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HABITAT RESTORATION PROJECT

Fact sheet

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Grassland creation for wildlife

This fact sheet provides guidance on the creation of new areas of lowland grassland using native species of grasses and wild flowers.

Where to create wild flower grasslands

New grasslands composed of native plant species will be of value in most situations, although they are most likely to benefit wildlife in the following locations:

- Adjacent to existing areas of agriculturally unimproved, semi-natural grassland.
- Adjacent to other semi-natural habitats such as woodland, hedges and ponds.
- Where they link otherwise isolated blocks of semi-natural habitat.

Planning grassland habitat creation schemes

Objectives

Clear objectives for the project should be set at the outset. These could be quite modest, such as the successful establishment of three grass species and ten species of wildflower, or much more ambitious such as attempting full replication of a naturally-occurring, species-rich community type. The complexity of the project and the size of the area of grassland to be created will need to be tailored to the resources available both for establishment and future management. The eventual management regime for the site should also be considered at the outset, as this may affect the choice of species to plant.

Site Suitability Survey and selection of grassland type

A suitability survey of the proposed grassland creation site and adjacent land should be carried out during the early stages of planning. The survey should include an assessment of soil type and site drainage, past management (which may give an indication of soil fertility), and the existing wildlife interest of the site. The survey will determine if the site is suitable for grassland creation, and also help decide what type of grassland to aim for. Sites with significant existing wildlife value should not be considered for grassland creation schemes.

There are four main types of grassland in lowland England:

- Neutral grasslands, which occur on lowland soils with neutral pH.
- Calcareous grasslands, which occur on alkaline soils in chalk and limestone areas.
- Calcifugous or acid grasslands, which occur on acid soils throughout lowland England but are more widespread in the south and east. They may or may not occur in association with dwarf shrub heaths.
- Fen meadows/rush pastures.

The type of vegetation which can be established in a grassland creation project will be largely influenced by whether the soil is acid, neutral or alkaline, as well as the hydrology of the site. Most unimproved, semi-natural grasslands occur on infertile soils, and so the high nutrient status of much arable land and improved pasture, resulting from the application of inorganic fertilisers, is potentially a major barrier to the creation of wildflower grasslands on these sites.

New grasslands will be of most wildlife conservation value where they attempt to replicate natural grassland communities. Surveys of any semi-natural grasslands near to the proposed site will provide information on the types of species which occur naturally and grow well in the locality.

Soil condition and reduction of soil fertility

The pH and soil fertility (particularly extractable phosphorus, exchangeable potassium and mineralised nitrogen) of the proposed grassland creation site should be measured and compared with the fertility of semi-natural grassland of the type which it is proposed to create. If the fertility of the site is low, habitat creation can proceed straight away. If nutrient levels are much higher than those required by the target community, measures will be needed to reduce soil fertility. Three main methods are available for reducing soil fertility:

- Growing crops with limited inputs of fertiliser and removing the nutrients with the harvested crop. Several years of cropping may be required to achieve significant reductions in nutrient levels.
- Deep ploughing to bury the topsoil and expose nutrient-poor layers of soil to the surface.
- Topsoil stripping (to remove the most fertile layers of soil) and removal of the stripped material from site. It may be possible to sell the topsoil to offset some of the other costs of habitat creation.

It is recommended that professional advice is taken regarding soil fertility level, since this is often a crucial factor determining the success or failure of grassland creation projects. It may take several seasons for soil fertility to drop sufficiently to enable the next stage of the project to proceed. If it is unlikely that fertility can be reduced to a level suitable for the proposed plant community, it may be better to consider an alternative habitat creation scheme.

Ground preparation

A firm, fine, weed-free seedbed is required for the successful germination and establishment of grass and wildflower seed, and care should be taken to ensure the ground is prepared sufficiently well before seeding. Problems caused by weeds can be reduced by deep ploughing (which will bury much of the seed bank) or by the treatment of any existing vegetation with a non-residual herbicide such as glyphosate. Roll after cultivation and again after sowing.

Seed sources

New grasslands are most easily established from seed. For wildlife conservation purposes, only seeds of native species of plant derived from British stock should be used. This is particularly important for new grasslands established next to existing semi-natural grassland. There are two main sources of seed for grassland creation schemes.

Seed harvested from semi-natural grasslands

This is generally preferable, especially if a donor site can be identified close to the creation scheme. This will ensure that the seed is of local provenance and is likely to have a species composition suited to the local climate and soils. Seed can be harvested by hay cutting, tractor-mounted vacuum harvester, or by hand collection. Mechanical methods will generally be required to obtain enough seed to establish all but the smallest areas of new grassland.

Seed obtained from commercial suppliers

An increasing number of seed merchants now supply wild flower and grass seed. Care should be taken to ensure that wherever possible the seed is of British provenance. In some cases it may be possible to obtain seed native to particular geographical regions. The grass species selected should be non-vigorous and capable of thriving in nutrient-poor soils. General seed mixes for particular soil types are available, though it is preferable where possible to obtain a mix which is matched specifically to the soil type and geographical location of the project site. A number of the publications at the end of this fact sheet contain advice on suitable species to plant. Local wildlife conservation organisations may also be able to provide advice on species selection. Mixtures containing rye-grass and clover should not be used.

Establishment of vegetation

Three main techniques are commonly used for establishing vegetation in wild flower grasslands:

Spreading of hay

- Cut the hay green so that a higher proportion of seed is retained in the flowerheads.
- Transport the hay (either unbaled or loose baled) to the prepared seedbed and spread over the ground surface. With baled hay, spread the material as soon as possible after cutting to prevent fermentation and resultant seed loss.
- Leave the hay on the ground where it will provide a mulch and suppress unwanted grass and weed species. The wild flower seeds are adapted to germinate beneath the partial shade provided by the hay.

Direct sowing of seed

- Sow 85% grass and 15% wild flower seed by weight. A typical sowing rate is 30 kg/hectare.
- Maintain the viability of seed by storing for as short a time as possible before use.
- Use sand or fine sawdust to bulk up the seed and ensure proper mixing and even coverage of the site.
- Sow in the autumn using a spreader mounted on a tractor or all terrain vehicle. Lightly harrow and roll the seedbed directly after seeding.

Direct planting

- If required, establishment of vegetation can further be encouraged by the direct transfer of pot-grown herbs into the habitat creation site. Plants can be grown from seed in nurseries before being planted out.

In some instances, for example on sites with low soil fertility which are adjacent to existing semi-natural grasslands, it may be feasible to establish grassland vegetation of wildlife conservation value by natural re-colonisation.

Initial aftercare

The initial stages of vegetation establishment are critical to the success of grassland creation projects.

- During the first year cut the vegetation to a height of 80-100mm. This will encourage the wild flowers by reducing the competition from weeds and the sown grasses. Cuttings should be removed from the site. Several cuts are likely to be required during the first season.
- Less frequent cutting will be necessary as the vegetation becomes more established.
- Protection from grazing animals will be necessary during the early stages of establishment.
- If necessary, persistent weeds can be controlled by spot treatment with herbicide.

Long-term management

A brief Management Plan should be produced outlining the proposed future management regime for the site. In the absence of management the vegetation will gradually progress to coarse grassland and scrub with a resultant loss of species diversity. The plan should identify conservation objectives for the site and include monitoring of the effects of management. Suitable management for a hay meadow might be cutting in the summer followed by light grazing in the autumn. Limestone and chalk grassland sites could be managed by grazing, or by a late cut of the vegetation and the removal of the cut material.

Sources of further information on grassland creation and management

Andrews, J. and Rebane, M. 1994. Farming and Wildlife: A Practical Management Handbook. Royal Society for the Protection of Birds, Sandy. 358pp.

Ash, H.J., Bennett, R. and Scott, R. 1992. Flowers in the Grass. English Nature, Peterborough. 68pp.

Crofts, A. 1994. How to Create and Care for Wildflower Meadows. Royal Society for Nature Conservation, Lincoln. 11pp.

Crofts, A. and Jefferson, R.G. (Eds.). The Lowland Grassland Management Handbook. English Nature/Royal Society for Nature Conservation.

Gibson, C.W.D. 1995. Creating Chalk Grasslands on Former Arable Land: A Review. Report to Blue Circle Industries by Bioscan. Blue Circle/Bioscan/English Nature. 39pp.

Luscombe, G. and Scott, R. 1994. Wildflowers Work: A Technical Guide to Creating and Managing Wildflower Landscapes. Landlife, Liverpool. 30pp.

Parker, D.M. 1995. Habitat Creation - A Critical Guide. English Nature Science No. 21. English Nature, Peterborough. 190pp.

Wells, T.C.E., Bell, S. and Frost, A. 1981. Creating Attractive Grasslands Using Native Plant Species. Nature Conservancy Council, Shrewsbury. 34pp.

Wells, T.C.E., Frost, A. and Bell, S. 1986. Wild Flower Grasslands from Crop Grown Seed and Hay Bales. Nature Conservancy Council Focus on Nature Conservation No. 15. Nature Conservancy Council, Peterborough. 32pp.

Wells, T.C.E., Cox, R. and Frost, A. 1989. The Establishment and Management of Wildflower Meadows. Nature Conservancy Council Focus on Nature Conservation No. 21. Nature Conservancy Council, Peterborough. 27pp.

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Habitat creation bibliography: grassland

Andrews, J. and Rebane, M. 1994. *Farming and Wildlife: A Practical Management Handbook.* R.S.P.B., Sandy. 358pp.

Handbook providing guidance on the management, restoration and creation of wildlife habitats on farmland in the UK. The first chapter deals with surveying the wildlife interest of farms and making wildlife management decisions. The remaining chapters cover the major wildlife habitats found on farms (arable land, pasture and meadow, lowland heath, hill and rough grazing, machair, farm woodland, hedgerows, farm trees and scrub, waterbodies and other wetlands, farm buildings and walls). For each habitat there are sections on wildlife requirements and effects of farm management, options for conservation management, prescriptions for the management, enhancement and creation of the habitat, references and further reading, and case studies of the implementation of wildlife conservation on farms. Also included are key features on selected species and numerous tables summarizing aspects of wildlife assessment and conservation management. (*Although the sections on habitat creation are relatively brief, this is nonetheless an invaluable source of information for those undertaking or advising on habitat creation on farmland*).

Ash, H.J., Bennett, R. and Scott, R. 1992. *Flowers in the Grass.* English Nature, Peterborough. 68pp.

Report of a research project on the creation and management of wild flower grasslands in urban areas, carried out for the NCC by the Groundwork Trust in association with Knowsley Metropolitan Borough Council. Contains detailed information on site choice, reduction of soil fertility, ground preparation and seeding, management and monitoring. Recommendations for the management of existing grassland sites are also included. The appendices include a list of native grass and herb species suitable for planting in different soil types. (*Although written primarily for urban sites, contains much information which will be of value for any grassland creation project*).

Baines, C. and Smart, J. 1984. *A Guide to Habitat Creation.* Greater London Council Ecology Handbook No. 2. GLC, London. 44pp.

General guide to the creation and management of wildlife habitats in an urban context. Grasslands, woodlands, wetlands and wastelands are each covered in separate chapters. Appendices include a list of suppliers of native wild flower seed from British sources, and a general list of plant species suitable for establishment in newly-created habitats. (*Good general guide, though more detailed and recent publications are now available for each of the habitats covered*).

Botanical Society of the British Isles. 1995. *Wild Flower Plants and Seeds.* BSBI, London.

Leaflet cautioning against uncontrolled establishment of wild flowers in the British countryside, but providing advice on how to obtain seed for "wild" gardens. Provides a list of common plants suitable for sowing on different soil types, and a list of suppliers selling wild flower seed from native British sources. (*List of seed sources may be useful if seed cannot be obtained from semi-natural sites local to proposed habitat creation schemes*).

Crofts, A. 1994. *How to Create and Care for Wildflower Meadows.* Royal Society for Nature Conservation, Lincoln. 11pp.

Booklet providing detailed practical advice on how to create wildflower meadows. Subjects covered include consideration of the options for grassland creation, sources of grant aid, choice of site, seedbed preparation and sowing techniques, weed control, choice of seed mix, and methods of aftercare. Includes lists of grass and herb species suitable for sowing on different soil types. The appendices include the names of wildflower seed suppliers and other useful addresses. (*Excellent publication summarising the available information on wildflower grassland creation. Highly recommended*).

Crofts, A. and Jefferson, R.G. (Eds). 1994. *The Lowland Grassland Management Handbook.* English Nature/Royal Society for Nature Conservation.

Provides comprehensive guidance on all aspects of the conservation management of lowland grassland sites. (*Valuable source of information on methods of long-term management for newly-created grassland*).

Department of Transport and others. 1992. The Wildflower Handbook. **In**: *Design Manual for Roads and Bridges, Vol. 10; Environmental design.* HMSO, London.

Manual providing advice on the creation of wild flower swards along motorways and trunk roads. Contains chapters on site evaluation, choice of seed mix, site preparation and sowing, other techniques for vegetation establishment (e.g. use of hay bales and container grown plants), management and monitoring. The appendix includes fact sheets detailing the morphology, site preference, and seed characteristics of 64 wild flower species. (*Although produced specifically for road schemes, much of the information will be applicable to other types of grassland creation project*).

Ecological Parks Trust. 1981. *New Life for Old Space: A Guide to Handbooks and Leaflets Covering the Principles and Methods of Converting Small Urban Sites into Nature Areas in Britain.* Ecological Parks Trust, London. 7pp.

Lists publications/leaflets covering urban wasteland projects, design principles, woodland creation, creation of herb-rich swards, pond creation and attracting fauna. (*Many of the information sources listed have been superseded by more recent publications. The strong urban bias reduces its applicability to habitat creation on agricultural land*).

Farming and Wildlife Advisory Group. 1996. *Creating Wildflower Swards.* FWAG, Kenilworth.

Technical Information Sheet concentrating on the practical aspects of establishing wild flower swards. Covers where to create swards, species choice, establishment methods (timing, choice of bare seedbed or sowing/ planting into existing swards) and aftercare in the first season of establishment and in subsequent years. (*Good basic leaflet, though lacks specific information on suitable species to plant - instead concentrates on which species to avoid*).

Firbank, L.G., Arnold, H.R., Eversham, B.C., Mountford, J.O., Radford, G.L., Telfer, M.G., Treweek, J.R., Webb, N.R.C. and Wells, T.C.E. 1993. *Managing Set-aside Land for Wildlife.* ITE Research Publication No. 7. HMSO, London. 146pp.

Report detailing management recommendations for set-aside land which will benefit wildlife. Introductory sections consider the conservation priorities on set-aside farmland as well as the potential for wildlife enhancement. These are followed by a series of management options for rotational set-aside (e.g. management for arable weeds and birds), non-rotational set-aside (e.g. enhanced field margins, natural regeneration) and longer-term restoration on set-aside land (e.g. creation of calcareous grassland and heathland). (*Good appraisal of the various options for set-aside, though partly out of date due to changes in the set-aside regulations*).

Gibson, C.W.D. 1995. *Creating Chalk Grasslands on Former Arable Land: A Review.* Report to Blue Circle Industries by Bioscan. Blue Circle/Bioscan/English Nature. 39pp.

A review of existing knowledge on the restoration of species-rich calcareous grassland on arable farmland, with an emphasis on natural successional processes. Topics covered include the origin of calcareous grassland, changes in arable land (particularly the increased usage of inorganic fertilisers), natural succession from arable to calcareous grassland, and techniques for restoration/re-creation (soil treatment, grazing, cutting, seeding, weed control etc). The advantages and disadvantages of each technique are discussed, and some recent re-creation projects are listed. (*A useful overview of techniques, although the practicalities of grassland creation are better covered in other publications*).

Hillier, S.H., Walton, D.W.H. and Wells, D.A. (Eds). 1990. *Calcareous Grasslands: Ecology and Management.* Proceedings of British Ecological Society/Nature Conservancy Council Symposium. Bluntisham Books, Huntingdon. 193pp.

A diverse collection of scientific papers on the ecology and management of calcareous grassland. The Proceedings are arranged into sections covering the distinctive features of calcareous grassland, the maintenance and manipulation of species diversity, management for individual species and reserve management. The latter section contains two papers relating to the establishment of chalk grassland on arable land. (*Of very limited value in habitat creation projects. More comprehensive and accessible information is available in other publications*).

Jefferson, R.G. and Robertson, H.J. 1996. *Lowland Grassland: Wildlife Value and Conservation Status.* English Nature Research Report No. 169. English Nature, Peterborough. 67pp.

A compendium of information on the distribution, extent and conservation status of lowland grassland and associated species in England. The report contains sections on the types and total extent of lowland grassland, loss and fragmentation of acid, neutral and calcareous grassland, species conservation interest, conservation status of grasslands, non-statutory conservation priorities and incentive schemes. Also included is a bibliography of key references on grassland issues. (*Useful as a source of information on loss and fragmentation of lowland grassland*).

Luscombe, G. and Scott, R. 1994. *Wildflowers Work: A Technical Guide to Creating and Managing Wildflower Landscapes.* Landlife, Liverpool. 30pp.

Gives guidance on all aspects of creating wildflower landscapes, including reducing soil fertility, choice of seed mix and sowing methods. (*Aimed primarily at urban sites, but much of the information will be relevant to all grassland creation schemes*).

Parker, D.M. 1995. *Habitat Creation - A Critical Guide.* English Nature Science No. 21. English Nature, Peterborough. 190pp.

Report examining the potential and actual problems of habitat creation in Britain, and presenting guidance on best practice in the planning, construction and management of habitat creation projects. The report draws on information obtained from a survey and review of 150 habitat creation projects throughout the UK. A general chapter on habitat creation planning is followed by chapters on grassland, woodland and scrub, heathland and moorland, peatlands and urban sites. Within each chapter there are sections on semi-natural habitat types, initial site survey and planning, preparation of a project plan and the setting of objectives, methods of habitat creation, and monitoring and long-term management. The report includes 26 case studies of habitat creation projects in the UK. (*Essential reading for anyone undertaking or advising on any significant habitat creation project).*

Penny Anderson Associates. 1993. *Roads and Nature Conservation: Guidance on Impacts, Mitigation and Enhancement.* Report for English Nature. English Nature, Peterborough. 80pp.

Document outlining the main impacts of road schemes on wildlife, and providing guidance on the most appropriate measures to mitigate these impacts. Includes some data on the loss and fragmentation of semi-natural habitats. Section 9 covers habitat creation, and addresses key issues including selection of habitat type, sowing versus natural regeneration, soil type, species selection, ground preparation and management. There are brief sections on creation of woodland, grassland, heathland and wetland habitats, and on habitat creation for butterflies and amphibians. Guideline costs for habitat creation are also given. (*Although written in relation to road schemes, much of the information given will be of value to habitat creation schemes on agricultural land*).

Royal Society for the Protection of Birds. 1994. *Farming and Wildlife: Pastures and Meadows.* RSPB, Sandy. (Leaflet).

Leaflet summarising chapter 3 of Farming and Wildlife: A Practical Management Handbook. Topics covered include the importance of grasslands for wildlife, the effects of grazing and mowing on plant variety and sward structure, and key recommendations for the management of these habitats for wildlife. The leaflet includes a short section outlining the main options for creating new grasslands, and lists the main sources of financial incentives. (*Suitable for direct distribution to farmers - though much more information would be required by anyone seriously considering undertaking grassland creation*).

Royal Society for the Protection of Birds, English Nature and Institute of Terrestrial Ecology. (In Press). *The Wet Grassland Guide: Managing Floodplain and Coastal Wet Grassland for Wildlife.* RSPB, Sandy.

A new management guide due for publication in late 1997. Section 4.5 deals with the establishment of wet grassland. Topics covered include natural regeneration, species reintroduction, use of container-grown plants and seeding. The section on seeding provides guidance on site preparation, sources of seed and seed collection, seed mixtures and sowing rates, as well as sowing times and the use of nurse crops. Recommendations for aftercare management are given, and there are two case studies describing practical examples of wet grassland creation. (*Valuable source of reference for anyone contemplating creation or restoration of wet grasslands*).

Wells, T.C.E., Bell, S. and Frost, A. 1981. *Creating Attractive Grasslands Using Native Plant Species.* Nature Conservancy Council, Shrewsbury. 34pp.

Report providing guidance, based on research carried out by the Institute of Terrestrial Ecology, on the creation of new areas of grassland using native species of grasses and herbs. There are separate sections on seed collection (collection methods, when to collect), post-harvest handling of seed, seed germination, propagation of plants for seed production, seed mixtures and sowing (including recommended mixtures for heavy clay, chalk and limestone and alluvial soils) and management of sown areas. (*Excellent reference, particularly for those wishing to sow seed gathered from local sources*).

Wells, T.C.E., Frost, A. and Bell, S. 1986. *Wild Flower Grasslands from Crop Grown Seed and Hay Bales.* Focus on Nature Conservation, No. 15. Nature Conservancy Council, Peterborough. 32pp.

Report summarizing some of the research carried out by the Institute of Terrestrial Ecology on the establishment of new grasslands of native plant species. Section 1 gives the results of experiments on the propagation of wild flower species for seed production. Section 2 presents an analysis of the seed content of hay bales from semi-natural grasslands, and the results of trials to establish new grasslands using seed from this source. Section 3 reviews the establishment success of grassland trial plots on clay, chalk and alluvial soils sown with appropriate seed mixes. (*Good source of information, particularly on seed collection/propagation, but of less practical use in habitat creation projects than some other publications*).

Wells, T.C.E., Cox, R. and Frost, A. 1989. *The Establishment and Management of Wildflower Meadows.* Focus on Nature Conservation No.21. Nature Conservancy Council, Peterborough. 27pp.

A summary of research carried out by the Institute of Terrestrial Ecology into the establishment of wild flower meadows. The report is divided into four parts: Section 1 reviews the loss of semi-natural grasslands as a result of habitat destruction and management changes. Section 2 provides guidelines on the establishment of new grasslands on previously arable land, covering topics such as seed availability, composition of seed mixtures, use of hay seed, sowing and aftercare management. Sections 3 and 4 deal with diversifying existing swards using slot-seeding and planting-out of pot grown plants. Lists of recommended grass and herb species for sowing in different soil types are included in the appendix. (*The section on establishment of new grasslands on arable land is particularly useful*).

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Fact sheet

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Wetland creation for wildlife

Wetlands encompass a wide range of habitats including ponds, lakes, gravel pits, rivers and streams, wet grasslands, bogs and mires, reedbeds and marshes. This fact sheet provides guidance on the creation of new wetlands, focusing on wetland habitats which could reasonably be constructed on arable land and improved grassland as part of habitat creation initiatives specifically for wildlife. As such the main topics covered are ponds, lakes and reedbeds. Further detailed information on wetland creation methods can be found in the publications listed at the end of this fact sheet.

Where to create wetlands

- To extend and add diversity to existing wetland sites.
- On land adjacent to other semi-natural habitats such as woodland and heathland.
- Adjacent to linking habitats such as hedgerows, field boundaries, ditches and rivers.
- As part of other habitat creation schemes (for example wet grassland, woodland, or heathland creation projects).

Particular care should be taken to ensure that the creation of new wetlands, especially pond construction, does not damage the hydrology of adjacent wetland sites of wildlife conservation importance, and that it is not targeted on existing wetland areas such as the wet corner of a field.

Planning new wetland sites

The following factors need to be considered when deciding the location of new wetland sites:

Water supply

- Ensure that there is sufficient water supply for the type and size of wetland proposed. Surveying the topography, drainage pattern and soil permeability of the site will help determine this. A thorough survey is essential if other wetlands are nearby as these could be inadvertently damaged.
- The main sources of water are ground water, surface water, and inflows from watercourses such as ditches and streams. Excavations below the water table will naturally fill with water, but they could dry out in summer so tests are required. Ponds and other wetlands above the water table will need to rely on surface water or inflows.
- To determine groundwater levels, dig test bores (for example using a fence post auger), and monitor water levels over at least a year before the proposed start of wetland construction.
- For reedbeds and wet grasslands, the water supply must be sufficient to compensate for losses due to evapotranspiration and ground seepage. Reedbeds ideally require a water depth of up to 30cm, together with some flow of water, during the summer months. There is also a need to ensure that there are adequate facilities to retain water on site and manipulate water levels.

Water quality

- Where possible, use water sources draining areas of semi-natural habitat, as these are likeliest to have the best available water quality. However, do not alter the drainage pattern from such areas by, for example, digging new ditches.
- Water draining arable land and improved pastures is likely to be polluted to a varying degree by inorganic fertilisers as well as pesticides, but can be used where there is no alternative.
- Avoid water contaminated by silage and slurry effluent, or run-off from farmyards or roads.

Soils and topography

- Impermeable soils such as clays will generally be necessary for the retention of water levels at sites above the water table. Care must be taken not to excavate below the clay seal. A test bore would determine the depth of the clay layer.
- The creation of areas of standing water on permeable soils (e.g. sands and gravels) above the water table will generally require the use of artificial liners (such as butyl rubber, polythene or bentonite) or the import of puddled clay.

Legal considerations

- Legal consent is required from the Environment Agency for impounding water, abstracting water, and any works in a watercourse or within a specified distance (which varies between regions) of a watercourse.
- Local Authorities may require notification of the construction of wetland sites. Planning permission may also be needed.
- Advice on whether legal consents are required should be sought in the early stages of planning of wetland creation projects.

Wetland design

Wherever possible, try to create wetland complexes of different habitats, for example permanent and temporary ponds, wet grassland, reedbed, tall herb, scrub and woodland. These will provide greater habitat diversity than any one feature and will increase the overall wildlife value of the site. Design guidelines for a number of wetland habitats are given below.

Ponds

- Incorporate as much physical diversity as possible, for example by varying the bank slope and water depth, and by creating a wavy edge to the pond. Maximise habitat diversity in the seasonal draw-down zone (the difference between winter and summer water levels).
- Maximise the area of shallow water (less than 0.4m deep) around the pond edge by incorporating a shallow gradient and extending the margin to include bays and spits. Shallow water will encourage a range of wildlife including marginal and aquatic vegetation and invertebrates.
- A maximum water depth of 1m is normally sufficient for small ponds, and a maximum water depth of 1.5 to 2m for larger ponds.
- If required, pond design can include features to encourage particular plant or animal groups such as dragonflies or amphibians.
- If possible, construct several ponds close together, varying in size, depth and permanence.
- Stream-fed ponds should include a sediment trap to slow down the rate of siltation. Stream-fed ponds will require consent from the Environment Agency. They are best sited adjacent to a stream rather than on the line of the stream. This will allow regulation of flow and isolation from any pollution incidents in the water course.
- Maximise the amount of semi-natural habitat around the pond. This will provide habitat for animals (e.g. amphibians) using the pond, as well as a buffer zone to help protect the pond from high nutrient inputs. Buffer zones should preferably be at least 20m in width.
- Plant a hedge (away from the pond edge to prevent too much shading), or allow scrub to develop at the edge of the buffer zone, to combat pollution from agricultural spray drift.
- Vary the bankside vegetation to include areas of short grassland, tall herb, scrub and trees. Some shading of the water surface is beneficial.

Lakes

- Maximise the area of shallow water less than 1m deep. Create a convoluted shoreline with sheltered bays.
- Provide islands as wildlife refuges. Islands should have an extended shoreline with shelter from prevailing winds, and be low-lying with gentle banks to allow easy access by waterfowl. Bare islands are best to attract wading birds, and vegetated islands to attract wildfowl.

Reedbeds

- Create as large an area as possible, within the limits imposed by water availability. All reedbeds, including narrow fringes to ponds and lakes, will be of value to wildlife, though only the largest (over 20 hectares in size) will be capable of supporting most specialist reedbed birds.
- Choose a flat site, but incorporate some variety of land form (e.g. a gentle ridge and furrow with 10m between crowns and 0.5m drop between crown and foot) to allow variation in water depths from permanently flooded areas to permanently dry areas.
- Construct bunds to isolate the site from neighbouring land and divide it into separate compartments for water management. Construct sluices to allow fine control of water levels in each compartment.
- Include meres with convoluted edges and a range of water depths.
- Construct ditches at maximum spacings of 50m. Ditches should be 1.5 to 2.0m deep and have shallow graded edges on one or both sides. Incorporate a shallow berm just below water level to encourage marginal vegetation.

Wet grassland and wader scrapes

- Wader scrapes should be in an open location, a minimum of 1ha in area, with a maximum water depth of 0.5m and extensive areas of water 5-10 cm deep. An adequate water supply and the ability to control water levels is essential.
- Wet grassland can be created from arable land or drained, improved grassland where site conditions and water availability permit. On peat soils wet grassland can be created by percolation from raised water levels in nearby drainage ditches. Surface flooding of the land will be required for sites with clay or alluvial soils.

Wetland construction

- Autumn or winter is generally the best time for wetland construction projects, though on particularly wet sites it may only be possible to use machinery during the summer months.
- Pond liners must be laid on a stone-free base and covered with a sufficient depth of soil (not topsoil) for aquatic and marginal vegetation to establish.
- Care must be taken not to dispose of excavated spoil on areas with existing wildlife value.
- Removal of topsoil from around the margins of a new pond will create a nutrient-poor soil capable of supporting a greater diversity of wild flower species.
- Consider creating new ponds in stages, so that the design can be modified in the light of experience.
- For reedbeds, land forming may be necessary to obtain a level site prior to establishment of vegetation.

Vegetation establishment and initial aftercare

Ponds and Lakes

Normally it is preferable to allow natural colonisation of ponds and lakes. However, if desired the process can be accelerated by selective introductions.

- Only introduce native plant species which are local to the area (e.g. from local pond sites) and are appropriate for the size of the water body.
- Invertebrates may be introduced by adding a little silt and plant litter from a local wetland site.
- Do not introduce fish to small ponds or ponds designed to encourage amphibians or dragonflies.
- Restrict planting of trees and shrubs to the north side of small waterbodies, and set them back from the pond edge. Do not plant trees adjacent to water bodies with artificial linings.

Reedbeds

- Existing vegetation on the proposed site should be removed by stripping the litter layer, deep ploughing, flooding or herbicide treatment.
- Establishment of common reed *Phragmites australis* can be achieved by sowing seed or planting of pot-grown plants, rhizomes or stem cuttings. The use of plant material rather than seed may be better

on nutrient-rich soils (e.g. former arable land) where competition with weeds is likely to prove a problem. Seeding/planting is best carried out in April or May.

- For sites adjacent to reedbeds, establishment may be possible through natural expansion of the existing area of reed.
- Where possible use seed or plants derived from a local reedbed with similar growing conditions to the new site. Seed should be tested for viability before use.
- Damp soil is required for the reed to establish. Once the shoots develop, shallow flooding (taking care to keep the shoot tips above water) will encourage further growth and suppress competing vegetation.
- Grazing by wildfowl, deer and rabbits may need controlling during the early stages of establishment.

Long-term management of wetlands

- Write a brief management plan setting out the main management objectives for the site and the actions needed to achieve these.
- Reedbeds, once established, may be suitable for commercial reed cutting. Cutting is normally carried out during the winter every year or in alternate years. Some wildlife on the site (e.g. birds, invertebrates) will benefit from areas being left uncut for up to ten years. Cutting during late summer (after the nesting season) will encourage more diverse fen vegetation communities to develop.
- Management of ponds and lakes should be carried out gradually over a number of years rather than in sudden, destructive bursts. Aim to maintain the diversity of habitats present on the site, for example by preventing emergent plants from completely covering the surface of the water body.
- Wherever possible avoid the use of herbicides and pesticides on wetland sites, and reduce their use in the water catchment area.

Sources of further information on wetland creation and management

Andrews, J. and Kinsman, D. 1990. Gravel Pit Restoration for Wildlife: A Practical Manual. RSPB/Tarmac Quarry Products. 184pp.

Andrews, J. and Rebane, M. 1994. Farming and Wildlife: A Practical Management Handbook. Royal Society for the Protection of Birds, Sandy. 358pp.

Biggs, J., Corfield, A., Walker, D., Whitfield, M. and Williams, P. 1995. New Approaches to Pond Management. British Wildlife, 5, pp273-287.

Brooks, A. 1981. Waterways and Wetlands. A Practical Conservation Handbook. British Trust for Conservation Volunteers, Wallingford. 186pp.

English Nature. 1996. Managing Ponds for Wildlife. English Nature, Peterborough. 24pp.

Hawke, C.J. and Jose, P.V. 1996. Reedbed Management for Commercial and Wildlife Interests. Royal Society for the Protection of Birds, Sandy. 212pp.

National Rivers Authority. 1993. Ponds and Conservation: A Rough Guide to Pond Restoration, Creation and Management. NRA, Northumbria and Yorkshire Region. 54pp.

Newbold, C., Honnor, J. and Buckley, K. 1989. Nature Conservation and the Management of Drainage Channels. Nature Conservancy Council/Association of Drainage Authorities. 108pp.

RSPB, NRA and RSNC. 1994. The New Rivers and Wildlife Handbook. Royal Society for the Protection of Birds, Sandy. 426pp.

RSPB, EN and ITE. (In press). The Wet Grassland Guide: Managing Floodplain and Coastal Wet Grassland for Wildlife. RSPB, Sandy.

Williams, P., Biggs, J., Corfield, A., Fox, G., Walker, D. and Whitfield, M. 1997. Designing New Ponds for Wildlife. British Wildlife, 8, pp 137-150.

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Bibliography

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Habitat creation bibliography: wetland

Amey Roadstone Corporation. (undated). *Wildlife on Man-Made Wetlands.* Proceedings of Symposium at ARC Wildfowl Centre, Great Linford. 223pp.

Collection of papers on the value of man-made wetlands for wildlife conservation, with the emphasis on waterfowl populations. Contains detailed case studies of a number of gravel pit sites within the UK. (*More up-to-date, accessible and comprehensive information is available in other publications, particularly Andrews and Kinsman (1990)*).

Andrews, J. and Kinsman, D. 1990. *Gravel Pit Restoration for Wildlife: A Practical Manual.* R.S.P.B./Tarmac Quarry Products. 184pp.

Comprehensive publication dealing with the creation and management of wildlife habitats after the extraction of sand and gravel deposits. The benefits of planning for wildlife conservation at the outset of the extraction process are stressed throughout the manual. The main text is divided into three parts: Part I gives the operational background to the sand and gravel industry in the UK, and summarizes the planning context, current restoration practice and the wildlife value of gravel pits. Part II covers the determination of conservation priorities, and includes detailed sections on the ecological requirements of invertebrates, fish, reptiles, amphibians, birds and mammals. Key pointers to habitat creation and management are given for each species group. Part III consists of detailed prescriptions for habitat creation and management, covering features such as exposure, water depth, soils, islands, aquatic and marginal vegetation, wildflower grasslands, and woodland, scrub and hedgerows. Contains summary tables of the habitat requirements of different wildlife groups, and recommendations for species of wetland plant, wild flower and trees and shrubs which could be introduced to newly restored sites. (*Highly recommended. Although aimed exclusively at gravel pits, much of the general information and prescriptions will be of use to anyone planning wetland creation schemes*).

Andrews, J. and Rebane, M. 1994. *Farming and Wildlife: A Practical Management Handbook.* R.S.P.B., Sandy. 358pp.

Handbook providing guidance on the management, restoration and creation of wildlife habitats on farmland in the UK. The first chapter deals with surveying the wildlife interest of farms and making wildlife management decisions. The remaining chapters cover the major wildlife habitats found on farms (arable land, pasture and meadow, lowland heath, hill and rough grazing, machair, farm woodland, hedgerows, farm trees and scrub, waterbodies and other wetlands, farm buildings and walls). For each habitat there are sections on wildlife requirements and effects of farm management, options for conservation management, prescriptions for the management, enhancement and creation of the habitat, references and further reading, and case studies of the implementation of wildlife conservation on farms. Also included are key features on selected species and numerous tables summarizing aspects of wildlife assessment and conservation management. (*Although the sections on habitat creation are relatively brief, this is nonetheless an invaluable source of information for those undertaking or advising on habitat creation on farmland*).

Andrews, J. and Ward, D. 1991. The Management and Creation of Reedbeds. *British Wildlife,* **3** (2), 81-91.

The emphasis of this article is on the management and creation of reedbeds for rare birds including the bittern, marsh harrier, bearded tit, Cetti's warbler and Savi's warbler. Topics covered include locations for new reedbeds, reed growth and successional processes, hydrological management, cutting regimes and scrub control, and the design of new reedbeds and establishment of vegetation. Contains a useful table summarising the habitat and management requirements of reedbed birds. (*Good general introduction to reedbeds and reedbed wildlife*).

Axell, H. and Hosking, E. 1977. *Minsmere: Portrait of a Bird Reserve.* Hutchinson, London.

An account of the development of the RSPB bird reserve at Minsmere. The section on the making of the scrape contains information relevant to wetland creation. (*Useful background information on one of the early wetland success stories, though more recent publications should be consulted to obtain detailed practical guidance on techniques of wetland creation*).

Baines, C. and Smart, J. 1984. *A Guide to Habitat Creation.* Greater London Council Ecology Handbook No. 2. GLC, London. 44pp.

General guide to the creation and management of wildlife habitats in an urban context. Grasslands, woodlands, wetlands and wastelands are each covered in separate chapters. Appendices include a list of suppliers of native wild flower seed from British sources, and a general list of plant species suitable for establishment in newly-created habitats. (*Good general guide, though more detailed and recent publications are now available for each of the habitats covered*).

Biggs, J., Corfield, A., Walker, D., Whitfield, M. and Williams, P. New Approaches to Pond Management. *British Wildlife*, **5**, 273-287.

Article providing guidance, based on the work of Pond Action, on how existing pond management techniques could be improved. The need to retain ponds at all stages of succession and a variety of water depths is stressed, as is the need to manage ponds gradually over a period of years rather than in a single, disruptive action. Contains guidelines on appropriate management of shallow, temporary and silty ponds, trees around ponds, marginal and aquatic vegetation, and grazing of pond margins. (*Good summary article which will be of value to those planning future management of newly created ponds*).

Brooks, A. 1981. *Waterways and Wetlands. A Practical Conservation Handbook.* British Trust for Conservation Volunteers, Wallingford. 186pp.

Comprehensive guide to the conservation management of wetland habitats. The ecological and management principles of wetland conservation are outlined, followed by detailed sections on the creation of new ponds (including the use of artificial liners), rehabilitation of existing water bodies, regulation of water levels through the use of dams, weirs and sluices, bank stabilisation techniques, drainage systems, and control of aquatic and marginal vegetation. (*Very useful for practical aspects of wetland management, though the date of publication means that some of the recent advances in our understanding of wetland management for wildlife are not covered. Section on pond creation will be of value, especially to those considering the use of artificial liners*).

British Trust for Conservation Volunteers. 1996. *Pond Conservation and Management.* BTCV, Wallingford. 12pp.

Leaflet presenting general principles and approaches to managing ponds for wildlife, much of it based on recent work by Pond Action, and highlighting the importance of managing ponds in a sensitive way and retaining a wide diversity of pond types. Topics dealt with include site survey and evaluation, wildlife value of different habitats within a pond, management of pond plants, silt control, drying out of ponds, management of adjacent land, trees and shading, timing of works and health and safety considerations. (*Lacks specific information on pond creation, but nevertheless useful as an introduction to pond management*).

Buckley, G.P. (Ed). 1989. *Biological Habitat Reconstruction.* Belhaven Press, London. 363pp.

Technical publication containing contributions from a wide range of authors with an interest in habitat reconstruction. The book aims to discuss the assumptions and ecological principles behind habitat reconstruction, a term used to embrace habitat creation, habitat transplantation and habitat enhancement/ diversification. Section 5 of the book deals specifically with habitat creation (papers include creating habitats on farmland and the feasibility of woodland reconstruction), although much of the information in other sections of the book is also relevant. (*Contains much useful information, particularly on the philosophy and principles of habitat creation, but likely to be of limited practical use for those planning and implementing habitat creation schemes*).

Ecological Parks Trust. 1981. *New Life for Old Space: A Guide to Handbooks and Leaflets Covering the Principles and Methods of Converting Small Urban Sites into Nature Areas in Britain.* Ecological Parks Trust, London. 7pp.

Lists publications/leaflets covering urban wasteland projects, design principles, woodland creation, creation of herb-rich swards, pond creation and attracting fauna. (*Many of the information sources listed have been superseded by more recent publications. The strong urban bias reduces its applicability to habitat creation on agricultural land*).

English Nature. 1996. *Managing Ponds for Wildlife.* English Nature, Peterborough. 24pp.

Booklet setting out the main principles of pond management for wildlife conservation, and emphasizing the need to retain a whole range of pond types (in terms of size, depth, permanence, successional stage etc) if we are to maintain our existing diversity of freshwater wildlife. Topics covered include features which enhance the wildlife value of ponds, survey and assessment, general pond management, management of pond plants and adjacent trees, management of silt and water depth, ponds of particular conservation interest, pollution prevention, and timing of management work. A list of appropriate plant species for transfer to new ponds is also included. (*Booklet deals specifically with pond management, though much of the information included will be of value to anyone planning the construction of new pond(s)*).

Environment Agency. (Undated). *Understanding Buffer Strips: An Information Booklet.* The Environment Agency, Bristol. 12pp.

Booklet explaining the various terms used to describe buffers, before concentrating on riparian buffer strips and how they can be used to reduce diffuse pollution (e.g. sediment, pesticides and fertilisers) from agriculture. Topics covered include a review of research on how buffer strips work, and a consideration of factors to take into account to ensure that buffers are established in appropriate locations. The opportunity for buffer strips to have multiple functions (e.g. wildlife corridors, beetle banks, boundary strips etc) is also discussed. (*Useful for distribution to riparian landowners - though contains little practical advice on how to establish buffers*).

Farming and Wildlife Advisory Group. (Undated). *Ponds and Wetlands.* FWAG, Kenilworth. (Booklet).

Farming and Wildlife Advisory Group. (Undated). *Ditches, Rivers and Streams.* FWAG, Kenilworth. (Booklet).

Giles, N. 1992. *Wildlife after Gravel: Twenty Years of Practical Research.* The Game Conservancy Trust/ARC Limited. 129pp.

Based on the experience gained from the creation and management of the wildfowl reserve at Great Linford. Contains habitat management guidance for specific bird groups (wildfowl, waders etc) and for maintaining a diverse wildlife community.

Hawke, C.J. and Jose, P.V. 1996. *Reedbed Management for Commercial and Wildlife Interests.* RSPB, Sandy. 212pp.

A practical guide to the techniques of reedbed management, rehabilitation and creation. The introduction includes a resume of the wildlife importance of reedbeds. The main text is divided into four parts. Part one highlights the importance of planning in reedbed management and creation (e.g. site evaluation, identification of factors influencing decisions), and Part 2 describes rehabilitation and management techniques. Part 3 covers the creation of reedbeds on arable land, disused land, or land with little or no existing wildlife value. There is detailed consideration of engineering operations (e.g. land forming and construction of water control and drainage systems) as well as the establishment of new areas of reed growth through natural expansion, seeding, and planting of rhizomes and stem cuttings. The use of reed beds in the treatment of effluents is also covered. Part four comprises 17 case studies detailing examples of reedbed management and creation techniques in the UK. Also included is a list of organisations to contact for further information. (*Essential reading for anyone considering creating new areas of reedbed*).

Lewis, G. and Williams G. 1984. *Rivers and Wildlife Handbook.* RSPB/RSNC. Sandy/Lincoln.

Jointly produced by the Royal Society for the Protection of Birds and the Royal Society for Nature Conservation, this handbook has now been updated and expanded by these organisations, together with the National Rivers Authority, and published as the New Rivers and Wildlife Handbook, edited by Ward, Holmes and Jose. (*Probably best to refer just to the New Rivers and Wildlife Handbook*).

National Rivers Authority. 1993. *Ponds and Conservation: A Rough Guide to Pond Restoration, Creation and Management.* NRA, Northumbria and Yorkshire Region. 54pp.

Provides guidelines on how to maximise the wildlife conservation value of existing and newly created ponds, ranging from small pools of water to ponds several hectares in area. Contains detailed information on planning a new pond (including siting, water supply and legal aspects), designing ponds and wetland complexes, and construction of natural and artificially lined ponds. Other sections cover pond management and restoration, and ponds for particular uses/faunal groups such as fishing, dragonflies or amphibians. Also included are sources of grants, information and advice on pond construction, and lists of plant species suitable for introduction to new ponds. (*Excellent publication for anyone giving advice on pond creation*).

Newbold, C., Honnor, J. and Buckley, K. 1989. *Nature Conservation and the Management of Drainage Channels.* Nature Conservancy Council/Association of Drainage Authorities. 108pp.

Open University. 1992. *Practical Conservation: Water and Wetlands.* Open University. 116pp.

Contains guidance on managing water quantity and quality, selection of sites for pond creation, and design and construction of ponds and wetlands.

Parker, D.M. 1995. *Habitat Creation - A Critical Guide.* English Nature Science No. 21. English Nature, Peterborough. 190pp.

Report examining the potential and actual problems of habitat creation in Britain, and presenting guidance on best practice in the planning, construction and management of habitat creation projects. The report draws on information obtained from a survey and review of 150 habitat creation projects throughout the UK. A general chapter on habitat creation planning is followed by chapters on grassland, woodland and scrub, heathland and moorland, peatlands and urban sites. Within each chapter there are sections on semi-natural habitat types, initial site survey and planning, preparation of a project plan and the setting of objectives, methods of habitat creation, and monitoring and long-term management. The report includes 26 case studies of habitat creation projects in the UK. (*Essential reading for anyone undertaking or advising on any significant habitat creation project*).

Penny Anderson Associates. 1993. *Roads and Nature Conservation: Guidance on Impacts, Mitigation and Enhancement.* Report for English Nature. English Nature, Peterborough. 80pp.

Document outlining the main impacts of road schemes on wildlife, and providing guidance on the most appropriate measures to mitigate these impacts. Includes some data on the loss and fragmentation of semi-natural habitats. Section 9 covers habitat creation, and addresses key issues including selection of habitat type, sowing versus natural regeneration, soil type, species selection, ground preparation and management. There are brief sections on creation of woodland, grassland, heathland and wetland habitats, and on habitat creation for butterflies and amphibians. Guideline costs for habitat creation are also given. (*Although written in relation to road schemes, much of the information given will be of value to habitat creation schemes on agricultural land*).

Royal Society for the Protection of Birds. 1994. *Farming and Wildlife: Waterbodies and other Wetlands.* RSPB, Sandy. (Leaflet).

Leaflet summarising chapter 9 of Farming and Wildlife: A Practical Management Handbook. The importance of wetlands and waterbodies for wildlife is outlined, followed by key management recommendations for maximising the wildlife potential of ponds, ditches, rivers and streams, wet grassland, reedbeds and other wetland habitats. Treatment of habitat creation is restricted to a brief mention of some of the features which might be re-created. (*Despite the lack of information specifically on habitat creation, a good general leaflet suitable for distribution to farmers*).

Treweek, J.R. *et al.* 1991. *Wetland Restoration: Techniques for an Integrated Approach. ITE/MAFF.* 92pp.

Investigates the scope for creating, re-creating and rehabilitating wetland habitats that have been under intensive agricultural management, with a view to improving their nature conservation value. Assesses the practicality of attaining wildlife objectives from a hydrological and socio-economic perspective. Provides guidance on technical aspects of water level management, and on grazing, mowing, and other aspects of management.

Ward, D., Holmes, N. and José, P. (Eds). 1994. *The New Rivers and Wildlife Handbook.* RSPB/NRA/RSNC. RSPB, Sandy. 426pp.

Jointly produced by the Royal Society for the Protection of Birds, the National Rivers Authority and the Royal Society for Nature Conservation, this handbook is intended as a practical guide to river management techniques which integrate the requirements of flood defence, wildlife and other river interests. Although ostensibly dealing with the management and restoration of existing riverine features, the handbook contains much valuable information on techniques for the creation of new wetland wildlife habitat, both within the river channel (e.g. shallow margins, bays) and in the adjacent floodplain (e.g. washlands and by-pass channels). There are also sections on the establishment and management of aquatic and bankside vegetation (including wild flowers and trees and shrubs), covering planting techniques and recommended species for particular areas of the country. In addition, numerous case studies are included to demonstrate the practical application of the techniques described. The book also contains sections on river processes and biology, and survey methods for river wildlife. (*Essential reference source for anyone considering habitat creation within or adjacent to watercourses*).

Williams, P., Biggs, J., Corfield, A., Fox, G., Walker, D. and Whitfield, M. 1997. Designing New Ponds for Wildlife. *British Wildlife*, **8**, 137-150.

Concise article outlining the principles behind the design and location of new wildlife ponds. Topics covered include sources of water and the need for good water quality, strategic locations for ponds, the desirability of linking new ponds to existing wetland habitats and creating wetland complexes, the importance of features such as bare mud, the drawdown zone and microtopographical variations, phasing of pond design/creation, natural colonisation of new sites as opposed to planting, and initial management of new pond sites. Includes a useful table of pond design features for specific plant and animal groups, together with source references. (*Highly recommended for anyone designing new wildlife ponds or advising others on pond design*).