No 21

Habitat creation - a critical guide

D M Parker

English Nature Science

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HABITAT CREATION - A CRITICAL GUIDE: FEEDBACK FORM	
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HABITAT CREATION - A CRITICAL GUIDE

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ACKNOWLEDGEMENTS

We would like to thank all those who responded to the habitat creation questionnaire sent out in 1989 and to those who assisted our investigations of the 26 Case Studies which were selected from the 104 projects which were identified and investigated further during the course of the project. Many other people have kindly given of their advice over the life of the project (1989 - 1994). Thanks are also due to the project originator, Dr John Hopkins (now JNCC) and the present English Nature staff who inherited the project, Dr Nick Michael, the nominated officer, Dr Richard Keymer and Dr Richard Jefferson.

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1. INTRODUCTION

1.1 The need for this guide.

This critical guide has been produced to inform a wide audience concerning the current position of habitat creation in Britain. It has been written to examine both the potential and actual problems of habitat creation and to present good practice in the planning, construction and management of habitat creation projects.

Habitat creation is widely portrayed as a new, exciting and worthwhile activity. However, there is a need to bring the aspirations of its practitioners into line with present understanding and to consider evidence from past habitat creation schemes.

Habitat creation should never be put forward as a substitute for the conservation of semi-natural habitat. There are too many examples of development proposals which promote such programmes as a full "mitigation" (ie. replacement) for the loss of existing semi-natural habitat. They argue that the created habitats will be as good as the semi-natural habitats which will be lost. However, the evidence is clear that a complete replacement will very rarely be achieved and it is a central aim of this *Guide* to present information on the true effectiveness of habitat creation projects in Britain.

Although habitat creation should not be promoted as providing a replacement of semi-natural vegetation, there is an important role for habitat creation in nature conservation. However, in order for this to be worthwhile and successful, there is a need for the better planning, funding, monitoring and management of habitat creation schemes. This *Guide* will introduce the concept of the **Project Plan** which will direct the habitat creation practitioner in the planning of effective projects.

Habitat creation is perceived by many people to be an "easy" procedure. This view is reinforced by articles in the professional and popular press, often with reference to a particular development proposal. Researchers in this field and most experienced ecologists know that the position is much more complex than this.

This *Guide* will also consider what might be described as the "philosophy" of habitat creation (Hopkins, 1989). On a particular site questions need to be asked as to why is habitat creation being suggested; is it the most appropriate solution for the site? Does the proposal complement or enhance existing semi-natural habitats in the area?

English Nature, through its newly promoted *Natural Areas* concept, is suggesting the use of habitat creation and the opportunities presented by current changes in agricultural management, in an attempt to link areas of semi-natural vegetation which are currently "islands" in a highly managed landscape. Such development of policy by English Nature will have implications for habitat creation planning in the future.

Other countryside policies and initiatives including such measures as Set-aside, Countryside Stewardship, the National Forest, Community Forests and MAFF's recently announced Environmentally Sensitive Area (ESA) Habitat Scheme, will also need to address habitat creation in a serious and objective manner.

1.2 Definition of habitat creation.

Habitat creation in this *Guide* is defined as the construction of interesting and attractive ecological communities on sites which currently support little of nature conservation interest. These sites would normally be bare ground, neglected unused land, or land under agricultural pasture or arable management. This land would not have existing significant ecological interest. Habitat creation can strive to create semi-natural plant communities, such as calcareous grasslands, but can also aim to create habitats of ecological interest but which do not have a precise semi-natural model. An example of this would be the creation, for amenity and educational purposes, of species-rich "wild flower meadows" in an urban location.

Habitat creation needs to be distinguished from *habitat restoration* which attempts to restore existing, perhaps degraded, semi-natural vegetation. This category also extends to *habitat enhancement* or *habitat diversification* which is building on what already exists on a site. In this *Guide*, the habitat creation definition is difficult to relate to peatlands where much of the work which is carried out is *restoration* and *re-creation* of former communities on peatland sites. For this reason, the definition of habitat creation is wider in the peatlands chapter (chapter 6).

Finally, the distinction needs to be made between habitat creation and *habitat transplantation*. Habitat transplantation can be defined as the removal of habitat from a donor to a receptor site. The transplantation of grassland, heathland and wetland habitats has been carried out for some time and a review was carried out in the late 1980s by the Nature Conservancy Council (Byrne, 1990).

It is of course quite possible, within a single scheme, for habitat transplantation, restoration and creation all to take place. However, for the purposes of this *Guide*, habitat creation, according to the strict "something from nothing" definition given above, will be used.

1.3 Survey of habitat creation projects, 1989-91.

As part of the background for the preparation of this *Guide*, a major survey and review of habitat creation projects has been undertaken. This has been done using a questionnaire survey which identified about 150 habitat creation projects throughout the UK from which 104 projects were investigated further. An attempt was made to find and include both successful and unsuccessful projects. An analysis of this survey was published in Jones (1990) which reported that some 80% of these projects failed to achieve their target objectives.

There were a number of conclusions from this survey which have been reinforced following detailed review of 26 of these projects and recently published literature. These conclusions are set out below and they should form the background against which all new habitat creation projects should be assessed:-

1. Many habitat creation projects failed because they were not fully thought out at the planning stage and precise objectives were not set.

2. Many projects were too ambitious and objectives should have been scaled down to match the short and long term resources which were available.

3. Too little attention had been paid to the soils of the proposed habitat creation sites. The most significant problem with this had been too high soil fertility with respect to the desired target community.

4. Project planning had not sufficiently addressed the need for aftercare (site management) which may possibly have to extend for an indefinite period. Aftercare implies a long-term financial commitment to the project.

5. In many cases, site monitoring was inadequate to determine whether the project was achieving its objectives. An insufficient level of monitoring was also found to lead to the management programme not being adapted to respond to changes in the vegetation or site conditions.

It is the aim of this *Guide* to enable the reader to incorporate the findings of this research (hereafter referred to as the *Review*) when planning or assessing a habitat creation proposal.

1.4 The fundamentals of habitat creation.

Chapter 2 of this *Guide* will consider in detail the planning of a habitat creation project. What is necessary in this introductory section is to set out a number of essential stages which must be included in any habitat creation project. These are as follows:-

1. *The setting of clear objectives*

   It is extremely important that a habitat creation project sets clear and unambiguous objectives. This should form the first section of a Project Plan and the basis from which the rest of the Plan is constructed.

2. *Choosing the right site and appropriate habitat*

   With the exception of some urban and derelict land sites, a habitat creation project must relate to the existing semi-natural habitats in the locality. In appropriate locations the creation of a particular habitat will be relatively straightforward, but in other locations it will be very difficult. A good example of this would be attempting to create lowland heath on alkaline chalk soils in southern England.

3. *Land ownership and access questions*

   It is vital that there are no legal problems concerning access to the land and carrying out the habitat creation project on the land. These arrangements must also assured for the aftercare period of the project which is likely to be for an indefinite time.

4. *Targeting the required vegetation*

   Once the required habitat has been determined, decisions have to be taken on the vegetation types which will be targeted in the project. These may or may not be semi-natural ones depending on the rural/urban location and other local factors. The degree of "naturalness" of the target community should always be a considered, however, as this will allow the community to fit into a local context.

5. *Deciding the choice of species*

   This will mainly determined by the choice of vegetation type. However, there can be crucial local factors, especially soils and adjacent vegetation, which may affect the precise choice of species.

6. *Project planning, including monitoring and aftercare*

The habitat creation *Review* has clearly demonstrated that whereas project planning can be improved, it is the long term monitoring and aftercare which is most often neglected and the cause of habitat creation failure. Human and financial resources often cannot be guaranteed on a long term basis and this constraint needs to be fed into project planning. A good example of this type of problem is the short period during which (town and country) planning conditions extend. With this background, decisions need to taken on whether the project is too ambitious and needs to be modified.

Even the best planned habitat creation project will take time to fulfil its objectives. This *Review* has only measured success using vegetation. There is the whole subject of faunal colonisation which needs to be considered as part of a continuing evaluation of the success of habitat creation projects in the future.

1.5 The positive side of habitat creation.

On the positive side, habitat creation projects can be a valuable part of a nature conservation programme, providing new habitats for wildlife to colonise. Excellent examples of this are to be found, especially in the creation of wetland habitats and in some recent heathland and grassland habitat creation projects. They can form a buffer to semi-natural habitats thereby protecting the often vulnerable boundaries of these areas and providing a means whereby some of these habitats can extend. There are currently also major opportunities to replace habitats which are of low ecological value, such as arable land as it becomes surplus to agricultural requirements.

Community involvement must form an important part of habitat creation planning, especially in urban and urban fringe areas. Whereas the success of most rural schemes will be dependent on human resource and financial commitments, urban schemes can often be more dependent on community involvement. This can involve both manual work and a wardening/caring function at the community level. In this context, habitat creation can have a major educational function.

1.6 Scope of this habitat creation guide.

The *Review* from which this *Guide* has been derived included all UK habitat creation project types, except the widely known and well reported wetland creation projects. Examples of these would be restored worked out gravel pits and the excellent wetlands created by the RSPB in such places as Elmley Marshes, Isle of Sheppey and Inner Marsh Farm, adjoining the Dee Estuary. Wetland types which were covered included peatland, riparian and coastal habitats (including saltmarsh).

The habitats covered by this guide are summarised in Figure 1.1 which presents data on the breakdown of projects with respect to the desired habitat creation objective. In the *Review*, some 26 case studies were examined in detail involving both literature review, consultation and site visits. The volume of the supporting evidence from the *Review* has led this *Guide* to be further confined to the habitat types listed below:-

Chapter 3 - Grassland (including saltmarsh)
Chapter 4 - Woodland and scrub (including riparian habitats)
Chapter 5 - Heathland (including dry and wet lowland heath and moorland)
Chapter 6 - Peatland
Chapter 7 - Urban

Before discussing individual habitat types, it has become clear that there are a number of general items concerning habitat creation planning which need to be considered. This forms the content of Chapter 2 which should be read in conjunction with the relevant habitat section.

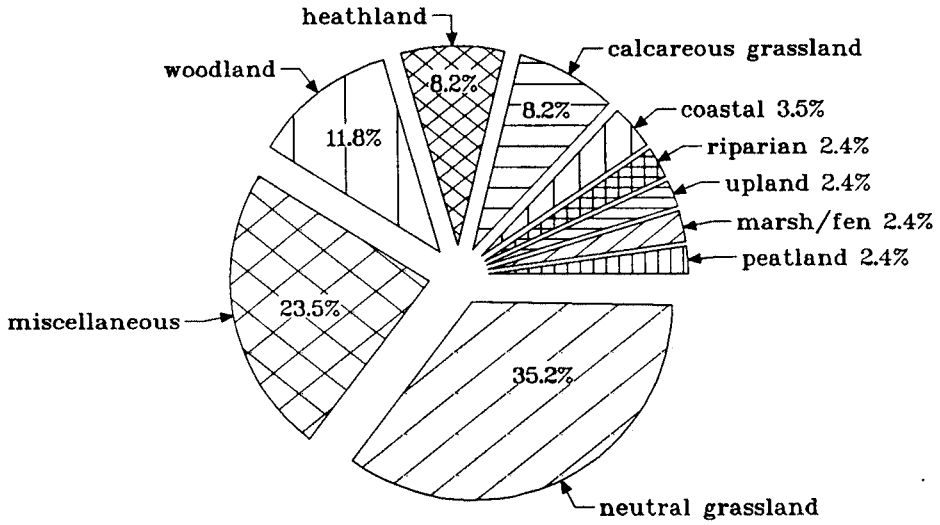
1.7 References.

BYRNE, S. 1990. *Habitat transplantation in England. A review of the extent and nature of the practice and the techniques employed*. England Field Unit, Report No.104, Nature Conservancy Council, Peterborough.

HOPKINS, J. J. 1989. Prospects for habitat creation. Landscape Design 179, 19-22.

JONES, G. 1990. Learning from experience. Landscape Design 193, 40-44.

Figure 1.1. **Habitat creation projects classified according to habitat type - data from *Review* questionnaire survey.**



2. HABITAT CREATION PLANNING

2.1 Choosing the best option.

This is perhaps the most important part of habitat creation planning. A potential site has many opportunities and constraints which relate both to the physical and biological background to the site and to the short and long term financial resources which are available. The *Review* has clearly shown that the ability to monitor and manage the site in the long term is crucial for success.

Habitat creation can best be classified into four groups, each employing a different strategy (Jones, 1990):

Strategy 1: doing nothing so that vegetation is allowed to develop as a result of natural processes.

Strategy 2: allowing the natural development of vegetation but with a management input or change.

Strategy 3: an initial intervention and then allowing natural unmanaged development of the vegetation.

Strategy 4: full intervention and management to produce a target community.

Strategy 1 has the advantage of being inexpensive and easy to instigate. However, it should be remembered the successional and soil related processes governing the natural colonisation and development of new habitats are incompletely understood. Whereas the development of semi-natural vegetation on old abandoned limestone quarries is well known, much less information is available concerning arable farmland. The ideal location for Strategy 1 projects is close to existing areas of biological diversity. These areas can act as a seed source for the habitat creation site given a suitable set of circumstances.

The amount of intervention increases until Strategy 4 is reached which is the most technically demanding approach to habitat creation, and requires the highest degree of commitment.

Any habitat creation scheme should only be undertaken where expert advice is available, where there is sufficient short and long term funding and where there is secure long term commitment to the site.

Land ownership, (town and country) planning and legal issues should also be taken into account in choosing the best option in habitat creation. These matters are of particular importance with respect to the long term security and management of the site. The habitat creation programme could form part of an agreement under Section 106 of the Town and Country Planning Act, 1990 (see section 2.5).

2.2 Defining habitat creation objectives.

The defining of objectives is the first stage of detailed project planning. It is likely that there may be more than one objective and, if so, it may be necessary to assign priorities in order of their relative importance to the project. These objectives should steer the project through the planning stage and can eventually be used as a measure of project success. Objectives can also be temporary as well long term.

It is important to commit the project objectives and all aspects of project planning to paper in the form of a **Project Plan**. Projects should be viewed as contributing to the pool of

knowledge about habitat creation and written records are essential for this. Written objectives ensure that the project aims are not changed in an unplanned or haphazard way in the future, and also allow continuity if project managers change during the project.

The many and varied objectives of a project may be classified into the following categories:

Nature conservation

Nature conservation objectives can be either "habitat" or "species" based. Habitat-based projects can have broad aims ranging from the creation of "general" wildlife habitat through to attempts to recreate specific types of natural or semi-natural habitat such as National Vegetation Classification (NVC) vegetation types (Rodwell, 1990). General habitat creation for wildlife may be served by such measures as the planting of native trees and shrubs and the creation of new hedgerows, all of which will provide habitat and shelter for birds and insects. With the attempted creation of NVC vegetation types, natural colonisation is ideally suited to this objective and the ideal location is immediately adjacent to existing biologically rich habitat. In general, such projects are long term but can have a low establishment cost. Species-based projects can be to provide suitable habitat for particular species of plant or animal. Examples might include the creation of grasslands for wintering geese, or habitat for a particular butterfly species. Habitat creation is an important technique in the current English Nature *Natural Areas* policy and its *Species Recovery Programme*.

Amenity

For a habitat creation project to provide an amenity function, it should aim to become established rapidly, be aesthetically attractive, lie close to a population centre and have good public access. Where an amenity function is desired, it is essential that consultation with local people is undertaken to ensure that the project fulfils a local need. An amenity objective may limit the nature conservation potential of a scheme.

Education

To provide an educational resource, it is important for the site to have safe and easy access, and should ideally be situated close to where the demand will arise. The project should aim to provide a diverse and attractive environment and a range of biological and ecological features designed to inform about biology and ecology in an interesting way.

Mitigation

Habitat creation is often put forward in mitigation for the loss of ecologically significant habitats and species to development projects. Whereas a strong theme of this *Guide* is that such action can never be put forward as a replacement for semi-natural habitats, there will be schemes where habitat creation will form part of a mitigation programme. This could have nature conservation as well as amenity and educational objectives.

Research

It has been mentioned above that each habitat creation project should be seen as an opportunity for research to add to our skill base on this subject. There is still much to learn and there is a role for habitat creation research to be carried out by Universities and by such organisations as English Nature as part of their long term programmes.

2.3 Survey of the habitat creation site

2.3.1 Site history

A knowledge of the history of a proposed habitat creation site is essential to the understanding of the biological and physical nature of the site. For example, it is essential, on an agricultural site, to have information concerning farming management and the use of fertilisers whilst on a former industrial or disused site it is necessary to assess whether contamination might be present.

Site history information can be obtained from old maps and records as well as by consultation with local landowners, farmers and residents.

2.3.2 Biological context

A thorough biological survey of the proposed habitat creation site is essential. This should include a detailed ecological survey both of the site itself and the adjoining land. Information from the adjoining land will, for example, indicate whether any significant seed source is present which could be exploited on the habitat creation site. Before entering any land, the landowner's permission should be obtained.

The three major reasons for carrying out such as survey are as follows:-

1. The survey will locate any areas of nature conservation value on or near the site. The needs of protected species should form part of this survey; for example, a rye-grass pasture of little botanical value could be the main foraging area for badgers from a nearby sett.

2. The survey will provide baseline information and, by comparing the baseline with the created habitat over a number of years, it will be possible to judge success and guide the management programme for the site.

3. The survey will assist with the design of a habitat creation scheme which will be appropriate for the location.

If the survey reveals that the chosen site supports valuable species for all or part of the year, then these areas may be of significant nature conservation value. These could be areas of semi-natural vegetation or agricultural land which is important for badgers of for breeding or wintering birds, such as stone curlew or waders. If this is the case, then it would be more appropriate to design a habitat enhancement scheme to optimise and perhaps increase existing ecological interest. Professional advice should be sought in this event either from a local wildlife trust or from the statutory agencies (English Nature, Scottish Natural Heritage, or the Countryside Council for Wales). Clearly, habitat creation is unlikely to be appropriate on such a site. One habitat creation project of this type was examined in the *Review*, a synopsis of which is as follows:-

> *A local conservation group wished to create a semi-natural grassland for conservation and amenity purposes on a neglected urban site. However, the site survey revealed that the rough grassland already present held a high diversity of common, but desirable plant species, albeit in low numbers. The habitat creation scheme was abandoned and a management regime was implemented which was designed to encourage the desired plant species to become more dominant on the site. The money saved by not undertaking habitat creation was spent on interpretative literature, signposts, footpaths and management.*

It is also important to consider the effect the proposed habitat creation project may have on neighbouring land. This would be particularly unfortunate where the surrounding habitat is of high nature conservation value. There have been numerous examples of pond digging resulting in the drainage of nearby marshy areas of high nature conservation interest. Other problems could arise from the seed production on the habitat creation site affecting the species composition of adjoining vegetation.

It is advantageous, perhaps as part of a nature conservation strategy, for a habitat creation site to lie adjacent to, or to link, areas of existing areas of nature conservation value. The main reasons for this are as follows:-

1. Given the creation of similar semi-natural habitat, the increased overall area of semi-natural habitat allows the existence of higher populations of resident species.

2. Given the objective of the creation of similar habitat to that adjoining, the existing areas of nature conservation value may act as a seed source for the habitat creation site.

3. Creating a different but complementary habitat adjacent to an existing area of semi-natural vegetation can enhance both the site and the neighbouring one. For example the creation of a flower rich meadow adjacent to an area of dense, herb poor woodland, would act as a nectar source for invertebrates, and subsequently as a feeding area for birds.

Adjacent managed land can have a strong influence on both the habitat creation project design and the type of aftercare that may be required. For example, a site bordered by agricultural land may be prone to nutrient-enriched run-off, or a "spray drift" cocktail of herbicides and pesticides. In such a case it would be necessary to create a physical barrier by either planting or laying a dense hedge, or instating a conservation headland on the agricultural land (Dover, 1991). On heathland and grassland habitat creation projects, invasion from adjacent areas of birch and gorse could be a potential problem which will need to be tackled by active management.

Another factor which needs to be taken into account is the potential invasion of the site by unwanted plant species from a neighbouring area (including arable land, forestry, and even gardens). Invasive species could include conifers (especially on heathlands), rhododendron *Rhododendron ponticum*, buddleja *Buddleja davidii*, and sycamore *Acer pseudoplatanus*. In riparian habitats, Himalayan balsam and Japanese knotweed can be a very significant problem. The presence of these species on an adjacent site might mean that intensive and expensive site management practices will be necessary. However, many urban ecologists now accept that sycamore can be valuable in urban areas and it is often an important and sometimes dominant component of the tree cover in such situations (see Morton Boyd, 1992).

2.3.3 Physical context.

(a) Site size. It is difficult to give guidance on the size of habitat creation site which should be chosen. Inevitably there will have to be a compromise between the size of the site and available short and long term finances, ie. an ability to both establish the project and to guarantee the long term monitoring and management of the site. It makes ecological sense to aim for as large a site area as possible, but the ideal area may not be possible to achieve.

(b) Site stability. If the removal of topsoil to reduce soil fertility is required (see section 2.3.4), then the question of soil stability needs to be considered. Some sites, particularly those on steep slopes, may suffer badly from soil erosion, removing any developing

vegetation before it has had time to establish. Wind erosion can also be a problem on flat but exposed sites. Although the dust generated on such a site may be a minor problem in terms of soil loss, the potential for public nuisance may be great and should be considered if the site has sandy or dusty soil. However, especially on lowland heathlands, bare ground can be of high value for reptiles, amphibians and invertebrates and, in these situations, a balance needs to be struck.

There are two main situations where the stability of the site is of particular importance:-

1. In upland areas where rainfall is often high, and plant growth can be slow, soil erosion and site stability considerations may be of crucial importance.

2. Bradshaw and Chadwick (1980) describe how erosion can be a major problem when working with the waste material from the mining industry which is often deposited in steep-sided mounds. The establishment of vegetation on such areas is difficult because the waste has both physical and chemical constraints.

(c) Water. The importance of water to a habitat creation project relates to soils, surface water (hydrology) and to groundwater (hydrogeology). Soil moisture content is an important factor in relation to plant establishment and will principally depend on the type of soil and the time of year. Soil moisture deficits are most likely on well drained sandy soils and least likely on heavy clay soils. The conservation of soil moisture is very important during soil stripping and stockpiling operations: it should not be carried out when there is a substantial risk of the soil drying out.

The hydrology of the site can be significant with the presence of waterlogged soils, watercourses and the likelihood of flooding. Hydrogeology can be very important with a fluctuating water table having a profound influence on vegetation. The surface geology of the site, such as the presence of clay lenses in sandstone rock, can also have a significant effect which, in the case of clay lenses, leads to seepage lines and locally wet and waterlogged conditions.

(d) Climate. Climate can be of great significance to a habitat creation project, particularly where it is harsh, such as on upland or coastal sites. Here, plant establishment and growth can be very slow; where this is the case, soil erosion can also become a major problem. To minimise these problems, species should be selected which are suited to the climatic conditions and are of local provenance. Where possible, fast growing species should be included in this selection.

(e) Shelter. The two major factors affecting the amount of shelter on a site are the prevailing wind direction and the site topography. In most cases neither of these can be modified greatly, but, for example, the strategic planting of bush and tree species can create effective and valuable sheltered areas. Shelter is essential for a great number of invertebrate species, including some of the more attractive species groups such as butterflies and dragonflies. Clearly, if these species are to be encouraged, areas of shelter should be created and planted with suitable plants thus providing shelter for dragonflies as well as nectar sources, food plants and appropriate micro-habitats for butterflies and other insects.

(f) Protection from disturbance. With heathland creation projects, especially in upland areas, it is necessary to protect the developing vegetation from high stocking rates of grazing animals and the effects of trampling. This is also necessary for grassland projects where protection from excessive animal and human pressure is required. The degree and length of protection will depend on the nature of the target community and local physical conditions, especially climate.

(g) Site access for machines. The management of the site throughout the life of the project may call on the use of a wide range of machinery. It must be ensured, therefore, that there is ample access on the site to admit the largest item of machinery the site will require throughout its foreseeable lifetime.

(h) Proximity to pollution sources. This factor should be borne in mind in, for example, such locations as adjacent to a landfill site or contaminated land.

2.3.4 Social considerations

Social considerations are most important in urban areas, and have both positive and negative impacts. In some urban areas vandalism can present an almost insuperable problem. Regardless of the nature of the target habitat, vandals can always leave their mark: pond liners may be punctured, grassland burnt, and young trees uprooted. As the ideal solution of full time site supervision is almost always impractical, the only solution may be to accommodate the problem in the design process. This can often best be achieved by involving the local community in the project. People are less likely to damage something they have had involvement with and local people may actively discourage vandals by using the site in large numbers. The "fear of crime" is important in some situations in preventing social uses of urban greenspace. A forthcoming (1995/96) English Nature Research Report by J. Burgess will consider this issue.

An important consideration in urban areas is public access and public pressure. For example where there is free access and public pressure is likely to be high, well marked tracks are of great value. Paths and signs will focus the public use of the site and stop damage to sensitive vegetation by routing the public away from these areas.

Finally, it is important that the project is not seen as a limitation or restriction by the local people; there are occasions when a football area is more value to the community than a conservation area. The overall needs of the community need to be taken into account. It is important that the habitat creator is able to assist the local community to achieve their goals rather than the local community being used to solely achieve the aim of the habitat creation practitioner.

2.3.5 Geology and Soils

The question of soil type, soil structure, soil-water relations and soil fertility are perhaps the most difficult, and underestimated, aspects of successful habitat creation. Soil fertility, particularly the presence of the major plant nutrients, nitrogen, phosphorus and potassium, is the most crucial factor. The importance of soil is reflected in its greater emphasis in this account than for other physical or chemical factors.

R.H. Marrs in a recent review of soil fertility and nature conservation (Marrs, 1993) has brought together and synthesised current knowledge on the subject and much of what follows is considered in greater detail in his review.

The problem with soil fertility is that target semi-natural heathland and grassland communities are generally communities of low nutrient situations. The effect of fertiliser on these communities is to encourage the growth of particular species, especially grasses, which then tend to dominate the sward. This then eliminates most of the slow growing, uncompetitive but desirable species.

Many habitat creation sites will be on agricultural land which will have been heavily fertilised. This level of fertility is likely to be too high to allow the creation of attractive ecosystems with a good diversity of plant species. However, it is also possible for soils to be too poor to achieve the establishment of a diverse plant community. This rare

occurrence is most commonly encountered in urban/industrial sites with a rubble substrate and poor soil water retention capability.

When faced with a potential habitat creation site, a number of questions have to be asked concerning the soil. Consideration will already have been given to whether the target habitat creation plant community is appropriate for the locality. The question of whether the geology and soil is suitable, or can be modified to be suitable, is extremely important. In this situation, the following factors need to be considered:-

1. Is the general soil type on the site is suitable for the desired plant community?

2. Is an assessment needed to determine the scale and nature of the fertility problem on the site?

3. If it is proposed to reduce soil fertility, then how can a monitoring system be set up to judge the success of any fertility reduction programme?

(a) Soil type. The habitat creation objective must be compatible with the soil type which is available on the habitat creation site. There is scope to import the correct soil for this purpose, but this is likely to be a rare event due to cost implications. Exceptions to this may be on small scale demonstration sites, say for educational purposes in an urban location or associated with commercial development.

Soil compatibility is a difficult subject beyond certain extreme positions. For example, a heathland or moorland habitat creation project will demand an acidic sandy or peat dominated soil, while a calcareous grassland will require a thin rendzina-like mineral soil with a high pH, preferably situated over shallow limestone bedrock. Other extremes can include coastal situations, with high salinity and wind exposure, for example.

Neutral grasslands, supporting species-rich hay meadows and pastures, are found on a wide range of soils in the semi-natural situation. However, these are usually deep loamy soils with a neutral to slightly alkaline pH. These are the soil types which are most likely to be available for grassland habitat creation projects as they are the predominant soil types in agricultural use in the UK. However, the high fertility of most of these soils is likely to be a problem and a programme of fertility reduction is then necessary at the start of a habitat creation programme.

(b) Measuring soil fertility. The measurement of soil fertility will enable a judgement to be made concerning the scale of the fertility problem on a particular site. The difference between the fertility of the site and the fertility required for the desired ecosystem is crucial. Fertility can be measured using chemical analysis or using a bioassay technique with a pot or field trial.

The question of target nutrient levels for soils required to support semi-natural vegetation is a subject where more research is needed. However, Marrs (1993) does present a summary table comparing the levels of extractable phosphorus and mineralisable nitrogen between agricultural soils and soils supporting semi-natural communities. A modified form of this table is shown in Table 2.1. With phosphorus, perhaps the most significant nutrient, Marrs and Gough (1989) have suggested that semi-natural grassland appears to be maintained if soil extractable phosphorus concentration is < 20mg/kg. Table 2.1 should, however, be treated with some caution as the measurement of extractable phosphorus, for example, is difficult, especially with peaty and highly calcareous soils.

(i) Chemical analysis.

Chemical analysis will give helpful information but there is a difficulty with interpretation which relates to where the nutrients are located in the soil; most are associated with the

Table 2.1 **A comparison of extractable phosphorus and mineralizable nitrogen concentrations on soils on both agricultural land and semi-natural grasslands on three parent materials (adapted from Marrs, 1993).**

	Clay		Sand		Limestone	
	Hatfield House	Coombe Hill/ Northchurch Common	Clumber Park	Sherwood Forest	Lathkill Dale	Monks Dale
a. Extractable phosphorus (mg/kg)						
Agricultural land	68	19	291	12	31	16
Semi-natural grassland	9	7	5	13	6	3
L.S.D. *n = 8, P < 0.05)*	19	11	9	8	12	3
b. Mineralizable nitrogen (mg/kg/14 days)						
Agricultural land	83	40	24	66	143	132
Semi-natural grassland	142	63	28	34	97	162
L.S.D. *n = 8, P < 0.05)*	70	32	20	23	48	55

organic matter within the soil and with the mineral component. There is usually only a small amount of plant available nutrient present at any one time which comes from the exchangeable/extractable portion of the total nutrient pool and from the soil solution.

In most soils fertility is controlled by the three major plant nutrients, nitrogen, phosphorus and potassium. Of these, phosphorus is probably the most important as it is, in semi-natural ecosystems, the nutrient most often in short supply. For example, a soil can contain abundant mineralisable nitrogen, but nitrogen demanding grasses can be suppressed if there are low levels of available phosphorus present.

The measurement of plant nutrients is best carried out using the methods given in Allen et al (1974) and Allen (1989). The parameters which should always be measured are as follows:-

pH and conductivity
Extractable phosphorus
Mineralisable nitrogen
(Available ammonium-nitrogen (with acidic soils))
(Available nitrate-nitrogen (with neutral soils))
Extractable potassium.

The approximate cost of this analysis is £50 per sample.

(ii) Bioassay.

Using a bioassay technique to measure fertility can be a useful approach. The method is to grow test plants in the projected soil and to compare plant growth with a number of controls, such as soil taken from a site where the desired semi-natural plant community occurs. This is most useful for a habitat creation site which adjoins an area of semi-natural vegetation where an extension onto former agricultural land is proposed.

There are some drawbacks with this technique. It does take time to conduct the experiment; it can be done most rapidly in a greenhouse pot trial, but an outdoor trial would take longer. The experiment will give comparative and not absolute information concerning fertility, but this may not be a problem, especially if some analytical data are obtained. Finally, the species chosen for the bioassay will mean that the results can only be applied for those species; for this reason, the choice of species in the bioassay should include species with a wide range of growth rates and nutrient demands. For example, with a grassland bioassay, choose both nutrient demanding species (such as ryegrass *Lolium perenne*) as well as slower growing, less competitive herbaceous species.

(c) The reduction of soil fertility. The aim in reducing soil fertility is to obtain a soil on which a target plant community can be established and maintained. The method by which this is achieved will depend on the scale of the problem which occurs. Whatever method is used, the aim is to ensure that nutrient losses and offtake from the site are greater than the inputs, and that the treatment produces a reduction in plant-available nutrient supplies. Possible methods will now be considered in turn:-

(i) Topsoil stripping.

Most soil nutrients and organic matter are contained in the surface layers of soils (the A horizon). This nutrient store, most especially the nitrogen and phosphorus, can usually be instantly reduced by topsoil stripping. This has, in fact, been practised historically in the UK with the exercise of "turbury rights" on heathlands and moorlands involving cutting of peat and the soil surface for fuel. A similar practice in Holland, "plaggen", has been reintroduced on heathlands, using specially designed machinery, as part of the management of these areas including habitat creation projects.

This rather drastic approach usually reduces fertility immediately and this is probably its greatest advantage. Additionally, the topsoil can be sold and this can offset the stripping costs as well as perhaps funding at least part of the habitat creation project. For example, stripping a 1ha former arable site to a depth of 250mm would produce 2500m^3 of topsoil; priced at £5-£8 /m^3, this would generate a revenue of £12,500 - £20,000 depending on the quality of the soil.

(ii) Vegetation cropping.

Taking an arable or grass crop continuously without the addition of fertilisers will reduce the nutrient capital and supply. Research has been carried out using wheat and rye as the arable crop, but there is no reason why other crops should not be used (with the exception of leguminous species, such as clover and lucerne because they fix nitrogen from the atmosphere).

The research indicates that the depletion of soil nitrogen is a long process which would extend beyond the planning period of most habitat creation projects. However, if all above ground material is removed, then significant reductions of potassium and especially phosphorus can take place in a few seasons. Further phosphorus reduction can also take place if inorganic nitrogen is added to a cereal crop; the additional growth which the nitrogen allows removes phosphorus from the soil. Unfortunately, the deposition of nitrogen from the air and rainfall, derived mainly from agricultural sources, will be a continuing problem if highly infertile soils are the objective, such as those required for heathland or chalk grassland habitat creation.

Similarly, with hay cropping or silage techniques where no fertilisers are added and material is taken off-site, the removal of nitrogen from the soil does not occur sufficiently quickly to be significant in the context of a habitat creation project. Nutrient depletion depends on the reduction in phosphorus which then becomes the limiting nutrient for plant growth. Studies have shown that phosphorus levels can be reduced to near semi-natural levels in a four to 12 year period depending on soil type (Marrs, 1993).

(iii) Burning.

The controlled burning of vegetation, together with its associated litter and thatch, is an effective management tool on heathlands, moorlands, acidic grasslands and some calcareous grasslands such as those on the Cotswold limestone. It has been shown to be most effective at removing most of the nitrogen *via* the smoke as well as about 25% of the phosphorus and potassium, the remainder of which is deposited as ash. From this ash much of the potassium leaches away, but the phosphorus becomes fixed although there is also evidence that there is a flush of available phosphorus which can be taken up by plants.

Burning is therefore a technique which is of use in some specialised cases of habitat creation (although some of this activity would best be described as habitat restoration). An example might be the objective of creating *Calluna* heathland on a site which supports acidic grassland, although turf-stripping is likely to be a more effective technique. Too frequent burning can also encourage grass dominance at the expense of ericaceous species, such as by wavy hair grass *Deschampsia flexuosa* on dry lowland heaths, purple moor grass *Molinia caerulea* on lowland wet heaths and by tor-grass *Brachypodium pinnatum* on chalk grassland. Care is therefore required if this technique is to be used.

(iv) Deep ploughing.

Deep ploughing to the depth of about 1 metre has the effect of diluting the fertile topsoil with usually less fertile subsoil. This can be an effective solution, especially if the fertility problem is very pronounced. However, some caution is required. The whole soil profile

should be examined in some detail before incorporation so that the ploughing depth can be determined correctly. For example, the necessary depth may vary across the site.

There is also the factor that the physical composition of the subsoil may differ significantly from the topsoils. For example, subsoils are usually richer in clays and silts which have leached down from the topsoil horizon. If these are brought to the surface it is possible that drainage problems may be introduced. On sites such as the Breckland, acidic sandy topsoils may also overlie calcareous subsoils; care is therefore needed in this situation.

(d) Assessing the success of fertility reduction. In making an assessment it is important that clear objectives are set at the outset of the treatment. For example, reducing the nutrient reserve of the soil is much less important than reducing the levels of nutrients available for plant uptake. It is also important to ensure that nutrient exports from the site are greater than inputs. Continuous inputs of nitrogen which derive from NOx emissions from industrial sources should also be accounted for in the fertility planning.

It is quite possible, and even likely, that it will be necessary to continue the fertility reduction management after the habitat creation seeding and the establishment of a new sward has taken place. Again, objectives need to be set concerning fertility levels, the most critical one being the level of plant available phosphorus.

(e) Increasing soil fertility. On occasions, the soil examination will reveal certain nutrient deficiencies which need to be rectified in order to allow a target community to be established. This is most likely to occur on derelict land sites and inner city areas where the substrate is waste material of some kind. Some of these materials, such as brick waste or blast furnace slag, can be useful mimics of more natural soils where high plant species diversity can occur. For this reason, care needs to be exercised not to add nutrients which will remove a special quality of the material which might be more suited to a different habitat creation objective.

(f) Contaminated sites. Especially in urban and derelict land situations, there is the additional problem of potentially contaminated land. Whereas hydrocarbons (oils, tars, solvents, etc.) are readily detectable, the presence of heavy metals is more difficult to detect without chemical analysis. Guidance on soils on urban sites is given in Bullock and Gregory (1991) and a practical manual or urban soils has been produced by English Nature (Hollis, 1992). The subject is also considered further in section 7.3.

The first step on such a site is to undertake research into the history and past use of the site. Find out what activities took place on the land. Be particularly wary of iron and steel works, gas works, chemical works, old railway sidings, old sewage works, mining wastes and power station sites. If there is any suspicion of former industrial activity, then specialist advice should be sought and a site investigation undertaken. An essential step in this is the taking of soil samples throughout the soil profile which should then be submitted for chemical analysis.

In the UK there are Government guidelines concerning the use and redevelopment of land which is contaminated. These are produced by the Interdepartmental Committee for the Redevelopment of Contaminated Land (ICRCL). ICRCL guidelines differ depending on the use to which the land is to be put and the degree of public access. This is particularly the case with heavy metals which are of concern to human health. Before a habitat creation project takes place on such a site, the project designer must be satisfied there will be no concerns relating to human health ie. that public health is not being put at risk. The possible presence of contaminated water on the site should also be reviewed. Specialist advice is likely to be required on issues relating to human health, surface drainage, groundwater and phytotoxicity. The necessary insurances should be operating before work is done on the land.

There are a second set of potential contaminants which reduce or inhibit plant growth, known as phytotoxic substances. These can include heavy metals (copper, zinc, nickel, chromium, boron), high soil conductivity (salinity), extremes of pH (well outside the normal range of 5.5 - 7.5) and organic substances.

The degree of the phytotoxic effect of heavy metals depends on the nature, and especially the pH and organic matter content of the soil or waste. For example, in highly alkaline, calcareous substrates, copper and zinc become "locked up" and unavailable to plants. However, similar levels of metals could be highly toxic at neutral or acidic pH levels.
This is not the place to consider the methods which are available to bring highly contaminated sites into a usable condition. It is very rare indeed that a site cannot be reused however contaminated it may prove to be. However, most remediation schemes are expensive and would not be carried out just to prepare the site for a habitat creation project. Despite this, there is some flexibility, and habitat creation projects could be built in as part of a larger development.

An example of a flexible approach would be a contaminated site with potentially phytotoxic levels of copper and zinc, but with no metals at a sufficiently high level to cause human health concerns. A habitat creation project could proceed on such a site given the use of heavy metal tolerant plant species. Such metal tolerant grass varieties are commercially available and certain herbaceous species do have some degree of tolerance. An alternative approach on such a site would be to apply lime to the substrate to raise the pH and make the heavy metals less available for plant uptake.

2.4 Preparation of the Project Plan.

2.4.1 Objectives

The clear definition of project objectives is amongst the most important aspect of habitat creation. Too many projects which have been examined in the *Review*, and even in the case studies, did not have clear objectives.

It is considered essential to prepare a **Project Plan** which will cover all the main aspects of the habitat creation project. The Plan should start with clearly stated project objectives which should not be too ambitious. The *Review* has found that many projects fail because their objectives were set at too high a level. The objectives should be clear; for example, in the establishment of a species-rich grassland on a roadside verge, the objective could be the successful establishment and maintenance of, say, ten key grass and herb species, which are named. The project could then later be assessed on this basis.

A much more ambitious target might be a specific NVC plant community, say adjoining an SSSI which is composed of this NVC community. Again, target species and their relative proportions should be listed and the project can later be assessed on this basis.

The Project Plan could also encompass objectives for a site which include, in addition to habitat creation, habitat restoration and enhancement.

2.4.2 Project resources

The setting of project objectives should be done at the outset within the scope of available resources. However, it is more likely that the project will have a clear objective and it will be a question of deciding whether the limited resources can achieve this. A vital component of the resources are those which are available for long term management (see section 2.5). Project resources will include the following aspects:-

(a) Skills and practical knowledge. These are, together with finance, perhaps the most valuable resources for successful habitat creation. External sources (other than the literature) include the British Trust for Conservation Volunteers (BTCV), the Groundwork Trusts, County wildlife trusts, English Nature (CCW in Wales and SNH in Scotland), Landlife, local authority agencies (such as London Ecology Unit) and environmental consultancy companies. Try to find organisations or individuals who have carried out similar habitat creation projects and learn from their successes and failures.

(b) Finance and legal matters. It is essential that it is known at an early stage how much the project will cost. This cost should include for preparation, establishment, initial maintenance and long-term monitoring and management. Tenders can be obtained for the work from specialist, agricultural or landscape contractors and suitable forms of contract adopted.

The question of land ownership and rights of access to the land should be determined to ensure that their is sufficient control of the land for the habitat creation project to succeed. The (Town and Country) Planning background should also be determined and whether the project, for example, falls within a Section 106 Agreement under the 1990 Act.

The financial aspect should include fund raising activity, applications for grant aid and internal monies in order to have this in place for the start of the project. A summary of the potential sources of grant aid is given in Table 2.2.

(c) Manpower. Volunteers are often used in habitat creation projects, especially in urban locations where a community involvement may be an important aspect of the project. Volunteers are likely to need technical supervision and this may have to be costed. Examples of support organisations include the Black Environment Network and the Greenspace Community Environment project. Given that a high degree of volunteer enthusiasm may "carry" a project through its establishment phase, some thought must be given to how this enthusiasm can be extended through into the long term monitoring and management phase.

(d) Tools and machinery. The hire of tools and machinery must be properly costed in the project finances. This can be a costly item and must be included in the Project Plan.

(e) Time. This is a precious resource and is all too often in short supply. It should be borne in mind that some habitat creation projects will create target habitats only after many years and will require aftercare in perpetuity. This aspect of the project should always be carefully considered, particularly where amenity is a major consideration.

To summarise:-

1. Design and cost the whole habitat creation project in detail at the outset.
2. Identify sources of money and other resources **before** the project begins.
3. Ensure that control of the land and access to it is assured.
4. Design and cost site aftercare within the overall planning.
5. Present supporting evidence for finance and/or resources which will be available for long-term monitoring and management.

2.4.3 Methodology and implementation

(a) The selection of plant species. It has already been discussed earlier in this chapter that the selection of plant species and the target plant community should pay particular regard to the local conditions, especially the existence of semi-natural vegetation. This vegetation can be used both as a model and a seed source for the habitat creation project.

Table 2.2 Potential sources of grant aid for habitat creation projects

Organisations	Schemes
Corporate Grants	Shell school grants scheme British Telecom etc...
Countryside Commission	Landscape conservation & management grants Countryside Stewardship
Countryside Council for Wales	Section 38 Project Grants Tir Cymen
English Nature	Section 38 Project Grants and others
European Community	ACE Fund and others
Forestry Commission	Woodland Grant Scheme
Grant Making Trust Funds	Consult relevant directory *
Local Authorities	Enquire locally
MAFF	The Farm and Conservation Grant Scheme ESA habitat creation schemes
Scottish Natural Heritage	Section 38 Project Grants

* Charities Aid Foundation (published annually). *The directory of grant making trusts.* Charities Aid Foundation, London.

Specific advice in the selection of plant species is as follows:-

1. Use species suited to the chosen target habitat(s) or those present in adjacent semi-natural vegetation. Information on the specific ecological requirements for a large number of species can be found in Grime et al. (1988) and, specifically for road projects, DoT (1993). Avoid the introduction of species already recorded from the site. Habitat enhancement may be more appropriate than habitat creation if desirable species already occur on the site. Such a strategy may give substantial financial savings, as well as preserving local genotypes.

2. Use species suited to the physical environment of the site. Many plant species are highly exacting in their demands, and, whilst the more common species tend to be less so, factors such as soil pH, water content, and nutrient status will all have an influence on which species will suit the site. Species should therefore be carefully selected so that their requirements match the characteristics of the site.

3. Invasive species should be avoided. Although some forms of site preparation, such as the lowering of soil fertility, may lessen the problem of invasive species, there are a great number of species which have the potential to become a serious management problem. These species should not be introduced onto a habitat creation site even if considered desirable. Indeed by their very nature these plants will eventually colonise the site, by which time it is likely that the site will have matured enough to prevent these species becoming a problem. Examples of such problem species are given in the appropriate habitat sections.

4. When attempting to create habitats of nature conservation value, only native plant species should be used. The definition of "native" needs some flexibility, especially in urban areas where non-rural plant communities have developed. However, it is the case that non-native species are usually of lower ecological value and may rapidly become invasive. An exception to this rule is the use of a nurse crop in the establishment phase of the project. These may be non-native or even artificially bred and are normally annual, fast growing species such as Westerwold's rye-grass *Lolium multiflorum*. They are used to provide ground cover or shelter for young native plant species. Once the native species have become sufficiently established, the nurse crop is then eradicated by appropriate management or suppressed by the growth of the desired vegetation.

5. Use native species which naturally occur in the area or region of the country, say within an English Nature *Natural Area*. This will serve to maintain the present naturally derived distribution of plant species and may enable the plant community to conform to an NVC type. Species sown outside their natural range are also less likely to survive in a semi-natural habitat.

6. Use native species which are common in their native area of distribution. The majority of the rarer native plants (some of which may be sold as garden plants) are very difficult to maintain in a semi-natural habitat as they become outcompeted by other species. Their highly specific habitat requirements are not easily accommodated within an artificial or created habitat. Such introductions lead to highly specific and often expensive management practices and are often a great disappointment. If uncommon species are being introduced, then the local county BSBI recorder should be notified.

7. Use species of a local provenance, wherever possible. The most practical reason for this is that species of local provenance are much more likely to thrive on a site than those brought in from another area. Such a procedure will also maintain the local genetic integrity of species. However, care with decisions on local

provenance is necessary, for example, an oak from a French acorn planted in an English park or plantation in the 1700s may well be taken as a local tree when collecting seed now.

8. If buying in seed from a commercial supplier ensure that the seed is from UK derived plants. Some commercial suppliers produce their seed in the UK but these seed-producing plants can be from less certain origins, such as from continental Europe.

(b) Site design. When considering the potential distribution of plant species on a habitat creation site, it is important to consider the range of micro-habitats and niches which are present. The choice of plant species can then be tailored to what is available. For example, wetter areas in a woodland habitat creation site can be planted with willows *Salix spp.* or alder *Alnus glutinosa*; different species can prefer north or south facing slopes in different localities, etc.

In addition to the passive utilisation of micro-habitats, there may be scope for their active creation. For example, shelter may be created to encourage a greater diversity of invertebrates. In the same way the planting of a hedgerow may create suitable habitat for a wide range of shelter-loving species including small birds, butterflies, and a wide range of attractive hedgerow plants. Ground modelling could take place to create a range of microtopography, such as banks suitable for invertebrates and reptiles.

The active creation of micro-habitats such as by creating hummocks and hollows in a flat substrate is particularly valuable when natural colonisation is the chosen strategy. Substrate manipulation to give varied hydrology, topography and microclimate can be used to direct colonisation.

(c) Site stability. Some habitats are by their nature unstable such as sand dunes, screes and intertidal habitats and habitat creation projects need to build this feature into the project design. However, there are sites where stability is required. Such sites require special treatment to encourage the quick stabilisation of the soil surface. This may be achieved in a number of ways:-

1. If there is a vegetation cover already on the site, consideration should be given to a vegetation enhancement scheme rather than a habitat creation project. Methods of diversification are many but include slot seeding (Wells 1989), turfing as discussed by EAU (1988), or by altered site management to encourage the more desirable species. Management could involve a hay cutting regime, cutting or grazing, or a change in grazing intensity.

2. The use of nurse crops, that is, fast growing species which establish rapidly to stabilise the soil. The nurse crop can later be eradicated by management once the desired vegetation has established.

3. Bradshaw and Chadwick (1980) point out the need for the use of fertiliser on some sites (particularly spoil heaps) if a sward is to be established which can withstand the erosive forces of wind and rain. Fertiliser should only be applied in specific cases as generally it impedes the process of habitat creation.

(d) The use of field trials. Even with the best planned project it is still not certain that all will go according to plan. This is because there are still a number of variables which are very difficult to prejudge. One solution would be to go ahead with the project and to "fine tune" the resulting habitat through appropriate management. The second option would be to run a limited field trial.

The advantages of this latter technique are clear; however, one major disadvantage is that for field trials to give any useful information, they must be conducted over a number of years. Clearly for many projects this would represent an unacceptable delay. However, with large scale long-term projects a number of years spent on initial field trials can represent a good investment, especially if the full scale habitat creation site is not ready because there is a need for a 3-4 year fertility reduction programme.

(e) Site preparation. Since planting and seeding is most effective in the spring or autumn, site preparation should start in early spring or early autumn. Unfortunately, the weather at these times can be inclement and this has important implications for machine work. Heavy machines should not be used in wet conditions as this is likely to cause soil compaction. This is particularly important with clay soils which are especially prone to damage in this way. Other soil related work may also be necessary, such as ripping and cultivation; these activities are discussed in the habitat chapters of this *Guide*. Care does need to be exercised with deep ripping, such as on sites where there may be newt hibernacula.

Where the habitat creation site has had a previous plant cover there may be a problem associated with the composition of the seed bank. The most likely problem species are the weed species such as thistles, docks and aggressive grasses. A number of methods can be employed to alleviate the problem including:

1. Depleting the seed bank by cultivating the land, allowing the seeds to germinate, and then applying non-selective weed killer, or recultivating. This can be repeated several times to ensure that the seed bank has been depleted to an acceptable level.

2. Diluting the seed bank by inverting the topsoil to the necessary depth in order to expose subsoil at the new soil surface. This is a further positive aspect of the technique primarily designed to reduce soil fertility.

3. Suppressing the seed bank by spreading freshly cut hay (used as the habitat creation seed source) over cultivated land before the germination of the seed bank.

(f) Methods of plant introduction. The choice of method for plant introduction is a fundamental one and it is important that the correct choice is made for a given project objective. The available methods include the following:-

Introduction of species by colonisation/seed bank

This method can only work if there is an existing persistent seed bank or a seed source in close proximity to the site. This is often a long term process. It is, however, cost-effective and can produce the most natural results. The ideal location for such a project would be adjacent to existing semi-natural vegetation in a non-urban setting. Here there would be no perception of visual nuisance caused by the slow colonisation of the site, and there is a good chance that, given favourable conditions, the site may develop a good level of ecological interest.

Introduction of species by seeding

Commercial Seed Mixes: These are now widely available and, in more recent times, the companies concerned have responded to the need to provide seed from UK sources and in appropriate seed combinations where seed mixes are sold. These companies will also make up a specified mix if the quantities required are significant.

However, despite the positive changes reported above, there are still a number of problems associated with the use of seed mixes in habitat creation. These include:

1. Loss of seed viability during seed storage; ideally seed should be stored for the minimum possible time and under cool dry conditions.

2. Commercial seed mixes are expensive and may be limited in the species available.

3. Commercial seed mixes can contain inappropriate species and cultivars, and the native species which are available will not be of local provenance.

Hand gathering: The hand gathering of seed is a time consuming task but which, on heathland and grassland (especially hay meadows), can be speeded up by the use of forage harvesters and vacuuming equipment. (It is important to obtain relevant permissions from landowners/managers before undertaking this work). Some of this seed will need to be treated before use, for example, a cold treatment may be required to break dormancy. However, despite the labour-intensive nature of these techniques, there are a number of distinct advantages:-

1. The provenance and species composition of the seed stock will be fully known.

2. If volunteers can be called upon to assist with the seed collection, then this method can represent substantial financial savings.

3. It may be possible to obtain seeds which are not available by any other means.

Hay-bales: In Holland and Sweden hay-bales have been successfully used to introduce plant species to a meadow creation site. This technique has now been proven successful in England by long term studies in Wolverhampton (Case Study No. 5) and Oxford. The process is straightforward; the hay is cut and loose-baled when it is still slightly green, most of the seed will then remain on the seed heads. The bales are quickly transported to the creation site (to prevent fermentation damaging the seed), and are spread over the prepared site and left to degrade over the winter.

The method works because the seed falling from the hay is protected, and readily germinates in the spring, whilst the weed species in the soil seed bank are suppressed by the hay cover. This method relies on the fact that the grassland species are adapted to germinate under a thin covering of hay, while the weed species germinate best under direct sunlight. The species composition of the resulting meadow is often similar to the donor site, and this is a valuable feature if nature conservation is a primary aim.

Hydroseeding: This is a specialised technique commonly used to seed extensive slopes and large inaccessible areas of low soil fertility like mineral waste and quarry spoil and embankments. A mix of seeds and fertiliser is sprayed directly onto the site, and this may be followed by an organic mulch.

Introduction of species by planting

The fundamental advantage of planting is that it creates instant visual interest, especially with tree and shrub planting.

If growing material is to be used, it is essential that care is taken to protect the plant(s) from damage during transportation from the donor site/nursery to the habitat creation site. Not only is there a danger of physical damage, but there is also the threat of desiccation. Clearly, the potential for problems increases the longer the plants are out of the ground. The set-back caused by temporary desiccation may still be evident after five years growth.

Pot-grown plants: Although this technique is costly both in terms of time and money, the vast majority of native species can be successfully grown using horticultural methods.

Tree Planting: There is a wide range of tree and shrub material available from nurseries and garden centres. The two main types are container grown and the cheaper bare rooted stock (whips). Although bare rooted material can only be used in the winter period, there is much practical and research evidence that this material produces better trees and shrubs than "standards" derived from container grown material. However, standards will instantly create a visually attractive wooded area although these may draw the attention of vandals. In urban habitat creation projects the relatively vandal-proof block planting of whips is preferred.

Turfing: Although strictly not a habitat creation technique, this technique has value in that small units of whole plant communities may be transplanted, including lower plants like mosses and liverworts. The technique can be used to diversify areas of existing herb-poor grassland or be placed within a newly created open grass sward. The one major drawback to this method is that a donor site is necessary. With grasslands, there is a sacrifice of material, but with some dry heathlands, the removal of a thin topsoil layer can result in no long term damage to the donor site. An alternative approach is to extract and use "cores" of desired communities. This has the advantage of less damage to the donor site, but requires the use of a grass nurse species to prevent erosion.

A mixed approach (planting and seeding)

Clearly the advantages of planting and seeding can be combined in a mixed approach. Examples might include the combined use of heathland litter and heathland topsoil or, with woodland habitat creation, the planting of trees and the seeding of appropriate ground flora species once an appropriate degree of shading has been achieved.

Nurse Crops

Nurse crops have three basic functions:

1. To provide a pleasing visual effect as quickly as possible.
2. To produce a stabilising vegetation cover preventing soil erosion.
3. To provide shelter for the developing community of introduced plants.

The species used as nurse crops are quick-growing species and are easily removed once they have served their purpose. In heathland creation projects grass species such as *Agrostis castellana* have been effective both as a "companion" species to the introduced plants, and as a protection from soil erosion (EAU, 1988). However, as *A. castellana* is not a native UK species, the use of the closely related and native common bent *A. capillaris* is to be encouraged.

Westerwold's rye-grass *Lolium multiflorum*, an annual species, is a good nurse crop for grasslands (Wells et al. 1983) although on fertile soils it may become too vigorous and it must be cut before seeding can take place. Scots pine *Pinus sylvestris* and alder *Alnus glutinosa* are suggested as woodland nurse crops in DoE (1992a) although they can be invasive on heaths and on wet soils respectively.

2.4.4 Fauna in habitat creation

This *Guide* concentrates on the establishment of vegetation as the key element in habitat creation. However, fauna is an essential element in successful habitat creation although very little research has been carried out in this field. Some observations on this subject are made below and further information is given in the habitat chapters.

On bare-ground surfaces on derelict land and in sand and gravel quarries it is very important that habitat creation projects do not destroy existing habitats of importance for invertebrates. Specialist advice should be sought on this matter.

(a) Attracting invertebrates. The key to invertebrate diversity is through site diversity. Much useful information concerning invertebrate habitat is presented in Kirby (1992) and Fry & Lonsdale (1991). Certain habitat features are particularly valuable in attracting invertebrates, which include:-

1. The inclusion of a pond in a project may significantly enhance a site's nature conservation value. A pond soon attracts a wide range of insects including dragonflies, damselflies, water beetles and bugs. A pond is also essential for amphibians although a successful amphibian pond should have no large predatory fish.

2. Nectar sources are essential if the habitat creation site is to support butterflies, bees, flies and some beetles.

3. Warmth, shelter and structural diversity are critical features for many species of invertebrate. These factors need to be taken account of in both site design and subsequent management. An example of this is the creation and management of a hedgerow.

4. Patches of bare ground, especially sandy material, which will be of value for breeding wasps. Piles of stone or brick can also provide valuable habitat for hymenoptera and other insects.

5. The introduction of piles of dead wood into the site can provide excellent habitat for specialised invertebrates and fungi.

(b) Attracting reptiles and amphibians. Individual species of reptile and amphibian have particular habitat requirements and it is possible to design features in a habitat creation project to encourage them. A good example of this is the provision in a heathland project of south-facing banks and bare ground to encourage the use of the area by sand lizards if they are present on adjoining heathland. With amphibians, ponds will form breeding sites, but suitable terrestrial habitat is also required for adult frogs, toads and newts.

(c) Attracting birds. Many common bird species will readily use habitat creation sites particularly if there is an abundance of invertebrate food, and sufficient cover for nests. Woodland, scrub and hedgerows are of particular value for common bird species, and such sites can easily accommodate bird boxes. Particularly in the early stages of colonisation, where plants which produce a lot of seeds are common, these sites are highly attractive to seed eating birds.

Many good wetland habitat creation schemes outside the scope of this *Guide* have been designed to attract particular wetland species to breed. A good example of this is the creation on worked-out gravel pits of suitable habitat for breeding and feeding little ringed plover *Charadrius dubius*. However, within the scope of this *Guide* is the creation of suitable grassland areas for wintering geese, such as for brent geese *Branta bernicla* in southern and eastern England and for pink-footed geese *Anas brachyrhynchus* in north-west England. The creation of flood-plain grasslands for breeding waders is also relevant here.

(d) Attracting mammals. It is possible that a habitat creation objective may be to provide habitat of value for a particular species of mammal, such as dormice or badger. The specifications will differ for each mammal, but there is a great deal of scope. Examples include grasslands for small mammals, artificial setts and worm-inoculated grasslands for badger, and boxes for bat and dormice hibernacula. At a more general level, if a habitat creation project has been successful in attracting an abundance of invertebrates, then it is likely to be attractive as a feeding area by bats. Such places may be suitable for the

placement of bat boxes and for habitat manipulation to encourage bats. Thompson (1989) is a useful source of information on this subject.

2.4.5 Initial (short-term) management

Initial management will normally cover a 2-3 year period for grasslands and heathlands and longer for woodland, scrub and hedgerow planting. This 2-3 year period also tends to be the maximum length of the "defects and liability" period following the completion of the establishment phase of a landscape contract. There are a number of important elements to this management, as follows:-

(a) Suppression of weed species. It is essential that a dense sward of weed species should not be allowed to develop. In woodland schemes, for example, the suppression of weed species using mulches or herbicides in the first few years of the project will greatly benefit tree establishment. The use of Tuley tubes can also assist in this process. In a grassland or heathland creation project weeds can be a problem and may need to be controlled by spot herbicide treatment and/or a regular cutting programme. Grazing may also be an alternative management method but only once the sward has been established. Herbicides which are used to control weeds and vegetation are, under UK law, pesticides and their use must conform with legislation. This legislation includes measures to protect those applying herbicides. A summary of the regulations concerning herbicides is given in DOE (1992b).

(b) Watering. There is the need for some contingency planning for watering in some habitat creation schemes. For example, immediately after the planting of bare-rooted trees and shrubs (and turves) they should, if possible, be watered. Watering may also be necessary during drought periods in the first growing season after planting. Watering is not usually necessary or practical for grassland and heathland habitat creation schemes. However, there is some evidence with heathland schemes, especially when this involves the planting of *Calluna* plants, that some watering may be beneficial.

(c) Managing nurse crops. If a nurse crop is used to provide shelter, or to stabilise the substrate, it is essential to manage it to prevent it dominating the site at the expense of the more desirable species (EAU, 1988 and Wells, 1986). This must be designed into the Project Plan.

(d) Protection from damage. If the habitat creation site is liable to be heavily grazed (by stock or by deer or rabbits), or suffer heavy trampling, then the site will need to be fenced to exclude these pressures. This will give the developing sward time to become established. Although fencing is expensive, it can be reused on other sites. This initial protection from trampling and grazing is particularly important on unstable sites where the vegetation is slow growing; for example heathlands, sand dunes, and upland areas. Guidance in EAU (1988) recommends that a heathland habitat creation site is protected from even moderate grazing for as many as three years. On these sites, therefore, fencing needs to be costed into the programme.

2.5 Long term management

2.5.1 Management Plan and long term objectives

It is essential that the Project Plan of every habitat creation project contains a Management Plan for the long term monitoring and management of the site. This Plan should be made to take account of the long term objectives of the habitat creation project. The mechanism and costing of the Management Plan should be worked out before the scheme proceeds. Guidance on the preparation of Management Plans can be found in a manual produced by the Nature Conservancy Council (1988) and a simplified manual directed at managers of

statutory Local Nature Reserves (English Nature, 1994). Management is essential, but to be effective it must be carefully planned, and the project designer needs to have a thorough understanding of the relevant management techniques. However, most sites will not need a Plan with the high degree of complexity which is implied by this document.

(a) Management Plan. Few truly natural habitats are left in Britain, the vast majority are either semi-natural or artificial. Most semi-natural habitats are maintained in their high value state mainly by active management. Such management includes the grazing and hay meadow management of grasslands and the coppicing regimes employed in some woodlands. Indeed, many species now rely on this management for their existence which must be maintained if their conservation value is to be retained.

A Management Plan requires that:-

1. The nature conservation interest of the site is properly assessed.
2. Clear objectives of the management should be laid down.
3. The relevant management is planned and carried out.

An essential part of a Management Plan is a method for the monitoring of the project and a mechanism whereby the results of this monitoring can influence the way the management of the site is carried out in the future. Monitoring should aim to achieve the following:-

1. To ensure that the project is achieving its objectives which should have been clearly stated before the project was started.

2. To ensure that changes which are detected in the created habitat are dealt with by the Management Plan (ie. a feedback loop exists). Clearly in order for this to happen, there must be a fair degree of flexibility and prediction in the Plan.

3. Since very little is known about the process of habitat creation, project recording and monitoring will add to the sum of knowledge, especially if the results are published. The published information will be particularly valuable if it reports on the success or otherwise of achieving target plant communities.

(b) Guidance on long term management. The importance of management has been stressed, and many of the most important techniques are outlined in the following books and journals.

Woodlands - Brooks (1988) is an excellent practical and comprehensive guide to woodland management.

Grassland - Duffey et al. (1974) gives a comprehensive and detailed account of grassland ecology and its management, whilst Wells et al. (1989) deal with the establishment and management of wildflower meadows. English Nature and RSNC have recently published a Lowland Grassland Management Handbook (Jefferson and Crofts, 1994).

Lowland Heathland - English Nature's Lowland Heathland Management Handbook (Gimingham, 1992) is the best source of information in this area. Other sources of information are Michael (1993), Andrews and Rebane (1994) and EAU (1988).

Peatland - The Peatland Management Handbook by Rowell (1988) covers this topic in some detail.

2.5.2 Resources and financial planning

It has been stressed on a number of occasions during this chapter that the provision of adequate resources, especially finance, are an essential component of a successful project.

This section has been placed at the conclusion of the discussion of Management Plans and long-term management because it is at this stage that the *Review* has indicated that many projects become poorly managed, unmanaged, or even forgotten. Sites where management does not take place will degrade and all the earlier effort can then be wasted. This is clearly not cost- effective.

It is possible that the establishment phase of some projects will extend over several seasons, woodland planting for example. During this extended period it is possible that additional sources of funding or other resources may become available. However, this should not prevent a Project Plan from having identified sufficient resources for the project at the start.

2.6 Project assessment checksheets.

The following checksheets are designed to ensure that in the planning of a habitat creation project all necessary aspects of project objectives, design and aftercare have been fully considered.

The checksheets are designed for the use of both project designers and project reviewers. The project reviewer will be someone, probably in a statutory agency or a wildlife trust, who is responsible for assessing a proposed habitat creation project, which is perhaps being put forward as mitigation for a development. In this case, the questions raised by the checksheet and the answers provided, should enable an assessment to be made as to the likely success of the project. It should also enable the reviewer to suggest improvements and modifications to the project proposal.

The checksheets are arranged under the following headings:

1. **Objectives**: identification of achievable objectives.
2. **Design**: elucidation of practical implementation.
3. **Aftercare**: definition of site management.
4. **Overall assessment**

CHECKSHEET 1

OBJECTIVES	Have the following been considered in a satisfactory manner?	Action YES	?	NO
Formation of ideal objectives	Clear objectives formulated?	☐	☐	☐
	Plant communities/fauna + land use + for whom?	☐	☐	☐
Evaluation of Site	Biological constraints/ opportunities considered?	☐	☐	☐
	Physical constraints/ opportunites considered?	☐	☐	☐
	Social constraints/ opportunities considered?	☐	☐	☐
	Does the site already have a nature conservation interest?	☐	☐	☐
Habitat to be created	Physical aspects considered?	☐	☐	☐
	Ecological aspects considered?	☐	☐	☐
Finance	Habitat creation costed?	☐	☐	☐
	Sources of finance + labour identified?	☐	☐	☐
	Site aftercare costed?	☐	☐	☐
Formation of operational objectives	Achievable objectives presented?	☐	☐	☐

Overall evaluation

Main action items/corrective action

CHECKSHEET 2

DESIGN

Have the following been considered in a satisfactory manner?

		Action		
		YES	?	NO
Species selection	Selection of appropriate species?	☐	☐	☐
Site design	Creation of suitable conditions?	☐	☐	☐
	Life span of project set out?	☐	☐	☐
	Full agreement with Project Plan objective?	☐	☐	☐
Site preparation	Methods identified?	☐	☐	☐
	Timing of preparation?	☐	☐	☐
	Seed bank?	☐	☐	☐
	Soil fertility?	☐	☐	☐
Species Introduction	Timing of introduction?	☐	☐	☐
	All introduction methods?	☐	☐	☐
Finance	Sufficient finance/labour available?	☐	☐	☐

Overall evaluation

Main action items/corrective action

CHECKSHEET 3

AFTERCARE

Have the following been considered in a satisfactory manner?

		Action YES	?	NO
Initial management	Initial management designed?	☐	☐	☐
Long term management	Management plan designed?	☐	☐	☐
	Are resources available?	☐	☐	☐
Monitoring	Are resources available?	☐	☐	☐
Update of management plan	Has project allowed for monitoring results to feed back to long term management programme?	☐	☐	☐

Overall evaluation

Main action items/corrective action

CHECKLIST 4

THE OVERALL ASSESSMENT

The questions in Checklists 1 - 3 deal with specific points, the following questions, however, must be answered if an objective and balanced assessment of the overall project is to be achieved. If the answers to the following questions are affirmative, then the project is likely to be a sound proposition.

	Yes	?	No
Has a comprehensive Project Plan been prepared?	☐	☐	☐
Has survey confirmed that the existing site has negligible nature conservation interest?	☐	☐	☐
Can the finance available, fulfil the objectives of the project?	☐	☐	☐
Can the species introduction method, site preparation, and planting design fulfil the objectives of the project?	☐	☐	☐
Is there a reasonable likelihood of the target habitat being achievable?	☐	☐	☐
Can the chosen monitoring and management methods fulfil the objectives of the project?	☐	☐	☐
Is there provision for project management and funding throughout its expected life span?	☐	☐	☐
Is there suitable commitment to the project from the project manager/s and funding entity?	☐	☐	☐

Reviewers comments

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