Reptile Habitat Management Handbook

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amphibian and reptile conservation

Esmée Fairbairn FOUNDATION

NATURAL ENGLAND

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Note that no criticism is intended of any site managers or organisations whose sites feature in photographs characterised here as poor habitat for reptiles. The images have been chosen simply to illustrate key points of principle. Their inclusion here is not a comment on the management or condition of the sites depicted.

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Feedback contact details
We welcome any suggestions for improving this handbook. Please email enquiries@arc-trust.org with 'RHMH feedback' as the subject.

Cover images:
Heathland, Sunningdale (Fred Holmes)
Sand lizard and grass snake (Fred Holmes)

Reptile Habitat Management Handbook

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Contents

Summary

Lizards and snakes in Great Britain have declined, primarily due to habitat loss, degradation and fragmentation. Even on protected sites they have not always been safe, as standard habitat management measures do not always encourage reptiles to thrive. In extreme cases, habitat management has even caused declines and local extinctions. This handbook encourages positive measures for reptiles across a range of land uses. It has been written primarily for managers of nature conservation sites, though the guidance will also help many other land managers.

Reptiles are ectothermic. They do not raise their body temperatures by metabolic processes, but instead rely on the external environment, which they can use to maintain relatively high temperatures when they are active. Consequently, they have variable body temperatures. The need for external warmth influences many aspects of reptilian biology, including habitat requirements.

Understanding the ecology and habitat requirements of reptiles can help in the planning and implementation of sympathetic management for these animals. Due to their need for warm sites, reptiles prefer south-facing slopes, or varied topography, usually on well-drained soils. They also need diverse vegetation structure, creating open areas and nearby cover, to provide protection from predators and the elements.

Reptile distribution within occupied areas tends to be patchy. Some microhabitats support many individuals, while other nearby areas are rarely used.

Reptile dispersal abilities are limited, so connectivity of habitat patches is very important. Managers should maintain connectivity, both within a site and looking beyond its boundaries. Fundamentally, managing habitats for reptiles involves maintaining areas in a mid-successional state, and providing a favourable vegetation structure at ground level. There should be abundant prey, cover from extremes of the weather, and connectivity to neighbouring habitat patches. Unlike some species, the precise floristic composition of habitats is often irrelevant to reptiles. Instead, the site's physical structure and thermal properties are crucial.

Site managers have to balance the needs of many species, and in some cases these may be conflicting. A section of this handbook is devoted to considering and resolving such conflicts.

Commonly used habitat management techniques are reviewed here for their application to reptile sites. Cutting, mowing and grazing are often the most acceptable means of maintaining reptile habitat. They must, however, be applied with care, or sometimes even avoided in particular instances. Scrub and tree removal are normally essential to retain the open character of reptile habitats but management causing large-scale damage to vegetation structure can be catastrophic for local populations.

Specific habitat features can enhance sites for reptiles. This handbook explains how to create brash and log piles, reptile banks, grass snake egg-laying heaps and sand patches for sand lizards.

The handbook also includes simple ways of incorporating reptile conservation into land use outside nature conservation areas, including farming, forestry, transport corridors, golf courses, gardens, allotments, churchyards and utility sites.

Although habitat management is the subject of this handbook, a summary of species management issues is provided, outlining the conditions under which reintroduction of native species, or control of non-natives, may be appropriate conservation actions.

An important challenge to conservation bodies today is that of engaging greater numbers of people while ensuring that public access does not damage wildlife interests. A section is therefore devoted to managing the interactions between reptiles and people.

Reptile survey is an important step in planning habitat management, and continued monitoring helps to assess and refine it. Visual searches and refuge surveys are both useful techniques. The fundamental principles and limitations of reptile survey are outlined here to monitor population trends within a site.

Finally, sources of additional information and advice and ways of getting further involved in the fascinating world of reptiles are provided, along with an appendix summarising Environmental Stewardship options that may be of value to reptile conservation.

Opposite: Smooth snake (Fred Holmes)

1. Introduction

This handbook is aimed at helping site managers to ensure the areas they look after are favourable for lizards and snakes. Managing sites to benefit reptiles is normally straightforward and uncontroversial. Practical management advice for most species has, however, been lacking up to now.

Reptiles suffered extensive declines in Britain during the twentieth century. There are several reasons for this but major factors were the destruction, degradation and fragmentation of habitats by humans, a fate shared by most British wildlife. Landscapes that once provided habitat for reptiles have changed radically in recent decades and, as a result, some species have been lost from whole counties. One species, the sand lizard, also had the dubious distinction of becoming extinct in an entire country (Wales) within the United Kingdom, the only part of its European range where this has happened.

Reptiles have relatively limited dispersal abilities, which make them particularly susceptible to the effects of habitat fragmentation. In general, they cannot cross large expanses of unsuitable terrain to move from one patch of habitat to another favourable, but distant, site. Prior to landscape modification by humans, habitats would change in suitability over time, and reptile populations themselves could shift and fluctuate considerably in both space and over time. Such dynamics are rarely possible in the modern British landscape. Many sites are now isolated so that reptile populations cannot function in this more 'natural' way, but rather must be managed *in situ.*

Reptiles have no means of sitting out long-term adverse conditions (as do plants, in a seed bank, for example), or of rapidly moving long distances to avoid poor conditions. Reptiles are therefore particularly vulnerable to declining habitat quality and inappropriate habitat management.

With some variation between species, reptiles prefer mid-successional habitats. They require both open areas, for warmth, and more vegetated areas, for shelter. Such conditions are met relatively easily, though some management objectives favour either extreme of the successional gradient.

Areas protected for their wildlife interest invariably require some kind of habitat management to retain their special value. Care is needed to ensure that this assists reptile interests on these sites and in the wider environment. Whilst most nature conservation management is positive for reptiles this is not always the case.

The recommendations given in this handbook reflect observations from the collective experience of many reptile ecologists and site managers. They also draw on a modest, but growing, literature on habitat preferences and management. Undoubtedly, reptile habitat management recommendations will become more refined in future, as more thorough studies are carried out.

Fortunately, with some understanding of reptile ecology, the habitat requirements of these animals are relatively easy to meet. Reptiles require warm, relatively open habitats, which are also favoured by a range of other species, especially invertebrates. In fact, the habitat management requirements of invertebrates and reptiles are very similar, to the extent that adopting recommendations given in Kirby's (2001) excellent *Habitat Management for Invertebrates* would be greatly beneficial to reptiles. A common approach, important to both groups, is attention to the fine structure of habitat. Habitat suitable for invertebrates and reptiles contains a high degree of structural diversity, providing a wide range of microhabitats within a site. Hence, managing habitat to achieve such diversity greatly increases its ecological value.

Although aimed specifically at habitat managers, and primarily for nature conservation purposes, the guidance here may also prove useful for those advising on improving habitats for mitigation purposes. Consultants will hopefully use the guidance to improve areas retained, enhanced or created. The handbook should not, however, be used as a technical guide to standards for other aspects of mitigation, such as legislation, surveys or the amount of habitat to be retained.

Opposite: Viviparous lizard (Fred Holmes)

2. Reptiles of Great Britain

Native reptiles of Great Britain		
Sand lizard	*Lacerta agilis*	England and Wales
Viviparous/common lizard	*Zootoca (Lacerta) vivipara*	England, Scotland, Wales
Slow-worm	*Anguis fragilis*	England, Scotland, Wales
Smooth snake	*Coronella austriaca*	England only
Grass snake	*Natrix natrix*	England, Wales, rare in Scotland
Adder	*Vipera berus*	England, Scotland, Wales

The six terrestrial reptile species native to Great Britain are listed in the table above. Although the leatherback turtle *Dermochelys coriacea* includes coastal waters as foraging grounds, justifying its native status, its ecology is so fundamentally different to that of the terrestrial species that it is not considered within this handbook. However, references relating to the leatherback are given in section 14. *Sources of Information and Advice.*

The current section summarises the distribution and conservation status of British reptiles as well as the basic characteristics of their life history relevant to habitat management. More detailed accounts of identification, ecology and status can be found in other texts e.g. Beebee and Griffiths (2000) and Inns (2009).

Note that this is a general summary, and there is local variation in, for instance, the timing of activity, clutch size and prey type.

2.1. Sand lizard *Lacerta agilis*

Male sand lizard in breeding coloration (Fred Holmes)

Distribution The sand lizard has always had a scattered distribution and limited range in England and Wales but this has been severely reduced even further by human activities. Native populations have been lost from the whole of Wales, where they formerly occurred on dunes along the north and west coasts, and from the English counties of Berkshire, Cheshire, Cornwall, Devon, Kent, East and West Sussex, Wiltshire and much of Hampshire. Original, non-reintroduced populations now remain only in Dorset, Hampshire, Surrey and on the coastal dunes of Merseyside. Reasons for this decline centre almost entirely on habitat destruction and the associated fragmentation and degradation of the small surviving areas. However, 65 re-introductions have taken place over the past thirty years in 13 vice-counties and the sand lizard has now been successfully re-established in Wales, Cornwall, Devon, Kent, West Sussex and the New Forest area of Hampshire.

Habitats Sand lizards are confined to two habitats in Britain; lowland heathland supports well over 95% of the national population, the remainder is found on sand dune.

Habitat requirements Within the sites where it is found, the distribution of the sand lizard is further restricted, often to relatively small areas, by its specific habitat requirements. This species is on the edge of its European range in Britain and requires warm, sheltered sites, with a varied topography, and especially south-facing slopes. Although sand lizards, especially dispersing juveniles, may be found at low densities across many parts of a heathland site, breeding adults are more or less confined to the later successional stages of sandy, dry heath (i.e. the mature and degenerate phases of heather growth). Areas with a luxuriant ground layer of bryophytes and lichens seem to be particularly favoured. Sand lizards also venture into adjacent areas of wet heath and valley mire, especially in

Opposite: Adder (Fred Holmes)

very hot weather. Sandy substrates are not only warmer than the gravels and clays underlying many heathland habitats but they are essential for egg laying purposes. On coastal sand dunes, this species favours frontal dune ridges, preferring areas of dense marram grass combined with abundant exposed sand and a south or southwest facing aspect. Fixed dunes further inland are avoided if they are heavily grazed, although high densities of sand lizards may be present where frontal dunes grade into heathland.

Diet The sand lizard preys on a variety of invertebrates, especially spiders, grasshoppers, crickets, bugs, flies and insect larvae.

Activity Sand lizards are wholly diurnal and daily activity is weather dependent. In the spring, these lizards spend most of the day basking, mating and foraging, whereas in hot summer weather they may be encountered only early in the day and late in the afternoon. Sand lizards hibernate for longer than other native reptiles. Adults, especially the females, often disappear into their hibernation burrows in late August or early September, regardless of the weather, although hatchlings can be active into October or even November. In the spring, male sand lizards may emerge in early March but the females often do not appear until several weeks later.

Movements Male sand lizards have fairly limited home ranges of only a few hundred square metres, which can overlap considerably. The ranges of females are often even smaller. If habitat conditions are especially suitable, adults may be remarkably sedentary and rarely cross unsuitable habitat. Individual lizards can be regularly seen in the same spot on repeated occasions, and often in successive years. Sand lizards show no territorial behaviour but a dominance hierarchy develops among the males each spring when they compete for females.

Reproduction The female digs a nest in which she lays 6-14 eggs in unshaded, bare, semi-compacted sand. One, or sometimes two, clutches of eggs are laid per year, usually from late May to June, but as late as July or August when second clutches are produced. In a typical year, hatchlings begin emerging in August.

Conservation status The sand lizard is a rare species confined to a limited number of sites. Its conservation status is unfavourable, given the massive reduction in population size, range and viability. Uncontrolled fires threaten all heathland populations.

Sand lizards require semi-compacted sand in which to deposit eggs (Paul Edgar)

2.2. Viviparous or common lizard *Zootoca (Lacerta) vivipara*

Male viviparous lizard (Fred Holmes)

Distribution The viviparous lizard is widely, though very patchily, distributed across the whole of England, Scotland and Wales.

Habitats Viviparous lizards occupy a wide range of habitats, including wet and dry heathland, moorland, mountain scree slopes, most types of grassland (especially chalk grassland and rough grassland with bramble scrub), woodland glades and rides, coastal dunes and cliffs, vegetated shingle (and, in some areas, salt marsh), hedgerows, allotments, old quarries, sea walls and road, railway and canal embankments. However, this species is now absent from large areas of the countryside. Intensively farmed land, dense woodland, heavily grazed or mown habitats and many urban areas are unsuitable. This is because they are structurally deficient or lacking invertebrate prey.

Habitat requirements Not all areas within occupied sites support viviparous lizards; the species avoids structurally uniform vegetation, whether it is rank

and completely closed or short and completely open. Typically, the viviparous lizard differs from the other widespread lizard species, the slow-worm, in preferring sites with a greater variation in the height of vegetation cover. Both humid and dry microhabitats are selected by viviparous lizards but the highest densities tend to be found in damp or wet areas, especially where abundant grass tussocks are present to provide food, shelter, basking and hibernation sites. However, as long as the vegetation is located in a sunny area, is structurally diverse and provides adequate cover, viviparous lizards can attain extraordinary population densities.

Diet Like the sand lizard, the viviparous lizard preys on invertebrates but, because of its wider habitat preferences, consumes a greater range of soft-bodied prey than the sand lizard.

Activity Viviparous lizards are diurnal and, since they can operate at lower temperatures and warm up faster than sand lizards, they spend less time basking. They can be active from February through to November in southern Britain but for shorter periods (March to October) further north, in Northern Ireland and on the Isle of Man.

Viviparous lizard basking on log (Fred Holmes)

Movements Movements of viviparous lizards are usually limited to a few tens of metres. Individual lizards often share the same basking areas and hiding places. Most dispersal is through the movements of juveniles, which can rapidly colonise new habitat, should it become available adjacent to a site already occupied.

Reproduction In the British Isles this species gives birth to its young in transparent egg membranes from which the baby lizards rapidly break out. This strategy gives live-bearing reptiles a distinct advantage over egg-laying species at northern latitudes, in that females can regulate the temperature of developing embryos by seeking microhabitat accordingly. Typically 4-10 young are born in July, but birth can occur from late June to early September. The female requires sheltered, humid microhabitat in which to give birth.

Conservation status Large declines have occurred in recent decades, mainly as a direct result of habitat loss. On surviving sites lizard status may be affected by reduction of structural diversity, the use of chemicals and predation by invasive introduced species (e.g. pheasants and domestic cats). The overall effect is that viviparous lizards are now more patchily distributed, and tend to occur at lower population densities.

2.3. Slow-worm *Anguis fragilis*

Male slow-worm (Fred Holmes)

Distribution The slow-worm is widely distributed in England, Scotland and Wales. However, populations tend to be smaller and more patchily distributed in the north, and the species is most abundant in southern England.

Habitats Slow-worms inhabit a wide range of habitats, including heathland, lower altitude moorland, most types of grassland (especially chalk grassland and rough grassland with bramble scrub), woodland glades and rides, hedgerows, disused quarries and other brownfield sites, and road, railway and canal embankments. As long as sufficient warmth, cover and food is available, they can be found in urban areas, for example in gardens and allotments, where they often inhabit compost heaps/bins.

Slow-worms have a broader range of habitats than the other lizards, tolerating a less diverse vegetation structure and often being found on impermeable as well as free-draining soils.

Habitat requirements In all habitats, slow-worms require dense vegetation, especially grasses coupled with sunny areas to allow thermoregulation and, preferably, loose soil into which to burrow. Very wet and very dry habitats are usually avoided.

Diet Soft-bodied invertebrates, especially slugs and worms, are the favoured prey.

Activity Slow-worms are primarily fossorial (living mostly underground, or underneath objects lying on the ground, or within vegetation litter and tussocks). Although the occasional slow-worm may be seen basking in the open (especially in early spring), most activity takes place out of sight of human observers. Slow-worms are mainly diurnal but have been observed foraging after dark on warm evenings.

Hibernation occurs usually from late October to early March and takes place in burrows, loose soil and dense vegetation. Slow-worms sometimes hibernate communally, and up to several hundred animals have been found overwintering together inside large tussocks of purple moor-grass *Molinia caerulea*.

Movements Slow-worms do not move long distances. Home ranges are probably only several hundred square metres, and the same individual may be found repeatedly in the same location. Although communal hibernation demands some annual movement, such movements are small compared with seasonal migrations of snakes.

Reproduction This species retains its eggs internally, giving birth to young within a thin egg membrane that is almost immediately ruptured. Six to twelve young are produced between mid-August and mid-September.

Conservation Status The slow-worm is the commonest reptile in the British Isles, although, like all species, it has suffered declines in recent decades due to loss of suitable habitat.

2.4. Smooth snake *Coronella austriaca*

Distribution In the British Isles, the smooth snake is found only in southern England. By the second half of the twentieth century, it had become extinct in Berkshire, Devon, East and West Sussex and Wiltshire, surviving only in Dorset, Hampshire and Surrey. More recently it has been reintroduced to Devon.

Habitats The smooth snake is confined to a single habitat, lowland heathland. It fares well on the warm, sandy heaths preferred by the sand lizard, but some important populations occur on heathland underlain by gravels and clays.

Smooth snake (Fred Holmes)

Habitat requirements Like sand lizards, smooth snakes tend to favour mature to degenerate dry heath, though especially where the heather is structurally diverse and grades into humid and wet heath areas. The dense ground cover often associated with optimal smooth snake habitat, particularly deep beds of bryophytes and lichens, provides the cool, moist conditions that this species seems to require during hot weather. The smooth snake also uses areas of humid and wet heath and valley mires. Large tussocks of purple moor-grass are a particularly important feature, because they harbour prey species and provide cover for this secretive reptile.

Diet The diet of smooth snakes consists predominantly of other reptiles, but also includes small mammals, particularly young from nests. The viviparous lizard and slow-worm are probably the most important reptile prey, although sand lizards make up a large proportion of their diet where the species co-exist.

Activity The smooth snake is extremely secretive. It has a lower preferred body temperature than other British snakes and rarely basks in the open. Thermoregulation tends to take place in dense cover, with only a small part of the snake's body exposed at any one time, or under objects warmed by the sun. Although largely diurnal, smooth snakes are known to be active during very warm nights in the summer. The main period of activity lasts from late March through to late October.

Movements Smooth snakes exhibit limited powers of dispersal. Daily movements are usually less than 20 m and only rarely exceed 100 m. Unlike grass snakes and adders, smooth snakes do not appear to undertake longer distance seasonal movements.

Reproduction Mating occurs in spring but has hardly ever been observed in the wild. The smooth snake gives birth to live young (typically 4-15) and this seems to take place in very dense, humid cover such as under moss and lichen layers or within large grass tussocks.

Conservation status The smooth snake is a rare species, with a limited range. Its cryptic behaviour makes population estimates difficult, but loss and fragmentation of its heathland habitat have reduced numbers. Uncontrolled fires in remaining habitat pose a particular threat to this species.

2.5. Grass snake *Natrix natrix*

Grass snake (Fred Holmes)

Distribution The grass snake is a lowland species, found widely across England and Wales, though distribution is very patchy in northern areas. Historical records exist for southern Scotland and recent sightings have been made, but current status there is largely unknown.

Habitats This species is often associated with wetlands, but can also be found in many other habitats such as heathland, many types of grassland (including some quite dry areas of chalk grassland), open woodlands, some coastal habitats, farmland, gardens (especially large gardens with ponds), allotments, brownfield sites including disused quarries and along road, railway and canal corridors.

Habitat requirements The grass snake requires some cover and a degree of structural diversity but, as it is more mobile than the other reptiles, it is often not reliant on a single site providing the necessary habitat for hibernation, feeding and egg-laying. Sunny areas are usually preferred, but during hot weather it is not uncommon to encounter grass snakes in woodland and other shaded habitats. Warm, humid, decomposing organic material is required for egg-laying.

Diet Grass snakes feed primarily on amphibians, but fish, small mammals and fledgling birds are also taken.

Activity Grass snakes hibernate from October to March. After their spring emergence they usually disperse rapidly. They are active foragers and may be seen in and around water bodies during the summer. However, they are also wary and quick to flee, so they can easily be overlooked on a site. Grass snakes are largely diurnal although they are known to be active at night during warm periods, especially in and around ponds. Though mostly found at ground level, grass snakes are occasionally seen in the lower branches of trees and scrub.

Movements The grass snake is the most mobile of our reptiles. Individuals disperse from hibernation sites relatively rapidly and may move over several kilometres during the course of the active season. Sometimes concentrations of snakes allow identification of specific population centres. This is most common for egg-laying sites, which tend to be communal and traditional, meaning that many females habitually use the same precise location year after year. However, snakes may migrate through relatively poor quality habitat to reach favoured egg-laying, foraging or hibernation areas.

Grass snake hatching. The grass snake is the only British snake that lays eggs (Paul Edgar)

Reproduction During the breeding season (April to June), several male grass snakes may simultaneously court a single female, in exceptional cases in large numbers, forming a ‘mating ball’. This species is the only British snake that lays eggs, typically 15-40 per female. These are deposited in decomposing organic material, such as heaps of vegetation, manure or woodchips in June or July. Females may congregate at egg-laying sites. The young hatch out from late August to September.

Conservation status Lack of systematic monitoring and high mobility make it difficult to determine the conservation status of this species. It is still relatively abundant in some parts of Britain but there have been severe declines in other areas, notably where egg-laying and foraging sites have disappeared.

2.6. Adder *Vipera berus*

Distribution The adder has a widespread, albeit very patchy, distribution throughout England, Scotland and Wales. It is rare in the English Midlands, much of northwest England, central Wales and parts of Scotland, but more abundant in areas such as the North Yorkshire Moors, East Anglia, the southern heathlands and chalk downlands, the coasts of west and south Wales and southwest England and the southern Highlands of Scotland.

Adder (Fred Holmes)

Habitats The adder prefers lighter chalk or sandy soils, and is almost never found in habitats based solely on heavy clays. Favoured habitats include heathland, moorland (usually at fairly low altitudes), grassland with a dense sward and low scrub, including acid and chalk grasslands, clearings, rides and edges in deciduous or coniferous woodland (including plantations and native pine forest in Scotland), coastal dune systems and cliffs, field edges, disused quarries, some brownfield sites such as disused allotments, sea walls, and road, railway and canal embankments. The adder tends not to be found in intensive agriculture, high, rugged mountainous terrain or urban areas.

Habitat requirements In all suitable habitats, dry, open, sunny areas with adjacent dense ground cover are essential. Hibernation sites tend to be on south-facing slopes; tree root systems, crevices in banks, and voids in piled materials are often used. Wetter areas around ponds, lakes, bogs or mires are also used (especially in the summer) providing there are dry banks or grass tussocks for basking.

Diet Adders eat mainly small mammals, especially voles. Lizards, nestling birds and frogs are also eaten.

Activity The first adders to emerge from hibernation may do so very early in the spring during mild spells in January (in southern England) or February-March (elsewhere). Emergence is followed by basking, which can last for several weeks, often very close to the hibernation site. This period of lying out is followed by sloughing, after which the males become much more active, competing for females and eventually mating.

Adders remain active through to late October or early November in the south, although the activity period is much shorter in the north of Scotland. Mainly a diurnal species, adders may also be active at night during very hot weather.

Movements Distinct seasonal movements have been recorded for adders, which often use separate spring breeding and summer foraging areas, sometimes as much as two kilometres apart. After mating activity, adders disperse and may migrate to a wetter habitat for the summer. At sites, where foraging and overwintering requirements are close together, adders may not move so far in the course of a year. Adders return to traditional hibernation sites in late summer, and often this is where the females give birth. Maintaing vegetation cover between different areas used by adders reduces the risk of predation during seasonal movements.

Reproduction Mating is preceded by ritualised combat (‘dancing’) between males. Dominant males may mate with several females. Female adders retain their eggs within the body and give birth to 3-18 live young during August and September.

Conservation status In common with the other widespread reptile species, the adder has suffered extensive declines in recent decades. However, as this species is more restricted in its habitat preferences, it has been less resistant to human-induced habitat changes. As a result, declines have been more severe than for other widespread reptiles, with many local extinctions occurring outside its core range. Adders are still sometimes deliberately killed by people, even though this is illegal. They also seem prone to disturbance by people and dogs, though this probably needs to be intense and sustained to have a population level impact.

3. Conservation of British Reptiles

3.1. Threats

The box below lists the key threats to reptiles. Currently, the greatest threats are habitat degradation through over-shading due to lack of management, loss of habitat and loss of habitat structure. The six species are affected in different ways; for example, viviparous lizards decline rapidly through 'tidying up' of urban green space; development is no longer a significant threat for the two rarest species.

Threats to reptiles

- Successional changes caused by a lack of habitat management, resulting in increased shading and degradation of key microhabitat features.
- Changes in land use (especially the intensification of agriculture) leading to habitat degradation.
- Habitat loss to building development, roads, farming, afforestation, and mineral extraction.
- Habitat fragmentation leading to population isolation.
- Fire. Burning as a management method or through accidents and arson is probably the most significant threat to heathland sites supporting rare reptiles.
- Loss of habitat structure due to unsympathetic management (especially inappropriate grazing, scrub clearance and burning).
- Non-native, invasive plant species.
- Predation by domestic cats and pheasants.
- Damage to habitats due to public access (especially off-road vehicle usage).
- Disturbance of animals due to public access
- Deliberate killing by people.

3.2. Legal protection

All native reptiles receive some legal protection in Great Britain, arising from the following main items of legislation:

- Wildlife and Countryside Act 1981 (as amended) and the Nature Conservation (Scotland) Act 2004.
- Conservation of Habitats and Species Regulations 2010.

In England and Wales all reptile species are listed on schedule 5 of the 1981 Act. The more threatened species are also listed on schedule 2 of the 2010 Regulations, which designate them 'European protected species'.

The legislation effectively creates two levels of protection. The European protected species, the sand lizard and smooth snake, receive strict protection. It is an offence to capture, possess, disturb, kill, injure, or trade in individuals of these species. In addition, it is an offence to damage or destroy the places they use for breeding or resting. The remaining species (viviparous lizard, slow-worm, grass snake and adder) are protected against killing, injuring and unlicensed trade only. The legislation applies to all life stages of wild animals only.

Legislation also provides protection for sites of particular value to nature conservation, including some occupied by reptiles. Sites of Special Scientific Interest (SSSIs) may be selected on the basis of important reptile populations, and indeed currently there are approximately 50 such sites in Great Britain. The majority are designated on the basis of their sand lizard or smooth snake interest, the rest because of important assemblages of the widespread species. In addition, many SSSIs designated primarily for other species, habitat or geological interests also support important reptile populations. SSSIs receive legal protection meaning that damaging activities are strictly controlled or prevented. Management is agreed with landowners to ensure that sites are maintained at, or restored to, a favourable condition. There are also special considerations in planning for development activities that might affect SSSIs. Reptiles may receive additional protection through by-laws where they occur on specific types of land, for example on some forestry land.

3.3. Biodiversity Action Plan and Section 41 listing

All six reptiles are now listed as priority species in the UK Biodiversity Action Plan (BAP). Action plans have been produced for all of them (see Amphibian and Reptile Conservation's website www.arc-trust.org). Further information on the BAP is available at www.ukbap.org.uk. All BAP species have been included in Section 41 and 42 lists produced by the Secretary of State of England and the Welsh Assembly. These are lists of species that, as specified under the Natural Environment and Rural Communities Act 2006, are of *principal importance for the purpose of conserving biodiversity*.

Further, the government introduced the 'Biodiversity Duty' under Section 40 of the same act, which gives responsibility to all public bodies *to have regard…to the purpose of conserving biodiversity*. Accompanying guidance produced by Defra and the Welsh Assembly also notes that biodiversity conservation extends to restoring and enhancing species' populations and habitats, as well as protecting them.

3.4. Implications for site managers

Compliance with legislative constraints An irony of habitat management is that activities that are often essential to maintain habitat in a condition favourable to reptiles, may have the potential to inadvertently kill, injure or disturb individual animals, and thus potentially result in an offence. However, site managers should not be deterred from undertaking management because of this, and guidance here should help achieve positive outcomes.

The legal situation regarding the widespread species is straightforward. These are protected under the Wildlife and Countryside Act 1981, only. Harming these animals is not an offence if it is the result of an otherwise lawful operation, and could not reasonably have been avoided. As a matter of course, site managers should make reasonable effort to avoid inadvertent harm to species or habitats within sites under their care. In practice this means, for example, careful timing of management and targeting away from sensitive areas. No licence is required for management works affecting these species.

Legal implications of habitat management for the sand lizard and smooth snake are more complicated. Otherwise unlawful activities (such as disturbance for conservation purposes) can be made lawful by a licence from the relevant government agency. Amendments to the legislation have removed the defence for incidental and unavoidable acts.

In practice, most typical habitat management for the sand lizard and smooth snake should not require a licence. Government agency advice is to plan works so that they will avoid committing an offence (such as killing smooth snakes through controlled burning). This may be done by careful timing, choice of methods and targeting operations away from sensitive areas. Actions that have a higher risk of committing an offence, and therefore being licensable, include large-scale habitat restoration projects. Here, there is often more potential for harm to protected species, but with careful planning this risk can often be minimised and the need for a licence avoided. If in doubt over a particular project, contact the licensing section of the relevant national agency (Natural England, Countryside Council for Wales, or Scottish Natural Heritage).

Interpretation of legislation is complicated by a number of factors, for example: the differing types of liability for offences (strict liability, intentional, reckless or deliberate); definition of terms such as 'resting place'; and recent changes to the European protected species offences. Given the aims of this handbook, we set out here pragmatic guidance that should allow site managers to plan their works for the benefit of reptiles. This involves striking a balance between ensuring activities potentially affecting individual reptiles are adequately controlled and considering the wider needs of the reptile population and other site interest features.

Site managers taking reasonable measures to avoid harm to reptiles during management that would be beneficial to them should not be penalised for inadvertent breaches, as this is contrary to the purpose of the legislation. A prosecution on this basis would be highly unlikely as it would not be in the public interest. Indeed a prosecution for harm during habitat management is only likely to occur if there were evidence of serious negligence or malicious intent.

Note that the above is a summary of the legislative constraints relevant to habitat management. It is intended for general guidance only, and should be used solely in the context of habitat management. It is neither authoritative nor comprehensive; the original legislation should be referred to for specific enquiries. Only a court can decide whether an offence has been committed.

Integration of reptile habitat management into local authority sites The 'biodiversity duty', places a responsibility on all public bodies to integrate biodiversity conservation into their activities. With regard to sites managed by local authorities effort should be made to determine which sites support reptiles. These sites should be managed sympathetically for reptiles, in balance with other conservation objectives. Sites managed by local authorities with the potential to support reptiles include local nature reserves, cemeteries, parks and public open spaces, allotments, tenanted farms, road verges and linear corridors along walking and cycling routes.

3.5. Accommodating reptiles within broader conservation approaches

Species live within habitats, so in theory managing a habitat should take care of a suite of resident species. However, in practice, without a species focus, general habitat management can produce undesirable results. Reptile habitats can even be managed in such a way that populations are harmed or eradicated. On the other hand, a focus on species conservation is sometimes criticised because it is difficult to decide how to meet the potentially conflicting demands of all species within a single site.

Reptiles are among a range of species that are sometimes poorly catered for in broad habitat management regimes. This issue has been explored in recent research (Webb, Drewitt and Measures, 2010). It appears that some widespread species, including reptiles, are declining because generalised, prescriptive management does not always provide the particular habitat resources they need.

Hence, a more desirable approach is to treat species and habitat management as complementary, rather than alternative guiding principles. As relatively sedentary predators, the presence of reptile populations is indicative of favourable management for a range of other species. If reptiles can thrive on a site, then so too will many other species requiring warm microhabitats or living within the diverse vegetation structures needed by reptiles. Incorporating a reptile focus within habitat management plans should not only enhance the reptile status on sites and avoid breaching legislation, but also increase overall biodiversity.

Landscape-scale and ecosystem approaches consider wildlife conservation from a broader perspective. Managing for reptiles can fit within these approaches. Reptiles have limited dispersal abilities; hence managing habitat for them requires attention to the maintenance of continuous, linked, or at least spatially close patches of habitat (see *4. Habitat Requirements*). The long-term survival of reptile populations is dependent on large areas of either continuous or connected habitat. To meet the needs of reptiles, a site manager should consider connectivity of habitat both within a site and beyond.

The ecosystem approach integrates management of land, water and living resources in a way that promotes conservation and sustainable use. It should also be consistent with the objectives of the Convention on Biological Diversity, which include conservation of biological diversity. Managing habitat for reptiles may seem to be operating at a different scale to the ecosystem, but, of course, not only are reptiles an element of biodiversity, but their habitats support a wider range of species and their presence is an indicator that habitat is hospitable to these as well.

The newer field of ecosystem services is yet to be applied broadly in the UK. Though reptiles have few utilitarian benefits (e.g. adder venom in medical research), this approach should consider their educational value and the enjoyment they bring to many naturalists. Of course, the intrinsic value of reptiles and their habitats must be considered in any application of ecosystem services.

The critical point in all these wider approaches is to ensure that the particular habitat requirements of reptiles are met in some way, such that populations are in favourable status. Management methods to deliver these will differ according to the scale and type of project.

3.6. Climate change

Reliance on external temperatures may make reptiles particularly sensitive to climate change. Although it is fairly straightforward to envisage how specific elements of their lives might be altered by climate change, the overall impact on species status is not as readily apparent. For example, sand lizards and smooth snakes, at the edge of their ranges in the UK and confined to very specific habitat, in future may be able to survive in a much broader range of habitats in an altered climate, as they do further south in Europe. However, in practice the fragmented nature of the natural landscape in the UK may prevent migration to alternative habitats. Conversely, the increase in hot weather and

droughts may result in an increased impact of arson attacks on the sites to which they are confined. Similarly, milder winters might negatively affect body condition and survival.

Strategies have been recommended to cushion wildlife from the impacts of climate change and maximise its potential to adapt to it in general (Hopkins *et al*., 2007), and specifically for heathlands (Alonso, 2009). At the site level maximising microhabitat diversity may allow species to move between microclimate patches in response to climate change. At the landscape level, it will be important to establish ecological networks to facilitate migration between habitat patches and colonisation of new areas according to climatic suitability. Both maximising microhabitat diversity and establishing links between habitat patches are consistent with the principles of sound reptile habitat management, irrespective of climate change.

4. Habitat Requirements

Reptile habitat requirements can be summarised as:

- Warmth
- Structural complexity
- Habitat connectivity

Some of the habitat requirements of reptiles relate to factors that are intrinsic to a particular site or geographical area, such as climate, topography or soil type, and are hence beyond the control of habitat managers. However, many requirements are met by features that can be directly and strongly influenced by management. An understanding of reptile habitat requirements should assist a site manager in management planning and implementation that will favour, rather than harm, reptiles and a host of other species.

4.1. Insolation (exposure to sun)

Reptiles are ectothermic. The popular term 'cold-blooded' is inaccurate as reptile body temperatures are in fact variable. Reptiles cannot generate body heat internally, but rather use external warmth to raise their body temperatures to optimal operating levels. A great deal of reptile behaviour and ecology is determined by ectothermy.

Adders basking in early spring, in a warm pocket of open ground, sheltered by gorse (Jim Foster)

To raise their body temperatures, reptiles either bask openly in direct sunlight, or they seek warm sites under cover (in vegetation or under objects lying on the ground) or partially exposed amidst dense vegetation (mosaic basking). The extent to which they use these different behaviours varies between species, and according to ambient temperatures. On warm days reptiles may bask in partial cover rather than in the open, or they may even avoid basking altogether and continue activity in more shaded habitats. Snakes and slow-worms may be active at night in hot summer weather. However, for most of their active periods reptiles require open, sunny habitats with low vegetation cover, where sunlight reaches ground level to provide them with the warmth they need. Direct sunlight is also important physiologically, as the ultraviolet-B this contains stimulates the production of vitamin D3 in the skin of some reptile species.

Varied topography (south-facing slopes are particularly favoured by reptiles) and a mosaic of open, sunny areas and dense cover provide the best range of basking opportunities.

South-facing slope in a warm, sheltered valley on the Devon coast. The aspect, topography and structurally diverse vegetation make this a superb reptile site (Paul Edgar)

4.2. Shelter from the elements (heat, dry weather and wind)

Thermoregulation by behavioural means not only entails seeking warm microhabitat to raise body temperatures, but also involves taking shelter from the sun to avoid fatal overheating. Shuttling between sunshine and shade allows reptiles to maintain a surprisingly high body temperature very precisely throughout much of the day. So, reptiles need vegetation cover and open areas in close proximity to each other. This is generally provided by structurally diverse habitats, or mosaics

Windbreaks provided by woodland edges and open, sunny glades can create warm microhabitats important for reptiles (Paul Edgar)

of vegetation of differing heights, ages or types. Different types of vegetation cover also provide different cooling effects. Deeper vegetation, such as scrub, grass tussocks or beds of mosses and lichens, provide cooler and more humid retreats, which allow more rapid cooling than simple shade.

Reptiles also need access to humid environments to help them to cope with extremely hot, dry weather. During such conditions they may enter a period of enforced inactivity, known as aestivation, for which they require retreats with a stable temperature and, in particular, high humidity. A structurally diverse habitat is more likely to provide these pockets of moisture. Alternatively, in such weather, reptiles may move to wetter areas than they would normally occupy. For instance, sand lizards on dry heath may migrate a short distance to a wet valley mire.

Strong winds can have a negative impact on reptile activity in several ways. Wind chill increases the time required for basking reptiles to reach their preferred body temperatures. Wind can also have a detrimental drying effect, especially on dry habitats such as heathland or chalk grassland. Finally, wind agitates vegetation, making it more difficult for reptiles to detect approaching predators. A varied topography and diverse vegetation structure create pockets of microhabitat sheltered from the wind. Trees, scrub, woodland edges and hedgerows often provide important windbreaks on reptile sites.

The close proximity of wet and dry habitats gives reptiles the opportunity to cope with very dry weather while still remaining active (Jim Foster)

4.3. Shelter during the winter

In the British Isles reptiles escape the winter cold by entering a period of hibernation or extended torpor (greatly reduced metabolic activity). Hibernation sites must be frost-free, humid (but not wet) and safe from flooding and predators.

Hibernation usually takes place underground, or less often within above-ground structures. Typical sites include: burrows dug by other species such as rabbits, or by the reptiles themselves (in the case of sand lizards), rotted tree stumps and root holes,

chalk fissures, large grass tussocks, ant-hills, old walls and building foundations, piles of rubble and other debris and under large logs and fallen trees. Hibernation sites almost always have a south-facing aspect, and are normally in full or partial sun.

Sand lizards, grass snakes, adders and, to a lesser extent, smooth snakes, usually make seasonal movements to hibernation sites. The other species do not travel so far and so their hibernation sites roughly correspond to the areas used during the active season.

Reptiles may hibernate singly or, in particularly suitable retreats, communally. Adders in particular tend to use communal hibernation dens, or hibernacula, with as many as several dozen snakes using an especially suitable site. They may share this with other reptile species. Communal hibernacula are critical features for reptiles in many habitats, especially because the adults of species such as the adder are very faithful to a particular site.

Inadvertent damage to a single, large hibernaculum by habitat management, especially when heavy machinery is being used, can cause severe harm to a local reptile population and may have disastrous consequences on a small site. Even removal of vegetation cover from a hibernaculum can increase exposure to predation when reptiles emerge in spring.

Fortunately, due to their specific characteristics and due to the propensity of reptiles to bask shortly after emergence from hibernation, it is possible to identify hibernation sites during springtime surveys. It should, however, also be noted that some are not readily identifiable based on physical characteristics alone. For example reptiles may return to the root system of a particular tree, which to our eyes may appear indistinct from many other nearby trees.

Small-scale topographic variations such as gullies and ditches provide valuable shelter from windy conditions (Paul Edgar)

Reptile hibernation sites

Root systems of gorse/birch clumps (Paul Edgar)

Rocky crevices on moorland (Paul Edgar)

Rabbit warren on dry bank (Jim Foster)

Brash windrow in woodland (John Baker)

Rotting tree stumps and roots (Paul Edgar)

Purple moor-grass tussocks (Paul Edgar)

Compost/rubbish heap (Jonathan Bramley)

Building rubble (Jim Foster)

4.4. Food

All British reptiles consume animal prey. Hence, habitat that supports these prey species is essential to maintaining reptile populations.

Reptile prey	
Legged lizards	Insects and other invertebrates such as spiders.
Slow-worm	Soft-bodied invertebrates such as slugs and worms.
Smooth snake	Reptiles and small mammals.
Grass snake	Amphibians and fish.
Adder	Mainly small mammals, occasionally lizards.

4.5. Shelter from predators

Most predatory birds and mammals take reptiles, given the opportunity and a suitable size advantage. Hence reptiles need the cover of vegetation, which must be near to basking sites, to allow escape from predators (as well as thermoregulation). A mosaic of open basking areas and vegetation cover is provided by a diverse vegetation structure.

Adder basking in gorse, which provides excellent protection from predators (Tony Blunden)

Thorny or prickly plants such as gorse and bramble can provide particularly good refuge from predators. The low growing dwarf gorse and western gorse appear to be particularly important on heathland in this regard. The sunny edges of bramble patches also provide basking sites with a refuge from predators nearby.

4.6. Breeding habitat

Breeding, in this section, encompasses courtship, mating, egg-laying, incubation and birth. The ready availability of potential mates is important, and they are more likely to be found where structurally diverse habitats encourage high population densities. Courting rituals and mating often occupy the attention of reptiles to the exclusion of everything else, so secluded areas close to, or under, secure cover are essential.

Viviparous lizards mating. Reptiles need cover for all breeding activities (Fred Holmes)

Egg-laying reptiles have the most specific requirements for breeding sites (see *9. Creating Reptile Habitat Features*). The sand lizard lays its eggs in bare ground. Semi-compacted sand is almost always used as it has good thermal properties and drains well while remaining humid only a few centimetres below the surface. Sites chosen for egg-laying are almost always in an exposed, sunny location, just far enough from nearby vegetation to avoid roots and shading, but not so far (usually <30 cm) that the female has to cross a large expanse of open ground. Small sand patches, of about 10-50 m^2 or so, or the semi-compacted sandy edges of paths, tracks and fire-breaks are, therefore, most often selected.

Grass snakes need access to decomposing material in which they lay their eggs. Sites include manure heaps, compost heaps, grass clippings, sawdust, cut reed and, in coastal areas, seaweed heaps.

4.7. Space and habitat connectivity

Reptiles require sufficiently large areas of habitat to support viable populations in the long term. The relatively short distances over which they can disperse mean that they are dependent either on large areas of continuous habitat, or closely spaced patches, ideally linked by favourable intervening terrain. The periodic movement of individual animals between local populations effectively combines them into a larger metapopulation, increasing effective population size and viability. This is essential to support genetic diversity in the long term, avoiding the ill-effects of inbreeding. It also reduces the risk of populations becoming extinct due to locally catastrophic events, such as fire.

Habitat connectivity is important not only at a landscape level, but also within a site. Reptile distribution within most habitats is generally not uniform. Sites should, therefore, be managed so as to enhance the connectivity of habitat patches favoured by reptiles.

4.8. Habitats providing favourable conditions for reptiles

The sand lizard and smooth snake have stringent demands for particularly warm sites and, for the former, open sand. This confines these species to heathland and, in the case of the sand lizard, also dunes. However, the key reptile requirements of a structurally diverse habitat, providing a mix of open areas close to vegetation cover, are provided by a much wider range of habitats. The actual plant species present are less important than the physical conditions they create. Therefore the more diverse the vegetation structure, the more suitable it is for reptiles. In any given area, a fine-scale, intricate mosaic of vegetation supports a greater number of features favourable to reptiles than habitats with a uniform structure.

Ideal reptile habitat; heathland with diverse vegetation structure on a south facing slope with varied topography (Paul Edgar)

Reptile habitats

- Heathland
- Moorland
- Grasslands
- Scrub
- Woodland (clearings and edge)
- Wetlands
- Sand dune
- Hard and soft cliffs
- Vegetated shingle
- Coastal lagoon
- Farmland
- Brownfield sites
- Gardens and allotments
- Parks and grounds
- Churchyards
- Mineral sites
- Road and rail embankments
- River and sea walls

4.9. Habitat interfaces

The interfaces between habitats are also important to reptiles. These transitional zones, or ecotones, generally contain a great diversity of plant species and habitat structure, and hence a range of microhabitats and microclimates favoured by reptiles and many other species. Examples favourable to reptiles include:

- Sunny woodland edge.
- Grassland-scrub interfaces.
- Interfaces within grassland of varying sward heights.

Interfaces between different habitat types are important to reptiles, for example the transitional zone between this footpath and adjacent woodland (Jim Foster)

Whilst this grazed field offers little value for reptiles, the edges are excellent habitat because of the ecotone from tree to shrub, to herb layer. Bramble and tussocky grasses have been managed to form a margin which provides connectivity through otherwise poor habitat (Jim Foster)

Strimmed pathways maintain interfaces between short sward and tall vegetation at Grimbridge Lagoon reserve for reptiles (ARC)

4.10. Habitat succession

Reptiles occupy dynamic, successional habitats and their requirements may be met only in certain stages. Some species tolerate a wider range of successional stages than others. Viviparous lizards, for example, are much less restricted in this regard than sand lizards. The crucial point, however, is that the best reptile habitats do not stay suitable without natural succession being interrupted in some way. Most habitats revert to woodland, the natural climax vegetation of much of the British Isles (although some good reptile habitats, such as heathland and sand dune, may form the natural climax vegetation on poor soils or in exposed locations). In the absence of natural factors, intervention in the form of management is necessary to maintain all successional stages of a habitat and the specialised wildlife that each supports.

Examples of favourable reptile habitat

Moorland (Jim Foster)

Rough grassland and bramble (Paul Edgar)

Chalk grassland and scrub (Tony Blunden)

Open woodland, sunny glades and woodland edge (Nigel Hand)

Pond supporting amphibians, set in terrestrial habitats with diverse vegetation structure (ideal for grass snakes) (Jim Foster)

Sea wall (Paul Edgar)

5. Principles and Planning

5.1. General principles

An understanding of reptile habitat requirements will help the development of effective management plans. These requirements can be used to formulate some fundamental principles of habitat management for reptiles:

- Sufficient suitable habitat must be present to support viable reptile populations. This may be a single, large block or a series of closely spaced and/or suitably linked habitat patches.
- Reptiles require both warmth and shelter from the elements.
- Reptiles require ready access to cover to escape predators
- The maintenance of a diverse vegetation structure, on both small and large scales, is important.
- Habitat edges/transitional zones, with a favourable aspect for basking, are important to reptiles.
- Habitat connectivity, within a site, and between sites, is important.
- Reptiles must have access to safe, undisturbed and climatically stable sites for hibernation.
- Reptiles require the continuous availability of suitable habitat within the areas occupied by a population or metapopulation.
- Reptiles have limited dispersal abilities and may not be able to re-colonise isolated sites once lost. It is therefore preferable that they are not lost in the first place.
- The type, scale, location and timing of management can all have profound effects on reptile populations; management activities should be modified to take account of reptile requirements and their impacts monitored, particularly at the microhabitat level.
- The requirements of UK reptile species are broadly similar, but there are some significant interspecific differences.
- Sand lizards and grass snakes need suitable egg-laying sites.
- Many other species, particularly herbaceous plants and invertebrates, benefit from the same successional stages, or particular aspects of the structurally diverse habitats, preferred by reptiles.
- Incorporating reptile requirements into general habitat management is usually simple and often saves money.

Key considerations in management planning

- Habitat extent
- Habitat connectivity, within and between sites
- Warmth/insolation
- Diversity in vegetation structure
- Temporal continuity of habitat

5.2. Habitat extent and connectivity

Reptile habitat must be sufficient in size to support viable populations (i.e. avoid local extinctions), and to avoid genetic impoverishment in the longer term. Lizards often occur in smaller habitat patches than snakes, reflecting their more sedentary nature. Adders and grass snakes move over larger areas and hence require a larger expanse of habitat. Site managers should examine how reptiles use their site and try to optimise the value of available habitat.

Reptile distribution across a site is usually patchy, rather than even, either because some parts of the site are particularly favourable to reptiles, or because other parts are unsuitable. Areas of high concentrations of reptiles, which are usually associated with a habitat feature (e.g. a tumulus or embankment) are referred to as foci. If these are reasonably closely spaced and linked by traversable intervening habitat, then individuals (usually juveniles) can readily move between clusters of animals, which will effectively form part of a single large population, or sub-populations of a single metapopulation. Movements between sub-populations do not need to be on a large scale or continuous. The movements of only a few animals from each generation are enough to maintain healthy metapopulations. The areas between sub-populations do not need to support prime reptile habitat on a permanent basis, but they should be suitable for reptile movements from time to time.

Increasing the connectivity of patches of suitable habitat:

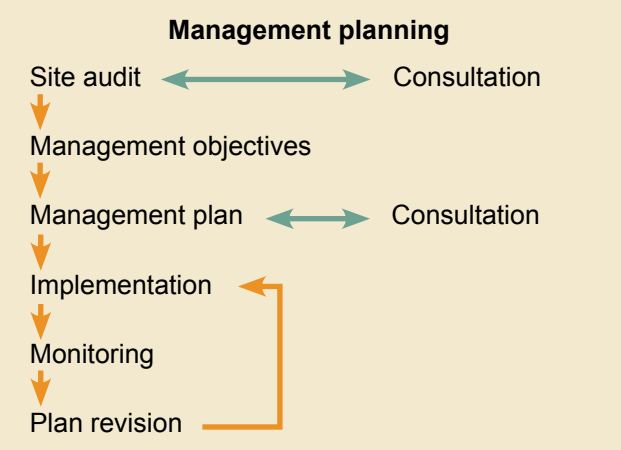
- Increases the area of habitat effectively available.
- Sustains larger, and hence more genetically viable, populations.
- Reduces the chance of extinction of otherwise isolated populations.
- Facilitates recolonisation of habitat patches, should reptiles disappear from them.

Site managers should seek opportunities to link patches of suitable habitat, or clusters of reptiles, within a site and between neighbouring sites. Habitat patches can be linked by favourable management of intervening habitat, either as continuous habitat blocks, or as habitat corridors such as hedgerows, field margins, boundary banks and forest rides.

5.3. Temporal continuity

It is crucial to maintain temporal continuity of extensive habitat within a site. The right sort of habitat, and enough of it, must always be present, especially on isolated sites. Reptile populations can be decimated if management such as scrub removal or intensive grazing affects the whole of a site at the same time. Reptiles are unable either to escape the harmful impacts of these operations or to recolonise isolated sites at a later date. Implementation of such management measures should be staged, so that not all habitat on site is affected (or removed) simultaneously.

5.4. Management planning



The process of planning habitat management for reptiles differs little from the development of plans for any other taxonomic group. Ongoing, attentive monitoring is recommended to assess the impact of management on vegetation structure and reptile occurrence, so that plans can be adjusted if necessary. If site managers are not familiar with local reptile status or habitat requirements, then expertise and advice may be available from Amphibian and Reptile Groups www.arguk.org or for the rare species, Amphibian and Reptile Conservation (see *14. Sources of Information and Advice*).

5.5. Site audit

Assessing what is already on site is the starting point for planning reptile habitat management. Reptiles are secretive animals, so their presence may go unnoticed. A site audit should involve consultation with interested groups to determine whether current or historical species records are available. It should, however, be noted that reptile recording effort is often incomplete, and hence a site survey is normally required. Long-term surveys, for example over the course of the reptiles' active season, are particularly useful, since site usage by grass snake and adder can change over the course of a year. A slope that is dominated by stands of bracken in late summer may offer little to reptiles at the time, but may be used as an overwintering site by snakes, which may be evident only in early spring.

Survey can also be a precautionary measure to avoid harming reptiles during the course of site management. In particular, management that potentially affects European protected species (sand lizard and smooth snake) may require particular care to avoid offences (see *3.4. Implications for site managers*).

A site survey should:

- Determine the presence/likely absence of reptiles.
- Identify general areas of the site used by reptiles.
- Identify significant features used by reptiles, such as habitat interfaces, favoured microhabitats and major hibernation sites.

An alternative approach is to map out areas of low, medium and high suitability habitat for reptiles. This can be done by assessing the characteristics important to reptiles. An objective scoring system (as exists for some species, such as the great crested newt) is yet to be developed for UK reptiles. The basic features may be identified using information given in *4. Habitat Requirements*. So, each compartment (or whatever unit is chosen) of the site could be assessed in terms of aspect, vegetation structure, refuge potential, etc. The result of this should be a map, dividing the site into low, medium and high suitability areas. Such mapping can incorporate species survey data, but can also be carried out when such information is unavailable.

Maps not based on species survey will be less reliable, but especially on very large sites it may be more practical to use habitat suitability for broad management planning purposes.

Both reptile survey and habitat suitability maps can be used to:

- Inform the scale, location and timing of general habitat management.
- Identify key features or areas of microhabitat that require special attention.
- Incorporate specific habitat management measures favourable to reptiles.

Information on how to carry out a reptile survey is summarised in *13.Survey and Monitoring* and given in full in several other publications (e.g. Foster and Gent, 1996; Gent and Gibson, 1998; Froglife, 1999).

5.6. Management objectives

Once the species present have been identified and areas and features important to them have been located, clear management objectives should be set. These could include:

Addressing threats
- Prevent arson.
- Reduce disturbance of reptile foci.

Providing favourable habitat
- Maintain a mosaic of open habitats and scrub.
- Maintain a diversity of ages of heather stands.
- Maintain scrub in mid-successional state.
- Increase the area of habitat suitable for reptiles.
- Maintain linkage between habitat patches.
- Create egg-laying sites.

Public involvement
- Inform the local population of the rationale for site management.
- Engage the local population in site wardening or survey.

5.7. Management constraints

There are always constraints to managing habitats. For example, on SSSIs, site management objectives are linked to conserving the interest features and achieving ‘favourable condition’. There may be other species or habitats requiring particular management. Funding for work on SSSIs may be focused on maintaining the interest features. Normally, this situation will be consistent with conserving reptiles, but in a minority of cases there can be conflicts. Guidance here should help to resolve such conflicts. The legal protection of reptiles may also impose constraints on habitat management. For example, burning a pile of brash that has become occupied by reptiles is likely to result in an offence; it should therefore be avoided and another method of brash disposal should be found.

Other statutory consents need to be considered e.g. felling licences, use of chemicals, Tree Preservation Orders, and Scheduled Ancient Monuments permissions.

Public perception of management practices is not always favourable. Consultation and education can be helpful, but habitat management may have to compromise to accommodate public sensibilities.

The site manager, therefore, has the challenging task of ensuring that reptiles are soundly conserved whilst balancing all these objectives and constraints. The task tends to be more difficult on smaller sites, and those with multiple scarce species.

5.8. Timing of management

See *Reptile habitat management calendar* (page 26), for a timetable of typical management methods. The timing of management operations may alter their effectiveness, as well as the chance of incidental mortalities of reptiles and other species. In the worst case, populations can be lost due to insensitively timed operations.

In general, substantial management should be undertaken in winter when reptiles are hibernating. Tree and scrub cutting has to be undertaken in winter to avoid disturbance of nesting birds. Even at this time, though, care should be taken to ensure that hibernation sites themselves are not damaged or left devoid of cover.

Bracken control, however, is effective only when vegetation is growing and therefore has to be undertaken in summer, when reptiles are active; hence precautions should be taken to avoid harming them (see *7.7 Bracken management*).

5.9. Impact assessments

When developing a management plan, impacts of proposed methods on reptiles (and other species) should be considered. For example, closely mowing a grassland site in a single operation risks directly

harming resident reptiles, removing their shelter from adverse weather and exposing survivors to predation. Such an operation could lead to the eradication of reptiles from the site; this could be a permanent local extinction if there are no sources of colonisation nearby.

Prompted by concerns about the adverse impact of some grazing projects on invertebrate and reptile populations, a *Grazing Impact Assessment* protocol has been developed to ensure that features important for these animals are considered (Offer, Edwards and Edgar, 2003). This is considered further under the advice on grazing, later. A similar approach is advised when considering substantial changes in management regime.

5.10. Management checklist

Factors that should be considered during reptile habitat management planning are as follows:

- Features of importance to reptiles should be incorporated into management plans, ensuring the continuity of those features in space and time.
- The identification of any communal hibernacula (especially those used by snakes) is crucial, as these usually localised features are particularly vulnerable to damage through management.
- High densities of reptiles may occur where there is favourable topography (south facing slopes, boundary banks, tumuli etc.) and other features (e.g. structurally diverse vegetation, degenerate dry heath). These often small areas (foci) can be targeted with more sensitive management specifically aimed at reptiles.
- Most of any particular site will invariably need long-term management to maintain habitat condition. If the type of management employed is suspected to have an adverse impact on reptiles (or other species) it should be considered in light of their conservation status.
- Occasionally, areas with very poor nutrient status soils can be left unmanaged, allowing natural vegetation cycling.

The sand wasp *Ammophila pubescens* (nationally scarce) is one of a range of species to benefit from the maintenance of warm, open habitats needed by reptiles (Mike Edwards)

Reptile habitat management calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mowing												
Scrub/tree cutting												
Stump treatment												
Bracken cutting												
Bracken spraying												
Sand rotovation												

Most effective and least damaging time to carry out work

Work may be less effective and/or requires more care to avoid disturbance

6. Resolving Management Conflicts

6.1. Background

Reptiles are one of many interests that site managers need to consider. Conflicts involving reptiles tend to arise most commonly in the following situations:

- Management is for general habitat maintenance, without reference to particular species requirements.
- Management focuses on particular species whose needs contrast with those of reptiles.
- Restoration from one state to another (usually from one with high tree or scrub cover to a more open habitat).
- Public access is a major factor in determining management.

These conflicts often come to light during management planning, but they may also be drawn to the attention of site managers by concerned site visitors and local specialist interest groups.

6.2. Precisely what is the conflict?

To help resolve these conflicts, it is often helpful to analyse the nature of the problem, or perceived problem. The following table lists the main classes of negative effects of habitat management or restoration (this is not exhaustive). The population-level impact will vary according to the circumstances. For example, the killing of five adult females would be insignificant to the viability of a moderately sized slow-worm population, but could be critical for a small, isolated sand lizard population. Advice here is given to help site managers to explore potential conflicts. Bear in mind, too, that this table considers the impacts from a simple reptile conservation viewpoint, regardless of legal issues, which should also be considered.

Effect	Example management operation	Effect on individuals	Impact on population
Direct harm to individual reptiles (instantaneous)	Strimming a limited proportion of long vegetation during active season	Death of small proportion of population	Normally low
Forced change in behaviour (short-term)	One-off burn of 0.2 ha patch of moorland in winter, in area used for basking	Reptiles temporarily move to alternative area for basking, possibly less suitable or more risky	Normally low
Increased risk of predation (short-term)	Annual flailing vegetation to ground level in area used for early spring basking	Reptiles more easily detected by predators, because of loss of cover, hence more are predated	Moderate
Long-term reduction in complexity of habitat structure, forcing altered behaviour (medium to long-term)	Introduction of high intensity grazing of heath-grass mosaic	Thermoregulation, courtship and other behaviour interrupted. Prey abundance and/or diversity reduced. Reptiles under stress, lowering reproductive success	High
Creation of habitat that is maintained in a state less suitable for reptiles (long-term)	Cutting back scrub to less than 5% cover, and then retaining at that level	Less refuge and edge habitat, reduced complexity, less prey. Reptiles under stress, lowering reproductive success	High
Harm to hibernating reptiles	Mechanised site clearance e.g. heathland restoration	Death during clearance, or later due to lack of cover	High

6.3. Factors to consider in reaching a resolution

As any management conflict will be particular to the site concerned, this handbook cannot offer a simple solution that will apply in each case. Rather, the following list of factors should be discussed with all interested parties and the possible remedies considered.

Factor	Remarks
Lack of information about reptiles on site	Undertaking major shifts in management is unwise until the presence and distribution of reptiles is known. For small sites, this means a straightforward survey. For very large sites, this may be impractical. In such cases it may be acceptable to survey representative habitat patches, combined with a habitat suitability survey (see *13. Survey and Monitoring*).
Method or outcome?	Is the conflict over the precise method being used, or the desired habitat outcome (i.e. the desired state of the habitat – effectively, what it should look like). Generally, it is more important to focus on the outcome. If the management plan envisages a site that would look very poor for reptiles, then this is a problem regardless of the methods proposed. The methods themselves can often be changed in some way to be acceptable for reptiles.
Timing of management	This may be critical. Often shifting the timing by just a few weeks may resolve the conflict. (See calendar in *5. Principles and Planning*).
Equipment	Sometimes there can be concerns about the kind of equipment used, or the way a method is applied. The reason for any concern should be explored and, if found to be of concern, an alternative sought.
Location	As reptiles are often unevenly distributed, with small areas being of disproportionate importance, management impacts on particular patches can be of concern. This is especially the case for breeding and hibernation areas. Shifting the area targeted for management will often resolve the problem.
Intensity	Sometimes the method itself is acceptable if simply applied with lower intensity. This might mean, for example, cutting less frequently, grazing with fewer animals, or removing less scrub.
Scale	Obviously, negative effects on one small area are less concerning than negative effects across a whole site. The species concerned is especially important here, as a less mobile species such as viviparous lizard is more likely to be harmed by a small impact on its core habitat than say grass snake, which can range over longer distances. For example, if the conflict would involve reducing habitat quality in an area used by grass snakes only for intermittent dispersal, it may not be very serious, and perhaps could be resolved easily by providing alternative connectivity.
Population viability	Large, continuous populations, as occur on large unfragmented sites, may be able to tolerate negative, localised effects of management. Small, isolated populations need much greater consideration as they have inherently lower viability. Generally, sand lizards, smooth snakes and adders are the most sensitive species, as they tend to exist at lower population densities and/or with higher fidelity to small habitat patches, compared to the other species.
Species specific concerns	Some elements of their ecology render each species vulnerable to particular actions. Grass snake populations, for example, will decline or vacate an area if their main egg-laying site becomes unsuitable or inaccessible.
Positive effects	Often, a management operation causing concern will also have some positive impacts for reptiles. These benefits may come about only some time after the management has taken place. It should be considered whether the long-term benefits outweigh the immediate negative effects.
Needs of other (non-reptile) species	What are the precise needs of the other species, and how do they conflict with those of reptiles? Is the conflict between the method or the outcome?
Funding constraints	Funds to undertake management, or more commonly restoration, sometimes mean that site managers must work to a tight timetable. The needs of reptiles and other species should be considered at an early stage to avoid last-minute compromises. Even if there is a pressing urgency then major efforts should still be made to accommodate reptile requirements.

Factor	Remarks
Public access	Generally reptiles are capable of tolerating public access, but there may be concerns if there are especially high volumes close to key areas, or if the access is likely to result in a major increase in, for example, fire risk, habitat damage or persecution. Routing access away from such areas, at least at certain times, may be sensible.
Public perceptions of site appearance or management	It is important to have good relations with neighbours and site visitors. Sometimes, however, there can be differences in opinion about what a site should look like, or how it should be managed. Particular problems tend to occur with tree clearance on heaths, and installation of fences. Early, detailed consultation and information programmes can help.
Relative status of reptiles, compared to other interest features	It is rare that reptiles are the sole conservation interest of a site. Hence, very few sites are managed entirely for optimal condition for reptiles. There are usually other species or habitats, whose needs also need to be considered. When there is a genuine conflict then compromise should consider the relative conservation significance of each interest. This would involve looking at conservation status, site designation criteria and legal protection. If reptiles outside the site are locally abundant and at little threat, then other interests may take a higher priority in site management objectives. In such cases, site managers must be able to justify the resulting reduction in reptile status, taking all factors into account.
Management to reduce risks to site integrity	Sites can be at risk from many threats that require management intervention, e.g. fires, drying out (in the case of bogs). Occasionally they can conflict with reptile requirements, but can be considered and resolved in the same way as other management conflicts.
Impact of no management intervention	Leaving a site unmanaged will normally mean that conditions decline for reptiles. However, this can be a false dilemma, since the choice is often not between just two options, but three: (1) no management, (2) the possibly damaging management causing concern, and (3) an option not yet determined, that is beneficial to reptiles and consistent with site conservation objectives.

With reduced grazing pressure and carefully planned scrub management on this chalk downland, a range of vegetation heights has been allowed to develop (Jim Foster)

Once the issues are properly understood, resolutions will normally emerge. The following table shows some common types of remedy, with examples.

Remedy	Example
Modify site management objective	Plan to remove most scrub on a chalk downland site left unmanaged for 30 years. The original plan focused on objectives for grassland habitat and butterfly interests. Following concerns over the loss of important reptile refuge and edge habitat, however, the objective was altered to achieve 30% scrub cover, present in scattered blocks and maximising south-facing edge.
Modify management timing	Mowing heather around hibernation site in March. Concern that individual reptiles were at risk of direct mortality. Timing of mowing was changed to November.
Modify management method	Large-scale mechanical heathland restoration. Concern over damage to existing patches of high quality grass-heather mosaic, where small, relict reptile populations persisted. Method of tree/scrub removal altered to either chainsaw/hand-tools where feasible, or long-reach (10 m) machine. Access routes to clearance area limited to only one (or as few as possible) to minimise damage by machinery.
Modify location	Proposal to burn 1 ha of moorland on a south-facing slope. Local surveyors regularly report viviparous lizards and adders there in March. Hence decided inappropriate to burn regardless of timing, since the burn would leave substantial habitat in poor condition for several years. Remedy: move the burn site to an area less suitable for reptiles 500 m away. Consider other options for moorland management at original site.
Modify management objective, location and method	Bog/acid grassland site, proposed to be grazed to keep in good condition. Concern over impacts on reptiles because the grazing regime is intended to eliminate large stands of *Molina*. Remedy is to either change the objective, to maintain the damp area as dominant, dense *Molina* stand, or change location of management by placing exclusion fence around a 4-ha area with the most important habitat patches for reptiles, so that livestock impacts are avoided.
Risk assessment	Large-scale mechanical heathland restoration on a very large site where it is impractical to survey all areas for reptiles. Remedy: carry out reptile survey of five sample patches, representative of main habitat types; assess habitat suitability over whole site; combine maps of suitability and survey results; modify management objectives to improve quality and connectivity of potential reptile habitat across site; implement sensitive restoration methods in high risk areas.
Prioritise reptile management objectives in defined area	Grass-heath mosaic managed for general access and nature conservation purposes. Plans to build new access track, and to manage for species preferring short swards. However, small, relict adder population discovered, one of only three in the whole county. Management objectives on core adder areas given high priority because of this. Access track re-routed to avoid adder hibernaculum; mowing intensity reduced to encourage better grass structure; trees shading banks cut back.
Demote reptile management objectives in priority in defined areas	Presence of natterjack toads. Management objective for natterjack toads is for very low sward, which is contrary to reptile requirements. However, due to rarity of natterjacks in the local area (compared to the reptile species present), the management objective was considered acceptable for part of the site. Management objectives in other areas of site, away from natterjack breeding ponds, were favourable for reptiles.

7. Habitat Management Methods

7.1. Overview

To maintain a habitat in the long term, or to retain a diversity of successional stages and characteristic species, some form of management is usually required. Natural processes that formerly performed this role have now been largely lost or severely disrupted. To maintain the diverse vegetation structure preferred by reptiles it is usually necessary, at the least, to control the growth of scrub, bracken and other dominant plants.

This section reviews widely used management techniques and considers how they can be applied to sites supporting reptiles. It is not the aim here to describe comprehensively how to undertake each technique, as the methods are well described elsewhere. Rather, the guidance here focuses on how to use these methods to achieve gains for reptiles. It also points out the potential risks to reptiles and how best to avoid them. Broadly speaking, the risks fall into two main categories: direct harm to individuals and reduction in habitat suitability. For further advice see *6. Resolving Management Conflicts*. Note that sometimes a combination of management methods is employed (e.g. controlled burning and grazing) and this can have a greater impact on reptile habitats/populations than if done separately.

A combination of grazing and repeated cutting have caused this area to become poor for reptiles, with very little cover available (Jim Foster)

7.2. Cutting/mowing

Repeated cutting of herbaceous vegetation can control succession to woody (shading) vegetation, diversify habitat age structures and create fire-breaks. However, cutting can also have adverse effects on reptiles:

- Immediate (direct killing or injury).
- Short-term (killing by the removal of cover and hence exposure to predation).
- Long-term (removal of key elements of habitat, such as ant-hills, grass tussocks or a diverse vegetation age structure).

It is important to implement a cutting regime that does not harm key features of a reptile site and it is essential to avoid simultaneous removal of all vegetation cover across a site, or substantial areas of it. This can be achieved by strategic selection of limited areas of a site to be cut (for example targeting areas where scrub encroachment is most severe) or by programmed, phased cutting of a site divided into management plots. Many smaller plots are preferable to few larger ones to maintain habitat diversity at a fine scale. Two hectares is a suggested maximum plot size on large sites; smaller plots should be used for smaller sites. Interfaces between plots of differing vegetation heights create transitional zones which provide useful habitat.

Mowing grassland plots at different times ensures that some cover is always available (John Baker)

Cutting should be undertaken when reptiles are least likely to be killed, ideally during the winter period of inactivity. In general, cutting should take place from November to February. However, attention should be given to weather conditions. For example, adders bask on fine spring days as early as January (in southern England) or February (elsewhere), which precludes mowing at hibernation sites at such times. Winter cutting or mowing should avoid creating large areas of very short sward vegetation around hibernation sites, where reptiles need some cover on emergence in the spring.

To maintain a diverse tussocky structure on rough grassland and prevent succession to scrub, plots should be cut on a rotation of no shorter than three years (i.e. one third of the plots are cut each year). Heather dominated habitats should be cut on a much longer rotation of at least 25 to 30 years for reptiles, with the most sensitive areas left out of the cutting regime altogether. Gorse can be kept at an optimum state when cut on a 15-year rotation.

On sites where botanical interest requires cutting during the reptiles' active season, then survey should be carried out to identify any foci to exclude these areas from the cut. The remainder of the site should be cut at intervals staggered over several weeks, so that there is always some vegetation cover available. The cut should be made as high as possible (minimum 15 cm).

Depending on the size and sensitivity of the operation, cutting can be undertaken by tractor-mounted forage harvester, hand-operated reciprocating cutter, brush-cutter, strimmer or hand scythe. Although mechanised cutting may be desirable on larger sites, on smaller sites, or near to reptile foci, hand cutting should be implemented as individual animals can be more easily avoided and cutting moderated to accommodate reptile habitat features that may be identified during the operation.

The habitat structure provided by this tussocky grassland should be maintained (Paul Edgar)

If cutting is likely to harm habitat features such as ant-hills, or remove habitat structure on a larger site where hand cutting is not feasible, then light grazing should be considered as an alternative (see *7.3 Grazing*).

Vegetation cuttings can be used to create grass snake egg-laying heaps (see *9. Creating Reptile Habitat Features*).

This site of grassland and scattered scrub is managed for reptiles by strimming selected areas during the winter. Local volunteers assist with raking cut vegetation into habitat piles. Patches of scrub are also cut to maintain the grassland/scrub mosaic. The grassland areas support common spotted and bee orchid, bird's foot trefoil, rest-harrow and sulphur clover. Pathways are kept open by strimming twice a year during the spring/summer months. Strimming during very hot weather seems to minimise the risk of harm to reptiles (John Baker)

7.3. Grazing

Grazing, using a range of livestock species, is currently used either to mimic natural processes or to replicate traditional agricultural regimes, with the aim of sustaining particular plant and animal communities. Timing, intensity and both species and breed of livestock all influence the outcome of grazing regimes. The response may vary between different habitats and even between different areas of the same site. Some important reptile habitats, such as dry heath, may prove very sensitive to grazing management. Therefore, a clear assessment of risks versus benefits is needed when considering this management technique.

Grazing can have the following positive effects for reptiles:

- Limiting the development of scrub, thus preventing a site from becoming too shaded.
- Creating areas of short vegetation amongst denser habitat, where reptiles can bask close to cover.
- Increasing the diversity of vegetation structure.

Grazing can also be detrimental to reptile populations, through the following effects:

- Creating a very low sward, hostile to reptile occupancy.
- Creating a uniform vegetation structure, unsuitable for reptile activity.
- Selectively removing key elements of vegetation structure, such as stands of *Deschampsia* or tussocky *Molinia*.
- Reducing prey abundance (through poor habitat condition).
- Enriching through dunging (leading to increased grass cover on heathland sites).
- Damaging the physical structure of degenerate dry heath, through trampling.
- Direct mortality through trampling (e.g. sand lizard eggs, significant at only a minority of sites).

Just like other management methods, then, grazing has the potential to benefit reptiles, yet it can also be harmful. Some grazed sites support excellent reptile populations. At the opposite extreme, reptiles have been extirpated through grazing others.

Grazing intended to control or prevent scrub colonisation is likely to be at an intensity that will significantly reduce the structural complexity of vegetation and hence be detrimental to reptiles. Alternative methods of scrub control should be sought in such cases.

Special care is needed where sand lizards or smooth snakes occur. Impacts of grazing may be particularly harmful on small, isolated sites. A balance may be difficult to achieve, but light grazing may benefit robust populations of rare reptiles on large sites, if properly planned and monitored.

The following advice is aimed at helping decide whether grazing is an appropriate method for a site supporting reptiles, and if so, how to maximise the benefits and minimise the risks to reptile populations. In some cases, grazing is not recommended at all, as the risks of serious harm to reptile populations are so great. This may be the case where:

- The site is very small (the smaller the site, the greater the risk of harm; generally, sites less than approximately 5 ha [less than 10 ha for dry heath] should not be grazed).
- Reptiles are largely restricted to small patches of vegetation types that would be reduced in suitability (e.g. stands of dense *Molinia* among dry heath may be preferentially grazed, yet these are often of great importance to viviparous lizards).
- Grazing would create a short sward, or one that is very uniform in structure over a large area.

A risk assessment for grazing heathland (Offer *et al.*, 2003) gives more detail to help predict the possible negative consequences. Where grazing is indicated as beneficial, the following precautions are recommended:

- Define objectives for what the grazing regime (along with any other methods) should achieve. This is best done in terms of vegetation structure, vegetation type and ground condition; these should be mapped across the site.
- Exclude livestock, or substantially reduce grazing pressure (reduce stock density or time on site), for any areas of especially high value for reptiles and high vulnerability to damage through grazing.
- Consider leaving some areas outside the grazing regime, both for wildlife and access.
- Consider reducing grazing period.
- Ensure there are plenty of reptile refuges, for example, brash piles, stone walls and scrub patches.
- Monitor vegetation structure at key locations to check for positive and negative effects (see photographs on following page).
- Monitor reptiles in key locations to detect changes in habitat use, breeding success or population density.

Regarding the latter points, monitoring vegetation structure is likely to provide the most effective tool for assessing the impact of grazing, and should alert a site manager to any problem much sooner than monitoring reptiles themselves. The latter is likely to yield results only in the long term. Moreover, increased visibility of reptiles soon after habitats are opened up can prove misleading (see *13.3 Monitoring reptile populations*).

With light, extensive grazing, it is possible to retain important features such as large stands of deep *Molinia*. Monitoring should check for detrimental effects since such areas may be preferentially grazed, depending on the site character and livestock (Jim Foster)

Early signs that grazing is having a detrimental effect: the structure of the vegetation, particularly that of grasses, is beginning to change, with larger patches of very short sward vegetation (Jim Foster)

High grazing pressure creates large areas of short sward, a grassland structure with virtually no value to reptiles (Jim Foster)

Livestock type Experience indicates favourable results with cattle. Note, however, that the livestock type chosen will depend on a range of factors, notably the precise management objective and the site conditions.

Different livestock are suitable for different tasks. Experience indicates that cattle may be the best choice for reptile sites (Paul Edgar)

Livestock density It is impossible to recommend a precise stocking density because this depends on many factors, and should follow from the management objective. In general, stocking rates often used for conservation management seem to result in poor vegetation conditions for reptiles. As a general guide, 0.2 livestock units per ha is recommended as a maximum (equivalent to 1 cow per 5 ha), since negative effects are frequently seen above this rate. However, it is stressed that the decision on stocking rate must be determined by what the grazing aims to achieve, and that adjustments be made based on monitoring vegetation condition. Even at very low densities, negative impacts can sometimes result if livestock congregates in, or regularly passes through, key reptile areas. Good planning should, hopefully, predict this, so that the regime can be altered to avoid such effects. Otherwise, monitoring should detect it, and thereby prompt remedial action.

Grazing can remove vegetation cover needed by reptiles, as seen here to the left of the fence (Paul Edgar)

7.4. Controlled burning

Burning is commonly used to manage moorland and is gaining popularity for heathlands. Used with great care, burning can sometimes be useful in maintaining good vegetation condition for reptiles. However, burning too frequently, or at too large a scale, can be highly damaging to reptile populations. There are three main negative impacts on reptiles:

- Direct mortality of reptiles caught in the fire.
- Post-burn mortality. Reptiles suffer increased predation rates following burns because they are more obvious to predators and are less able to evade predation.
- Reduced habitat quality. A reduction in sward height and an increase in uniformity can lead to population declines over several years following a burn.

Controlled burning on too large a scale can leave a landscape devoid of vegetation cover, which can take twenty years or more to regenerate (Paul Edgar)

Heathland and moorland that are burned too frequently develop a very uniform, even-aged structure that is poor for reptiles (Jim Foster)

On heathland it may take 20 years, sometimes more, for the vegetation to recover the state of sward height and complexity preferred by reptiles. Other habitats may recover more quickly. In addition, burning often results in colonisation by dominant stands of bracken, gorse or grasses; substantial additional management may be required to achieve a favourable vegetation composition.

The fragmented nature of many reptile sites makes burning a risky method for their management. Fire can eradicate reptiles from small, isolated sites, with little opportunity of recolonisation.

Given the negative effects of burning, it is rarely recommended as a management technique where reptiles occur. Often other management methods can achieve the same objective, but without the risks. There are, however, some exceptional cases where burning may be acceptable:

- As a highly focused technique, e.g. high intensity burns to control small but dense gorse stands.
- On highly uneven or remote terrain, where operating machinery poses particular problems.
- On larger (>50 ha) sites with robust reptile populations, where burn patch size is kept small and other precautions are taken (see below).

Where burning is considered, the following precautions are advised:

- The possible benefits and harm to reptile populations must be considered beforehand. This should assess the likely effects on medium- to long-term habitat condition, as well as immediate harm to individuals. If the harm outweighs the benefits, an alternative management method should be sought.
- Prior reptile surveys should inform the exact location of burn sites, with any particularly sensitive areas excluded (e.g. major hibernation sites or favoured basking banks).
- Burning should be done when reptiles are in hibernation, and are thus less prone to direct mortality. The safest period is generally from November to the end of January, though local reptile activity should be taken into account.
- Burning methods should encourage a quick, cool burn rather than a slow, deep one. This promotes much better re-growth and the faster recovery of a more useful vegetation structure.
- Burning should employ as small a patch size as feasible, with a maximum of 1 ha on very large sites (>50 ha) ranging to a maximum of 0.1 ha on small (<3 ha) sites.
- Some grassland and heathland vegetation types are especially vulnerable to burning and may not recover well. Mature or degenerate heather is an example that is also highly valued by reptiles. Such areas must be excluded from burns.

Further advice is given in *The Heather and Grass Burning Code* (Defra. 2007). Note again, however, that the burning season of November to March, is unsafe for reptile sites. Burning on sites where reptiles occur should not take place after they have started to emerge from hibernation (early February onwards).

7.5. Fire control

Fire control is essential on many sites to reduce accidental and deliberately set fires. It is highly beneficial to liaise with local fire brigades and provide them with detailed maps showing access points and routes onto sites.

Where the risk of fire is high, it is important to make sites accessible to fire-tenders. Permanent, major fire-breaks serve a dual purpose of stopping the spread of fire and providing access routes for fire-fighting vehicles. On heathland, such fire-breaks can be created by digging 2-m-wide strips of bare sand and mowing 2-m strips on either side to create breaks approximately 6 m wide.

Major, permanent fire-break, incorporating bare sand and borders mown to 15cm to provide cover for sand lizards (Nick Moulton)

The exposed sand elements of fire-breaks can serve an additional function as sand lizard egg-laying sites (see *9.4 Sand lizard egg-laying sites*). Note that on sand lizard sites, the mown strips bordering a major fire-break should not be cut too short. If the vegetation is cut to less than approximately 15 cm, female sand lizards are exposed to predators as they cross the mown strips to reach bare sand.

Small, semi-permanent fire-breaks (approximately 2 m wide), created on a rotational basis can also reduce the spread of fire, and can play an important part in maintaining a range of vegetation structure within a site. Mown strips should be cut running east to west, in a sinusoidal pattern. This maximises the diversity of microhabitats created at the interfaces between cut and uncut vegetation, increasing the habitat value for reptiles and invertebrates (e.g. silver-studded blue butterfly).

Bare sand can be incorporated into small, mown fire-breaks by scraping strips of sand along their edges with a bulldozer or back-hoe. Stripped topsoil should be piled on the northern edge of the exposed sand. These sand strips should be rotovated on a three- or four-year cycle, staggered so that only a third or a quarter, respectively, is rotovated in any one year. This maintains a range of successional stages on site. Low ground pressure machinery should be used to ensure that other important features are not damaged.

A small fire-break, including bare sand scraped from a mown strip and piled on the north side to increase microhabitat diversity (Chris Dresh)

Strips destined to become open sand should be mown in the preceding winter, to prevent birds nesting in targeted areas, and then topsoil scraped in late April to May after reptiles have emerged from hibernation.

Engagement of local communities is also vital in controlling fire on sites close to populated areas, and can ensure a rapid response from fire brigades. Notice boards informing the public of high fire risk periods and asking them to contact the fire brigade in the event of fire can also be successful. Volunteer wardening schemes have proved helpful in controlling illegally started fires and are essential in high fire risk periods.

7.6. Scrub and tree management

On many sites scrub and tree management is necessary to maintain mid-successional stage habitats. Nevertheless, the value of scrub and trees to reptiles should not be underestimated. Such cover can create windbreaks and pockets of warm microhabitat favoured by reptiles, and be a refuge in hot weather, overnight and sometimes during winter. It is also important in supporting prey populations, especially for snakes. The root systems of living and dead scrub and trees provide refuge and hibernation sites.

Scrub and trees increase the structural diversity of a site and so some should be retained, even on heathland (John Baker)

Here the slope in the background is at risk of becoming too shaded by birch. Partial clearance or thinning would be recommended, taking precautions over methods given the ground cover remains suitable for reptiles (Jim Foster)

Management should be phased over time, retaining vegetation of varied ages. Even on heathlands, mires and grasslands, small to moderate amounts of scrub and trees should be retained.

Generally, sunny, south-facing aspects favoured by reptiles should be managed as a priority, and most shading scrub and trees removed from such areas. The amount managed should depend upon the habitat and the management target species. For example, sand lizards prefer mainly unshaded habitats whilst adders and slow-worms prefer more scrub and tree shelter.

The interface between tree/scrub cover and shorter, herbaceous or ericaceous vegetation is of major significance for reptiles. Site managers should maximise the amount of edge or interface habitat, and vary its character. Even ‘hard’ edges, as can be found for example at the bases of hedgerows, can be good microhabitats for reptiles. Of rather higher value are graded ecotones, where the height and density of the vegetation reduces gradually from the tree/scrub edge to shorter herbaceous vegetation. Importantly, edge habitat should be oriented to allow sun exposure. This means focusing on the south-facing edge of scrub/tree blocks, or creating south-facing open areas within such blocks. Creating a scalloped edge along a southern scrub/tree block will generate sheltered bays for reptiles.

On bogs, the edges of peat cutting (as here on left) can create banks used by reptiles. Management should aim to keep them open, so the shading treeline to the south should be taken back, as here (Jim Foster)

The bank along the left of this track is used for hibernation by widespread reptile species. Management of trees on the right side of the track has retained its open nature. Periodic birch removal will be needed to keep the bank in good condition (Jim Foster)

Scrub and tree cutting should take place between mid-September and February to avoid disturbance of nesting birds. The stumps of deciduous trees and gorse can be allowed to re-coppice or they should be treated with herbicide (e.g. Garlon 2, Timbrel or Roundup) to prevent re-growth. Dead tree stumps should be left in place, to provide valuable habitat, in particular creating refuges and hibernation sites for reptiles.

Cut material should generally be removed from sensitive sites, e.g. those supporting sand lizards, otherwise it will continue to smother and kill ground vegetation. It should be chipped and removed, or dragged to a sterile area of the site and burnt. On less sensitive sites, cut material can be stacked and retained to create brash piles or hibernation sites (see *9.1. Brash and log piles*).

Scrub and tree control can be achieved by various hand-tools (chain-saw, bow-saw etc.) used by professional or volunteer work parties (Paul Edgar)

Whether to use hand-tools or machinery depends on the situation. Machinery is best used on large sites, where it is most effective and the risk of population-level impacts is reduced (though see precautions, below). Hand tools are appropriate for small sites or where very small-scale management refinements are indicated.

If done without sound planning, scrub and tree control risks harm to individual reptiles, and can reduce habitat quality resulting in longer-term population declines. The risk of direct mortality can be reduced by careful timing and methods (e.g. doing work in winter, and not disturbing below the ground surface). The risk of creating degraded habitat can be reduced by ensuring the right balance between removal and retention, and planning the locations of areas targeted for such. It is generally unwise, from a reptile perspective, to remove all or virtually all scrub right across a site. Retaining scrub in key locations, for example at the top of south-facing slopes, will help. A sound survey helps to plan beneficial scrub and tree removal.

Gorse, bramble and rhododendron Gorse and bramble both offer important cover for reptiles. Holes in the ground at the base of both plants can be used for overnight sheltering. During the day reptiles often bask at the edges of gorse and bramble stands, where they can quickly seek cover if threatened or needing to find shade. Voids among the root systems of older gorse plants can sometimes be used for hibernation. When controlling these plants, then, care normally needs to be taken to retain some cover. Typically it is best to retain small, scattered blocks on south-facing slopes. Both species require repeated management as they are fast growing. Gorse can be a particular problem after fires, or in the early stages of heathland restoration, when it can quickly become dominant. Large, dominant stands of gorse are undesirable for reptiles and, especially if old and leggy, pose a high fire risk, particularly close to access points and footpaths.

Rhododendron is commonly the target of removal, and is certainly undesirable from a reptile conservation perspective. Occasionally, however, reptiles use the root systems for hibernation and so care may be required to retain the below-ground structure when removing rhododendron.

Shallon *Gaultheria shallon* Shallon is a non-native, evergreen shrub that is invasive on some heathland sites. Individual plants and small stands can be spot-treated with Roundup Biactive or a triclopyr-based herbicide such as Garlon or Timbrel. Spraying can be carried out at any time of year, but is most effective in the spring when leaves have not hardened off. Large stands should be bulldozed to bare sand and any re-growth sprayed.

Gorse is most valuable when grasses are allowed to develop at the base, providing a gradient of vegetation heights (above). Gorse has very little value for reptiles when the area is kept heavily mown or grazed, meaning that no ground cover is available between gorse stands and the bases offer little basking potential (below) (Jim Foster)

7.7. Bracken management

Bracken is frequently an invasive plant species within habitats preferred by reptiles, especially following habitat restoration. It can form extensive stands preventing light from reaching other vegetation and creating a mat of litter, which further inhibits growth of other plants, while protecting its rhizomes from frost. Bracken, however, can also be a significant microhabitat for reptiles, so its control should be undertaken with care and should not aim at complete eradication.

When planning bracken control, site managers should consider the potential value of this vegetation type on site. At many sites where it occurs in moderate amounts, it is of great value to reptiles and invertebrates. It creates warm microclimates in early spring, when it is favoured by reptiles emerging from hibernation. Reptiles disperse through, and hunt among, bracken thatch up to around June, after which shading from annual growth makes it less suitable, although it may still be used to escape extreme heat. Retaining small, scattered stands of bracken, especially close to hibernation sites, is often desirable.

Dead bracken creates an excellent microclimate and microhabitat for reptiles on emergence. Bracken control should retain some stands, unless other vegetation performs the same function (Jim Foster)

Bracken control methods include herbicide application, rolling, to crush the growing stems, or cutting. These measures have to be applied at a time when reptiles are active, but of the three, herbicide application is usually the best option.

A very effective means of controlling bracken on reptile sites is the application of the selective herbicide Asulox. This should be sprayed on to the upper surfaces of the fronds, using a backpack applicator, as this is less likely to damage the site than use of a vehicle-mounted device. Secondary spraying of any re-emergent fronds in the following season is usually necessary.

Spraying the selective herbicide Asulox from backpack-mounted systems is an effective means of controlling bracken (ARC)

Bracken spraying should be undertaken between July and mid-August, when the fronds are fully unfurled, but not hardened off. It should be carried out on dry days, as herbicide absorption is low if fronds are wet. Windy conditions should be avoided to prevent chemical drift and herbicide should not be used near to water bodies or livestock. Warning signs should be placed on site to warn of spraying in progress. Spraying controls bracken without harming either reptiles or their habitat. However, it is both cost and labour intensive. It can be carried out only by trained, certified persons and is also dependent on weather conditions.

Both rolling and cutting may harm reptiles. Within large, dense and continuous bracken stands, however, these options pose a low risk, as reptiles are unlikely to inhabit such areas. Around the edges of such stands, rolling or cutting should be avoided, or done with extreme caution, as reptiles are more likely to be present here. These methods should also not be used on small patches of bracken, or on large, fragmented stands. In both cases there is a reasonable chance of reptile presence (though a thorough survey can be done to verify this).

Rolling or cutting are most effective after the period of most rapid bracken growth, in late June or July. Although bracken re-grows, it does so with reduced vigour. Re-growth requires further control measures (repeated rolling or cutting, or herbicide application).

7.8. Managing introduced predators

Natural predators, such as native birds, are rarely a conservation concern. Reptile populations are resilient to losses from such predators. Problems can arise, however, with predators that have been introduced by humans. The two key species of concern are domestic cats and pheasants.

Cats can be a serious concern, especially for reptile populations on small patches of habitat, surrounded by houses. In this circumstance cats can take large numbers of reptiles and threaten population viability. Site managers can speak to householders to ask them to keep their cats in as much as possible, and to discourage them from taking reptiles. It is recognised, though, that there is little hope of restricting cats' behaviour. A more productive approach is to ensure the site has plenty of refuge habitat which could render reptiles safer, such as bramble and gorse. Feral cats can also be a problem, and in this case removal and re-homing, in conjunction with appropriate authorities, would be the best option.

Pheasants prey on (or just kill) reptiles, among other prey items. In the UK, they are even known to kill adult adders. Low levels of predation may not be a conservation problem, but a particular concern with pheasants is that releases of large numbers of birds are common. This may result in a high rate of reptile mortalities, perhaps sufficient to cause population declines. Particular problems arise when birds are released in large numbers close to key areas for reptiles, especially hibernation sites, breeding sites or favoured basking banks. Regular sightings of groups of pheasants on, or very close to, such areas should trigger concern. The Game and Wildlife Conservation Trust advises not to place release pens on, or close to, reptile breeding or hibernation areas (Game Conservancy Trust, 2006). For concern over existing pheasant releases, site managers may request that these are at least modified to pose lower risks to reptiles. This might mean moving release pens to a less harmful location, or substantially reducing the number of birds released, for example. As a last resort site managers may request the release is ceased.

7.9. Research

There is still much to learn about reptile habitat management. Doubtless, with increased experience, advice on reptile habitat management will become more refined in future. Meanwhile, there is scope for site managers and associated surveyors to make a contribution to this process, through research projects of varying complexity, for example:

- Recording the responses of reptile populations to specific habitat management regimes.
- Experimenting with novel variations on the recommended approaches.
- Reporting on successful, or indeed failed, management in particular habitats (e.g. grassland, moorland).

The authors are interested in the development of reptile habitat management techniques and reptile survey methods, so please do make contact to discuss potential research projects.

8. Habitat Restoration and Re-Creation

8.1. Habitat restoration

Former reptile sites, which have been neglected for long periods or damaged in some way, can normally be restored to a suitable condition. Sites suitable for restoration are those that may still support recognisable remnants of the original vegetation and wildlife.

Areas like this require special care during habitat restoration, as relatively open patches may support remnant reptile populations (Jim Foster)

Restoration should always be preceded by a detailed site survey to identify areas that may still harbour reptiles and to ensure that other sensitive species are not harmed during restoration work. This is an issue of particular importance with respect to heathland and mire restoration. The scale of some restoration projects necessitates the use of large, powerful machinery, often resulting in the wholesale removal of vegetation and topsoil. In using such approaches there is a high risk of direct harm to reptiles and damage to their relict habitats. To ensure that large-scale restoration projects minimise such risks, the following steps are recommended:

- Prior survey of areas targeted for restoration to identify habitat occupied by reptiles, or to identify areas of low to high quality reptile habitat.
- Mapping these areas to ensure that heavy plant or other operations do not damage them.
- Undertaking special precautions. In areas of medium to high risk, for example switching to hand-tools.

Often only a small proportion of a restoration site will be occupied by reptiles. Usually they will be found in the more open, less tree-covered areas, and these will normally be of least interest for major mechanical clearance. Hence, excluding such areas from mechanised clearance (they should be clearly marked for contractors) will have little impact on the amount of land restored. The maintenance of patches of habitat used by reptiles is also likely to increase the structural diversity of a restored site, to the benefit of other species as well.

The dense tree cover in the background offers little value for reptiles and can be removed with few precautions. The edges are of potentially high value, however, and care is required when planning restoration or management works here (Jim Foster)

At first sight, major works such as large-scale gorse clearance can appear harmful to reptiles. It is important to consider the previous state of the habitat, in this case dense gorse stands with little value as reptile habitat (Jim Foster)

8.2. Habitat re-creation

There can be opportunities to re-create habitat from where it has been completely lost to another land use (such as agriculture, forestry or mineral extraction), or to invasive species (such as rhododendron) or to succession.

Forestry Commission policy (Forestry Commission, 2010) recognises the potential wildlife benefits of converting woodland to open habitat. Reptiles are Biodiversity Action Plan priority species that may potentially benefit from such measures.

Many formerly open areas have reverted to secondary woodland following cessation of heathland management. Large-scale restoration can bring major gains for reptiles, by creating more open habitat. Careful planning helps maximise the benefits and minimise the risks (Jim Foster)

Mature plantation with no understorey offers no real value for reptiles, and so such areas should be low risk (and high priority) in open habitat re-creation projects (Jim Foster)

To re-create heathland from pine plantation, the crop should be commercially cut and arisings removed. It may be necessary to bulldoze the area to remove excess nutrients, litter layer and bracken rhizomes, which can prevent natural re-vegetation from the existing heather seed bank. Litter and arisings may be used to create brash piles within cleared areas, or windrows along the south-facing edges.

Topsoil, litter and arisings piled at the edge of a restoration site, sheltered by a belt of trees on the northern side, create a habitat feature favourable to reptiles (John Baker)

An area formerly entirely shaded by pine plantation, now cleared and showing the scope for new reptile basking banks once the heath begins to regenerate (Jim Foster)

On mineral sites the seed bank is often lost so forage harvesting of heather seed (for example from fire-breaking adjacent sites) is often needed to restore habitats. This should be spread over a layer of compacted sand. Nursery species (e.g. native pioneer grass) are often necessary to stabilise ground conditions and allow heather germination, which will in time succeed the nursery crop.

Reptile habitat can sometimes be created, or re-created, on grassland sites simply by reducing the density of grazing stock, or excluding it from some areas which can then be managed by winter mowing or allowed to develop scattered scrub cover. Enriched grassland sites may require removal of topsoil and re-seeding with seed mixes appropriate for the habitat type. County Wildlife Trusts may be able to provide advice with regard to sources of seed.

9. Creating Reptile Habitat Features

9.1. Brash and log piles

The value of brash and log piles lies in;

- creating cover,
- providing additional structure to existing habitat,
- enhancing prey availability.

On sites where vegetation structure is limited brash and log piles may be invaluable features for reptiles. In particular, the addition of brash piles to grassland habitats seems to be attractive to viviparous lizards and adders.

Brash/log piles can be created from arisings of scrub control. Piles should be placed in a sunny location and set within existing vegetation (for example, areas of long grass or long grass and scattered scrub), so that there is cover immediately surrounding, or adjacent to, the pile.

To be useful to reptiles brash does not have to be tightly compacted, as recommended for invertebrates. To provide diverse structure within a brash pile, it is recommended that the central core be compacted, while the outer layers are laid more loosely on top. Vegetation growing through the outer edges of the brash pile will provide additional cover.

Brash piles can utilise arisings from scrub and tree control to enhance habitat by increasing structural diversity (Jim Foster)

Brash piles should be maintained by adding additional material as the pile decomposes. This can be provided from ongoing tree and scrub management activity.

Log piles should contain a mixture of sizes and shapes, with some small-diameter material present. A standard log pile comprising similarly-sized timber, as results from normal forestry operations for instance, is of limited value to reptiles because the voids tend to be too large and the structure lacks complexity.

Brash and log piles should be located away from areas of high public access, to reduce the risk of disturbance, collection or arson. On sites subject to high levels of public access, the materials can be either partially buried in the ground, or anchored with wire or secured with wire stapled to the larger logs.

A log pile sited in a sunny location, providing additional structural diversity to a grassland site (Jim Foster)

9.2. Hibernation sites and basking banks

Creating hibernation sites (hibernacula) is a useful management measure either following recent habitat restoration, where such features may be absent, or where traditional hibernation sites are degrading through subsidence or excessive shade. In many cases, however, the creation of new hibernation sites may not be critical, since it is likely that the animals already have adequate overwintering quarters. Hibernation sites are also used for refuge and basking during the active season, so to refer to them as ‘hibernacula’ may be slightly misleading. However the term is used here to distinguish them from simple basking banks (see below).

Creating new basking banks is often a valuable measure, though again the value of this depends on the site: if the site is already very open with a south-facing aspect, there is probably little point in spending resources on new banks.

Reptiles have exploited human made features such as road and rail embankments or windrows in forestry plantations. They may be used for basking, refuge during the active season, or hibernation. The characteristics of such features provide pointers to help design banks and hibernation sites specifically for conservation purposes.

The body of a reptile hibernaculum can contain a range of materials. For example, cut timber, brash, inert hardcore, bricks, rocks, grubbed up tree roots or building rubble. These features can provide a convenient way of using waste materials and arisings from site management. Materials that will decompose should not be placed beneath heavy components such as bricks or rocks, to avoid the risk of collapse. Wood chippings or loose topsoil can be incorporated into the construction, to pack some of the larger cavities (reptiles can squeeze into small spaces, which may afford them protection from predators, such as mustelids or rats).

There should be access points around the edges. These are best created by ensuring that timber or rubble protrudes from the edge, creating crevices that allow reptiles to get deep inside. It is not recommended to use pipes to create access points. Reptiles appear to prefer using more 'natural' cracks and holes. Pipes are also prone to blocking or becoming dislodged with time, meaning that access is considerably limited if they are the only entrance and exit points.

There is no single perfect hibernation site, and managers should consider what fits best on their site. The key design features are;

- a sunny position,
- a well-drained site, not prone to flooding,
- orientation so that one of the long banks faces south,
- access to reptiles through openings of some sort,
- location in a patch of habitat favourable for dispersal, such as tussocky grassland,
- minimal public disturbance,
- size at least 4 m long, by 2 m wide by 1 m high, and ideally much larger.

Depending on soil conditions and hydrology, it is often preferable to dig a pit, and then place the materials partially buried inside, rather than just creating a mound on the surface. Materials to help drainage, such as slotted pipes and gravel, can be placed in the structure. However, on impermeable soils or in low-lying areas it may be safer to create an entirely above-ground structure, to reduce the risk of winter flooding.

In areas of grassland or other herbaceous vegetation, turf should be removed from the footprint of the reptile bank, so that it can used to cover the completed construction. In most cases the rapid establishment of vegetation cover on reptile banks will be important. If this cannot be achieved by use of turf, then seeding with a meadow mix may be required. It can be beneficial to plant or translocate scrub to the immediate north of the feature, as this will provide shelter and cover.

A reptile bank under construction. Turf has been stripped to ceate a shallow pit to receive a pile of hardcore and logs. This will be covered with the stripped turves (Lee Brady)

Hibernaculum designs for mitigation projects have met with some success (Stebbings, 2000; Showler *et al*., 2005). These designs could be used on nature conservation sites. Note, however, that the consensus now is that it is normally unnecessary to use pipes to create access holes. The design should therefore incorporate openings, continuous with voids deeper inside the structure.

Simple, south-facing basking banks can increase the opportunities for reptiles to warm up on sites that are otherwise poor in aspect or topographical variation. Banks can be created very rapidly by machine. They may be long and straight, or crescent-shaped, or sinusoidal. They should be turfed or seeded to encourage a good vegetation structure, ideally with patches of scrub, and occasional log or brash piles should be placed on top.

9.3. Grass snake egg-laying heaps

For many sites with grass snake present, creating egg-laying heaps is one of the most productive management measures. Egg-laying sites are often a limiting factor, and population declines may be traced back to their destruction or reduction in quality. If grass snakes currently only disperse through a site (as is often the case with this highly mobile species), creating an egg-laying site may encourage the snakes to form a new population centre, and spend more time there.

Semi-natural grass snake egg-laying site, a rotting hornbeam stump (ARC)

Grass snakes usually nest in heaps of decaying organic material of various kinds, where the heat of decomposition incubates the eggs. Natural nesting sites include piles of vegetation deposited by flood water or cavities within dead, rotting tree trunks and, in coastal areas, seaweed piles. More commonly, grass snakes use material provided by humans, including heaps of manure, compost, grass clippings, sawdust, garden waste or cut reeds. The material must be actively decomposing and producing heat. However, in some habitats grass snake eggs are laid where the vegetation or ground substrate itself is warmed by the sun, such as deep moss layers found on the older successional stages of heathland, or crevices in the ground. Tens of females may lay their eggs in a particularly suitable site.

An aggregation of female grass snakes on an egg-laying site comprising discarded hay bales (Tracy Farrer)

The creation of piles of organic material can, therefore, be beneficial to this species. The disposal of arisings from vegetation cutting or mowing is often a problem for habitat managers – but such waste material can be used to create grass snake egg-laying sites.

The key to a successful grass snake egg-laying heap is to ensure the material provides the necessary heat and humidity to incubate the eggs. Larger heaps of vegetation are more likely to be successful than small heaps. Heaps should be at least 1 m^3, but ideally much larger. It is also necessary to replenish existing sites with fresh material or to regularly create new egg-laying sites.

Heaps that are used by grass snakes should not be interfered with between June and September, to avoid harming the animals. Replenishing is best done in April to May or October, and normally should be done at least once every two years (though this depends on how quickly the material loses the capacity to generate heat, which can be tested easily by hand). Occasionally grass snakes (and slow-worms) also hibernate in the heaps, so they are best left undisturbed over winter.

Some grass snake egg-laying heaps have been constructed by piling vegetation (meadow cuttings) on top of a base, or framework, of brash. Whether this sort of construction improves conditions for grass snakes has not been rigorously tested. However, the brash is intended to create spaces within the heap to allow easy access to nesting females. It may also increase aeration, hence aiding decomposition of the organic material.

A large compost heap, in a sunny location with adjacent cover provided by logs and herbaceous vegetation (Paul Edgar)

Compost containers should allow access to air and grass snakes (Lee Brady)

If space allows, creating several egg-laying heaps may be beneficial. This may increase the chances of females locating a heap, while reducing the distances they have to move to do so. Multiple heaps are also likely to create a wider range of egg-laying conditions and ensure that not all of the eggs are in 'one basket'. Mass mortality of eggs may occur due to the weather (especially if it is very hot and dry), predation, severe disturbance of the site, or due to disease, fungal infection or parasites. The impact of adverse factors may be reduced if eggs are spread over a number of egg-laying heaps. Locating several egg-laying sites in both full sun and partial shade can ensure that, whatever the weather over the course of the incubation period, some eggs should hatch.

Individual females tend to return to the same egg-laying site year after year. Therefore, new heaps are best located close to existing, used ones, or at least in high quality habitat where grass snakes are known to pass through.

Egg-laying heaps must be sited in sun or partial sun. If the surrounding scrub or tree cover grows up and creates substantial shading, it should be cut back. Heaps should also be connected to vegetation that provides secure cover for adult and hatchling snakes moving to or from the site. Decomposing vegetation causes local soil enrichment, so egg-laying heaps should be constructed in locations within sites where this will not create a problem.

Covering, or partially covering, a heap with a tarpaulin, or similar, weighted down to keep it in place, may help to retain heat and humidity. Such covers can also be useful in monitoring the egg-laying site. Lifting the cover may reveal a gravid female or, later, hatchlings (which measure around 17 cm long); snakes spend some time around the heap prior to egg-laying and hatchlings do not all disperse immediately. Pieces of discarded carpet or corrugated iron have also been used to the same effect. These covers should extend to the base of the heap to allow easy access to grass snakes.

Covering, or partially covering, a heap with a tarpaulin, or similar may help to retain heat and humidity (ARC)

It can take several years for grass snakes to start laying eggs in a newly created heap. To check if a heap is being used, site managers can either check around the heap in late August and September for hatchlings, or carefully dismantle the heap in October to check for egg shells, before reconstructing the heap.

Numerous, irregularly sized and shaped sand patches, scattered across sunny, south-facing heathland slopes, provide a range of egg-laying choices for sand lizards (Paul Edgar)

9.4. Sand lizard egg-laying sites

Sand lizards lay their eggs in bare, semi-compacted sand, or sandy gravels. Egg-laying sites must be;

- unshaded,
- close to dense vegetation cover (for the safety of both females and hatchlings),
- undisturbed during the incubation period.

Historically bare sand has been maintained by natural processes (e.g. disturbance by wild herbivores) and human activities (e.g. turf cutting and creation of footpaths, cart tracks etc.). Now it is a rare commodity on heathland.

Due to the scarcity of bare sand on many heathland sites, most sand lizards are forced to lay their eggs along tracks and paths. Although this source of exposed sand can be critically important, eggs here may be vulnerable to horses, mountain bikes, motorbikes and four-wheel-drive vehicles. A certain level of public access is useful in maintaining the open nature of paths across heathland. Seasonal closure to horses may reduce the risk of harm to sand lizard eggs.

Bare sand exposed by erosion on heathland can also be important for sand lizards. Care should be taken that this is not overgrown during heathland restoration programmes. Where practical, erosion features should be managed to maintain open areas.

Exposed sand of tracks can be an important egg-laying substrate, although eggs are at risk of harm from footpath traffic (Nick Moulton)

Where possible exposed sand should be managed and allowed to undergo succession from bare ground to full vegetation cover. Ideally, on heathland, new areas of bare sand should be created annually and should cover at least 5% of small sites, (a smaller proportion of larger sites may be acceptable). This is consistent with the mandatory 1-10% bare ground cover recommended within Common Standards Monitoring for lowland heath SSSIs (JNCC, 2004). Bare ground is not only vital for sand lizards but also valuable to more than half of the BAP species found on lowland heath (Webb, Drewitt and Measures, 2010).

Bare sand can be provided through the creation of fire-breaks (see *7.5. Fire control*) as long as care is taken to avoid forcing animals to cross exposed, closely-mown areas to reach the sand. Patches of sand can be created in the same way as fire-breaks, by mowing vegetation in winter and stripping topsoil and rotovating in late April to early May.

The following points should help to create good egg-laying sites for sand lizards:

- A minimum size of 1 m by 2 m is recommended.
- Only the edges of the sand patch, where lizards can remain near cover, are used for egg-laying. Hence, a long, narrow patch is far preferable to a large expanse of bare sand; long strips measuring tens of metres can work very effectively. For the same reason, several smaller patches are better than one large one,
- Sand patches should be located across a site, in sunny, south-facing areas.
- A sand patch may be flat or angled toward the sun.
- Sand patches should generally be within about 50 cm of mature heather or other suitable cover.
- Small sand patches can be dug by hand. Machinery, such as a rotovator or mini-digger, however, will be more practical on most sites.
- Sand should be dug annually preferably by digging new patches or, if that is not feasible, re-digging a third or a quarter of existing patches, to create a range of successional stages.
- Rotovation or digging should be carried out from late April to early May to avoid harming sand lizard eggs or hibernating reptiles.

Bare sand can be provided by the creation of fire-breaks. Here a sinuous strip has been dug into a mown fire-break (ARC)

Small sand patch. Note turves piled on northern side to create a sunny basking bank (Jim Foster)

10. Opportunities for Reptiles in Specific Land Use Regimes

This boundary bank is ideal reptile habitat in itself and provides connectivity between two otherwise separated, occupied habitat patches (Paul Edgar)

10.1. Farmland

Unfarmed corners can be managed to provide refuges for reptiles (Chris Gleed-Owen)

Most of lowland Britain comprises farmland. Cropped fields and improved pasture offer little habitat for reptiles, but hedgerows, ditches and ditch banks, stone walls, meadows, orchards, field margins, ponds and manure heaps can all provide habitat for the widespread reptiles and their prey.

The potential of linear features both to support wildlife and to create habitat networks can be exploited to the benefit of reptiles. South-facing banks and hedgerow edges and sunny field margins can be managed sympathetically for reptiles to provide linked habitat networks.

Hedgerows and field margins have the potential to form the type of habitat interface favoured by reptiles, effectively mimicking a woodland/grassland interface:

- Field margins should be managed as rough grassland or scrub.
- Grassland areas should be maintained by winter cutting every one to three years.
- Hedgerows or woodland should be allowed to develop soft edges through scrub growth.
- Scrub should be managed by the removal of individual bushes or bramble patches as required to maintain a scattered scrub habitat (a mix of rough grassland and scrub).

Environmental Stewardship options to benefit reptiles are given in the appendix.

Hedgerow and field boundary with little potential for reptiles (Tony Blunden)

Hedgerow and field margin (up to left of mown track) suitable for reptiles (John Baker)

10.2. Forestry

Historically, some prime reptile habitat (especially heathland) has been converted to forestry plantation. Reptiles often persist in these areas, which have great potential for them. Recent policy on *When to convert woods and forests to open habitat in England* (Forestry Commission, 2010), encourages open habitat creation when this would significantly benefit key species. This should improve the value of wooded areas for reptiles.

Reptiles can be found in large numbers on forestry re-stock sites before the crop matures to generate extensive shade (up to around 15 years, but probably with highest favourability at around five years). Clear-felled or thinned sites can also be of value to reptiles. Generally speaking, little active management of such areas is needed to improve conditions for reptiles. Any invasive ground works, such as scarification or brash-raking, need careful attention to avoid harming reptiles. It is best to undertake such tasks whilst the habitat is still in a poor state for reptiles, e.g. immediately after clear-felling, rather than waiting for a few years when the area may be colonised by reptiles.

Woodland edges and rides can provide excellent reptile habitat (Paul Edgar)

Due to the requirement for open, insolated sites, closed-canopy plantations provide limited opportunities for reptiles. In contrast, woodland edge can provide excellent habitat. Forestry rides can provide habitat in themselves and their potential to link habitat patches (such as glades, clearings or habitat beyond the plantation) should be considered.

The sunny side of a ride is the most useful to reptiles. Maintaining wide rides, or open borders on the sunny side of rides, can benefit reptiles. Narrow, shaded rides can be improved by removing shading trees. This also creates an effective fire-break with minimal loss of timber crop and increases the amenity value of the footpath, by creating open vistas.

Woodland ride widened to create reptile habitat (Jim Foster)

Human passage along woodland rides often maintains a footpath and keeps immediately bordering vegetation short. However, if vegetation overgrows a path, it can be kept open by annual, winter mowing. Ride edges should be mown on a longer interval, to allow a taller vegetation sward to develop, but to control scrub. Scrub should be managed so as to create a gradual transition between woodland and open ride.

Creating scalloped bays on the south side of a woodland block by felling small areas will increase useful edge habitat (Jim Foster)

In some areas windrows are created by forestry operations. Windrows comprise tree stumps, or other unwanted timber, bulldozed from felled areas to form long mounds of timber arisings mixed with soil and leaf litter. Windrows create excellent habitat features for reptiles and are often used as hibernation sites. Hence, they should be managed with reptiles in mind. Existing windrows should not be destroyed without checking for the presence of reptiles. Windrows being newly created, either through conventional forestry operations, or through habitat restoration projects, should be located with thought for reptile usage. A new windrow should:

- Be sited in a sunny location.
- Run in an east-west orientation, to provide a long, south-facing side.
- Be located away from areas of high public usage, such as footpaths.
- Be close to, or contiguous with, other reptile habitat.

10.3. Transport corridors

Land associated with roads, railways, canals and footpaths has great potential to create linear habitat for reptiles, linking other sites.

South-facing roadside embankments on well-drained soils can provide excellent reptile habitat. Within areas subject to routine maintenance, some vegetation cutting must be carried out as necessary for reasons of safety/visibility. However, other areas, subject to routine swathe cuts, should be mown only annually (minimum height of 15 cm), during winter, hence providing cover for reptiles and their prey during the active season.

This road verge in the New Forest, where vegetation has been allowed to create a structurally diverse habitat on a sunny bank, is ideal for reptiles (Jim Foster)

Outside areas subject to the above routine maintenance:

- Vegetation should be allowed to create structurally diverse habitat.
- Tree planting, for screening purposes, should be confined to the top of embankments, leaving the rest of the area as either scattered scrub or grassland.
- Tree planting and management should aim to provide scalloped edges to plantations, creating sheltered bays of warm microhabitat.
- Plantation edges should be managed to create gradual transitional zones between woodland and open grassland.
- Bays created by scalloping should be managed as grassland (cut on one- to three-year cycles) or scattered scrub (selected patches cut periodically).

Canal towpaths and their immediate borders require frequent maintenance mowing. However, beyond 0.5 m from the path herbaceous vegetation can be allowed to create tall swards. On the nearside of the path this can provide cover for grass snakes (and water voles) at the water's edge. On the offside, where space allows, small meadows can be maintained with transitional zones into bordering hedges. The herbaceous vegetation should be maintained by annual winter mowing to a sward height of 5-10 cm, and then left to grow.

A tall grass sward and the windbreak created by the screening scrub/trees provide habitat for large numbers of viviparous lizards (John Baker)

The *Cotoneaster* planting scheme on this road verge offers very little scope for reptiles to find the variation in vegetation structure they require for thermoregulation (Jim Foster)

Herbaceous vegetation along the towpath of Birmingham and Fazeley Canal, cut annually in winter, provides cover for grass snakes at the water's edge and creates a useful transitional zone along the hedgerow (Paul Wilkinson)

10.4. Golf courses

In general, management of roughs as grassland and scrub will meet the needs of reptiles. Grassland should be cut on an annual basis during the winter (less often in some areas to allow tussocks formation) and areas of scattered scrub should be allowed to develop.

At Royal Birkdale and Hesketh Golf Club courses, habitat creation measures have been taken to benefit sand lizards. Bare sand, essential for egg-laying (see *9.4 Sand lizard egg-laying sites*) but sometimes absent from golf course roughs has been incorporated by the strategic placement of sand piles. South-facing dune banks provide habitat within the golf courses and sand patches are maintained within these. When sand has been moved during course improvements, it has been used to benefit sand lizards by strategic creation of new habitat patches, linking occupied areas within the golf courses and creating linkage with sand lizard populations outside the course boundaries.

Course modifications created this marram grass covered bank, linking sand lizard habitat on Royal Birkdale Golf Course with a neighbouring SSSI (John Newton)

A mosaic of bare sand and vegetation cover provides sand lizard habitat within the rough of Hesketh Golf Course (John Newton)

10.5. Gardens and allotments

All native reptiles have been found in gardens and in some areas these are now an important habitat for them. The species most likely to be found here are the slow-worm and grass snake. The widely-ranging grass snake is more likely to be a garden visitor than a resident. Grass snakes are especially attracted to garden ponds which provide them with amphibian and fish prey, and they may also use compost heaps as egg-laying sites.

Grass snakes are attracted to garden ponds to feed on amphibians and fish (Tony Phelps)

A key factor in determining whether reptiles use a particular garden is its proximity to other reptile habitat. Reptiles may colonise gardens adjacent to external reptile territory, such as rough grassland, allotments, railway and road embankments or heathland.

Adopting wildlife gardening principles will generally benefit reptiles; for example, creating a wildflower meadow, growing native plant species and minimising use of chemical pesticides. However, there are other, specific features of gardens that can be of benefit to reptiles:

- A diverse vegetation structure can provide a mix of insolated basking sites and nearby cover.
- Rockeries can provide good habitat for reptiles; the rocks and low-growing mats of vegetation provide cover and basking sites.
- Compost heaps or bins are invaluable to reptiles, especially grass snakes and slow-worms. The compost heap should be in a sunny location. The larger the heap the better. Having two heaps/bins allows slow-worms to be transferred from one heap to another as matured compost is removed.

Compost heaps can be attractive to slow-worms and provide grass snakes with egg-laying sites (Jim Foster)

To help reptiles in gardens:

- Create a wildlife pond, to attract amphibians, which are the prey of the grass snake.
- Allow areas of lawn to grow long to provide cover, for example along the sunny base of a hedge.
- Create log or brash piles to act as refuges.
- Do not disturb compost heaps used as grass snake egg-laying sites from June to September, or during the winter.
- If space allows, place reptile survey refuges in sunny locations. Reptile refuges are described in the section *13. Survey and Monitoring*. In the garden, roofing slates or paving slabs provide visually less intrusive refuges than those commonly used in surveys.
- Garden netting should be used with care, or avoided. Stretching netting over a log pile or rockery may help common lizards to escape from cat predation. However, the mesh of any netting should be larger than four cm, and kept taught, as snakes can become fatally entangled in smaller gauge netting.

More information can be found in the booklets *Reptiles in Your Garden* (Natural England) and *Dragons in Your Garden* (Amphibian and Reptile Conservation).

Allotments often support reptiles and hence in developed areas these may be key reptile sites. Some of the features of allotments, which are warm, sunny sites, often supporting numerous compost heaps, sheets of corrugated iron, plastic sheeting and debris, make them attractive to reptiles. If an allotment is adjacent to a reptile habitat corridor, such as a railway line or river, then this increases the likelihood that it will support reptiles.

Even small areas within allotments managed sympathetically can enhance a site for reptiles. The following steps may be beneficial:

- Set aside areas for wildlife, rather than cultivation. These are best sited at the edges of the allotment.
- Monitor compost heaps to check for the presence of reptiles.
- Leave heaps used as grass snake egg-laying sites undisturbed (June to September).
- Create a pond on the allotment.

10.6. Churchyards

Churchyards are widely recognised as potential oases for wildlife within developed or rural areas. In general, they are relatively undisturbed sites and usually free of agro-chemical application. Subject to sympathetic management, they can provide habitat for a wide range of species, including reptiles. Reptiles may benefit from basking sites and refuges provided by gravestones, and they may thrive under wildlife management regimes already applied to some churchyards. However, some specific measures are particularly beneficial:

- Allowing some areas of grass to grow long will increase the cover available for reptiles and their prey.
- Long grass areas should be cut during the winter, when reptiles are inactive.
- Grass cuttings should be removed by raking and stacked to create a grass heap, which could provide additional habitat for slow-worms and a potential egg-laying site for grass snakes (see *9.3 Grass snake egg-laying heaps*).

Churchyard vegetation in a plot due to be cut (by hand scythe) over winter. The grassy sward supports ant-hills, which provide additional microhabitat diversity (John Baker)

Habitat management in churchyards should always be carried out with community consultation and care should be taken to respect the wishes of those visiting graves. In general, areas of tended graves should be managed more formally than less-frequented parts of the churchyard, which provide the greatest opportunity for wildlife-orientated management.

10.7. Utility sites

Sites such as water treatment works and electricity sub-stations often encompass areas of grassland, which are generally kept mown short. The potential of these relatively undisturbed sites to support wildlife is great but rarely exploited.

Grassland that is unlikely to be disturbed by future development within the utility site should be identified and demarcated for wildlife usage. This area, or areas, should then be managed as grassland or scattered scrub. Grassland should be cut during winter on a one- to three-year cycle and the cuttings raked and stacked to form a potential grass snake egg-laying site.

Reduction in the intensity of grassland management should result in cost savings to the site owners.

Vegetation management under power lines (wayleave clearance) is undertaken to ensure that trees do not come into contact with them. The maintenance of relatively open habitat can potentially be beneficial to reptiles. The management of such land should follow the principles set out earlier for grassland and scrub/tree management.

Wayleave clearance can also provide important wildlife corridors by linking habitats that would otherwise be fragmented by dense vegetative cover.

Wayleave clearance under power lines can create open habitats favourable to reptiles (Jim Foster)

11. Species Management

This handbook focuses on habitat measures, yet species management is sometimes needed for effective reptile conservation. Only an outline is given here: the issues and methods are more specialised than habitat measures, and are relevant to relatively few sites. For detailed advice, readers are invited to contact Amphibian and Reptile Conservation or statutory agencies.

11.1. Reintroductions

Reptiles are good candidates for reintroduction programmes. They have been lost from many isolated sites, where they have low chances of re-colonising because of their limited dispersal abilities. To regain their former range, then, it is often necessary to release animals into suitable areas. Reintroductions are not to be undertaken lightly, however. They need to be carefully planned, implemented and monitored. General principles are given by JNCC in *A Policy for Conservation Translocations of Species in Britain* (McClean, 2003). All reptile proposals should follow this guidance. They key points are that the reintroduction must be:

- Consistent with the conservation status of the species concerned.
- At a site where the species no longer occurs, but has conditions suitable for supporting a viable population, or is capable of being modified to such a state.
- At a site where the landowner is sympathetic to the reintroduction, and there are no serious foreseeable threats to the reptiles.
- Implemented using appropriate stock, taking into account disease, genetic and other important issues.
- Implemented such that there is minimal detrimental impact at both donor and release sites.
- Planned taking advice from the relevant statutory agency and specialist groups at the local and national levels.

Reintroductions have been carried out very successfully for sand lizards in Britain, with approximately 50 populations established through releases of captive-bred stock. This has helped re-establish the range of the sand lizard, a species lost from many areas over the last century. A smaller number of smooth snake reintroductions have also been done, with good indications of success. These have used translocated wild-caught snakes. Further reintroductions, managed by Amphibian and Reptile Conservation, are planned.

There have been relatively few reintroductions for the widespread species. These have often not closely followed good practice, or been well monitored, so it is difficult to assess their effectiveness. However, reports from several projects indicate that populations have been successfully established by translocating wild lizards and snakes.

There is some potential for further reptile reintroductions in the UK, where natural colonisation is unlikely, especially for the widespread species. Site managers looking after large, unoccupied but apparently suitable sites could consider a reintroduction. The first steps would be to look through the JNCC policy, to ensure that the proposal matches with guidance, and to speak to local and national specialist organisations, and the relevant government agency.

The sand lizard reintroduction programme, managed by Amphibian and Reptile Conservation, involves releases at a schedule of carefully selected sites. At the time of writing, the captive rearing programme has no further need to expand, as the level of reintroductions largely matches habitat availability.

11.2. Reinforcement and genetic management

Reinforcing declining populations, (adding individuals) is rarely advisable. If a population is in decline, more often than not there will be some factor, often related to habitat, that needs remedying. Adding further individuals will not normally rectify this. Indeed, it may mask the underlying problem.

Reinforcement is normally advisable only when a population has declined to a critically low level, and requires additional individuals to increase viability as a holding measure, while the underlying causes of decline are urgently addressed.

Small, isolated reptile populations may be at risk from genetic impoverishment. Over multiple generations, the combination of small population size and lack of gene flow from nearby populations can lead to inbreeding depression. It is not yet clear

whether this is a problem facing British reptiles, though there are some reasons to suspect it is. The best conservation response is to 'de-fragment' the population, so that there is exchange of animals (and hence genetic material) with nearby populations.

Where restoring population linkage is not feasible, it may be an option to translocate animals from another site into the population at risk. This practice has disadvantages, though, not least the risk of outbreeding depression. Before any translocation, there should be a firm assurance that inbreeding is a genuine problem. Genetic management is a very new practice, as yet largely untested in the UK. Given the degree of uncertainty in this subject area, it is not advised without careful investigation, and the statutory agency should be consulted for advice. A project has recently started to attempt genetic rescue for the natterjack toad, at a site in Lincolnshire. The results of such studies will help to assess whether it should become a more widespread tool.

11.3. Invasive reptile species management

Some non-native, invasive species pose threats to native animals. A range of non-native reptiles has been introduced to the UK, and their impacts are poorly understood. Such introductions are illegal and further releases are to be strongly condemned. The conservation response to invasive species releases depends on the circumstances. Whilst their presence is undesirable from a nature conservation perspective, it is not feasible to remove all non-native populations. The high priority candidates for removal are:

- Recent introductions, detected at the stage when there are still few animals present in a small area, and hence removal is straightforward.
- Introductions of species known or suspected to pose a high risk to native species, for example by competition or disease.

For queries about what to do in response to finding non-native species, site managers can contact Amphibian and Reptile Conservation or the statutory agency. The website alienencounters.org.uk gives further details, including identification advice.

The wall lizard *Podarcis muralis* is the most abundant non-native reptile established in Britain. Its impact on native lizards is not fully understood, but establishment of wall lizards at new sites should be discouraged and eradication considered where there may be threats to native lizards (Tracy Farrer)

12. Reptiles and People

12.1. Public access and reptiles

Public engagement with the natural environment is undoubtedly key to the success of wildlife conservation programmes. Public access to wildlife sites, however, can create considerable pressures on habitats and their resident species through legitimate and illegal activities (such as unauthorised motorbike scrambling, fly-tipping, arson and persecution of reptiles). A minority of dog-owners can be hostile towards adders (sometimes all snakes) due to the perceived risk of harm to their pets.

Arson is one of the most damaging aspects of illegal public pressure, especially on the urban fringe. Adequate wardening and the installation of fire-breaks are essential (Paul Edgar)

Dogs running loose can cause serious disturbance of reptiles (especially snakes) and ground-nesting birds. They also have adverse impacts on vegetation through fouling.

Not surprisingly, the heaviest impacts on reptiles and their habitats are seen in urban and urban fringe areas, where disturbance can be almost continual. Occasionally, the impacts can be so great that reptile populations decline. In general, however, reptiles are not as severely affected by public access as are, for example, ground nesting birds.

12.2. Reducing negative impacts

On sites heavily used by people, routing of walkers, horse riders and mountain bikes can prevent damage to sensitive habitats and species. Similarly, the careful siting of access infrastructure (tracks, paths, boardwalks, car parks, picnic areas, fencing etc.) can concentrate access to selected areas while minimising impacts on more sensitive habitat.

Fencing to control erosion of sand dunes. Control of public access can prevent damage to sensitive habitats and help reptiles to survive in areas otherwise subject to high visitor pressure (Helen Demopoulos)

Local education and public engagement programmes are also valuable. Presentations to community groups and schools and guided walks can help increase understanding and appreciation of local reptile populations and their habitats. The recruitment of local volunteers as site wardens can assist professional wardening.

Information board on an urban fringe reserve managed by Amphibian and Reptile Conservation. Keeping local people informed and involving communities in conservation activities can greatly reduce the adverse impacts of public access (Paul Edgar)

12.3. Managing people, pet and livestock conflicts with adders

Although adder bites are potentially life-threatening, they are thankfully very rare. It is important that the public is provided with accurate information regarding the risks posed by adders. About 50-100 cases of adder bites on humans are reported each year by British hospitals. Most bites are caused by attempts to pick up adders, far fewer by accidentally placing a hand or foot on one. Typically, around half of adder bites result in no effects or only minor symptoms, about one third moderate, and the remainder severe.

Treatment of adder bite is now well understood and most bitten persons make a full recovery. Deaths and long-term disability resulting from adder bite are rare. In Britain, there have been 12 human deaths attributed to adder bite since 1900, the last being in 1975. However, the effects of adder bite should not be trivialised. Any adder bite, even if no obvious symptoms are apparent, should be treated as medically serious. A bitten person should be rapidly transported to an accident and emergency department where medically qualified assessments can be made.

Bites to dogs occur most frequently when they paw or sniff at adders encountered on walks. An advisory note for dog walkers, *Dogs 'n' Adders*, can be obtained from Amphibian and Reptile Conservation. Vets in areas where adders are common are often experienced in treating bites, and it is rare for bitten dogs to die. However, adder bites may cause considerable suffering to pets and there are occasional fatalities; once again the effect of a bite should not be downplayed. Confirmed cases of adder bites on farm livestock are extremely rare, and serious effects appear to be similarly uncommon. Any bites to pets or livestock should be referred to a vet as soon as possible.

Bites to dogs occur most frequently when they paw or sniff at adders encountered on walks (Tony Phelps)

12.4. Responses to adder conflicts

Adders have a poor public image in some quarters, and media stories often exaggerate threats to people, pets or livestock. However, on closer inspection many claims turn out to be groundless or minor in nature, so it is important to establish whether there is indeed a real conflict. The first step is to establish whether adders are genuinely involved. Many reports of adders are in fact misidentifications of grass snakes or even slow-worms. It is also worth noting that harm to people, pets and livestock is sometimes wrongly attributed to adder bite, even by medical and veterinary professionals. Various other bites, stings, puncture wounds and allergic reactions can cause symptoms that resemble adder envenomation.

Adders usually have a well-defined local distribution so information from local experts can often be helpful when investigating perceived conflicts (See *14. Sources of Information and Advice*). If the presence of adders is confirmed, the next step, again, is to establish whether there is indeed a genuine conflict, and how serious this is. The likelihood of harm may be very low. Adders occur in many countryside areas frequented by large numbers of visitors and yet bites are extremely rare.

Carefully worded information on site signboards, indoor display panels and leaflets can be extremely useful. Signs that say *Beware adders* or similar should be avoided because they can perpetuate unfounded fears and may even encourage persecution. Wording such as the following may engender a more positive attitude, while still providing useful information: *We are proud to have adders on this site. Adders are becoming rarer in some areas. They are a natural and important part of our wildlife. Adders are timid and will not try to bite unless they feel threatened, and even then they normally try to hide. Please keep to paths, keep dogs on a lead and do not try to handle the adders.*

In some cases *Beware adders* signs are erected irrespective of adder presence, presumably to deter public access. Such practice should be strongly discouraged as it is detrimental to reptile conservation. Interpretation material should not point out exact adder locations within a site, in case the information is misused by those intent on harming the snakes.

In some instances it can be helpful to engage in local publicity to engender a more positive image for adders and especially to counter negative reporting. Local media are often fascinated by reptile stories

and there is ample opportunity to correct common misconceptions. Great care must be exercised, however, to encourage coverage that is genuinely positive, as sensationalist 'killer snake' stories are unhelpful.

Reducing the risk of human or dog and adder interactions can also be achieved by the management of public access to sites, as described earlier to minimise impacts on sensitive areas. Adder hibernation sites or aggregation areas can be identified by spring time visual surveys and public access discouraged from these areas.

In exceptional situations, exclusion of adders from specific areas may be required due to a high risk of bites. This should be pursued only if there is a demonstrable high risk, for example following repeated bites or near-miss incidents. If such areas fall within regularly used habitat, this is very difficult to achieve in practice. There are several options to pursue, but all of them have drawbacks:

- Installation of barriers.
- Negative habitat management.
- Capture and removal.

The installation of barriers is most practical where materials can be fixed to an existing fence or other boundary structure, otherwise a whole new barrier (such as a wall) could be constructed. Note that the barrier must be tightly flush with, or buried in, the ground, so that adders cannot squeeze underneath. Barrier materials include plastic sheeting and overlapping corrugated iron sheets.

However, to be completely impermeable to snakes, a barrier has to be carefully constructed and maintained. In practice, it is often unfeasible to guarantee total exclusion by barriers except within certain confined areas.

The most practical option is negative habitat management. Adders can be dissuaded from using certain areas by reducing the habitat quality. This may entail: keeping grass cut extremely short (< 5 cm), removing scrub such as gorse and bramble, and removing shelter materials such as wood and debris. This type of approach cannot guarantee complete exclusion, rather it aims to substantially reduce the frequency of use by adders. Experience shows this technique works very well. It may be an option, for example, if there were repeated bites in a car park immediately adjacent to a favoured bank; adders could be persuaded to use that area less through negative management. Unfortunately, such negative habitat management is likely to reduce the value of the site for other wildlife too. Compensatory positive management should be done elsewhere on site to offset the damage.

Capture and removal of adders should be undertaken only as a last resort. It is often a sensible option only when an individual is 'stranded' in an area away from its usual range, where it poses a risk to people (or indeed, vice versa). Translocation may be disorientating to the snakes moved and it is likely to be only a superficial solution to a situation – it does not guarantee that no further adders will move into a particular area.

If removal is necessary it should be carried out by experienced persons. Snakes should be moved to the nearest core habitat area, from which they are most likely to have originated. Translocating adders away from their home range, or moving large numbers of adders, are to be avoided unless there are exceptional circumstances and these actions would not adversely affect local conservation status.

13. Survey and Monitoring

13.1. Reptile surveys for habitat management

Reptile survey is a key step in management planning and assessment. For the site manager, the most common objectives for a reptile survey are:

- To determine if a given species is present on site.
- To establish which areas of a site are currently of high value for reptiles.
- To assess the impacts of habitat management, by monitoring reptile habitat use, breeding success, population size, and/or habitat condition.
- To produce recommendations on the potential for expanding or linking reptile populations.
- To assess the suitability of a site to support a (re-) introduced reptile population.
- To assess the impact of potentially negative factors such as arson or disturbance.

Detailed methods for reptile survey are given in full in other publications (Foster and Gent, 1996; Gent and Gibson, 1998; Froglife, 1999), and only a brief guide is given here. The methods necessary will obviously depend on the survey objective.

13.2. Reptile survey methods

The two most frequently used methods are visual searches and refuge surveys, which are most effective when used in combination. Visual searches (sometimes called 'visual encounter surveys') require inspecting likely habitat (see *4. Habitat Requirements*) under suitable weather conditions. The most effective time to search is when reptiles are basking. Reptiles bask between air temperatures of approximately 10-20ºC, but there are complex variations due to species, season, age and habitat. For example, viviparous lizards and adders are commonly observed at lower temperatures than grass snakes, sometimes less than 10ºC in early spring. Adult grass snakes are more frequently found than juveniles by visual searches.

Visual searches are most effective in the early spring, shortly after emergence from hibernation. At this time vegetation cover is minimal and reptiles spend a lot of time basking in preparation for breeding. Spring time visual surveys are an excellent means of locating communal hibernation sites. At other times of the year they are useful only for the legged lizards. Smooth snakes and slow-worms are invariably only found under refuges, so visual searches are almost worthless for these species.

Refuge surveys exploit the reptilian attraction to warm microhabitats created under objects lying on the ground, heated by the sun. Objects specifically placed to attract reptiles for survey purposes are commonly referred to as survey refuges or cover objects. Materials vary in their effectiveness and practicality (see table below).

Checking under a sheet of weathered corrugated iron during a refuge survey (Peter Stafford)

Summary of advantages/disadvantages of commonly used refuge materials

Refuge material	Advantages	Disadvantages
Corrugated Iron	Very attractive to reptiles Discarded sheets sometimes available	Heavy Difficult to cut to size Risk of injury from sharp edges
Roofing felt	Cheap Easily cut to size Portable	Not always effective for snakes Not very durable Eaten by livestock
Coroline/Onduline	Attractive to reptiles Light	Available in limited sizes Difficult to cut to size

Opposite: Slow-worms under roofing felt (ARC)

Corrugated iron or 'tin' (rusty seems better than new) and roofing felt are commonly used by reptile surveyors. Corrugated bitumen-based roofing sheets (Coroline or Onduline) have been used recently and show some promise. Wooden boards, carpet tiles and rubber floor mats from cars have also been used. The differing thermal properties of the refuge materials affect their attractiveness to reptiles. Relative attractiveness seems to alter under differing environmental conditions. For example, corrugated iron generally tends to be more attractive than roofing felt – yet at the tail end of the survey season, when the sun is lower in the sky, roofing felt seems to retain heat more readily than corrugated iron and hence attracts more reptiles. It is clear from research that corrugated iron is more attractive than roofing felt to snakes, though for most management purposes the difference may not be critical.

Larger refuges tend to attract more reptiles than small ones, so use the largest size that is practical to handle and which can be rapidly searched under when lifted. Care should be exercised on adder sites as surveyors have been bitten when lifting refuges.

Refuges should be placed at locations likely to be used by reptiles, for example in tussocky grassland, or along the base of a sunny hedgerow. They are best placed by pressing them down on to herbaceous vegetation, which allows a greater range of microclimate and humidity to be created underneath than if the refuge were placed on bare ground, for example.

Reptiles may find refuges very quickly on sites with high population densities. There is some evidence that refuges are more attractive to reptiles if they are left to 'bed in' for several weeks. At low population densities, it can take weeks or months for animals to start using refuges.

The use of refuges on sites prone to public disturbance requires caution. Reptiles under refuges may be more prone to collection by, or harm from, other site users. Further, sharp-edged corrugated iron refuges can pose a danger to livestock, dogs or people and must either be sited appropriately, or safer alternatives used.

On some sites a surveyor may be able to use refuges already in place, such as fallen road signs on verges or discarded corrugated iron on farmland or other discarded material almost anywhere.

Other survey methods include searching for grass snake eggs (see *9.3 Grass snake egg-laying heaps*), and searching for sand lizard egg (or test) burrows. The latter requires considerable experience and has a very limited window of opportunity. The shed skins (sloughs) of reptiles are sometimes found during surveys. The scale patterns and pigmentation can be used to identify species (e.g. see Inns, 2009).

Locations are best recorded using a global positioning system (GPS) unit. GPS units can also be useful for recording the locations of the refuges themselves on sites where seasonal vegetation growth can make it difficult to relocate them. Additional survey information that may be useful includes:

- Date.
- Time.
- Weather conditions.
- Reptile behaviour.
- Habitat and microhabitat.

Refuges can attract other, non-reptilian, species of conservation interest, for example glow-worm larvae and water shrews.

GPS data can be plotted on large-scale maps and aerial photographs using a geographic information system (GIS). The resulting maps can be used in planning habitat management (see *5. Principles and Planning*).

Reptiles can be difficult to find, so lack of detection during a survey visit does not necessarily imply their absence. Repeated visits (seven or so is recommended for most site management purposes) are needed to be fairly sure that lack of detection equates to absence. However, the effort required varies in a complex way, depending largely on population size and habitat type. A small population of smooth snakes, for example, can take tens of visits over months or even years to detect. Adders and grass snakes may use a particular area for only part of the year, so to evaluate site use by these species, survey visits should be spread over the course of the reptiles' active season. A very high level of effort to conclude absence would be needed if there were a proposal to reintroduce, since it would be most unwise to release animals into an existing population.

13.3. Monitoring reptile populations

Ideally, reptile population size at a site would be used to determine the conservation status of species and changes therein could be tracked over time. Unfortunately, there are no reliable means of relating the numbers of animals recorded in typical surveys to actual population size. The most reliable method of estimating population size is a capture-mark-recapture (CMR) study. This method suffers from the drawback that it can be time consuming, especially on larger sites, or when multiple sites are being monitored. It also requires repeated disturbance.

Hence, counts of reptiles seen during repeatable surveys (e.g. walking a defined transect in a set time, and/or comparing captures per refuge set) are often the best option for site managers. Results can be expressed as encounter rates (number of animals observed per hour, or per visit if this is standardised). This can provide a population index for a particular site that may allow trends to be tracked over time.

Interpreting trends in counts is further complicated by the fact that changes in habitat often alter reptile detectability (effectively, how easy it is to observe a reptile). A common example involves scrub clearance. This can render reptiles more visible shortly after the operation. As a result, survey counts can increase immediately following management. This increase in counts is probably not, however, due to any actual population increase. UK reptile populations generally do not fluctuate dramatically within one year (unlike with some amphibians, where this is common), as their reproductive biology does not allow this. Major differences in survey counts obtained over a space of months or low numbers of years are more likely due to differences in detectability. This could, in turn, be due to habitat management making snakes more visible, or perhaps because a survey was done in more favourable weather conditions. Similarly, lower counts need not necessarily indicate a declining population; they may occur simply because the animals are less easy to locate, or because they have moved outside the survey area. Hence, count data should be interpreted cautiously, using all contextual information, and ideally collected over at least five years to allow proper assessment.

CMR studies remove the problems associated with detectability, but are more labour intensive. A useful addition to count surveys is to record the presence of breeding. This can be based on finding neonates or hatchlings in late summer, and (for sand lizard) egg burrows in late spring.

13.4. Monitoring reptile habitats

In addition to studying the reptile populations themselves, it is also recommended to monitor the extent and condition of their habitats. This is particularly useful for informing management decisions as it highlights key reptile areas and other important features, such as hibernacula, that are not always obvious on the ground.

The crucial point here is that monitoring should relate to management objectives. So, for instance, monitoring may record progress towards creating a mosaic of uneven-aged swards, or a rough grass margin around a pond.

Mapping reptile habitats and potential habitats with GIS is invaluable, especially since they may change over time due to management, succession and events such as fires. Fixed point photography, taken in the same season each year, can be extremely valuable. It is also important to determine the value of these areas in a wider context and this will facilitate landscape scale management. An experienced reptile surveyor can identify areas of potential habitat, based on factors such as geology, aspect, vegetation type and historical records.

13.5. National survey projects

Several schemes are now underway in Britain that will add enormously to our knowledge of reptile distribution, conservation status, habitat use and management requirements. The National Amphibian and Reptile Recording Scheme (NARRS) is an umbrella for various monitoring projects (see *14. Sources of Information and Advice* for more details). Site managers are encouraged to contribute to relevant projects.

14. Sources of Information and Advice

Add an Adder
National adder survey run by Amphibian and Reptile Conservation.
www.adder.org.uk

Amphibian and Reptile Conservation
The non-governmental organisation dedicated to amphibian and reptile conservation, which manages more than 80 reserves, oversees all UK herpetological Species Action Plans and is involved in national and European level policy work. ARC has over twenty years of experience of reptile habitat management.
www.arc-trust.org

ARG UK
Umbrella organisation for the Amphibian and Reptile Groups of the UK. There are groups in most parts of Britain and new members are always welcome. ARGs carry out many valuable surveys and monitoring activities. Site managers are encouraged to forge links with their local ARG, as this will be mutually beneficial. ARG members may be able to assist with surveys, and practical management. ARG members are especially valued for providing a local and historical context for site management.
www.arguk.org

Biodiversity Action Reporting System
Planning and reporting for the UK Biodiversity Action Plan.
www.ukbap-reporting.org.uk/default.asp

British Herpetological Society
One of the oldest and foremost herpetological societies in the world; has scientific, conservation, captive breeding and education committees.
www.thebhs.org

BTCV Practical Conservation Online
Online advice from the British Trust for Conservation Volunteers.
handbooks.btcv.org.uk/handbooks/index

Buglife
National invertebrate conservation charity, gives useful advice on habitat management, much of which is compatible with reptile conservation.
www.buglife.org.uk

Conservation Evidence
Website aimed at sharing practical knowledge and evidence about conservation interventions, including habitat management.
www.conservationevidence.com/index.shtm

Countryside Council for Wales
Provides policy and guidance on nature conservation in Wales.
www.ccw.gov.uk

Defra
Department for Environment, Food and Rural Affairs. Strategic policy on nature conservation.
www.defra.gov.uk

Environmental Stewardship
Natural England website giving advice on habitat management funding options and application procedures for the various Environmental Stewardship schemes.
www.naturalengland.org.uk/ourwork/farming/funding/es

Farming and Wildlife Advisory Group
Practical management advice for farmers.
www.fwag.org.uk

Froglife
Amphibian and reptile charity with a strong emphasis on people involvement.
www.froglife.org

Habitats and Species Directive
European Union directive concerning conservation. Its main aim is to achieve and maintain 'favourable conservation status' for all habitats and species identified as being of community concern.
www.europa.eu.int

Herefordshire Amphibian and Reptile Team
Part of the ARG UK network, HART has run an education and survey project *What's That Snake?* in partnership with the Herefordshire Nature Trust, aimed at raising awareness of native reptiles and training volunteers to take part in surveys.
www.herefordhart.org

Joint Nature Conservation Committee
Statutory advisor to the Government on UK and international nature conservation issues.
www.jncc.gov.uk

Opposite: Male adders in combat (Tony Blunden)

Learning Through Landscapes
Charity aimed at improving school grounds for nature conservation and increasing educational awareness.
www.ltl.org.uk

NARRS
The National Amphibian and Reptile Recording Scheme run by Amphibian and Reptile Conservation.
www.narrs.org.uk

National Biodiversity Network Gateway
Interactive distribution maps and wildlife data for Britain.
data.nbn.org.uk

National Trust
One of the largest landowners in Britain, manages many areas important for nature conservation, including some excellent reptile sites.
www.nationaltrust.org.uk

Natural England
Government agency dealing with nature conservation in England. Guidance, research, site protection and regulation affecting reptiles.
www.naturalengland.org.uk

Pond Conservation
Pond and wetland conservation body.
www.pondconservation.org.uk

RAUK
Reptiles and Amphibians of the UK. An internet discussion forum that focuses on native British species and their conservation.
www.herpetofauna.co.uk/forum

Royal Society for the Protection of Birds
Manages large areas of reptile habitat. Website contains plenty of useful habitat management advice.
www.rspb.org.uk

Scottish Natural Heritage
Provides policy and guidance on nature conservation in Scotland.
www.snh.org.uk

The Wildlife Trusts
Umbrella body for the county Wildlife Trust network.
www.wildlifetrusts.org

UKBAP
Website for the UK Biodiversity Action Plan, including individual species and habitat action plans.
www.ukbap.org.uk

UK Statute Law Database
A consolidated, hyperlinked, searchable database of UK legislation.
www.statutelaw.gov.uk

The Herpetofauna Workers' Meeting provides a good opportunity to learn more about reptiles and their conservation (Paul Edgar)

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Appendix: Environmental Stewardship Options

This appendix summarises the options available in Environmental Stewardship (the main agri-environment scheme in England) that may directly, or indirectly, benefit reptiles. Similar options may be available under schemes in other countries of the UK. Natural England's website on Environmental Stewardship provides guidance and handbooks, which include payment rates and application procedures **www.naturalengland.org.uk/ourwork/farming/funding/es**

Environmental Stewardship Following the last EU reform of the Common Agricultural Policy, a range of farm subsidies was simplified into the Single Payment Scheme. This pays eligible farmers and land managers for complying (through what is known as cross compliance) with certain environmental standards. Environmental Stewardship is in addition to this basic support. Older schemes, such as the Environmentally Sensitive Areas (ESA) scheme and the Countryside Stewardship Scheme (CSS), are still running their course, but are no longer open to new applicants. Environmental Stewardship has two main strands: Entry and Higher Level.

Entry Level Stewardship (ELS) ELS is a five-year agreement involving basic work to improve the general environment on farms and can provide many benefits for reptiles in the wider countryside. ELS is divided into:

- Entry Level Stewardship (ELS).
- Organic Entry Level Stewardship (OELS).

Most farms enter either ELS or OELS, but both can also be located on the same farm. Where land occurs in Severely Disadvantaged Areas, both types of agreement can also include Uplands Entry Level Stewardship (UELS) elements. UELS may cover part of a holding or the entire farm.

A minimum points target must be met to qualify for ELS. This target is based on the size of the farm, with a certain number of points/ha being required. This points total then determines an annual payment. Basic ELS applicants currently need 30 points per ha. For example, a 100 ha farm would have a target of 3000 points; if achieved or exceeded, the annual payment would be £3000 per year for five years. The OELS requirement is 62 points/ha, while the target ranges from 8 to 92 points/ha for UELS agreements. Applicants select from a wide range of point-scoring management options (e.g. hedgerow maintenance, taking field corners out of production, etc). Selection of entry level options is facilitated by a Farm Environment Record (FER), a simple survey map that indicates all features of environmental interest, such as hedges, woods, ponds, etc. All farms that meet certain basic requirements are guaranteed an ELS agreement.

Higher Level Stewardship (HLS) HLS is run for Defra by Natural England and involves much more targeted and specific options, many of which are absolutely crucial for the conservation of reptiles and their habitats. For example, the main funding mechanism for the vast majority of lowland heathland management in England is now HLS. HLS agreements may be:

- Combined with ELS or OELS agreements, either of which may also include UELS elements. In this situation, there is still a requirement to meet the ELS points target. Once this has been achieved a range of more specific HLS options can then be selected.
- Stand alone HLS agreements, generally for land of high environmental value where it would not otherwise be possible to gain any entry level points. Most lowland heathland is entered into HLS by means of this type of agreement.

HLS options involve straight payments per unit of measurement, e.g. £ per ha or £ per m and many are available only under this scheme. Some entry level options may also be used in HLS, in which case they become paid options too. Unlike ELS, a range of capital works is available under the HLS scheme. HLS options and capital items are linked to 'features' on the holding, which are all recorded on a Farm Environment Plan (FEP). The FEP includes a detailed spreadsheet for recording relevant features, plus maps to show their location, along with a range of background information about historical features and farming practices. The specific features that need to be recorded are grouped into 12 categories, with various sub-groups, all of which are listed in Natural England's FEP manual.

HLS is a competitive, ten-year scheme and entry depends on meeting certain criteria that are summarised in regional targeting statements and theme statements available on Natural England's website. Rare species and habitats, such as sand lizards and lowland heathland are among the specific features targeted. The HLS options selected

will be governed by the features identified in the FEP. Natural England advisors produce prescriptions for HLS options, and capital works, and these list the actions to be undertaken by the agreement holder. Where appropriate, relevant prescriptions can be specifically tailored to reptile conservation, but a wide range of general Environmental Stewardship options may also benefit reptiles.

Environmental Stewardship options that may benefit reptiles Note that the details below are subject to change by Defra as the scheme develops. A range of additional capital items that may be relevant to reptile habitat management are also available under HLS. All options have a general group code (e.g. B1, C25, etc) and, depending on the scheme they apply to, they will also have one or more of the prefixes below.

ELS prefixes (used to earn points toward the minimum entry level points target):
E = entry level
O = organic entry level
U = uplands entry level
UO = organic uplands entry level

HLS prefixes (paid per unit of measurement, e.g. £ per ha or £ per m):
H = higher level
OH = organic higher level
UH = Uplands higher level
UOH = organic uplands higher level

B Boundaries
EB1/EB2 or OB1/OB2: Hedgerow management on both sides/one side.
EB3 or OB3: Enhanced hedgerow management.
EB4/EB5, OB4/OB5, UB4/UB5 or UOB4/UOB5: Stone-faced hedge bank management on both sides/one side.
EB6/EB7 or OB6/OB7: Ditch/half ditch management.
EB8-EB10 or OB8-OB10: Combined hedge and ditch management options.
EB11, OB11, UB11 or UOB11: Stone wall protection and maintenance.
EB12/EB13, OB12/OB13, UB12/13 or UOB12/UOB13: Earth bank management on both sides/one side.
UB14 or UOB14: Hedgerow restoration.
UB15 or UOB15: Stone-faced hedge bank restoration.
UB16 or UOB16: Earth bank restoration.
UB17 or UOB17: Stone wall restoration.
HB11/12: Management of hedgerows of very high environmental value on both sides/one side.
HB14: Management of ditches of very high environmental value.

HLS requires adequate surveys. This seemingly average hedge bank is, actually, of historic importance and supports excellent adder and common lizard populations. It was therefore recorded as a high environmental value boundary in the FEP (Paul Edgar)

C Trees and woodland
EC4, OC4, HC4 or OHC4: Management of woodland edges.
EC24, OC24, HC25 or OHC24: Hedgerow tree buffer strips on cultivated or rotational land.
EC25, OC25, HC25 or OHC25: Hedgerow tree buffer strips on grassland or organic grassland.
UC5 or UOC5: Sheep fencing around small woodlands.
UC22, UOC22, UHC22 or UOHC22: Woodland livestock exclusion.
HC7/HC8: Maintenance/restoration of woodland.
HC9/HC10: Creation of woodland in/outside Severely Disadvantaged Areas.
HC11: Woodland livestock exclusion supplement.
HC12/HC13/HC14: Maintenance/restoration/creation of wood pasture and parkland.
HC15/HC16/HC17: Maintenance/restoration/creation of successional areas and scrub.
HC18: Maintenance of high-value traditional orchards.
HC19/HC20/HC21: Maintenance/restoration/creation of traditional orchards.

D Historic and landscape features
ED2, OD2, HD2 or OHD2: Take out of cultivation archaeological features currently on cultivated or rotational land.
ED4, OD4, HD4 or OHD4: Management of scrub on archaeological features.
ED5, OD5, HD4 or OHD5: Management of archaeological features on grassland or organic grassland.
HD7: Arable reversion by natural regeneration.
HD9: Maintenance of designed/engineered water bodies.
HD10/HD11: Maintenance/restoration of traditional water meadows.

E Buffer strips
EE1-EE3, OE1-OE3, HE1-HE3 or OHE1-OHE3: 2, 4 or 6 m buffer strips on cultivated or rotational land.
EE4-EE6, OE4-OE6, HE4-HE6 or OHE4-OHE6: 2, 4 or 6 m buffer strips on intensive or organic grassland.
EE7, OE7, HE7 or OHE7: Buffering in-field ponds in improved permanent grassland or organic grassland.
EE8, OE8, HE8 or OHE8: Buffering in-field ponds in arable or rotational land.
EE9 or OE9: 6 m buffer strips on cultivated or rotational land next to a watercourse.
EE10 or OE10: 6 m buffer strips on intensive or organic grassland next to a watercourse.
HE10: Floristically enhanced grass buffer strips (non-rotational).
HE11: Enhanced strips for target species on intensive grassland.

Well-sited Environmental Stewardship options have the potential to create excellent reptile habitat and link isolated populations. These arable buffer strips link other local reptile habitat (Paul Edgar)

F Arable land
EF1, OF1, HF1 or OHF1: Management of field corners.
EF2, OF2, HF2 or OHF2: Wild bird seed mixture.
EF4, OF4, HF4 or OHF4: Nectar flower mixture.
EF7, OF7, HF7 or OHF7: Beetle banks.
HF12: Enhanced wild bird seed mix plots (non-rotational plots are preferable for reptiles).

Other arable options, such as those for unfertilised/unharvested cereal headlands, uncropped areas on cultivated land or low input spring cereals, can provide indirect benefits to adjacent reptile populations by reducing chemical inputs and generally increasing prey species.

J Soil and water protection
EJ5, OJ5, HJ5 or OHJ5: In-field grass areas to prevent erosion and run-off.
EJ9, OJ9, HJ9 or OHJ9: 12 m buffer strips for watercourses on cultivated or rotational land.
EJ11, OJ11, HJ11 or OHJ11: Maintenance of watercourse fencing.
UJ3 or UOJ3: Post and wire fencing along watercourses.
UJ12, UOJ12, UHJ12 or UOHJ12: Winter livestock removal next to streams, rivers and lakes.
HJ3/HJ4: Arable reversion to grassland with low fertiliser input/unfertilised grassland to prevent erosion and run-off.
HJ8: Nil fertiliser supplement.

K Grassland outside the Severely Disadvantaged Areas (SDAs)
EK1, OK1, HK1 or OHK1: Take field corners out of management.
EK2/EK3, OK2/OK3, HK2/HK3 or OHK2/OHK3: Permanent grassland with low/very low inputs.
EK4, OK4, HK4 or OHK4: Management of rush pastures.
HK6/HK7/HK8: Maintenance/restoration/creation of species-rich, semi-natural grassland.
HK9/HK11/HK13: Maintenance/restoration/creation of wet grassland for breeding waders.
HK10/HK12/HK14: Maintenance/restoration/creation of wet grassland for wintering waders and wildfowl.
HK15/HK16/HK17: Maintenance/restoration/creation of grassland for target features.
HK19: Raised water levels supplement.

L Upland rough grassland and moorland inside the Severely Disadvantaged Areas (SDAs)
EL1, OL1, HL1 or OHL1: Take field corners out of management in SDAs.
EL2/EL3, OL2/OL3, HL2/HL3 or OHL2/OHL3: Permanent grassland with low/very low inputs in SDAs.
EL4, OL4, HL4 or OHL4: Management of rush pastures in SDAs.
EL5, OL5, HL5 or OHL5: Enclosed rough grazing.
EL6, OL6, HL6 or OHL6: Unenclosed moorland rough grazing.
UL17, UOL17, UHL17 or UOHL17: No supplementary feeding on moorland.
UL18, UOL18, UHL18 or UOHL18: Cattle grazing on upland grassland and moorland.
UL22, UOL22, UHL22 or UOHL22: Management of enclosed rough grazing for birds.
UL23, UOL23, UHL23 or UOHL23: Management of upland grassland for birds.
HL7/HL8: Maintenance/restoration of rough grazing for birds.
HL9/HL10/HL11: Maintenance/restoration/creation of moorland.

HL12: Supplement for management of heather, gorse and grass by burning, cutting or swiping.
HL13: Moorland re-wetting supplement.
HL15: Seasonal livestock exclusion supplement.

Environmental Stewardship options can fund reduced livestock densities on overgrazed moorland, thereby encouraging recovery of this habitat. Such support allows consideration of factors other than commercial pressures, such as biodiversity and flood control, while still allowing food production (Paul Edgar)

O Lowland heathland (HLS options only)
HO1/HO2: Maintenance/restoration of lowland heathland.
HO3: Restoration of forestry areas to lowland heathland.
HO4: Creation of lowland heathland from arable or improved grassland.
HO5: Creation of lowland heathland on worked mineral sites.

P Inter-tidal and coastal locations (HLS options only)
HP1/HP2: Maintenance/restoration of sand dunes.
HP3/HP4: Creation of coastal vegetated shingle and sand dunes on arable land/grassland.
HP5/HP6: Maintenance/restoration of coastal salt marsh.
HP10: Supplement for extensive grazing on salt marsh.
HP11: Salt marsh livestock exclusion supplement.

Q Wetland (HLS options only)
HQ1/HQ2: Maintenance of ponds of high wildlife value (less/more than 100m^2).
HQ3/HQ4/HQ5: Maintenance/restoration/creation of reedbeds.
HQ6/HQ7/HQ8: Maintenance/restoration/creation of fen.
HQ9/HQ10: Maintenance/restoration of lowland raised bog.
HQ11/HQ12: Wetland cutting/grazing supplements.

Additional HLS Supplements
HL16: Shepherding supplement.
HR1: Cattle grazing supplement.
HR2: Native breeds at risk grazing supplement.
HR4: Supplement for control of invasive plant species.
HR5: Bracken control supplement.

Reptile habitat in the farmyard. The restoration of traditional farm buildings through HLS is extremely valuable in historic and landscape terms, but such work still needs to take into account the legal protection afforded to any reptiles that may occupy adjacent areas (Paul Edgar)

Examples of how Environmental Stewardship can improve farmland for reptiles

Buffer strips on grassland can be valuable for reptiles. On pasture, buffer strips may need some protection from grazing (Paul Edgar)

Although targeted at farmland birds, this non-rotational bird seed mix plot on arable land still provides cover for reptiles (Paul Edgar)

Farmers can receive payments for awkward field corners that may be difficult to work but provide excellent habitat for a range of wildlife, including reptiles (Paul Edgar)

Stone walls can increase in value for reptiles and other wildlife as they age. Decisions about the restoration of such boundaries should take this into account (Paul Edgar)

Areas of the farm that may not be included in an Environmental Stewardship agreement, such as bordering this track, can still provide valuable habitat connectivity within the holding (Paul Edgar)

A good ELS or HLS agreement will examine the potential for linking habitats, such as this remnant chalk grassland, in the wider landscape (Paul Edgar)

Interface between woodland and reedbed supporting all four widespread reptile species (ARC)

amphibian and reptile conservation

Amphibian and Reptile Conservation

The Amphibian and Reptile Conservation (ARC) Trust (Registered Charity No 1130188) is the UK's leading non-governmental organisation dedicated to native herpetofauna (amphibians and reptiles). Formerly named The Herpetological Conservation Trust it benefits from the experience of that organisation, which was founded in 1989. ARC's work includes:

- Protecting key sites for herpetofauna
- Improving habitat through practical conservation management
- Furthering understanding of herpetofaunal ecology and conservation
- Promoting effective legislation, policy and action for conserving biodiversity
- Raising awareness

ARC owns or manages 80 nature reserves. It has pioneered habitat management techniques for reptiles (and amphibians) and is an active member of the Lowland Heathland Habitat Action Steering Group). ARC also provides advice, training and assistance to a variety of people, including major landowners, on all aspects of reptile conservation through formal courses, workshops, site visits and guided walks.

ARC works throughout the British Isles (including the Channel Islands) in partnership with other nature conservation organisations, government bodies and institutions. Its role in promoting and developing legislative and policy mechanisms for wildlife conservation extends its remit and influence into Europe and beyond. This is achieved, in particular, though a close working relationship with the European Herpetological Society (Societas Europaea Herpetologica) and participation in the European Habitats Forum. Hence, ARC influences conservation action for threatened amphibians and reptiles in Britain and abroad.

NATURAL ENGLAND

Natural England

Natural England is an independent public body whose purpose is to protect and improve England's natural environment and encourage people to enjoy and get involved in their surroundings. The work of Natural England includes designated areas, spatial planning, licensing, and support for sympathetic farming and land stewardship.

Through its key role in biodiversity, Natural England plays a major part in the conservation of England's reptiles. It designates special sites for reptiles, advises on habitat management, and looks after a range of important populations on National Nature Reserves. Natural England's regulatory advice aims to protect reptiles from harmful activities. It runs recovery projects and communications to raise the profile of reptiles. Much of this work is done in conjunction with partners such as Amphibian and Reptile Conservation.