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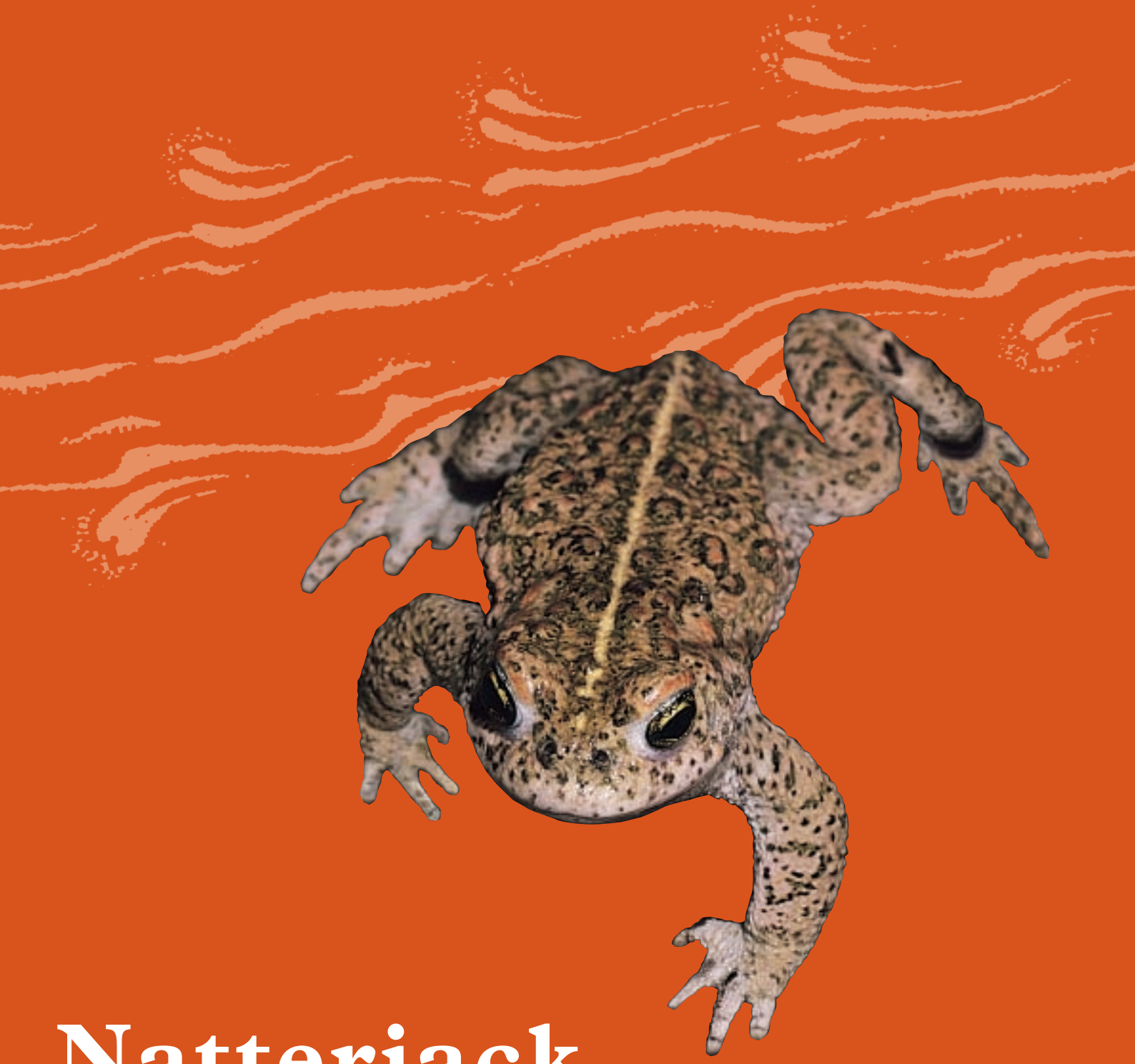

Natterjack toad

Conservation Handbook

Species recovery programme

The Natterjack Toad Conservation Handbook

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ENGLISH NATURE

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Contents

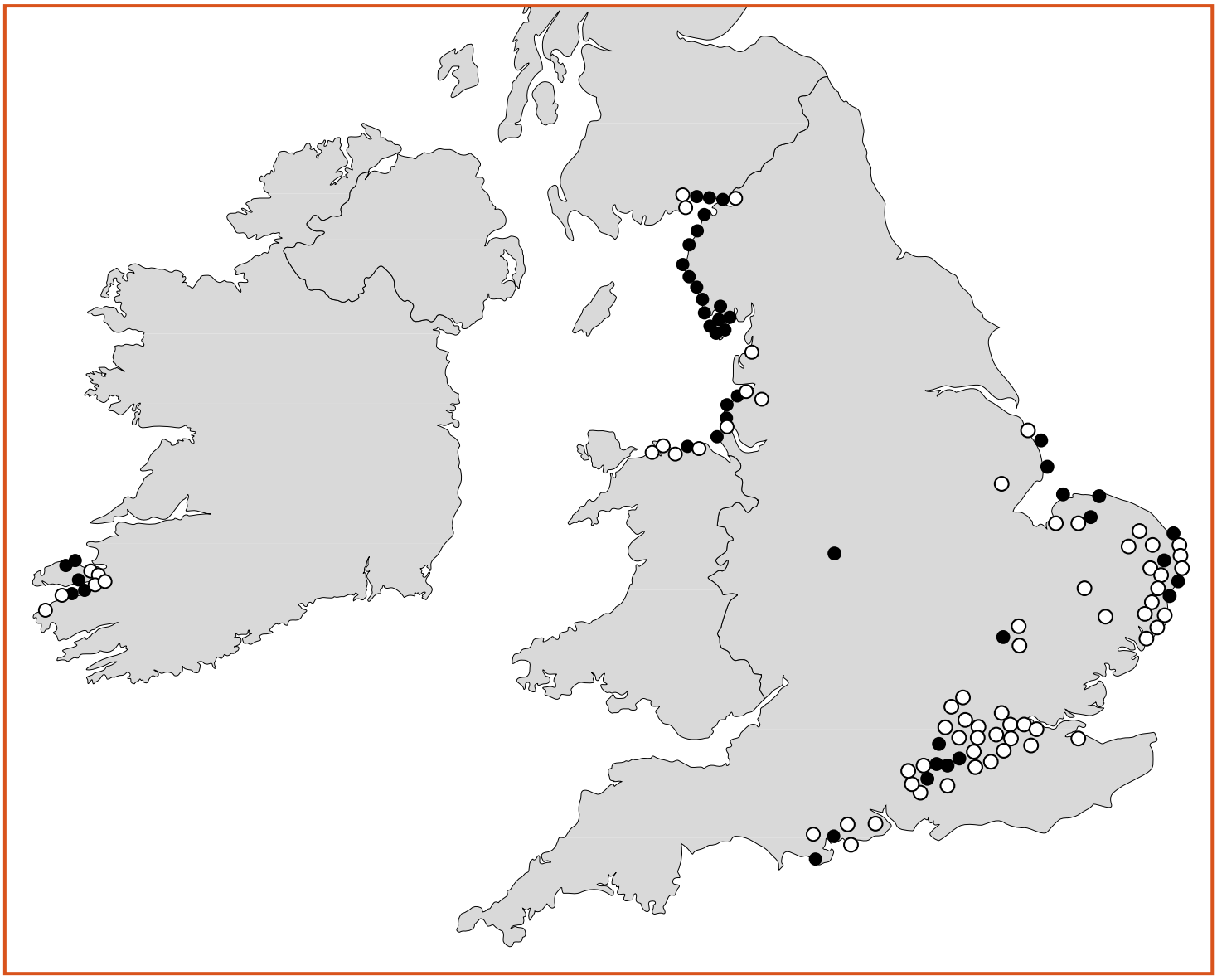
1.General introduction

The natterjack toad *Bufo calamita* is on the north-westerly edge of its biogeographical range in Britain, and within historical times has always had a much more restricted distribution than the other five native amphibians (this excluding the recent indications that a further species, the pool frog, may be native). During the twentieth century there were substantial losses of natterjack populations, particularly from heathlands in southern and eastern England, and after an overall decline estimated at over 70% the species was considered sufficiently endangered to receive protection through both national and international legislation (see Section 2).

Following considerable autecological research during the 1980s and an English Nature Species Recovery Programme in the early 1990s, there has been some reversal of the natterjack's misfortunes and a current (1995) UK distribution is shown in Figure 1.

The stronghold of this amphibian remains the coastal dune and upper saltmarsh habitats of the Irish Sea coast from Liverpool Bay north to the Solway estuary, but there are also populations on east coast dunes in Norfolk and Lincolnshire, and on heathlands in Norfolk, Suffolk, Staffordshire, Bedfordshire, Surrey, Hampshire and Dorset. All but two of the heathland populations, however, are the result of post-1980 translocations. In 1995 there were approximately 50 populations of *Bufo calamita* known in Britain, using perhaps 200-300 breeding ponds and with an estimated total of 15000-20000 adults compared with estimates of more than 20 million common toads *Bufo Bufo*. Natterjacks have also declined substantially in many other parts of their north European range, and are now considered to be one of the continent's most vulnerable amphibians.

Figure 1 Natterjack distribution in 1995. Solid circles = extant sites, open circles = extinctions during the twentieth century



The general strategy for natterjack toad conservation in Britain comprises the following elements:

- Site protection, with most if not all localities acquiring Site of Special Scientific Interest (SSSI) status and the largest or otherwise most important ones becoming nature reserves.

- Management of sites, where necessary, to maintain conditions suitable for natterjack toads using methods compatible with overall habitat management objectives.

- Translocation of natterjacks to sites within their historical range where conditions are or can be restored to those suitable for the species. In general, the emphasis should be on recreating heathland populations in southern and eastern England because this is where declines have been most severe. However, there are other areas where minor range contractions have occurred, including the coastal belts of North Wales, north and south Merseyside, Lancashire and south Cumbria. These areas should also be considered for translocations if opportunities arise.

This handbook provides practical guidance for the conservation of natterjack toads on the basis of current knowledge. It therefore covers management and translocation of natterjacks, site protection and mitigation, survey and monitoring and where to obtain further advice and assistance. It is of course possible that these guidelines will need amendment in future on the basis of further research, but the methods described here have all been tried and tested and are thus known to work even if they do not ultimately turn out to be the best possible procedures. Of these methods, grazing regimes using domestic livestock are among the most important but also the least well characterised at the time of writing. This should be borne in mind when considering the introduction of grazing management; particular care should be taken to monitor its effects and there should be a readiness to modify its style if experience suggests the need to do so.

2. Legal protection and licensing

The natterjack toad is protected through both national and international legislation. It was one of the first wild animals to receive protection in Britain through the Conservation of Wild Creatures and Wild Plants Act 1975. In 1979 a Council of Europe Convention called The Convention on the Conservation of European Wildlife and Natural Habitats (also known as the Bern Convention) was signed. This placed an international duty on the Governments of participating nations to provide further protection for the species. In Britain this was instigated through the Wildlife & Countryside Act 1981 and it was one of the species of animal listed on Schedule 5 of the Act.

In 1992, further protection was afforded through the European Communities Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (also known as the Habitats Directive or Habitats & Species Directive). This has been implemented in Great Britain through a further piece of national legislation called the Conservation (Natural Habitats & c.) Regulations 1994 where it is listed on Schedule 2.

Taken together, the Act and the Regulations make it illegal to :

- Intentionally or deliberately kill, injure or capture natterjack toads.

- Deliberately disturb natterjack toads (whether at the breeding ponds or not).

- Damage or destroy natterjack breeding sites, resting places or places used for shelter or protection.

- Possess a natterjack toad, or any part of a natterjack toad, unless acquired legally.

- Sell, barter, exchange or transport for sale, etc, natterjack toads or parts of them.

The legislation covers all life stages; spawn, tadpoles and adult natterjack toads are all equally covered by the legislation.

There are some cases where the law allows these actions to occur. For example, injured animals can be kept to tend them provided they are released as soon as they have recovered and 'mercy killing' of severely injured animals is allowed. The law also allows actions which would otherwise be illegal provided these are the incidental result of a lawful operation and could not reasonably be avoided.

Licences can be issued to allow otherwise prohibited acts (eg. capturing or handling natterjacks). Licences for scientific study and conservation, education and photography are issued by the statutory nature conservation organisations (namely English Nature in England, Countryside Council for Wales in Wales and Scottish Natural Heritage in Scotland). Occasionally other licensing authorities, such as the Ministry of Agriculture Fisheries and Foods (MAFF) or the Department of the Environment (DoE) may need to be consulted for certain reasons. For example MAFF are responsible for licensing actions where these are necessary for public health and safety; DoE are the licensing authority for sale and, under the Conservation (Natural Habitats & c.) Regulations 1994, for reasons of overriding public interest.

This is only a general guide to the main provisions of the law. The Wildlife & Countryside Act 1981 and the Conservation (Natural Habitats & c.) Regulations 1994 should be consulted for further details.

People involved with natterjack toad conservation, including those studying them, managing their habitat or owners of land where natterjack toads are present, need to be aware of the law.

3. Habitat requirements of natterjack toads

Wherever they occur in Britain, there are two critical elements of habitat structure that are essential for natterjacks to thrive. These are:

- **Open, unshaded terrestrial habitat with extensive areas of unvegetated or minimally vegetated ground (i.e. with vertical plant growth of no more than 1 cm or so).** Adult and juvenile natterjacks require this kind of terrain for hunting their invertebrate prey, which they do by active pursuit. They also, however, need to be able to escape the heat of the midsummer sun and subzero temperatures in winter, and thus require a substrate (usually sand, occasionally slag or rock piles) into which they can burrow.

- **Unshaded, ephemeral ponds with shallow, gradually shelving margins and few predators or competitors, for reproduction.** Because the existence of such ponds is highly weather-dependent and thus unpredictable from year to year, natterjack reproduction is characteristically "boom or bust", with spectacular successes interspersed with partial or total failures.

  Occasionally larger, permanent water bodies suffice providing they fulfill the same criteria with respect to shallow margins and low competitor and predator numbers. Other amphibians can cause problems for natterjack toads. Where common frogs *Rana temporaria* and toads *Bufo Bufo* are found these will tend to dominate all breeding ponds available. Natterjack tadpoles are competitively inferior to those of common frogs and toads, and will not survive in the presence of large numbers of these commoner species. Great crested newts *Triturus cristatus* consume large numbers of natterjack tadpoles. Most other vertebrates leave them alone because of their distasteful skins. On account of their relatively small size the tadpoles are also very vulnerable to predation by aquatic invertebrates, especially dytiscid water beetles (adults and larvae), dragonfly and damselfly (Odonata) nymphs and water-boatmen (notonectids).

Both of these habitat features, the terrestrial and the aquatic, should be within the same patch of land or very close to one another. Natterjacks will not cross extensive areas of unsuitable terrain to move between summer/winter and breeding habitats.

These conditions are generally met on only three habitat types in Britain, notably coastal dunes, upper saltmarshes and lowland heaths. The specific habitat structures of these habitats are outlined below:

Coastal dunes

Terrestrial habitat requirements are best met by yellow dunes with extensive areas of bare sand but with some vegetation cover (marram *Ammophila arenaria,* etc) to support invertebrate prey and also to provide cover for toads to burrow under. In some sites (such as Winterton in Norfolk and Silloth in Cumbria), dunes grade rapidly into dune-heath, an internationally important habitat also used by natterjacks. Over-fixed dunes (e.g. with extensive birch *Betula* spp., willow *Salix* spp. or sea buckthorn *Hippophae rhamnoides* scrub, or with dense mats of rank grasses) are unsuitable for natterjacks because they provide few suitable hunting areas and also encourage colonisation by other amphibians. These common species do not survive well in the more open habitat favoured by the natterjack toad. Over-stabilisation of dune systems is therefore highly disadvantageous to natterjacks.

Aquatic habitat requirements are typically met by shallow, ephemeral slacks that desiccate around

midsummer, especially those near frontal ridges which tend to be the most poorly vegetated and so have the lowest numbers of tadpole predators. Upper saltmarsh and other ponds, where these occur on the seaward side of dunes, may also be suitable. Typical high-quality dune habitat for natterjacks is shown in Plate 1 (see page 13).

Upper saltmarshes

Terrestrial habitat. Close-cropped turf typical of many areas of upper saltmarsh (especially those grazed by domestic livestock) constitutes ideal terrestrial habitat for natterjacks, providing that substantial parts of it are inundated only occasionally by the highest of tides. Most upper saltmarsh habitats occupied by natterjacks also have other features important to the toads, such as embankments, small areas of dunes, or dry stone walls in which the toads can find cover.

Aquatic habitat is usually in the form of shallow pools or ditches at the upper edge of the saltmarsh which are inundated by high tides in autumn and early spring but which rapidly freshen up, due to direct rainfall or run-off from inland, in late spring and early summer. This salt water scouring reduces predator and competitor numbers, again providing ideal conditions for survival of the later arriving natterjack tadpoles. However salinity must fall below 15% seawater (approximately 0.5% NaCl), if natterjack spawn is to survive well. A typical upper saltmarsh natterjack site is shown in Plate 2 (see page 13).

Lowland heaths

Terrestrial habitat. Areas of open sand (such as tracks and eroded gullies) or of low growing mosses (and other bryophytes) or lichen, interspersed with heather shrubs (eg. ling *Calluna vulgaris* and bell-heather *Erica cinerea*), form ideal natterjack terrestrial habitat on heathland. Uniformly dense stands of heather provide few opportunities for hunting and are thus a poor habitat, but mature heather communities (Callunetum) with areas of die-back and bryophytes adjacent to open patches of sand is quite satisfactory. As with dunes, scrub encroachment is highly deleterious because it improves the prospects for competitively superior anurans and for the major tadpole predator, the great crested newt.

Aquatic habitat. Breeding pools on heathland may be shallow and ephemeral and so are similar in nature to dune slacks. Occasionally though they may be larger, permanent water bodies with shallow margins. In the latter case coarse fish (such as perch *Perca fluviatilis*) are usually present and keep invertebrate numbers low while leaving toad tadpoles unmolested. In both cases only circumneutral ponds with pH of 6 or above, and with minimal growth of macrophytes, provide good natterjack breeding sites. Spawn mortality is high and tadpole growth rates low under more acid conditions, although some survival is possible down to around pH 5. A typical heathland natterjack site is shown in Plate 3 (see page 13)

Other habitats

Atypical (for Britain) natterjack habitats include a disused sand quarry, the remains of an old ironworks and an upland moor, all in Cumbria and of similar habitat structure to those described above. Thus the ironworks site is covered in slag and rubble with little vegetation but plenty of refugia, and fortuitously has an ephemeral pool. The moorland site is similar in vegetation structure to a lowland heath, and has multiple shallow pools in a spring-fed, partially alkaline bog system.

4. Management methods applicable to natterjack toad sites

The habitat descriptions listed previously represent ideal conditions not just for natterjacks but also for many other endangered or declining fauna and flora characteristic of pristine dune, saltmarsh or heathland habitats. In this section, practical methods for creating and/or maintaining such conditions in these inherently fragile ecosystems are documented. They will, of course, often need tailoring to meet the requirements of particular sites and flexibility is often the key to success. Also other important factors relevant to natterjack management but not a particular habitat are highlighted towards the end of this section.

An important general point is that natterjack population size is usually limited by the number of suitable breeding ponds available rather than by the extent of terrestrial habitat. Since large populations are less susceptible than small ones to genetic impoverishment and to extinction by accident, a sound management strategy is to maximise the numbers of breeding sites as the first priority in most situations.

Coastal dunes

Terrestrial habitat

a. Restoration of over-fixed dunes.

When large areas of scrub encroachment have developed, there is little alternative to manual or mechanical clearance as a first step towards re-creation of open habitats. Mechanical methods are not as damaging to the habitat as might be expected, and have been used very successfully at Ainsdale Local Nature Reserve (LNR) in Merseyside. Visual evidence of heavy machine activity on dunes disappears remarkably rapidly, but it is generally prudent to precede such work with local publicity about its expected benefits to pre-empt complaints that arise from misunderstandings among local people. A Hi-mac excavator tracked vehicle with wide (75 cm) pads for low ground pressure and a long hydraulic arm is ideal (see Plate 4, page 14). It can reach up slopes and also clear scrub from very small hollows and has proved extremely effective when fitted with specially designed rake attachments (1.5 m wide, with 70 cm teeth) as shown in Plate 5 (see page 14). Skilful use does not damage existing dune topography. The large volumes of scrub grubbed out by this machine are most efficiently moved to deposition (burning) sites by a light four-wheel drive tractor with an adapted (wide-gape) silage grab and additional mesh radiator guard (see Plates 6 and 7, page 15). JCB-type vehicles with front buckets are also useful for clearance over level ground such as slack basins. Chain-sawing larger trees at ground level and dragging away by tractor may be necessary in some cases, but powerful track vehicles can usually pull out entire trees together with their root systems and this is generally to be preferred.

The accumulation of nutrients in the humus layer on grey dune under scrub (especially sea buckthorn *Hippophae rhamnoides*) causes, if left in place, the rapid development of a rank secondary vegetation structure after clearance. Soil inversion is a satisfactory answer, burying the surface layers beneath yellow mineral sand using the same machinery as for scrub clearance. Where areas of pine are clear-felled to restore open dunes, a bulldozer should be employed to remove the top layer of pine needle litter, uproot stumps and thoroughly break up the leached soil layer (micropodzol), once again bringing mineral sand to the surface. If the pine plantation is too dense for this approach to be feasible, it may be possible to bury the cleared area with yellow mineral sand of high pH and a seed bank of dune species. Alternatively, the pine litter layer can be burnt off after clearance especially if the site will then be available for grazing to control the ruderal plant species that are likely to appear. Scrub and trees are in any event best burnt on site, during or immediately after the clearance operations.

b. Creation of new yellow-dune habitat.

Much of the best natterjack habitat on dunes is generated by the wind, which continuously shapes the fore dunes and maintains large areas of open bare sand. The extent of such habitat can be increased by the use of brash fences seaward of foredunes which act as groynes to catch the sand and thus create new embryo dune ridges. Beach cleaning operations should be discouraged because they usually retard or prevent altogether the formation (accretion) of such new dune ridges.

Where frontal dune ridges are over-exposed or subject to erosion by trampling, excessive sand loss can be checked by the use of brash sand traps and marram *Ammophila arenaria* planting. Such areas are highly favoured by natterjacks. Marram and lyme grass *Leymus arenarius* generate cover for prey and hold the dunes together sufficiently as to provide secure refugia for hibernation.

c. Maintenance of suitable dune habitat.

The tendency of dunes to over-fix inland of the frontal ridges can be countered either by regular clearance as described above, by mowing, or by a suitable grazing regime. The latter is by far the most preferable, because (a) it generates the best habitat, and (b) it is likely to be cheapest in the long term. Mowing can be useful, especially as a stop-gap measure pending the establishment of a grazing regime, but requires special machinery and is labour intensive, especially the essential collection and removal of clippings which otherwise rot and can cause ground water eutrophication. Grazing can be by wild animals (usually rabbits *Oryctolagus cuniculus*), domestic stock, or a mixture of both.

Rabbits are attracted to existing open areas and where absent can be encouraged by providing access corridors and warren sites. The latter can be accomplished by using a tractor-mounted augur to pull up a plug of substrate, opening bare sand into which the rabbits can easily dig. Similarly, large root balls can be half uprooted and left during scrub clearance; these are often used as entrances to warrens.

Figure 2a

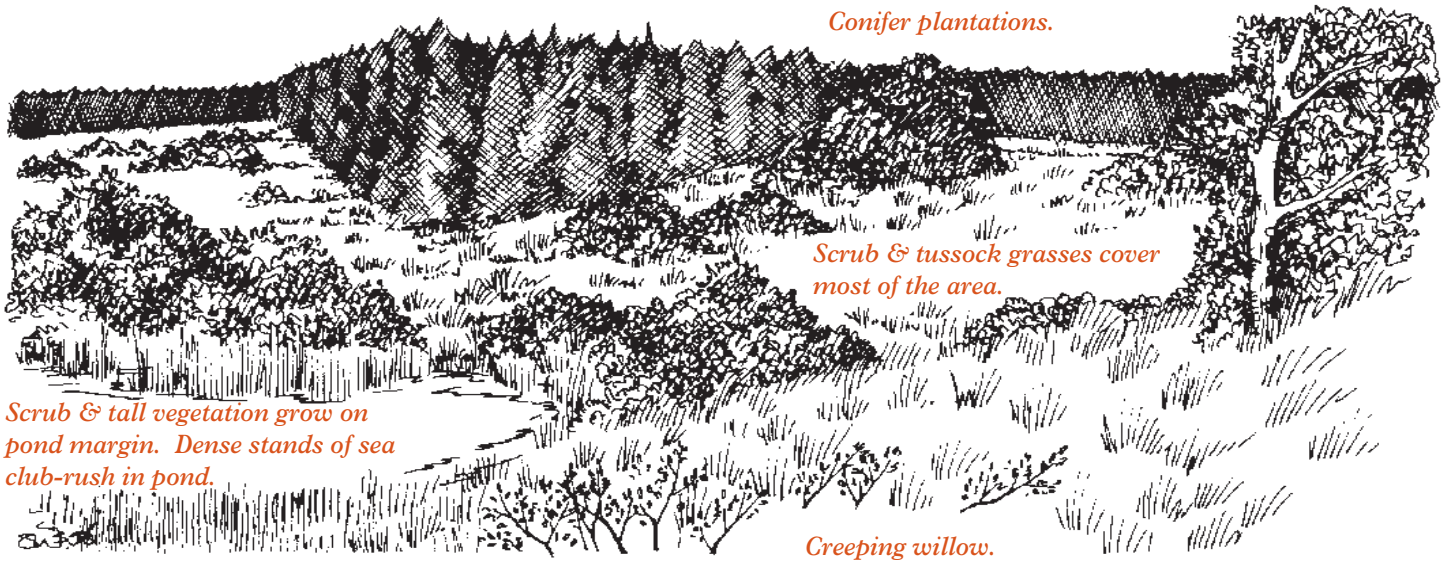
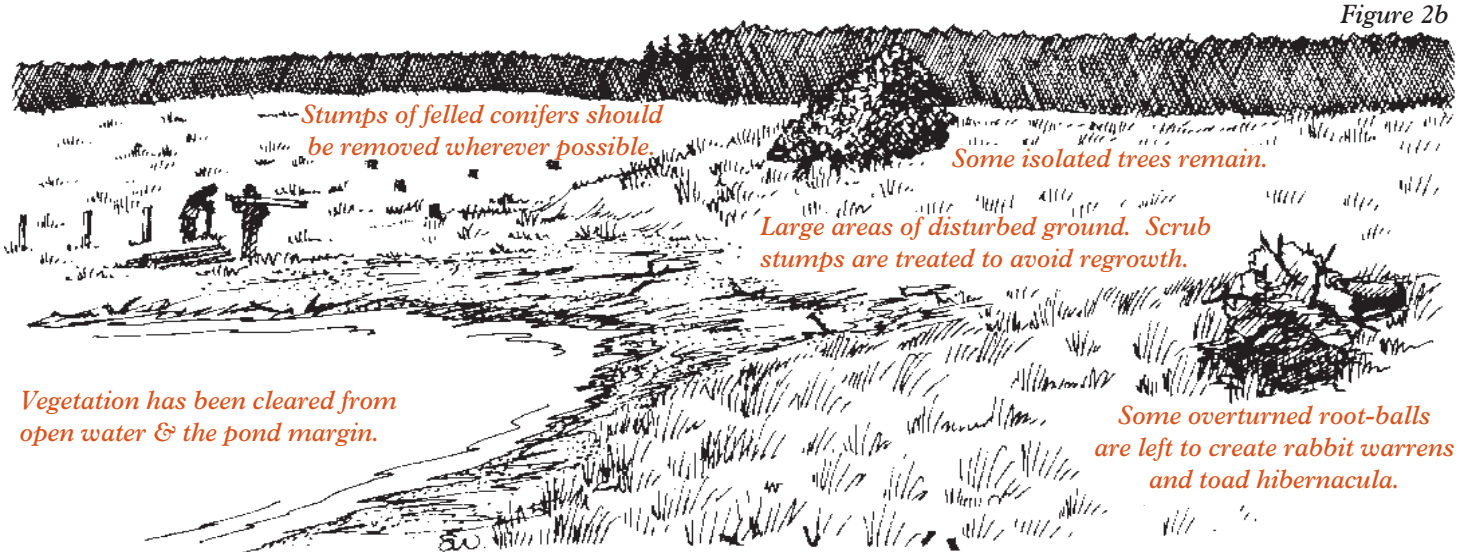


Figure 2b



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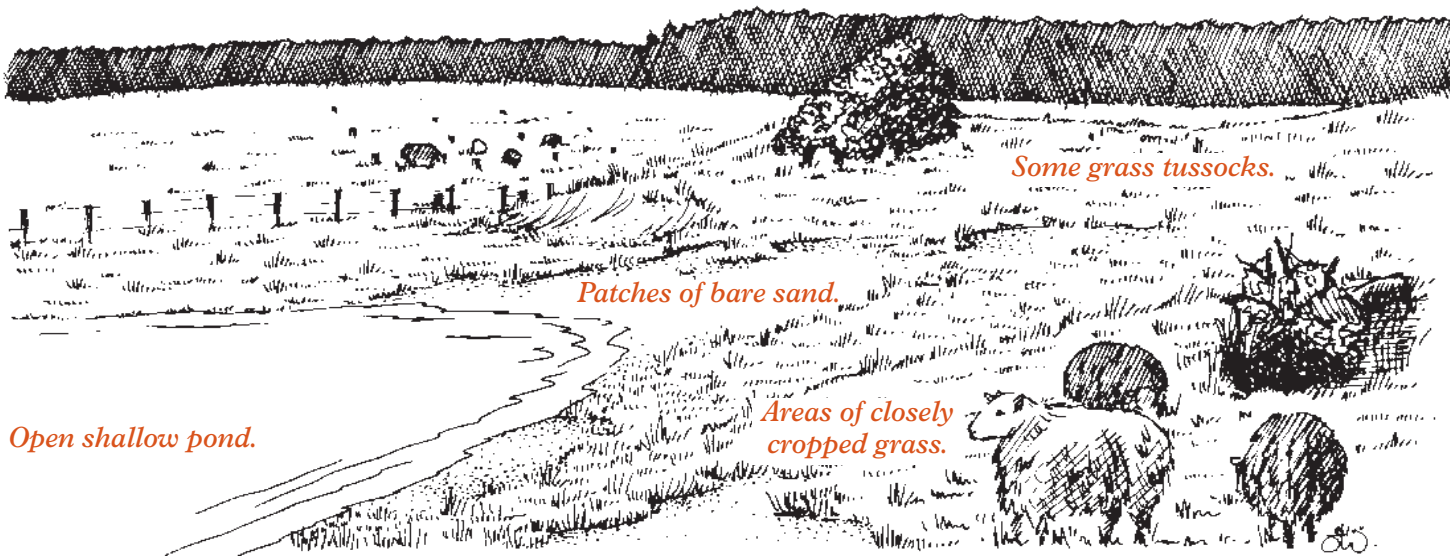


Figure 2 Dune (a) with extensive scrub stands before clearance, (b) after mechanical clearance and (c) grazed after clearance.

The two major dune systems which support natterjacks in Cumbria (Drigg and Sandscale) both have a long and continuous history of grazing by domestic livestock, mostly cattle. Absence of domestic grazing, especially after myxomatosis annihilated rabbit populations in the 1950s and 1960s, has been a major cause of over-fixation of dunes and subsequent natterjack declines (commensurate with increases in common amphibian species) in areas such as north Merseyside. The habitat created by recent restoration of sheep and cattle grazing on parts of the Merseyside dunes includes increases in open ground that should be very favourable for natterjacks. It will be important to establish appropriate grazing regimes with domestic animals on as many dune systems as possible if various aspects of their ecology, including natterjacks, are to persist. Cattle are probably the most suitable animals because they require less attention than sheep and are less prone to interference from dogs. Stocking density will be critical and is likely to require further study and tailoring to individual sites, dependent on factors such as existing rabbit numbers and levels of natural erosion.

Livestock can be obtained to graze dunes either by lease-lend arrangements with local farmers or by purchase for exclusive use by conservation organisations. Initial costs also include the erection of stock proof fencing and, where necessary, a supply of drinking water. However, this will usually work out cheaper than indefinite scrub clearance operations which, in any case, do not create long-standing areas of close cropped vegetation or bare sand that are essential for natterjacks and some other dune inhabitants.

Clearance and maintenance of dune habitat is illustrated in Figure 2.

Aquatic habitat

a. Maintenance of freshwater slacks.

Slack pools are formed naturally as the wind erodes sand to below the water table, and are then subject to the normal processes of natural succession. Accretion of new frontal ridges increasingly distances slacks from the sea, and without management a dense vegetation structure often develops. Scrub in slack basins provides ideal conditions for common toads. These invade in early spring before conditions on the open dunes become too hostile for them and then breed in the ponds before the natterjacks. Mowing slacks with a powerful tractor-hauled drum-mower is an effective way of removing creeping willow stands up to 1 m in height and 5 cm in stem diameter; the best machines can operate in shallow water, and cut debris should always be collected and removed. Grazing once again provides the best long-term solution to maintaining these relatively inland slacks in open condition in which characteristic dune slack flora are also likely to thrive.

Unless there is reason to believe that the water table is experiencing a long-term downward trend, any temptation to deepen slacks should be resisted. Over deepening is likely to benefit competitors and predators of natterjack tadpoles rather than the natterjacks themselves. However, digging small sumps in the lowest part of a slack basin can be beneficial as a rescue measure for tadpoles in very dry years.

b. Creation of new pools.

This can be a valuable method for boosting natterjack populations, especially if old ponds are lost or have deteriorated for some reason. Such pools can be excavated by machinery and should be designed like natural slacks, i.e. shallow with gradually shelving margins. Spoil can be arranged as banks, preferably south facing near the pond, since these constitute good terrestrial habitat for natterjacks. Critical in the design of natterjack ponds is ensuring that they are not too deep, with the ideal pond desiccating in midsummer in a year of average rainfall. This may have to be accomplished by trial and error, i.e. making an excavation and then slightly deepening or infilling it in a subsequent year depending on how the water table behaves. In areas of dune where the water table is too low to reach, the excavations can be lined (e.g. with butyl) and partially covered with sand to appear natural. They can then be filled from a bowser or left to collect rainwater. Care is necessary, however, to ensure that sand around the edges does not draw water out rapidly by capillary action and thus cause premature desiccation.

Alternatively, natural sand accretion along the seaward side of frontal dunes can be encouraged and this will often lead to new slack formation as well. In some sites, streams flow through dunes and these can be partially dammed at their seaward exit to cause the formation of shallow pools. However, “flowing water” pools are particularly prone to overgrowth with reed *Phragmites australis*, which will then require arduous physical control by cutting or pulling unless a grazing regime is in place.

Some dune system pools are subject to occasional tidal inundation and thus suffer from problems more characteristic of upper saltmarsh ponds (see upper saltmarshes, aquatic habitat).

c. Pond protection.

In areas subject to high public pressure, ponds can be at least partially protected from disturbance by the erection of fences (such as chestnut paling) and signs. These are often subject to regular vandalism, however, and are probably only worth considering in circumstances of exceptional risk.

Upper saltmarshes

Terrestrial habitat

a. Maintenance of suitable conditions.

The lawn-like appearance (with vegetation less than 5 cm tall) of upper saltmarsh habitats used by natterjacks is maintained by a combination of occasional saltwater inundation together with grazing by domestic livestock. Relatively high stocking rates of sheep are compatible with natterjacks in this situation, but some sites are prone to invasion by rushes *Juncus* spp., which sheep do not seem to control well; cattle grazing is apparently more effective for this purpose, and should be used where a choice is available. Excessive stands of rushes or of scrub, such as gorse *Ulex* spp., favour competitors (common frogs and toads) and should therefore be removed or minimised, by preliminary mowing if necessary and followed by a grazing regime if one is not already in place.

b. Other important features.

The absence of mobile dune on many saltmarsh sites means that toads are more reliant on appropriate surface refugia. Collapsed dry stone walls provide adequate cover in some areas, as does strand line debris. It is important to ensure that such features are not inadvertently removed.

Aquatic habitat

a. Maintenance of existing ponds.

Upper saltmarsh ponds suitable for natterjack breeding are those which are flushed out occasionally by high tides, mostly in autumn and early spring, but which freshen up again rapidly afterwards to less than 15% seawater salinity. They are usually shallow, and desiccate in midsummer like dune slacks. Management must ensure that nothing interferes with this cycle; sea walls that prevent the inundation, or inland constructions such as roads, roadside ditches or embankments that reduce freshwater run-off, are equally disastrous. Becoming permanently salty will make ponds toxic to natterjack spawn and larvae, while becoming permanently fresh (usually accompanied by increasingly rank terrestrial vegetation around the ponds) results in colonisation by intolerably high numbers of tadpole competitors and/or predators. Excessive growth of sea club-rush *Scirpus maritimus* is a problem at some sites; this plant is poorly controlled by sheep grazing whereas cattle may do better. Sea club-rush can also be controlled by spraying with Roundup (glyphosate) when infestation becomes excessive. In this case, dead stems should be cut and removed during the winter after spraying to avoid any shading or eutrophication effects.

b. Creation of new ponds.

There is sometimes scope on saltmarshes to increase natterjack breeding success, and thus population size, by creating extra ponds. As always for natterjacks, pools should be shallow with gradually shelving margins and they can be created either by hand or by machine. Even very small pools (of just a few square metres surface area) can be highly productive, and are often the most appropriate on saltmarshes. Siting on saltmarshes is of particular importance; the position must be such that an inundation/re-freshening cycle of the type described above occurs, and this can be anticipated by taking water samples from prospective sites (such as shallow flood zones which could be deepened to make ponds) intermittently through a calendar year and measuring their salinities by simple conductivity tests.

Lowland heaths

Terrestrial habitat

a. Restoration of degraded habitat.

Heathlands have been subject to invasion by scrub, especially birch species *Betula* spp., pine *Pinus* spp. (plantation and self-seeded) and bracken *Pteridium aquilinum* over recent decades. One of the first objectives in management for natterjacks (as well as many other heathland species) is the removal of most or all of these plants. The best strategy is to clear-fell large areas, partly because this removes all seed sources and will therefore have a relatively long-term effect, and partly because even small areas of scrub can support competitor species (especially common toads) that would be damaging to natterjacks.

Scrub control

Machinery should only be used for scrub removal in areas where degradation is so severe that the heather understorey is beyond salvation. In such cases, a caterpillar type tractor fitted with a 3 in 1 bucket or grab is ideal and can both uproot and pile up the scrub species for later disposal. The edges of mature or thinned pine woodland are often used by natterjacks where light penetration is sufficiently high, as needle litter prevents plant growth and provides foraging conditions which persist long after the trees are removed. Clear-felling such areas with chain-saws rather than uprooting by machinery is therefore the best option. Elsewhere, the fragile nature of mature Callunetum and the long time required for recovery after damage dictate a need for manual clearance methods to restore heathland. Young pine and birch can be hand pulled, but taller plants should be cut off as low as possible (and always below the lowest branches in the case of pines) and all material removed from the heather. Stumps of deciduous species should always be treated with a suitable herbicide, such as Amcide (ammonium sulphamate) or Garlon 4 (triclopyr) , as soon as possible after cutting. Low birch scrub can also be sprayed with Krenite (fosamine-ammonium) using backpack sprayers, but results are variable and not wholly satisfactory in many cases.

Uprooted or cut scrub should be burnt or, if the machinery is available, can be shredded to produce sawdust that has a commercial market.

Clearance of heathland habitat is illustrated in Figure 3.

Figure 3 (a) Uncleared and (b) cleared heathland site showing recovery of heather understorey.

Figure 3a

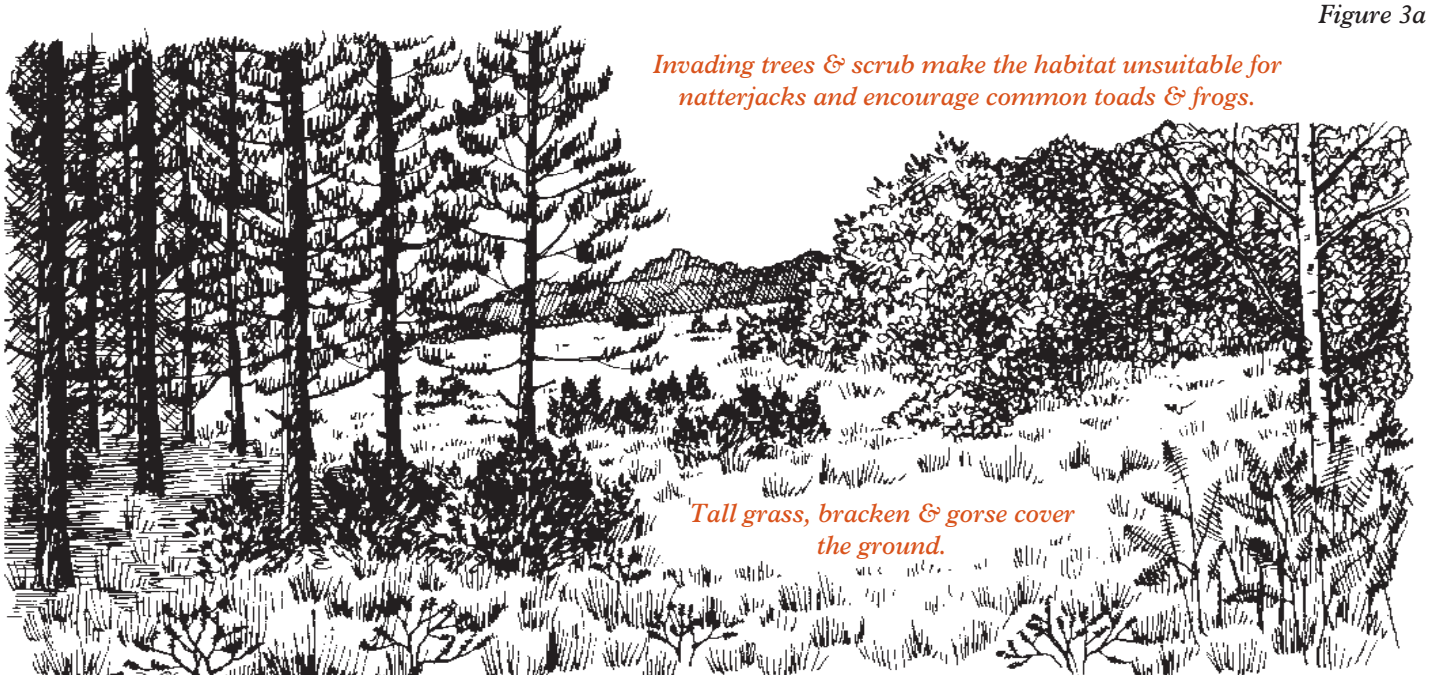
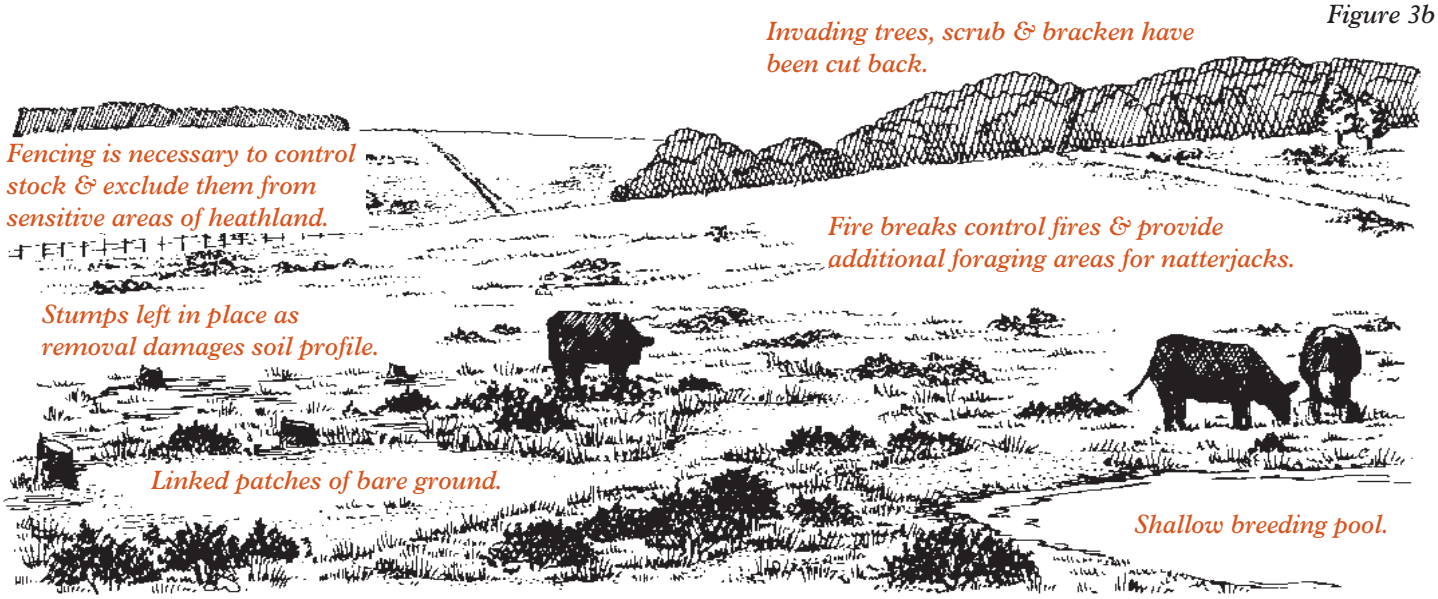


Figure 3b



Bracken control

Dense bracken does not constitute suitable natterjack habitat. In areas without a heather understorey, bracken can be reduced by several successive cuts using tractor drawn blades early in its growing season (June) over two or three years. More commonly, however, bracken is a problem in areas still dominated by heather and in this situation the only effective treatment is the selective herbicide Asulox (asulam) applied at high concentration (1:10 dilution) during July, either by backpack or from the air when large areas are involved. This is an expensive procedure and often needs repeating every few years. As with all herbicide applications, weather conditions are important and the timing should be such that rain is unlikely for at least 24 hours afterwards and preferably longer.

Regeneration of open areas

Patches of open ground are essential to natterjack foraging behaviour, but may become infrequent in dense mature heath. Mowing patches or tracks appears only marginally suitable for natterjacks as the toads are reluctant to scramble over even low-growing heather. Scraping areas down to the mineral soil is far preferable and is useful to a range of other heathland species presently in decline, such as sand lizards *Lacerta agilis*, wood tiger beetles *Cicindela sylvatica* and various bees, wasps and ants (aculeates). It also aids leaching, reducing humus nutrient load and thus discouraging the spread of grasses. Scraping can be done by heavy machinery with blades to create wide tracks (firebreaks), or on a smaller scale using rotovators. The best time for such operations (i.e. that likely to cause minimum damage to fauna) is in late April or early May, while adult natterjacks are congregated around breeding ponds and before sand lizards lay their eggs. It is difficult to be prescriptive about the optimal amount of bare ground, but in general as much as possible up to at least 10% of the total surface area and designed in such a way as to form a network over the whole site, is probably ideal.

b. Maintenance of terrestrial habitat.

Regenerative management of the type described above is both expensive and labour intensive; it can be repeated indefinitely, but a return to the historical methods that maintained heathlands for thousands of years until the early twentieth century, notably livestock grazing, is probably preferable wherever feasible. As with dunes, natural grazers such as rabbits and deer should be encouraged but seem unable, in most cases, to maintain heathland by themselves though they can have valuable local effects. Cattle seem on the basis of current evidence to be the most suitable domestic animals, though sheep, ponies and goats may have their place. Winter grazing of heath with cattle is an effective way of controlling young pine trees and grasses such as purple moor grass *Molinia caerulea* which otherwise spread in the damper areas. Birch is mostly browsed by cattle in early spring, whereas sallow *Salix cinerea* and aspen *Populus tremula* are more palatable and are attacked at any time in summer. Bracken stands may be reduced by trampling. Goats will eat bracken with apparent impunity, though it is toxic to (and normally avoided by) other livestock. All scrub is better controlled after coppicing, and spring browsing of regrowth from cut stumps often kills the plants. Poaching of the ground is also beneficial to natterjacks by creating open areas, and cow dung attracts flies and beetles which are eaten by the toads.

Ling is also grazed, especially when in flower in late summer and also in winter, and low bushes are often cropped back to produce open ground. This and trampling of adults and toadlets represent particular dangers of grazing, which if excessive can ultimately lead to replacement of heathers by grasses. Low stocking rates (for cattle, perhaps one animal per 3-4 hectares) are therefore critical, and it is important to emphasise that more work is necessary before grazing can be advocated as a ubiquitous tool for heathland maintenance. Each site should be considered on its merits, and care taken to ensure that overstocking does not cause unacceptable damage to mature stands of Callunetum important to other animals such as reptiles. Cattle tend to return to favoured sheltering areas each day and defecate nearby; if shelter and water can be provided in marginal habitats, this will reduce nutrient recycling into the heath ecosystem and minimise other damage as well.

As on dunes, grazing animals can be leased from farmers or purchased specifically for conservation use. Cattle require less attention than sheep, but of course all livestock need access to freshwater and goats need simple shelters (such as corrugated iron covers) to get out of the rain. Also as with dunes, initial expense is likely to include stock proof fence and gate erection, but in the long term costs will fall and grazing may even become marginally profitable.

Aquatic habitat

a. Pond maintenance.

Acidification from atmospheric pollutants is a fairly common threat to naturally oligotrophic (poor in nutrients) or dystrophic (rich in organic matter and low in oxygen) heathland ponds that are otherwise circumneutral (commonly with pHs between 5.5 and 7.0). There are two possible remedies if pH falls, as part of a long-term trend, to below 5.0. In some cases it is possible to remove the accumulated sediment from the pond basin when, as normally happens, the pool desiccates in late summer. This sediment acts as a repository for sulphur and nitrogen compounds accumulated from acid rain, and these leach out continuously to acidify the pool. The peat layer (usually only a few centimetres thick) is scraped off by a machine with a blade, and moved as far away from the pond as possible. It is important when doing this to avoid over-deepening, and thus to remove the minimum possible amount of material. Of course the respite will only be temporary if acid rain continues to fall, but it can last for at least several years. A second and commoner solution is to neutralise acidity by addition of chalk or quicklime, using a quantity sufficient to raise pH up to about 7. The minimum necessary to achieve this result should be added, since excess is likely to cause wide alterations to the animal and plant life in the pond and possibly also that of its immediate environs. In a shallow pool, around 1 kg of lime per 20 square metres of winter surface area is the most that should be needed. The lime should be sprinkled on the surface in late March or early April, before the natterjacks breed but preferably after the season of the common amphibians (thus selecting against them). If the dose is right, lime addition will probably need repeating every year or every other year and pH should be checked regularly to monitor its effects.

Plant succession in nutrient-poor heathland ponds tends to be slow, though *Molinia caerulea* in particular can eventually choke up large areas and may need to be removed. Grazing, however, minimises this problem and is in general a useful management tool for ponds as well as dry heathland. The presence of dung also enriches the oligotrophic pools and improves tadpole growth rates. Problems can arise, however, if only one or a few small pools are available to serve a substantial herd of animals. Pollution and trampling will then need to be controlled by fencing off most of the ponds leaving only a small area for the animals to drink from.

The immediate environs of the pond also warrant particular attention. Provision of sandy banks is especially useful because during the breeding season some males remain for several weeks in the vicinity of the pools, and without somewhere to burrow, tend to sit in vegetation and become very vulnerable to grass snake (and perhaps other) predation. Areas of damp moss or other very low-growing vegetation around the pond banks are valuable to toadlets, which desiccate more readily on bare sand if the weather is hot when they metamorphose. Such vegetation normally develops naturally, but if grazing regimes are employed care must be taken to try to ensure that the animals do not destroy all these vegetated pond surrounds.

b. Pond creation.

New pools for natterjacks can be created on heathland along much the same lines as those on dunes (see coastal dunes, creation of new pools). They should be sited as far away as possible from any scrub and with the proviso that ground water in the areas selected should first be checked for pH. If circumneutral sites are not available, ponds can still be made but are likely to need regular liming as a management tool (see pond maintenance).

An alternative on heathland where ground water is too acid or completely unavailable is to create small, saucer-shaped concrete ponds. If made to a maximum depth of 50-80 cm, and with diameters of 7-10 m, such ponds rarely dry out and the concrete substrate seems to inhibit the development of large invertebrate populations. They are also inherently buffered against acid rain. Natterjacks breed very successfully in ponds of this kind, which should be sited in areas of suitable terrestrial habitat such as bare sand or close cropped turf and be completely unshaded. A hollow is first excavated by hand or by machine, to a width and depth exceeding the final dimensions by about 60 cm and 30 cm respectively to allow for ballast and concrete. Rubble to a depth of 15 cm, and/or chicken fence wire, is used to line the excavation and a fairly dry ("sticky") mix of concrete, preferably incorporating "Fibrin" (a concrete additive used to increase strength and impermeability), then spread to a final thickness of 15-20 cm throughout.

Plate 1 Yellow-dune and dune slack, "Natterjack valley" in Cumbria.

Trevor Beebee

Plate 2 Upper saltmarsh with breeding pools, Cumbria.

Peter Carty

Trevor Beebee

Plate 3 Heathland with breeding pool, Norfolk.

Plate 4 Hi-mac excavator at work.

Paul Rooney

Paul Rooney

Plate 5 Close up of rake attachment on Hi-mac excavator.

Plate 6 Four-wheel drive tractor at work.

Paul Rooney

Paul Rooney

Plate 7 Wide-gape grab on four-wheel drive tractor.

Plate 8 Completed concrete saucer pool. Photo: T. Beebee.

Trevor Beebee

Plate 9 Natterjack spawn in a shallow pond margin, exposed.

John Buckley

John Buckley

Plate 10 Natterjack spawn in a shallow pond margin among vegetation.

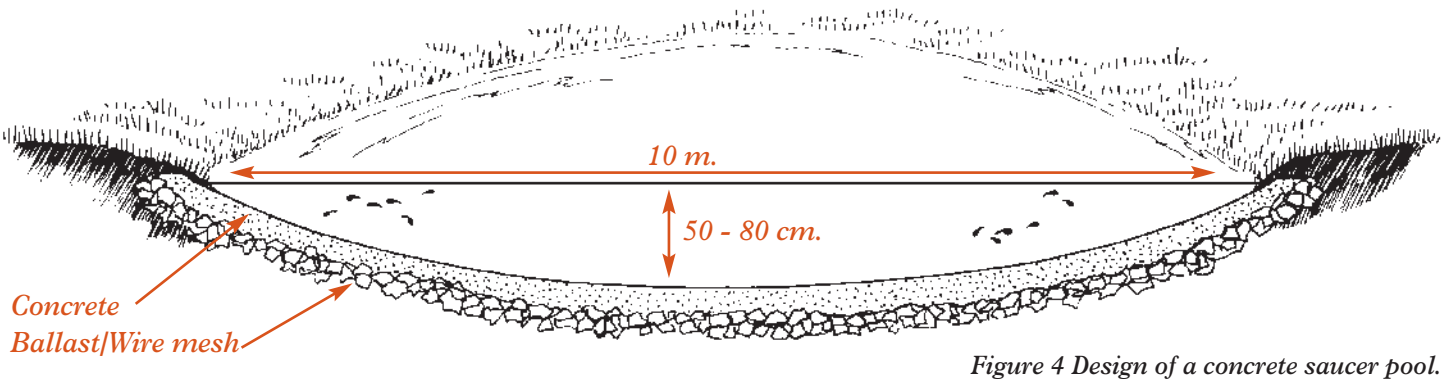


Figure 4 Design of a concrete saucer pool.

As a rule of thumb, one lorry-load of ready-mix provides about enough concrete to complete a 7 m diameter pond. The concrete should be smoothed off with a float to generate a saucer without lips (see Figure 4), and left to harden for at least a week. Concreting should not be carried out when there is a risk of frost, in hot weather or in heavy rain.

The pond can be left to fill naturally with rainwater or filled artificially from a bowser, but in either case steps must be taken to reduce the alkalinity that seeps out of the fresh concrete and generates toxic pHs of 10.5 or above. The pond should be drained at least 2 weeks after its first fill, and then allowed to fill (or refilled) again. One such water change may be enough, but another after a further two weeks or more is desirable. pH should be below 9.5, and preferably below 9.0, to be acceptable.

The pond should be kept as free as possible of vegetation and silt but sand and turf, preferably with moss, should be laid around the rim top to provide cover for emerging toadlets. Such ponds look remarkably natural after quite a short space of time, (see Plate 8).

Other important factors relevant to natterjack toad management

Other aspects of natterjack management are general rather than specific to a particular habitat type, and are therefore of potential importance to managers at any kind of site.

Control of competitor species

After years of scrub encroachment, the numbers of competitor species (especially common toads, but also frogs) can become dangerously high even in frontal dune slacks some distance from the scrub itself. In this situation, pending management to remove scrub, direct removal of competitors may be necessary as a short-term palliative. Adult frogs and toads should be collected en route to or at the ponds (usually in February or March), if possible before they have spawned, but any spawn laid should also be collected. Adults and spawn should be placed in buckets with a little water, and moved at least 2 km away before being released at some other suitable pond. Adults are likely to return to the original pond if released at lesser distances.

This process is more difficult and time-consuming than it sounds, and must be repeated every year until the primary problem (scrub) is addressed. When scrub is removed and a grazing regime established, numbers of competitor species can be expected to diminish naturally as the habitat becomes unsuitable for them.

Since natterjacks spawn later than either of the other two anuran species, at some sites competitors can be controlled by keeping breeding ponds dry until around mid-April, ie. after the other species' breeding seasons have ended. This can be done through use of sluice gates or filling ponds from bowsers. Though this can be effective, it is highly artificial and can be time-consuming.

Competitor control should not, therefore, be considered an alternative to proper habitat management but very much a short-term measure.

Use of fish to improve natterjack breeding success

Although most ponds used by natterjacks are ephemeral, some (especially on heathlands) are naturally permanent and others (such as concrete saucers) are artificially made so. Naturally large ponds often have native coarse fish populations, and by consuming invertebrates and common frog tadpoles these fish reduce both predation on and

competition with natterjack tadpoles. Certain species of fish can be used in concrete ponds, and even in ephemeral ponds, to the same effect. Small (70-80mm) perch *Perca fluviatilis* are particularly good and are readily available from many coarse angling clubs. These can be added to ponds (5-10 per typical concrete pool) in March or April. In permanent ponds the fish can be left in place, but in temporary pools they can be rescued and released elsewhere just before pond desiccation in midsummer. In either situation the fish generally survive very well, and improve the numbers of natterjack tadpoles surviving to metamorphosis dramatically. Their effects however are smaller in weedy ponds than in those with minimal vegetation. This management tool is useful in situations where natterjack reproduction has been poor for several years, as may happen (for example) after a series of wet summers in which ponds desiccate briefly or not at all; predatory invertebrates therefore become unusually abundant. However trials using three species of fish have shown that care needs to be taken with the choice of species used. Carp *Cyprinus carpio* and perch have been shown to remove aquatic invertebrates and result in enhanced natterjack toad tadpole survival and growth rates. Rudd *Scardinius erythrophthalmus*, on the other hand, predate natterjack toad tadpoles and are therefore not suitable. Fish species therefore vary dramatically in their value for natterjack management.

Captive rearing of spawn

Occasions sometimes arise when it is useful to take spawn from the wild and rear tadpoles to a large size, or even through to metamorphosis, in captivity. This can be an effective way of boosting reproductive success at sites where there is concern over population size or an obvious decline in numbers. This is because survival from egg to toadlet in captivity is easily made 90% or better compared with an average of less than 5% in the wild. This method is also preferable to captive breeding, ie. where adult animals are kept in captivity and bred, for several reasons:

- Natterjacks often do not breed well in captivity and consequently the production of spawn may be erractic and unreliable.
- A substantial investment in time and cost is required to house and feed the natterjacks and this could be better deployed elsewhere.
- It is a long term commitment keeping animals in captivity in vivaria, which need to be maintained to house natterjacks over many years.
- If a captive population breeds successfully then it is likely that year after year large numbers of toadlets will be produced. This can lead to a surplus of young and it may be difficult to find suitable places to release them.

Collecting spawn strings for specific purposes avoids these problems and ensures that animals from the most 'appropriate' site are chosen for introductions. It causes little or no impact on the 'donor' population.

Spawn, perhaps (though not necessarily) taken from a shallow pool on the verge of desiccation, can be kept in a bucket with pond water for a day or two or transferred immediately to a rearing pool if one is already available. Rearing pools are produced simply and quickly using polythene or butyl sheets either sunk into a shallow depression or with banks raised above ground with wood or brick supports (Figure 5). The bigger the better, since tadpole overcrowding should be minimised to obtain the best growth rates, and a surface area of perhaps 3 x 3 m is a reasonable target size that could support several thousand tadpoles at stocking rates of less than 5 per litre.

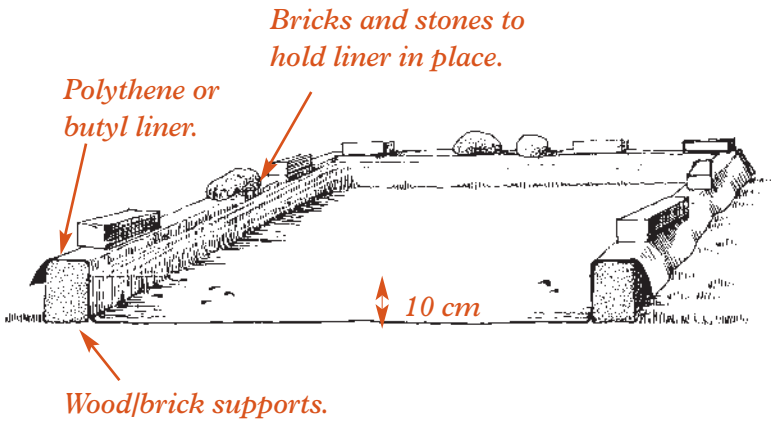


Figure 5 Design of artificial rearing pool.

A uniform depth of around 10 cm is ideal, with the pond positioned to receive full sunshine, filled with tap water and left for 24 hours to dechlorinate before adding spawn or tadpoles. No aquatic vegetation or sediment is necessary or desirable. When they are free-swimming, the tadpoles can be conveniently fed using pellets (the cylindrical sort) of compressed vegetable matter sold commercially as rabbit food, or with various other material including pelleted fish food. Food should not be added in excess or the water will foul and the tadpoles die; by trial and error, a level of feeding should be found such that the pellets are always consumed within less than a day and food added at least every two or three days. If the water becomes at all murky, feeding should cease and if the

tadpoles seem distressed or mortalities occur, the water should be changed quickly. In practise, rearing natterjack tadpoles is normally a very simple matter. Tadpoles can be released when very large (c. 20-25 mm) but not too close to metamorphosis if water is still available in the natural ponds, or metamorphosis can be allowed to proceed and toadlets collected for release as soon as they develop front limbs (i.e. within a day or so of when they would leave the water). This is rather labour intensive since metamorphosis often continues for several weeks, and toadlets should not be kept for more than a day or so before release. They need to feed quickly at this stage, and soon die of hunger if no small invertebrate food is available. Toadlets should be transported in boxes of damp moss, and released in the cool of evening in areas of similar damp, mossy vegetation. They drown easily, so they should never be liberated into even the shallowest of water.

A licence is required to take animals (including tadpoles and spawn) from the wild for any captive rearing programme.

Encroachment of New Zealand stonecrop, Crassula helmsii.

This pernicious alien weed is well adapted to sandy, shallow ponds typical of the kind used by natterjacks and has appeared at several natterjack sites. Dense growths are likely to disadvantage natterjacks because they can harbour large numbers of invertebrate tadpole predators. Several points arise:

- Great care is necessary to try and avoid spreading *Crassula helmsii* further, once appears at a site. Nets, boots etc. must be checked carefully between visiting different ponds, since the smallest fragment will found a new invasion by rampant vegetative growth. Similarly, precautions should also be taken to avoid *Crassula helmsii* contamination when using spawn or tadpoles for translocations. One problem with grazing regimes is that although livestock such as cattle consume *Crassula helmsii* and may effectively control it, they do not destroy it, and are likely to spread it between ponds.

- Herbicide treatments including massive doses of sodium chlorate have proved unable to eradicate *Crassula helmsii,* though they do drastically reduce its abundance for a while and can be employed as a short-term respite.

- Burying (to a depth of 10 cm) small areas of the plant manually, or large areas of scattered patches by machine, is effective at eradication and should be done when the infestation is caught early enough to be manageable in this way.

- In extreme cases, the only practicable solution is to infill the entire pond and create a new one somewhere nearby. This has worked well at a Merseyside sand dune site.

Control of predators

Different species of predators can affect natterjack populations by predation of spawn, tadpoles and adults. Occasionally these effects can be significant and some populations are even believed to have been lost as a consequence. However, with robust populations of natterjacks the impacts of predation are usually likely to be insignificant and predation should be accepted as a natural component of the system. Small populations may be more vunerable. Consequently it is usually better practice to aim to enhance natterjack numbers through habitat management, rather than to try to control predators. The need for, and practicality of, controlling predators varies between sites and the species concerned and should only be considered if predators pose a real threat to the population. Issues such as legislative contraints and public perception also need to be addressed.

Possible impacts of predation should be considered when managing natterjack habitat, especially in connection with translocations. For example, siting a natterjack site near a rubbish dump could attract problems from both gulls and rats.

Invertebrate predators, such as the great diving beetle *Dytiscus marginalis* do consume large numbers of tadpoles. Similarly other aquatic invertebrates (eg. water boatmen), or aquatic phases of invertebrates (such as the larvae of dragon and damselflies), will also prey on the natterjack tadpoles. Aquatic invertebrates are best managed by controlling water levels or water quality. For example, inundation by tidal water in winter at some sites prevents the development of large invertebrate faunas. Where natural inundation is prevented it may be necessary to mimic this process, eg. by flooding ponds with sea water in winter to allow enough time for rain and seepage to freshen the ponds up before natterjack breeding. Elsewhere ensuring ponds dry out can have the same effect. This is best achieved by not having too deep a pond.

Another method of controlling invertebrates is by introducing fish (see *Use of fish to improve natterjack breeding success*).

Vertebrate predators include grass snakes *Natrix natrix*, birds and mammals. In most cases the impacts of these animals will have an insignificant impact on natterjack populations. Generally, control should only be undertaken if there is a clearly demonstrable link between predation and a threat to the population.

The impact of grass snakes on natterjack populations can best be reduced through habitat management. Grazing around ponds makes the habitat structure less suitable for grass snakes while making it more favourable for natterjacks. This, together with the effect of physical disturbance from the grazing animals, will reduce the numbers of grass snakes. Grass snakes are protected and should not be intentionally killed.

Predation by birds is generally insignificant. The most likely threats are from crows (Corvidae) and especially magpies *Pica pica,* though herons eg. *Ardea cinerea*, gulls (Laridae), ducks (Anatidae) and even waders (Charadriidae) may take adults, toadlets or tadpoles. In some areas crows seem to take common toads more often than they take natterjacks; consequently the presence of predators may even benefit the natterjack population. If necessary, crows can be controlled by shooting or trapping. Often a better approach is to remove perching and nesting sites; eg. by removing trees and scrub. This is very often consistent with other site management objectives. Most other bird species are protected against killing or trapping, etc. Bird scaring may be considered or birds can be discouraged by habitat management. Rarely, though will these actions be justified.

Mammals, including stoats *Mustela erminea*, mink *Mustela vison* and foxes *Vulpes vulpes*, may take natterjacks. Usually though this would be insignificant and would not justify control or management to reduce predation. While generally their habitats do not coincide, in some circumstances rats *Rattus norvegicus* may be a threat. Poisons, eg. warfarin, may be considered but extreme care needs to be given to their use to avoid harming non-target species.

5. Translocation of natterjack toads

Translocation of natterjacks to establish new populations has become a successful conservation tool, and suitable protocols are outlined as follows:

Choosing the site

Several factors must be considered before a natterjack translocation is initiated, if there is to be a reasonable chance of success:

- Geographical location. Priority should go to those areas within the well authenticated historical range where natterjack declines have been greatest (see Section 1). These include: coastal dunes in Lincolnshire, Norfolk, Clwyd and the Wirral; coastal saltmarshes in south Cumbria; and most especially heathlands in Norfolk, east Suffolk, north Surrey and the western Weald.
- Site security. Potential translocation sites should have at least SSSI status and a sympathetic landowner, and preferably a management agreement or nature reserve status.
- Natterjack presence/absence. Potential translocation sites should be properly surveyed (see Section 7) to ensure that the species is absent before translocation is undertaken, unless the translocation is to rescue a population on the verge of extinction. In the latter case, every effort should be made (by habitat management) to restore adequate conditions and thus revive the native population before a translocation is entertained.
- Habitat quality. Both terrestrial and aquatic habitats should meet the criteria outlined in Section 3, or should be readily restorable to such quality. In the former case, reasons why natterjacks are currently absent should be well understood; in the latter instance, the necessary restoration should be completed before the translocation starts.
- Predators and competitors. Large adjacent populations of common frogs or toads have considerable management implications for the establishment and maintenance of natterjacks, as do large numbers of predators such as rats, gulls, grass snakes or aquatic invertebrates. Possible problems from such factors should be carefully assessed at any potential translocation site.

- Permissions and agreements. It is of course essential to consult widely with, and gain the approval of al interested parties including landowners and managers of donor as well as recipient sites, herpetological experts and the appropriate statutory nature conservation organisation (English Nature, Countryside Council for Wales or Scottish National Heritage) from which a licence will be required.

Preparing the site

Management to prepare a site, if required, should follow the guidelines given in earlier sections. Concrete ponds have proved particularly popular and successful for heathland translocations, but preference should always be given towards using the natural water table where this is possible.

Carrying out the translocation

Critical but simple steps to follow in a natterjack translocation:

- Choice of donor site. This should be agreed well before the translocation is due to start, and should normally be the nearest population to the proposed recipient site that is on the same habitat type. Occasionally, suitable captive-bred stock may be available and this possibility should also be investigated.

- Material to be moved. The equivalent of at least two spawn strings (normally c. 4000-8000 eggs), but preferably made up from short sections of several strings to give the broadest genetic base, should be obtained from the donor site. This will normally be in April or May; fresh laid spawn should be chosen because it travels well, sections cut *in situ* with sharp scissors, and carried in a bucket containing 2-5 litres of water from the pond(s) in which the spawn originated. Although fresh spawn is fairly robust, it should be kept reasonably cool (buckets not left in the sun behind glass) but not colder than 15°C and transported to the recipient site as quickly as possible, certainly within 1-2 days. Small or medium-sized (ideally 15-20 mm) tadpoles can also be moved, but well developed spawn or tadpoles near metamorphosis should be avoided because mortality during transportation can be high. All toad tadpoles are susceptible to suffocation, and should be moved in cool water with minimal amounts of dissolved or suspended organic matter.

- Release and monitoring. Normally the spawn is released directly into the recipient pools, though it can be kept back and tadpoles grown up in artificial rearing pools to maximise survival if desired (see Section 4, *Captive rearing of spawn*, page 18). Spawn should be laid out in extended form, not clumped, in shallow (perhaps 10 cm deep) margins of the recipient ponds. If water levels are falling fast, daily inspection may be necessary until the tadpoles hatch and are free-swimming (maybe 7-10 days, rarely longer) and the spawn gently moved if need be to prevent death from desiccation. After hatching, occasional visits should be made to get an idea of survival and ultimately to determine whether, and roughly how many, toadlets emerge (see Section 7).

- Subsequent work. The translocation (previous two parts) should be repeated in two consecutive years, unless some form of catastrophe in the first year indicates that the translocation effort should be aborted. Moderate toadlet production (at least many 10s, preferably low hundreds) in two consecutive years is normally enough to start a population. Adult males are likely to return and call in late May or June two or perhaps three years after the first translocation, but females (and thus the first lot of second generation spawn) usually do not appear until a year later. Such spawning is a strong indicator of success, but several further years and the appearance of third generation spawn is the most convincing evidence that a colony is established. It is therefore important to monitor translocation sites carefully for at least 5 years, and preferably longer, after starting the process.

6. Site protection and mitigation

Natterjack toad sites are protected by a number of different means. Many sites receive protection through various levels of designation. They may be protected as nature reserves; these can be as National Nature Reserves (NNR's) that are declared by the statutory nature conservation organisations (SNCO); ie. English Nature, Countryside Council for Wales or Scottish Natural Heritage, or as Local Nature Reserves (LNR's) designated by local authorities. The majority of natterjack sites in Great Britain have been designated Sites of Special Scientific Interest (SSSI).

This is a statutory designation made by the SNCOs which means that certain actions on the site are regulated to stop these threatening the interest on the site. The landowner and local authority are made aware of the presence of the natterjack toads and of the actions which cannot be carried out unless specially consented by the SNCO. SSSI designation is also an important consideration in planning; the SNCO is consulted on planning applications or other operations which can threaten the site, such as laying water pipelines. Such designations are very valuable in safeguarding sites.

As well as the possibility of a site designation the animals and their habitats are protected by 'species conservation' provisions of the Wildlife & Countryside Act 1981 and the Conservation (Natural Habitats & c.) Regulations 1994 (see Section 2). These provisions provide a useful further tier of protection. Even on sites that have no designation, damage or destruction of the habitat and any activities that are likely to result in death, injury or disturbance to natterjack toads are prohibited unless this cannot reasonably be avoided. In many cases such damage can be avoided, for example by changing timing of operations, doing things in a different way or not doing something at all in an area that will affect natterjack toads. Where this can be accommodated there is a legal obligation to do so.

Furthermore planning guidance produced in October 1994 by the Department of Environment for England (Planning Policy Guidance note on Nature Conservation : PPG 9) gives very explicit direction that the presence of protected species must be taken as a material consideration when determining land use changes or developing local plans. Consequently natterjack toads must be taken into account by the planning authorities. There is similar, though less explicit, guidance for Scotland and Wales.

There are, however, circumstances where natterjack habitat has to be lost; sometimes even on designated sites. For example sea walls may need to be built to protect towns, or planning permission is granted to allow a development, or the siting of a pipeline. In such cases the nature conservation case needs to be fully addressed when determining what course of action is appropriate at any site. Even where a site is to be lost the animals on that site remain protected under species conservation legislation and reasonable steps must be taken to safeguard them. A mitigation package should be expected. Usually the mitigation is sorted out in advance as part of the conditions of a planning consent. In any event adequate effort needs to be spent to safeguard the animals (eg. capturing and moving animals) and to provide them with a suitable alternative place to live. What constitutes a 'reasonable' amount of effort is dependent upon the specific circumstances; the size and nature of the population, the extent of habitat loss or damage and the nature of the threat. For example it may be appropriate to create new habitat elsewhere, to provide sluices in sea walls to irrigate ponds or simply to move small numbers of animals to other existing parts of a site.

7. Surveying and monitoring natterjack toads

The presence and abundance of natterjacks can be investigated by a number of methods. Although only handling animals or disturbing them or their resting places require a licence, and it is possible to monitor natterjacks both qualitatively and quantitatively without doing these, it is safer to hold a licence and thus be free to examine individuals (e.g. for measurement) if required. Various data are useful for acquiring a better understanding of natterjack populations. Simple 'presence or absence' data (ie. qualitative data) allow an assessment of the distribution of the species. This not only helps give an ecological understanding of where the animals are but it is also important for site safeguard or for developing management or mitigation proposals. In other cases an understanding of population size or population structure becomes important. This may help identify the 'best sites'.

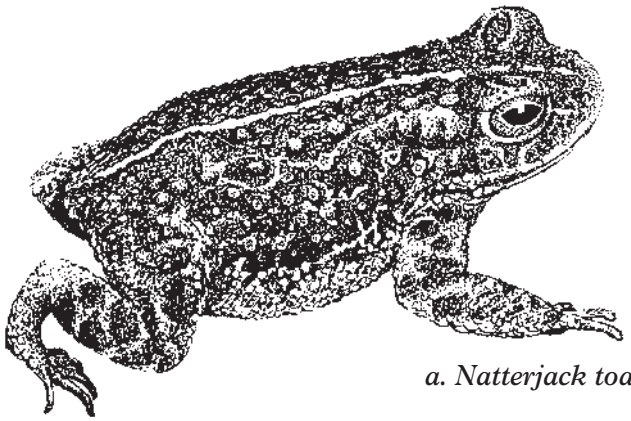
Survey data can be used to see whether there are changes in population status. This requires the collection of comparable data at different times; typically this is between different years and allows changes is population status to be monitored. Monitoring is a valuable activity for assessing the effects of different management methods on a population.

To help achieve a national overview of natterjack populations the *Natterjack Toad Site Register for the UK* (Beebee 1989) has been compiled on behalf of the British Herpetological Society's Conservation Committee. This was first compiled in 1986 (collating information from 1970 where available) and is updated annually. The register provides information about natterjack sites, including population sizes, management of sites, etc. For obvious reasons this is confidential and is only circulated to those involved in conservation. For the inclusion of natterjack records onto the *Site Register* contact English Nature in Peterborough (01733 340345) who will advise on the current holder of the database.

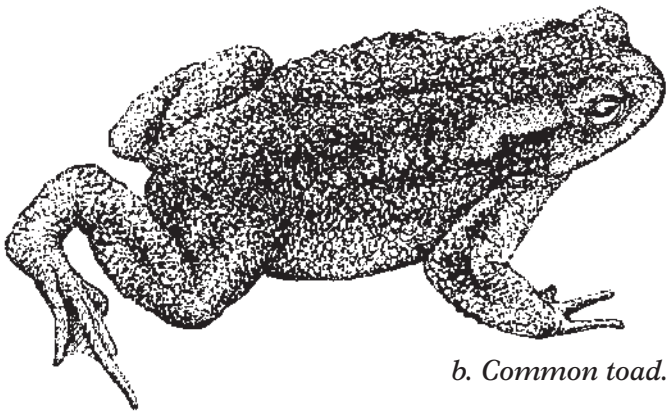
Identification

An obvious pre-requisite to natterjack survey and monitoring is the ability to identify the species. There are other species of anuran in Britain with which the natterjack can possibly be confused, namely the common toad, the common frog and the three species of 'green frog', ie. the pool frog *Rana lessonae*, edible frog *R. esculenta* and marsh frog *R. ridibunda,* which have been introduced and become established. Good field guides can be consulted (such as Arnold and Burton 1978 - see Section 10) which describe and illustrate these species indicating the different features between them. Animals may need to be identified as adults, toadlets, tadpoles or spawn.

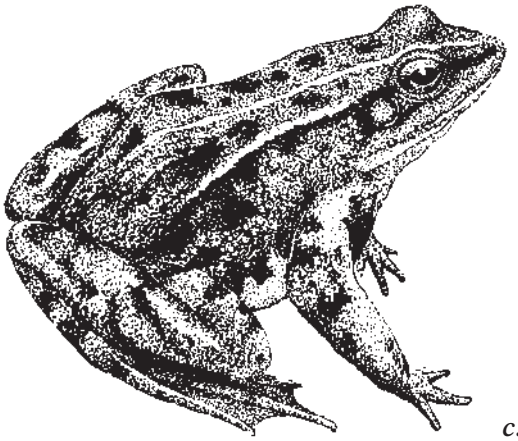
Figure 6 (a) Natterjack toad. (b) Common toad. (c) Edible Frog.



a. Natterjack toad.



b. Common toad.



c. Edible frog.

Adults and toadlets

A clear distinguishing feature of natterjack toads is the yellow stripe that runs down the centre of the back (however it should be noted that some of the species of green frog, eg. edible frog, can have distinct yellow stripes on their backs). Very rarely, though, individual natterjacks may lack this yellow stripe. They are relatively short limbed, their back legs are notably shorter than those of the common toad and the natterjack tends to run, rather than move about by crawling or hopping (as do common toads). The skin is warty in appearance with a generally brown-grey coloration, similar to the common toad, though the natterjack often has a greenish tinge to it and may exhibit darker markings. The large paratoid glands behind the eyes run parallel with each other (compared with the common toad where these are slightly oblique). Usually the natterjack toad is up to 70 mm in length (see Section 7, Quantitative assessment: *Population size structure*, see page 26). The call, which is often in a chorus made by a number of males, is a loud rolling croak, like a ratchet, which is repeated a number of times. It is loud enough to be heard some distance away; on quiet still nights over 1 km. Each croak begins and ends quite abruptly and usually only lasts for one or two seconds; the call is produced by inflating the throat as a single vocal sac.

The common toad also has a generally uniform coloration to its warty skin; like the natterjack it is usually brown-grey, though it may vary in colour from almost brick red to olive and to dark brown. The large paratoid glands run slightly oblique behind the eyes. It has notably longer legs than the natterjack and typically moves in a series of crawls and short hops. Common toads are generally larger than natterjacks of comparable age and may typically grow up to 80 mm in length. No external vocal sacs can be seen and common toad calls are quiet and slow. More frequently heard are the rather high pitched 'qwark-qwark-qwark' release calls made by males when grasped by other toads.

The common frog is highly variable in colour, with the back ranging from reddish, through browns and yellows to olive, and is usually patterned with darker coloration. The underside is paler, usually white or yellow. A dark flash of colour is found behind the eye. The skin is smooth (compared with the two toad species). Frogs have long hind legs and move mostly by hopping. Frogs call in a dull, rasping sound, often produced under water. Generally this is quite quiet.

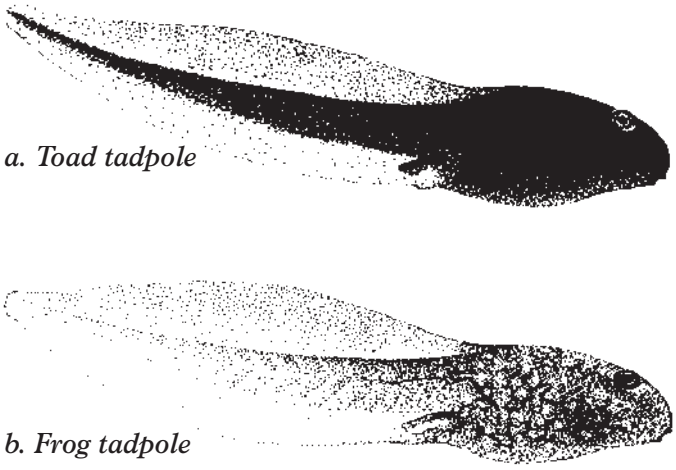
The three species of green frog that occur in Britain, are highly variable in pattern and background colour. They may be mistaken for natterjacks where they have distinct back patterns. The fact they are also noisy can also be misleading. The calls though are noticeably different from natterjack toads. Although there is a difference between the different green frog species their calls vary between 'quacking' and 'laughing' sounds which are quite different to the chur of the natterjack. Green frogs that can be seen calling are also noticeably different; their calls are created by inflating two vocal sacs which are white or grey in colour, one on either side of the mouth rather than by inflating the throat under the mouth as is the case with natterjacks.

Behavioural difference can also be used to help separate species. Common frogs tend to spawn first, usually during February or March; common toads tend to spawn a little later, but usually in March. These species tend to have a fairly short mating period, though numbers may build up slowly before the main period of egg laying. Generally the bulk of egg laying is over within a week or two. Natterjacks spawn later and so appear at the ponds later. This is typically between mid-April and mid-June and the breeding season may last a couple of months. The green frog species breed even later, often between May and July.

Tadpoles

Frog tadpoles can be distinguished quite simply from toad tadpoles. Although when they very first hatch they appear as a writhing black mass, once they start to grow, frog tadpoles become a brown to olive colour with a mottled appearance. Toad tadpoles are almost uniform black. It is very difficult to tell natterjack and common toad tadpoles apart. Some natterjack toad tadpoles have a white patch under their chin which appears when they are half grown. However this is not a fully reliable means of separating the two toad species as tadpoles. Very often because common toads spawn earlier, their tadpoles will be larger than natterjack tadpoles if they occur together. This also is not a reliable means of separating the species and it may be necessary to take a small number of individuals and rear these on in captivity, or use biochemical analysis, to be sure of identification.

Figure 7 (a) Toad tadpole. (b) Frog tadpole.



a. Toad tadpole

b. Frog tadpole

Spawn

Spawn produced by the two toad species differs notably from that produced by frogs. Toad spawn is laid in strings while frog spawn is laid as clumps.

- Natterjack spawn is usually laid as extended strings along the bottom of shallow areas of ponds (5-10 cm deep), whereas that of common toads is usually laid in masses (many females together), in deeper water (maybe 20-30 cm) and intertwined around vegetation.

- Eggs in natterjack spawn usually form a single row, those in common toad spawn a double row. Very fresh natterjack spawn, however, sometimes looks double-rowed.

- Common toad spawning is usually complete by early or mid-April, whereas natterjacks are normally just starting up at this time and continue for up to several weeks thereafter. So although there is a small temporal overlap during which difficulties with identification can arise, spawn laid from May onwards is almost certain to be natterjack.

- Since natterjack and common toad tadpoles are extremely difficult to distinguish, the only ways of confirming spawn identification are by either taking a few eggs and rearing them right through to metamorphosis, or arranging for a biochemical analysis of a small sample of the spawn jelly.

Qualitative assessment

Calling males

In spring, mostly between early April and early May but occasionally as late as June or July, males vocalise loudly under suitable weather conditions (ideally warm, damp nights between dusk and midnight) and can be heard up to 1 km or more away from the breeding ponds. This is not, however, an appropriate method for assessing numbers because only a proportion of males will be at the breeding sites at any one time, and not all of these will in any case be calling. During a quiet spell, males can sometimes be induced to call by playing a tape recording of a natterjack chorus at or near the likely breeding ponds.

Animals in refugia

Throughout their activity period (i.e. spring through to autumn), natterjacks can be found in daytime under stones, flotsam or any other kind of cover that can easily be overturned for inspection. Artificial refugia (such as roof tiles) can be laid out on a site if none are already present, and inspected days or weeks later for use by toads. Such refugia are best when of reasonable size (at least 40 x 30 cm) and are most attractive to toads when laid on bare sand rather than vegetation. Natterjacks make their own burrows as natural refugia, and are likely to desert artificial ones in favour of burrows in periods of hot weather. Artificial refugia should be used with care, because they may render toads more vulnerable to predation by snakes and, at sites with heavy public pressure, also by humans.

Night searching

Natterjacks emerge at dusk and after dark between spring and autumn to hunt their invertebrate prey. Because they prefer to hunt on open ground, including sandy tracks and paths, they are relatively easy to find at this time just by walking the habitat and panning around with a powerful torch. This method is particularly useful for summer and autumn searching of sites with few or no artificial refugia, but is very weather dependent. Hot, dry spells will keep the toads underground and the best conditions are on mild or warm nights during or after rain.

Quantitative assessment

Serious monitoring of natterjack populations requires estimates of adult population size and breeding success on a regular (annual) basis. The best measures of these two parameters are spawn string counts and toadlet numbers respectively, and where available both of these data sets are recorded every year in the *Natterjack Toad Site Register for the UK*. The size and structure of natterjack populations can also be a useful guide to the regularity of breeding success.

Spawn string counts

Natterjacks usually spawn in shallow, unvegetated water and separately from one another (see Plate 9, page 16). This makes it possible to count the numbers of spawn strings laid each year with an accuracy of +/-5% if sufficient time is put in. An initial prerequisite, of course, is identification of natterjack as opposed to common toad spawn.

The method involves walking around the margins of, and sometimes through if they are very shallow, all prospective breeding pools at least once a week and recording every spawn string seen on each occasion. Fresh laid strings are easily recognised, and where public pressure is low old strings can in any case be flagged with a stick so they are not scored twice. Because the natterjack breeding season is a protracted one, inspection may have to be repeated for eight weeks or more, from early April to at least early June; however, bouts of spawning activity are often triggered by appropriate weather conditions (especially rain after a dry spell) and with experience the monitoring effort can safely be reduced at times when breeding is unlikely. Occasionally strings are laid close together and are thus difficult to distinguish, and in some peaty ponds (especially heathland ones) or vegetated ponds strings can be missed (see Plate 10, page 16). In most pools however the method is accurate and straightforward.

Cumulative spawn string counts at a site are taken to reflect the approximate adult female population size, and since the sex ratio of natterjack populations is usually about unity, doubling the numbers of spawn strings gives an approximate total adult population size. But there are important caveats; there is evidence that not all females spawn every year, the proportion of non-spawners increasing as a function of the dryness of the spring. In occasional very extreme dry years, such as happened at several sites in the mid 1970s, no females at all may spawn. By contrast, some females may spawn twice in the same year though this seems to be a rarer problem. Spawn string numbers should therefore be interpreted with caution, taking account both of the monitoring effort (and thus the likelihood of missing some) and climatic conditions (and thus the proportion of females that may not have bred).

In general, variations between years either up or down should not be taken too seriously unless there is a particular reason for concern, but long term (5 years or more) trends scrutinised for a more accurate impression of how the population is faring. Even this is not entirely satisfactory, because it is known that some amphibians have population sizes which oscillate for natural reasons over quite long time spans. In cases where there may be uncertainty about whether the spawn is that of the natterjack or of the common toad, as long as these are only occasional strings out of a large total that are uncertain, then it is probably simplest to discount them from any assessment.

Toadlet production

Getting an idea of how many toadlets are emerging each year is a direct measure of breeding success, and adult population size is directly related to average toadlet production over a period of years. Knowing about toadlet production is therefore very helpful in putting any apparent trends in spawn string numbers into perspective; persistent breeding failure obviously indicates that a serious problem has arisen.

Metamorphosis can occur at any time between mid-May and July, sometimes even later, but June is the peak month for most sites in most years. A frequent (but not invariant) sign that metamorphosis is imminent is an apparent mass disappearance of large tadpoles in ponds previously teeming with them, reflecting a behavioural change that makes them much more secretive (hiding in bottom silt) in the few days before they emerge. Ponds should be inspected at weekly intervals, looking carefully around the margins for the tiny (7-8 mm) toadlets. The metamorphs have the characteristic yellow vertebral stripe and are thus easily identified, but are so small as to be easily mistaken at first glance for invertebrates crawling through bank side vegetation. Great care is necessary at this time to avoid trampling the toadlets, which often (but not always) emerge from a few favoured spots around each particular pond and frequently aggregate in clumps to conserve moisture. Toadlets are active in daytime, but estimates of numbers can be made only to within an order of magnitude (0, 10s, 100s etc). Once the first metamorphs are seen, the pond should ideally be checked intensively over the next week or two and the maximum number seen on the best day used as a measure of toadlet output. Depending on weather conditions, toadlets sometimes disperse rapidly away from the pond and failure to monitor for more than a week can completely miss evidence of successful metamorphosis.

Population size structure

Adult body size (measured from vent to snout tip by gently pressing a ruler along the animal) is, in most populations, quite strongly correlated with age. The presence of immature natterjacks (less than 40 mm long) indicates that breeding has been successful within the previous two years, and animals more than 70 mm long are usually more than four or five years old. A healthy natterjack population should include individuals with a variety of sizes including immature and old animals but with a median in the 50-60 mm range. Populations dominated by or containing exclusively large animals (65 mm and above) should be examined carefully, because such a size structure implies little or no breeding success for several years.

One caveat with this method is that the relationship between size and age is very poor in dense populations, but such situations are by definition not ones in which there is likely to be concern about reproduction rate.

8. Advice and assistance

Advice and both financial and practical assistance can be found from a number of different sources. A first point of enquiry is the headquarters of the appropriate statutory nature conservation organisation (SNCO); English Nature can be contacted at their headquarters in Peterborough (01733 340345), Countryside Council for Wales in Bangor (01248 370444) or Scottish Natural Heritage in Edinburgh (0131 447 4784). Alternatively the local or regional offices of these can be contacted especially if the enquiry relates to a site specific or planning issues; their addresses and telephone numbers can be found in the telephone directory or by contacting the organisation's headquarters. Where handling or capture is contemplated, or other activities such as photography that may cause disturbance, a licence is required. Enquiries should be directed towards the appropriate SNCO's headquarters.

Financial support may be available from the SNCO. This may be available through grant aid (where a maximum of 50% of the costs can be covered), via a Management Agreement for work on designated sites or possibly through contract work. English Nature's Species Recovery Programme has provided funding over a three year period for the conservation of the species (1993-1995).

The Herpetological Conservation Trust (HCT) is continuing work started through English Nature's Species Recovery Programme and is working throughout the UK and Ireland. This organisation now employs an officer specifically to take work forward for this species. Practical assistance and advice can be obtained from HCT in Bournemouth (01202 391319)

Other advice can be obtained through commercial environmental consultancies, especially where these specialise in herpetological work or have undertaken work on this species previously.

9. An outline ten year plan for the natterjack toad

Background

Habitats used by natterjacks

The conservation of the three main types of habitat required by this species in Britain is important to sustaining natterjack toad populations. These are : upper saltmarsh, coastal dune and inland heath. Of these, some upper saltmarsh and dune sites require little positive management and might persist for long periods without human assistance, but increasingly both types of habitats are suffering degradations of various kinds. Thus some saltmarshes are undergoing invasion by cord grass *Spartina* spp. or sea club-rush *Scirpus maritimus* and many dune systems are becoming over-fixed by expansion of sea buckthorn *Hippophae rhamnoides*, along with other scrub species and dense ground vegetation. Heathland is an inherently sub-climax ecosystem which will always require positive management to maintain it into the future. Much the same is true of yellow dune, a plagio-climax community also subject to seral change. It follows that in many natterjack toad sites there will be a long-term need for some kind of management.

Natterjack sites in Britain

Presently there are 52 known natterjack sites in Britain (assuming Cockerham and Workington are extinct). The breakdown of natterjack sites by habitat type can be seen in Table 1.

From this breakdown it is evident that a substantial proportion (at least 32, about 60%) of natterjack sites will require substantial long-term positive management; but only 17 (about 30%) currently have the intensive wardening and other back-up needed to achieve this. This wardening cover does not always relate to the sites most in need of it.

Even at wardened sites additional back-up, monitoring and other long-term support will often be needed. Central coordination has been a feature of natterjack conservation for many years, brought together in the *Natterjack Toad Site Register for the UK*, and without such an overview the species would be in a more precarious position than it currently enjoys. In our view the continuation of this centralised approach is vital if conservation gains are to be maintained.

Habitat type	Total No.	Sites needing long-term management	Adequate warden cover
Saltmarsh (predominantly)	10	1	1
Sand dune (predominantly)	24	15	11
Heathland	14	14	4
Other	4*	2	1

Table 1 Natterjack habitat types

* Notably: sites at an ironworks, a moorland site, a sandpit and a cliff site.

Future work

Monitoring

Adequate monitoring of natterjack populations is the essential background upon which future conservation work depends. This is currently carried out with varying degrees of efficiency by full-time wardens, volunteers, etc. depending on the site and is summarised annually in the *Natterjack Toad Site Register for the UK*. Better monitoring of many sites, including developing monitoring regimes at recent reintroduction sites to determine their success, is an essential part of this 10 year plan. Monitoring requires two key observations:

- An assessment of spawn string deposition, so cumulative totals for each site are available every year.

- An assessment, to within an order of magnitude, of toadlet production.

The former is a measure of current adult population size, and the latter of reproductive success.

Management

The English Nature Species Recovery Programme project highlighted the need for management plans, especially for the multiple small sites in Cumbria, to take account of natterjack requirements. Some of these plans have been produced, but most are still not done. An important task is therefore to complete plan production for all outstanding sites.

A follow-up from the production of management plans is discussion of them with the various site owners and the instigation or extension of management as necessary. This work is essential to avoid more natterjack populations being lost by accident or neglect.

Translocations

Not all potential sites identified as suitable for natterjack translocations have been acted upon and there is still scope for further translocations (eg. at new sites, by expansion and consolidation of sites eg. saltmarsh sites in Solway and South Cumbria, and by further development of sites initiated during the Species Recovery Programme project). It is highly desirable that the experience with translocation obtained during the Species Recovery Programme project is capitalised upon, as and when opportunities become available in future.

Research

Most research essential for natterjack conservation has now been completed, but there are at least four areas in which further applied research would be useful:

a. The impact of grazing on natterjack populations is only partly understood; some grazing is highly beneficial, but overstocking is likely to be detrimental both to terrestrial and aquatic habitats. There is scope, and a real need, for obtaining more information on getting the right balance with this important management tool. This is particularly important as part of an assessment of the newly discovered moorland habitat in south Cumbria, an environment in which more ecological study of *Bufo calamita* is warranted in any case.

b. Competition between tadpoles. Although we know much about competition between natterjack tadpoles and those of competitively superior species (common frogs and toads) in the laboratory and in replicated ponds, studies in the field are still sparse, and we do not really known what level of competition is tolerable to natterjacks.

c. Breeding success in large, fish-stocked ponds. Although ponds of this type seem to have been important natterjack sites in the past, particularly on heathland, we know little about how successful they were, or can now be made under management. Studies on the impact of factors specific to such large ponds (especially wind action, wave-washing of banks etc) on natterjack breeding would be very useful.

d. Colonisation of new ponds. We still understand the colonisation of new habitat, especially newly created breeding sites, very imperfectly; sometimes it happens within a year, other times not for many years, for no obvious reason. More information about this would also be very useful, especially since the Species Recovery Programme project has opened up a lot of new habitat.

Plan of action

The central requirement for a 10 year (and beyond) follow up to the Natterjack Species Recovery Programme project is, in our view, a full-time post. One person could ensure that the 'future work' outlined above was carried through, if organised as follows:

a. Spring and early summer months (March-July). This period would be taken up mainly by monitoring sites not well covered by full-time wardens, including the enlistment of volunteers to help out wherever possible. Key sites occur in four widely separated parts of Britain, ie. Southern and Central England; Eastern England; South Irish Sea; North Irish Sea.

   One person could not monitor all key sites every year, but a rota system concentrating on geographically close clusters of sites each year (and delegated other clusters to lower intensity volunteer cover) would be adequate.

   Translocation of spawn to any new reintroduction sites, and their subsequent monitoring, would also be carried out in spring.

b. Late summer and early autumn (August to October). This time would be spent compiling monitoring data, writing or amending management plans, seeking funds for and obtaining permissions for management or new translocations, and investigating possible site purchase.

c. Late autumn to early spring (November-February). Supervision of and, where necessary, active contribution to management operations.

   Throughout the year there will be a continuous need to liaise with site owners to promote good management practice and aid development of long-term management methods, especially grazing regimes at sites where money has been invested to prepare the ground. At other sites grazing will need to be further developed and introduced elsewhere when permissions and finance are available. Research on grazing effects, use of large ponds and pond colonisation could be pursued alongside this development. Development on competition between tadpoles will probably require separate input if and when financial support can be obtained.

Useful addresses

English Nature, Northminster House, Peterborough PE1 1UA

Countryside Council for Wales, Plas Penrhos, Ffordd Penrhos, Bangor, Gwynedd LL57 2LQ

Scottish Natural Heritage, 2-5 Anderson Place, Edinburgh EH6 5NP

Herpetological Conservation Trust, 655a Christchurch Road, Boscombe, Bournemouth BH1 4AP

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