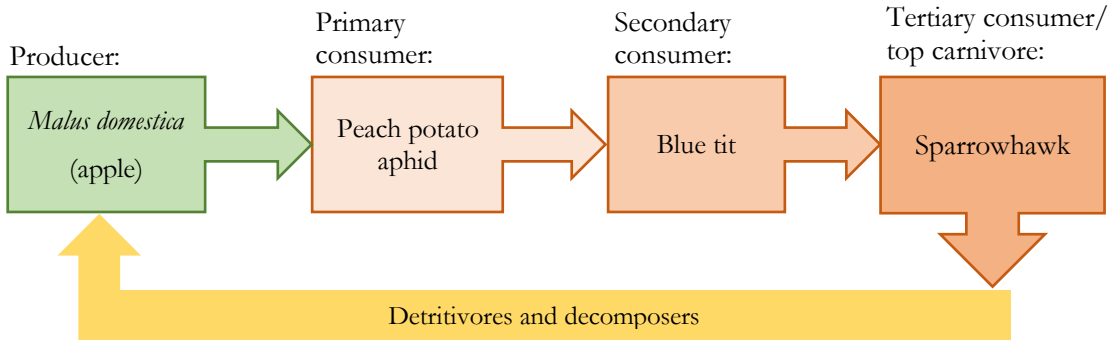
Consumers are heterotrophic (hetero = other, trophic = nourishment), meaning they gain nutrition from other organisms by eating or parasitising them. There are tiers of consumers, from those that eat plants (**herbivores**) to those that eat animals (**carnivores**). Some animals are **omnivores**, meaning they eat plants and animals.

All living organisms produce waste (e.g. fallen leaves from plants or faeces from animals) **and all living organisms eventually die**. Organic waste and dead organisms do not build up on the soil surface. A group of organisms feed on them and break them down. **Detritivores are animals that eat dead organic matter**, such as earthworms eating dead leaves or some beetle larvae that consume dead wood, e.g. staghorn beetle larvae. **Decomposers include most species of fungi and some bacteria**. These complete the breakdown process. **The end product is small inorganic molecules that plant roots absorb as nutrients**. This completes the circle of life.

An example food chain:



[Note that most food chains don't tend to show detritivores and decomposers. They are included here for completeness]

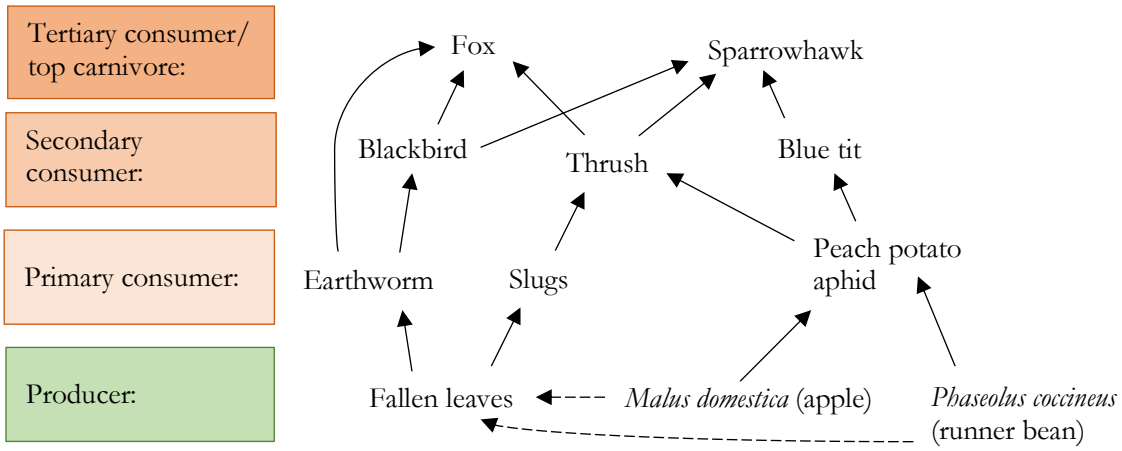
Food webs:

The food chain above represents a simplified version of the feeding relationships that happen in a habitat. In reality, peach potato aphids feed on a wide range of plants, blue tits consume many different sources of food, and sparrowhawks prey on many different types of animals.

Food webs represent this complexity:

- **Most heterotrophic species can be described as polyphagous** (poly = many, phagous = eating), meaning one species consumes several different species. Food webs can show these more complex feeding relationships.
- **Rarely, monophagous** (mono = one, phagous = eating) **dependencies occur**. This is where a species only consumes a single food source – either a single species or a small number of closely related species. One example is the cinnabar moth caterpillar, which primarily feeds on *Senecio jacobaea* (ragwort), and can also be found on *Senecio vulgaris* (groundsel). Small blue butterfly caterpillars only feed on *Anthyllis vulneraria* (kidney vetch). Monophagous species are especially vulnerable to local extinction. If their food plant is removed, they will be lost with it.

An example food web is given below:



- **Green spaces should create a range of habitat types to maximise the number of different ecological niches. This increases the range of species that can live within an area, increasing biodiversity.** Habitat types that can be created include:
  - **Woodland** with layered planting including canopy, understory shrubs and groundcover layer,
  - **Woodland edge**: trees, shrubs and semi-shade tolerant herbaceous plants,
  - **Scrubland**: shrubs and herbaceous plants, such as the combinations found in a mixed border,
  - **Wildflower meadow**: insect pollinated plants and (wind pollinated) grasses. Wildflowers are better able to compete on low-nutrient soils where grass vigour is reduced,
  - **Pond and bog**. Ponds are a UK BAP Priority Habitat (see topic 4.5 Biodiversity Action Plans)

  These habitats are detailed further in topic 4.3 Creating Habitats.

- **Domestic gardens**, which collectively make up a significant landmass, **should also prioritise a range of habitat types to maximise biodiversity**. Smaller gardens may not be able to include a wide range of habitats, especially woodland. **Smaller sites will benefit from inclusion of woody and herbaceous plants which flower and fruit in differing seasons. Lawns should be developed into wildflower areas where possible, and hard surfaces minimised, favouring planted areas**. This way, a balance between woodland edge, scrub and wildflower can be achieved.
- In the selection of animal (insect) pollinated plants, **preference should be given to varied flower shapes and timing of flowering**. For example, corymb flowers, such as those produced by *Achillea millefolium* (yarrow) favour hoverflies, racemes with large tubular flowers such *Digitalis purpurea* (foxglove) favour bumblebees, densely packed panicles of small flowers such as *Buddleja davidii* (butterfly bush) favour butterflies and honey bees.

Crocus tommasinianus (early crocus) flowering in early march with a honey bee pollinating it.

- **Fruit and nut producing species attract birds and mammals**, e.g. *Corylus avellana* (hazel) produces large nuts eaten by mice, voles and squirrels. *Sambucus nigra* (common elder) and *Viburnum opulus* (guelder rose) both produce fruits eaten by birds and other animals.
- **Planting an array of winter and spring flowering bulbs, corms, tubers etc. offers pollinators nectar and shelter for garden wildlife when little else is flowering. Winter and spring flowering bulbs, corms, tubers etc. die down during summer, meaning they can be planted amongst other plants, increasing the biodiversity of a single area.**
- **Inclusion of evergreen species** such as *Hedera helix* (common ivy) or *Ilex aquifolium* (holly) **provides wildlife with year-round cover, including nesting birds**.
- **Prioritise native mixed species hedgerows** over monoculture hedgerows. Replace worn fences with hedgerows. Hedgerows are a UK BAP Priority Habitat (see topic 4.5 Biodiversity Action Plans). Walls, which are long lasting, should be clothed with climbers.
- **Avoid double flowered plants where access to nectar and pollen is reduced**. Only single flowered plants should be used.
- Prioritise UK BAP species, ideally local BAP species (see topic 4.5 Biodiversity Action Plans).

It is important to consider the potential for biodiversity in different design styles. Some, such as Renaissance and Gardenesque gardens have limited scope for high biodiversity compared to other styles. Renaissance gardens are characterised by swathes of monocultures. Gardenesque style features generally sparse plantings of non-native species, as well as vast tracts of lawn and island beds planted with seasonal bedding. There are a range of viewpoints on whether historic styles should be preserved in totality, or adapted to be more biodiverse. Some argue that in historic settings the original style should be preserved as part of horticultural heritage.

Modern gardens preference repeats of a small number of low maintenance species, limiting biodiversity. However the individual species selections can focus on encourage biodiversity by creating varied habitat types and offering nectar and fodder throughout the year.

A lot of gardens are designed in other styles, such as Landscape gardens, Picturesque gardens, Arts and Crafts gardens or Wild Gardens (which includes Cottage gardens, wildflower meadows, prairie gardens, woodland gardens and wildlife gardens). These can all be adapted to maximise biodiversity by increasing the range of species, prioritising the points made above.

A **wetter, more humid cool season will allow moss to grow more vigorously** over a longer season. This can be **detrimental to high quality lawns**, especially those on damper soils and in shadier locations. However, **more moss can benefit birds that use it to line their nests**.

Camellia flower blight

If **increased dry weather and hot temperatures occur during summer, humidity will be lower**. This **will increase the rate of transpiration in plants, expediting soil drying and drought conditions developing, negatively impacting plant health**. Two spotted mite (sometimes called red spider mite), which thrives in heat and low humidity, may become a more common garden pest.

Susceptibility to pests and pathogens:

There is an increased risk of some pests and pathogens becoming more prevalent, whilst others may decline.

Plants that are exposed to continuous cool, damp, high humidity weather as may occur more persistently in the **cool season** are **more likely to suffer from pest or pathogen attack** if they are not evolved to tolerate this type of weather.

Powdery mildew favours dry weather and is more prevalent in hotter, drier summers

- Diseases like *Botrytis cinerea* (grey mould) or downy mildew species may become more prevalent.
- If early autumn or spring weather is persistently cool and damp, pests such as aphids may become infestations as their insect natural predators are less active. This can be a problem in spring when insect natural predators such as ladybirds can be slow to emerge from their overwintering sites, and before migratory birds have returned for the warmer months.
- Increased heavy rain events can cause more rain splash, moving water-dispersed spores of rose black spot further, increasing its prevalence on roses.

Plants that are stressed by hot temperatures, dry soil and low humidity are more likely to suffer from pests or pathogens during summer.

- Two spotted mite (previously called red spider mite) may become infestations on heat-stressed plants more frequently than in the past.
- Powdery mildew may become more prevalent in summer, potentially affecting plants earlier and more intensely. This can impact the health and aesthetic of e.g. *Berberis thunbergii* f. *atropurpurea* (purple Japanese barberry) where the powdery mildew coats purple foliage white. Powdery mildew readily infests *Cucurbita pepo* (summer squash, including courgette and marrow) when plants are heat and drought stressed, reducing yields.

Phenology:

This is the study of plant growth patterns in response to environmental factors such as day length, temperature and rainfall. Plants from temperate regions have growth cycles that relate to the cool and warm seasons, with most plant growth commencing in spring and ceasing in autumn. A small range of species grow through the cooler season and are summer dormant, including spring flowering bulbs.

Whilst day length patterns are not changing, temperature and rainfall patterns are. **Reduced winter chill can affect woody plants. For example, apple trees require a minimum number of winter chill hours to set a high number of flower buds that open in spring**. Chilling hours are when the temperature is below 7°C but above freezing. **Most apples require around 1000 chilling hours during the winter. Less than this and they may not flower as heavily, reducing potential apple yield the following autumn.**

Many other woody plants need winter chill hours to set high flower bud count. Ornamental (and edible) cherries e.g. *Prunus* 'The Bride' (cherry 'The Bride'), or spring flowering plants such as *Ribes sanguineum* (flowering currant) may have a reduction in their spring flower display if winters become milder. Reduced fruiting means less food for wildlife (and people), negatively impacting garden biodiversity.

Milder winter temperatures may cause plants to produce unseasonal growth that will be damaged by subsequent cold snaps. This wastes a plant's winter energy reserves, reducing its potential to enter vigorous growth in spring. Roses are an example of a plant that readily enters growth in mild winter weather. An intense cold snap can damage this new growth.


This barley field is a monoculture that does not support biodiversity

The proportion of land used for agriculture is hugely problematic for UK biodiversity. Mechanisation of agriculture and the chemical age has transformed farming practices. Arable fields are ploughed annually and treated with herbicides, pesticides, fungicides and synthetic fertilisers. Vast monocultures occupy increasingly large fields that can be efficiently harvested by large machinery. The expansion of field size by removing hedgerows has reduced valuable rural habitat, meaning fewer spaces for animals to shelter and nest. The UK has lost around half its hedgerows since the 1970's. Pastural fields are often treated with selective herbicides (like those used on lawns) to kill eudicotyledon species, reducing their biodiversity. Non-organic agriculture practices kill plants, animals, fungi and damages the soil ecosystem.

The State of Nature Report 2023 details the decline in UK biodiversity. This report has found a 19% decline in UK species since 1970. The full report can be accessed at: www.stateofnature.org.uk

The good news is that gardens can be highly biodiverse spaces if they're designed and maintained in ways that maximise their range of habitats. Private gardens and public green spaces can provide habitat for rare and endangered species, protecting them from local extinction.

Whether large or small, all gardens offer native plants and wildlife space to grow, nest or feed within. Most gardens are in urban areas and connect with neighbouring gardens. This means that, collectively, urban gardens can host a far greater range of species than an equivalent area of farmland. This is because the variety of habitats in gardens is far greater than a farmer's field. Rural properties with gardens present an even starker contrast in biodiversity where they back on to fields. They are important refuges for wildlife where removed hedgerows and chemical use has reduced rural wildlife populations.

Gardeners can collectively act to increase Britain's biodiversity, garden by garden. Every garden and green space has the potential to be highly biodiverse. **The most important foci to achieve high biodiversity is to maximise the range of habitats in a garden or greenspace, and to focus on inclusion of UK BAP priority habitats and species**. This is explored in topic 4.5 Biodiversity Action Plans (BAPs).

Creating Different Habitats within Gardens:

A range of habitat types that can be created in gardens was overviewed in topic 4.1 Plants and Biodiversity, and is repeated below:

- **Woodland** with layered planting including canopy, understory shrubs and groundcover layer,
- **Woodland edge**: trees, shrubs and semi-shade tolerant herbaceous plants,
- **Scrubland**: shrubs and herbaceous plants, such as the combinations found in a mixed border or where shrubs are grown within a wildflower meadow,
- **Wildflower meadow**: insect pollinated plants, and grasses. Wildflowers are better able to compete on low-nutrient soils where grasses' vigour is reduced,
- **Pond and bog**. Ponds are a UK BAP Priority Habitat (see topic 4.5 Biodiversity Action Plans)

Each of these habitat types are explored further below, including ways in which they can be incorporated into gardens.


Even small planted areas in urban locations support local biodiversity

It is important for gardeners to consider what's realistic in their garden; **bigger gardens can incorporate a larger range of habitats. Gardeners should consider their garden as part of a local habitat matrix**. If woodlands or large trees are found nearby it would be better to focus on creating scrubland, wildflower plantings and pond habitats. This will increase the range of habitats in a locality.

Each habitat type should focus on maximising the number of different plant species, which inherently increases biodiversity. **The greater the range of producer (plant) species, the greater the range of consumers. This maximises biodiversity at all levels of a food web**.

- **Wildflower meadows**. Consisting of **annual, biennial and perennial herbaceous plants**.
  - These can be allowed to develop in lawn areas that are not used for recreation. Initially lawns should be heavily scarified in autumn before wildflower seeds sown, exposing bare soil to optimise wildflower germination.
  - Maintaining a mown edge alongside borders and including mown paths through a meadow ensures these spaces are practical and usable.

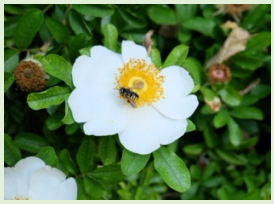
Herbaceous borders replicate aspects of wildflower meadows, but lack meadow grasses and have fewer native species. Their biodiversity value can be increased through inclusion of native grasses such as *Molinia caerulea* (purple moor grass), which is host to chequered skipper caterpillars. This butterfly has been reintroduced in parts of the UK as parts of ongoing conservation efforts

- Meadow wildflowers include *Achillea millefolium* (yarrow), *Centaurea cyanus* (cornflower), *Leucanthemum vulgare* (ox-eye daisy), *Papaver rhoeas* (field poppy) and *Rhinanthus minor* (yellow rattle).
- Herbaceous borders replicate many benefits of wildflower meadows, although the lower proportion (or total lack) of native species means there is potentially less fodder for wildlife, such as caterpillars that feed on specific native host plants. An example is small copper butterfly caterpillars which feed on *Rumex acetosa* (common sorrel), *Rumex acetosella* (sheep's sorrel) and *Rumex obtusifolius* (broad-leaved dock), all native wildflower species. This is a justification for not removing 'weed' species (spontaneous plants) from gardens unless they're becoming invasive.

- **Pond and bog**. **Open water with a range of depths, sloping sides** for wildlife access, aquatic plants and marginal/bog plants in areas of **permanently saturated soil** (bog).
- Pond plants should include submerged (oxygenators) e.g. *Ceratophyllum demersum* (hornwort), deep water aquatics e.g. *Aponogeton distachyos* (water hawthorn), floating plants e.g. *Stratiotes aloides* (water soldier) and marginals e.g. *Myosotis scorpioides* (water forget-me-not).
- Bog plants could include *Bistorta officinalis* (common bistort), *Darmera peltata* (umbrella plant), *Iris sibirica* (Siberian iris), *Primula japonica* (Japanese primrose) or *Rodgersia pinnata* (rodgersia)

A high diversity of different plant types creates a myriad of opportunity for different wildlife species to feed, nest, shelter, rear young, overwinter and travel through. Additional garden features can be integrated to further expand habitat provision. A range of plant types and garden features are explored below:

Plant Type or Garden Feature	Benefits For Wildlife and Important Installation/Maintenance Tips	Examples of Associated Wildlife Species
Woody plants 	**Nesting space for birds**. Species with a dense growth habit provide good cover, such as *Crataegus monogyna* (hawthorn) and *Ilex aquifolium* (holly). These also have sharp defence structures (thorns and leaf prickles, respectively), which help to deter predators. **The pruning of hedges creates a dense growth habit suitable for nesting birds**. They should not be pruned between March and September to avoid disturbing active nests. **Woody plants also offer fodder for wildlife**. For example, aphids feeding on young growth or caterpillars feeding on foliage are primary consumers, which in turn are food for secondary consumers.	Birds such as blackbirds, greenfinch, goldfinch, robins and song thrush nest in trees and shrubs. Blue tits, lacewing and their larvae, and ladybirds and their larvae eat aphids, such as peach-potato aphid on *Malus sylvestris* (crab apple). Purple emperor butterfly caterpillars feed on *Salix caprea* (goat willow), *Salix cinerea* (grey willow) and *Salix* x *fragilis* (crack willow).

Dense herbaceous growth (e.g. wildflower meadows, woodland groundcover, herbaceous borders, vegetable gardens) 	This provides **cover for wildlife** moving through gardens, protecting them from predators. Lawns do not have a significant benefit in this regard. **Primary consumers feed on herbaceous plants' foliage and flowers**. These support secondary consumers. **Herbaceous material** (dead deciduous stems or evergreen parts) **creates overwintering sites** for invertebrates, especially in dense growth such as *Miscanthus sinensis* (eulalia). Dead deciduous growth should be left standing over winter. When it is cut down at the end of winter/early spring the arisings are best left in situ as a mulch so overwintering insects are not removed.	Primary consumers and associated secondary consumers include: Slugs and snails, which are eaten by thrushes, blackbirds, hedgehogs, ground beetles, frogs, toads and newts. Aphids (see above) Cabbage white caterpillars are parasitised by a wasp called *Cotesia glomerata*. Spiked shield bugs also feed on cabbage white caterpillars. Overwintering insects that can be found in dead herbaceous material include ladybirds, lacewings, spiders and pollen beetles.
Animal (insect) pollinated flowers 	These produce **nectar and pollen essential for the survival of bees, moths, butterflies and other species.** Other species such as pollen beetles also feed on flowers. To maximise a garden's potential to host pollinators, **only single flowers** (not double flowers) **should be used**. **Various species should be selected so flowers are present throughout the year.**	Flower-insect associations include: Bumblebees favour *Digitalis purpurea* (foxglove). Hoverflies feed on *Anthriscus sylvestris* (cow parsley) flowers. White admiral butterfly favours *Lonicera periclymenum* (common honeysuckle).
Fruit, seed and nut bearing plants 	**These typically bear in late summer and autumn, providing important food for wildlife as winter approaches.** Species that produce fruits, medium to large seeds or nuts are valuable fodder for wildlife. **Plants should not have their flowers deadheaded to increase food provision for garden wildlife.** **Use of dioecious species should favour female plants** which bear seeds. A male pollinator may be needed for non-native species.	*Sorbus aucuparia* (rowan) produces autumnal berries eaten by birds such as blackbirds, song thrushes, redstarts and redwings. *Corylus avellana* (hazel) nuts are eaten by squirrels, voles and shrews, dormice, woodpeckers and nuthatches. *Nigella damascena* (love-in-a-mist) seeds are eaten by goldfinches, bullfinches, sparrows and chaffinches.
Hedgerows 	These create **wildlife corridors** that connect gardens to each other and extend into the countryside. **Species can move through them without being exposed to predators**. They also offer **nesting spaces and fodder**. **Hedgerows benefit from a herbaceous understory** and ideally herbaceous plants adjacent to the hedge base to increase cover for wildlife, as well as fodder.	Hedgehogs, harvest mice, bank voles and hazel dormouse all benefit from hedgerows.

A selection of priority species from the 2010 UK BAP list are given below, along with advice on how support them in a garden situation. These are still a priority today. If you find different named species on your local county council's LNRS you could research a similar level of detail with the aim of adding them into a local garden or greenspace:

Plants:

- ***Campanula patula* (spreading bellflower)**: a herbaceous biennial or short lived perennial suitable for herbaceous borders or wildflower meadows on nutrient poor soil, banks or slopes. Seeds can be sown direct and in suitable conditions it will self-sow.
- ***Carum carvi* (caraway)**: a tap rooted biennial that can be grown in herbaceous borders, preferring an open, sunny position. May self-sow in the right conditions.
- ***Centaurea cyanus* (cornflower)**: an annual that is best grown from seed sown into exposed soil. Self-sow's more reliably on poor, sandy soil in full sun. Often included in annual wildflower meadow mixes. It is an excellent species for wildflower meadows but these will need to be scarified each autumn to expose bare soil as the seeds don't germinate readily in shade.
- ***Chamaemelum nobile* (chamomile)**: A spreading, mat-forming evergreen herbaceous perennial that requires full sun and well-drained soil. Ideal for raised beds, rock gardens, front of borders, herb gardens and wildflower meadows on thin chalk soils. There are non-flowering cultivars available which do not benefit pollinators or produce seed. These should be avoided as they don't have as much biodiversity benefit.

Centaurea cyanus (cornflower)

- ***Juniperus communis* (juniper)**: an evergreen dioecious conifer species. To best benefit wildlife, a male pollinator plant should be included upwind of any female plants to maximise pollination and production of juniper berries (note these are not true berries, they are modified female cones). Song thrushes (detailed under 'birds', below) eat the berries and are known to nest in their dense evergreen growth. Junipers need full sun, well-drained soil and can be planted into mixed borders as part of a scrubland habitat type.
- ***Polygonatum verticillatum* (whorled Solomon's seal)**: a deciduous, rhizomatous herbaceous perennial with upright stems that feature whorls of leaves and greenish-white flowers in early summer followed by red autumnal berries. This is an adaptable species that can be grown in most soils, in sun, semi-shade or shade. It can be incorporated into mixed borders (emulating scrubland) or semi-shade near or beneath trees (emulating woodland edge or woodland habitats).
- ***Pulsatilla vulgaris* (pasqueflower)**: a low growing deciduous herbaceous perennial with purple spring flowers that develop into fluffy, silky seed heads in summer. Like chamomile this needs well-drained soil in full sun. It can be grown in raised beds, rock gardens, front of borders and wildflower meadows on thin chalk soils.

Terrestrial mammals:

- **Brown long-eared bat**: widely distributed across the UK. Like all UK bats it is protected under the UK Country and Wildlife Act 1981 and is a Priority Species under the UK post-2010 Biodiversity Framework. Roosts in holes in trees and old buildings; this species is also known to roost in bat boxes. Hunts in parks, gardens and woodland. Catches nighttime flying insects like moths, therefore plants that attract moth pollinators are beneficial in gardens. Plants such as *Hesperis matronalis* (sweet rocket), *Lonicera periclymenum* (common honeysuckle), *Nicotiana sylvestris* (woodland tobacco plant) or *Oenothera biennis* (evening primrose) attract moths.
- **Dormouse**: a rare UK species with patchy populations that are more common in the south. Spring to autumn they live and nest in woody growth, predominantly feeding on insects, fruits, seeds and nuts. Garden habitats that benefit them include layered woodland, woodland edge, and scrubland. Garden trees, shrubs and hedgerows all benefit dormice, especially those that produce nuts or berries such as *Crataegus monogyna* (hawthorn). Dormice hibernate in small nests at ground level and benefit from leaf piles that are sheltered from rain. These provide insulation to reduce winter cold during their hibernation.
- **Greater horseshoe bat**: rare in the UK and only found in south west England and south Wales. Like all UK bats it is protected under the UK Country and Wildlife Act 1981 and is a Priority Species under the UK post-2010 Biodiversity Framework. Roosts in caves, old houses, churches and barns. One of the UK's largest bats, they need a larger space to