Definition of Favourable Conservation Status for limestone pavement

Defining Favourable Conservation Status Project

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Executive summary

This document sets out Natural England's view on favourable conservation status for limestone pavements in England.

Favourable conservation status is the situation when the habitat can be regarded as thriving in England and is expected to continue to thrive sustainably in the future. The definition is based on the available evidence on the ecology of limestone pavements. Favourable conservation status is defined in terms of three parameters: natural range and distribution; extent; structure and function attributes (habitat quality).

A summary definition of favourable conservation status in England follows. Section 1 of this document describes the habitat and its ecosystem context, Section 2 the units used to define favourable conservation status and Section 3 describes the evidence considered when defining favourable conservation status for each of the three parameters. Section 4 sets out the conclusions on favourable values for each of the three parameters.

This document does not include any action planning, or describe actions, to achieve or maintain favourable conservation status. These will be presented separately, for example within strategy documents.

The guidance document Defining Favourable Conservation Status in England describes the Natural England approach to defining favourable conservation status.

Summary definition of favourable conservation status

Limestone pavements are natural exposures of limestone with the surface divided into 'blocks', known as clints, by crevices, known as grikes. They were created by geological processes and have a limited distribution and extent in England. Limestone pavements offer a variety of microclimates, allowing the establishment of distinctive, complex mosaics of vegetation habitats and communities.

The natural range and distribution of limestone pavements is determined by the underlying geology and the geological and geomorphological processes that brought them into being, including glacial scour and subsequent sub-soil weathering forming the characteristic surface patterning. There is no evidence that limestone pavement occurred within National Character Areas (NCAs) other than those where it currently occurs. Therefore, current range and distribution are regarded as favourable.

The area of limestone pavement has, however, been significantly reduced by the removal of pavement clints to provide decorative stone for garden rockeries. Latterly, Limestone Pavement Orders have effectively addressed this issue, such that damage and loss since designation has been minimal but more than 40% of the original habitat has been destroyed. There is no prospect of recovery of this loss. Therefore, the favourable area of the habitat is the current area of 2,343 hectares.

The structure and function of pavements describes the relationship between the variety of ecological niches and the physical form of the pavement and its vegetation. In many English settings, intensive grazing has led to a simplification of vegetation structure and function, a reduction in the number and quality of ecological niches and the loss of grazing-susceptible species and woody cover. Favourable status would be achieved when 100% of the area of the habitat meets the structure and function requirements including maintenance of the current physical structure, the presence of the full range of characteristic vegetation communities, including associated lichen and bryophyte communities and vegetation transitions, and maintenance of the low productivity soils and herbivory at levels which enables achievement of the structure attributes.

Table 1 Confidence levels for favourable values

Favourable conservation status parameter	**Favourable status**	**Confidence in the parameter**
Range and distribution	The current range and distribution – present in five National Character Areas: West Cumbria Coastal Plain; Morecambe Bay Limestones; Yorkshire Dales; Forest of Dean and Lower Wye; Orton Fells.	High
Area	The current area - 2,343 hectares.	High
Structure and function	At least 100% of the favourable area of the habitat meets the structure and function requirements as detailed in section 4.3. All species partially or wholly dependent on this habitat should be IUCN GB Least Concern.	High

As of July 2021, based on a comparison of the favourable values with the current values, limestone pavement is not in favourable conservation status. Note, this conclusion is based solely on the information within this document not on a formal assessment of status nor on focussed and/or comprehensive monitoring of status.

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About the Defining Favourable Conservation Status project

Natural England's Defining Favourable Conservation Status (DFCS) project is defining the minimum threshold at which habitats and species in England can be considered to be thriving. Our Favourable Conservation Status (FCS) definitions are based on ecological evidence and the expertise of specialists.

We are doing this so we can say what good looks like and to set our aspiration for species and habitats in England, which will inform decision making and actions to achieve and sustain thriving wildlife.

We are publishing FCS definitions so that you, our partners and decision-makers can do your bit for nature, better.

As we publish more of our work, the format of our definitions may evolve, however the content will remain largely the same.

This definition has been prepared using current data and evidence. It represents Natural England's view of favourable conservation status based on the best available information at the time of production.

1. Habitat definition and ecosystem context

1.1 Habitat definition

Limestone pavements are natural exposures of limestone, usually horizontal or gently inclined (a few are steeply inclined) with a surface divided into blocks (clints) by narrow crevices (grikes). They were created by the scouring of limestone beds by the movement of ice during the Ice Ages with the subsequent surface patterning developing as water dissolved the limestone over thousands of years. The patterning developed beneath soil or peat but current pavement surfaces are characteristically bare. Patches of shallow skeletal or loessic soils are characteristic and there are transitions to more extensive areas of deeper soil or peat. Soil washed into the grikes provides a substrate in a locally relatively humid and warm environment creating conditions suitable for the development of a rich assemblage of woodland plants.

The morphology of limestone pavements provides almost infinite variety in gradients of slope, aspect, humidity, acidity and light within a very small area, promoting the establishment of complex vegetation community mosaics. This range of community types includes chasmophytic vegetation (including lichens and bryophytes), calcareous grassland, acid grassland and heath, scrub and various types of woodland. Occasional wetland communities, fragments of fen and flush, can also occur. The vegetation of limestone pavements is unusual because of the combinations of these floristic elements.

A distinctive assemblage of vascular plants gives limestone pavements much of their character and a particular nature conservation importance. Species with a particularly strong association include dark-red helleborine *Epipactis atrorubens,* rigid buckler-fern *Dryopteris submontana,* angular Solomon's-seal *Polygonatum odoratum,* downy currant *Ribes spicatum,* scented oak-fern *Gymnocarpium robertianum,* lily-of-the-valley *Convallaria majalis,* bloody crane's-bill *Geranium sanguineum,* fingered sedge *Carex digitata,* pale St John's-wort *Hypericum montanum,* baneberry *Actaea spicata,* yew *Taxus baccata,* lesser meadow-rue *Thalictrum minus,* juniper *Juniperus communis,* northern holly-fern *Polystichum lonchitis,* mountain melick *Melica nutans* and narrow-leaved bitter-cress *Cardamine impatiens.* The rigid buckler-fern is unique in that it is exclusively confined to limestone pavement and allied habitats (for example, limestone quarries) in the British Isles.

There are some floristic differences between limestone pavements in upland and lowland situations. Lowland pavements are distinguished by species such as rustyback fern *Ceterach officinarum*, dark red helleborine, angular Solomon's-seal, fingered sedge and yew. Upland pavements are distinguished by species such as brittle bladder-fern *Cystopteris fragilis*, green spleenwort *Asplenium viride*, lesser meadow-rue, baneberry, and narrow-leaved bitter-cress.

Woodland plants are a characteristic element of the flora of all limestone pavements, reflecting both the shady, humid environment within the grikes which promotes their development and relict features of the period when woodlands were more extensive on pavements.

The shade-tolerant bryophytes that occur in deep humid grikes have similarities with those found in calcareous woodland, however other species such as the various *Tortella* species that occur on exposed clints are adapted to higher light levels. One of the most notable bryophytes occurring on limestone pavement in England is turgid scorpion-moss *Pseudocalliergon turgescens* (previously known as *Scorpidium turgescens*). This Nationally Rare and Schedule 8 glacial relict species is restricted to a single site in North Lancashire, where it grows in water-filled solution hollows in the limestone (Porley & Hodgetts 2005), usually in well-lit locations or in partial shade (Hill and others 2007).

In addition to their biodiversity value, limestone pavements are also important for their geological attributes and in a landscape context.

Limestone pavement is described by a hierarchy of three European Nature Information System (EUNIS) habitat codes:

- H3.5 Almost bare rock pavements, including limestone pavements
- H3.51 Pavements, rock slabs, rock domes
- H3.511 Limestone pavements

Whilst limestone pavement was not described within the National Vegetation Classification (NVC), some stands of vegetation, found amongst the mosaic of vegetation types on limestone pavement, correspond to the following six NVC types:

- OV38 *Gymnocarpium robertianum - Arrhenatherum elatius* community
- OV39 *Asplenium trichomanes - Asplenium ruta-muraria* community
- OV40 *Asplenium viride - Cystopteris fragilis* community
- CG9 *Sesleria albicans – Galium sterneri* grassland
- CG10 *Festuca ovina-Agrostis capillaris-Thymus praecox* grassland
- W9 *Fraxinus excelsior - Sorbus aucuparia - Mercurialis perennis* woodland

Sources: European Commission 2013; JNCC 2019; Webb & Glading 1998.

1.2 Habitat status

Limestone pavement is listed as a Habitat of Principal Importance in England under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 reflecting its high nature conservation value. It is also listed under Annex I of the Habitats Directive.

Limestone pavement is listed as Least Concern (LC) under the European Red List of Habitats (Janssen and others 2016).

1.3 Ecosystem context

This habitat only occurs on limestone bedrock which is sufficiently soluble for the clint and grike pattern to have developed in the 10,000 years since the end of the last glaciation. The level and near-level surfaces which characterise the pavements are the result of earlier glacial scouring and for this reason the habitat is concentrated in the north of England, in the counties of Cumbria, Yorkshire and Lancashire. Here, hard Carboniferous limestone was scoured by glacial ice before peat and soil developed on much of its surface. Forest clearance, grazing and erosion has subsequently re-exposed the limestone surface. Because of its origins, the habitat is rare in England and, after much has been destroyed for building and decorative purposes, it now covers just over 2,300 ha. Elsewhere in the British Isles, outliers of pavement are found in the Forest of Dean and in north and south Wales, north-west Scotland and Northern Ireland. Much more extensive pavements are found in southern Ireland, particularly in County Galway and County Clare (notably including The Burren).

In England, limestone pavements occur at a range of altitudes from 620 m in Yorkshire down to sea level on the Morecambe Bay coast. The character of the pavements changes across this altitudinal range with open and bare pavements generally found in the uplands and pavements with a higher cover of woodland and scrub being characteristic of more lowland settings. This, however, relates more to the predominant land management than the ecology of the habitat with many upland pavements being heavily sheep grazed. Ungrazed examples of the habitat in the uplands have a higher woodland and scrub cover.

Limestone pavements abut a diversity of other habitats with areas of transition between them. The most frequent of these are ash woodland or limestone scrub communities characterised by hawthorn or juniper. In lowland pavements, the scrub community retains these elements but also supports a more southern assemblage of spindle, alder buckthorn, dogwood and wild privet. Transitions to yew-dominated woodlands are occasional in lowland settings as yew is a component of this woodland type and single species stands of yew are not uncommon.

Pockets of limestone grassland amongst the pavement clints are ubiquitous in both upland and lowland pavements. Where the covering soils are acidic or peaty, transitions will be to acid grassland or heathland. Rarely, direct transitions to blanket bog occur. Small fragments of fen or alkaline flush vegetation may occur in depressions in the pavement surface or where level surfaces result in restricted impeded drainage.

Sources: Webb 1995; Webb & Glading 1998; Webb 2013.

2. Units and attributes

2.1 Natural range and distribution

National Character Area

2.2 Area

Hectare

2.3 Structure and function attributes

The geological formation and the varied ecological niches within the pavement features and surfaces are the primary determinants of the ecological richness of limestone pavement vegetation. Variation in shade, humidity, soil fertility and hydrology lead to the species and vegetative diversity. Microclimate (relative dampness/humidity) within grikes is particularly important for lichens and bryophytes. Where pavements have been damaged and clints removed, the resulting vegetation has a reduced diversity (Webb & Glading 1998).

Characteristic vegetation includes niches which are on the clint tops - the uppermost surface of the pavement. These are characterised by shallow, gravelly skeletal soils and transitions to chasmophytic vegetation. In the Yorkshire Dales these fragile habitats are home to a few very localised species such as Yorkshire sandwort *Arenaria norvegica* subsp. *anglica*, spring sandwort *Minuartia verna*, hairy stonecrop *Sedum villosum* and silvery lady's-mantle *Alchemilla glaucescens*. In heavily grazed pavements these niches are degraded or lost.

Transitions to other habitats, such as base-rich mires, are frequent and large uniform stands are unusual. This results in rich and colourful mosaics and high species-diversity.

Scrub and woody cover, reflecting the physical structure of the pavement, is a natural component of pavement vegetation. This increases shelter, habitat edge and overall vegetation complexity. It also increases the value of pavements for invertebrates. Age class variation further builds on these aspects. The thin soils and resultant summer drought restrict succession and development of woody cover such that even ungrazed pavements will have some open areas.

Invasive non-natives and introduced species are not especially frequent on pavements. The primary threats are cotoneaster species and red valerian *Centranthus ruber*. Bracken can dominate pavements filling grikes and outcompeting other flora. Restoration from the effects of invasive species is difficult and resource intensive.

Limestone pavement vegetation has low productivity. In many cases, succession of habitats is not occurring as the processes are dominated by progressive soil and vegetation loss. Grazing or herbivory will therefore have a significant impact on habitat quality. Livestock grazing, especially by sheep can lead to a loss of characteristic vegetation, a reduced cover and distribution of key plant species, especially ferns, herbs and shrubs, a loss of transitions and a reduced cover of scrub or woody species.

The diverse assemblage of vascular plants is also a function of low soil fertility and summer drought. Change to soil function, including by atmospheric deposition has the potential to result in reduced floral diversity.

Structure attributes

- Existing geological formation and resultant characteristics of the physical niches within the patterned pavement surfaces
- Characteristic vegetation community composition
- Natural vegetation zonations and transitions
- Species cover and distribution
- Cover of invasive, non-native and/or introduced species
- Cover of dense bracken
- Scrub and woody cover reflecting the physical structure of the pavement
- A range of age classes and structural variation in woody cover

Function attributes

- Properties of the soils
- Grazing
- Concentrations and deposition of air pollutants.

Sources: Webb & Glading 1998; Webb 2013.

3. Evidence

3.1 Current situation

Natural range and distribution

As limestone pavement was created by the action of glacial ice and subsequent weathering of a pre-existing limestone geology over thousands of years, it only occurs in England in those five National Character Areas where this interaction has taken place: West Cumbria Coastal Plain; Morecambe Bay Limestones; Yorkshire Dales; Forest of Dean and Lower Wye; Orton Fells.

Confidence: High

Area

The current area is measured as 2,343 hectares.

Source: This area is calculated from survey data referenced in Ward & Evans (1976), Webb (1995) and Webb & Glading (1998).

Confidence: High

Patch size and connectivity

The patch size is extremely variable between a few square metres and hundreds of hectares. This size was determined by past geological processes (see above) and by the more recent piecemeal removal of stone.

Quality of habitat patches

The fourth UK Habitats Directive Report (JNCC 2019) concluded that around 3.05 km^2 of this habitat was reaching favourable conservation status with 13.78 km^2 not reaching favourable conservation status and there was a further 2.96 km^2 where there was insufficient data upon which to make an assessment.

The structural requirements of favourable conservation status are represented within site monitoring by the presence and condition of the individual plant species. The only functional attribute that will be detected by standard monitoring is grazing, either by livestock or deer.

It is the prevailing land management practices that lead to the startling visual contrasts between upland and lowland pavements. In the uplands the pavements are predominantly grazed by sheep with some localised rabbit grazing. Woody cover is therefore low, vegetation cover is reduced to low levels and plants are confined to the shelter of the grikes. These pavements are in poor condition with degraded vegetation. In the lowlands

pavements are often set amongst wooded and scrubby land and are often ungrazed. Vegetation shows higher cover, with higher, more complex woody cover. These pavements are regarded as in better condition as their structure and function is less impacted by grazing. Deer browsing in these lowland settings can be a localised issue, but this does not often impact on the condition of pavements.

Sources: Natural England data; Webb & Glading 1998.

Confidence: High

Threatened species

Four vascular plants associated with limestone pavement have been assessed as at risk of national extinction within the England red list (Stroh and others 2014) namely bloody crane's-bill (Near Threatened), juniper (Near Threatened), frog orchid *Coeloglossum viride* (Vulnerable) and northern holly-fern (Endangered). Two species are assessed as at risk at a GB level: narrow-leaved bitter-cress (Near Threatened) and pale St John's-wort (Near Threatened).

Turgid scorpion-moss is a Nationally Rare S41 species that has Schedule 8 protected status. In England it occurs on a single limestone pavement site, and the most recent bryophytes red list (Callaghan & Hodgetts, in prep.) assesses this moss as Endangered at a GB level.

Five other S41 Species of Principal Importance are associated with limestone pavement, wall mason bee *Osmia parietina* and four butterflies: high brown fritillary *Argynnis adippe* (Critically Endangered), pearl-bordered *Boloria euphrosyne* (Endangered) and small pearl-bordered *B.selene* (Near Threatened) fritillaries and the northern brown argus *Aricia Artaxerxes* (Vulnerable).

Sources: Fox, Warren & Brereton 2010; Stroh and others 2014; Webb, Drewitt & Measures 2010.

Confidence: High

3.2 Historical variation in the above parameters

The distribution of limestone pavement has not changed from the time of exposure following the retreat of the ice at the time of the last Ice Age but the area of pavement has decreased due to the extraction and collection of stone for ornamental purposes by the horticultural industry, agricultural clearance and use in walling.

Limestone Pavement Orders (LPOs) have been very successful in reducing the amount of physical damage to pavements and removal for rockery stone is now infrequent (Webb 1995, Webb & Glading 1998). Section 34 of the Wildlife and Countryside Act 1981 contained provision for the making of LPOs by local authorities and damaging an area within an LPO became a criminal offence. Recommendations to local authorities were

made by The Nature Conservancy Council on a reactive basis but the creation of English Nature saw a change to a more systematic approach and by the year 2000, 99 Limestone Pavement Orders covered the bulk of pavement in England.

Many particularly upland pavements have been heavily sheep grazed such that they have lost most woody cover.

Natural range and distribution

Unchanged.

Area

The historical area is estimated as at least 4,033 hectares indicating just under 1,700 ha of limestone pavement has been totally destroyed.

This is difficult to precisely measure, as damage to limestone pavement can occur to varying degrees and it can be a matter of judgement as to when the pavement is fully destroyed.

Sources: This historic area is calculated from survey data referenced in Ward & Evans (1976), Webb (1995) and Webb & Glading (1998).

Confidence: Moderate, subject to the caveat about measuring historical destruction.

Quality of habitat patches

It is known from Ward & Evans (1976) that the extant pavements are significantly damaged by removal of surface clints. The Ward & Evans national survey of 537 limestone pavements found that only 3% were undamaged. This damage may not be detectable in terms of habitat area, as although individual clints or blocks may be removed there is still a limestone “base” remaining. The cartographic area therefore may be the same, but the volume, variety and structure is reduced.

Heavy sheep grazing in the uplands in the post-war period has impoverished the vegetation, reducing the number of characteristic vegetation types and adversely impacting upon structure and function (Condliffe 2009).

A reduction in coppice management in the lowlands (probably dating from more than 100 years ago) has reduced the open space in some lowland pavements but scrub and woodland cover would have been and will be constrained by the physical structure of the clints and grikes and drought stress.

Sources: Analysis of SSSI condition data*;* Webb & Glading 1998*.*

Confidence: High

Threatened species

There are no data for this assessment as all GB IUCN assessments have been conducted in the 21st century.

3.3 Future maintenance of biological diversity and variation of the species

There remains a residual risk of loss of habitat to provide rockery stone, for agricultural improvement or built development. The Limestone Pavement Orders considerably reduce this risk.

The ability of the habitat to function appropriately in the future is dependent upon factors such as livestock grazing at the local level as well as diffuse pressures such as atmospheric deposition leading to vegetation community changes. Natural England & RSPB (2019) assess limestone pavement as having a low sensitivity to climate change.

Grazing pressure is a key factor in determining ecological quality and variation in limestone pavements. Where grazing pressure is low, vegetation characteristically spills out onto clint tops and emerges from within the grikes. Where there is heavy grazing pressure, vegetation is supressed and occurs only within the deeper and narrower grikes. In this situation, the vegetation is not likely to be species-rich nor structurally diverse and, the combination of disturbance from grazing animals and the enrichment of nutrients through dung can result in the presence of undesirable species such as common nettle *Urtica dioica.*

There is no habitat-specific evidence for the impact of atmospheric deposition. There is a risk that nutrient enrichment will lead to more generalist vegetation out-competing species that are adapted to poor soils, short growing seasons and summer drought. Further research in this area is required.

Natural range and distribution and area

As the habitat derives from a geological feature there is no scope to expand range, distribution and area of the habitat.

Quality of habitat patches

To safeguard the habitat and species into the future, the structure and function requirements must be met. Provided the existing resource is safeguarded and subject to appropriate management there are no reasons to assume that structure and function will not be maintained into the future.

Confidence: Moderate

3.4 Constraints to expansion or restoration

Extension of the range, distribution and area of limestone pavement is not possible. As pavement formation is initiated by glacial scouring and is reliant on the slow process of sub-soil erosion, once destroyed limestone pavement cannot be re-created. The complete loss of the geological resource is identified as an immovable constraint to restoration when defining favourable conservation status (Mousley & Van Vliet 2021).

There is considerable scope for restoration of the biological aspects of structure and function through the establishment of appropriate management – largely the manipulation of grazing intensity through a change in livestock numbers. This is evidenced by the difference in habitat quality between heavily grazed pavement and ungrazed or lightly grazed pavement. Contrasts between sites of similar altitude and aspect, under different grazing management show the significant potential for restoration.

Sources: SSSI condition data; Webb & Glading 1998.

Confidence: High

4. Conclusions

4.1 Favourable range and distribution

The existing range is the favourable range and distribution – present in five National Character Areas: West Cumbria Coastal Plain; Morecambe Bay Limestones; Yorkshire Dales; Forest of Dean and Lower Wye; Orton Fells.

4.2 Favourable extent

The current area of the habitat – 2,343 ha.

4.3 Favourable structure and function attributes

Common Standards Monitoring (CSM) in its current form is not sufficient to assess the full function attributes that are required as deposition, soil status etc require specialist investigation. Monitoring and evaluation of structure and function should include an assessment of the presence of a full range of characteristic vegetation types along with the extent of natural vegetation zonations and transitions that are present.

Structure attributes

- Maintenance of existing geological formation and distribution at individual site level.
- Presence of a full range of characteristic vegetation community composition (to include chasmophytic, woodland scrub, grassland, heathland and wetland elements). Pavement vegetation cover should include niches on the tops of the clints and in shallow grikes.
- Natural vegetation zonations/transitions present.
- Species cover and distribution not constrained by herbivory.
- Lack of invasive, non-native and/or introduced species.
- Cover of dense bracken at, or less than, 10% of the feature.
- Woody cover should reach a minimum cover of 10% on all pavements.
- Woody cover should display a range of age classes and structural variation.

Function attributes

- Grazing at a rate where structural attributes are unaffected and species intolerant of grazing occur within suitable ecological niches. Vegetation should not be confined to the shelter of the grikes by grazing impact.
- Typical values for the properties of the underlying soil types, including structure, bulk density, total carbon, pH, soil nutrient status and fungal/bacterial ratio.
- Concentrations and deposition of air pollutants at or below the site-relevant Critical Load or Level values.

Quality of habitat patches

100% of the favourable area of the habitat must meet the structure and function requirements as described above.

Threatened species

All species partially or wholly dependent on this habitat should be Least Concern, when assessed using IUCN criteria (or considered to be Least Concern if not formally assessed), as regards to this habitat.

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