# 5. HEATHLAND AND MOORLAND

## 5.1 Introduction

The active restoration and creation of heathlands and, to a lesser extent, moorlands have been researched and practised for some 20 years. A significant reason for this activity has been the need for the restoration of pipeline routes where they cross heathland and moorland areas. The knowledge gained from this has subsequently been applied to mineral waste sites, roadside verges, moorland restoration projects following major fire damage, and a wide range of other projects including the restoration of overgrazed moorland and moorland reinstatement in relation to wind-farm developments. Some of these schemes have aimed to restore or create semi-natural vegetation, some just to create a dominant sward of heather or ling *Calluna vulgaris* and others in between these two extremes. In the *Review*, some 10.6% of the habitat creation projects were heathland creation schemes.

Gimingham (1992) suggests that the sites for lowland heathland habitat creation schemes generally fall into one of four categories:-

(i) *Clear-felled forestry plantations* - probably the best choice of site for lowland heathland habitat creation due to the possible survival of a heathland seed bank and the survival of the heathland soil profile without fertiliser addition as would be found with agricultural improvement. However, given the strict definition of habitat creation used in this *Guide*, these projects are more correctly termed habitat restoration/enhancement schemes.

(ii) *Exposed mineral surfaces* - good success can be achieved on artificial substrates produced by mineral/mining activity such as china clay waste, sand and gravel overburden and colliery spoil.

(iii) *Pipe-line crossings* - with careful planning, the re-establishment of heathland on pipe-line routes is a restoration rather than a habitat creation process; often it requires a combination of both restoration and creation techniques, sometimes with the use of heathland turves.

(iv) *Abandoned agricultural land* - potentially the most difficult heathland habitat creation sites due to high plant nutrient levels produced by agricultural improvement and management. There are exceptions to this such as where the land had not received substantial lime and fertiliser input, eg. some pasture sites in Dorset.

In the upland situation, mineral workings, pipeline crossings and former agricultural land will also provide sites for habitat creation schemes, but local issues and past management will differ from those on lowland sites and these is need to be taken into account. The restoration of blanket peat is considered in Chapter 6, section 6.5.4.

It is important for the habitat creation planner to have an understanding of the heathland and moorland community types which occur in the British Isles. There is a common misunderstanding that heathland habitat creation consists solely of the establishment of heather and all else will follow from this. However, the situation is more complex and requires a knowledge of the heathland types which occur.

## 5.2 Types of heathland and moorland

### 5.2.1 General description

Heathland is a term applied to open, relatively treeless landscapes supporting dwarf-shrub vegetation, often dominated by common heather or ling *Calluna vulgaris*. In many parts of Britain, the words "heath" and "moor" are interchangeable, but frequently a distinction is made between moorland, which generally occurs on the wetter and more upland soils and heathland on drier, more lowland sites, eg. <250 metres in altitude. Moorland is often the area of unenclosed land above the moor/fell wall. This distinction is enhanced by the predominance of organic, peaty soils in the uplands, and sandy acidic soils in the lowlands.

The distinction between heathland and moorland does break down in many parts of the British Isles, especially in Scotland, and transitions occur into mire communities such as valley mires on southern England heaths and blanket bogs on mainly northern, upland moorland areas. This problem with distinguishing between heathland and moorland has led the National Vegetation Classification into classing all such non-mire communities as types of heathland, in fact some 22 community types (Rodwell, 1991).

Most heathland communities, excepting those on the most elevated upland areas, have arisen as a consequence of human activity. This mainly relates to the clearance of woodland from Neolithic times onwards accompanied by increased grazing pressure which prevented woodland regeneration. Woodland clearance on sandy, infertile and peaty soils led to the development of the dwarf-shrub heaths which we see today. Heathlands have been maintained to the present time by direct management, especially by grazing, but also by burning and cutting. In recent times, especially in lowland Britain, economic changes have lead to a decline in grazing on most heathlands. This has allowed the natural successional process to scrub and woodland to proceed, leading to the loss of open heathland. An understanding and allowance for this successional trend is an essential component of habitat creation planning for heathlands. In contrast, most upland moorlands have remained under grazing management, resulting in fewer successional problems.

A full description of all heathland types will not be given here and, if more information is required, the NVC descriptions should be consulted (Rodwell, 1991).

### 5.2.2 Lowland dry heaths

Much of our UK dry heathland vegetation is relatively species-poor and can be classified into a series that can be related broadly to variations in regional climate, soils and management. These heaths occur on a wide variety of acidic substrates derived from parent materials such as sands, gravels, shales, sandstones, igneous and metamorphic rocks.

On drier acid sands and podzols throughout the generally warmer lowland areas of Britain, five kinds of heath have been distinguished by the National Vegetation Classification (H1-H4 and H6) with dwarf-shrub canopies made up of various combinations of *Calluna vulgaris*, bell heather *Erica cinerea*, dwarf gorse *Ulex minor*, western gorse *Ulex gallii* with a local contribution from cross-leaved heath *Erica tetralix* and bilberry *Vaccinium myrtillus*. Common gorse *Ulex europaeus* is widespread on most lowland heaths.

Regional variation in lowland dry heath can be quite pronounced. For example, *Ulex minor* occurs mainly in the south and east of England and *Ulex gallii* in the south west and Wales. Other species occur which have restricted distributions but which are locally abundant. Examples include bristle bent *Agrostis curtisii* on heathlands in south west England; Dorset heath *Erica ciliaris* on Dorset heathlands to the west of Poole Harbour, and Cornish heath *Erica vagans* on the Lizard Peninsula in Cornwall.

On free-draining acid to neutral soils in warm oceanic regions of lowland Britain, *Calluna vulgaris-Ulex gallii* heath (H8) occurs. This heath is a characteristic mixture of *Calluna vulgaris, Ulex gallii* and *Erica cinerea*. It is found in south west and north west England, Wales and the coast of East Anglia. It is often present in coastal locations but is not confined to them.

On acid and impoverished soils at low to moderate altitudes in the Midlands and northern England, a *Calluna* dominated heathland type occurs with wavy hair-grass *Deschampsia flexuosa* consistently present (H9). Much of the character of this heath derives from its grazing management and frequent burning, together with the effects of heavy atmospheric pollution. It forms a transition to the upland heaths (discussed below) due to the increasing abundance of such species as bilberry, cowberry *Vaccinium vitis-idaea* and crowberry *Empetrum nigrum*.

Heathland can occur on highly leached and deeper soils on limestone, for example in the Peak District and on the chalk in Sussex. These "limestone heaths" can be of a number of types which conform to NVC communities but, with the exception of NVC H8c, are not separately recognised by the NVC system.

The NVC communities in this section are:-

H1 *Calluna vulgaris-Festuca ovina* heath
H2 *Calluna vulgaris-Ulex minor* heath
H3 *Ulex minor-Agrostis curtisii* heath
H4 *Ulex gallii-Agrostis curtisii* heath
H6 *Erica vagans-Ulex europaeus* heath
H8 *Calluna vulgaris-Ulex gallii* heath
H9 *Calluna vulgaris-Deschampsia flexuosa* heath

5.2.3 <u>Lowland wet heaths</u>

On almost all lowland heathlands there are gradients of soil wetness ranging from dry heath on freely draining soils, through humid heath on moist soils with impeded drainage, to wet heath on soils which are waterlogged for varying periods of the year. These communities can be very distinct on heathlands in central and south eastern England, but in the more oceanic conditions of the south west the boundary becomes more diffuse because wet heath plants are able to survive in better drained soils because of the overall wetter conditions.

Humid heath is mainly a feature of western areas. *Calluna* is usually dominant, but cross-leaved heath is also abundant. Common grass species associated with this heath are purple moor grass *Molinia caerulea* and bristle bent *Agrostis curtisii*.

Wet heath vegetation is widely distributed on gley (waterlogged) and peaty soils throughout Britain. In lowland areas, *Calluna* and *Erica tetralix* dominate together with a number of *Sphagnum* moss species. Other species include deer grass *Scirpus cespitosus*, common cottongrass *Eriophorum angustifolium* and bog asphodel *Narthecium ossifragum*. In some places rare species occur in these communities including marsh gentian *Gentiana pneumonanthe* and marsh clubmoss *Lycopodium inundatum*.

The NVC communities which cover lowland wet heaths are as follows:

M15 *Scirpus cespitosus-Erica tetralix* wet heath;
M16 *Erica tetralix-Sphagnum compactum (=Ericetum tetralicis)* wet heath;
H5 *Erica vagans-Schoenus nigricans* heath.

H5 *Erica vagans-Schoenus nigricans* heath is confined to the Lizard Peninsula in Cornwall.

5.2.4 Maritime heaths

Although the lowland heath types covered above can extend onto coastal cliffs and dunes, salt spray and other factors have led to the development of distinctive maritime heathland types.

The first (H7) occurs on clifftops with coastal plants including spring squill *Scilla verna* and sea plantain *Plantago maritima*, as well as the uncommon prostrate forms of certain shrubs. The vegetation form is a low wind-shaped mat, with *Calluna* and *Erica cinerea* present and with prostate shrubs and herbaceous species also occurring.

The second type (H11) occurs on coastal sand dunes where the sand, somewhat unusually, is non-calcareous or where calcareous sands have become leached with the passage of time. The dominant heathland species are again *Calluna* and *Erica cinerea*, although there is a good deal of local variation. The soils of these communities frequently becomes podsolised.

The NVC communities which characterise the above are:-

H7 *Calluna vulgaris-Scilla verna* heath
H11 *Calluna vulgaris-Carex arenaria* heath

5.2.5 Upland (sub-montane) heaths and moorland

At higher altitudes in Wales, northern England and Scotland, a number of types of heather moorland occur on free-draining acidic soils. Intensive grazing management in many areas has resulted in a loss of *Calluna* and an increase in grasses and rushes. An indicator of heather moorland is the increased constancy and abundance of bilberry, cowberry and crowberry.

As with lowland heaths, differences in climate, soils and soil moisture lead to vegetational differences. With permanently waterlogged conditions, for example, blanket peat can be present with one of a number of different NVC mire communities, such as:

M19 *Calluna vulgaris-Eriophorum vaginatum* blanket mire,

which is widespread in upland areas, especially the Pennines and the southern uplands of Scotland.

Away from the mire communities there are two major types of heather moorland, the "Atlantic heather moor" and the "Boreal heather moor". Atlantic heather moor (H10) is found on acid brown earth soils and podzols at the lower and more western upland areas. The vegetation is composed of a *Calluna-Erica cinerea* mix, with in the cool oceanic conditions, little *Vaccinium* and *Empetrum*, but with associated species including purple moor-grass *Molinia caerulea*, hard fern *Blechnum spicant* and the sedges *Carex binervis* and *C. pilulifera*.

With a shift to a colder environment on the higher ground in the north and west away from the more oceanic uplands, there is a shift to the Boreal heather moor (H12), a *Calluna-Vaccinium myrtillis* heath. The vegetation differs from the Atlantic heather moor in that *Vaccinium myrtillis, V. vitis-idaea* and *Empetrum nigrum* are the usual dominant species with *Calluna*. The Boreal heather moor is the most extensive heathland type in Britain and much is managed for grouse and sheep using a burning regime. Examples of this habitat are the extensive grouse moors of the Pennines. In the east-central highlands of Scotland, the drier, more continental conditions produce a *Calluna-Arctostaphylos uva-ursi* (bearberry) heath (H16). This is also often managed by burning and grazing and usually has a distinctive suite of herbaceous species including chickweed wintergreen *Trientalis europaea* and lesser twayblade *Listera cordata*.

The NVC communities referred to above are:-

H10 *Calluna vulgaris-Erica cinerea* heath.
H12 *Calluna vulgaris-Vaccinium myrtillis* heath.
H16 *Calluna vulgaris-Arctostaphylos uva-ursi* heath

5.2.6 Other heathland types

There are a number of heathland types which occur mainly at high levels in Scotland and, more locally in northern England, the Lake District and North Wales. These often occur in restricted areas and can have high nature conservation interest. They have strong affinities with sub-arctic, arctic and, to a lesser extent, alpine communities in continental Europe. There are often strong links with Scandinavian montane communities.

These heathland types will not be considered further in this *Guide* as there is likely to be little habitat creation activity with these communities. The only exception to this will be activity arising from the operation and continuing development of the skiing industry in Scotland. Damage caused by this activity has lead to work being carried out on habitat repair, but we are not aware of any habitat creation programmes which are underway.

**5.3 Planning of a heathland habitat creation scheme - the preliminary site survey.**

Chapter 2 of this *Guide* has emphasised the importance of certain in-depth surveys of the proposed habitat creation site as the first stage in the preparation of a Project Plan. These surveys, with respect to heathland habitat creation, will need to cover the issues described below:-

5.3.1 Site history

Information will need to be gathered on the history of the proposed habitat creation site. With heathlands, this is most important with respect to its treatment and management over the last 100 years or so. The most important factors to determine are whether the site has been ploughed and thus has an altered soil profile from its semi-natural state; whether the site has been limed or fertilised and with what; whether or not the site has been grazed; and whether the site has been subjected to any land drainage schemes.

5.3.2 Existing vegetation

Information on the existing vegetation of the habitat creation site is important as this can give a guide both to present site soil conditions and, if remnant heathland vegetation is present, the composition of the former semi-natural heathland vegetation on the site. Further information can be obtained on this point by examining existing heathland vegetation in the locality. If the habitat creation scheme has a target community, then this should accord with the semi-natural heathland communities in the locality and/or to the remnant vegetation on the site. The NVC will be helpful here.

5.3.3 Soils

The soils of the habitat creation site should be examined using the parameters set out in Chapter 2.3.5 and assessing whether the soils of the site are suitable for the target community. Heathland soils are acidic (neutral on the Lizard), nutrient poor and with free or impeded drainage. Free-draining soils are usually podzols and soils with impeded drainage are usually gleyed. Available soil nutrients, nitrogen, phosphorus and potassium are at low levels (Table 5.1). If the soils do not conform to the necessary conditions then either action has to be taken (methods discussed in 2.3.5) to treat the soil to make the right conditions or a different target community has to be put forward. It is possible that unsuitable soil conditions will lead to the abandonment of a heathland habitat creation project for the site.

5.3.4 Physical conditions

The physical condition of the site is an important factor. Note should be taken of steep slopes, the presence of drainage lines and any other factor which will require attention in the Project Plan. For example, unstable soil conditions may require the use of nurse grasses which will quickly stabilise the soil surface. However, stable bare ground is of high value for invertebrates and reptiles on lowland heath and a complete vegetation cover may not, therefore, be desirable.

## 5.4 Preparation of the Project Plan.

5.4.1 Setting objectives

This *Guide* has recommended the preparation of a Project Plan which will record and present every stage of the habitat creation project. An essential part of the Project Plan is the setting of objectives for the project.

With heathland habitat creation, there will one of the following three overall objectives:-

1. To create heathland which conforms to a semi-natural model, eg. an NVC heathland type adjoining an intact heathland area having this NVC type.

2. To create heathland which does not conform with a semi-natural model but which sets certain target species, eg. on a roadside verge, perhaps not adjoining heathland, where the aim is to establish a *Calluna* dominated sward.

3. To create heathland in a non-heathland district, primarily for educational purposes, eg. a demonstration heathland vegetation located within an urban nature park.

There is also a fourth potential objective that overlaps with habitat restoration which covers schemes which are attempting to reverse the effects of intensive (grazing) management on upland moorland.

5.4.2 Realising the objectives

With each of the above it is then important to broadly determine what kind of habitat creation strategy is required to realise the objective. In Chapter 2 (2.1) four strategy types were given ranging from letting natural colonisation take place (Strategy 1), through to full intervention (Strategy 4).

In order to determine the strategy which is required, there is a need to correlate the findings of the site survey with the project objective and then determine the methodology which will need to be employed. Consideration must then also be given to short and long term management.

At this stage the resourcing and cost implications of the proposed project should be to the fore. This analysis should cover both implementation and management costs. If, for example, the costs are too high, then some reconsideration of the scale and perhaps the objectives of the project need to be made.

## 5.5 Methods of heathland habitat creation

### 5.5.1 Introduction

Within the heathland habitat creation literature, there has been little distinction made between habitat *restoration* and *creation*. Part of the reason for this is that much heathland habitat creation experimentation has been carried out on sites where heathland already exists. An example of this is heathland restoration following pipeline installation; some methods use turves and others use seeding techniques.

This methods section will start with a summary of ecological and practical principles which research has shown is necessary for successful creation of heathland vegetation. It will then continue with an outline of possible methodologies. The methodologies which are proposed are strongly dependent on the sources and types of seed and propagules which are used in the heathland creation project. Such sources include:

- heathland topsoil;
- heathland litter;
- seed harvesting;
- the use of commercially available seed;
- the direct planting of heathland species.

Each of the above may be combined with techniques especially the use of nurse species to stabilise the soil surface and provide improved microclimatic conditions for the germination of heathland species.

Space does not allow this section to cover all items in detail and, for further information, the reader should refer to publications such as Environmental Advisory Unit (1988) and Gimingham (1992).

### 5.5.2 Ecological principles

Much of the research which has been done in this area has concentrated on the establishment of *Calluna vulgaris* and *Erica cinerea*. Following this through to the development of heathland communities which resemble NVC communities has yet to be carried out.

**(a) Soil conditions** The physical nature of the soil is very important for the germination of heathland species, especially heathers. Some evidence suggests that germination more readily occurs on peat-rich soils, but will occur, given time, directly on mineral soil. Excessive litter on the soil surface leads to poor germination.

**(b) Surface stability and the use of companion "nurse" grasses** Surface erosion can be a problem and, if not dealt with at the outset, can lead on unstable sandy soils on sloping ground to the development of erosion gullies. On a smaller scale, heavy rain on an unstable surface can affect the germination of seed and the establishment of seedlings, especially of more sensitive species. A number of methods are available to treat this problem including the use of companion grass species such as *Deschampsia flexuosa* or *Agrostis capillaris*. The use of wild oat and barley has been used with some success, with the dead stubble continuing to provide stabilisation into the second year.

The use of companion grasses is most necessary in the uplands where the likelihood of erosion is greater and, without stable conditions, the germination and establishment of heathers would not occur. Experimental evidence for the efficacy of this method is given in EAU (1988). This review suggests the use of Highland bent *Agrostis castellana* and wavy hair-grass *Deschampsia flexuosa* in upland sites, and *A. castellana* on lowland sites. However, given the principle of using native species only, *Agrostis castellana* should be replaced by *Agrostis capillaris*.

Some evidence suggests that care should be taken with the use of *Deschampsia flexuosa* on lowland sites due to its invasive qualities. If this species is present as a natural component of the local heathland vegetation where the habitat creation is to be carried out, then *D. flexuosa* could be a useful species to use. In south-west England, the grass *Agrostis curtisii* is a significant component of the heathland vegetation and, in habitat creation schemes, can form a useful companion species.

It should be an aim of the heathland habitat creation scheme that the companion grasses should gradually disappear from the created sward to be replaced by ericaceous vegetation or other indigenous species. This will happen as the fertility of the soil drops due to leaching activity and plant uptake. Should fertiliser topdressing of the vegetation take place, then this will favour the grasses at the expense of the ericaceous species. For this reason, fertiliser applications are rarely recommended for such schemes.

**(c) Seed germination and seedling establishment** The soil surface must present a suitable environment for the germination and establishment of heathland species. There must be suitable conditions of humidity at the soil surface and this can be provided by the use of companion grass species which are present at a density which provides bare ground between the individual grass plants.

The time of year of sowing is also crucial, with sandy heathland soils being very prone to drought. The spring is not always the best time for seed germination as May can often be a very dry month. However, successful germination and establishment in the spring, followed by a summers growth, will place the system in a better position to pass the first winter. Autumn can be a good time to start a heathland habitat creation project, but it does run the risk of insufficient growth to enable winter survival. Frost-heave of young seedlings can be a particular problem. On balance, autumn sowing is better in the lowlands and spring sowing in the uplands.

**(d) Soil nutrient status** On some lowland heath soils there are sufficient nutrients to support the establishment of heathland vegetation. However, especially on upland peats and sandy, free-draining soils, nutrient addition may be required and this can include, in certain circumstances, the addition of lime. The application of lime to peat, thus raising the pH, can lead to increased microbial activity and release of nutrients. The deficiency of potassium can be pronounced on heathland soils which is rarely the case with loam and clay soils.

The determination and, if necessary, the correction of soil nutrient status is a crucial element of heathland habitat creation planning. Too high a level of nitrogen, phosphorus or potassium can lead to, for example, vigorous growth of nurse grasses to the exclusion of heathers and other heathland species. Too low a level will lead to areas of bare ground which will be prone to erosion.

Ideally, field trials should be carried out to determine the requirements of the soil in terms of fertiliser and lime application. If there is no time for trials, then a soil analysis should be carried out and this can be related to typical analyses taken from semi-natural heathland sites (see Table 5.1). The need for, and the level of fertiliser application, can be determined using this method. Soil fertility can be reduced using the techniques summarised in section 2.3.5.

Due to the need for highly infertile, generally sandy soils, for heathland habitat creation, these are most likely to be found on former heathland or moorland sites, especially where these have been used for forestry, rather than improved for agriculture. The correct conditions can also be found on mine wastes such as those from china clay working and many colliery spoils. The difficulty of bringing moorland soils which have been improved for agriculture back to a suitable condition has been well demonstrated, a good example being the Nab Farm experiments carried out by the North York Moors National Park (Case Study No.18). More success has been achieved in Breckland at Ropers Farm (Case Study No.17).

Evans et al (1993) describe an ambitious project being undertaken on the Suffolk Sandlings heaths at Minsmere nature reserve. Some 158ha of arable land has been purchased adjoining heathland on the Minsmere reserve. This area was heathland up until the late 1930s and the aim of the RSPB has been to restore heathland and acid grassland on this area. The project is now three years old and work has concentrated on the soils and methods whereby elevated soil pH, calcium and phosphorus can be reduced. The methods used have been as described in section 2.3.5 with the addition of the use of sulphur to acidify the soil. This is a long term project which is being funded by the RSPB and supported by researchers from academic institutions.

**(e) Source of seed and propagules** Although most heathland habitat creation has concentrated on the establishment of the dominant heathers *Calluna vulgaris* and *Erica cinerea*, the more ecologically sound objective is the establishment of a heathland vegetation consisting of a characteristic range of species with realistic levels of abundance.

The best way to ensure a naturalistic vegetation is to either use the top 50mm of heathland soil from a donor site which will contain a seed bank of the heathland species, or to harvest seed from a donor heathland using such techniques as forage harvesting of ripe heather seed heads or using a vacuuming technique to pick up heathland litter with seed.

A new technique has been developed by the Nickerson Project which uses a machine to "brush off" seed from heather plants before they fall to the ground. The efficiency of this method has yet to be determined.

The main limitation with the collection of heather seed is that by the time the heather seed has ripened and can be collected, the seed from other plants has long since matured and shed.

**(f) Protection of developing vegetation** Disturbance of the soil surface by grazing or trampling can be highly damaging to developing vegetation. Young heather plants, in particular, are easily damaged. Grazing and human access should therefore be prevented for such time as the sward appears to have reached a mature stage. The time required for this stage to be reached will depend on site conditions, especially climate and stocking rate; some upland sites, for example, may require fencing for at least five years.

5.5.3 The use of heathland topsoils

This is perhaps the most reliable approach available for the creation of diverse lowland heathlands although it has the distinct disadvantage that a heathland area needs to be

Table 5.1 - Chemical analysis of a heathland and a moorland soil

| Heathland type and location | Depth (mm) | pH | N (%) | P | K | Ca |
|---|---|---|---|---|---|---|
| **1. Moorland; Shap, Cumbria [1]** | | | | | | |
| Peat (Oh) | 20 | 3.1 | 1.02 | 723 | 725 | 230 |
| Amorphous peat (Oh) | 60 | 3.0 | 0.80 | 568 | 560 | 230 |
| Peaty sandy loam (E) | 100 | 3.1 | 0.35 | 293 | 600 | 195 |
| **2. Heathland; Mugglewick Common, Durham [1]** | | | | | | |
| Fibrous/sandy peat (Oh) | 20 | 3.4 | 1.24 | 950 | 780 | 315 |
| Sand/clay/peaty loam (E) | 60 | 2.8 | 0.50 | 418 | 460 | 315 |
| Silty clay & gravel (B) | 100 | 2.8 | 0.20 | 350 | 695 | 475 |

**Soil Horizon Symbols:** Oh - humic or peaty layer
E - elluviated mineral soil (modified A)
B - subsoil

**Units for P, K and Ca:** mg/kg

[1] Data from EAU (1988)

sacrificed to allow the habitat creation to happen. However, development projects such as roads, mineral workings and housing developments do occur on heathland sites and there are, therefore, opportunities for topsoil-based habitat creation in these circumstances.

A good deal of research has been done using this technique, for example, on china clay workings in Cornwall, moorland sites in the Pennines, Cannock Chase and at lowland heathland sites in Dorset and Surrey. The impetus for this research came from the need to establish vegetation on mineral wastes, such as china clay waste and from research into the restoration of pipeline routes where they cross heathland areas.

The use of topsoil provides an excellent source of seed of *Calluna* and *Erica* species as well as seed and rhizome fragments, rooted stem bases and tillers of other species. This means that the vegetation on the habitat creation site will have some diversity and there is a good chance that, in time, its species composition will resemble that of the semi-natural communities in the locality. The regeneration of native species from heathland topsoil has been shown to be rapid when compared with other techniques.

Methods which need to be followed in the use of this technique are as follows:-

**(a) Survey of donor site** The first stage is to determine the depth of the organic horizon and the location of the seed bank in the soil. Research has shown that the majority of seed is in the top 40mm of soil. On some heathland soils, this means that most of the seed bank is in the organic horizon, but on others the seed bank will be in the mineral soil, part of the A horizon. Time should be set aside for the digging of test pits to examine the soil and the presence and depth of particular horizons. Information on the physical nature of the material will assist with planning the later stripping of the soil.

Soil samples should be taken, ideally at 20mm intervals down the soil profile, for a site-specific test of the seed content of the soil. This can be done in a semi-quantitative way by taking a standard weight of soil and sieving it onto the surface of a seed tray filled with sterilised compost. Ideally, this will then be put in warmth, with a mist unit (covering with polythene will do) and left for 8-12 weeks. After this time the quantities of seedlings of heathland species will be apparent. More details of this technique are given in Gillham (1980). A conclusion can then be drawn concerning the optimum depth of soil to use from the donor site.

**(b) Removal of soil from the donor site** The first step, if the vegetation is not short (following a fire, for example) is to either flail mow the heathland or, if the timing is right, to use a forage harvester to collect heather seed for use as an additional seed source. If the organic horizon is deep, say greater than 20mm, then it is an advantage to rotovate the site down to between 50 and 100mm depending on the depth of the seed bank. Where there is a shallow organic horizon of less than 20mm, especially on lowland heathland, rotovation should not be carried out as this likely to dilute the seed bearing soil layers. Rotovated soil can be collected using machinery which will not extract below the rotovated depth.

Similarly, on unrotovated sites, the stripping of soil should be kept as close as possible to the recommended depth. In practice, stripping to less than 50mm is very difficult, and some dilution of the seed bank is to be expected. It may be necessary to break up the soil using a mechanical shredder before it is sent to store or relocation.

**(c) Storage of heathland topsoil.** Storage of topsoil should be avoided, if possible, but if it is necessary, then it should be stored in shallow heaps not more than 1.0-1.5m high on sheeting of some kind, such as terram. Storage should be for as short a time as possible so that the physical structure of the soil is not damaged, vegetative propagules survive and seeds remain viable. Research has shown that most degradation of soils occurs within the first 1-3 months of storage; little further degradation takes place after this period.

**(d) Spreading of topsoil on donor site.** This can be done using a manure spreader or spaced out in heaps from a trailer and later levelled using a bucket attached to a tracked excavator, or similar machinery. The spreading depth should be 25mm which means that is should be possible to create heathland vegetation on 1.5-2.0 times the area of the donor site given a typical depth of donor topsoil. On very coarse mineral substrates research has suggested that the spreading of a mineral subsoil followed by the heathland topsoil increases the rate of heathland development. This effect is due to increased moisture retention and improved exchange of plant nutrients between soil and plants.

**(e) Soil surface stabilisation - companion (nurse) grasses and geotextiles.** The use of a companion grass mix is recommended on most heathland habitat creation schemes in order to stabilise the soil surface and to create sheltered "microsites" for heathland seed germination. On steep slopes biodegradable geotextiles such as Geojute show promise. Other solutions are presented in Coppin and Richards (1990).

**(f) Timing of works.** On lowland heathland sites it should be possible, if the soil is not waterlogged, to spread heathland topsoil at any time. However, climatic conditions for the germination of heathland species are best in the spring and autumn when drought conditions are less likely. This also equates with the best time to sow companion grasses. In the uplands, the spreading of soil should be confined to spring and early summer to allow time for vegetation to establish before the difficult winter conditions commence and erosional pressures increase.

CASE STUDY 13: GALLOWS (DUCK) HILL, WAREHAM, DORSET (1).

In this case study, part of the heathland habitat creation programme used heathland topsoil from a site which was about to be quarried for sand and gravel. The donor site was wet heath and the habitat creation site supported a nutrient-poor waterlogged soil overlying a landfill site. The waterlogged soils were created by the clay capping of the landfill. Some success has been achieved on this site together with the use of heather brashings (discussed in 5.5.4, below).

Critical Comment

1. The success of this scheme, which was started in 1986, has been due to the far-sighted manager of the time who, on his own initiative, set up the habitat creation scheme on Duck Hill. He was aided in his success by the fact that the receptor site supported waterlogged soils similar to those of the wet heath donor site. If Duck Hill had supported dry soils then it is likely that the scheme would not have been as successful. This is the only known site where the creation of wet heath has been attempted although a large scale scheme is underway at the British Coal Opencast Executive site at Bleak House, Staffordshire.

2. Despite the far-sightedness of the Duck Hill scheme, it is an excellent example of a project where poor records were kept of the methods and the timing of operations. This has hindered our understanding of the reasons for the success of the scheme despite its subsequent monitoring. This demonstrates the need for a clear Project Plan being prepared at the outset which gives clear project objectives.

**CASE STUDY 19: FERNDOWN BYPASS, DORSET.**

Dorset County Council used heathland topsoil on this site to re-create heathland vegetation on the roadside verges of the new bypass which crosses a heathland SSSI known as Slop Bog and Uddens Heath SSSI. The top 50 mm of heathland soil was stripped from the road easement in May, 1985 following cutting of vegetation and rotovation of the soil. It was then stored for 18 months before being spread at 75mm depth over imported topsoil on north and south facing roadside verges. A nurse mix was also used to stabilise the soil.

Monitoring of the site in 1988 (Dorset County Council) and 1990 (SGS Environment) indicated a heathland sward had become established, especially on the north-facing verge. Drought had been a likely cause of the death of heathers on the south facing verge and the appearance of bare ground areas. A potential problem was identified in the local abundance of common gorse *Ulex europaeus* on the verges. This problem continues in 1993, but it has been recognised by the Dorset Area Field Team of the Department of Transport who are responsible for managing the site.

Critical comment. This has been an outwardly successful scheme and, if the current management problem can be resolved, then it has a long term future. However, there are some critical but constructive points which can be made:-

1. The 18 month long storage of topsoil allowed the survival of the seed of many heathland species despite the longer than recommended storage time. However, there was apparently no assessment of the seed bank of the soil before it was stripped or after storage and so it is not possible to say how this changed over time and whether there could have been any effect on the species composition of the created sward.

2. Long term monitoring and management of the verges was not specifically budgeted for. However, there appears to have been sufficient local interest from Dorset County Council (who have recently bought part of the adjacent SSSI) and the Exeter office of the Department of Transport to have allowed some monitoring and discussion concerning the management of the verges. It is to be hoped that the management of the verges can be carried out together or coordinated with that of the SSSI which is shortly to become a Local Nature Reserve. If management does not take place then it is likely that the dwarf shrub vegetation will be shaded out by the development of gorse.

3. There was no vegetation survey of the heathland before the soil was stripped to allow an objective comparison to be made between the present verge flora and the previous semi-natural vegetation on the site. This is unfortunate as it makes it difficult to fully assess the success of the project, especially in NVC terms.

### 5.5.4 The use of heathland litter

The advantage of this method is that desirable heathland plant species can be obtained from an existing heathland without causing significant damage to the existing vegetation. Whereas not all species will be collected using this method, there is a good chance of obtaining usable quantities of the seed of dominant species such as *Calluna* and *Erica cinerea*. It is also likely that the seeds of some further species of the NVC heathland communities will be collected using this method. However, this technique will never be as effective as the use of heathland topsoil for the transfer of all elements of a heathland community. With this technique, it is also possible to collect undesirable species, such as soft rush *Juncus effusus*, which can then germinate on the disturbed soil of the habitat creation site. This often happens with upland heather moorland restoration, especially on poorly drained soils. Other undesirable species include pine *Pinus spp.*, birch *Betula pendula, B. pubescens* or gorse *Ulex europaeus*. For this reason, the management of the heathland habitat creation site may have to include programmes for the control of these species.

Litter is easy to handle and can be stored dry for several years without significant loss of seed viability. It is also easy to spread by hand and can be used in hydroseeding mixes. However, it will be necessary to obtain permission from the landowner before the seed is collected. On SSSIs it will also be necessary to obtain consent from English Nature or the country agency.

Methods which need to be followed in the use of this technique are as follows:-

**(a) Collection of heathland litter.** Litter can be collected either by hand or by using collection equipment based on a vacuuming system. Hand collection is effective enough for subsequent application on small sites but, in most instances, the hire of collecting equipment is advised. Suitable equipment includes "Billy Goat" vacuum litter collectors (EAU, 1988) and a new system developed by ADAS/Nickerson Trust.

Collecting may be carried out from most areas of lowland and upland heath without causing permanent damage. It does cause physical and noise disturbance and, for this reason, collecting should avoid the bird breeding season (February-August) and sensitive areas for fauna, such as sand lizard *Lacerta agilis* sites on southern heaths.

There are generally greater quantities of litter available on upland than lowland heaths where the breakdown of litter is more rapid. Stands of heather of medium age (10-15 years) appear to be the optimum age for collection as old heather contains too many partly buried prostrate stems which interfere with collection. However, on southern lowland heaths, 15-25 year old stands produce the best litter (EAU, 1988). Collecting rates given in EAU (1988) are hand-collecting rates of 30-40 kg/day and 80-100 kg/day using a vacuuming system.

**(b) Assessment of heathland litter for seed content.** Before time and money are spent on the spreading of litter, it is advisable to assess the litter for its seed content. This can be done by taking weighed amounts of sieved litter and spreading it 2mm deep on the surface of sterilised soil/compost in seed trays. If possible, these should be placed in a greenhouse mist unit, but covering with polythene is also effective. Research has indicated that 90% of ericoid (*Calluna* and *Erica spp.*) seeds will germinate within 2 weeks. Counting these seedlings will enable an approximate assessment of the number of seeds per unit weight of litter to be made. EAU (1988) recommends the application of 300-500 seeds/m2 which equates to a litter application rate of 100-150 g/m2 (1000-1500 kg/ha).

**(c) Storage of heathland litter.** Litter should be stored dry and then put through a coarse sieve to remove woody material. In this dry state litter can be stored in paper or hessian sacks for at least three to four years in a dry place or cold store. Wet litter can be stored outside in the winter; in summer, composting will take place in these conditions and this will kill seed.

**(d) Spreading of heathland litter.** On small sites, less than 0.5ha, spreading by hand has been shown to be an effective technique. On larger sites a number of techniques have been tried including the use of fertiliser spreaders and hydroseeding, the latter being most useful on steep slopes where it is not possible to use agricultural machinery.

**(e) Cost of technique.** EAU (1988) gives a cost of £2,000 - £2,500 /ha for this technique using manual labour, with more mechanised operations costing £1,200 - £1,500 /ha. This included collecting, storing and spreading.

In retrospect, this technique should have been used in Case Study No. 17 at Ropers Heath in Breckland.

5.5.5 <u>The use of harvested seed</u>

This technique which, for example, uses a forage harvester to cut and collect ripe heather seed capsules on extensive heathlands, is a highly cost-effective way of obtaining large quantities of viable seed. It has advantages of low cost and it causes little permanent damage to the heathland, but it has the disadvantage of collecting mainly one species of seed. On upland heather moorland, for example, where the technique has been perfected, *Calluna* is the predominant seed which is collected. The earliest project where good evidence of the success of this technique was on the Derbyshire Peak (Tallis & Yalden, 1983).

**(a) The harvesting of seed.** The high cost of transport and the desirability, if possible, of using seed of local provenance, suggests that a donor site should be found as close as possible to the habitat creation site. Donor sites will need to be flat or of even slope and with as even ground as possible to enable machinery to work effectively.

The equipment used in this task has to be able to successfully cut and collect the fruiting seed capsules of *Calluna* and other heathers. Equipment which has proved to be successful includes forage harvesters and combine harvesters. The woody nature of the heather stems is more suited to a heavy duty forage harvester. If the heather is very woody and the cut is not taken at a high enough level, large volumes of heather material can be obtained containing very little seed. Care therefore needs to be taken determining the height of the cut.

The new Nickerson machine for the collection of heather seeds from fruiting stems without cutting shows some promise. However, there is some advantage in having the cut heather stems which provide more resistance to wind movement, especially in upland locations.

The cutting and collection should take place between October and December, when the majority of the seed capsules are mature. As *Calluna* seeds are retained in the capsules for some weeks, the cutting period is not too critical. The inevitable delays caused by bad weather in this period, especially in the uplands, are not an insurmountable problem.

**(b) Storage of harvested material.** On lowland heathlands where the harvesting takes place in early October (or possibly earlier) the cut material can be immediately spread on the heathland creation site, but in most cases, storage will be required. EAU (1988) recommends the drying and bailing of cuttings and, at high altitude, the bailing of freshly cut material. Alternatively, material can be stored in low mounds, no more than 0.5m high. Even in this situation, some heating can occur, though this should not be serious enough to affect the seed bank in a significant way. There seems to be no evidence available on whether wet-bailed material heats in the same way. In the uplands and lowland coastal areas, it is necessary to cover the storage mounds with open mesh to stop the material being blown away.

**CASE STUDY 17: ROPERS HEATH, BRECKLAND.**

This is a project which commenced in 1978 which has aimed to create Breckland heath and grassland on former heathland which was brought into arable use in the early 1950s and farmed in this way until 1978. This area, Ropers Heath, is situated between Cavenham and Tuddenham Heaths. Following a three year period of fertility reduction using arable cropping (rye), the area was allowed to vegetate naturally from its seed bank and postulated "seed rain" from adjacent heathland. There has been some success with this approach, although heather is only entering the sward where it is close to existing heathland; the rest of the site is dominated by the grasses *Festuca ovina* and *Agrostis capillaris*, species which are common on Breckland heaths. The area is being monitored by the Cavenham Heath National Nature Reserve (NNR) warden.

Critical comments

1. The passage of time has shown that the arable period of Ropers Heath, over some 25 years, all but eliminated its buried seed bank. It has also shown that the seed rain from adjacent heathland is insufficient to influence the whole site. It can be concluded from this that some seeding of Ropers Heath should have taken place. This would have been an ideal opportunity to use litter and seed-rich brashings from the adjacent heathland as a seed source. However, there remains the possibility that simply more time is required for this natural colonisation approach to be proved successful.

2. Grazing exclosure plots have revealed greater success with the establishment and growth of heathers which is, therefore, in conflict with the overall management of the NNR. It does suggest that the control of grazing pressure may be vital to the success of Breckland schemes of this kind. How this is influenced by the relative fertility of the Ropers Heath soils is unclear although there is some evidence of preferential grazing in this area due to the predominance of unpalatable wavy hair-grass *Deschampsia flexuosa* on the NNR.

3. The scheme is a good example of the difficulty of creating heathland on soils which have been through a long term arable period. These soils have been traditionally shown to be amenable to a return to heathland following a short, perhaps only one year arable period. The key to success of this traditional system must have been the retention of the seedbank though the arable period and not significantly raising soil fertility in the long term.

**(c) Spreading of harvested material.** Spreading should take place during the autumn or early spring (February-March, to May in upland areas). Lack of moisture is the main inhibitor of germination and establishment of seedlings. As heather seed is long-lived, germination may not take place for up to three years following application. For this reason, the Project Plan for the scheme needs to allow for an extended establishment phase. The use of cut heather material also helps to prevent erosion and acts to create more sheltered microhabitats within which heathland seeds can germinate.

There can be no definitive guide to the application rate of harvested material because there are too many variables concerning seed quantity and the nature of the application site. EAU (1988) recommends 400-600 g/m2 of freshly cut material and Firbank (1992) recommends 600-1000 g/m2. No evidence has been produced to demonstrate any cost-effectiveness of producing cleaned seed from the harvested material.

**CASE STUDY 13: GALLOWS (DUCK) HILL, WAREHAM, DORSET (2).**

In this Case Study, part of the heathland habitat creation programme used heather brashings taken from an area of semi-natural heathland using a forage harvester. The nature of the heath on the donor site is uncertain but the habitat creation site supported a nutrient-poor waterlogged soil overlying a landfill site which was suitable for wet heath development. Some success has been achieved on this site together with the use of heathland soil from a wet heath donor site (discussed in 5.5.3, above).

Critical comments

1. Most of the comments concerning Duck Hill have been given at the end of section 5.5.3 above.

2. One specific comment concerning the use of heather brashings at this site is that the recording has shown that initially the heathland soil areas were the most successful in the short term. However, the seeded areas have good longer-term potential. This illustrates that even with lowland heathland habitat creation, where growing conditions are good, habitat creation is a long term proposition with the most successful techniques not always being evident at the start of the project when enthusiasm is at its greatest. It is possible that poor decisions may arise from this misconception and again, a clear Project Plan would improve the chances of success.

**(d) Cost of technique.** Estimates given in EAU (1988) for cutting upland heather moor give the ultimate restoration cost at £150/ha. This is based on the costs of two men plus machinery harvesting at 2ha/day giving sufficient material to seed 4ha and assuming 1000 kg of material used per hectare of restored land. North York Moors National Park (1991) give a higher cost of £260-320/ha which includes cutting and spreading.

5.5.6 The use of commercially available seed

The seed of many heathland species, especially heathers, is available commercially and it is possible to prepare heathland seed mixes which contain a naturalistic range of heathland species. The disadvantage of this technique in the rural environment is that the seed will not be of local provenance but, in the urban environment, this may not matter.

A further disadvantage with using this method, especially on large sites, is one of cost. It is far more cost-effective to collect heather seed using the forage harvesting or heather litter techniques. The typical cost of heather seed is £1-2/g.

The use of commercially acquired heather seed has had mixed results in the research which has been reported. This may be due to the inappropriate origin of the seed for the environment in which it was introduced. The seed is also very small and light and easily moved by wind and water. If not applied with a mulch or woody material, the seeds can easily be removed from the site or have no suitable microhabitat in which to germinate and establish.

## CASE STUDY 18: GLAISDALE MOOR, NORTH YORK MOORS

Following extensive moorland fires in 1976, the North York Moors National Park started a wide range of research to determine the best methods for the restoration of moorland vegetation on its 1300 acres of badly damaged moorland. Much of what was required was "habitat creation" because fire had destroyed both existing vegetation and the seed bank of the peat and mineral soils.

A variety of techniques have been employed including the use of nurse grass mixes, the application of cut heather and natural recolonisation. These techniques have been successful, the nurse grass system for its power to stabilise especially the mineral soils and the cut heather which has been highly successful. This has been in contrast to untreated areas which although close to unburnt areas, in many cases, were poorly colonised even after many years. Furthermore, during this uncolonised period, much soil erosion took place.

The use of cut heather has also been successful in introducing other species in the moorland flora especially common cotton-grass *Eriophorum angustifolium*. This has been both due to the transfer of seed and to suitable conditions being present to enable naturally dispersed cotton-grass seeds to germinate and the plants to become established. The success of the above has been critically assisted by the fencing of 500 acres of moorland to exclude grazing animals.

In 1988 the North York Moors National Park started a programme to restore moorland at Nab Farm. At this site there was former moorland, changed to grassland by ploughing, liming and fertilising, situated adjacent to unmodified moorland. The results of this have shown the difficulty of changing the improved soils back to those characteristic of moorland, in terms of physical condition, pH and plant nutrient status. The best results have been achieved by the deep ploughing of the improved land to bury the higher pH and higher fertility soils.

Critical comments

1. The habitat creation element of the North York Moors National Park's Moorland Management Programme has been largely required due to the damage of the 1976 fire. The work that has been carried out, often in association with researchers and organisations from outside the park, has been of high quality. Again it is a case study which demonstrates the effectiveness of long-term commitment to a site by a managing authority.

2. Along with recent research carried out by ADAS, the Game Conservancy and the Nickerson Project, the work has indicated the effectiveness of the use of heather cuttings spread as a mulch on the moorland surface. It has also demonstrated that on highly erodable substrates, the establishment of a nurse grass mix is important. This is despite the fact that in some research (eg. at the British Coal Plenmeller site in Northumberland being carried out by SGS) suggests that well established nurse grass mixes can inhibit the establishment of *Calluna* and other moorland vegetation due to the too vigorous early growth of *Agrostis capillaris/castellana*.

3. This case study has reinforced the need for the protection of moorland creation sites from grazing. Whereas this has proved possible to do on the North York Moors, many moorland creation, restoration and enhancement projects have failed, or been prevented from starting, by the difficulty of fencing common land. On common grazing land, say used by ten commoners, each commoner has a veto, for example, concerning a fencing proposal.

4. The Nab Farm study which is aiming to bring improved land back to moorland vegetation has illustrated just how difficult this can be. The improved grasslands were created from moorland in 1970, and 18 years was sufficient time to remove the moorland seedbank and dramatically change the soil profile and chemistry. The research is now concentrated on restoring the soil to its moorland condition.

5.5.7 The direct planting of heathland species

This method involves the production of heathland plants in cultivation followed by their introduction into the environment. This can be a valuable technique which, although of high cost, increases the rate of successful establishment of heathland species on a habitat creation site. The method has mainly been used for the production of *Calluna vulgaris* plants. The high cost of this technique rules out planting out an entire habitat creation site. For this reason, irregularly shaped patches of planting are recommended which will act as nuclei for subsequent colonisation by seed.

**(a) Source and production of heather plants.** This can be effectively done through the use of cuttings taken from plants found close to the proposed habitat creation site and raised in cultivation. Alternatives include the raising of plants from seed, collected from heathland litter or harvested material, or the collection of seedlings from a recently burned heathland site using a bulb planter. These techniques need not be confined to the production of *Calluna* plants; species such as *Erica tetralix, Empetrum nigrum* and *Vaccinium myrtillus* can be raised in the same way. Small paper multipots are the best method for raising the plants and for subsequent ease of planting. Methods for the raising of seedlings and cuttings are given in EAU (1988).

**(b) Planting out raised material.** It is likely on most sites that plants should be placed into a pre-existing open "nurse" grass sward which will have stabilised the substrate. On sites not prone to exposure, the nurse grass could be sown at the same time as the heather planting. The density of planting will depend on the desired effect and the timescale of this. EAU (1988) recommends a planting density of 10-15 plants/m2, but Parker and McNeilly (1991) report planting of *Calluna* at 4/m2 and a cover of 10-40% on experimental plots after three years.

The optimum time of planting will depend on the location of the habitat creation site. Lowland locations should be planted in September/October and February/March; in the uplands this should be February/May and late August/October. Protection from all but very light grazing for up to five years will be essential.

**(c) Costs of technique.** The large number of plants required for this technique, some 100,000-150,000/ha to achieve complete cover, makes it likely that no more than 10% cover can be achieved depending on the density of planting. The cost of this given in EAU (1988) is £5,000/ha for raising the plants and planting out costs and at RAE Farnborough (EAU Case Study No.14) the cost was closer to £12,000/ha. Costs of grazing protection must also be added to this.

## CASE STUDY 14: RAE FARNBOROUGH, HAMPSHIRE

The construction of a new radio station at Pyestock Wood, part of the RAE Farnborough complex, required the clearance of 20ha of dense pine woodland which had mainly developed from an open heathland over the last 30 years. The woodland was very dense, with little surviving *Calluna* and dense bracken in places. This elevated site is an SSSI as it adjoins Eelmore Marsh which is a complex nationally important mire system.

In 1983, the proposed vegetation of the cleared 20ha, around and between the radio aerials, was a ryegrass-clover grassland established on imported topsoil. This would have required cutting up to eight times a year to keep it managed and below the 500mm maximum vegetation height specification required by the radio station.

In late 1983 an alternative scheme was put forward to use the native subsoils on the site and to establish an acidic grassland/*Calluna* heathland. The reasoning behind this was one of cost (as no imported topsoil would be required and management costs would be reduced), the reduction of potential impact on the adjacent mire system (due to, for example, nutrient enrichment) and the potential to create habitat of ecological interest which would be compatible with the site.

The project had the advantage of a field trial programme which was able to model different techniques for the establishment of target vegetation on this site. These trials ran from 1984-1990, when the site works took place. The techniques used for the establishment of vegetation were based on the results of the experimental trials. They included the use of a nurse grass mix, based on *Agrostis capillaris, Festuca rubra*, and *Deschampsia flexuosa* and the planting of some 10,000 *Calluna vulgaris* plants. The *Calluna* plants were raised in cultivation using cuttings taken from *Calluna* plants in the Pyestock Wood area. At the time of planting the plants were in small biodegradable pots and some 50mm high. They were planted in patches, mainly on the sloping ground, at a density of 4/m2; some plants of *Erica cinerea* were also raised in the same manner. The cost of these plants was about £10,000 which gives a cost of £1.25/m2, but for material of local provenance. At this density, some 0.8ha of *Calluna* was planted.

The substrate was formed from a mixture of the native sandy subsoil of the site mixed with the topsoil/organic matter (leaf-mould) from the pine woodland. The field trials had not suggested that a significant seedbank was present in the woodland soils. In certain areas, where there was no need to alter the topography of the site, the soil profile was left intact.

Hydroseeding techniques were used to apply the nurse grass mix. The field trials had indicated that low levels of fertiliser were required and this was included in the hydroseeding mix. Unfortunately, at the last minute, the contractor insisted that Westerwolds ryegrass was added to the grass mix to ensure that the site "greened up" before the winter. The hydroseeding took place in September, 1990 and the heather planting in October, 1990 when the grass sward, mainly *Lolium* was well established.

The site was then managed for the first year by cutting which avoided the *Calluna* planting areas but caused the plants to be somewhat swamped by the grass growth. Management in 1992 and 1993 has been by a single cut in late summer which has resulted in the successful elimination of *Lolium* and the control of pine invasion. The cutting is at a height of between 100 and 150mm which is a little low for the heather. Bracken is being controlled less successfully and will require control by herbicide application.

By November, 1993, there had been an excellent survival of *Calluna* in the planted areas where a close to 100% cover had been achieved. Furthermore, these areas had acted as a source of seed and much downslope spread of *Calluna* had been achieved. Ryegrass *Lolium* had been all but eliminated and the nurse sward was dominated by *Agrostis capillaris* with some *Deschampsia flexuosa*.

CASE STUDY 14: RAE FARNBOROUGH, HAMPSHIRE (CONT'D)

A significant result was the presence of large quantities of heather seedlings and plants throughout most of the remaining parts of the site. These were within the nurse sward which had the open character required for enabling the establishment of *Calluna*.

This establishment was most pronounced in the areas where the soil profile had been left intact. This results suggests that there was a significant *Calluna* seed bank in the dense pine woodland area despite the loss of open heathland character some 20-30 years before. Some *Erica cinerea* is also establishing in this manner.

The site will continue to be managed by the authorities of the Defence Research Agency (DRA) and has total security, there being no public access. The Hampshire Heathland Project is advising on the site management together with their work on the adjacent Eelmore mire system. The 1984 field trials are still present and continue to yield useful information. Scientific details of the field trials have been published (Parker & McNeilly, 1991).

Critical comments

1. This project confirms recommendations that heathland habitat creation is best carried out on former heathland areas which have been afforested. It further confirms the general survival of a heather seed bank over much of an extensive 20ha site which had lost its open heathland character some 20-30 years before. As was not the case in this project, it suggests that priority should be given to the investigation of whether a seed bank is present on a heathland habitat creation site before any detailed site plans are drawn up.

2. Although the establishment of *Calluna* at the site has been successfully achieved by the planting of heathers and these areas are now acting as a significant seed source on the site, the presence of a significant heather seed bank in the woodland has thrown into question the high cost of producing and planting heather plants for the site.

3. The creation of the soils, the hydroseeding and the first year of vegetation management formed part of the contract for the construction of the Cove Radio Station. The landscaping contract was commercially let and was well funded. However, despite the professional approach in this habitat creation project, it did reach a critical point with the hydroseeding contractor's preference to include Westerwolds ryegrass in the seed mix. Ryegrass had not been tested in the experimental trials. The contractor was concerned that the *Agrostis-Festuca-Deschampsia* grass mix would not grow sufficiently before the winter and the contractor might be liable for defects payments or having to re-seed. His argument was that the faster growing *Lolium* would establish and grow faster and create the right visual effect before the winter. Although appropriate management and nutrient deficiency has now largely removed ryegrass from the site, the lesson to be learnt from this is that the scientific basis of a habitat creation scheme must not be undermined by short-term contractual matters; the environmental scientist must prevail at this time otherwise there is a chance that a sound, well researched scheme may be ruined.

4. This project has shown the value of a long term commitment from the landowner to the management of the heathland/grassland habitat on the site. The landowner has also been willing to involve the local authority in the site through the Hampshire Heathland Project.
The project therefore demonstrates a factor found in all successful habitat creation projects, that is **long term commitment to site management.**

## 5.6 Monitoring and long term management

### 5.6.1 The importance of monitoring and management on heathland projects

The establishment of heathland and its subsequent management is all part of the same habitat creation programme. This *Guide* has been constantly stressing the need for monitoring and management to be considered in the Project Plan and for mechanisms and finance to ensure that this happens.

An excellent handbook on lowland heathland management has recently been written by Gimingham (1992) for English Nature. This handbook stresses the need for a Management Plan to be prepared for any given heathland site. In the context of heathland habitat creation, this should form the final section of the Project Plan. A summary of lowland heathland management techniques has recently been published by English Nature (Michael, 1993). Other useful information on management can be found in individual project reports such as the Sandlings Project in Suffolk (Fitzgerald et al, 1987).

Scrub invasion and related successional factors are one of the most important aspects of heathland management but with heathland habitat creation schemes there are other factors which can be important such as the nutrient status and pH of the soil affecting the establishment of desirable species and, on former agricultural land, the presence of typical weed species such as thistles and docks. These subjects will be dealt with in turn in the following sections.

### 5.6.2 Controlling scrub and bracken invasion

One of the most important aspects of successional change on heathlands is that due to the invasion of the habitat by scrub, especially on lowland heathland. The most important species in this regard are birch *Betula pendula* and *B. pubescens*, Scots pine *Pinus sylvestris*, common gorse *Ulex europaeus* and rhododendron *Rhododendron ponticum*; bracken *Pteridium aquilinum* can also be invasive. There is therefore a need to monitor this potential colonisation and, if it becomes a problem, have methods in place to control it.

Scrub invasion can be lessened on some sites by the use of heather cuttings which act as a mulch, at least in the early stages. On smaller habitat creation sites, the labour-intensive pulling of birch and pine can be an effective control. Cutting is an effective control of pine, but not birch, gorse or rhododendron which will regenerate from the cut parts.

With the species which regenerate from cut stumps, one would hope that the control methods employed at an early stage on the habitat creation site would have prevented the first flush of colonisation resulting from the large area of bare ground which was present. However, if this was not the case, then it will be necessary to resort to herbicides to control these species. The most important herbicides are glyphosate and triclopyr for birch, gorse and rhododendron and asulam for bracken. There are stringent Government regulations as to who is able to apply herbicides and these should be followed. Detailed information on the method and application of herbicides is given in Gimingham (1992), Michael (1993) and EAU (1988).

Bracken can be a particular problem on heathland habitat creation schemes. It is best treated before the plant has established a hold on the site. The treatment depends on a programme of cutting when the reserves of the plant are at their lowest. This involves cutting in June, July and, if possible, again in August. This treatment may be effective, or alternatively a herbicide programme based on the application of asulam used (see above references for detailed information). With the treatment of bracken, including cutting, care should be taken in case of the presence of ground nesting birds.

5.6.3 Cutting and grazing management

Light grazing was the main traditional use of lowland heathland which can still be seen in the New Forest. It prevented the establishment of tree and shrub species and prevented competitive grasses, such as purple moor grass, from outcompeting other plant species. The stocking rates must be carefully considered as overgrazing leads to the loss of heather and to its replacement by grasses. This has happened over large areas of upland Britain, including Snowdonia and the Pennines.

Grazing should not be considered on a heathland habitat creation site until the vegetation is well established. Typically on a lowland site this will take three or four years, whilst on upland sites, this could take longer. Guideline stocking rates for sheep, cattle, and ponies are given in Michael (1993).

On most heathland habitat creation sites, which will be small, cutting may be the most practical management option which, in some ways, mimics the effects of grazing. Much of the experience in this area is with established heathlands, but there seems no reason to believe that the techniques used in these situations cannot be applied elsewhere. Mechanical cutting using tractor mounted machinery requires relatively even ground and a suitable site access. Cutting height will depend on objectives but will typically be at a height of 150mm at 3-4 year intervals and 200-250mm at 5-10 year intervals (EAU, 1988). Cuttings should be removed from the site and, if cutting takes place in late summer, then the seed-rich material could be used for heathland habitat creation projects elsewhere.

5.6.4 *Juncus* invasion

The invasion of soft rush *Juncus effusus* particularly in upland moorland habitat creation schemes can be a difficult problem. Whilst poorly draining soils can be the most susceptible, no soil type is immune from this problem.

The best treatment for this is prevention; ensure that the introduced heathland seed supply (topsoil, forage or litter) does not contain large quantities of *Juncus effusus* seed. If time permits it is worth carrying out a germination experiment or undertake a microscopic examination using a reference seed collection. The second and later aspect of prevention is to monitor closely your habitat creation scheme for signs of *Juncus* invasion; it is easier to treat early than later when the plants are well established.

If plants are becoming established on the site, then there are a number of treatment options; unfortunately, these require further research which is being undertaken in Scotland and Northumberland. These treatments include regular cutting and the application of herbicide.

5.6.5 Soil nutrient status

On particularly nutrient deficient substrates soils it is possible that during the establishment phase of a newly created heathland a low level of fertiliser input may be desirable to assist with the establishment of the nurse grass mix and the growth of ericaceous species. Some lime may also have to be added to raise the pH on certain upland peat soils, such as peat hags in the Derbyshire Peak.

In spite of the above, it is important that soil fertility remains low and falls to allow the companion grasses, if used, to be replaced by heathland species. Research which has been carried out on this subject indicates that a fertiliser application in the second season will aid the growth of grasses at the expense of the growth of heathers. However, on sites where heather was dominant and grasses absent or sparse, evidence summarised in EAU

(1988) suggests that an Enmag application at 100kg/ha improved the growth of heather on china clay waste in South Devon. China clay waste is, however, an especially nutrient deficient substrate.

The question of fertiliser applications following the establishment phase is therefore dependent on the particular set of circumstances at the site. However, a broad recommendation is that post-establishment fertiliser applications are rarely necessary or desirable for most heathland creation projects.

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# 6. PEATLANDS (FENS AND BOGS)

## 6.1 Introduction

Peatlands, for the purposes of this chapter, encompass both fens and bogs. A summary of the main vegetation types involved is given in section 6.2.

The consideration of peatlands and habitat creation brings into sharp focus the distinction between habitat "restoration" and "creation". Peatlands have not, with some rare exceptions, such as the creation of new *Phragmites* reed beds, been a subject for habitat creation according to the "something from nothing" definition used in this *Guide*.

Raised bogs have, however, been the subject of restoration due to their seriously degraded state throughout Britain. Here the aim is to "rehabilitate" environmental conditions conducive to the development of, in the short term, acid mire communities and, in the long term, raised mire communities and domed peatlands. The term "restoration" is also used to describe the restoration of environmental conditions suitable for the conservation of good quality remnant areas of bog. The term "re-creation" is also used to describe the re-creation of acid mire communities within bogs which have been completely cut-over and which may or may not adjoin an uncut remnant area.

There is also a problem in distinguishing between restoration and habitat creation within fen communities. There has been very limited creation of fens, new *Phragmites* reed beds are an example, but restoration, such as the reinstatement of management to restore previously open fen vegetation types or to restore the species-richness of the existing community is the most common type of activity. However, it is a point of discussion whether peat excavation within fens, in order to regenerate the hydrosere, is restoration or habitat creation.

The priority of the statutory nature conservation bodies in Britain has rightly been the protection of what remains of our peatland resource, especially lowland bog and fen areas. Considerable resources have been expended to acquire sites and to establish programmes which attempt to restore the natural and semi-natural plant communities which formerly occurred on the sites. On some relatively undisturbed peatlands this would mean the protection of site hydrology and controlling scrub invasion but on peatlands with a long history of human intervention, this may mean carrying out active programmes to restore the various types of management which had created a high degree of ecological interest on the site.

The present situation with the conservation of UK peatlands, especially with a number of the lowland raised bogs which are subject to peat extraction, is one with a high political as well as scientific profile. Whereas it may indeed be possible to create habitats of ecological interest, these are unlikely to be a full replacement for the habitats and plant communities which have been lost. Some of these habitat creation programmes are also, for example, creating different habitats, such as large open water areas on worked out peatlands on the Somerset Levels.

In the *Review*, only 2.4% of the reported habitat creation projects concerned peatlands. The aim of most of these projects, such as work at Risley Moss, Warrington, has been to restore/re-create past peatland nature conservation interest. These projects, although strictly not habitat creation as defined in this *Guide*, are considered in this chapter as the practical and technical project planning issues are similar. This should also be read with Chapter 2 which considers general project planning.

## 6.2 Types of peatland

### 6.2.1 Introduction

Ratcliffe (1977) defines peatlands as *"ecosystems in which vegetation of wet ground builds up organic deposits over the underlying mineral substratum under conditions of waterlogging that are usually anaerobic"*. The term mire is generally applied to all peatlands whether they be of a bog or fen type; however, fens may have either a peat or a mineral substrate. The NVC (Rodwell, 1991) uses the term mire to also include related vegetation which occurs on mineral soils.

Mires may be divided into two main types on the basis of their water supply-

**(a) ombrogenous mires (bogs)** which are fed solely from rainfall and occur in areas of high rainfall; there are two main types:

(i) **blanket bogs** - found mainly in the uplands

(ii) **raised bogs** - found mainly in the lowlands

**(b) minerotrophic mires (fens)** which are fed by water derived from mineral ground either from the surface or from the aquifer as well as rainfall. These can be further subdivided into two main groups of fens:

(i) **soligenous fens** - in which the lateral movement of water is important, eg. *valley mires*; *springs and flushes*; these may be base-rich or base-poor.

(ii) **topogenous fens** - in which vertical water table movement is more important than lateral movement, eg. *open water transition and flood plain mire*; *basin mires*; these may be base-rich or base-poor.

Full NVC descriptions of fens and bogs are given in Rodwell (1991), habitat-based descriptions in Ratcliffe (1977) and Rowell (1988). Fojt (1989) presents a quick reference guide to fen vegetation communities.

### 6.2.2 Blanket mires.

Blanket mire (blanket bog) is the most extensive mire type in Britain and is characteristic of many upland areas and coming down to sea level in western and northern Scotland. The two most widely distributed NVC communities of blanket mires are:
M17 *Scirpus cespitosus-Eriophorum vaginatum* blanket mire;
M19 *Calluna vulgaris-Eriophorum vaginatum* blanket mire.

The M17 *Scirpus-Eriophorum* mire is the characteristic blanket bog of the more oceanic parts of Britain, generally below 500m in altitude and more than 2000mm of rain per year. Apart from an extensive carpet of *Sphagnum*, the characteristic species are deer-grass *Scirpus cespitosus*, purple moor-grass *Molinia caerulea*, harestail cotton-grass *Eriophorum vaginatum* with some *Calluna vulgaris* and cross-leaved heath *Erica tetralix*. At higher levels the M19 *Calluna-Eriophorum* mire is the typical community on the blanket peats. In this vegetation, *Sphagna* are less important, *E. vaginatum* is abundant and an important builder of peat, and montane sub-shrubs such as crowberry *Empetrum nigrum* and cowberry *Vaccinium vitis-idaea* are common. This community occurs in the uplands of Wales and from the Peak District northwards. Other NVC communities occur on blanket peats but the two described are the most significant in terms of area.

### 6.2.3 Raised mires

Raised mires (raised bogs) occur in a wide variety of situations including flood plains, at the heads of estuaries, and in hummock-hollow topography in a glacial deposited landscape. In the lowlands they are usually discrete peatland systems although, in Scotland, they may occur as part of a blanket bog complex. Many, if not most, have been drained and reclaimed for agriculture and, where not reclaimed, their peat deposits have been exploited. In the past this was on a small scale but in modern times the extraction of peat is on a large commercial scale.

Typically on an undisturbed raised mire, the convex central part of the mire is bounded by a steeply sloping margin (rand) and an adjacent stream course with associated fen vegetation (lagg) with more nutrient-rich water which limits the spread of the bog communities. Disturbance of these raised mires has resulted in a general drying of any remnants and a resultant change in the vegetation mosaic.

The vegetation of the undisturbed raised mire is the NVC M18 community:

M18 *Erica tetralix-Sphagnum papillosum* raised and blanket mire.

A raised bog is typically covered with a *Sphagnum*-dominated vegetation with an undulating surface giving a hummock-hollow pattern. Vascular plants in this vegetation include common cotton-grass *Eriophorum angustifolium*, white-beaked sedge *Rhynchospora alba*, sundews *Drosera anglica* and *D. rotundifolia* and bog asphodel *Narthecium ossifragum*. Bog rosemary *Andromeda polifolia* and cranberry *Vaccinium oxycoccus* can be locally abundant. Other communities occur, especially on the rand and bordering the lagg of the bog.

### 6.2.4 Soligenous fens.

**(a) Valley mires.** This type of soligenous mire is located within valleys. It develops along the lower slopes and floor of the valley where there is some water movement. Springs and seepage from the valley sides provide the main source of water. The topography of the valley also helps to maintain a high water table. Valley mires occur throughout England and Wales and there are good examples in East Anglia and the New Forest.

There are a number of NVC mire communities found in these systems, both in the lowlands and the uplands, as follows:-

M4 *Carex rostrata - Sphagnum recurvum* mire
M6 *Carex echinata - Sphagnum recurvum/auriculatum* mire
M7 *Carex curta - Sphagnum russowii* mire
M10 *Carex dioica - Pinguicula vulgaris* mire
M11 *Carex demissa - Saxifraga aizoides* mire
M12 *Carex saxatilis* mire
M13 *Schoenus nigricans - Juncus subnodulosus* mire
M14 *Schoenus nigricans - Narthecium ossifragum* mire
M17 *Scirpus cespitosus - Eriophorum vaginatum* blanket mire (occurs in valleys in northern Britain)
M21 *Narthecium ossifragum-Sphagnum papillosum* valley mire.
M29 *Hypericum elodes - Potamogeton polygonifolius* soakaway

In southern England, the valley mire communities, especially NVC M21, show transitions into wet heath communities. Here where the shallower peat or mineral soils are only periodically waterlogged, there is a transition into the NVC community M16 *Erica tetralix-Sphagnum compactum* wet heath where peat-forming *Sphagna* are absent. It is in this community, especially on the heaths on the western side of Poole Harbour in Dorset, that the uncommon marsh gentian *Gentiana pneumonanthe*, Dorset heath *Erica ciliaris* and marsh clubmoss *Lycopodium inundatum* occur.

Valley bogs have also been exploited by man for peat cutting to a lesser extent than raised bogs, and the cutting has generally been on a small scale over a long period of time. The quality of the mire vegetation therefore remains good in many places, especially in the New Forest.

**(b) Springs and flushes.** Whereas valley mires may form fairly large fen areas along a valley side, where flushes and individual springs emerge, the fen occupies smaller, more discrete areas.

There are a number of NVC communities which are found in these situations:-

M6 *Carex echinata-Sphagnum recurvum/auriculatum* mire
M31 *Anthelia julacea - Sphagnum auriculatum* spring
M32 *Philonotis fontana - Saxifraga stellaris* spring
M33 *Pohlia wahlenbergii var. glacialis* spring
M34 *Carex demissa - Koenigia islandica* flush
M35 *Ranunculus omiophyllus - Montia fontana* rill

6.2.5 Topogenous fens

**(a) Open water transition and flood-plain mire.** Open water transition fen develops around a body of open water; these show colonisation by aquatic vegetation to form swamp communities. Flood plain fen develops on a waterlogged, often periodically inundated flood-plain adjacent to a river or stream. The swamp vegetation of open water transition fens and flood-plain fens are strongly related, hence their treatment together in this account.

Open water transition fens include the following NVC communities:-

S1 *Carex elata* swamp
S2 *Cladium mariscus* swamp and sedge-beds
S3 *Carex paniculata* swamp
S4 *Phragmites australis* swamp and reed-beds
S5 *Glyceria maxima* swamp
S6 *Carex riparia* swamp
S7 *Carex acutiformis* swamp
S8 *Scirpus lacustris ssp. lacustris* swamp
S9 *Carex rostrata* swamp
S10 *Equisetum fluviatile* swamp
S11 *Carex vescaria* swamp
S12 *Typha latifolia* swamp
S13 *Typha angustifolia* swamp
S14 *Sparganium erectum* swamp
S15 *Acorus calamus* swamp
S16 *Sagittaria sagittifolia* swamp
S17 *Carex pseudocyperus* swamp
S18 *Carex otrubae* swamp
S19 *Eleocharis palustris* swamp
S20 *Scirpus lacustris ssp. tabernaemontani* swamp
S22 *Glyceria fluitans* swamp

Flood-plain fens have the following NVC communities:

S24 *Phragmites australis - Peucedanum palustre* tall-herb fen
S25 *Phragmites australis - Eupatorium cannabinum* tall herb fen
S26 *Phragmites australis - Urtica dioica* tall-herb fen
S27 *Carex rostrata - Potentilla palustris* tall-herb fen
S28 *Phalaris arundinacea* tall-herb fen
M4 *Carex rostrata - Sphagnum recurvum* mire
M5 *Carex rostrata - Sphagnum squarrosum* mire
M8 *Carex rostrata - Sphagnum warnstorfii* mire
M9 *Carex rostrata-Calliergon cuspidatum* mire

In addition to the above there are also a number of fen meadow and rush pasture communities which are grazed or cut which have affinity to typical flood-plain fen vegetation.

Open water and flood plain mires have been the mire type which has been most extensively destroyed by man in Britain. This type of vegetation covered most of the East Anglian fens, where there are small remnants at sites such as Wicken Fen. Once drained, the richer types of fen peat give very fertile soils. Some compensation is provided by the Norfolk Broads which were created by peat cutting in the Middle Ages and the flooded hollows now support a wide range of fen vegetation.

**(b) Basin mire.** Basin mires (fens) develop in a waterlogged basin with limited through-flow of water. These mires mostly develop where there are kettle-holes or drainage of a valley has been impeded by deposited glacial material. Within the basin the water table is level, but small flushes may occur along the basin's sides. The proportion of open water, if present, is small. There is a variety of vegetation types found in basin fens reflecting local environmental and management characteristics. Types of vegetation include raised mire communities or topogenous fen vegetation depending on the pH and nutrient status of the feeding water. These sites can have spectacular *Sphagnum* lawns and hummock-hollow topography similar to the surface of a raised mire.

6.2.6 Fen meadows.

Fen meadows have been derived from other fen types by management practices, especially grazing and cutting. They occur in a wide variety of situations and may be associated with topogenous and soligenous fens. There are seven NVC communities which make up this group of fens:-

M22 *Juncus subnodulosus - Cirsium palustre* fen-meadow
M23 *Juncus effusus/acutiflorus - Galium palustre* rush pasture
M24 *Molinia caerulea - Cirsium dissectum* fen-meadow
M25 *Molinia caerulea - Potentilla erecta* mire
M26 *Molinia caerulea - Crepis paludosa* mire
M27 *Filipendula ulmaria - Angelica sylvestris* mire
M28 *Iris pseudacorus - Filipendula ulmaria* mire

Many fen-meadows are under threat at the present time due to both agricultural improvement and a change from traditional management practices.

## 6.3 The planning of a peatland habitat restoration/creation scheme - the preliminary site survey.

### 6.3.1 Site location and history

The first stage in project planning is to carry out a site survey aiming to determine whether the site is a fen or bog and which type it is. With a peatland site it is important to obtain historical information concerning the exploitation of the site. For example, when were the main periods of peat cutting? Was drainage installed on the site and, if so, when? This information can be obtained by consulting old maps and estate records and by talking to local people about the site. Given time it should be possible to piece together the history of the site which can then be correlated with the current vegetation. The kind of information that this might give is, for example, the time that is required for the development of certain types of mire vegetation following peat cutting. The location of the site in relation to the surrounding land is also important; for example, the site may be farmland on peat which adjoins an unreclaimed peatland area.

### 6.3.2 Existing vegetation

A thorough vegetation survey of the proposed site is essential. This will provide information on the type of peatland which is present and the location of plant communities which will need to be conserved in the restoration programme. Part of the programme might be to attempt to enhance this vegetation. The surveying should also extend to peatland areas close to the project site. If less disturbed areas are present, then the plant communities there may provide a model for the restoration/creation of communities on the project site. The surveys should also determine the present and past nature conservation interest of the site.

### 6.3.3 Environmental factors affecting the site

It is important to determine those factors which are affecting the site at the present time. Those factors which affected the site in the past and those factors which may affect the site in the future also need to be considered. The local factors include:-

* Substrate and its fertility
* Hydrology
* Water quality
* Refugia (ie. a highly isolated peatland site)
* Seed bank
* Past, present and future site management
* Land use surrounding the site.

More general factors which may need to be considered are:

* Regional hydrology and hydrogeology
* Ground and water pollution
* Air pollution.

Information on the above will help to define objectives for the site and the factors which need to be tackled in order to restore the site. Two of the most important factors, substrates and hydrology/hydrogeology, are considered in the following sections.

6.3.4 Substrates

It is important to determine the nature of the substrate, especially whether a peat or mineral soil is present and whether a permeable or relatively impermeable substrate underlies the peat. Additionally, information on the type and the pH of the peat which is present, whether there is any correlation between variation in peat and differences in plant communities, and whether any mineral soil is present, will all be useful in planning the proposed project.

6.3.5 Site hydrology and hydrogeology

The type of mire vegetation which is present/desired is so dependent on the water regime of the peat that this information is vital in order to be able to plan which communities will be targeted in the restoration. An understanding of the surface and subsurface water behaviour at the project site, involving inputs, outputs and fluctuations, is essential to planning. An attempt should be made to obtain information covering the whole year so that any constraints can be identified, such as the extent of groundwater level drop in the summer. Even one year's data may not be representative of the long term situation. Specialist advice will often be needed to obtain this information.

Data on the chemistry of the waters, especially those inputs running onto the site, are most important. In most situations it is essential that water running onto the site is unpolluted; for example, even low levels of nitrogen and phosphorus can have a profound effect on mire vegetation. (However, enriched water may be tolerated if the aim is to create/restore *Phragmites* reedbeds). Indeed, the constraints, influences and opportunities presented by the surrounding land are very important. This can include the influence of farm drainage on adjacent land and the loss of former spring feeding of a mire due to groundwater abstraction.

## 6.4 Preparation of the Project Plan

6.4.1 Setting objectives

The completion of the preliminary survey will allow an assessment to be made as to the feasibility of the proposed project. If it is considered to be feasible and desirable, this will then lead on to the preparation of a **Project Plan**. The purpose of the Project Plan is to record and plan out every stage of the habitat restoration/creation project. The first stage of the Plan is to decide on project objectives.

Possible objectives may include the following:-

1. The restoration of specific NVC mire communities on the site which have either degraded or been lost from the site. This may involve the enhancement of remnant communities or the reintroduction of species.

2. The restoration/creation of specific habitat for a particular target species of plant or animal. A good example of this is the maintenance of some areas of open water and bare peat at Fenns and Whixhall Moss, Clwyd, for the uncommon dragonfly *Leucorrhinia dubia*.

3. The restoration of the open nature of the peatland by the removal of scrub and invading trees, such as Scots pine from local plantations.

There may be both short and long-term objectives of a project. For example, for a raised mire the short term objective would be to achieve colonisation of open water in pools by

*Sphagnum spp.*, and the long term objective would be the development of NVC community M18. Objectives can also change over time given the way the site develops; flexibility must therefore be built into the Project Plan.

6.4.2 Realising the objectives

Once the objective(s) of the project have been set, then the methodologies need to be developed to cover the establishment, monitoring and management of the project. To some extent this will have been done during the preparation of the project objectives - it makes no sense setting a project objective for which no reasonable methodology exists. Therefore planning needs to be an interactive process. Directed monitoring is very important as this is the only way to measure the success of the project.

A vital part of this part of the project is to cost out the resources which will be required both at the establishment phase and in the long term. If insufficient funding exists, then the objectives of the project may have to be changed.

**6.5 Methods of peatland restoration/habitat creation**

6.5.1 Introduction

There is very little literature available on the restoration of peatlands beyond that given in Rowell (1988), which is more concerned with site management, and Fojt & Meade (1989) which considers some issues and methods but is not a detailed restoration manual. There is information on the restoration of bare eroding peat on damaged and degraded blanket mires (Tallis & Yalden, 1983; EAU, 1988; Anderson, 1993). The Department of the Environment commissioned a study in 1992 to examine the range of experience which is available concerning the restoration of peatlands. It has not proved possible to obtain an advance copy of this as yet unpublished report; it is possible that its findings might require a revision to this chapter of the *Guide*. Another as yet unpublished source of methodologies and theory is Shaw *et al* which should be published in 1994.

This methods section seeks to guide the practitioner into developing a methodology for their project. It firstly covers some ecological and practical principles and then, in the absence of clear methodologies, presents case studies both from the literature and from this *Review*.

6.5.2 Ecological principles

**(a) Hydrology and water quality.** This is a subject intimately linked to peatland substrates and their nutrient status. In terms of peatland restoration, site hydrology will have been examined in the preliminary site survey in terms of water supply and groundwater levels and fluctuations. Given some problems highlighted by the survey, it may be necessary to, for example, restore the original hydrology of the mire before drainage was installed using methods given in Rowell (1988) and Brooks (1981). Water quality problems may be more difficult to solve but it may be a question, for example, of isolating one particular source of nutrients from the flow into the mire. An example of this kind of problem has been experienced at a basin mire, Wybunbury Moss in Cheshire, where high levels of nitrogen and phosphorus were draining into the site from an adjacent agricultural source.

**(b) Substrate condition and nutrient status.** The preliminary site survey will have examined these factors and this will have guided the development of project objectives. The most critical technical point here is whether the physical and chemical condition of the substrate is suitable for the restoration of a particular target vegetation. It is not certain that the technical background data will always be available to answer these questions and it may be necessary to carry out some research and physical/chemical analysis on a model site in the locality. On blanket peat, technical data with respect to restoration are available from sites in the Pennines (Tallis & Yalden, 1983; EAU, 1988).

**(c) Substrate surface stability.** Bare exposed peat at both lowland and upland sites is prone to drying and erosion. Whereas this might result in a stable consolidated covering (which can be a difficult substrate for seed germination and establishment), some peats when dried will powder and be prone to wind-blow. If this is the case with the peat on a restoration site, then methods need to be introduced to ensure rapid vegetation establishment.

On eroding peat in the uplands, stabilisation is a key issue and has been achieved by ensuring plant establishment by applying lime, fertiliser and a grass stabiliser. At Holme Moss, West Yorkshire, the use of chemical stabilisers and a mulch fibre in the hydroseeded grass mix applied to the peat has been successfully used (Anderson, 1993). However, the use of a grass stabiliser will not be applicable to all sites and conditions.

**(d) Seed germination and seedling establishment.** It is necessary to provide a suitable substrate surface if seed germination and establishment is required in the restoration project. If time allows, a small field trial could give useful guidance before resources are spent on a large scale project. This could also yield information on the best time of sowing seed; on peatland sites in the uplands, spring is usually the best time for sowing seed (EAU, 1988). Seed-bank investigations could also be carried out to determine whether any additional seeding is needed.

**(e) Source of seed and propagules.** This is a crucial element in a peatland restoration/habitat creation project. Ideally some remnant vegetation will have remained on the site and this, given appropriate management, can be enhanced. It may be possible to collect seed from an adjacent peatland or from another part of the site using hand-gathering or vacuuming techniques. Harvesting using machinery is unlikely to be an option due to the soft and uneven ground conditions although it may be possible with some fen meadow communities. The gathering of bryophytes using these techniques is difficult and it is necessary to rely on natural colonisation via spores from nearby vegetation.

With lowland raised and valley mires, it may be possible to use vegetative material collected locally or from another part of the site. This will be most straightforward with bog-pool and very wet vegetation. The use of cut turves may also be possible and these could act as nuclei for colonisation on the receptor site. However, it is necessary to ensure that the receptor site has the right environmental conditions and to ensure that the donor site can absorb the loss.

**(f) Protection of developing vegetation.** It will usually be necessary to exclude grazing animals and the public from lowland raised or valley mires or blanket peats to protect the peat surface from erosion. It may also be necessary to stabilise bare sloping peat on blanket bogs using geotextiles or a grass nurse crop.

6.5.3 Restoration of lowland raised mires.

Although national nature conservation policy is geared towards the protection of these steadily diminishing mires, their protection from peat extraction or development needs to be reinforced by an active management, enhancement and restoration programmes in order to maximise their ecological value. In this context, the distinction between peatland management, the enhancement of existing habitats and the restoration/creation of habitats is unclear as they overlap.

The case studies which have been investigated are, with one exception, all restoration projects and not habitat creation. The first case study, Risley Moss, Cheshire is an example of an attempt to provide suitable conditions for the natural regeneration of this raised mire:

**CASE STUDY No.22: RISLEY MOSS, WARRINGTON, CHESHIRE**

Risley Moss is one of the largest remaining fragments of the raised bog system which once covered large areas of South Lancashire and parts of North Cheshire.

These bogs have mostly been drained and now support arable agriculture. Risley Moss has been drained and cut for peat, although much peat remains beneath its gently sloping surface.

The restoration aim on this site is to achieve a self-sustaining raised mire. To do this conditions are being modified to provide a suitable environment for the natural regeneration of the mire flora. The first step was the blocking of the outfall drains in the early 1980s which has resulted in the re-wetting of part of the mire. The sloping nature of the site appears to be preventing a larger area being rewetted. By 1991, the wetter areas were being colonised by *Sphagnum* mosses which had become rare on the site before the regeneration started.

A number of raised mire species had become extinct on the site and three species were reintroduced in 1987 some five years after the re-wetting programme started. These species were sundew *Drosera rotundifolia*, common butterwort *Pinguicula vulgaris* and lesser bladderwort *Utricularia minor*. In 1991, these species, with the exception of lesser bladderwort, were still present.

Other features have been created on the site including bogpools for dragonflies and damselflies.

Critical comments.

1. A Management Plan for Risley Moss was prepared in 1977 (by Duncan Moffat) and the regeneration work which has been carried out implements the objectives set out in the Plan. This is one of the few examples in the *Review* where a project had such a plan setting out the project objectives.

2. The problem with the hydrology of the mire following the blocking of the outflow ditches suggests that insufficient hydrological survey was carried out before the action was taken. The arrangements for the current monitoring of the hydrology are not known.

3. The scheme is a highly positive one given the history of raised mires in the district (peat extraction and landfilling is still taking place on some sites). The scheme has received local authority funding and has become a Local Nature Reserve thus ensuring continuity of management and funding.

4. The policy of introducing species is questioned in terms of both the allocation of scarce financial resources and the scientific case. The aim of the project has been to achieve the natural regeneration of the mire flora. The expansion of the *Sphagnum* mosses since rewetting is a good example of this natural regeneration which is being sought. With the known longevity of seed and the habitat improvements which were being made, some of the reintroduced species may have been capable of re-establishing themselves on the site.

5. The regeneration programme has been successful in the creation of habitat for dragonflies and damselflies and other invertebrates. Specialist raised mire species which were formerly present in very low numbers have now increased their populations.

Mire regeneration is also being achieved at the much less damaged Cors Caron National Nature Reserve in Wales. Tillotson & Vickery (1993) report an increase of *Sphagnum* and a suppression of purple moor grass *Molinia caerulea* as a result of raising water levels; it is not reported whether peat is being formed. However, like Risley, it is another example of peatland enhancement and restoration rather than of habitat creation.

The Risley case study forms a contrast with Thorne Moors (Appendix B, case study No.21) , where the emphasis has been on the protection of existing interest as well as encouraging the regeneration of peatland communities. This is a large and complex restoration project on a nationally important site for nature conservation and published results of this project are awaited with interest.

The second case study, also used as a case study by DOE (1992), is located on part of another formerly large area of mires, the Somerset Levels, at Westhay Moor, Somerset. It is mainly a site of wetland habitat creation and the conservation and enhancement of the remaining mire community:

**CASE STUDY No.15: WESTHAY MOOR, MEARE, SOMERSET**

The site of the present case study at Westhay Moor was only partially extracted for peat and the planned restoration to agriculture did not take place. Some 27 ha was acquired by the Somerset Trust for Nature Conservation (STNC) in 1986. They are currently creating a range of habitats to form the Westhay Nature Reserve.

The 6ha of acid mire vegetation was included within an objective to create a mosaic of wetland habitat types including open water, *Phragmites* reedbeds, islands and the mire vegetation. Water level control has been achieved using a pump coupled with a network of ditches and sluices.

The site is now being managed as a nature reserve and local volunteers warden the site. A full management plan has been drawn up for the reserve.

<u>Critical comments</u>

1. This site is developing well and has the potential to become a significant nature reserve. It has a management plan, commitment (funding) from STNC and enthusiasm from local volunteers.

2. The management plan does not state what priority is being placed on the conservation and enhancement of the mire system or whether it is compatible, in the long term, with the more mesotrophic communities being created, such as the large *Phragmites* reed areas.

3. In view of the very small areas of acid mire vegetation remaining on the Somerset Levels, perhaps a higher priority should have been placed on the mire community (it is only briefly mentioned in the DOE (1992) account) in terms of increasing its area on the reserve.

The *Review*, the literature and the case studies have indicated that much of the restoration/habitat creation activity taking place on raised mires is the protection and enhancement of existing mire vegetation. The methodologies which are being used are broadly those covered by Rowell (1988) but there is a need for more publishing of techniques and case studies.

6.5.4 Revegetation of blanket mire.

**(a) Introduction.** The *Review* did not include any blanket mire case studies but there is a small literature on the subject which overlaps with that of heathlands and moorlands (Chapter 5). There is also some current work taking place on windfarm sites which should increase knowledge in this area. The work which has been carried out can be broadly divided into revegetation, habitat creation/restoration and natural re-colonisation although, as with other mires, the differences between these categories is rather imprecise.

Much of the work which has been carried out centres on the establishment of appropriate moorland vegetation on bare eroding peat on the Pennines of Derbyshire and West Yorkshire. These bare peat areas have been created with a combination of acid rain pollution, overgrazing by sheep and, locally, by human trampling although the causes are still being studied. The plant communities affected are mainly NVC M19 *Calluna vulgaris-Eriophorum vaginatum* blanket mire.

**(b) Revegetation.** The research which has been carried out, reported in Tallis & Yalden (1983), EAU (1988) and Anderson (1993), has broadly agreed that bare peat can be revegetated by using a two stage method:-

1. The establishment of a stabilising grass sward; highland bent *Agrostis castellana* is an effective species and, although it is not native, it does tend to become eliminated with time. At Robinson's Moss, Derbyshire, wavy hair grass *Deschampsia flexuosa*, already present at the site, was also used. This took longer to establish, but then persisted. At the same time that the seed is sown, it is essential that ground limestone and an NPK general purpose fertiliser is applied to the peat; this is due to the low pH and extreme infertility of the peat. This can be done by hand, although at Holme Moss, West Yorkshire, hydroseeding was used; in addition to the seed, lime and fertiliser, a chemical binding material, alginate was used together with a mulch fibre (Anderson, 1993). At Holme Moss some 4.5ha was treated in 1984 and a further 4.1ha in 1986.

2. The introduction of an ericaceous component has been most successfully achieved by application of forage-harvested heather *Calluna vulgaris* seeding heads which were cut locally and spread over the site. This has been done successfully at Kinder Scout (EAU, 1988), Holme Moss (Anderson, 1993) and at Plenmeller, Northumberland (EAU, pers. comm.). In addition, container grown plants have also been successfully introduced into the stabilised peat at Holme Moss. This has generally involved mainly *Calluna*, but at Holme Moss bilberry *Vaccinium myrtillus*, crowberry *Empetrum nigrum* and cross-leaved heath *Erica tetralix*, all grown from locally collected cuttings, have been successfully introduced (Anderson, 1993).

**(c) Habitat creation**. Little has been reported from these programmes on the colonisation by other moorland species which will lead towards the re-creation of the native moorland vegetation. Anderson (1993) reports the successful incorporation of introduced species into a matrix using cotton grasses *Eriophorum vaginatum* and *E. angustifolium* from the surrounding blanket bog.

Part of the work by SGS Environment (unpublished) at Plenmeller, Northumberland, has been to examine methods for the creation of blanket mire vegetation following opencast coal extraction. This work is in its early stages but promising results have been obtained using blanket mire turves seeded into bare wet peat, with vegetative and seed-based colonisation taking place outwards from these turf nuclei. Another approach has been to seed bare wet peat with gathered seed of harestail cotton-grass *Eriophorum vaginatum* (the commonest species of the blanket peat in the area) and a good recruitment from seed has been obtained.

**(d) Natural recolonisation.** At Plenmeller, other blanket mire species have also colonised blanket mire experimental area including *Sphagna*. Natural colonisation plays at least some part in all blanket mire revegetation and re-creation projects which have been examined. A decision needs to be taken at an early stage in project planning whether artificial seeding or natural colonisation is the most appropriate technique for the site.

**(e) Implementation and aftercare.** The timescale required for these upland programmes to be effective is quite long. The harsh climatic conditions and short growing season are not conducive to plant growth. The Derbyshire sites reported in EAU (1988) gave a nurse grass cover establishment in one season, but the *Calluna* growth took longer although the plants flowered and set viable seed in their second season. Subsequent establishment of plants from this seed then occurred. In the Holme Moss programme, Anderson (1993) reports a 52% cover of *Calluna* after six years and 84.5% cover after nine years.

The use of nurse crops to stabilise the peat surface and to provide suitable microclimatic conditions for seed germination is solely a temporary measure. Ideally the nurse crop should be designed to gradually disappear as the native, desired species enter the sward. The use of a nurse crop in heathland and moorland conditions is discussed in more detail in section 5.5.2 (b).

All authors agree that it is essential to exclude grazing animals from these programmes although the fencing and exclusion of animals from common land can be difficult. At Robinson's Moss, sheep were allowed to enter one of the enclosures after 18 months and this had a highly detrimental effect on all the vegetation, with *Calluna* being particularly affected (EAU, 1988). However, it must be the intention to ultimately restore sheep grazing to these areas. Research is needed on the tolerance of restored vegetation to grazing pressure.

**(f) Monitoring.** There is a need for the monitoring of the site so that the success of the restoration can be determined. If the technique which has been used is not successful, then the monitoring should be able to suggest alternative techniques which can be attempted.

6.5.5 Restoration and creation of fen vegetation.

Much of the work which has been carried out on the restoration of fens centres around the restoration of former management to either conserve what already exists or to restore a former community. The management involved is usually grazing or a cutting/mowing regime.

Work on the re-creation of fen systems has consisted so far of two types:

**(a) Reed beds (*Phragmites australis*).** This is often pure habitat creation as defined by this *Guide*. Many reedbeds are being created for root zone water treatment, such as at the outflows of sewage treatment works. The root zone of the reedbed, with roots and waterlogged substrate, acts as a sink for organic matter and heavy metals. Most of these reedbeds are being created on former agricultural land on mineral soils. They have poor botanical value, but the habitat is of value to breeding and wintering birds and certain insects. Current practice in this subject is summarised in Shaw *et al* (1992) and Ward (1992).

**(b) Swamp communities**. Attempts have been made to create the early stages of a hydrosere and associated rare species by carrying out pond excavation and allowing colonisation of the open water to take place.

6.5.6 Peatland habitat creation

There appears to be very little reported work on the creation of peatland communities within the strict definition of habitat creation. This is because the emphasis has been on the better management and enhancement of the remaining peatlands in Britain. The *Review* found two examples of work being carried out, one of which is primarily an education project.

Fojt & Meade (1989) report on techniques being developed in the Netherlands on the restoration of peatlands following peat extraction. The costs of such programmes are high with £10,000 /ha being paid in compensation for the remaining peat, the need for assured hydrology and the need for site management. So far the creation of an active bog with accumulating peat has not been achieved, but there seems to be no reason why *Sphagnum* cannot be established and achieve the peat accumulation of 2mm per year which is seen in nature. In the Dutch example, the environmental conditions conducive to peat accumulation have been established and it will be some years before it is known whether the project is successful. Another approach suggested by Rowell (1990) is to start the creation process at the swamp stage with no peat; this will take decades or centuries to achieve a peatland system.

A *Sphagnum* bog has been successfully created in a school grounds in Wolverhampton which, although on a small scale, has considerable educational potential and some scientific interest (see box).

There does, however, seem to be very limited scope for the creation of new peatlands at the present time, excepting perhaps small examples for educational purposes (and then it may be better for children/students to see a real peatland and its vegetation).

## 6.6 Monitoring and long-term management

As with all habitat creation projects, habitat restoration and enhancement programmes need to be monitored and managed. The monitoring will guide the management which is practised. Peatland programmes will be long-term in nature and secure funding and commitment are necessary to safeguard the initial investment and maximise the chance of success. Guidance on long-term management can be found in Rowell (1988).

**CASE STUDY No.20: MERRIDALE SCHOOL, WOLVERHAMPTON**

The aim of this project was to construct some miniature examples of heath and acid bog communities for educational purposes and to offer "refuge" to some uncommon plant and animal communities. The construction took place in 1983 and consisted of two excavations for the bog communities, one for a moorland pool with the excavated material being used as a substrate for heathland creation.

To create the bog pools, two 10m diameter and 0.5m deep excavations were made in an amenity grassland area of the school grounds, lined with sand and finished with butyl liners. They were then filled with *Sphagnum* moss peat and filled to saturation point with tap water; a pH range of 3.8 - 4.6 was achieved.

The first of the "peat bogs" was planted with turves collected from a valley bog and were left as islands in the peat from which colonisation could take place; a bog pool was also excavated. The second of the peat bogs was planted with material from Wem Moss, Shropshire using turves cut during pool creation on the site.

Both bogs (in 1991) supported a diverse peatland vegetation with much *Sphagnum* which appeared to be building. Most of the uncommon peatland species had persisted. Unfortunately, mesotrophic vegetation was developing in places suggesting that some additional nutrient input is taking place, perhaps from leaves.

Critical comments

1. Within the objectives set by this habitat creation project to create a small-scale peatland community for educational purposes, the project has been a great success, at least over a 10 year period.

2. The principle of using turves from existing peatlands, one an SSSI, is not to be encouraged, and the use of commercial peat to create the correct substrate is not acceptable

3. The project has shown the feasibility of using turves to "seed" unvegetated peatland. This principle could be used within lowland raised mire sites where a large area of wet peat surface is available at some distance from the nearest suitable vegetation and therefore seed/propagule source.

## 6.7 References

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# 7. URBAN SITES

## 7.1 Introduction

Whereas this habitat creation *Review* has been principally concerned with the creation of terrestrial habitats, grassland, woodlands, heathlands and peatlands, these habitats do occur in urban areas and these form important sites for both wildlife and local people. Urban areas also have other related kinds of habitats, usually based on wasteland sites, and this disused land can also be of high wildlife value.

As in rural areas, priorities for nature conservation in urban areas centre around the protection of sites of existing ecological interest. Much energy in recent years has also centred on the enhancement of these sites involving habitat management and securing their long-term future in terms of funding and community use. In addition, however, the societal benefits of natural spaces in urban areas are widely recognised; these are discussed by Harrison *et al* (1987) and Rohde & Kendle (1994).

The subject of urban nature conservation developed during the 1980s and now forms a significant element in the urban planning process in such documents as Local Plans, Borough Plans and Unitary Development Plans. Guidance on planning for wildlife in towns and cities was published by the Nature Conservancy Council in 1987 and has now been updated (English Nature, 1994). Recognising the national importance of nature conservation in urban areas, the Nature Conservancy Council published guidance in Barker & Graf (1989) and Simmons *et al* (1990).

The development of the urban wildlife movement has resulted in the formation of urban wildlife groups around the country and a strong recognition of the role of urban nature conservation in the community and in education. The social aspect of urban nature conservation was reviewed for the Trust for Urban Ecology by Millward & Mostyn (1987) and the Nature Conservancy Council later published a *framework for action for nature conservation in towns and cities* (Simmons *et al*, 1990).

It has been recognised for some time that good opportunities exist for habitat creation in urban areas. It is the case that in many urban districts there are few "natural greenspaces" and even fewer with public access. Habitat creation has always formed an important part of the urban wildlife movement's activities and was assisted by publications such as Baines & Smart (1984) *A guide to habitat creation* which gave habitat creation an urban perspective for the first time and Emery (1986). With habitat creation being recognised as an important element of urban nature conservation, many local projects have been carried out with much pioneering work mainly in the larger connurbations, such as Liverpool, Newcastle-upon-Tyne, Birmingham and London.

It was outside the scope of the *Review* to consider urban nature conservation projects specifically. However, guidance is provided on methods in relation to certain specific differences arising in the urban context, such as contaminated land and urban soils.

## 7.2 Types of urban habitat creation site

Potential sites for habitat creation in urban areas occur in a wide variety of situations. They can centre on sites which were former industrial sites, demolished housing areas, waste disposal sites or undisturbed land awaiting development. Other sites are associated with active/disused railway land, hospitals and mineral extraction. Many of these sites are on artificial/disturbed soils derived from urban demolition and waste substrates which contrasts with the more rural sites considered throughout this *Guide*. The question of the reclamation of derelict land to nature conservation uses and the cost-effectiveness of such an approach is the subject of current DoE research.

Another large area of land which has potential for habitat creation is contained in amenity land, including urban parks and sports fields. Whereas much of the activity to date has been concerned with the enhancement of existing wildlife interest in urban parks, with such guidance as Flint (1985) and Ash et al (1992), there is much scope for the creation of woodlands, scrub, species-rich grasslands, ponds and other wetlands. Buildings also have potential for habitat creation as is shown in Johnston & Newton (1994).

### 7.3 Planning an urban habitat creation scheme - the preliminary site survey

The first stage before the preparation of a habitat creation **Project Plan** is to carry out a survey of the proposed habitat creation site in order to determine whether it is suitable for the project which is proposed.

#### 7.3.1 Site history

With urban sites, knowledge concerning the history of the land is of vital importance, especially concerning potential contamination of the site and resulting pollution. This will often require the searching old records and maps and interviewing older people who used to work on the site or who are familiar with the site. The main subject areas are:-

**(a) Former industrial use.** Information on date industrial activity started and stopped, the type of business undertaken (and therefore likely contaminants produced) and whether any remediation has been undertaken. Industrial use could include activity such as old railway sidings, for example; these are usually contaminated with heavy metals from the cleaning of steam railway engine boilers. Former occupiers and activities with high risk can also be identified, such as the MOD and former gasworks.

**(b) The presence of services.** Information on services crossing the site, culverted streams, etc can be very important and may pose constraints on proposed habitat creation. An example of this may be the planting of trees above gas, water or electricity services.

**(c) Land ownership and planning history.** Information on land ownership (freehold and leasehold) and existing planning consents is a vital part of project planning.

**(d) Liability and insurance issues.** The habitat creation planner should be aware of environmental liabilities and insurance issues. For example, a former industrial site should not be taken on without full knowledge concerning the site (an "environmental audit" is required). If the site is acquired, then the liability for previous environmental pollution moves with the ownership of the land.

#### 7.3.2 Existing vegetation and ecological interest

As with all habitat creation schemes, it is very important to carry out a thorough vegetation survey of the site to determine whether there is any existing interest. There may be some published information on the site which contains old records and other relevant data. Surveys should also include any existing fauna on the site. The faunal surveys will have to be targeted and directed to key groups, for example, breeding birds, lepidoptera, and ground nesting hymenoptera. The surveys which are carried out will depend on the characteristics of the site and the resources and expertise which are available.

The existing ecological interest of the site may have developed given special conditions of inner city climate and poor air quality. These factors should also be taken into account in the surveys.

7.3.3 Soils

It is quite likely that an urban habitat creation site will not have a undisturbed topsoil/subsoil soil profile, which makes an early soil survey an essential part of project planning. Other likely substrates include brick rubble and industrial waste which includes colliery spoils (acidic), blast furnace slag (alkaline), Pulverised Fuel Ash (PFA; neutral pH but boron toxicity) and mixed domestic/industrial landfill. There are a number of recent publications which deal with this key aspect; these are: Bullock & Gregory (1991) and Craul (1992). English Nature have also proposed a new classification of urban soils (Hollis, 1992).

Contaminated soils and consequent pollution can be a major constraint to habitat creation. A distinction needs to be made between land which is lightly altered by previous uses and land which is badly polluted. On lightly altered sites, for example, contamination can be an advantage in encouraging diversity. This has been discussed in section 7.3.1 above and further guidance is given in section 7.5.2 (a) below.

7.3.4 Physical conditions

The physical condition of a site can provide major constraints for a habitat creation project. The presence of old building foundations, for example, will have safety implications and make it difficult for machinery to work on the site. There may also be physical difficulties imposed by substrates such as fused slags, highly compacted materials and the presence of services.

7.3.5 Existing public use and related issues

The existing use of the site and the value placed on it by the public is also of importance. This can include, on the positive side, existing community and educational use and, on the negative side, undesirable public use of the site. Likely public safety insurance can also be an issue. An example of this is concern about the safety of trees in public situations.

## 7.4 Preparation of the Project Plan

7.4.1 Setting objectives

Once the preliminary survey has been completed, there should be sufficient information to prepare a **Project Plan** which is being recommended by this *Guide* for all habitat creation projects. The purpose of the Project Plan is to record and plan out every stage of the project. The most important early item is to set out the project objectives.

7.4.2 Realising the objectives

The next stage is to develop the necessary methodologies to cover the establishment, monitoring and long term management of the project. The practitioner will find guidance on this in Chapter 2 of this *Guide* and in Emery (1986). The resourcing and cost implications of the scheme will be a major factor affecting project objectives; these costs should cover both establishment and long term management. The community aspects of the site and the proposed project must also be taken into account.

For the above reasons, this stage will be an interactive one and it may be necessary to modify the objectives of the project to take account of unforeseen opportunities and constraints, in particular resourcing and costing factors.

## 7.5 Methods of urban habitat creation

### 7.5.1 Introduction

Specific habitat creation methods for habitats which will form part of urban projects are covered in this *Guide* for grasslands (Chapter 3), woodlands and scrub (Chapter 4) and heathlands (Chapter 5), with general habitat creation planning in Chapter 2. Specific guidance on the creation of these habitats in urban areas is given in Emery (1986), Dawe (unpublished), Baines & Smart (1984), Barker & Graf (1989), Carr & Lane (1993) and a number of specific sources which will be referred to below.

This chapter will firstly consider certain technical principles and then habitat creation methods, including one case study from Newcastle-upon-Tyne which was included in the *Review*.

### 7.5.2 Ecological principles

**(a) Soils and contaminated land.** The preliminary site survey will have categorised the soils or substrates which are present according to the methods presented in Hollis (1992). The soil and historical surveys may also have revealed the possibility of soil/substrate contamination on the site. The most important factor in any programme to establish vegetation onto contaminated land is to fully understand the nature of the site contamination and the constraints that this will impose on plant growth and the future public use of the site. This requires detailed information on the physical and chemical condition of substrates on the site (see also section 2.3.5 (f) of this *Guide*).

There is value in looking at the natural colonisation of the substrates to assist in the design of a habitat creation programme. Natural colonisation gives an indication towards the types of species and plant communities which are adapted to the physical and chemical conditions of the substrate and the climatic conditions of the site. Indeed, unless a good case can be made for doing anything different, the best habitat creation approach is to let natural regeneration deal with the situation.

All these factors then need to be related to the Project Plan proposals. If the site conditions (including human health concerns) and proposed habitat creation programme are incompatible, then this will require the redesign of the scheme, the amelioration of the contaminated materials or the removal of materials from the site.

There has been much research on the use of amelioration techniques on contaminated wastes so that normal plant growth can occur. Research and experience have indicated that amelioration by the incorporation of inert materials into the contaminated wastes can be the best long term solution. Inert materials can also be used to cover more inhospitable wastes. With the use of inert materials nutrient levels are very low but this may be very helpful for a grassland habitat creation scheme. Specialist advice may be necessary at this stage.

**(b) Problems for plant growth on urban sites.** There are a number of physical and chemical factors which may cause problems for plant growth on urban sites. These can be summarised under a number of headings:-

1. *Physical problems*. Urban substrates, such as iron/steelworks wastes, can often be coarse, well drained and very prone to drought. Conversely, PFA can be poorly drained and produce difficult anaerobic conditions for plant growth. Wastes, such as brick rubble are often loose whilst reclaimed sites can often be in a highly compacted condition. Treatment then needs to be designed to create a substrate more suited to the plant growth which is required.

2. *Presence of phytotoxic materials*. Such materials can include heavy metals, especially zinc, copper, nickel and chromium. In pulverised fuel ash (PFA), high levels of boron can be a particular problem. It is the cumulative effect of phytotoxic heavy metals which contribute to the inhibition of plant growth.

3. *Soil pH and conductivity levels*. Urban substrates can often have extremes of pH which will inhibit or reduce plant growth. Extremes of pH also allow contaminants, especially heavy metals, to become more available to plants and thereby cause toxicity problems. Many industrial wastes have high conductivity which can also inhibit plant establishment and growth; conductivity should ideally be below 1.5mS/cm (measured using a standard 1:2.5 soil/water dilution).

4. *Plant nutrient and organic matter levels*. Many waste materials and contaminated soils have very low levels of the major plant nutrients, nitrogen, phosphorus and potassium. This problem is compounded by very low levels of organic matter in the soil; organic matter holds much of the soils' reserve of nitrogen and aids its water retention ability. However, low fertility can be great value to the successful creation of species-rich grasslands and heathlands.

**(c) Source of seed and propagules.** Urban habitat creation schemes can, as in rural sites, obtain seed from nearby sources, such as development sites and other managed land. The need to purchase seed from commercial sources will depend on what is available locally and the project objectives which have been set. It is possible that a local source of seed, seed-rich topsoil or turves will determine the type of habitat creation project which is put forward. Natural colonisation and succession should also be part of a successful project.

**(d) Proposed species composition of the created habitat.** This is an important area of planning and concerns natural plant and animal communities in urban areas, ie. proposed target communities for the habitat creation project. It has a bearing on, for example, site evaluation and the relationship of these communities to those in rural areas. In urban areas, the communities can include non-native species which form part of the urban scene. These species therefore need to be taken account of in habitat creation planning (see Gilbert, 1989).

**(e) Protection of developing vegetation.** This is an important aspect with urban sites and goes beyond the measures which need to be taken at rural sites. For instance, it is essential that the project has community involvement to ensure that site policing takes place.

7.5.3 <u>Grassland habitat creation</u>

Much of the literature which is available on urban habitat creation methods concerns the creation of species-rich grasslands. Broadly speaking, the same habitat creation methods apply with the creation of grasslands on urban sites as on rural sites (Chapter 3). The additional factor involved is the wide variety of substrates on which the grassland creation is taking place. These may confer both advantages and disadvantages, with the principle advantage being the infertility of many of the substrates and the principle disadvantage being difficult physical conditions and potential contamination of the substrate.

One of the case studies examined in the *Review* was an urban habitat creation project in Newcastle-upon-Tyne, Benwell Nature Park (also reported as a case study in Simmons et al, 1990). The *Review* concentrated on the meadow creation in the Park. (Other case studies, such as Hampstead Heath (Case Study No.3) reported in the grasslands chapter, are also urban projects, and should also be referred to here).

**CASE STUDY No.2: BENWELL NATURE PARK, ATKINSON ROAD, NEWCASTLE-UPON-TYNE**

Benwell Nature Park, established in 1983, is an example of an "urban ecology" park created with the primary objective of providing an environmental education resource for city schools and members of the public. The Park was created on a former housing area and has a variety of demonstration habitats including a pond, rockeries, displays of native trees, shrubs and herbs, herb gardens, a drystone wall and herb-rich meadows. The Park was formerly run by the education department of Newcastle City Council, later the Leisure Services Department.

The creation of meadows at the Park had mixed fortunes at first with the infertile clay soils of the site proving difficult for the establishment of vegetation. In response to this, some 100 tonnes of topsoil from an unimproved meadow was imported to the site, mixed with horse manure, and spread over the bare clay soils. It is possible that this soil had a seed-bank of meadow species. However, commercial wild flower meadow seed was purchased. No records been kept of the detailed methods used in the habitat creation.

The management of these grasslands has been divided into two sections, one having an early summer cut to encourage spring flowering species and the other cut in late summer to encourage the summer flowering species. The hay is taken off-site. In 1990 a total of 45 plant species were recorded with the meadow having an unnatural appearance emphasised by the non-native cultivars of the leguminous species. However, despite these factors, the meadow is successful in terms of the Park's objectives to create a demonstration meadow habitat.

<u>Critical comments</u>

1. It has not proved possible to learn from the difficulties faced with the meadow habitat creation because detailed records have not been kept.

2. The meadow creation is an example of a habitat creation scheme which has been successful in creating both a locally ecologically valuable site and a demonstration meadow habitat of high educational value.

3. Benwell Nature Park is a good example of its type. The presence of an on-site classroom and a teacher/warden showed a commitment to the site by the local authority. The local community respected the site and benefited from it and this has been reflected in its good use by local schools and by the lack of vandalism. However, it is our understanding that the teacher/warden has, from April, 1994, been made redundant. This undermines the whole concept of the project and also affects the informal aspects of education too. It is to be hoped that this situation will be rectified.

### 7.5.4 Woodland habitat creation

There is some literature on the creation of woodland in urban areas, much of it relating to the New Towns (discussed in Chapter 4). Again, Emery (1986) gives a good account of scrub and woodland habitat creation in an urban context. The Black Country Urban Forestry Unit has carried out some trials, some with the Forestry Authority, which have tested mixtures of pioneer species and made recommendations. With the exception of the Sankey Valley Park in Warrington (Case Study No.24), the *Review* did not include an urban woodland case study.
Whereas the methods required for the design and establishment of a woodland/scrub habitat creation programme are similar to those adopted in the wider countryside, there are some special problems on urban sites due mainly to poor soil conditions plus vandalism of planted trees.

Most trees are tolerant of slightly elevated levels of heavy metals and conductivity, but the danger comes when the contaminated land has been ameliorated using a barrier layer which is then covered with soil forming material. Although the roots of most trees are within the top 300mm of soil, some species of tree do put roots down deeper than this, especially in drought-prone soils (the latest research on this subject is summarised in Dobson & Moffat, 1993). This can then expose the tree to high levels of potentially toxic contaminants. A further factor is that toxicity-induced shallow rooting of trees can make them prone to windthrow on exposed sites. The waterlogging of soils, especially where the soils have been compacted, are also a very common cause of tree failure.

For these reasons, the establishment of trees and shrubs on difficult and contaminated substrates has to be considered with care and professional advice may be needed. There are a number of possible approaches:-

1. To create pockets of substrate which can support trees and shrubs. This can be done by removing difficult/contaminated material to a depth of up to 1m and importing inert fill ameliorated with subsoil, organic matter and fertiliser. The danger with this approach is that the planted trees outgrow the resources and space available, but this danger can be minimised by the choice of species.

2. To use direct tree seeding techniques. There is good research and observational evidence that in difficult conditions tree and shrub establishment from seed (and also from small (whip) planted material) is more successful than from planted older stock. Tree seeding also has the advantage that a range of species can be tried on the site for minimal extra cost. The subsequent natural selection of species and individuals can be of real value in favouring species and individuals suited to the substrate and the site conditions. For example, birch and alder can be very successful on difficult sites.

3. To choose shallow rooting species, such as willows or birches, which will be less likely to be affected by conditions at a lower level in the soil profile. In wet soil conditions, willows will also do well, but then alder should also be considered as it fixes nitrogen from the atmosphere, assisting its establishment and growth.

### 7.5.5 Heathland and peatland habitat creation

With the exception of small demonstration areas there appears to have been little heathland habitat creation on urban sites. This is not surprising given the restricted occurrence of heathland in much of lowland Britain. In urban districts where heathland does occur naturally, the emphasis has been on its conservation and restoration in its urban setting.

However, heathland creation is feasible in an urban context and has been carried out with new road schemes in Poole, Dorset although nothing has yet been published on these projects.

The peatland creation project at Merridale School, Wolverhampton (Case Study No.20) has been described in Chapter 6.

7.5.6 Other urban habitat creation

Unfortunately the *Review* did not reveal a suitable case study which consisted of the creation of a typically urban habitat; the concept is not yet in place in the UK. Examples are found in Germany (Barker, pers. comm.) which range from large-scale (eg. Hahneburg Park, Spandau) to "eco-park" patches (Okowerk Teufelsee, Berlin and BUGA site, Berlin). The principles used were based on achieving the correct substrate and then using natural succession in parks and selective seeding in eco-parks.

The William Curtis Ecological Park in London, now no longer functional, was monitored with care and the results published. This is outlined and referenced by Cotton (1982).

Review of the literature on urban habitat creation has indicated that it is not worthwhile trying to create poor and stressed examples of rural habitats in highly urban settings. Urban habitat creation needs to be pragmatic and highly focussed to the opportunities and constraints of each site.

## 7.6 Monitoring and long-term management

As with all habitat creation projects, the monitoring and long-term management of the sites is of vital importance. The principles given in section 2.5 of this *Guide* should be followed. The urban dimension to this management is outlined in Emery (1986) and a number of sources already quoted. The main differences to rural situations relate to the need for greater community involvement and the need for active measures to protect the site from acts of vandalism. There are also other differences such as the acceptance of certain invasive species in the urban situation which would not be acceptable to a scheme in the open countryside.

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