Forest Research

LOWLAND CALCAREOUS GRASSLAND
Creation and management in land regeneration

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BPG

NOTE 18

Best Practice Guidance for Land Regeneration

(Photo: © Tim O'Hare Associates)

Introduction

Calcareous grasslands are characterised by species-rich grass and herb communities which grow on shallow, lime-rich soils (Figure 1). UK biodiversity legislation recognises both upland and lowland calcareous grasslands and that these are of principal importance in England (Natural England, 2010), Scotland (Anon, 2013), Wales (Wales Biodiversity Partnership, 2008) and Northern Ireland (Department of the Environment Northern Ireland and the Northern Ireland Environment Agency, 2011). This guidance note focuses on the lowland types.

Current estimates suggest that up to 30 000 ha of lowland calcareous grassland remain in the UK, following significant decreases of about 13 000 ha in the area of this habitat between 1990 and 2007 (Natural Environment Research Council, 2009). Major concentrations are found on the chalk downs of Wiltshire, Dorset, Kent and Sussex, with other significant areas in the Chilterns, Mendips and Cotswolds, and along the limestone outcrops and coastal cliffs of north and south Wales. Only small areas are found in Scotland and Northern Ireland. Losses are mostly due to agricultural improvement and reductions in traditional grazing management practices. While natural calcareous grasslands typically develop on dry valley slopes, semi-natural calcareous grasslands can develop in areas disturbed by human activities, including on exposed rock in disused chalk and limestone workings, along road verges and railway cuttings, and on post-industrial land (JNCC, 2011). The establishment of calcareous grassland on reclaimed land is contributing to UK national conservation targets for this priority habitat (e.g. the *Calcareous Grassland Habitat Action Plan for Cardiff,* Cardiff Council, undated). This BPG Note reviews the essential considerations and practices for establishing lowland calcareous grasslands on reclaimed land. As with other lowland semi-natural grassland types, creation of this habitat should only be considered where there is a strong commitment to a long-term management regime.

Figure 1 Chalk downland flora
(Photo: © Natural England/Chris Gomersall)

Defining features of calcareous grassland

Calcareous grasslands favour chalk and limestone soils, which are rich in calcium carbonate. They can have high species diversity; 1 m^2 can support up to 40 species of flowering plants. This diversity arises through a combination of mineral nutrient stress and grazing/cutting management, which prevents domination of the grassland by a few rank species.

The UK Habitat Action Plan (HAP) recognises 13 different types of calcareous grassland, identified through their distinct flora. Lowland[1] calcareous grasslands are defined as the National Vegetation Classification (NVC) types CG1 to CG9, plus examples of CG10 where they occur below the level of agricultural enclosure (Rodwell, 1992). Typical calcareous grassland species include Meadow Oat-grass, Upright Brome, Salad Burnet, Lady's Bedstraw and Kidney Vetch (see Tables 3 and

[1] Lowland is defined as land below the level of agricultural enclosure. The altitude at which this occurs varies across the UK, typically becoming higher as one travels south.

4 for scientific names). These grasslands can also support nationally rare or scarce species such as Hoary Rock-rose (*Helianthemum oelandicum*) and Pasqueflower (*Pulsatilla vulgaris*), Monkey Orchid (*Orchis simia*) and Late Spider-orchid (*Ophrys fuciflora*).[2]

Calcareous grasslands are associated with a diverse fauna, including some amphibian, bat and bird species of principal importance in England (Natural England, 2010). These include the Pool Frog (*Pelophylax lessonae*), the Common Pipistrelle bat (*Pipistrellus pipistrellus*) and the Corn Bunting (*Miliaria calandra*). Invertebrate species of principal importance in England associated with this habitat include varieties of ground and leaf beetles, butterflies (particularly members of the Hesperiidae (Skipper, see Figure 2) and Lycaenidae (Hairsteak, Copper and Blue) families) and moths such as the Chalk Carpet (*Scotopteryx bipunctaria*).

The surface soils found within existing unimproved lowland calcareous grasslands are characterised by shallow topsoil depths, moderate to rapid drainage rates, high organic matter contents and total nitrogen levels, and low levels of available phosphorus. Levels of available potassium and available magnesium are not found to have a strong influence on floral diversity of the sward. Acceptable limits are summarised in Table 1.

Table 1 Characteristics of soil suitable for calcareous grassland establishment.

Parameter	Level
Topsoil depth	100–200 mm
Drainage	Moderate to rapid (often sloping)
pH	Alkaline to strongly alkaline (pH 7.8–8.5)
Available phosphorus[a]	25 mg l^{-1} (5–10 mg l^{-1})
Organic matter[b]	4% (6–19%)
Total nitrogen[b]	0.2% (0.30–1.16%)

[a] Acceptable upper limit. A level of available phosphorus of less than 10 mg kg^{-1} is ideal to maximise floristic diversity within unimproved, semi-natural grassland communities (Marrs and Gough, 1989). While values of 11 to 25 mg kg^{-1} have potential, expect reduced floral diversity and increased risk of competition from rank and pioneer species.

[b] Acceptable lower limit. While values for upper limits are not available the values in parentheses serve as a useful guide.

Values in parentheses are primary data collected from example sites – Aston Rowant, Oxfordshire (SSSI) and Saltbox Hill, Kent (SSSI). Table 1 and photo kindly provided by Tim O'Hare Associates, Oxfordshire.

Site suitability

As with all reclamation projects, preliminary site investigation surveys should be conducted to identify potential risks to human health and the environment (see BPG Notes 1 and 2 for further details). Ecological surveys of prospective sites and their surrounding habitats should also be conducted and the suitability of the substrates for habitat establishment assessed. Exposed alkaline substrate can provide a refuge for early successional calcicoles (plants that thrive in lime-rich soil). Surveys are therefore required prior to any reclamation activities to ensure existing interest is not destroyed. The impact of species introduction on neighbouring habitats should also be considered as part of the planning process.

[2] Nomenclature follows Stace (2010) throughout.

Sites should have a topography that allows for management by grazing or cutting and the slopes of former mineral working sites can be ideal locations. Wherever possible, the topsoil and subsoil at mineral extraction sites should be kept for use in the site reclamation; however, calcareous topsoils are rarely available as they can be thin and difficult to store. Early stages of calcareous grassland habitat can be established directly onto the mineral substrate. Other potentially suitable materials include calcareous mineral wastes and ballasts from former chalk and limestone quarries. Weathered alkaline industrial wastes such as pulverised fuel ash may also be used, although these are typically more suited to supporting pioneer communities, which include mosses, halophytes (salt-tolerant plants) and orchids.

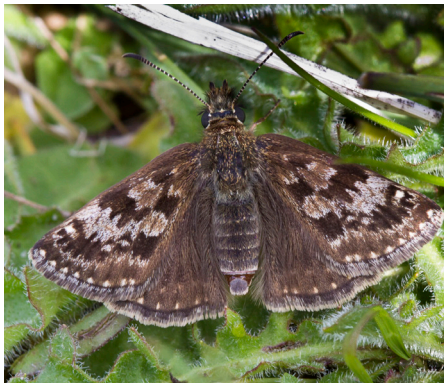

Figure 2 Dingy Skippers are a species characteristic of lowland calcareous grassland
(Photo: © Natural England/Allan Drewitt)

Raw mineral substrates may require cultivation, mulching and/or nutrient addition in order to support typical calcareous grassland species. Substrate compaction will hinder vegetation establishment, and cultivation should be conducted to a minimum of 100 mm depth to provide a friable seedbed (see BPG Note 19). Cultivation may encourage the native seed bank to develop, to the detriment of the introduced species, and this should be considered in the habitat management plan (see BPG Note 11). Organic matter addition is required where the water-holding capacity of the substrate is low. Where this is the case, incorporate subsoil or mulch into the top 50 mm. Ensure that nutrient levels are not raised too high as this will favour nutrient-demanding rank grass species; paper-mill sludge or spent-mushroom compost are suitable, for example. As a general rule, total nitrogen level should be 0.2 to 1.2% soil dry weight (Table 1), and available phosphorus and potassium less than 15 and 120 mg l^{-1}, respectively (Crofts and Jefferson, 1999).

Soil fertility can be tested through chemical analysis and/or through growth trials (either pot-scale or field-scale). Growth trials will indicate whether bare, unweathered calcareous substrates require nutrient addition to enable successful plant establishment. In such cases, provide the minimum nutrient levels to avoid competition by rank plant species. Calcareous grassland can be successfully established using inorganic fertiliser addition at 25–50 kg ha^{-1} of 25:25:25 NPK in a slow-release form (Department of the Environment, 1996). However, preference should be given to the use of legumes (e.g. vetches, trefoils and Sainfoin (*Onobrychis viciifolia*) for nutrient provision. Where initial soil fertility is shown to be too high, measures may need to be taken to reduce soil fertility. This can involve techniques such as blending with a low fertility substrate or through a strict regime of clippings removal when the grass sward is cut. More information on these and other methods can be found in Crofts and Jefferson (1999).

While it is possible to adjust soil pH and fertility, you should aim to create a habitat that is most suited to the quality and conditions of the planting medium on your site and that is in keeping with the local character and landscape, as this is likely to be a more sustainable practice.

Habitat creation and establishment practice

Substrate, desired time frame, and site proximity to areas of grassland similar to the target type will dictate which establishment techniques are most appropriate. Four options are considered below.

Natural colonisation of bare substrates may be suitable where long establishment time frames are acceptable and species-rich calcareous grassland communities are adjacent. If lowland calcareous grassland existed in the area prior to disturbance and subsequent reclamation, a seed bank may remain in the existing substrate and should be assessed using germination trials. Natural colonisation can produce species-rich habitats that are appropriate to the local area. The process tends to be very slow and it may take several decades to establish a stable community. Natural

colonisation can be accelerated through the selective introduction of grassland species via turf inoculants, seeding or green-hay strewing.

Turf inoculants can be taken from adjacent donor areas and incorporated into the bare substrate. These can be either whole turf fragments or plugs of grassland containing desirable species. Permission must always be sought from landowners before taking any materials. If there is doubt about the type of donor NVC Calcareous Grassland, a vegetation survey should be conducted by a trained botanical surveyor. Where either natural colonisation or turf inoculant methods are being adopted, it can be advantageous to first sow a pioneer/nurse mix (see Table 2 for an example pioneer/nurse mix). The benefits of thinly sowing pioneer species include the stabilisation of substrates, and the rapid creation of an attractive sward while leaving sufficient bare soil to allow natural colonisation to occur.

Table 2 Example seed mixture for pioneer/nurse mix.

Common name	Scientific name	
Common Bent	*Agrostis capillaris*	10%
Sheep's-fescue	*Festuca ovina*	40%
Red Fescue	*Festuca rubra* ssp. *megastachys*	20%
Red Fescue	*Festuca rubra* ssp. *rubra*	20%
Smooth Meadow-grass	*Poa pratensis*	10%

Sown at a low rate of 12.5 kg ha^{-1}. (Adapted from Department of the Environment, 1996)

Green-hay strewing is a useful alternative to turf inoculants or natural colonisation. It involves taking freshly cut hay containing seeds from local calcareous grassland, and spreading this over the site to be colonised. Ensure that the hay is cut after flowering but while the seeds are still attached; good working knowledge of the target species and when their seed is at point of dispersal will yield best results. Hay should be spread within 24 hours of collection to prevent the spoiling or loss of seeds during storage. Using a local source means that a closer match can be made between the new and existing grasslands and the grasses will be of native genotype; it will also help to keep transport costs to a minimum. Where a local calcareous grassland donor site is not available, a commercial seed mix may be used as a starter sward.

Seeding can be undertaken using seed collected from a local donor site. Care must be taken not to deplete the donor site of seed by over-harvesting. Alternatively, seed may be bought. A reputable seed house will supply seed mixtures suited to the climate and principal soil conditions of your site. Seed should be of local provenance, where available. Wildflowers and grasses are normally sown together as grasses help to stabilise the soil and provide important cover in winter. Seed is normally sown in September/October, either by hand or using agricultural machinery such as slot seeders and seed drills, which maximise the area sown for the amount of seed used (Crofts and Jefferson, 1999). If sowing by hand, mix with damp sand to help ensure the seed is evenly distributed and lightly roll or tread the soil surface. Raking should be avoided as it can concentrate seed distribution or bury the seed too deep. If there is a prolonged dry period, the seeded area may be lightly watered. Birds and other seed predators should be kept off the land as much as possible. Tables 3 and 4 provide examples of calcareous grassland seed mixes.

Biosecurity (the objective of reducing the transmission of pests and diseases) is important and good working practice should be observed when using the turf inoculant, green-hay strewing or seeding techniques to minimise the risk of

transporting harmful organisms between sites. For example, clean and disinfect tools and boots before leaving donor and regeneration sites.

Whichever establishment method is selected, it is important to recognise that it will take several years for the grassland to establish and develop into a stable community. Appropriate management of the grassland is essential for allowing a species-rich community to develop and be maintained.

Habitat management and monitoring

Calcareous grassland should only be created where there is strong commitment to a long-term management regime, directed by a site management plan. Management is required to prevent domination of the sward by scrub and other aggressive species and to maintain high species richness.

Grassland establishment typically takes 3 to 5 years. During this period a regime of cutting and light grazing is required; exact requirements will be site specific. Typically, first-year cutting regimes will not be necessary for grassland established on bare mineral substrate, though may be required for richer sites to keep the sward shorter than 10 cm. Mowing must be timed to avoid conflict with ground-nesting birds. Mowing encourages tillering; it also reduces competition from rank species and the encroachment of scrub. After mowing, cuttings should be removed from the site. If the sward has seed available, this may be used for hay strewing on other sites. The grassland should be mowed once in the second and third years after the flowers and grasses have set seed. Grazing by rabbits, cattle and sheep should be controlled or prevented during these first 3 years to allow the grassland to become established; that is, for seedlings to develop sufficient root systems to prevent uprooting when grazed. Once the grassland is established, light grazing can begin.

Long-term management through grazing and/or cutting is essential for maintaining species richness. Historically, grazing has been the typical management technique; however, mowing may be suitable for small sites and those on gentle slopes. Cattle and sheep can provide year-round grazing management if used at low stocking rates, though this depends on site productivity (Figure 3). A rule of thumb is to use 0.5 cattle or 2.5 sheep ha^{-1} yr^{-1} (Department of Transport, 1993). Unproductive sites may only be suitable for winter grazing; though this must be monitored for poaching – the compaction or physical breakdown of soil structure under the feet of heavy animals. Grazing should aim to produce a mosaic of grassland of varying lengths, and small patches of scrub (no more than 25% of the total area). For example, different types of grazing animals are selective in the plants that they eat and can be used to create the mosaic. Cattle consume coarser herbage and trample more heavily than sheep. The trampled patches create gaps for new plants to establish. More detailed information on management can be found in Crofts and Jefferson (1999).

Even where the creation works take place in a very suitable location, evaluation of the management practices is required to get the right mix for establishment and long-term success. A site-specific long-term management plan is required. This should include a monitoring and evaluation programme that will enable the management regime to be adapted as necessary. The JNCC (2004) reports that monitoring of lowland grassland habitats should include:

- Extent of the grassland establishment: % ground cover, bald patches and presence of leaf litter.
- Sward composition: grass to herb ratio, positive indicator species, negative indicator species, species with local distinctiveness.

Figure 3 Early Purple Orchid on cattle-grazed limestone grassland

Table 3 Limestone grassland seed mixture.

Common name	Scientific name		
Grasses		**% by weight of grasses**	**kg ha^{-1}**
Meadow Oat-grass	*Avenula pratensis*	5	1.2
Upright Brome	*Bromopsis erecta*	10	2.4
Crested Dog's-tail	*Cynosurus cristatus*	15	3.6
Sheep's-fescue	*Festuca ovina*	25	6.0
Red Fescue	*Festuca rubra* ssp. *juncea*	20	4.8
Crested Hair-grass	*Koeleria macrantha*	5	1.2
Narrow-leaved Meadow-grass	*Poa angustifolia*	10	2.4
Yellow Oat-grass	*Trisetum flavescens*	10	2.4
Total		**100**	**24.0**
Forbs		**% by weight of forbs**	**g ha^{-1}**
Yarrow	*Achillea millefolium*	4	240
Kidney Vetch	*Anthyllis vulneraria*	4	240
Betony	*Betonica officinalis*	2	120
Common Knapweed	*Centaurea nigra*	5	300
Greater Knapweed	*Centaurea scabiosa*	2	120
Wild Basil	*Clinopodium vulgare*	2	120
Dropwort	*Filipendula vulgaris*	2	120
Lady's Bedstraw	*Galium verum*	3	180
Rough Hawkbit	*Leontodon hispidus*	2	120
Oxeye Daisy	*Leucanthemum vulgare*	15	900
Common Bird's-foot-trefoil	*Lotus corniculatus*	2	120
Black Medick	*Medicago lupulina*	2	120
Sainfoin	*Onobrychis viciifolia*	5	300
Spiny Restharrow	*Ononis spinosa*	2	120
Wild Marjoram	*Origanum vulgare*	2	120
Burnet-saxifrage	*Pimpinella saxifraga*	1	60
Ribwort Plantain	*Plantago lanceolata*	5	300
Hoary Plantain	*Plantago media*	5	300
Salad Burnet	*Poterium sanguisorba* ssp. *sanguisorba*	4	240
Cowslip	*Primula veris*	4	240
Selfheal	*Prunella vulgaris*	10	600
Bulbous Buttercup	*Ranunculus bulbosus*	2	120
Wild Mignonette	*Reseda lutea*	4	240
Yellow-rattle	*Rhinanthus minor*	10	600
Bladder Campion	*Silene vulgaris*	1	60
Total		**100**	**6000**

(Adapted from Department of Transport, 1993). Mixture consists of 80% grasses to 20% forbs (by weight). Grasses sown at 3914 seeds m^{-2}, forbs at 894 seeds m^{-2}. Sowing rate of grass–forb mixture: 30 kg ha^{-1} (= 3.0 g m^{-2}).

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Table 4 Calcareous meadow seed mixture.

Common name	Scientific name		
Grasses		**% by weight of grasses**	**kg ha^{-1}**
Common Bent	*Agrostis capillaris*	10	2.4
Sweet Vernal-grass	*Anthoxanthum odoratum*	2	0.5
Crested Dog's-tail	*Cynosurus cristatus*	15	3.6
Sheep's-fescue	*Festuca ovina*	18	4.3
Red Fescue	*Festuca rubra* ssp. *commutata*	15	3.6
Meadow Barley	*Hordeum secalinum*	5	1.2
Smaller Cat's-tail	*Phleum bertolonii*	10	2.4
Narrow-leaved Meadow-grass	*Poa angustifolia*	10	2.4
Yellow Oat-grass	*Trisetum flavescens*	15	3.6
Total		**100**	**24.0**
Forbs		**% by weight of forbs**	**g ha^{-1}**
Yarrow	*Achillea millefolium*	4	240
Betony	*Betonica officinalis*	2	120
Common Knapweed	*Centaurea nigra*	5	300
Greater Knapweed	*Centaurea scabiosa*	2	120
Wild Basil	*Clinopodium vulgare*	2	120
Dropwort	*Filipendula vulgaris*	2	120
Lady's Bedstraw	*Galium verum*	3	180
Perforate St John's-wort	*Hypericum perforatum*	2	120
Rough Hawkbit	*Leontodon hispidus*	2	120
Oxeye Daisy	*Leucanthemum vulgare*	15	900
Common Bird's-foot-trefoil	*Lotus corniculatus*	5	300
Musk-mallow	*Malva moschata*	4	240
Burnet-saxifrage	*Pimpinella saxifraga*	1	60
Ribwort Plantain	*Plantago lanceolata*	5	300
Hoary Plantain	*Plantago media*	5	300
Salad Burnet	*Poterium sanguisorba* ssp. *sanguisorba*	1	60
Cowslip	*Primula veris*	4	240
Selfheal	*Prunella vulgaris*	10	600
Meadow Buttercup	*Ranunculus acris*	10	600
Yellow-rattle	*Rhinanthus minor*	10	600
Common Sorrel	*Rumex acetosa*	3	180
Meadow Saxifrage	*Saxifraga granulata*	1	60
Ragged-Robin	*Silene flos-cuculi*	1	60
Bladder Campion	*Silene vulgaris*	1	60
Total		**100**	**6000**

(Adapted from Department of Transport, 1993). Mixture consists of 80% grasses to 20% forbs (by weight). Grasses sown at 5795 seeds m^{-2}, forbs at 1133 seeds m^{-2}. Sowing rate of grass–forb mixture: 30 kg ha^{-1} (= 3.0 g m^{-2}).

Further information and useful links

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More information on biosecurity and plant health can be found at www.forestry.gov.uk/biosecurity

Additional information may be found from the following organisations:

Bumblebee Conservation Trust
www.bumblebeeconservation.org

Butterfly Conservation
www.butterfly-conservation.org

Flora Locale
www.floralocale.org

Joint Nature Conservation Committee
www.jncc.defra.co.uk

Landlife National Wildflower Centre
www.wildflower.co.uk

Natural England
www.naturalengland.org.uk

Nature after Minerals
www.afterminerals.com

Plantlife
www.plantlife.org.uk

Royal Horticultural Society
www.rhs.org.uk

Royal Society of Wildlife Trusts
www.wildlifetrusts.org

RSPB
www.rspb.org.uk

The Grasslands Trust
www.grasslands-trust.org

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