relatively low density and were probably too small for electrofishing and because dozens of traps would have been needed for a long time for complete trapping

out. It is considered that they could be used effectively and efficiently to collect animals elsewhere when tadpoles/froglets are present at high density although final drainage would remain essential.

Exotic species imported accidentally

There are any number of press cuttings concerning escaped reptiles and amphibians and accidental importations with animals being found in imported fruit, building materials and miscellaneous objects. Yalden (1965) provided an initial baseline of records. These join more recent reports of those found in buildings close to pet shops, in cars and hotel rooms, but as these are not usually considered truly wild they have not been included. Suffice to say that from a constant tide of escapes, it is not surprising that many end up in gardens or open spaces to join those that have been abandoned.

Non-native amphibian and reptile hotspots in and around the London Area

Greenwich sites:

Kidbrooke Green/Birdbrook Road Nature Reserve (NR)

These are urban green spaces, surrounded by dense housing and busy main roads. Together they are well-known locations for non-native European amphibians and reptiles (Snell 1981, 1983, 1984). It is also notable for having the greatest number of introduced non-native herp species recorded in Greater London. Since the 1970s at least seven non-native amphibian and one non-native reptile species have been recorded, some on both sites. There are two areas, one of which (Birdbrook Road NR), adjoins gardens where non-native European species have been kept and moved away from and there is evidence of direct releases into the areas since that time. The area had been proposed for a centre for breeding and keeping of non-native species but as they became more formalized during planning decisions involving changes to the land use, the London Wildlife Trust became more involved and favoured a native-species-only policy.

Charles Snell, a local resident who has kept European species in his back garden adjoining the site, has been involved in both native and non-native European herpetofauna in this area and protecting the wasteland habitat. Having described the native fauna, a number of species began arriving and he began advertising European tree frog and edible/pool frogs bred by him for sale at 50 pence each or for exchange in the British Herpetological Society Bulletin in 1983. In 1993, surveys revealed five species of non-native amphibian were recorded at Birdbrook Road NR and two at Kidbrooke Green in addition to the five native species that were detected during three night-time visits (BHSCC 1993). The Water Frog types located were pool/edible frog, and so potentially marsh frog although these do not seem to have been recorded. London Wildlife Trust conservation staff had concerns about proposals to establish a non-native species breeding centre at the Kidbrooke site and advice on removing those then present was sought. Partly as a result a lock was fixed to the gate to try better to control public access to the area. In the late 1990s there was a report of others in the area keeping non-natives in their gardens and the finding of a dead green toad *Bufo viridis* and a dead banded newt *Triturus vittatus* was reported, apparently with no obvious external signs of cause of death, suggesting that escapes/releases of new species were still occurring and possibly in association with disease. Around this time, awareness of disease transfer from such events was becoming better known.

Newdigate/Beam Brook Nurseries

This location has more non-native herpetofauna than any other site in the London Area or the UK as a whole and has been a major supply source of Water Frogs over an extensive area in Surrey. This includes numbers at the former

Xenopus Ltd site that also had high numbers of non-native species present. Beam Brook non-natives include Alpine newt, non-native crested newt and hybrids/intergrades; European tree frog, fire-bellied toad and wall lizard are also recorded. There are in addition historical records of Italian grass snake, European pond terrapin, fire salamander and green lizard, although the last three have not been seen for many years (Danial Winchester, pers. comm.). In addition Julia Wycherley identified five and suspected up to seven types (species and hybrids) of Water Frog largely from acoustic recordings (Wycherley 2003*a*, Wycherley et al. 2003).

Up to around sixteen different species/types have therefore been reported over the years of which at least eight are considered to have bred. Only the Water Frogs and newts have bred for many years, but the level of any further release of herps at the site over the years seems unreported. Froglife took action to halt the selling of great crested newt/newt hybrids in the mid 1990s by buying some to demonstrate that unlawful sale was taking place and then working with the police to prevent further sale and the resulting releases to the wild through further escape and abandonment.

Hampstead Heath and Epping Forest, north London

In addition to the information on Water Frogs there are a number of other species that have appeared at these large City of London Corporation (CoL) open spaces. These and others such as Burnham Beeches, a few kilometres beyond the LNHS boundary, have been regular dumping grounds for unwanted urban pets due to the proximity of dense housing and large annual visitor numbers. At Hampstead Heath sites, including Golders Hill Park, the Hampstead and Highgate ponds and Kenwood ponds, terrapin numbers peaked around 2007 with up to forty being visible on one day (Adrian Brooker, pers. comm.), although he has seen fifteen or more at one time on the Bird Sanctuary pond alone. There were probably more and a steady number being abandoned each year despite winter mortality. News stories of 150 terrapins present were exaggerated, this figure is closer to representing an estimate of the total number released on the Heath over the years. The CoL authorities discussed the issue of how to deal with increasing numbers from 2006. Humane traps were built and anchored in the ponds in 2007 and sixteen terrapins were initially caught. One idea was to send them to a sanctuary in Italy but rumours of them escaping and breeding there resulted in them being sent to a sanctuary in Norfolk.

FIGURE 33. Floating basket trap used at Corporation of London and other sites to catch abandoned terrapins. A proportion of terrapins basking on the edge, dive off into the middle when approached. They can then be easily netted as the base is covered by chicken wire, preventing escape. *Photo: City of London Hampstead Heath*

At Hampstead Heath in 2007, one person was intercepted while intending to release four terrapins and the specimens were confiscated. Over the years a number of terrapins have been sent to a large heated conservatory on the third floor of the inner London Barbican Centre where terrapins have been kept (see later). Within the Hampstead Heath sites there have been multiple terrapin species and probably other less-obvious species in many of the ponds including the Stock Pond, Vale of Health Pond, Ladies Ponds and Kenwood Ponds. Even in 2011 a new African terrapin species was captured. Since at least the 1840s at Hampstead Heath and Epping Forest, terrapins, Water Frogs and no doubt many other species have been repeatedly released by the public. These public sites are places with largely unrestricted access by day and night.

Hackney, Walthamstow and the River Lee

Either side of the river that runs through central north London in the centre of dense urban occupation, it is perhaps not surprising that this is a focus for dumped pets in north London. Wanstead Park is a well-known location and Clissold Park has had hundreds of terrapins abandoned there, particularly since 2000. This practice does not seem to diminish as shown by new terrapins arriving after attempted catch-outs. This is since the more-recent desilting operations to improve the conditions as a function of tidying up in advance of the 2012 Olympic Games that seems to have given people the idea that conditions are even more suitable now for them. The extent to which non-native species are being released in urban areas is exemplified by web site blog postings by Jo Wood in 2003. She found in her Hackney garden and in close proximity of Hackney Marshes, an Oriental fire-bellied toad *Bombina orientalis* type, a Water Frog type, European tree frog *Hyla arborea* and green toad *Bufo viridis*. These were probably releases/escapes from an adjoining garden. Generally, as mentioned earlier, Essex has a large number of reports of escaped and released exotic pets. Several aquatic centres and pet shops have a wide range of species regularly for sale including Alpine newt, midwife toad, green toad, marbled newt and green lizard, all sold without guidance to the law in respect of their release.

Problematic aspects of the chelonian pet trade

Unfortunately, according to Andrew Highfield of the Tortoise Trust (web postings) the Mediterranean tortoise trade can be considered as having returned and he reports that large numbers of tortoises, both *Testudo graeca* and *Testudo hermanni*, including the extremely vulnerable Western subspecies, *Testudo hermanni hermanni* are flooding the market described as 'captive bred'. They are reported to be accompanied by fake or fraudulently derived CITES documents giving their origin as either 'Slovenia' or 'Lebanon'. Similarly highly suspect animals accompanied by French, German and Belgian paperwork are also in circulation. Pet stores, garden centres and back-door dealers are offering Mediterranean tortoises in bulk, nearly thirty years since the initial 1984 tortoise import ban. These are illegally collected wild-caught animals that post the 1980s ban initially appeared in a steady trickle, mostly smuggled from Morocco, Tunisia and other localities such as Turkey. Most were sold by small adverts in newspapers — although several of the more unscrupulous 'specialist reptile dealers' were implicated. Vary rarely, a smuggler or dealer would be detected and prosecuted. Today a much bigger and far more effective and profitable fraud has been developed with low risk of being caught, and one designed to mislead tortoise keepers who would not buy other than tortoises with paperwork indicating that they are bred in captivity. A growing proportion of London's pet tortoises are illegally obtained.

The red-eared terrapin, turtle or slider *Trachemys scripta elegans* has been the world's most commonly internationally traded pet reptile for many decades. The history of exploitation of this and other species of terrapins in North America is

a long-standing one that has switched from an initial local use of them as human food, then commercialization for the pet trade and then more recently back towards human consumption by Chinese and other Asian US communities, including the extremely concerning mass exportation of this and other species to China. Because of the immediate and urgent nature conservation and animal welfare concerns surrounding this and related species, further details are supplied in Part 2 of this paper.

Harvesting of female terrapins in the USA with an element of ranching to obtain hatchlings from their captive-laid eggs began on a commercial level in the 1940s (Warwick 1991). The initial sale of hatchling terrapins as a children's 'starter' pet within North America rapidly grew in the 1960s. However, as a side effect doctors began to relate a significant proportion of salmonella-related gastric and other bacterial infections in school children to the keeping of terrapins and other pet reptiles. This was probably due to the very hot summer temperatures in parts of the USA and rapid growth of bacteria in terrapin tanks. On public health grounds, the sale of terrapins under 10 cm (4″) was banned across the USA and Canada by 1976. By this time over seventeen million red-eared terrapins had been traded each year. Shortly after the ban a drop in national reptile-related child infection rate was detected and the ban was made permanent. US dealers then began exporting around two million terrapins per year, growing to four to six million by the late 1980s (Warwick 1991). Red-ears were exported for sale as pets, although some countries, e.g., Japan imported them for human consumption.

Hatchling terrapins small enough to fit in the palm of your hand were sold cheaply in London and around the UK, often with a tiny perspex bowl with a small raised central island with a plastic palm tree in the middle. These were sometimes placed in front rooms on sideboards or the top of televisions that then were large, with a warm flat top. Terrapin hatchings are naturally robust, being adapted to emerge from their egg and survive a winter before feeding and so may survive twenty weeks or more before starting to deteriorate. Sold quickly they could remain as unfed ornaments for some time before care became essential. With such a long pre-death period it was harder for people to link cause of death to the pet shop and their unsuitability as pets. Those surviving shipment to pet shops were often sold with the minimum of information and the main income for the shop was selling the housing and pellet food. The trade succeeded, in part because they were so cheap and replaceable. Most hatchlings died in the first three to six months from sale. Those owners complaining were then given a new one by the vendor, up to three times in a row until after many months the proportion complaining reduced, as people gave up trying to keep them or out of guilt that it was their fault that they were dying. Those surviving required a fish tank that was soon outgrown and so sale of a bigger tank was necessary. Tanks required almost daily cleaning due to faecal matter in the water creating a smelly undesirable object in peoples' houses or large pumps and filters could be bought. Over time, many owners cannot cope and those terrapins not dying from neglect are offered around carefully or casually and given away (e.g., when a teenager leaves home), killed or left to escape or released at a local open space.

At one terrapin rescue centre run by Terry Bunn, 'Turtle Rescue', in 2010 they helped rehome from London sources twenty red-eared terrapins, nine yellow-bellied and two map turtles. Five of the red-ears (25 per cent) were captures from the wild. From Surrey, of eight red-ears rescued, one (12.5 per cent) was wild-caught having been brought into a vet's surgery after being found in the wild. These six wild-captured animals represent around four per cent of a total of 138 (97 red-eared and 41 yellow-bellied) unwanted terrapins. Overall at present only a small proportion of abandoned terrapins seem to be recaptured.

There has been no strategy within the small and more serious group of UK terrapin keepers for dealing with the scale of terrapin numbers needing rehoming in any one year and the consequences have been euthanasia or release into the wild, which is cheaper. However, nationally over the last ten years at least 800

terrapins from Britain were sent by the British Chelonia Group to a holding lake project that went wrong in Italy (see Part 2). At least low thousands of terrapins have been euthanased by veterinarians or shot by anglers and park keepers since 2000. This level of removal however may not overall be significant and terrapin numbers at sites where removals have been undertaken are rising again, for example at Clissold Park in Hackney.

FIGURE 34. Red-eared terrapins removed from Clissold Park in Hackney during refurbishment work. Considerable shell deformities can be observed as a result of poor care during their early years of captivity. *Photo: Roman Muryn*

Ecological impacts and implications

Nature conservation concerns

The pattern of mapped distribution of exotic herpetofauna in general is not surprising. It reflects density of human population, the source of home-keeping of the species and the nearby parks and open spaces where they have subsequently been released. Water Frog and terrapin records dominate and their locations in the wild correspond with wetlands and waterways. Linear progression along waterways is not that obvious in most places but terrapin records are frequent either side of the Thames in central west London and in a line that approximates to the River Lee in central north London. Water Frog records are associated with the edge of the Thames in north Kent, the Mar Dyke in Essex and the rivers in and around the Borough of Hounslow.

Terrapin distribution is well scattered and there are far fewer records on the outskirts of London. This may reflect lower density of recorders. Most of the records fall inside the Greater London boroughs, again a reflection of where many of the exotic species are sold and kept by the general public.

Most of the abandonments of herpetofauna are by the public who buy them, cannot cope or get bored and release them. Equally, those involved professionally working in universities and fisheries, the international transit of animals including airport handling staff and in particular biological supply companies, have allowed or facilitated escapes and releases to occur in a manner that is no longer acceptable. As with intentional releases by hobbyists and birdwatchers, it might be hoped that modern awareness of the risks from letting exotic animals go would have increased. However the evidence points if anything to an increase in releases, perhaps now a slight shift over the last fifteen years from the above-listed professional types to an increase in those released by the public. It seems that anything that is in trade is likely to get released and at present it should be assumed that any species in the general pet trade will in time be found in the wild.

Impacts of exotic herpetofauna in the wild

Recently, interest in the ecological impact and invasiveness threat of species has been under review as the ability to prevent international transfer of species appears to be very limited in the UK and Europe as a whole. Some species such as American bullfrog are out of control in France and a review by the German Federal Environment Agency suggested that eradication in France would cost euro 4.4 billion (Reinhart et al. 2003). In Germany, the same study showed that bullfrogs have colonized in Karlsruhe where five ponds have been pumped out to catch bullfrogs using volunteers but without complete success (Reinhart et al. 2003). An annual anticipated cost of euro 50,000 per pond per year was estimated for future eradication and in the London Area the removal costs at one location exceeded £100,000.

As a general point, the impact on smaller or more-isolated sites such as individual ponds may be more harmful due to the less frequent spatial interchange of species. Awareness of fragmentation as an overarching major issue in nature conservation has grown in recent years. In London, declining species are increasingly isolated, such as the great crested newt *Triturus cristatus*, where seventy per cent of remaining populations are restricted to a single water body for breeding (Atkins and Herbert 2006). Many London sites, as well as rural ones in typical modern agricultural landscapes, are relatively isolated and aquatic animal populations present may be small and already threatened. With the introduction of Water Frog or terrapin species into places where nature is already isolated and suffering inbreeding effects, the arrival of a new mid-range trophic predator could in theory finish off already small and stressed populations of amphibian, crustacean or other invertebrate. The change could be via predation or perhaps even alteration of vegetation or a range of subtle factors.

FIGURE 35. Marsh frog type eating water beetle larva (probably great silver water beetle *Hydrophilus piceus*). *Photo: Howard Vaughan*

The increase of predation pressure on prey species both rare and common is an obvious risk from escapes and releases of exotics. Autopsies of American bullfrogs in France has suggested that forty per cent of their diet is made up of native frog species, thirty-four per cent was fish, seventeen per cent insects and four per cent molluscs. Cannibalism represented three per cent of food items, and very small mammals and birds have been observed as being taken. With Water Frog, an impact upon the local fauna is also likely and anecdotal reports of them suppressing numbers of other species is similar to the manner that other dominant amphibians can achieve, e.g., large great crested newt populations can suppress common frog and smooth newt numbers in a pond. With the taking of juvenile water birds and other small vertebrates, the terrapin species likely to do this are the common snapping turtle, alligator snapping turtle and possibly the softshells

but not the red-ears and yellow-bellies that get blamed. Given the low level of release of the more predatory species the threat is relatively low although little is known of the extent of impact when it occurs. There have been a few reports of frogs and ducks with missing limbs but these can be due to many causes. A few cases were also mentioned by the National Terrapin Survey and are sometimes attributed to terrapins often without any evidence. On larger sites as well as on rivers and canals these events are more likely to be from northern pike *Esox lucius* or other large predatory fish. At some sites where ducklings diminished, such as Sheepwash Pond in Barnet, there was no clear evidence of predation by terrapins despite media claims although a softshell was present. Here diminished pond quality may have been more an impact due to terrapins consuming vegetation, combined with the over-feeding of ducks and consequent eutrophication. Elsewhere there has been some suggestion that terrapins can bask on waterfowl nests and hence displace water birds and predate eggs and chicks.

Introduced species may be consumed by species in the community into which they are placed and to an extent that may be highly significant. This offers a direct pathway for pathogen transfer between species that have not been in contact with each other. A recent example in London of this was feeding by grey heron, lesser black-backed gull and carrion crow on the introduced thin-clawed Turkish crayfish *Astacus leptodactylus* in The Serpentine and The Long Water over the last decade (Wiltshire and Reynolds 2006).

Marsh frog type at RSPB Rainham marshes are watched most of the time by birdwatchers and have been seen to be predated by grey heron, great white egret (a rare visitor), little egret, red fox, kestrel, carrion crow, stoat, weasel, kingfisher (taking young-of-year froglets), marsh harrier and grass snake (H. Vaughan, pers. comm.). They seem to be an integral part of trophic transfer at an increasing number of sites and may even increase species richness at a large site at least in the short term. The minimum size of ponds/wetland at which the arrival of a large abundant species as marsh frog does not negatively impact prey fauna via predation is not known but long-term studies might be useful.

FIGURE 36. Grey heron catching an adult marsh frog type at RSPB Rainham Marshes.
Photo: Freddie Roll

There are clearly limitations with many species' ability to breed in the London Area climate. Water Frogs seem to have better breeding years in long hot summers, illustrating their range-edge limitations. Released terrapins may mate in the wild and do so when kept at rescue centres. We came across several records of terrapins nest building and egg laying in London on banks and islands around ponds and lakes and the laying or jettisoning of eggs by freshly caught females. Captured wild-caught females at one rescue centre dug holes in a garden but did

FIGURE 37. Grass snake swallowing marsh frog type at RSPB Rainham Marshes.
Photo: Sula Riedlinger

not seem to lay a 'proper' nest and instead released the eggs into their retaining pool. It is not known if the eggs are fertile as no one seems to have incubated them although Wayne Rampling reports successfully incubated yellow-bellied slider eggs from a captured female. Although she looked like she had been in the wild some time it is not certain that she had not mated prior to being abandoned. The fact that hatchling terrapins have not been seen after many instances of opportunity in London and elsewhere implies that wild breeding has not as yet occurred but that might not be the case with other species, given time.

At present, damage by terrapins and Water Frogs from their competitive and predation forces is more theoretical than proven due to lack of research. Many urban situations are so disrupted that the relative importance of it seems lower than elsewhere on nature reserves or good quality less-protected areas. Impacts may be significant and even cause the disappearance of other species, such as aquatic snails.

Trends in London's wild terrapin numbers

The National Terrapin Survey (Weeks 1995, 1997) guesstimated that there would be a national UK non-breeding wild terrapin 'population' of around 1,500, by 2000. Guesstimating numbers today is not simple but the following figures are an attempt at approximation. The figures may well be wrong but are offered as a basis for further consideration and refining. Trends may vary from area to area and in places including park ponds it is suspected that some people taking in terrapins for rehoming actually then take them for outdoor release in a regular location where they carry out multiple releases over many years.

In the past, if the UK has had up to 300,000 terrapins imported each year until 1997, then it may have imported around four million since 1960. Based upon an average of around 250,000 mixed terrapin species imported for sale per year, if London has ten to twelve per cent of UK households, this might suggest that at least 25,000 terrapins were traded here each year. Of these, say ten per cent (2,500) survived until one-year old. If ten per cent of these survivors are released in the wild, around 250 have been released in the London Area per year and 2,500 (25,000 nationally) in the ten years to 1997. This might imply that the NTS survey was an underestimate or that most terrapins released died within a year or so which is also quite possible.

Today, terrapin numbers sold annually are less well monitored yet probably lower on average than that prior to the 1997 attempted trade controls, but some of the new species being released may be better at surviving.

Overall, the anecdotal impression gained from the records and accounts gathered for this study is that at some locations released terrapins can survive for longer than one year. There do not seem to be records of long-term survival. Survival is perhaps split into two classes: those dying in one to three years from release in the most unsuitable places (or unhealthy/stressed) and those surviving for up to ten years or more at sites with better quality thermal, water purity and food (aquatic plant) conditions. This could be further investigated. Equally, numbers being released in the London Area seems to be higher than 125 per year and could perhaps be as high as 1,000, but it is not currently possible to judge. From this we guesstimate minimum UK wild (abandoned) terrapin numbers for 2010 at around 4,000 with up to 1,000 (twenty-five per cent) within the LNHS recording area, most of which are within Greater London. Annual mortality of abandoned terrapins might be expected to vary somewhere between forty and eighty per cent and be highest in periods when winter ice cover exceeds two weeks.

Numbers of bullfrogs can clearly grow very rapidly with such a fecund species, but control efforts seem to have worked at the two sites and further cases that are in hand elsewhere in England. Water Frog removal has not been attempted to our knowledge but the impression gained is that although numbers can build up to high levels, very rapid spread is not a feature of these species if the habitat is interrupted by lower quality habitat, unless additional movements by human transfer is also taking place, as is the case with marsh frog type in Kent.

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Record Centres and charities that work with recorders and hence that have primary record-making capacities and that have assisted in some way in the supply or records include BRIE/Essex Wildlife Trust, Bedfordshire and Luton Biodiversity Recording and Monitoring Centre, Buckinghamshire and Milton Keynes Environmental Records Centre, Hertfordshire Biological Records Centre, Kent and Medway Biological Records Centre, Kent Reptile and Amphibian Group, London, Essex and Hertfordshire Amphibian and Reptile Trust (formerly London Amphibian and Reptile Group and incorporating the Hertfordshire and Middlesex Herpetological Standing Committee), London Ecology Unit, Passmore Edwards Museum and Southend Biological Records Centre. Buckinghamshire, Essex, Surrey and Kent, Amphibian and Reptile Groups have all assisted with records as have the Essex and Kent Field Clubs.

The account draws on a considerable amount of research and activity by commercial consultancies and work created by industry and government commissions. Over the last twenty-five years these have appeared and have taken centre stage in conservation work, often tackling situations where land use change from development initiates a wide range of professional response including ecological and practical/policy evaluation, survey and or practical habitat and species management work. These bodies include Amphibian Reptile and Mammal Conservation Ltd, GPM Ecology, Herpetofauna Consultants International Ltd (HCI staff working on non-native species control work include Catherine Langton, Kevin Morgan, Terry Venn and Andrew Wilson) and The Ecology Consultancy.

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APPENDICES

APPENDIX 1. Notes on climatic and zoogeographic considerations relating to exotic herpetofauna in London and southern England in general

The tendency of humans to move animals around and to release them presents a degree of confusion in zoogeography throughout the world. One of the earlier records of amphibian transfer is that of the fire toad or fire-bellied toad *Bombina bombina*, a species thought close to extinction in 1900 in Sweden. Its survival is proposed by some to be the result of releases by the wealthy Danish Chancellor Peder Oxe (1520–1575), quite possibly the first person documented as trying to acclimatize a wild animal by wild-to-wild transfer. Nearly 300 years before the European Acclimatization Societies began in the 1850s, Oxe moved what became known as 'Peder Oxe's frogs' into Denmark and south Sweden, releasing them throughout his estates and elsewhere. Their presence, with its distinctive male 'booming' call, appears to have been as a status symbol, the details of which do not appear to have been, yet might usefully be researched.

Toads were moved alongside live carp, other fish and crayfish that were carried in special 'fish chests' (Gilsen and Kauri 1959). Fish and other animals were packed in a purpose-made box within supported layers of saturated grass and

with a trickle system using clean water taken from along the roadside. Fish could remain alive in transit for several days. This was at a time when the spread of carp through land, waterway and sea transfer became more widespread across Asia and northern Europe. It was probably carried out during the cooler Continental early spring months (March/April), when sea travel condition is less stormy and fish transport is less risky in terms of survival. This is also a time when small amphibian eggs and tadpoles and aquatic invertebrates could also have been picked up and carried unintentionally. The re/introduction of fire-bellied toads was also reported from 1830 in Denmark in response to a slight trend in climate 'recovery' that continued until 1850 (see below). The evidence from measured climatic variables and more-restricted habitat availability in countries such as Britain, Denmark and Sweden suggests that in northern Europe several amphibian and reptile species are naturally more vulnerable than others to decline and extinction. This does not make them any more or less valuable per se, but points to a more difficult situation against which conservation efforts can be placed, particularly those of fragmentation/inbreeding effects caused by isolation. Poor, slightly deteriorating summer weather in Sweden from 1861 to 1930 and in the 1950s is pointed to as causing retreat by that time of fire-bellied toad *Bombina bombina*, natterjack toad *Bufo calamita*, green toad *Bufo viridis* (*Pseudepidalea virdis*) subgroup, spadefoot toad *Pelobates fuscus* and tree frog *Hyla arborea* (Gilsen and Kauri 1959).

Fish and presumably amphibian importation using the transport methods similar to those described above was featured during the monastic and early medieval period and is possibly an ancient practice. An increase from around 1600 was possible as the transport of carp and other fish by boat into Britain gained momentum with demand for food from London's growing urban population.

Gilsen and Kauri (1959) also reported on the distribution of Water Frog in Sweden. The single isolated population based on Kungsangen marshes in Uppsala is unlikely to have been previously missed by the local cluster of early Swedish naturalists and in the absence of an explanation might be considered as likely to be an introduction as to be native. The origins of those isolated on the Uppland coastland and particularly the numerous small islands, is worthy of debate, as are the mammals, reptiles and amphibians of the island of Gotland, some ninety kilometres from the mainland. Water Frog in Finland is considered to be introduced and the origin of a single population in Norway is also debated and hard to prove in terms of its native status. Gilsen and Kauri took a view that the Uppland coast Water Frog was a post-glacial relict. In southern Sweden all of the three main northern European Water Frog types; marsh frog, pool frog and edible frog exist. Prior to the land bridge between Denmark and eastern Britain submerging in the Mesolithic period, there is little reason to suggest that all three types were not present. This is because they had similar distances to recolonize from glacial retreats on both sides of the Rhine and other large rivers in Germany that form geographic barriers to dispersal from the south.

Water Frog bones occur in the fossil record in Britain but have tended to be indeterminate at species level. This is because the fragile head bones that determine species precisely are easily broken unless extraction methods take this into account. This seems not to have happened due to a lack of specific studies to investigate past occupation of Water Frogs. Probably due to cost and a lack of interest, such studies have been the responsibility of the Joint Nature Conservation Committee; a government agency that has had little funding and capacity in this area, despite the serious financial implications of applying interpretations of any evidence.

The water level rise and tsunami of around 8100 BP that are thought to have helped finally sever Britain as an island, occurred at a time immediately prior to maximum post-glacial temperatures some two degrees warmer than those today.

At the time of separation, Britain would have had around 1,000 years of temperatures as warm as or warmer than today, explaining its receptiveness to colonization by species now found in north and central Europe (Ford 1982).

Despite warm periods in the first millennium, around AD 1250 a series of poor summers caused noticeable slow-down in biological processes in Britain, for example grape growing became unviable. There was a fifteen-year stretch of poor summer temperatures in the next century, 1310–1325, with famine in England between the years 1311 and 1317 and again from 1345 to 1348. This is a likely phase (1310–1350) when a number of species that had colonized at the edge of their thermal range and requiring warm summer temperatures contracted in range or became extinct. There were other periods with severe winters that may have also reduced the survival of some species. Amphibians and reptiles found today in northern Europe that could just possibly have hung on until then, if present, could have died out naturally as their tadpoles simply had insufficient warmth to develop fully. This is the time when other native species, found more widely distributed in Britain in the sub/fossil record (sand lizard, smooth snake, natterjack toad), may have contracted in range and habitat preferences and become more confined to 'warmer' sandy soils, as is observed today. This is suggested by the wider distribution of sub-fossil finds of those species. The main period when UK temperature-sensitive species contraction and extinction may have prevailed, the 'Little Ice Age' lasted around 300 years (1550–1850). In some years permanent thick ice formed in the sea off the north Norfolk coast, in Fenland, and across the River Thames (1683–1684). If reptile and amphibian species not present naturally today had survived deteriorating climate in the first millennium, or been introduced and formed small distributions, then this is most likely the time of their final disappearance. Unfortunately, without further field research we will not uncover the true sequence of events and the speculation can only continue.

The retreat of pond terrapin from northern Europe is well documented from archaeological finds indicating presence in Sweden, Demark, Britain and Holland up to around 4,500–5,000 years or so ago. This followed a post-glacial expansion from the southeastern Balkans into Britain, central Europe and Scandinavia. North-eastern Europe was colonized from another refuge further east. Around 5,500 years ago pond terrapin records suddenly terminate in Sweden, some 1,500 years before the Holocene thermal maximum ended in Scandinavia and distinctly earlier than previously thought (Sommer et al. 2009). This extinction coincides with a temporary cooling period during the Holocene thermal maximum and is likely related to lower summer temperatures deteriorating reproductive success of this and probably several other herpetofauna species. Although climatic conditions improved later again, recolonization of Sweden from southern populations was prevented other than by human transfer by the Holocene submergence of the Danish Straits around three thousand years earlier.

Lever's (2009) view that there is a distinct possibility of European pond terrapin becoming established in southern England seems speculative and improbable at present. This is because of the combination of temperature constraints on egg survival, a lack of habitat and the fragmented and often polluted state of the UK wetlands. Equally, global warming may in fact lead to the cooling of UK temperatures within decades. There is no conservation case for the release of this and similar kinds of species for a range of reasons, not least uncertainty over future shift in weather patterns. This may not be accepted by a small group who feel they can argue a case for releasing species of butterfly, reptile, amphibian and mammal secretly or without proper consultation or rationale, and so the possibility of future (illegal) deliberate releases must be considered likely.

Appendix 2. Further notes on the taxonomy, distribution and origins of Water Frogs in Britain and the London Area

Taxonomy and general biology

Pool, edible and marsh frog types can be distinguished to a greater degree by their head bone morphology although the degree of overlap leaves some uncertainties (Boehme 1977, Boehme and Gunther 1979). Genetic tests and vocalization/calls (Wycherley 2003*a*,*b*) offer additional methods. Pool frog and marsh frog are considered by most to be two distinct species. The edible frog is a hybrid (technically a klepton indicated with 'kl.' between the generic and species names) which is a fertile hybrid of these two species. Edible frogs occur when a male pool frog mates with a female marsh frog. Male marsh frogs seem rarely to mate with female pool frogs. In the wild, hybrids tend to occur amongst both parent species and are infertile, often low in number and relatively unsuccessful. With Water Frogs however, the edible frog shows vigour and can maintain itself once established by coexisting with pool frog alone and they are almost always found together. When they mate with each other edible frogs do produce some marsh frog offspring although these are reported to be weak, with a low survival rate. When edible frog mates with pool frog more edible frogs are created. So in theory, at an edible frog colony, both parent species as well as their hybrid may be found although edible frogs may occur in proportions that reflect a range of things such as habitat quality. In rare cases edible frogs can even self-sustain themselves without pool frogs. This makes recording and reporting difficult because breeding edible frogs may well include pool frog and marsh frog, and over time it is possible that in the right habitats an edible frog colony can result in a pool or marsh frog population emerging. With the range of other similar species and hybrids that we now know about, the combinations and outcomes are potentially extremely complicated.

Water or Green Frogs are generally greener and grow larger than the Brown Frog group which includes our native common or grass frog *Rana temporaria*. Their name reflects their residence in or at the edge of water for a much greater period than Brown Frogs. The former are diurnal and like to sunbathe, making a splash when approached by diving at the water's edge.

Water Frogs interbreed and as a group have a massive international range due to their occupation of a wide range of habitats, cannibalistic tendencies and ability to use the land/water interface so effectively. The slightly larger marsh frog is the most aquatic and typically hibernates under water. Marsh frog populations in France and Switzerland are derived from frogs imported and bred for the food trade, marsh frogs being slightly bigger and hence favoured for culinary use.

The marsh frog has a particular and principal competitive advantage over pool and edible frog, in that its tadpoles are unpalatable or less palatable to fish and hence it has a competitive advantage in fish-occupied habitats. They are voracious feeders under water, particularly the marsh frog that also breeds a little earlier in the year, April or May, than pool frog and the hybrid edible frog. Anecdotal observation suggests that in some cases marsh fog populations occur in larger more-open and unvegetated ponds while pool frogs prefer smaller more-vegetated ponds but there is substantial overlap. Generally, edible frogs seem to prefer extreme disturbed habitats typical of quarries and seem to have expanded greatly, exploiting the new habitats resulting from human activities.

Water Frogs are hard to tell apart and they have striped, spotted or plain coloration that is quite variable. Edible frogs almost always have a light-coloured stripe along their back. The Water Frogs are relatively similar looking amphibians and hard to determine exactly other than in the hand and then often not conclusively. Coloration is variable despite broad trends and in truth an animal cannot be exactly recognized without genetic tests. The marsh frog has slightly longer legs and bumpier skin. Smith (1951) indicated that in his experience only a small proportion of marsh frogs had a dorsal stripe, however, this may have

changed or been a reflection of his material at the time. Smith also noted how Water Frogs in captivity or in the wild after hibernation and in less-sunny places are browner than those that have basked in the sun which turns them greener. Tadpoles also cannot always easily be distinguished in the field.

A survey in France and northern Spain (Schmeller et al. 2007) has investigated Water Frog populations, looking at twenty-two localities in the Rhone drainage basin and four in the Ebro drainage basin. It was reported that the marsh frog has the ability to replace native species such as Graf's hybrid frog *Rana grafi* and the Iberian Water Frog *Rana perezi* and to dominate. The competitive advantage is related to its ability to cross-breed with other Water Frogs and preferentially to produce more marsh frogs, the ability of female marsh frogs to live longer, and for them to be more fecund and to grow faster.

Marsh frogs seem to prefer larger, deep steeper-sided water bodies. Pool frogs seem to have found a niche in smaller and high-altitude pools that are not dominated by marsh frog. In Britain, Water Frog tadpoles metamorphose after August each year but many do not, due to insufficiently warm temperatures for them to develop fully, pointing to this factor in their persistence. This is most likely to be one of the main limitations to survival and spread along the edge of northern Continental Europe until relatively recent runs of warm years in addition to increased human movements of the species. The warm summers of the late 1980s and 1990s appeared to cause a noticeable increase in Water Frog numbers and spread, as evidenced by reports to common frog spawn telephone 'advice lines' run by London-based charities in the 1980s (TESL, pers. obs.).

Distribution and origins

The story is one of two similar species, expanding their range after the last glaciation. The pool frog appears to have moved north and east from the Adriatic/Mediterranean coast, around the Alps, while the marsh frog has moved north and west from the Caspian Sea/Ponto Mediterranean region. Bones of both species are recorded at Pisede in Germany in archaeology dated to between 5,000 and 7,000 years ago, so presumably they met and may have been interbreeding at or around that time and probably beforehand, inhabiting land masses that from around 6,100 years ago became submerged by land that is now under the North Sea. If both species arrived more or less simultaneously in northern Europe a few thousand years earlier as would be expected, with the marsh frog colonizing east of, or along the Rhine, that used to confluence with the Thames near what is now Dover, then in theory both species would have been present together with their hybrid the edible frog in south-east England/East Anglia.

A similar frog to marsh frog, *Rana perezi,* occurs in Spain and western France and a frog close to pool frog, *Rana bergeri,* occurs in Italy. Pool frog appears to be rare now in pure populations and seems unable to out-compete its hybrid. Pool frogs may appear in edge areas such as mountain ponds as a pure species if it has competitive advantage other than geographic isolation (such as cold tolerance), but this has not been demonstrated. It seems likely that edible frog is effectively for now 'the future' of pool frog and that maintaining isolated pure pool frog populations will only be viable if a large amount of habitat is available for big populations of many thousands and without a probability of proximity of other Water Frogs that would inevitably breed with them.

The discussion over the possible nativeness of Water Frog in Britain rumbles on despite a strange and relatively rapid series of events from the 1990s that culminated, following minimal public consultation, in a declaration by government that pool frog was a recent native species to the UK and of its protection in the wild by law. This was despite scientific challenge to the quality of the supporting research (Burton and Langton 2005, Langton and Burton 2005).

It is known from the ancient fossil record of West Runton in Norfolk 600,000 years ago that at some time in the distant past the area now defined as England was inhabited by a marsh frog-like animal. When sea water rose and split Britain

off after the last Ice Age and the climate was warmer than today it seems difficult to argue why one of the two Water Frog species *R. lessonae* and *R. ridibunda* would be present and not the other and most probably with the hybrid. The fossil records in northern Europe prove pool and marsh frogs to be present together around 6,000 years ago. As the waters rose, both pool and marsh frog (with edible frog) could have been present, and should be detectable given adequate archaeological investigation, albeit that there was only a few thousand years before the climate began to drop towards temperatures in which they would struggle to survive. Denmark was a last link of the English coast with the wide open European mainland (Doggerland, now under the North Sea) and today has all of three types. Theoretically in the warmer Iron Age London Area and East Anglia it is hard to imagine why marsh, pool and edible frog would not have been present through the various interactions of humans and animals in natural and disturbed habitats. Once this is accepted, together with the apparent decision not to try to eradicate them, then it seems pointless today to use finite resources to try to prevent their inevitable spread or to try and maintain 'pure' enclaves.

However, some speculation has been that the lack of evidence of Water Frog bones in general in the post-glacial English fossil record indicates that it existed in only remnant numbers, although this only rests on the difficulty in finding intact head bones for accurate identification. The use of leg bones is equivocal (Langton and Burton 2005). The fact remains that there is no legacy of fossil or sub-fossil remains for Water Frogs in Britain after the last Ice Age until relatively recently. What has been found, largely incidentally, is a very few bones that can be attributed to Water Frog from domestic sites only and only after human migration to Britain picked up after the start of the Roman period.

Appendix 3. Further notes on claims about Water Frogs and their translocation in England

In London in the 1840s, a newly established magazine *The Zoologist* provided a basis for debate on the subject of the status of Water Frogs in Britain, and over the years the initial claim that it was native to East Anglia were refuted. In 1884, Boulenger commented on the insufficiency of the case by Thomas Bell, who announced that he suddenly remembered that his father had heard something that might have been Water Frog calling in Cambridgeshire in the eighteenth century (Boulenger 1884*a, b*). Bell had slipped his assertion into a reprint of his book (Bell 1849) on British herpetofauna, basing it also on the claims of an entomologist Frederick Bond from Kingsbury in Brent (Bond 1844*a, b*) who helped establish *The Zoologist* and who appears to have been losing face until Bell decided to back up his argument.

One suspects when reading Wolley's (1847, 1849, 1859) contributions that there is a degree of suspicion towards Bond and his claim. Bond had an ally in the influential Bell, whose other strange claim of the time was to name a new frog for Scotland '*Rana Scotia*' without seeing any specimens, a claim soon withdrawn, and perhaps indicating poor judgement. Bell later failed to find favour with Charles Darwin's research. Bond appears to have declared the finding of a colony of Water Frog similar to those he revealed at Fowlmere in Cambridgeshire, near to his home at Kingsbury in Brent, north London, which was then a rural village. Water Frogs from Fowlmere (that were later described as pool frog) travelled between Cambridgeshire and Epping (see below), organized by Charles Thurnall, a linseed and mustard oil merchant from Duxford. Clearly frogs were being moved around and the possibility of Bond's London Water Frogs having been taken to Fowlmere cannot be ruled out, which may be what Wolley was hinting at in 1847 when he queried their true status. Fowlmere is around ten miles south of Cambridge, the university town where frogs were used in huge numbers for around 200 years for teaching purposes, and this raises some rather obvious and

interesting opportunities for archival research. Water Frogs have been released from Cambridge in recent times having been 'spared' dissection, and may have been for as long as they have been used there. Certainly in the 1840s Henry Doubleday moved Water Frogs from Fowlmere for release near to his house in Epping Forest, as reported in *The Zoologist* (Newman 1848). The records around the period of mass importation of Water Frogs to the UK from the late 1830s leaves, as it did at the time, a blur that has not yet been sorted out. However, Boulenger's enquiries showed the difference between the 1830s/1840s edible frog imports and the other localities in East Anglia that he described as Italian *lessonae* (pool) type and of obscure origin. He too found Bond's accounts inconclusive.

If Water Frog was present in Eastern England before the 1830s then, why is there no record as there is in other European countries from or before the seventeenth or eighteenth century? In the mid nineteenth century, John Wolley, finding edible snail *Helix pomatia* at one pool frog site, suggested a link with imported frogs from Roman times and others since have mentioned the probable traffic of frogs into the UK with the carp culture associated with medieval monks and monasteries (e.g., Fitter 1959). If Bond was not responsible for the origin of pool frog at the sites that he reported then others may have done earlier. We are back to the conclusion that only the sub-fossil evidence can truly solve this dilemma, the written accounts so far located are inconclusive (Langton and Burton 2005).

The claim that pool frog in Britain is a recently extinct native species (Beebee et al. 2005) has been recently commented on by John A. Burton (a previous LNHS member and recorder) in terms of it being the 'Piltdown Frog', in as much as most of the specimens date from a time after there were known to be extensive introductions and releases. His extensive research into hoax/fraudlent claims in zoology and botany over many years identifies unusual situations and there are some parallel characteristics in the two cases. In the Piltdown Man case, Charles Dawson actually forged skull bones to suggest an early human species had been discovered. His results were taken in good faith by a range of interested parties in different disciplines who then worked up theories alongside and developed evidence to embellish Dawson's initial find with supporting interpretation. Another example Burton described in an article in The Linnean Society newsletter, which was not deliberate, concerns a single erroneous record of alpine shrew (actually a dark-bellied water shrew), which became embellished over the years to include the whole of the Pyrenees, way outside the species' actual range. With the recent pool frog bone descriptions, the identification was taken in good faith by generalists for several years until the nature of their uncertain identification was revealed. Those producing supporting evidence to the pool frog bone claim individually had or developed circumstantial cases with supporting evidence. As with the Piltdown case, if the initial bone evidence cannot be trusted, any consequential theories simply remain inconclusive.

APPENDIX 4. Further notes on American bullfrog control in the London Area

On the outer edge of the London Area in 1999, the Environment Agency and Froglife, together with a concerned landowner, located America bullfrog *Rana catesbeiana* tadpoles and metamorphs in large numbers at two ponds on farmland at a site around five kilometres south of Edenbridge on the Kent/Sussex border (Banks et al. 2000). Two small fly-fishing lakes, one discharging into the other, were located together, one of which also had a small shallow side pond. The specialist aquatic management team from the Peterborough office of Herpetofauna Consultants International (HCI Ltd) were deployed with financial support from English Nature under the direction of Brian Banks. Amphibian drift fencing and pitfall traps were placed in the autumn of 1999 to minimize the

dispersal of bullfrogs away from the lake during draining down to remove them using screened pumping techniques. English Nature also commissioned HCI to do field work in 1999 and in 2000 to try to establish the extent of any bullfrog distribution in sites around the original source ponds, and to trap further bullfrogs.

The origin of the bullfrogs, later found to be accompanied by African clawed frog *Xenopus laevis* was thought to be linked to Blades Biological Supplies nearby where the owner kept and bred bullfrogs and African clawed frogs to sell as biological specimens. Reports of the escape of 'a bullfrog called George' around the mid 1990s pre-dated the shooting of a 'large noisy frog' on one of the ponds in 1996/7.

After draining and removal of thousands of tadpoles and froglets in 1999, survey work in spring 2000 made it clear that immature bullfrogs at up to 65 mm body length had dispersed to a number of water bodies around the original breeding ponds and that other adults were in the area. Twenty-three ponds were identified within a one-kilometre search area and visited to check for the presence of bullfrogs. A further 108 sub-adult bullfrogs were located in 2000 and removed from the original ponds and four others of twenty-three checked, all additional ponds occupied being within 500 metres of the original breeding pond. The few remaining immature froglets around the original breeding ponds reached 110 mm body length by summer 2000 while at newly colonized ponds, body size was only up to 75 mm.

In 2001 all ponds were visited every three to seven days, May to August, to determine numbers of bullfrogs visible, to check for adult male calling activity and for signs of spawning. This was not ideal but cost constraints prevented the visiting of all of the ponds every three days, including night visits. Further culling of residual numbers by landowners in 2001 was monitored with thirty-two immature bullfrogs being taken. Observations by day and night in 2001 suggested that numbers of adults in the area were at or close to nil at the four remaining ponds where they had been seen in 2000 and 2001. In late summer 2001 however, to disappointment, bullfrog tadpoles were again found in the original 1999 emergence site. After fencing the ponds again, over 1,000 tadpoles and froglets were removed over winter 2002/03.

The draining down following the prior rescue of rainbow trout *Oncorhynchus mykiss* and tench *Tinca tinca,* was again achieved through pumping and with use of seine and hand nets by the Environment Agency. The narcotic/anaesthetic rotenone was used to ensure all froglets were removed. No adults were found. In January 2003 the adjoining lake was netted and checked with scuba diver search by Kevin Morgan but no tadpoles were found.

During 2002, in ponds in the general vicinity to the initial breeding, seven more bullfrogs were culled and checks for calling males and spawn were reduced to every week to ten days. One or two adults were seen at two large ponds near to the initial breeding site but low numbers made catching/culling opportunities very stretched. In autumn 2003 bullfrog tadpoles and froglets were found in another pond about 300 metres to the north suggesting a post-1999 breeding, and spawn that was missed by the monitoring checks, possibly due to their infrequency or because bullfrogs sometimes lay eggs below the surface on vegetation that are not visible from the bank without a high-power torch. In some cases a boat is needed to get close enough to find it but government resources were insufficient to cover such proactive (as opposed to responsive) effort. These ponds were also fenced off and pumped. In September and October 2003, 2,731 tadpoles/froglets were removed from 'carp' pond and seventy-nine from the 'Weedy' pond. To everyone's astonishment, 350 *Xenopus laevis* tadpoles and one adult were also found and removed and a further albino adult was found around 2005.

Of the few bullfrogs reported by pond owners at the more dispersed sites (two ponds with up to five sightings) most could not be found during inspections, and over time, herons were considered to have predated several or possibly all, apart

from three that were caught or killed by owners. In total there were eight ponds with confirmed bullfrog presence, and a wider sweep of around fifty ponds followed in later checks.

American bullfrog tadpoles take three or four years to mature and this is an important factor in the ability to control their numbers. However, the solitary and territorial nature of adults appears to make it hard to locate and remove every single individual, as might generally be expected with amphibians. Equally, the aquatic habitats comprise relatively small ponds. In a larger lake or similar waterway situation control measures would be more difficult and expensive because drainage, fencing, netting and culling might be difficult or impossible without great expense.

More recently from this site the fungal disease chytridiomycosis (Longcore and Pessier 1999) was identified by the Institute of Zoology, London in both American bullfrog and common toad *Bufo bufo*. This suggests that pathogen transmission has occurred as the result of non-native species release/escape into the wild.

Book review

A new atlas of the Kent flora. Eric G. Philp. Kent Field Club. 2010. A4 hardback, glossy cover, 348 pp. £39.50 + p. & p. From Kent Field Club, Brogdale Farm, Brogdale Road, Faversham, Kent ME13 8XZ. ISBN 978 0 9561926 2 2.

This book is a remarkable achievement, being almost entirely the work of one man in the twenty years from 1991 to 2010. Kent is only the second county to have been the subject of a second atlas flora (Hertfordshire was the first). Eric Philp wrote the first *Atlas of the Kent flora*, published in 1982, and now he is the author of the new one.

How does this new volume differ from the last? It is more up-to-date, of course, but it is also more comprehensive. It is also more attractive, having colour on almost every page (including some fine plant portraits and evocative landscapes, but with no obvious criteria for their choice) whereas the 1982 atlas had no colour. The first atlas flora, though written by one man, resulted from the recording effort of a team of botanists (180 helpers are listed) who made 265,511 records; the new book is almost entirely the work of Eric Philp who has made over 250,000 records himself (whilst acknowledging particular help with the brambles, hawkweeds, docks and willowherbs, and listing eighty helpers).

Mapping is on a tetrad basis as it was for the first atlas flora. There are 1,043 tetrads in the survey area which is the administrative county of Kent together with the now separate unitary authority of Medway. That part of vice-county 16 West Kent which is in the area of the Greater London Authority is not included on the grounds that it was adequately recorded in the *Flora of the London Area* published by the LNHS (Burton 1983).

Short introductory sections locate the county in the British Isles, define the survey area and describe the geology and weather and the methodology and results of recording from 1991 to 2005. The bulk of the book comprises brief descriptions of the status of all species of vascular plant ever found wild in Kent (including comparative figures for tetrads in each survey period) together with distribution maps for all but the rarest species found during the survey period. Following the example of *A flora of Norfolk* (Beckett et al. 1999) selected maps have coloured background layers demonstrating the significance of woodland, rivers, water bodies generally, urban areas and main roads, and underlying geology for the distribution of certain species. Three examples are mind-your-own-business *Soleirola soleirolii* largely in or close to urban areas, hare's-foot clover *Trifolium arvense* restricted to the sandy soils of the Folkestone Beds, the Eocene Sands and the shingle, blown sand and shell sand around Sandwich and Dungeness/Romney Marsh, and Danish scurveygrass *Cochlearia danica* on sandy and shingle coasts and along the major roads of the county (in the last case showing a huge increase in distribution from 17 tetrads to 209).

Other plants which have expanded their range include narrow-leaved ragwort *Senecio inaequidens* (1 to 15 tetrads), sea mayweed *Tripleurospermum maritimum* (29 to 84, a case of more accurate recording?), Guernsey fleabane *Conyza sumatrensis* (0 to 218) and lizard orchid *Himantoglossum hircinum* (6 to 17).

There has been no change for many of the most common species, at least two of which were found in exactly the same number of squares in each survey period: ribwort plantain *Plantago lanceolata* (1,031) and common nettle *Urtica dioica* (1,032). It is pleasing to learn that several of the nationally rare plant species for which Kent is important appear to be holding their own. Examples include the late spider-orchid *Ophrys fuciflora* (9 to 10 tetrads), early spider-orchid *O. sphegodes* (16 to 21) and lady orchid *Orchis purpurea* (48 to 44).

The distribution of many species has declined (or appears to have done). In some cases there are obvious reasons. Wool-shoddy is no longer used on market garden crops or in hop-gardens so the associated non-native weed species have disappeared from the Kent flora. A similar loss has arisen from a change in the management of rubbish tips: as they are now continually covered with soil the casual plants that used to be found are no longer. Another is that as waste from the vegetable oil-milling industry is no longer deposited in the county the associated interesting plants are also gone. Apart from these very specific examples the general reason for the decline of species is loss of habitat. The author relates this to population increase during the twentieth century (which continues) and the consequent demand for more houses and related infrastructure to be built. He does not discuss the effects of changes in agricultural and forestry practices, the management of roadside verges or public open spaces or the fashion for tidiness in urban and suburban areas.

Brief reference is made to two major surveys of wildlife habitats conducted in Kent in the last twenty years, but there is no attempt to relate their findings to the author's findings about plant distribution. This is disappointing, but would probably have lengthened the period between the end of the survey and publication of the book.

Commendably, the author has attempted to ensure that voucher material for all the species recorded in Kent is housed in the herbarium of Maidstone Museum. He emphasizes the value, scientific and historical, of this material and the importance of its being maintained for future consultation.

The author is justifiably proud of his achievement but this reviewer can't help thinking that a team of recorders would have achieved better coverage, particularly of non-native species in urban environments. Despite this reservation this is a significant expression of the (more or less current) state of distribution of flowering plants and ferns in administrative Kent and an essential purchase for anyone interested in the flora of the county.

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JOHN SWINDELLS