EU HABITAT ACTION PLAN

Action plan to maintain and restore to favourable conservation status the habitat type 4030 European dry heaths

European Commission, 2020

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Picture on the front cover: coastal dry heaths in Ireland. Philip Perrin.

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SUMMARY

This action plan is aimed at providing guidance to maintain and restore, at a favourable conservation status, the Annex I habitat type 4030 - European dry heaths, which is protected under the Habitats Directive[1]. It is addressed to all those interested and involved in the conservation and management of this habitat type, including governmental and non-governmental organisations, local communities and stakeholders, habitats specialists, etc.

This plan has been developed in the context of Action 7 of the Action Plan for nature, people and the economy[2] as well as Action 4A of the pollinator initiative[3].

European dry heaths (4030) are present in almost the entire European continent, from lowland to mountain level, and host a large number of threatened species. These heathlands are generally associated with well-drained, nutrient poor, acidic soils.

Most of the European dry heath vegetation is semi-natural, derived from woodland through a long history of grazing, cutting and burning over millennia. Key requirements to maintain habitat in good conservation status are the maintenance of low soil fertility, combined with appropriate levels of recurrent management to prevent succession.

The total area reported for this habitat type in the EU in 2013[4] was around 25,500 km^2, and the conservation status was unfavourable in most of the habitat range, according to the reporting by Member States covering the periods 2007-2012 and 2013-2018.

Nearly 40% of the habitat surface is included in the Natura 2000 network. The conservation status inside the network seems to be better than outside the Natura 2000 sites.

The main threats to this habitat type are:

- Abandonment or decrease of traditional management (grazing, cutting, turf-cutting, burning)
- Inappropriate grazing (both overgrazing and undergrazing)
- Atmospheric Nitrogen deposition and eutrophication
- Afforestation
- Habitat fragmentation and a reduction in habitat connectivity are also considered a threat for this habitat type in some countries.

In general, these heathlands need to be maintained by regular management through extensive grazing or cutting, cutting turf or soil scrapping and/or controlled burning.

[1] Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora - OJ L 206 of 22.7.1992, p. 7.

[2] COM(2017) 198 final http://ec.europa.eu/environment/nature/legislation/fitness_check/action_plan/communication_en.pdf and SWD(2017) 139 final, http://ec.europa.eu/environment/nature/legislation/fitness_check/action_plan/factsheets_en.pdf.

[3] COM(2018) 395 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. EU Pollinators Initiative. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1528213737113&uri=CELEX:52018DC0395

[4] According to the reports provided by the Member States in 2013 under Article 17 of the Habitats Directive.

Restoration is also needed to recover degraded patches and expand the area in some parts of their range.

The conservation and management of these habitats could be funded through the EU's Common Agricultural Policy (CAP). In particular, the European Agricultural Fund for Rural Development (EAFRD) is the most important source of funding for heathland management for biodiversity in some EU countries, including through agri-environment measures, training for implementation of measures, and investments in restoration. The European Regional Development Fund (ERDF) has been used for heathland restoration and management in some EU countries. The LIFE programme continues to be a very important source of funding for restoration of this habitat type.

The overall goal of the action plan is to ensure its maintenance or restoration at favourable conservation status in the long term (up to 2030), along with ensuring favourable future prospects in the face of pressures and threats.

The **framework for action** on the next pages presents specific objectives and key actions to achieve this overall goal.

The following sections of this document provide more detailed information about the status of this habitat and its conservation management, including key recommendations that underpin the framework for action.

While the focus of this action plan is the habitat type 4030 - European dry heaths, it is important to keep in mind that this habitat interrelates with other habitats and land uses in complex landscape settings, and this needs to be considered when planning and implementing conservation management. The plan also recognizes the importance of this habitat for wild pollinators.

Maintaining habitats and species requires an integrated approach that considers their relations with the socio-ecological system in which they exist. A broad landscape perspective enables us to take into account these interdependencies and gives us greater chances of success in conserving the natural environment.

FRAMEWORK FOR ACTION

The framework for action presents the objectives and key actions of this EU action plan. It is based on the ecological requirements and characterisation of the habitat type, its conservation status, main threats and pressures, conservation management experience and other relevant information that is presented in more detail in the subsequent sections of this action plan.

Overall goal of the action plan

To ensure restoration and maintenance at favourable conservation status of this habitat type in the long term (up to 2030), along with ensuring favourable future prospects in the face of pressures and threats.

Specific objectives to ensure habitat conservation in the medium-long term

1. Maintain the current range and prevent further loss and deterioration of the area of 4030 habitat by ensuring appropriate management of the areas where the habitat is present.
2. Establish conservation objectives for 4030 at biogeographical and national level to reach favourable conservation status in the long term, and ensure that the site-level conservation objectives for Special Areas of Conservation are in line with these objectives set at higher level.
3. Establish and implement the necessary conservation measures, including habitat restoration and re-creation where required, to achieve the defined conservation objectives at biogeographical, national and site-level.
4. Ensure ecological connectivity for 4030 across the habitat range, including through restoring areas outside the Natura 2000 network, in line with the defined conservation objectives at biogeographical and national level.
5. Improve knowledge, conservation status assessment and monitoring schemes for 4030 habitat.
6. Promote the implementation of the habitat action plan, disseminate and share knowledge and experience in protecting and managing 4030 habitat.

The table below presents key actions to achieve these objectives, together with the means and input required, geographical scope, responsibilities and suggested timescale for implementation.

Further guidance and details for implementation of the actions are provided in different sections of this action plan, as indicated in the framework for action.

Although the action plan identifies and promotes conservation measures specifically focused on the habitat type 4030, an integrated approach that properly takes into account the relations of this habitat with other habitats and land uses, and the interdependencies with the socio-ecological system should be applied. A landscape perspective, which takes into account these complex interdependencies, is recommended to maintain or improve the conservation status of this habitat and its associated species.

FRAMEWORK FOR ACTION – EU HABITAT ACTION PLAN – 4030 European dry heaths

Objective 1: Maintain the current range and prevent further loss and deterioration of 4030 habitat area by ensuring appropriate management of the areas where the habitat is present				
Key actions	**Activities, means and input required**	**Geographical scope**	**Responsibilities**	**Timescale**
1.1 **Support extensive farming systems that benefit the habitat and maintain or re-establish appropriate management regimes** (grazing, cutting, controlled burning where required) and integrate heathland conservation priorities into other extensive management types (see sections 5.1, 6.2.1)	1.1.1 **Assess risks of habitat loss** identify habitat areas threatened with abandonment or unsuitable management and report on the scale of potential habitat loss and deterioration and how to address it. 1.1.2. **Identify and designate priority intervention areas** to ensure the preservation of the habitat diversity and typical communities. 1.1.3 **Ensure that the CAP strategic plan includes relevant measures** identified in the Habitat Action Plan and provides adequate funding to ensure appropriate habitat management (see 6.2.1): - Develop national agri-environment schemes to maintain the habitat in good condition and incentivise participation. Encourage Member States to ensure sufficient coverage of 4030 by these schemes. - Support measures to increase income from farming systems that maintain this habitat. - Provide advisory services that promote the measures. 1.1.4 Make sure co-funding of complete (complex) habitat types (including all stages of heath, also partial scrub cover) is possible under the CAP. 1.1.5 Work with large landowners to **integrate heathland conservation measures into military, hunting or recreational land use priorities** and find synergies. 1.1.6 Develop mechanisms to **remunerate land managers for heathland management that yields products and services** that are valued by society.	All areas where the habitat is currently present, particularly in regions/areas where the habitat is threatened by abandonment of traditional practices, overgrazing or afforestation.	National and regional nature and agriculture authorities. Farm advisory services. Farmers' associations, local action groups. Organisations and landowners managing land with heath – military, hunting and shooting interests, local authorities. European Commission (DG AGRI, DG ENV).	Short term action (within the next 2 years)

Objective 1: Maintain the current range and prevent further loss and deterioration of 4030 habitat area by ensuring appropriate management of the areas where the habitat is present (cont.)				
Key actions	**Activities, means and input required**	**Geographical scope**	**Responsibilities**	**Timescale**
1.2 Create mechanisms/tools to **prevent changes in land use, particularly afforestation** that would affect the habitat inside and outside Natura 2000 sites (see section 3.4.1).	1.2.1 **Make sure that no habitat is lost** from areas where it is present because of lack of support or damaged by overgrazing (conditionality, eco-schemes, voluntary coupled support, etc.). 1.2.2 **Disseminate information about the importance of the habitat**, its distribution and critical areas for its conservation and connectivity, and ensure that **any possible effects of land uses changes on the habitat are properly assessed**. 1.2.3 **Ensure that no measures that are detrimental to the habitat**, as the conversion to other land uses, such as afforestation, residential areas or intensive land-use practices on heathland areas, are financed. 1.2.4. Ensure that **regeneration or restoration of heathland from successional forest stages or planted forest is possible** and facilitated (that no legal or administrative barriers exist to maintain or compensate for forest losses). 1.2.5 **Facilitate mixed pasturing systems** to maintain heathland areas within forest landscapes.	All areas where the habitat is currently present, particularly in regions/areas where the habitat is threatened by abandonment, afforestation, changes in land use and new projects/plans developments.	Nature and agriculture authorities. European Commission (DG AGRI, DG ENV).	Immediate action (within the next year)
1.3 Ensure that **Impact assessment and appropriate assessment** of plans and projects properly take into account the conservation objectives set for this habitat in Natura 2000 sites and the conservation of important areas for this habitat outside Natura	1.3.1 E**nsure that possible effects on this habitat in Natura 2000 sites are properly assessed**, including cumulative impacts of multiple activities and ongoing activities such as tourism and recreation. 1.3.2 **Promote new (or adapt existing) biodiversity mitigation and compensation mechanisms** that prevent or mitigate the loss of 4030 habitat due to developments (both infrastructure in rural areas and urban sprawl) and		National and regional authorities for impact assessment (SEA and EIA) and appropriate assessment (Article 6.3 of the Habitats Directive). Competent	Immediate action (within the next year)

2000.	ensure net gain of habitat. 1.3.3 **Identify and catalogue important areas for this habitat outside Natura 2000 sites** that contribute to the coherence of the network (see action 3.1).		authorities for strategic and spatial planning and green infrastructure/ ecological networks.	
1.4. Implement measures to ensure a significant **reduction of nitrogen deposition** in the areas of habitat occurrence (see 5.1.4) and to minimize pesticide deposition from adjacent areas.	1.4. 1 **Reduce and regulate air pollution** with the long-term objective of **not exceeding the critical loads / levels** that mark the limits of ecosystem tolerance. 1.4.2 Implement measures to respect the **limits of the Directive on the reduction of national emissions** (EU 2016/2284) for NO_x and NH3. 1.4.3 **Review regional and national air quality regulations**. 1.4.4 **Identify critical areas for the habitat** in relation to Nitrogen deposition and eutrophication. 1.4.5 **Create buffer zones** between the habitat and intensively used arable land or forest plantations with pesticide use. 1.4.6 Ensure that **nutrient budgets are considered** for any proposed land use change on adjacent areas, which could impact on 4030 habitat. Presumption should be on reducing nutrient inputs. 1.4.7 Implement **mitigation measures / action to remove nutrients at a field level** where necessary, e.g. replace cutting and burning by turfing to remove the accumulated nutrients.	All areas where the habitat is present and potentially affected by nitrogen deposition and eutrophication, especially in most affected countries including BE, CZ, LU, NL, UK, and DE.	National and regional competent authorities for nature, agriculture and pollution control.	Medium term (within the next 5 years)

Objective 2: Establish conservation objectives for 4030 at biogeographical and national level to reach favourable conservation status in the long term and ensure that site-level conservation objectives for Special Areas of Conservation are in line with those objectives				
Key actions	**Activities, means, input & resources required**	**Geographical scope**	**Responsibilities**	**Timescale**
2.1. Define **conservation objectives and strategic approaches to improve the conservation status of the habitat** at biogeographical and national level (see 4.3 and 4.4.).	2.1.1 Consider the **Favourable Reference Values** (result from action 5.2) 2.1.2 **Analyse the ecological diversity** of the habitat, including identification and distribution of typical communities, rare communities and sub-types and important areas for the preservation of the habitat diversity in the EU. 2.1.3 **Analyse and review conservation status assessments** (all parameters) at biogeographical and national level. 2.1.4 **Analyse fragmentation and connectivity issues** for this habitat type across its range (at biogeographical and national level). 2.1.5 Consider the **main pressures and threats**, including likely effects of **climate change** on the habitat. 2.1.6 **Discuss methodologies, approaches and strategies** in the Biogeographical Seminars.	All EU biogeographical regions All EU Member States where the habitat is present. All Natura 2000 sites designated for this habitat type.	Nature conservation and agriculture authorities. Working groups set up at biogeographical level. National experts.	Short-term action (within next two years).

2.2. Develop **national conservation strategies or plans for conservation and restoration** of 4030 habitat (see 4.4 and 5.5)	2.2.1 **Analyse the relations of dry heath with other habitats and land uses**, and the interdependencies with the **socio-ecological system,** with a view to promoting strategic action (with a landscape perspective or at appropriate scale) to maintain or improve the conservation status of this habitat and its associated species. 2.2.2 **Identify priority areas and key actions at regional/ national level** both inside and outside the Natura 2000 network, in order to achieve favourable conservation status in the biogeographical region and to improve habitat connectivity. 2.2.3 **Identify restoration needs** to improve the area, structure and function, where needed, and ways to address the main threats and pressures. 2.2.4 Identify action needed to make 4030 habitat more **resilient to climate change**, considering possible range shifts and additional threats (see section 3.5).	All EU biogeographical regions. All EU Member States where the habitat is present. All Natura 2000 sites designated for this habitat type.	Nature conservation and agriculture authorities. National experts. Farmers' associations, local action groups.	Short-term action (within next two years).
2.3. Review/establish **site-level conservation objectives** in Natura 2000 sites in order to maximise their contribution to achieving favourable conservation status of this habitat at the national, biogeographical and EU level (see 4.5).	2.3.1 **Analyse the role of the Natura 2000 network** and the **relative importance of each Natura 2000 site** for achieving the conservation objectives set at biogeographical and national level. 2.3.2 Where necessary or appropriate, **revise or update conservation objectives** for this habitat type in Natura 2000 sites and establish conservation objectives where these have not yet been established.	All EU biogeographical regions. All EU Member States where the habitat is present. All Natura 2000 designated for this habitat type.	Nature and agriculture authorities. Natura 2000 site managers. Farmers' associations, local action groups. National experts.	Short-term action (within next two years).

Objective 3: Establish and implement the necessary conservation measures, including habitat restoration and re-creation where required, to achieve the defined conservation objectives at biogeographical, national and site-level				
Key actions	**Activities, means, input & resources required**	**Geographical scope**	**Responsibilities**	**Timescale**
3.1 In light of the conservation objectives set at biogeographical, national and site-level, promote, **establish**, **support and implement specific conservation measures, including habitat restoration and recreation** in suitable areas (see section 5.2 of this action plan).	3.1.1. Develop**, test and implement guidelines on managing the habitat with regional variation** as required. 3.1.2 **Establish habitat conservation measures in Natura 2000 management plans** or other management instruments. 3.1.3 Identify **priority areas for habitat restoration,** assess restoration feasibility and develop and implement **heathland restoration plans** for 4030. 3.1 4 Develop **support schemes to implement restoration and conservation measures**: agri-environmental and other support schemes including investment payments and support for collective action measures to increase income from farming (CAP and other funds). 3.1.5 **Promote Life Integrated Projects** to restore the habitat in larger regions/ whole biogeographical regions. 3.1.6 Promote **locally supported small-scale projects** aimed at restoring or conserving the habitat across its range. 3.1.7 Implement **monitoring and assessment** of results.	Identified priority areas for habitat restoration at regional/ national level (historical range). Areas where the habitat has been recently lost or degraded, especially in countries and regions where a significant proportion of the historical area has been lost (e.g. over 30%)	Nature and agriculture authorities. Farmers' associations, local action groups. Local authorities and spatial planners	Conservation measures: short to medium term action (within the next 2-5 years) For habitat restoration: medium to long-term action (5-10 years)

Objective 4: Ensure ecological connectivity across the habitat range, including by restoring areas outside of the network, in line with the defined conservation objectives at biogeographical and national level				
Key actions	**Activities, means, input & resources required**	**Geographical scope**	**Responsibilities**	**Timescale**
4.1 In light of the conservation objectives set at biogeographical, national and site-level, **establish a programme for defragmentation of 4030**, including habitat restoration outside Natura 2000 in areas that are important for providing ecological connectivity for the habitat and associated species (see 5.2).	4.1.1 In view of habitat fragmentation and connectivity analysis (results of action 2.4.), **define habitat networks, identify key areas and elaborate a strategy, plan or programme to improve ecological connectivity** among habitat areas and relevant associated species populations. 4.1.2 Results from action 2.4. Analyse the **role of the area outside the Natura 2000 network** to reduce fragmentation and improve connectivity for this habitat type.	Identified critical areas for connectivity across all the habitat range and distribution area in all the biogeographical regions.	Nature an agriculture authorities and organisations, managing authorities for ERDF. Farmers, local action groups, relevant stakeholders. National experts.	Short to medium term action (within the next 2-5 years)
4.2 Implement **measures to reduce and prevent further fragmentation** through maintenance or restoration of suitable areas	4.2.2 Implement specific **conservation measures, including habitat restoration and recreation** in suitable areas with a view to prevent and reduce fragmentation of this habitat (in line with action 3.1). 4.2.3 **Provide funding** under various national and EU funds (EAFRD, ERDF, etc.) to support the measures required to prevent and reduce fragmentation of this habitat.			

Objective 5: Improve knowledge, conservation status assessment and monitoring schemes for 4030 habitat				
Key actions	**Activities, means, input & resources required**	**Geographical scope**	**Responsibilities**	**Timing**
5.1. Improve **knowledge about the habitat and its importance** for biodiversity and for the society.	5.1.1 Improve **habitat mapping and assessment of ecosystem services**. 5.1.2 **Disseminate** relevant **information about services and benefits** that the habitat provides to the society**.**	All the habitat range and distribution area. Biogeographical regions and countries with habitat occurrence.	Nature authorities. National experts. Expert networks (e.g. European Heathlands Network)	Short to medium term action (within the next 2-5 years)
5.2. Promote **harmonisation of methodologies** for assessment of conservation status, habitat monitoring and assessment of threats and pressures, which enable the comparison between countries, considering the variability of the habitat across its natural range (see sections 3.3 and 3.4).	5.2.1 Define **Favourable Reference Values** (FRV) for the habitat. 5.2.2 **Share and compare methods used to assess conservation status** in the Member States where the habitat is present. 5.2.3 Develop **agreed standards and methods** for conservation status assessment and monitoring across all Member States within the range. 5.2.4 Promote the **consideration of typical animal species** in regular conservation status assessments and monitoring. Encourage Member States to support regular **monitoring of key target species** supported by 4030. 5.2.5 Agree on **common standards to assess threats and pressures** on this habitat type.			

Objective 6: Promote the implementation of the action plan, disseminate and share knowledge and experience in protecting and managing 4030 habitat				
Key actions	**Activities, means, input & resources required**	**Geographical scope**	**Responsibilities**	**Timing**
6.1. Develop a **Communication Strategy** and **promote the implementation and coordination** of the Action Plan	6.1.1 **Disseminate and discuss the action plan in regional and national event**s (e.g. Natura 2000 Biogeographical seminars and events, agriculture workshops, etc.).	All countries and regions with habitat occurrence	Nature authorities. National experts. Expert networks	Short –term action (within the next 2 years).

	6.1.2 Include all relevant conservation measures for this habitat type in the **Prioritised Action Framework** for Natura 2000 (2021-2027). 6.1.3 Promote **common goals and coordinated actions** among countries for the implementation of the EU Habitat Action Plan (4030). 6.1.4 Support and **communicate at the EU level** the **role of extensive livestock farming** and its potential for positive impact on biodiversity.		(e.g. European Heathlands Network)	
6.2. **Exchange information** among Member States and regions on national/regional action plans, management experiences, conservation and restoration projects, best practices, etc.	6.2 1 Organise and participate in relevant **workshops, biogeographical seminars** and related events. 6.2.2 Disseminate and promote **best practice, and case study examples** of projects and initiatives that benefit the habitat across its range.		Nature and agriculture authorities. Farmers associations. Site managers. National experts. Expert networks (e.g. European Heathlands Network)	Short –term action (within the next 2 years).
6.3. Develop and promote **management guidelines and good practice** for the habitat.	6.3.1 Organise **workshops and biogeographical events** to compile and promote best practice guidance. 6.3.2 Develop, distribute and promote good practice guidelines, **guidelines for farmers and other site managers**.			
6.4. Develop **similar approaches in support schemes** (e.g. concerning goals and types of subsidies, incentives, etc.).	6.4.1 Review and analyse **support schemes and incentives** used in the different countries by an expert group under the biogeographical process. 6.4.2 Prepare and implement **regional plans**. 6.4.3 Develop **cooperation projects**.	All countries and regions with habitat occurrence	Nature and gericulture authorities. Farmers' associations, local action groups	Short term action (within the next 2 years)

Abbreviations: CAP = Common Agricultural Policy. EAFRD = European Agricultural Fund for Rural Development. ERDF = European Regional Development Fund

1. INTRODUCTION

Under the EU Action Plan for nature, people and the economy (COM(2017) 198 final), the European Commission, in cooperation with Member States and stakeholders, committed to developing and promoting the implementation of EU Action Plans for two of the most threatened EU habitat types[5]. Under the pollinator initiative (Action 4A), the Commission committed to further develop action plans for the most threatened pollinator species and habitats listed in the Habitats Directive.

This action plan aims to provide guidance to maintain and restore at a favourable conservation status the Annex I habitat type 4030 - European dry heaths, which is protected under the Habitats Directive[6]. This habitat is recognized among the most important for wild pollinators.

These heathlands are present in almost the entire European continent, from lowland to mountain level, and host a large number of threatened species.

This action plan is addressed to all those interested and involved in the conservation and management of this habitat type and in the implementation of conservation measures for it, including governmental and non-governmental organisations, local communities and stakeholders, habitats specialists, etc. It is expected that the action plan will be used:

- for developing the necessary instruments at the EU and national or regional levels and to establish, promote and implement actions in the context of agricultural policy (e.g. agri-environmental schemes), projects financed by the LIFE programme, and in the context of other policies and actions (to combat eutrophication, nitrogen deposition, etc.),
- by site managers, as a reference for the design and implementation of conservation measures and as a knowledge base for the better understanding of the management of heathlands.

This action plan includes a description of this specific habitat type, as protected under the Habitats Directive, its distribution and conservation status, and its connections with other habitat types and species protected under the EU Nature Directives[7]. It examines the main threats and pressures and presents the main actions needed to address them. The measures proposed in this action plan are aimed at the conservation and restoration of this habitat type wherever necessary, but also address the need to improve knowledge and monitoring.

However, as other types of heaths and scrub share similar problems and conservation needs, this action plan can be useful also to manage other dry heathland, grassland or scrub communities that are not exactly covered by this habitat type definition. In particular, dry Atlantic coastal heaths with *Erica vagans** 4040) is a priority habitat type so the measures considered in this action plan can be valid for that habitat type.

The European Commission has previously published management guidelines for other

[5] An EU Action Plan has been prepared also for habitat 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (*important orchid sites).
[6] Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora).
[7] Habitas Directive (Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) and Birds Directive (Directive 2009/147/EC on the conservation of wild birds).

types of heaths[8].

Applying a landscape perspective and an integrated approach to the implementation of the proposed actions will considerably increase the chances of achieving the goals of the Action Plan. An integrated approach takes into account the connections between habitats and species and land uses and the complex interdependencies in the socio-ecological system.

1.1 Action plan geographical scope

This action plan covers all the biogeographical regions and the Member States of the European Union where the 4030 habitat type is present. According to the Reference Lists for the biogeographical regions (April 2018[9]), it is present in **24 countries** and **7 biogeographical regions** (Atlantic, Alpine, Boreal, Black Sea, Continental, Mediterranean and Pannonian).

Table 1. Biogeographical regions and Member States where the habitat 4030 is present

Region	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	HU	HR	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SK	UK
ALP	X							X		X		X		X							X	X	X	
ATL		X			X	X		X		X			X					X		X				X
BLS			X																					
BOR							X		X						X		X					X		
CON	X	X		X	X	X				X		X		X		X			X			X		
MED								X		X				X						X				
PAN				X							X												X	

Member State acronyms. AT: Austria; BE: Belgium; BG: Bulgaria; CZ: Czech Republic; DE: Germany; DK: Denmark; EE: Estonia; ES: Spain; FI: Finland; FR: France; HR: Croatia; HU: Hungary; IE: Ireland; IT: Italy; LT: Lithuania; LV: Latvia; LU: Luxembourg; NL: Netherlands; PL: Poland; PT: Portugal; RO: Romania; SE: Sweden; SK: Slovakia; UK: United Kingdom.

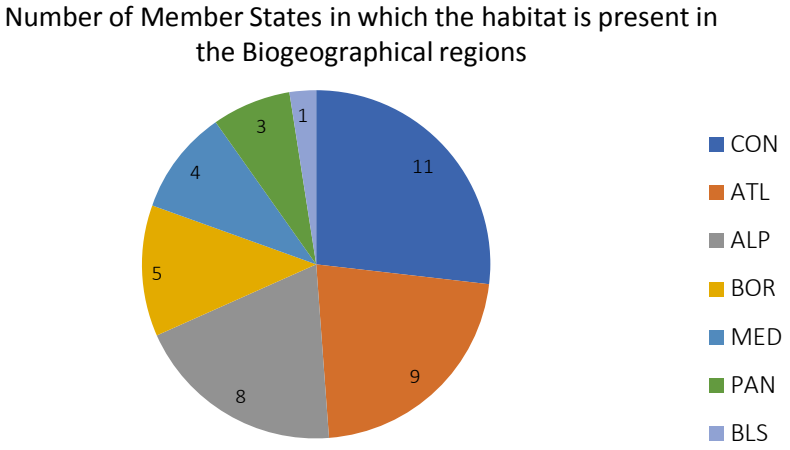


Figure 1: Number of Member States where 4030 habitat type has been reported in the Reference Lists of the biogeographical regions

[8] See Management of Natura 2000 habitats in particular for 4010 Northern Atlantic wet heaths with *Erica tetralix*, 4050* Endemic macaronesian heaths, and 4060 Alpine and Boreal heaths. Available at: http://ec.europa.eu/environment/nature/natura2000/management/habitats/models_en.htm

[9] Reference Lists: https://bd.eionet.europa.eu/activities/Natura_2000/chapter2

2. DEFINITION, ECOLOGICAL CHARACTERIZATION AND DISTRIBUTION

2.1 Habitat definition

2.1.1 Habitat definition according to the Interpretation Manual of European Union Habitats

The Interpretation Manual of European Union Habitats - EUR28 (EC, 2013) is a scientific reference document that provides a definition for all habitat types included in Annex I of the Habitats Directive.

4030 European dry heaths

PAL. CLASS.[10]: 31.2

Mesophile or xerophile heaths on siliceous, podsolic soils in moist Atlantic and sub-Atlantic climates of plains and low mountains of Western, Central and Northern Europe.

Sub-types:

31.21 - Sub-montane *Vaccinium-Calluna* heaths. *Calluno-Genistion pilosae p.(Vaccinion vitisidaeae p.):Vaccinio myrtilli-Callunetum s.l. i.a.*
Heaths rich in *Vaccinium* spp., usually with *Calluna vulgaris*, of the northern and western British Isles, the Hercynian ranges and the lower levels of the Alps, the Carpathians, the Pyrenees and the Cantabrian Mountains.

31.22 - Sub-Atlantic *Calluna-Genista* heaths. *Calluno-Genistion pilosae* p.

Low *Calluna* heaths often rich in *Genista*, mostly of the Germano-Baltic lowlands. Similar formations occurring in British upland areas, montane zones of high mountains of the western Mediterranean basin and high rainfall Adriatic influenced areas are most conveniently listed here.

31.23 - Atlantic *Erica-Ulex* heaths. *Ulicenion minoris*; *Daboecenion cantabricae* p.; *Ulicion maritimae* p.

Heaths rich in gorse (*Ulex*) of the Atlantic margins.

31.24 - Ibero-Atlantic *Erica-Ulex-Cistus* heaths. *Daboecenion cantabricae* p.; *Ericenion umbellatae* p., *Ericenion aragonensis*; *Ulicion maritimae* p.; *Genistion micrantho-anglicae* p. Aquitanian heaths with rock-roses. Iberian heaths with numerous species of heathers (notably *Erica umbellata*, *E. aragonensis*) and brooms, rock-roses and often *Daboecia*. When the rockroses and other Mediterranean shrubs become dominant they should be classified under sclerophyllous scrubs (32).

31.25 - Boreo-Atlantic *Erica cinerea* heaths.

Characteristic plant species: 31.21 - *Vaccinium* spp., *Calluna vulgaris*; 31.22 - *Calluna vulgaris*, *Genista anglica*, *G. germanica*, *G. pilosa*, accompanied by *Empetrum nigrum* or *Vaccinium* spp.; 31.23 – *Ulex maritimus, U. gallii, Erica cinerea, E. mackaiana, E. vagans*; 31.24 - *Erica umbellata*, *E.aragonensis, E. cinerea, E. andevalensis, Cistus salvifolius, Calluna vulgaris*; 31.25 – *Erica cinerea*.

[10] Code based on "A classification of Palaearctic habitats" 1995 version.

Corresponding categories

- United Kingdom classification: "H1 *Calluna vulgaris-Festuca ovina* heath", "H2 *Calluna vulgaris-Ulex minor* heath", "H3 *Ulex minor-Agrostis curtisii* heath", "H4 *Ulex gallii-Agrostis curtisii* heath", "H7 *Calluna vulgaris-Scilla verna* heath", "H8 *Calluna vulgaris-Ulex gallii* heath", "H9 *Calluna vulgaris-Deschampsia flexuosa* heath", "H10 *Calluna vulgaris-Erica cinerea* heath", "H12 *Calluna vulgaris-Vaccinium myrtillus* heaths", "H16 *Calluna vulgaris-Arctostaphylos uva-ursi* heath", " H18 *Vaccinium myrtillus- Deschampsia flexuosa* heath" and "H21 *Calluna vulgaris- Vaccinium myrtillus-Sphagnum capillifolium* heath".

- Nordic classification : "5111 *Rhacomitrium lanuginosum-Empetrum hermaphroditum*-typ", "5113 *Calluna vulgaris-Empetrum nigrum-Vaccinium vitis-idea*-typ", "5115 *Calluna vulgaris*-typ", "5116 *Vaccinium myrtillus- Calluna vulgaris*-typ", "5117 Calluna vulgaris-*Hieracium pilosella*-typ", "5131 *Deschampsia flexuosa-Galium saxatile*-typ", "5132 *Agrostis capillaris-Galium saxatile*-typ".

2.1.2 Habitat definition according to the EUNIS habitat classification

According to the EUNIS habitat classification[11], this habitat type (4030) corresponds broadly to F4.2 Dry heaths, which includes the following subtypes:

Subtype F4.21 - Submontane *Vaccinium* - *Calluna* heaths[12]. They are submontane, or sometimes lowland or coastal heaths rich in *Vaccinium* spp., usually with *Calluna vulgaris, Nardus stricta, Luzula campestris* and *Genista* spp., of the northern and western British Isles, of the North Atlantic islands, of Fennoscandia, of the Hercynian ranges and the lower levels of the Alps, the Carpathians, the Pyrenees and the Cantabrian Mountains. Secondary stands originating after deforestation of pine and oak acidophilus forests also belong to this unit.

Subtype F4.22 Sub-Atlantic *Calluna* - *Genista* heaths[13]. They are low *Calluna vulg*aris heaths often rich in *Genista* spp., *Armeria vulgaris, Jasione montana, Saxifraga granulata, Teucrium scorodonia* mostly of the German-Baltic, but extended south- and eastwards to the Pannonic lowlands. Similar formations occurring in British upland areas, montane zones of high mountains of the western Mediterranean basin and high-rainfall Adriatic influenced areas are included. Vegetation of the alliance *Genistion pilosae* is included in this subtype.

Subtype F4.24 Ibero-Atlantic *Erica* - *Ulex* - *Cistus* heaths[14]. They are Aquitanian heaths with rock-roses and the Iberian heaths with numerous species of heathers (notably *Erica umbellata, Erica aragonensis*) and brooms, rock-roses and often Daboecia. When the rock-roses and other Mediterranean shrubs become dominant they should be classified as maquis or garrigues (units F5 or F6).

Subtype F4.23 Atlantic *Erica* - *Ulex* heaths[15]. It includes heaths rich in gorse (*Ulex* spp.) of the Atlantic margins of Europe.

[11] http://eunis.eea.europa.eu/habitats.jsp
[12] https://eunis.eea.europa.eu/habitats/774
[13] https://eunis.eea.europa.eu/habitats/775
[14] https://eunis.eea.europa.eu/habitats/777
[15] https://eunis.eea.europa.eu/habitats/776

Subtype F4.25 Boreo-Atlantic *Erica cinerea* heaths[16]. They are low, open heaths of northern hyper-Atlantic Europe, north of the range of gorses, dominated by *Calluna vulgaris* and *Erica cinerea*.

2.1.3 Habitat definition based on the European checklist of vegetation

An updated version of EuroVegChecklist was published in 2016 (Mucina et al. 2016). The revised EUNIS classification has been cross-walked with EuroVegChecklist (Schaminée et al. 2018) as follows[17].

New code S42 [old code F42] - Dry heaths includes the following EuroVegChecklist vegetation units:
ULI-01A - *Ericion cinereae* Böcher 1940
ULI-01B - *Ulicion* Malcuit 1929
ULI-01C - *Daboecion cantabricae* (Dupont ex Rivas-Mart. 1979) Rivas-Mart. et al. in Loidi et al. 1997
ULI-01D - *Ericion umbellatae* Br.-Bl. in Br.-Bl. et al. 1952
ULI-01F - *Stauracanthion boivinii* (Rivas-Mart. 1979) Rivas-Mart. et al. 1999
ULI-02B - *Calluno-Genistion pilosae* P. Duvigneaud 1945
ULI-02C - *Euphorbio-Callunion* Schubert ex Passarge 1964
ULI-02D - *Genisto pilosae-Vaccinion* Br.-Bl. 1926

Those vegetation units are covering several Annex I habitats (EIONET 2016):
2310 Dry sand heaths with *Calluna* and *Genista*
2320 Dry sand heaths with *Calluna* and *Empetrum nigrum*
4030 European dry heaths
4040* Dry Atlantic coastal heaths with *Erica vagans*

Minsmere-walberswick heaths and marshes SSSI-Suffolk. © Natural England. Peter Wakely

[16] https://eunis.eea.europa.eu/habitats/778
[17] http://www.sci.muni.cz/botany/chytry/Schaminee_etal2018_EEA-Report-Forest-Scrub-Grasslands.pdf

2.1.4. Habitat description from the Red list of European habitats

This dry heath of ericoid and genistoid sub-shrubs, grasses and herbs is characteristic of the mild, moist climate of the Atlantic region of Europe occurring on siliceous soils, often podsolised but rarely or never waterlogged.

This habitat has its main distribution in Atlantic Europe, a region of oceanic climate with high precipitation and a low continentality, with some extensions towards interior areas of the continent in some siliceous mountains and on sandy plains. It has been traditionally maintained by grazing, brush cutting and burning within wide landscapes in mosaics with other wetter heaths and grasslands. Almost everywhere the habitat is under threat from a decline in traditional management and land-use change, particularly afforestation. Dry heaths are assessed as Vulnerable in the European Red List of Habitats (EIONET, 2016).

2.2 Differences across countries and regions - interpretation problems

All countries hosting this habitat type have developed a definition adapted to their specific characteristics (e.g. species composition, soil, altitude), including sub-types. Examples of definitions available from some countries and some of their interpretation problems are included in Annex 1.

Although, from a physiognomic point of view at the landscape level, this habitat seems relatively uniform and should hence not present interpretation problems, it actually does. Interpretation problems can be linked to the close ecological relation and intergradation of dry heaths with other habitat types, such as other heathland communities (e.g. 4010 wet heath, 4060 Alpine and Boreal heaths), dunes (e.g. 2140, 2310 and 2320), bogs, scrub or woodland (e.g. *Juniperus* formations) and grasslands (e.g. 6230 Species-rich *Nardus* grasslands, 6210 Semi natural dry grasslands). See the next section 2.4 on related habitats for further details.

There are however some common elements and components that can be considered to define and distinguish this habitat type, which are summarily described below.

Table 2. Typical features, elements and components of European Dry heaths (4030) habitat

Aspect, physiognomy	Dwarf shrub vegetation dominated by heaths.
Species	*Calluna vulgaris, Erica* spp. (e.g. *E. cinerea*), *Vaccinium* spp., *Ulex* spp.
Soil	Acidic[18], sandy (or sandy-loamy), freely-draining, nutrient-poor soils
Altitude	Lowland to montane (e.g. from sea level up to 1,900 m above seal level in Spain).

[18] In Britain however there is "chalk or limestone Heath" which appears in areas with basic underlying rocks with loess or other acidic deposits on top, more or less continuous. They are included within the H8c in the National Vegetation Classification, and therefore a dry European heath type. The vegetation is a mix of calcifuges and calcicole species, which is rare and highly dependent on appropriate management. Also in the H10d heath type, species-rich forms of dry heath occur where acid surface deposits overlie calcareous materials such as limestone or moderately base-rich rocks, for example on the isle of Rum in the Inner Hebrides. Such heaths contain unusual combinations of heath and calcareous grassland species, including northern bedstraw *Galium boreale*, intermediate wintergreen *Pyrola media*, stone bramble *Rubus saxatilis*, alpine bistort *Persicaria vivipara* and thyme broomrape *Orobanche alba*.

Problems of habitat definition and interpretation would need a broader discussion, which could take place for instance in the Natura 2000 biogeographical seminar process.

2.3 Ecological requirements and management needs

European dry heaths (4030) are generally associated with well drained, nutrient poor, acidic soils, or at least on superficially nutrient poor soils.

Dry heaths vary in their flora and fauna according to climate, and are also influenced by altitude, aspect, soil conditions (especially base-status and drainage), maritime influence, and management intensity (e.g. grazing and burning). There is a variation from southern to northern types of dry heath (e.g. southern heaths are richer in species than northern heaths), and there are also differences between western (oceanic) and eastern (more continental) forms.

Most of the European dry heath vegetation is semi-natural, derived from woodland through a long history of grazing and burning. Key requirements to maintain habitat in good conservation status are the maintenance of low soil fertility, combined with appropriate levels of grazing, brush and turf cutting and/or recurrent burning to prevent succession.

Primary stations of this habitat type are most probably linked to the coastal cliffs of Atlantic SW Europe, where shallow soils in the rocky habitats provide the adequate conditions for preventing succession and even an adequate refuge for survival during Pleistocene ice ages. Other primary *Calluna* heathland can be present in large fluvio-glacial river valleys, linked to inland dunes belonging to habitat types 2310 and 2320.

In Central-Eastern Europe (e.g. in the Czech Republic), some natural formations on cliffs and boulder screes dominated by *Vaccinium* species are included as European Dry heaths (4030).

In most situations out of its primary stations, this habitat is associated with a particular well-defined, historically prolonged and intense disturbance regime. Heathlands came into existence following initial forest clearance by Neolithic man, and where they have persisted, they do so only owing to the intensive management that prevents their reversion to scrub and woodland (Webb 2001). Plant materials like heather, bracken, gorse and turf were used for burning, thatching, animal bedding or fodder (Webb 1986).

Grazing, cutting, burning, top soil removal and sod cutting have been the main practices carried out by humans on heathlands since early times and nowadays rural abandonment and the relaxation of such activities have triggered secondary succession and led to its disappearance in many locations. Many of the areas formerly and nowadays still covered by heaths are secondary stands resulting from such human interventions and they form part of a cultural landscape (Gimingham & de Smidt, 1983; Webb, 1986).

The recurrent presence of fire is considered key for the maintenance of this habitat in some parts of its range (Gimingham 1972; Webb 1986; Ojeda 2009a). Ideally, no post-fire management would be needed (nor desirable), apart from controlling an excess of ungulate (game and livestock) herbivory (Ojeda 2018). However, in heathland with abundant grass cover or adjacent to woodland, e.g. with *Pinus* and *Betula*, there is the risk that grasses and trees become dominant, also after prescribed burning. Then, post-fire management, mostly grazing, is needed.

Like many species from naturally fire-prone ecosystems, *Calluna* shows smoke-adapted germination, which might be considered as an evolutionary response to the anthropogenic fire regime. A study by Vandvik et al. (2014) shows that smoke-induced germination in *Calluna* is found in populations from traditionally burnt coastal heathlands but is lacking in naturally occurring populations from other habitats with infrequent natural fires.

It is also important to note that some subtypes need specific management – e.g. in Scotland the subtype *Calluna vulgaris-Arctostaphylos uva-ursi* heath must be burnt periodically or it will disappear.

It shall be stressed however that the occurrence of frequent wildfires can have negative impacts related to biodiversity loss and soil erosion (see section 3.4.5 Fire and fire suppression).

Abandoned stands will be sooner or later colonised by tall shrub and trees. The slowdown/impediment of successional processes can be achieved by recurrent biomass removal to counter reforestation and reduce nutrients increase due to pollutants (especially to nitrogen emissions).

Dry heaths form dense sub-scrubs in which dominance is dependent on the type of management: high fire frequency combined with grazing leads to the dominance of graminoids, even to a sort of grassland with few or no dwarf-shrubs, acid grassland (*Nardo-Galion*, *Nardo-Agrostion*); regular mowing without grazing leads to the dominance of heathers, gorses and ferns (particularly *Pteridium aquilinum*), in a treatment much oriented to obtaining large quantities of vegetative material for cattle bedding and for manuring (EIONET, 2016).

Dry heath, as other heathland types, is a dynamic ecosystem. The early-stage successions are of particular importance for invertebrate and lichen communities that depend on open vegetation structures and patches of bare soil without litter (Webb et al., 2010). By the time the canopy is closed by ericaceous shrubs, its habitat value for specialist species is greatly diminished. Therefore, a recurrent management practice that halts succession is a necessity. However, heath that has developed for a considerable long time without major disturbance also supports a particular heathland community with own species and specific soil characteristics (Bijlsma et al., 2013). Therefore, a well-developed heath should ideally consist of a mosaic of patches of the different development phases of Calluna.

Dry heath is part of a complex landscape that evolved and expanded as a result of intensive interactions between natural and man-driven processes (Gimingham & de Smidt, 1983; Webb, 1986). The overall result was a highly dynamic and heterogeneous landscape with high species diversity.

The definition of conservation objectives and the selection of appropriate management measures should take full account of the dynamic landscape mosaic and the processes behind it.

2.3.1. Lowland, upland and coastal dry heaths

In relation to ecological characterisation and management needs, three main categories of dry heaths can be distinguished, which correspond to different conditions and relate to distinct management regimes, i.e. lowland, upland and coastal heaths. Usually, lowland and upland heaths are subject to different pressures and management needs.

Lowland heath developed following prehistoric woodland clearance, and has been kept open through the centuries by grazing, burning and cutting. As the economic value of these uses declined, a considerable area of heath was lost to agriculture, forestry, housing, mineral working and other uses.

Lowland heath grades into upland heath but can be defined by the upper limit of agricultural enclosure and typically supports a different range of birds, reptiles and invertebrates different from those found on upland heath. However, in practice, there is rarely a clear ecological cut-off between lowland and upland heathland, as the vegetation exhibits a continuum of change from the lowlands to uplands influenced by a range of factors, particularly the temperature, rainfall and insolation regimes, which, in turn, influence soil characteristics.

As regards coastal dry heaths, they are in general considered a natural habitat, e.g. on the coastal cliffs of Atlantic SW Europe, where shallow and rocky soils prevent succession, and they may not require any recurring management for their conservation. A similar situation occurs in the natural formations found on cliffs and boulder screes in Eastern Europe previously described (e.g. in the Czech Republic).

Pressures tend to come from overgrazing on upland heaths and undergrazing on lowland heaths (e.g. in the UK). Upland heaths may therefore need less grazing than lowland heaths. Grazing by deer and/or other wild mammals, which interact with livestock grazing, may also need to be taken into account in particular in upland heathlands.

2.4 Related habitats

The vegetation of European dry heaths (4030) is often in transition or in mosaic with different vegetation types. It can be found in complexes of dunes, heathlands and grasslands, or together with areas of mire, scrub and woodland (Cordingley et al 2016).

The following habitat types can be associated or in contact with the European dry heaths (4030), can have similar management needs or somehow influence their management.

2140* Decalcified fixed dunes with *Empetrum nigrum*.
Decalcified heathland on fixed dunes with dominant crowberry on North Sea and Baltic coasts. Natural or primarily non-wooded coastal heath in wind-exposed sites. Unlike *Calluna vulgaris, Empetrum nigrum* can tolerate a limited amount of sand accumulation as it responds with the formation of new leaf rosettes above the old ones. Coastal *Empetrum nigrum* heathland on Geest soils (e.g. at Cuxhaven, Germany) as last, endangered remnants of this habitat type are included[19].

2150* Atlantic decalcified fixed dunes (*Calluno-Ulicetea*)
Decalcified Atlantic dunes with Atlantic species, such as *Erica ciliaris* and *Ulex* spp. of the alliances *Ulicion minoris*, *Calluno-Genistion* or *Ericion umbellatae*.

2310 Dry sand heaths with *Calluna* and *Genista* (inland dunes, old and decalcified)
Dry heaths on decalcified or calcium-poor inland dunes dominated by dwarf shrubs (*Calluna vulgaris, Genista anglica, Genista pilosa*) usually with scattered scrub[20].

[19] https://www.bfn.de/en/lrt/natura-2000-code-2140.html
[20] https://www.bfn.de/en/lrt/natura-2000-code-2310.html

2320 Dry sand heaths with *Calluna* and *Empetrum nigrum* (inland dunes)
Dry sand heaths with *Calluna* and *Empetrum nigr*um on inland dunes. The criterion for the delimitation of this habitat type is the dominance of *Empetrum nigrum* on inland dunes.

2330 Inland dunes with open *Corynephorus* and *Agrostis* grasslands
Inland dunes with open *Corynephorus* and *Agrostis* grasslands can be found in mosaic with European dry heaths on alluvial acidic deposits. Management requirements are similar, mainly consisting in soil disturbance (sod-cutting more suitable for the habitat 2330 and top soil inversion for the habitat 4030).

2340 Pannonic inland dunes
In Slovakia, Pannonic inland dunes occur in mosaic with European dry heaths on acidic sand dunes of Military Area Záhorie. Management requirement are similar and restoration management has been carried out for both habitats (e.g. see LIFE06 NAT/SK/000115 project).

4010 Northern Atlantic wet heaths with *Erica tetralix*
North Atlantic and Central European wet heaths and heather-moors with Crossed-leaved heather (*Erica tetralix*). The delimitation should be based on the presence of vegetation of the syntaxa given above. In Germany, the cover of *Calluna* should not exceed 50% of dwarf shrub cover (if *Calluna* cover exceeds 50% the vegetation should be considered under European dry heaths-4030 of planar to montane zones)[21]. On the contrary, this does not apply in the UK, where *Calluna* cover can exceed 50% in 4010.

4020 Temperate Atlantic wet heaths with *Erica ciliaris* and *Erica tetralix*.
In wet conditions, dry heaths are replaced by Atlantic wet heaths (4010, 4020). They share some species and degraded stands of dry heaths are often very similar to the degraded wet heath stands. Soil eutrophication by elevated atmospheric nutrient deposition threatens both habitats, although this threat is more marked in wet than in dry heaths, likely because of the poor soil drainage of the former.

4040* Dry Atlantic coastal heaths with *Erica vagans.*
Coastal heaths of temperate areas with *Erica vagans* and *Ulex europaeus* on well-drained soil, other than prostrate maritime formations. This is a priority dry heath habitat type and management recommended in this action plan can be valid also for it.

4060 Alpine and Boreal heaths
Dwarf or prostrate shrub formations of sub-alpine and alpine zones on siliceous or calcareous soils. Dominated by ericaceous species, *Dryas octopetala*, and Dwarf juniper *Juniperus nana*. There is often a conspicuously high proportion of lichens (*Cladonia* a.o.) in the low-growing vegetation. This type includes alpine dwarf ericoid wind heaths, *Vaccinium-Empetrum* heaths, and *Dryas* heaths. The delimitation of the dry heaths of plains to montane zones (4030) is based on their location in a different altitudinal belt and on the presence of subalpine flora elements[22].

5130 *Juniperus communis* formations on heaths or calcareous grasslands
Habitat 4030 can sometimes be found in mosaic with *Juniperus communis* formations. Both are known to have very similar ecological requirements and management needs. Management practices however are different as the presence of *Juniperus* makes the use

[21] https://www.bfn.de/en/lrt/natura-2000-code-4010.html
[22] https://www.bfn.de/en/lrt/natura-2000-code-4060.html

of burning more problematic, while grazing or cutting are more appropriate. Formations with *Juniperus communis* of plain to montane levels may correspond to phytodynamic succession of the mesophilous or xerophilous calcareous grasslands, grazed or let lie fallow, of the *Festuco-Brometalia* (EC 2013, Cooper et al. 2012) or especially in the sandy siliceous lowlands to succession stages of heathlands of the *Nardo-Callunetea*-class after abandonment of grazing or with too low grazing intensity.

6120 Xeric sand calcareous grasslands and 2330 Inland dunes with open *Corynephorus* and *Agrostis* grasslands

Habitat 4030 can be found in complexes of dunes, heathlands and grasslands, e.g. on military training areas in Poland, so they should be conserved together.

6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*)

In Italy, habitat 6210, particularly the acidophilous subtype 34.34, is occurring in mosaic with European dry heaths on sandy-pebbly soil, where pioneer patches (*Thero-Airion*) can be found mixed to mature patches (*Koelerio-Phleion*).

6230 Species-rich *Nardus* grasslands on siliceous substrates in mountain areas (and submountain areas in Continental Europe)

The habitat 4030 is usually distributed in contact with the 6230-Species-rich *Nardus* grassland, on siliceous substrates in mountain areas (e.g. in Romania) and submountain areas (in continental Europe) where grazing is necessary to some extent. Unfortunately, certain grazing regimes may have negative effects on the conservation of 4030 because they modify the nutrient-poor character and the acidity of the substrate. In Slovakia, communities of *Genisto pilosae-Vaccinion* create the most common transitions with grassland communities of *Nardo-Agrostion tenuis* belonging to the habitat 6230.

8240 Limestone pavement

In some parts of its range, habitat 4030 can be part of a complex habitat which may consist on blocks of limestone bedrock intermixed with dry grasslands, heath, small boggy areas, etc.

9190 Old acidophilous oak woods with *Quercus robur* on sandy plains

In the sandy northern lowlands (e.g. in Germany, Denmark and Poland), acidophilous oak forests with *Quercus robur*, sometimes also with *Quercus petraea* and ad-mixture of *Fagus sylvatica* are the potential natural vegetation of the *Calluna*-heath, which is developing when *Calluna*-heath is no longer managed. These forests can have substantial ground cover of *Calluna vulgaris* together with a number of acidophilous herbs and grasses in common with the habitat 4030.

9330 *Quercus suber* forests and 9230* Galicio-Portuguese oak woods with *Quercus robur* and *Quercus pyrenaica*

In the Mediterranean region, the dry heathland habitat is generally found on mountain high slopes, crests and summits. Below them, on middle and lower slopes, we can find cork-oak (*Quercus suber*) forests (habitat 9330). Most of these forests have been heavily managed for cork since the middle XIX century, and their range might have been anthropically extended up into the dry heathland habitat. At high elevations (higher than 750 m asl), in wind protected slopes and cool environments, the dry heathland is replaced by deciduous oak forests with *Quercus pyrenaica* (habitat 9230).

2.5 Related species

Some species included in Annexes II, IV and V of the Habitats Directive and Annex I of Bird Directive or protected species at the national level are strongly linked with the habitat and may require some particular management prescriptions for their conservation.

2.5.1 Plants

Different plant species of conservation value can be present in dry heaths in the different countries.

In Belgium, the following taxa listed on Annex V of the Habitats Directive have all or a substantial share of their habitat in heathlands: *Arnica montana, Lycopodiaceae, Cladonia subgen. Cladina.*

In Denmark, the following Annex V species can be found related to dry heaths: *Cladonia ciliata var. ciliate, Diphasiastrum tristachyum, Lycopodium annotinum, Arnica montana, Cladonia arbuscula, Cladonia portentosa, Cladonia stygia*

Endemic plants are unusual in Italian heathlands, with few exceptions such as *Euphrasia cisalpina* on dry soils (Martignoni, 2014). In general, disturbance suppresses competition by surrounding plants and provides micro-sites for its establishment. On the other hand lichens, mostly belonging to genus *Cladonia*, frequently occur and species found in lowland heathlands often have a biogeographical and conservation value (Gheza, 2018; Gheza et al., 2018)

In France, there are 18 subtypes of dry heaths with a diversity of plant species, including many species of conservation value (Bensettiti et al. 2005).

In Germany, besides the dominance of *Calluna vulgaris* (mixed in some regions with *Chamaespartium saggitale*, *Chamaecytisus supinus*, and sometimes *Agrostis capillaris*, with *Molinia caerulea* in wetter heathlands) some important stands of *Arnica montana* occur within this habitat. Typical species include many *Lycopodiaceae*, ericoid dwarf shrubs, sedges and grasses. A whole group of rare or declining plants are shared with the remnants of lowland *Nardion grasslands* (6230), such as *Antennaria dioica*, *Botrychium lunaria*, *Nardus stricta* or *Potentilla erecta*.

Mosses and lichens frequently occur in dry heaths. Some mosses, such as *Dicranum polysetum, D. scoparium, Hypnum jutlandicum* or *Pleurozium schreberi*, can be dominant, others belong to the set of typical species in Calluna-heathland for example *Polytrichum juniperium* and *P. piliferum*. Older, less disturbed, stages of the habitat can also accumulate a considerable cover of typical species mainly of the genera *Cladonia* (e.g. *C. stellaris*, *C. arbuscula*) and of *Cetraria* (e.g. *C. ericatorum*, C*. aculaeata*). Some fungi-species preferring the nutrient-poor sandy soils belong to the typical species of the habitat 4030.

In Poland, some rare and locally endangered plants associated to this habitats are: *Genista germanica, Genista pilosa, Scabiosa ochroleuca, Arctostaphyllos uva-ursi* (typical for some subtypes), *Lycopodium clavatum, Lycopodim tristachyum,* and *Botrychium lunaria*.

In Spain, the Mediterranean heathlands, in particular those found in the Gibraltar Strait area are particularly rich in endemic species, as *Drosophyllum lusitanicum* (Gil-López et al. 2017, 2018), a carnivorous plant species associated with recurrent fire (Paniw et al. 2017).

Teucrium scorodonia, a sub-Atlantic element and very rare taxon occurring in Tríbeč Mts. only occurs in Slovakia within the alliance *Euphorbio cyparissiae-Callunion vulgaris*. This plant is nevertheless is very common in other Atlantic areas, e.g. in UK heathlands and other acidic environments.

In the UK, many of the ericoid dwarf-shrubs associated with dry heaths can also be found in other dwarf shrub-rich habitats including scrub and woodlands but bearberry *Arctostaphylos uva-ursi* is rare or absent under shade and the rare blue heath *Phyllodoce caerulea* (Vulnerable on UK Red List), is limited to H18 *Vaccinium myrtillus-Deschampsia flexuosa* heath (Jackson & McLeod, 2000). This type of dry heath is very restricted in the UK context, associated with the higher northern 4030 habitat only. In addition, *Genista anglica* (Near Threatened on UK Red List) is limited to dry and wet heath (Rodwell, 1981). Intermediate wintergreen *Pyrola media* (Nationally Scarce, Vulnerable), is closely associated with dry heath, especially species-rich forms of H16 *Calluna vulgaris-Arctostaphylos uva-ursi* heaths (*Calluno-Genistion pilosae* in Mucina et al 2016) with bitter vetch *Lathyrus linifolius*, and slender St John's wort *Hypericum pulchrum*. In England many species of national conservation concern are dependent on heathlands. These include 21 species of vascular plants, 10 of bryophytes, 3 of lichens and 1 fungi (Web *et al* 2010). H21b heath found in the north-west of Scotland is exceptionally rich in oceanic bryophytes, including rare species.

Bearberry *Arctostaphylos uva-ursi.* ©Mike Smedley, SNH

Some clubmosses are closely associated with dry heaths and related habitats where the frequency of burning is not too high. In Scotland, these include interrupted clubmoss *Lycopodium annotinum* (Nationally Scarce), and Issler's Clubmoss *Diphasiastrum complanatum* ssp. *issleri (Nationally Rare)*. Other rare vascular plants found occasionally in dry heath with absence or very low frequency of burning include twinflower *Linnaea borealis* (Nationally Scarce) and dwarf birch *Betula nana* (Nationally Scarce).

In Sweden, heathland areas of high natural value harbor *Genista* species, *Gentiana pneumonantheand* and *Pedicularis sylvatica*, mainly in western Sweden's coastal areas.

2.5.2. Birds

European dry heaths provide habitat for threatened or rare bird species, including many that are listed in Annex I of the Birds Directive.

The dartford warbler (*Sylvia undata*), woodlark (*Lullula arborea*) and nightjar (*Caprimulgus europaeus*) are generally associated with dry heaths.

Nightjar (*Caprimulgus europaeus*). © Natural England. Allan Drewitt

Other Annex I species can be found in dry heaths in different parts of the EU, including the following:

- Black grouse (*Lyrurus tetrix*): in mosaics of heath, pine forest and meadows in Netherlands, Germany and Sweden.
- Chough (*Pyrrhocorax pyrrhocorax*): maritime heath in W UK, Ireland, NW France, upland and coastal areas in NW Spain.
- Red-backed shrike (Lanius collurio): France, N Iberia, Netherlands, Germany and Sweden.

In the UK, also the following species occur in dry heaths: red grouse (*Lagopus scoticus)*, hen harrier (*Circus cyaneus)*, Merlin (*Falco columbarius*), twite (*Carduelis flavirostris)*, short-eared Owl (*Asio flammeus*), whinchat (*Saxicola rubetra*) and golden plover (*Pluvialis apricaria*) (Webb et al 2010).

Black grouse (*Lyrurus tetrix*) and golden eagle (*Aquila chrysaetos*), are especially associated with the Scottish Highlands, and whimbrel (*Numenius phaeopus)* and great skua (*Stercorarius skua)* with the northern maritime moors of Scotland (Jackson & McLeod 2000).

In Belgium (Wallonia), 8 bird species listed in Annex I of the Birds Directive have regular breeding populations in heathlands. Four of them (*Lyrurus tetrix, Caprimulgus europaeus, Saxicola rubetra, Lanius excubitor)* have undergone substantial population declines and a reduction of their breeding range over the last decades, mainly as a result of loss and fragmentation of suitable breeding habitats. *Pluvialis apricaria* is a very irregular breeding species (end of the last century in the Hautes-Fagnes) in its southern limit of its global distribution. *Circus cyaneus* and *Jynx torquilla* are not declining but are still very rare and with fragile breeding populations, while *Lullula arborea* is also rare but benefits from

restoration projects. Restoration of heathlands through LIFE Projects has already helped to maintain and/or increase available habitat. However, further restoration is still necessary, along with tackling other threats such as artificially high density of wild boar, which damage ground breeders.

Habitat fragmentation and deterioration has a direct impact on those bird species that use this habitat as breeding sites.

2.5.3 Amphibians and Reptiles

Various reptiles and amphibians are closely associated with heath including several European Protected Species e.g. natterjack toad *Bufo calamita*, smooth snake *Coronella austriaca* and sand lizard *Lacerta agilis*. Other typical reptile species include the adder *Vipera berus* which is increasingly a subject of conservation concern in many European countries, viviparous lizard *Zootoca vivipara* and slow worm *Anguis fragilis*.

In the United Kingdom, southern heathlands are the only habitat to support all of the UK's six native species including sand lizard (*Lacerta agilis*) and smooth snake (*Coronella austrica*). Reptiles require mature heath habitats with favourable conditions for them, e.g. at least 1% bare ground though not unconsolidated or trampled, at least 80% cover deep heather, for Sand lizard and smooth snake[23].

Adequate habitat for these species can be lost due to inappropriate or lack of management, including unsuitable grazing and burning (e.g. as reported in England under Article 17). Heather age management issues (often related to scale and intensity) need to be considered, as well as the preservation and appropriate management of habitats for some amphibian species, as pools (see section 5.3 on management for wildlife).

Sand Lizard. © Natural England-Allan Drewitt

Smooth snake. © Natural England-Allan Drewitt

2.5.4 Invertebrates

It must be stressed the high diversity of invertebrate fauna associated with this habitat type, which is also related to the physical conditions of good drainage and low-nutrient, acidic soils that give rise to the European dry heaths (4030). This relationship may be via

[23] Favourable Condition Tables (FCT) for these species In Dorset Sites of Special Scientific Interest (SSSI).

the specific plants associated with the habitat, of which heathers, notably *Calluna vulgar*is, are a major component, or through the physical conditions alone. These physical conditions are particularly relevant for invertebrate species on the northern edges of their range: heathlands provide areas that are locally warmer between March and September, but may well be colder in the other months. This, to some extent, mimics a Continental climatic regime. Many of the species primarily reliant on the physical conditions are predatory and, where on the edge of their ranges, often listed in country Red Lists.

This consideration of typical invertebrate species of 4030 looks at a small number of representative species by invertebrate grouping, noting these two influences - physical conditions only and plant-association as appropriate.

Aranea - spiders. These are all predatory and hence associated with the physical conditions of 4030 and species are much more widespread in the southern parts of their range, especially where dry, sparsely vegetated grasslands are present.

- *Eresus* spiders (3 very closely related species). These spin tube webs and appear to be uncommon and restricted to 4030 and similar habitats throughout their range. Males are bright red, females black and larger. They are red-listed in several MS.
- *Philaeus chrysops*, a red-marked jumping spider. Although red-listed in several countries and associated with heathlands, it is not closely linked to these, but rather to sparsely-vegetated, rocky or sandy habitats generally. Its association with heathlands in the north of its range is due to its requirement for heat. In the south of the region it is widespread and common.
- *Cheiracanthium pennyi,* a sac spider, is similar. Whilst its two UK localities are very much classic 4030 habitats, it is much more widely distributed in dry, warm habitats elsewhere in Europe.
- *Oxyopes ramosus,* the lynx spider, lives on mature *Calluna vulgaris* in northern Europe. The species camouflages very well with Calluna branches.
- *Rhysodromus histriois* is another species adapted to mature heather.

Oxyopes ramosus. © Jørgen Lissner

Rhysodromus histriois. © Jørgen Lissner

Neuroptera - Ant Lions (and others). Ant Lions are all predatory. The larvae create small pits in sandy soil and lie in wait at the bottom for their prey to fall in. This means they are often associated with 4030 through the physical properties of the soils.

Orthoptera - Grasshoppers and crickets. This group of insects is strongly associated with warm places and many species are found on heathlands and other dry, warm habitats. Whilst *Chorthippus vagans* is known as the Heath Grasshopper in the UK, it is called the

Steppe Grasshopper elsewhere in Europe. Likewise, *Stenobothrus lineatus* is found on both 4030 and 6210 habitats, as is *Decticus verrucivorus*.

Lepidoptera - Butterflies and Moths. These have plant-feeding larvae, many of which are restricted to a few closely related plants (or even just one) and there are many associated very strongly with 4030.

- *Euphydryas aurina*, a looper caterpillar moth is Red Listed in Poland and is associated with northern and montane areas of 4030 where its food plant *Arctostaphylos uva-ursi* grows.
- *Anarta mrytilli*, a Noctuid moth, is very widespread on 4030 and largely restricted to this habitat where the larvae feed on the shoots of *Erica* and *Calluna*.
- *Entephria caesiata*, a looper caterpillar moth, feeds on *Erica*, *Calluna* and *Vaccinium* (all *Ericaceae*). It has a northern and montane distribution within 4030.
- Specialist moths of bearberry heaths (H16 in UK) include the netted mountain moth *Macaria carbonaria*, the small dark yellow underwing *Coranarta cordigera* and the bearberry case-bearer *Coleophora arctostaphyli*. These moths may also be found in 4060 Alpine and boreal heaths, but they occur throughout the altitudinal range of bearberry heath in 4030.
- *Plebejus argus*, a Blue butterfly, is well-known in the UK as being associated with *Lasius niger* group ants on 4030. However, it is also known to be associated with different ants of the *Lasius niger* group on a wide range of grassland types throughout Europe, and is present (rarely) in 6201 in the UK. This seems to be another case where the insect is much more habitat-specialised on the edges of its range.
- *Rhogades pruni* is a Zygaenid moth whose caterpillar feeds on *Vaccinium, Calluna* and *Andromada* (all *Ericaceae*). Although it is widespread in Europe, it is not known from the UK.
- The green hairstreak *Callophrys rubi* has larvae that feed on *Vaccinium myrtillus, Calluna vulgaris* and various other plants. The wide range of food plants means that this butterfly is able to use a wide range of habitats including heathland, moorland and clearings in woodland.
- *Endromis versicolora*, an Endromid moth, feeds on young birch in warm situations. It is widespread in montane situations, including 4030 habitat, but very sensitive to the successional transition to woodland. As such it is typical of the need for maintenance of a variety of successional stages of vegetation other than heathers.
- *Petrophora chlorosata,* a looper caterpillar moth, feeds on the roots of *Pteridium aquilinum*, a plant which is frequently considered a problem on 4030, especially in the Atlantic zone.
- *Maculinea alcon* is found in dry heaths in western Sweden's coastal areas.

Heteroptera - bugs. Mostly plant-sucking, but many are also predatory as well, some exclusively so; many are warmth-loving, maturing at the end of summer. Hence they depend on both the physical and vegetation characteristics of 4030.

- *Ulopa reticulata*, a plant-hopper, is a specialist feeding on heathers. It is restricted to NW Europe, so does not extend over all the areas of 4030 considered in this management plan.
- *Coranus sub-apterus*, an assassin-bug, is a predatory species associated with 4030.
- *Kleidocerys ericae*, a ground-bug, is closely associated with heathers, feeding through the stem and in the seed capsules.

- *Orthotylus ericetorum*, a capsid bug, feeds on the sap of heathers and is found in a range of micro-habitats within 4030.

Coleoptera - beetles. Both phytophagous and predatory species are typical of 4030.

- *Lochmaea suturalis*, a leaf beetle. The larvae feed on the leaves of *Calluna* and may cause extensive defoliation, especially when the plants are mature or over-mature. The adults fly in the spring and, at this time, form a large part of the potential food source for insectivorous birds living on 4030.
- *Micrelus ericae*, a weevil, feeds in the flowers of heathers.
- *Cicindela sylvatica*, a tiger beetle, has larvae which lie in wait in burrows for insects to pass overhead, whereupon they seize them. It is strongly associated with warm habitats and consequently closely associated with 4030, especially in the northern part of its range.
- *Neliocarus sus*, a vine weevil. This weevil has a larva that feeds on the roots of heathland plants and adults that are most often swept from heathers - suggesting that these are the main larval food-plants too.
- *Cryptocephalus punctiger*, a pot beetle. The adults feed on saplings, mainly birch, growing over heathers on 4030. The larvae feed on the dead leaves under these. Suitable saplings must not be at low density so as to maintain the warm conditions underneath.

In Spain, several Coleoptera endemic species (*Calathus asturiensis*, *Cryobius cantabricus, Nebria asturiensis and Pterostichus cantaber*) that are geographically restricted to the Cantabrian Mountains are found in heathlands dominated by *Calluna vulgaris*, *Erica australis* and *E. arborea* (Cuesta et al., 2006).

Diptera - flies. There are both predatory and herbivorous/detritivorous species on 4030, including the following species:

- *Nephratoma sullingtonensis*, a cranefly. The larvae fed in the humic layer under heathers on dry heathland growing on light, sandy soils.
- *Empis vitripennis*, a dance fly. This fly is frequently swept from flowering heathers but little is known about its biology. It has reportedly been bred from puff-ball fungi collected on a heathland.
- *Chrysotoxum octomaculatum*, a hoverfly. This is a scarce species throughout its European range and is, as far as is known, restricted to 4030. This may be through its association with particular ant species as its larvae feed on aphids associated with ant nests.
- *Lasiopogon cinctus*, a robber fly. The larvae of this fly are predators in loose, sandy soils and the species is consequently typical of 4030.
- *Thyridanthrax fenestratus*, a bee fly. This bee fly is a parasite on the pupae of a sand wasp, *Ammophila pubescens*, which is restricted to 4030 (see below).

Aculeate Hymenoptera - ants, bees and wasps.

Numerous bee species (and their cleptoparasites) are specialised in this habitat, many of which mainly collect pollen from heathers or other Ericaceae (genera *Calluna*, *Erica*, *Vaccinium* etc.). For example, in France, a study found 57 different bee, wasp, hoverfly and other fly species visiting *Calluna vulgaris*, and previous studies in Belgium and the Netherlands found similar species numbers (Descamps et al 2015). Many of these species are red listed at national level and European level. Some examples are:

- *Andrena fuscipes*, a mining bee, only collects pollen from the flowers of heathers and is hence largely restricted to 4030. *Andrena lapponica* is mostly associated with *Vaccinium* species on wet, dry and sandy heaths.
- *Colletes succinctus*, a mining bee, also only collects pollen from the flowers of heathers (although it may display some plasticity in response to environmental stresses).
- *Epeolus cruciger,* a cuckoo bee*,* is the specialist cleptoparasite associated with bees of the *Colletes succinctus* group and hence largely restricted to 4030.
- *Nomada rufipes*, a cuckoo bee, is a specialist cleptoparasite of *Andrena fuscipes* (but also of several other *Andrena* mining bees). It is most frequent on 4030.
- The bumblebees *Bombus jonellus* and *Bombus magnus* are most abundant on heathland and show a preference for heather flowers (though they occur in other habitats also).
- *Ammophila pubescens*, a sand wasp. This wasp only stocks its nest with the caterpillars of a few species of Geometrid moth larvae feeding on heathers, especially *Anarta myrtilli* (above).
- *Crossocerus wesmaeli*, a digger wasp. The nest of this species is almost always excavated in fine, sandy soils, hence it is most frequent on 4030. It stocks its nest with small flies.

Mollusca - slugs and snails[24]. Owing to their high requirement for calcium, snails are not a major component of heathland ecosystems.

- *Ponentina subvirescens* may frequent on the south-western Atlantic heaths of Great Britain and Ireland and a new species of *Ponentina* has recently been discovered in similar habitats in Portugal. Slugs are more frequent.
- *Arion ater,* a large black or orange slug is very conspicuous on heathlands after rain.
- *Geomaculatus maculosus***,** the Kerry Slug, is found in acidic habitats, including 4030, from Ireland to Spain. However, it is generally more associated with wooded habitats towards the south of the range. This mollusc is included on Annex IV of the Habitats Directive.

82 species of invertebrates of conservation concern are associated with lowland heathlands in England (Webb et al 2010). Most of them require bare ground and short vegetation typical of the earlier stages of succession. Ssymank et al. 1998 (revised edition for 2020 in prep.) and Offer et al. 2003 also provide extensive lists of typical species in heaths.

2.5.5 Mammals

Dry heaths are an important habitat for Mountain hare (*Lepus timidus*, Annex V species) in some European regions.

2.6 Ecosystem services and benefits

Heathland ecosystems are amongst the oldest cultural landscapes in Europe and host a huge proportion of the biodiversity typical of open, acidic sites. They are also landscapes of high conservation value.

[24] Contribution by Martin Willing, Conchological Society of Great Britain and Wales.

Besides the exceptional value that heathlands have from a nature conservation point of view, they provide important ecosystems services for society. The value attached to these services changed over time (Morán-Ordóñez et al. 2013). Today, carbon and nitrogen storage, groundwater recharge, or their appreciation as landscapes of high recreational value are becoming more and more important (van der Wal et al. 2014).

The biodiversity value and provision of selected ecosystem services (carbon storage, recreation, aesthetic and timber value) were analysed on patches of lowland heathland in the southern English county of Dorset (Cordingley et al. 2016). Carbon storage (t C/ha) was assessed by directly measuring the amount of carbon in the following carbon pools: vegetation, soil (to 30 cm depth), roots, humus and dead organic matter, on ten heathland sites. Carbon storage on dry heaths was 159 t C/ha, higher than the values measured on grasslands (137 t C/ha) and wet heaths (125 t C/ha), but lower than the values measured in woodland (244 t C/ha) and other scrub (181 t C/ha) (Cordingley et al. 2016).

Historically, being easily cultivated, 4030 habitats have been settled by humans since the beginning of agricultural systems. However, their poor retention of nutrients has resulted in the development of various systems to return these to cultivated areas, most notably plaggen, whereby heather turfs were cut and used to bed domestic stock with the resulting mix of manure and peat spread on the cultivated areas. Many cultural uses of 4030 habitats in England are recorded in Howkins, 1997.

The importance of dry heaths for wild pollinators is widely aknowledged, as also indicated by the long list of pollinator species included in the section on species associated to this habitat (see section 2.5.4).

On the other hand, one of the most widespread cultural uses of 4030 is the setting out of honey-bee hives during July to September when the heathers are flowering. The extensive and plentiful flush of pollen and nectar far outstrips the needs of the many natural insect inhabitants of heathland and this excess production has been well-used by man to provide both honey and wax products from honeybee hives as well as reserves to support the honeybees themselves over the winter period.

Ortigosa & Ojeda (2018) showed that dry heaths in Spain include species that bloom throughout the year, but one of the most important characteristics is the profuse blooming in the months of autumn and winter of the species *Calluna vulgaris* and *Erica australis*. This guarantees the presence of natural food for the bees during winter, which improves the quality of the hives. Therefore, dry heaths provide an important service to the apiculture of the region and are key to the survival of some important domestic pollinators in winter.

It is important to note, however, that domestic bees compete for resources with wild bees, so if the density of beehives is too high for the flower resources available, beekeeping might have an adverse effect on wild pollinator biodiversity.

Heathland as a pharmacy for bees

Interestingly, *Calluna* nectar acts as a prophylactic drug to prevent infection by a trypanosome parasite in bumblebees (Koch et al 2019). Lowland heath is thus providing an ecosystem service as a pharmacy for bees to manage their health.

Acknowledging and considering the ecosystem services when defining conservation objectives helps to elucidate the importance and the role of heathland for society and may increase public support and acceptance for the actions taken. Specific management arrangements may be needed to balance the different objectives and to guarantee active stakeholder participation. This involvement will not only be prompted by direct material or financial interests, but also by the value of a heathland as a place of personal appreciation and link with the landscape.

From a biodiversity conservation point of view, the motives to integrate objectives and to involve local communities in order to achieve them, can be summarized as 1) increasing the effectiveness of management of these complex systems, 2) increasing conservation policy effectiveness, and 3) increasing stakeholders' interest (De Blust, 2013).

Heathlands can indeed sustain the local economy, at least when all stakeholders providing services can operate in a level playing field and some public support compensates for the delivery of the non-tradable natural assets (Ozinga & Schrijver, 2013; Schrijver et al., 2013; Van der Heide et al., 2013). This challenge is valid for most of the cultural landscapes in Europe. Over half of the present Natura 2000 area in Europe has previously been farmed, is still farmed or is in a process of abandonment.

Most of the heathland habitat types are fully dependent on agricultural practices (Luick et al. 2012), which are today, in part of the heathland range, executed as conservation management measures. Supporting and adapting current functional relationships and revitalizing the former ones are thus important focal points for nature policy in general and for the local management plans in particular.

Dry heaths in Sierra del Aljibe, Southern Spain. © Fernando Ojeda

2.7 Geographic distribution

The information included in this section refers specifically to the distribution of the habitat type protected under the Habitat Directive "4030 – European Dry Heaths" and is based on the information reported by the Member States where the habitat type is present for the period (2007-2013)[25].

It must be pointed out that there are some issues with data quality in the Article 17 reports, so the information included in this action plan, which is based on that data must be taken with caution and considered indicative.

2.7.1 Distribution of 4030 at Biogeographical region and country level

The habitat type is present in 24 countries and included in biogeographic regions of the EU: Alpine (ALP), Atlantic (ATL), Black Sea (BLS), Boreal (BOR), Continental (CON), Mediterranean (MED) and Pannonian (PAN). The Atlantic region has the biggest surface area of this habitat type.

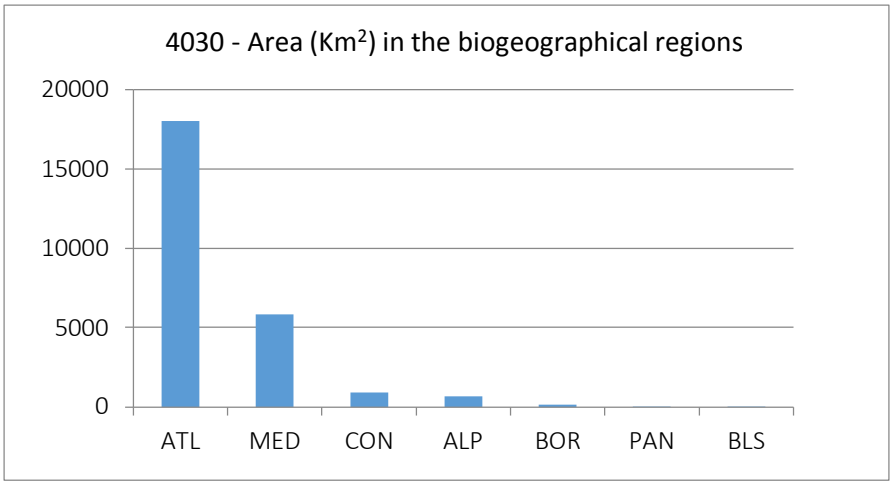


Figure 2: Coverage surface area (km^2) of 4030 in each biogeographical region according to Art. 17 reporting in the period 2007-2012; based on partial data, as data from some countries are missing

Although 4030 habitat is present in 24 countries in the EU, near 90% of its reported distribution area is within 5 countries. Spain is the country with highest area of 4030 in the European Union (11,722km^2), followed by UK (8,935 km^2), France (2,428 km^2), Ireland (1,094 km^2) and Germany (264 $km^{2)}$. The rest of countries have reported areas below 250 km^2 (in 2013).

The surface area and range were estimated for most of the countries based on partial data with some extrapolation and/or modelling. Data are missing in the Atlantic and Mediterranean regions for Portugal, in the Alpine region for Austria and in the Atlantic region for Germany.

[25] EU Member States report on the distribution and conservation status of all EU habitat types included in the Habitats Directive every six year, in accordance with the Article 17 of the Habitats Directive. The Article 17 Dataset contains tabular data reported by Member States for the 2007-2012 period. Croatia (HR) did not submitted the Art. 17 report in the last period and for this reason data from HR are not included in this action plan. For Germany, in the 2007-2012 reports, the area in the Atlantic region is missing.
Article 17 Dataset is available at: https://www.eea.europa.eu/data-and-maps/data/article-17-database-habitats-directive-92-43-eec-1/article-17-database-zipped-ms-access-format

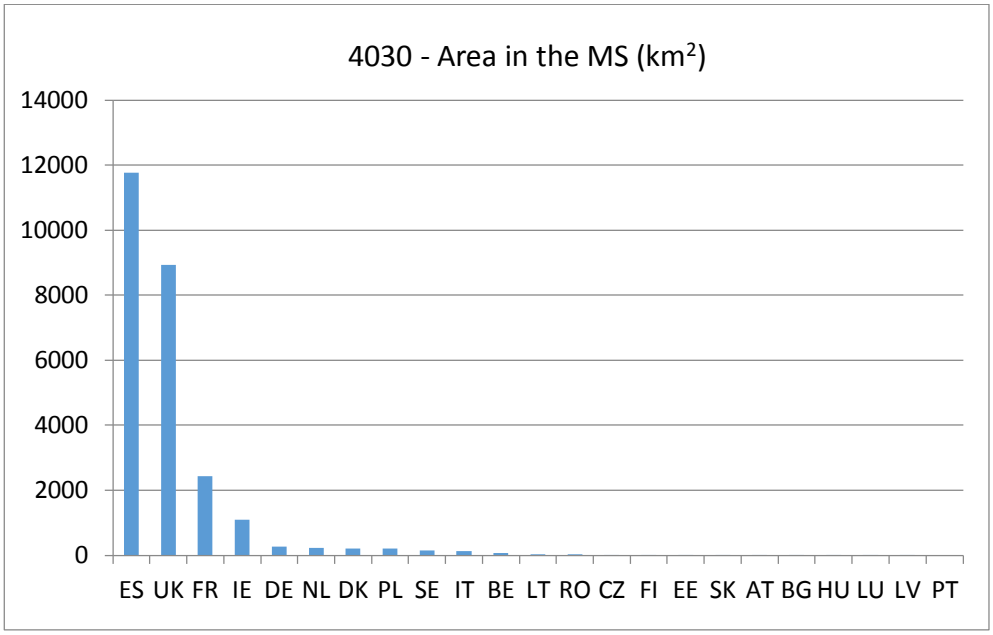


Figure 3: Coverage surface area (km²) of 4030 in the Member States (according to Art. 17 reporting in the period 2007-2012)

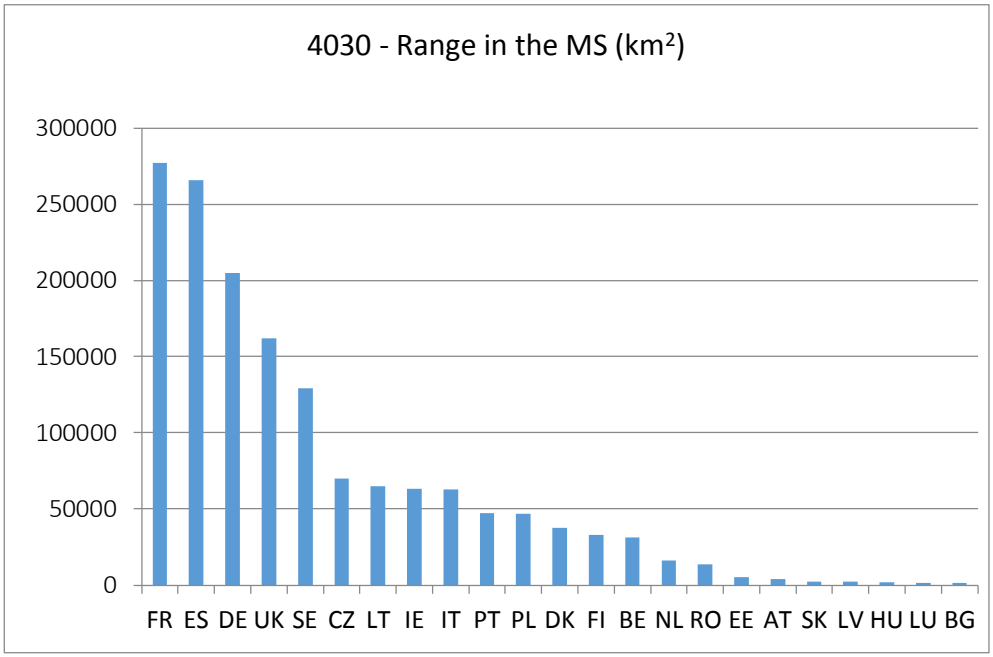


Figure 4: Range surface area (km²) of 4030 in the Member States (according to Art, 17 reporting in the period 2007-2012)

In every Member State the trend of the surface area was reported for each biogeographical region (2007-2012 period). The trend in surface area was reported as decreasing in more than 25% of the assessments (10/38). In more than 40% of the assessments the trend was stable. Only in 8% of the assessments an increasing trend was reported. There is however no information about the trend in surface area of this habitat in 24% of the assessments.

Changes in surface area reported from the previous period (2001-2006) are due to better knowledge/data or use of different method in most of the cases.

Trends are decisive for the assessment of conservation status and attention should be paid to the methodology of surveillance systems to improve the quality of trend information.

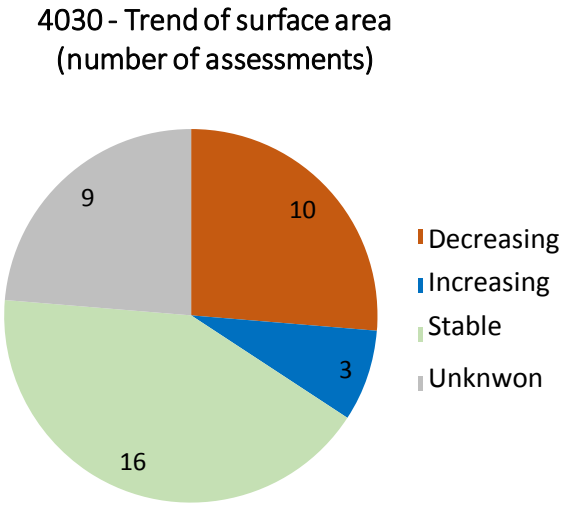


Figure 5. Trend of area of 4030 habitat type: nr. of assessments reported in each trend category

2.7.2 Distribution of 4030 in Natura 2000

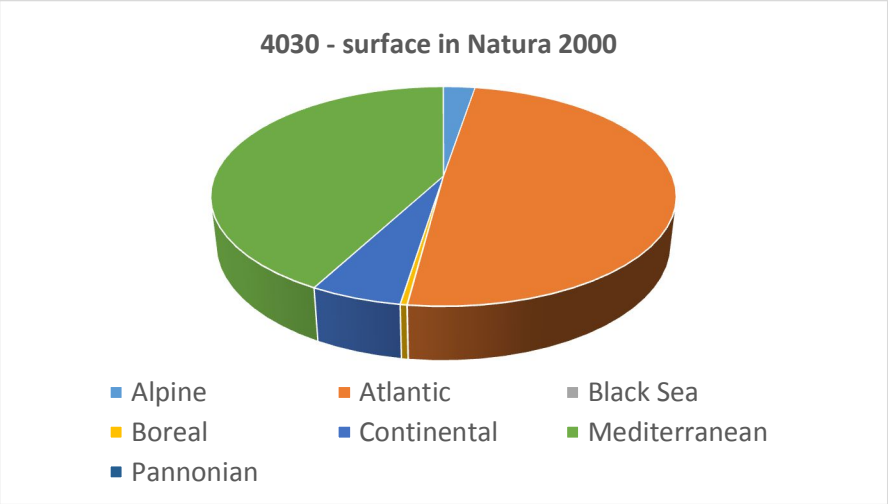
The following data have been extracted from the Natura 2000 database (European Commission, 2017). The habitat surface in the database is estimated from the habitat cover indicated in the Standard Data Form for each site (as a rough estimate of the % of the site covered by the habitat) and should be therefore considered only indicative of the habitat surface included in Natura 2000.

There are 2,095 Natura 2000 sites where 4030 is reported with significant presence[26]. Nearly 40% of the total surface area of habitat 4030 in the EU is included in Natura 2000. The regions where the greatest surface area of 4030 within Natura 2000 sites are the Atlantic and the Mediterranean. The Continental region has however the highest number of sites where 4030 is present.

Table 3. Surface area (ha) of 4030 within Natura 2000 sites in each biogeographical region (Natura 2000 database, 2018)

Biogeographic region	Number of Natura 2000 sites	Estimated surface in Natura 2000 (ha)
Alpine	132	33,570
Atlantic	826	637,355
Black Sea	2	196
Boreal	127	5,054
Continental	1004	69,164
Mediterranean	340	543,026
Pannonian	15	288

[26] Without including the sites where the habitat type is reported with Representativity D: non-significant presence.



Spain is the country with highest area of this habitat type in Natura 2000 sites. When looking at the number of sites with 4030 presence however, Germany has the highest number of designated sites but these sites have a small presence of the habitat, partly because the average size of sites in Germany is relatively small.

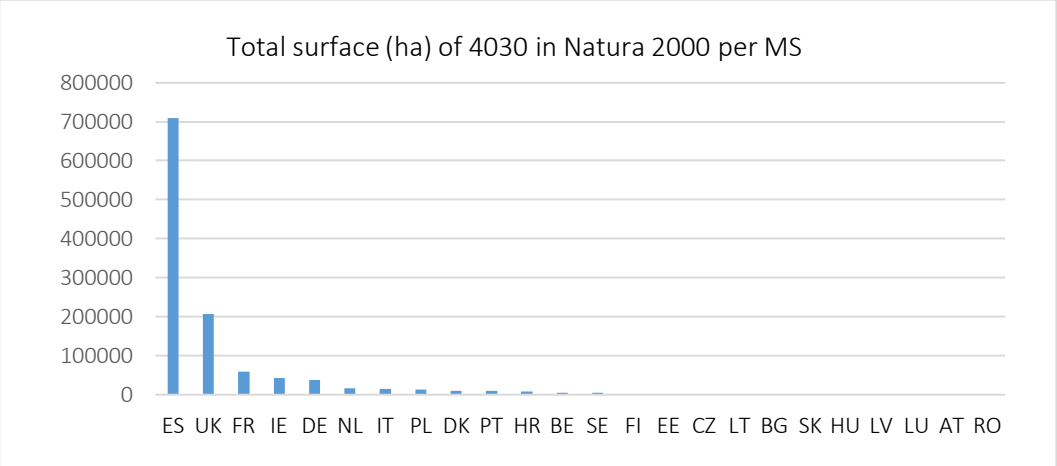


Figure 6: Surface of 4030 in in Natura 2000 in the Member States

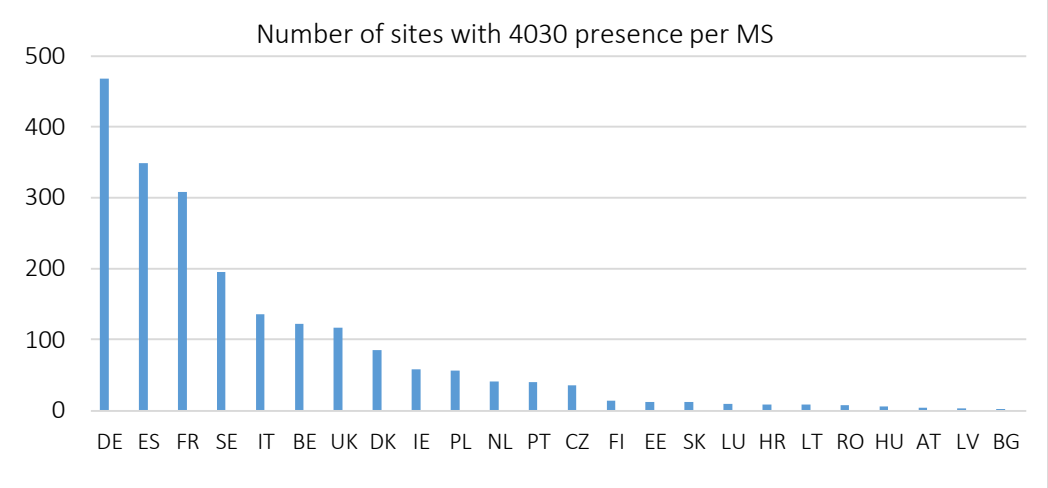


Figure 7: Natura 2000 sites with presence of 4030 in the Member States

The total area of the habitat and its surface in Natura 2000 can also be obtained from the Article 17 reporting dataset (2013), as shown in Table 4 below.

Table 4. Area of 4030 habitat in Natura 2000 (from Art. 17 Dataset, 2013)

Biogeo Region	Country	4030 Total area (km2)	4030 area in Natura 2000 (km2)	% in Natura 2000 (indicative – inaccurate data)
ALP	AT	NA	NA	-
ALP	ES	85.0	53.0	62.4
ALP	FR	550.0	96.0	17.5
ALP	IT	5.9	5.0	85.0
ALP	RO	20.0	17.0	85.0
ALP	SK	1.5	1.4	93.3
ATL	BE	47.5	40.0	84.2
ATL	DE	NA	127.6	-
ATL	DK	142.0	70.0	49.3
ATL	ES	6,024.0	2,852.0	47.34
ATL	FR	1,553.0	213.0	13.72
ATL	IE	1,094.2	630.7	57.64
ATL	NL	227.0	170.0	74.89
ATL	PT	NA	NA	-
ATL	UK	8,935.4	2,076.4	23.24
BLS	BG	1.2	1.2	100.00
BOR	EE	11.6	11.0	94.83
BOR	FI	15.0	11.0	73.33
BOR	LT	20.0	4.5	22.50
BOR	LV	0.2	0.2	100.00
BOR	SE	59.0	18.1	30.68
BOR	LV	0.2	0.2	100.00
CON	AT	3.0	2.0	66.7
CON	BE	20.5	18.0	87.8
CON	CZ	17.8	6.6	37.2
CON	DE	263.6	246.8	93.7
CON	DK	58.0	26.0	44.8
CON	FR	213.0	213.0	100.0
CON	IT	58.7	44.0	74.9
CON	LU	0.4	0.1	16.3
CON	PL	200.0	110.0	55.0
CON	SE	73.0	26.6	36.4
MED	ES	5,663.0	2,298.0	40.6
MED	FR	111.6	111.6	100.0
MED	IT	55.1	55.1	100.0
MED	PT	NA	NA	
PAN	CZ	0.3	0.3	86.2
PAN	HU	0.5	0.4	80.00
PAN	SK	5.4	5.2	96.30
TOTAL	EU	25,536.3	9,561.8	37.4

Note: Missing data for DE in ATL; AT in ALP; PT in ATL and MED regions.

3. CONSERVATION STATUS, THREATS AND PRESSURES

3.1 Conservation status and trends

The conservation status is unfavourable and deteriorating in most of the habitat range, according to the reporting by Member States for the periods 2007-2012 and 2013-2018. Conservation status inside the Natura 2000 network is better than outside (38.3% of the habitat surface in Natura 2000 is in excellent conservation status, around 50% is in good conservation status and 11% is in less than good conservation status). The use of harmonized methods should be proposed to allow comparison of conservation status assessments, at least between countries belonging to the same biogeographical region.

The information included in this section is mostly based on data reported by Member States for the 2007-2012 and 2013-2018 periods and included in the Article 17 Dataset[27].

The methodology used for assessing conservation status depends on data from a variety of sources. Ideally, the data would have been collected during the reporting period, using comparable methods across all Member States. However, Member States have used data collected for diverse purposes and over varying time periods. In many cases, suitable data do not exist and expert opinion has been used to allow assessments to be made.

3.1.1 Conservation Status at the biogeographical and Member State level

The conservation status of European dry heaths (4030) was unfavourable in all the biogeographical regions, according to the reports submitted by the Member States for the 2007-2012 period: unfavourable-inadequate (U1) in Alpine, Black Sea, and Mediterranean regions and unfavourable-bad (U2) in Atlantic, Boreal, Continental, and Pannonian regions. Its trend was either stable (4 regions) or deteriorating Boreal, Continental and Pannonian regions).

Table 5: Conservation status of 4030 by Biogeographical region in the period 2007-2012
(Source: Art 17 Dataset, 2013)

Region	Range	Area	Structure & Funct.	Future prosp.	**Current CS**	Trend in CS	**% in region**	Previous CS
ALP	U1	U1	U1	U1	U1	=	2	U1
ATL	FV	U1	U2	U2	U2	=	39	U2
BLS	FV	FV	U1	U1	U1	=	0.13	XX
BOR	U1	U2	U2	U2	U2	-	10	U2
CON	U1	U2	U1	U2	U2	-	30	U2
MED	FV	FV	XX	U1	U1	=	19	U2
PAN	U1	U2	U1	U2	U2	-	0.4	U2

Favourable	FV	Unknown	XX	Unfavourable - inadequate	U1	Unfavourable - bad	U2

Trend: (+) improving (-) deteriorating (=) stable (x) unknown (n/a) not reported

[27] https://www.eea.europa.eu/data-and-maps/data/article-17-database-habitats-directive-92-43-eec-1/article-17-database-zipped-ms-access-format. Croatia (HR) did not provided the Article 17 report in the last period and for this reason data from this country are not included in this section. It must also be noted that there are issues with data quality in the Article 17 reports, so the information included in this section must be taken with caution and considered only indicative.

A map with the distribution of 4030 and its overall conservation status (as reported in 2013) is given in Figure 8 below. The map shows both Conservation Status and distribution using a 10 km x 10 km grid. Conservation status is assessed at biogeographical level. Therefore the representation in each grid cell is only illustrative.

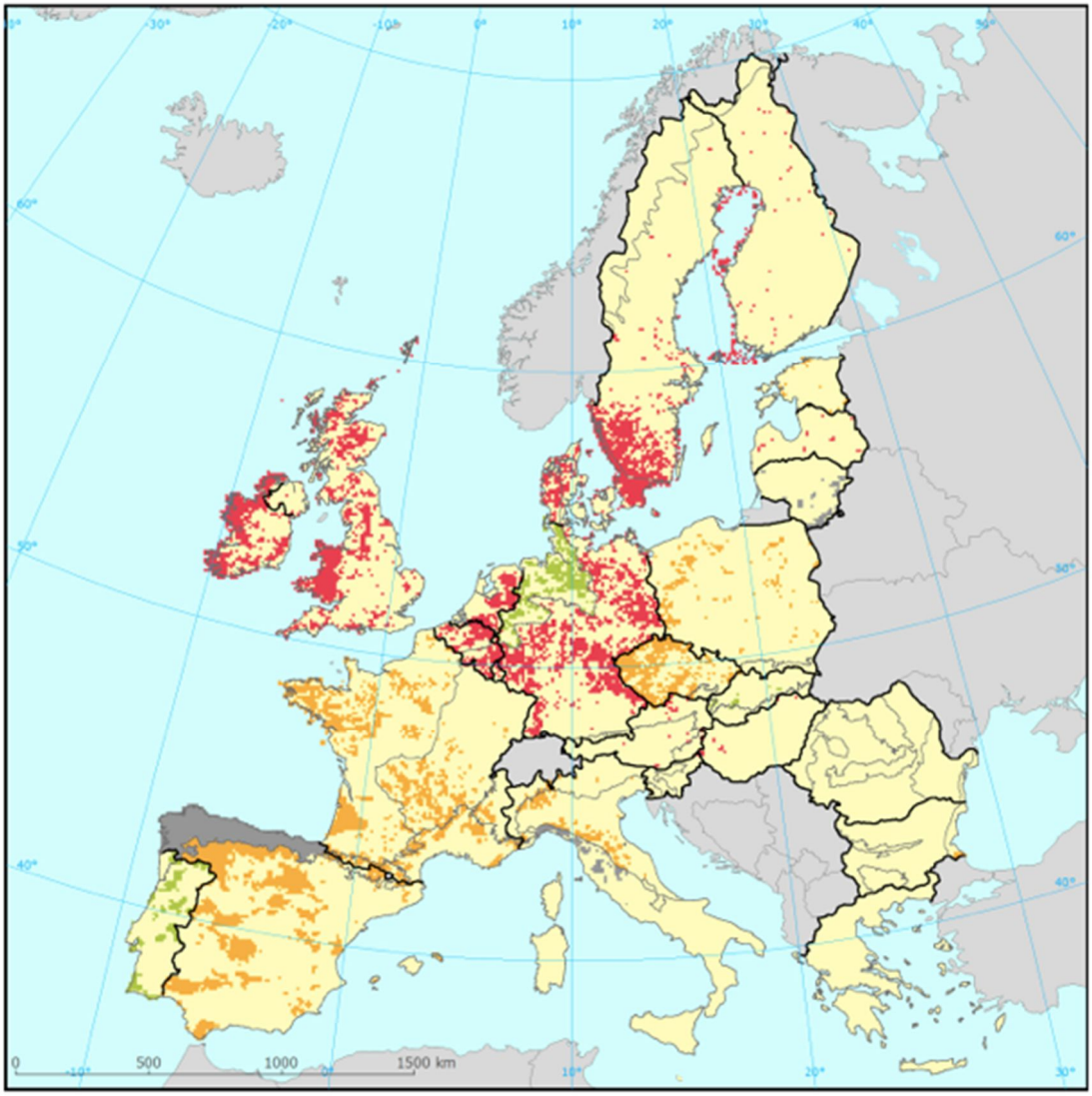


Figure 8. Map with distribution of 4030 and conservation status at MS level (except Croatia) Note: red represents unfavourable-bad status (U2), orange is unfavourable-inadequate (U1) and green is favourable-FV)

In the EU Red list of habitats (Jansen et al. 2016) dry heaths were assessed as vulnerable (VU) both at EU28 and for Europe (EU28+).

The conservation status reported in each Member State at then biogeographical level for the last two periods (2017-2012 and 2013-1018) is included in the Table 6 below.

Conservation status is mostly unfavourable and has deteriorated in some cases, as in Portugal (Atlantic region) and Italy (Continental region). In some areas however it has improved like in Spain and Italy in the Alpine region, and in Estonia in the Boreal region.

At MS level, conservation status is also unfavourable in most of the assessments. The only favourable assessments were reported for Romania in the Alpine region, Slovakia in the Alpine and Pannonian regions, Germany in the Atlantic region and Portugal (Atlantic and Mediterranean regions).

Table 6. 4030 Conservation status and trends (Art.17 reports)

BIOGEOG. REGION	MS	2007-2012	2013-2018
ALPINE	AT	U2x	U2x
	ES	U1=	FV =
	FR	U1=	U1+
	HR	NA	U1x
	IT	U1=	FV+
	RO	FV	FV=
	SK	FV	FV=
ATLANTIC	BE	U2=	U2 x
	DE	FV	FV
	DK	U2=	U2 -
	ES	XX	U1=
	FR	U1=	U1-
	IE	U2=	U2=
	NL	U2=	U2=
	PT	FV	U1-
	UK	U2=	U2+
BLACK SEA	BG	U1=	U1=
BOREAL	EE	U1=	FV=
	FI	U2-	U2=
	LT	XX	U2=
	LV	U2x	U1x
	SE	U2-	U2-
CONTINENTAL	AT	U2x	U2 x
	BE	U2+	U2 +
	CZ	U1-	U1 -
	DE	U2=	U2 -
	DK	U2=	U2 -
	FR	U1-	U2x
	HR	NA	U2x
	IT	U1-	U2=
	LU	U2-	U2-
	PL	U1=	U1=
	SE	U2-	U2-
MEDITERRANEAN	ES	U1=	U1x
	FR	U1=	U1=
	IT	XX	U1-
	PT	FV	FV=
PANNONIAN	CZ	U1-	U1=
	HU	U2-	U2-
	SK	FV	FV=

3.2 Conservation status of the habitat in Natura 2000 sites

The conservation degree of each habitat is reported in the Natura 2000 Standard Data Form for each site where the habitat is present according to the following categories:

- A: Excellent conservation
- B: Good conservation
- C: Average or reduced conservation.

The figures below show the conservation degree of the habitat in Natura 2000 sites, as percentage of the habitat surface in the different categories in each biogeographical region, based on the information included in the Standard Data Form for each site where the habitat is present.

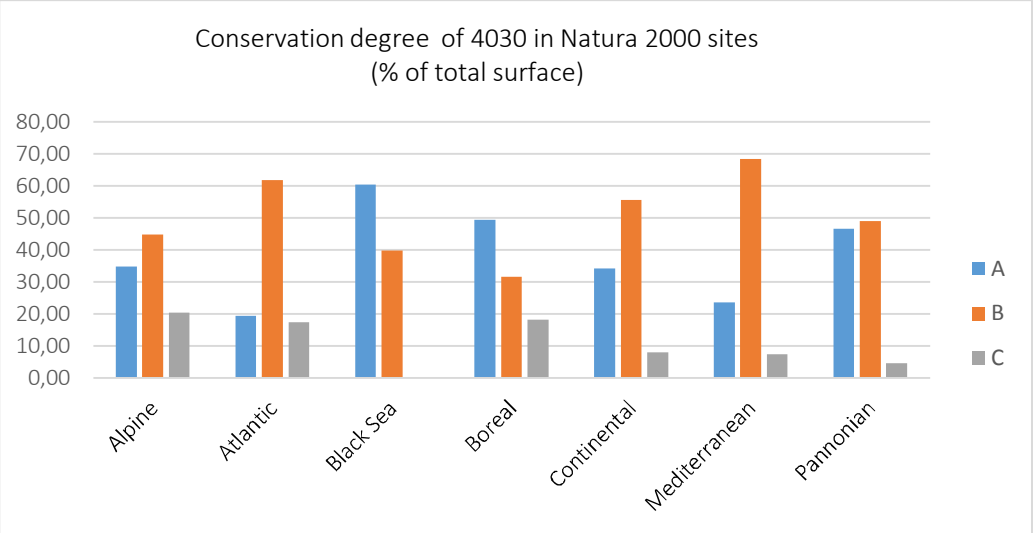


Figure 9. Percentage of total surface of the habitat 4030 in each class of conservation degree in Natura 2000. A: excellent, B. good, C: Average or reduced.

Overall, 39% of the habitat surface in Natura 2000 is in excellent conservation status, around 50% is in good conservation status and 11% is under reduced conservation status.

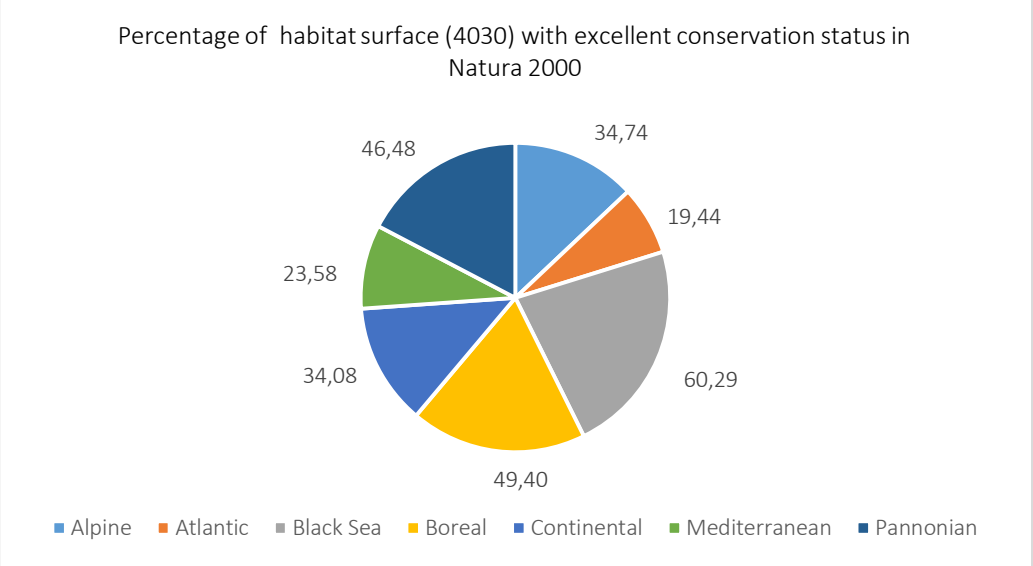


Figure 10. Percentage of habitat surface with excellent conservation degree in Natura 2000 sites for each biogeographical region

3.3 Methodologies for conservation status assessment

Member States undertake surveillance of the conservation status of the natural habitats and species, according to Article 11 of the Habitats Directive and these should be the basis of the Article 17 assessments[28].

Member States have developed methodologies for assessing conservation status of habitat types and species of Community interest or are in the process of developing/ improving such methods (see also chapter 6 on Monitoring). These methods usually define criteria and threshold values for the key parameters (range, area, structure and function, etc.) that indicate whether the habitat type is in a favourable conservation status (FCS).

The methods and systems implemented by some MS to assess conservation status of this habitat type are described in Annex 1.

The harmonisation of methods for conservation status assessment would be ideal but difficult to implement because there are different systems already in place in the Member States. A possible approach would be to identify common parameters and how to measure them more uniformly.

There are some structural and functional attributes that are common or similar in the different methods applied for conservation status assessment of European dry heaths, which are summarised in Table 7 below.

Table 7. Structural and functional attributes and variables commonly used in conservation status assessment in different Member States

Key parameters	Examples of attributes
Habitat structure condition	Coverage of bare ground and of ericoids (Belgium, Germany) Figure 6: Surface of 4030 in in Natura 2000 in the Member States Presence of the different *Calluna vulgaris* phases of growth (Belgium, Germany, Denmark) *Calluna* coverage (Poland) Presence of various age stages of key species (positive), status of species important for biodiversity (Poland) Percentage cover of four layers: moss layer, herb layer, shrub layer, tree layer (Slovakia, Denmark) Total % ground cover of *Calluna* and/or other typical species; number and frequency of *chamaephyte* and typical species; occurrence of endangered and/or protected species (Italy) Abundance of post-fire recruitment (Spain) Vegetation structure, including bare ground and mosaics with other habitats; cover of ericoids (UK, Germany, Denmark)
Species composition	Number of typical species, ratio of species from the series (Belgium) Number of characteristic and indicator taxa (Slovakia) Abundance and richness of perennial species, abundance of key

[28] Reporting under Article 17 of the Habitats Directive. Explanatory Notes and Guidelines for the period 2013–2018. Final version, May 2017.

	species (endemics or strongly associated to the habitat) (Spain) Frequency of typical species (graminoides, herbs, lichens and bryophytes) (UK, Germany) List of grasses, sedges, herbs, shrubs and trees and presence of mosses/lichens within a 5 m diameter circle. Additional list of typical species, Annex II plant species, invasive species and red listed species from outside the circle (Denmark).
Indicators of negative trends	Coverage of trees and shrubs, grasses and bracken, presence of exotic species, eutrophication indicators, soil disturbance (Belgium, Germany) Occurrence of expansive taxa and neophyte alien taxa (Slovakia) Defoliation damage (Spain) Degree of forestation, nitrophilous species presence, occurrence of invasive tree species and alien species (Italy) Grass coverage, tree coverage, alien and native expansive species (Poland) Above-threshold coverage of trees and shrubs, grasses and bracken, presence of exotic species, eutrophication indicators, soil disturbance (UK) Nitrogen deposition: estimated xx% exceeding site relevant critical loads (England)
Other abiotic features	Soil pH (Spain) Hydrology, air quality (England)

It would be advisable to include connectivity (or lack of it) as a structural and functional attribute in the assessment of this habitat type, taking into account the fragmentation problems it faces in many areas across its range.

It must be taken into account that heathland is a dynamic habitat which undergoes significant changes in different successional stages, from bare ground (e.g. after burning or tree clearing) and grassy stages, to mature, dense heath and further into scrub and woodland. These different stages often co-occur on a site providing a mosaic that support rare and specialised species.

The species associated with the habitat require the presence of a diverse structural vegetation including bare ground and mosaics of short and tall vegetation and other features. Their presence and numbers are important indicators of habitat quality. The woodland and scrub components, including, for instance, common gorse *Ulex europaeus*, can have value in their own right (e.g. for birds) and as part of the succession but they often pose a management problem.

Heathland is usually a landscape-scale habitat that occurs in association with acid grassland, scrub and woodland. These other habitats are often included within the mapping of the heath extent. Mapping a habitat mosaic can present significant difficulty.

Example. Conservation status assessment and monitoring in Germany

In Germany, specific assessment schemes were developed by 2007 with habitat experts for every single habitat type, especially targeting the parameter structure and functions, but also giving information on threats and pressures. These assessment schemes are used for Art. 11 monitoring, as well as at local or site level to assess the degree of conservation.

Major parameters used for 4030 are:

1. completeness of typical habitat structures (completeness of development phases and percentage of open patches of sandy soil);
2. completeness of the typical species inventory (so far for *Calluna* heath based on plant species only) and
3. important threats. The latter include as indicators for *Calluna* heaths the percentage of negative indicator species (neophytes, ruderal species or nitrophytes), percentage of direct visible trampling, percentage of shrubs or trees or afforestation and percentage of grass dominance or invasion into heaths; it allows the reporting of additional negative impacts.

In the Atlantic and the Continental biogeographical regions a set of 63 samples from each is monitored in every 6 year period of the reporting.

For all habitats, the assessment schemes were revised in 2010 and again in 2017, with a detailed quality check after the 2013 reports. They were adapted and updated by scientific experts and agreed with the German Federal States. They are available online and include substantial lists of typical plant species (65 species) of typical mosses (8 species) and lichens (20 species) These species lists include species which are only present in some subtypes and are not spread evenly over the geographic distribution of the habitat. Therefore the Federal States may use regional modifications in the assessments.

BfN & BLAK 2017. https://www.bfn.de/themen/monitoring/monitoring-ffh-richtlinie.html

3.3.1 Favourable Reference Values

In general, there are no well-defined FRVs for habitat 4030 in most countries. A recent study supported by the European Commission has proposed methodologies for the definition of FRVs for species and habitats included in the Habitat Directive (Biljsma et al. 2018). Some countries are currently working on the definition of FRVs for their EU habitat types.

Improved habitat mapping, understanding of historical development, range and extent, and consideration of habitat connectivity are considered important aspects to be taken into account when defining FRVs for this habitat type.

Possible long term negative impacts of fragmentation and other threats need to be quantified before FRV can be estimated for this habitat type, in particular in the Continental region. When the habitat type becomes highly fragmented, its historical distribution is important to estimate FRVs.

It must be acknowledged however that FRVs are very difficult to define for habitat types and further guidance on setting them is required. It is also necessary to take into account that setting FRVs for one habitat is likely to have implications for others.

3.4 Threats and pressures

3.4.1 Identification of main threats and pressures for the habitat

Member States report the most important threats and pressures for each habitat type using an agreed hierarchical list under Article 17 of the Habitats Directive. Pressures are activities that are currently having an impact on the habitats and threats are activities expected to have an impact in the near future.

Main threats and pressures identified in the 2007-2012 Article 17 of Habitat Directive reporting period were similar in all biogeographical regions[29] and are coincident with those identified by the national experts during the elaboration of this action plan.

The main pressures and threats reported in all biogeographical regions were: grazing by livestock (both undergrazing and overgrazing) and vegetation succession. Afforestation, air pollution, air-borne pollutants, and both fire and fire suppression were also identified as important threats for this habitat type. Other pressures and threats were also indicated, such as modification of cultivation practices, invasive alien species and other changes in ecosystems.

The key threats identified for dry heaths in the European Red List of habitats (Eionet 2016) are the same: scrub encroachment due to abandonment or decrease of traditional uses such as mowing and grazing, intensification of agriculture and related nutrient enrichment, airborne pollution, afforestation, and wildfire. Climate change, in particular warming, may increase the risk of losses due to wildfires.

Fagúndez (2013) identified the drivers of biodiversity loss affecting heaths by reviewing literature. The main negative drivers that trigger these changes include land-use changes (i.e. habitat destruction and fragmentation), pollution, climate change, natural succession and human management, as well as the presence of invasive exotic species.

A description of the main threats and pressures identified for this habitat type is presented below.

3.4.2 Abandonment of traditional grazing and unsuitable grazing by livestock

The abandonment of agricultural practice in rural areas and, therefore, lack of grazing represents one of the most important threats for this habitat type. The cessation of grazing leads to succession and secondary forest expansion.

For instance, the dry heaths of Wallonia, previously grazed by domestic livestock or occasionally burnt and cultivated, have suffered from a long period of abandonment (since the second half of the 19th century). Many are currently afforested by natural succession.

In Italy, successional changes caused by the widespread abandonment of traditional management which removed biomass (through more or less occasional mowing and grazing, litter removal etc.) represent a problem for the conservation of this habitat type in the Continental region.

[29] There were however inconsistencies in how countries reported threats & pressures making comparisons difficult. The guidance to report threats and pressures was revised and the standardized "List of pressures and threats" updated for the latest reporting period (2013-2018) to avoid previous inconsistencies in how countries reported them in order to facilitate the comparisons.

Abandonment of traditional management substantially acts to favour and accelerate succession, so that the first effect on habitat structure and functions is the rapid decrease of *Calluna* abundance and other shrubby species due to the spreading and shading of larger shrubs and trees. The decrease of *Calluna*, with eventual disappearance, is accompanied by a loss of heliophilous species. Further along the successional process, initially low nutrient soils gradually accumulate organic matter originating with the decomposition of litter in the top-layer. This process may favour larger grasses (e.g. *Molinia* or *Deschampsia* spp.), bracken or gorse. Further succession after ceasing disturbances leads to scrub and tree expansion (e.g. *Pinus sylvestris, Betula pendula*; in some cases also common broom *Sarothamnus scoparius*).

In Romania, European dry heaths are a pioneer habitat type and there is a high risk of *Betula pendula* or *Salix caprea* invasion, which will accelerate the changes in species composition and vegetation succession towards forests.

In Spain during the last century the traditional management of these communities by use as summer grazing with flocks of merino sheep and cutting of vegetation for fuel, nearly disappeared in the Cantabrian Mountains due to changes in agricultural practices and other socio-economic reasons. In this area, heathlands and other shrub dominated vegetation types were regularly cut and burnt to provide pasture (Calvo *et al*.2002, 2005). The lack of traditional management (grazing systems with transhumance flocks) sometimes also using fires to generate pasturelands has negatively affected the conservation of *Calluna* heathlands, which are invaded by other species like *Cytisus oromediterraneus*.

Lack of grazing is also a problem in a number of cases in the UK, mainly in lowland heathland sites.

Dry heathland- Ash Ranges, Surrey © Natural England, Des Sussex.

On the other hand, overgrazing can represent a pressure for this habitat in some areas. For example high levels of grazing (mainly sheep grazing) is considered problematic for this habitat type for instance in Ireland. Damage by deer grazing is also mentioned in Ireland, where culling of dear is required as a positive conservation measure, e.g. in some National Parks.

In the UK, overgrazing by livestock (mainly sheep) and/or deer can be a threat for this habitat type in some areas, mainly in the uplands. The impacts of herbivores interact, and the removal of sheep can result in expanding deer populations and continued grazing impact on heather, unless deer pressure is also controlled. Overgrazing, especially in winter, has a negative effect on vegetation structure and composition, generally favouring grasses over dwarf shrubs, and this effect can be magnified when also associated with inappropriate burning. Overgrazing in general has a negative effect on the habitat, and especially where there is supplementary feed or other source of additional nutrient input, as it influences the naturally low nutrient levels and the acidic soils which are crucial for this habitat structure and function.

3.4.3 Eutrophication and nitrogen deposition

Soil eutrophication by agriculture fertilisation and increased atmospheric nutrient deposition is an important threat to this habitat, which is strongly associated with infertile soils. Nitrogen addition affects the stress sensitivity of *Calluna* (Power et all., 1998) and hence decreases its dominance in vegetation cover. Eutrophication leads to the spread of plants with a higher production of biomass. It essentially acts by accelerating successional processes, but it can also lead to permanent alteration/change of the ecology of the habitat.

Air-borne nitrogen deposition is considered one of the main threats to this habitat type in Belgium, Denmark, Germany, Ireland, Italy, Poland, Spain, the Netherlands and the UK (Diemont et al., 2013c).

The critical load has been estimated in Germany between 8 and 21 kgN/ha/year (SMB method, Balla et al. 2013. Loads ACLBB-LFC 2014), empirical critical loads are between 10 and 20 kgN/ha/year (Bobbink & Hettelingh 2011, Baden-Württemberg ACl 2019). However, the actual input in several regions exceeds these limits considerably, with up to 60 kgN/ha/year. With such large air-borne nitrogen pollution, even grazing or mowing cannot counteract the nutrient input (Härtle 2006) and controlled burning or removal of top soil is sometimes the last possibility. The problem is not only NOx-pollution from combustion but also increasingly NH_3-emmissions from agriculture, which need to be dramatically reduced (mainly fertilizers, and intensive animal breeding). NH_3 critical level is estimated at 2-3 micrograms/cubic meter air. This is especially important for typical mosses and lichens as nitrogen enters and damages the tissues directly.

Diffuse eutrophication (by air-borne pollutants or adjacent cultivated fields or grasslands) in Belgium causes the extension of long-lived nitrophilous species (e.g. *Deschampsia flexuosa* is dominating dry heath over large areas in the north of Belgium).

Nitrogen deposition causes major reductions in plant richness (Britton and Ross, 2018, Field et al 2014) and may also encourage more nutrient-demanding species such as grasses (Britton et al. 2001; Friedrich et al. 2011; Southon et al. 2013).

Field-scale surveys and N-manipulation experiments testing the effects of a variety of N-loading rates over different temporal scales in Spain have evidenced substantial N-driven changes in the composition, diversity and functioning of nutrient-poor *Calluna vulgaris* heathland (Calvo et al., 2005, 2007). Increased N inputs alter a multitude of heathland characteristics such as soil and litter properties (e.g., nutrient availability, enzyme activities or microbial biomass) or plant traits (e.g., growth, flowering, tissue and litter chemistry) or plant susceptibility to biotic (e.g., *Lochmaea suturalis* –heather beetle) (Taboada et al., 2016) and abiotic (e.g., frost or drought) stressors.

Elevated N inputs stimulate N mineralization rates, resulting in enhanced soil N availability. N accumulation in heathland ecosystems promotes enhanced rates of nutrient uptake by *Calluna* plants and subsequent increases in foliar tissue N and P contents (Calvo et al., 2007), as well as increases in litter N and P contents (Calvo-Fernández et al., 2018). Some studies also highlight the relevance of taking into account the age of vegetation when investigating the responses of the plant-soil-microbial-enzyme system of heathlands to cumulative N loading. *Calluna* stands in the mature phase of development have lower plant tissue N and P contents and litter N content than young ones, owing to higher nutrient demands and uptake rates by mature *Calluna* plants with more above-ground biomass. These greater nutrient demands of mature *Calluna* plants possibly lead to (1) lower N content in the soil microbial biomass and (2) greater root mycorrhizal colonization by ericoid fungi under high N availability.

Alonso *et al* (2001) investigated the interactions between Nitrogen deposition and grazing. This study showed that appropriate management of *Calluna* moorlands by regular burning and the prevention of overgrazing helps to maintain a young and healthy *Calluna* canopy and it may also prevent grass invasion, even under increasing nutrient inputs, by allowing *Calluna* to eventually overtop potential invading grass species and outcompete them for light.

3.4.4 Afforestation, forest plantation and succession

Both afforestation and natural tree colonisation, represent important problems for the conservation of European dry heaths in many countries, but especially in the Mediterranean region. In addition, there are sometimes practical or legal obstacles for restoration, such as preservation or compensation rules for forests after succession due to abandonment of management of heathlands.

Afforestation, mainly with conifer species (including non-native species), is considered a threat for this habitat type in Belgium, Bulgaria, Czech Republic, Ireland, Italy, Slovakia and the UK. In Germany most of the large losses of heathland are historical and happened long before the Habitats Directive came into force. In some sites *Prunus serotina* is invading the *Calluna*-heathland and makes management very costly. Counteracting the regrowth of cut *Prunus serotina* by grazing/browsing with (Heck) cattle seems to be effective (Seifert et al. 2015).

Besides afforestation and succession, changes in species composition with a loss in quality can be observed with dominance of grasses due to eutrophication and in some regions *Calamagrostis epigejos* can become dominant and outcompete many of the typical species of *Calluna* heaths, especially in places where there is a loamy component to the soils and the sands are more nutrient rich.

In Spain, commercial afforestation with pines and eucalyptus is considered a main pressure and threat for this habitat in some areas. Many afforestation practices were implemented in the past either to provide potential economic benefits from a supposedly unproductive habitat or even to restore what was considered a 'tree-less' degraded vegetation. Plantations have had negative effects on Mediterranean heathlands. Abandoned pine plantations become dense and shade out heathland species. Moreover, the dense tree cover and the thick layer of needle litter represent a serious risk for uncontrolled, severe wildfires (Gómez-González et al. 2018; Ojeda 2018). Besides, the strong change of the structure of dry heathlands caused by afforestation (Andrés & Ojeda 2002) may also threaten their associated fauna.

In Poland, the main cause for the decrease of the habitat area has been afforestation. In some regions, there is evidence of a decrease from ca. 20% to 1% in the last 10 years (Kunz et al. 2008).

Sometimes other policies like the Scottish woodland expansion plan can create possible conflicts between priorities and nature conservation objectives. It is necessary to plan actions under the various policies consistently.

3.4.5 Fire and fire suppression

Wildfire and suppression of fire are considered important threats for this habitat type in some parts of its range.

Controlled heather burning is practiced in some countries as a management tool, which can produce a diverse structure of heather of high conservation value. However, whilst burning can be an important tool in heathland management, uncontrolled high-frequency burning can damage the long-term viability of this habitat.

In Ireland, for instance, regulated, small-scale heather burning is used for heathland management. However, in some parts of its range heather burning is conducted too frequently, in a poorly or uncontrolled fashion over large areas, probably with the aim of promoting grassland for grazing. Inappropriate burning within sensitive areas of this habitat was recorded at 50% of the sites surveyed by the National Survey of Upland Habitats (NSUH).

In Germany it is used, e.g. on decommissioned military training areas, where management is limited by the contamination of Unexploded Ordnance (UXO) (Ellwanger & Reiter 2018). Prescribed burning was considered impossible on heavily contaminated areas only a short time ago. Therefore a pilot project was undertaken on a heath that was a highly contaminated military training area in Eastern Germany between 2010 and 2013 (Goldammer et al. 2016). Converted military tanks were used as armoured fire ignition and fire-fighting vehicles. The same techniques and equipment were successfully used on other UXO contaminated areas in Germany as well.

Both burning for agriculture and game, and suppression of fire, are considered negative pressures in the UK. Although heathland is a fire adapted biotope, there are places (e.g. uplands in the UK) where excessive use of fire as a management tool can cause damage to the habitat.

An increase in fire frequency or fire followed by a heavy ungulate (game and livestock) herbivory is considered an important pressure on this habitat.

3.4.6 Invasive alien species

Invasive alien species represent a threat in some parts of the habitat range, e.g. in Denmark, Ireland, Belgium, Netherlands, Italy, Poland and the UK.

In Denmark, *Pinus mugo*, *P. contorta*, *Picea ssp., Abies ssp., Prunus serotina* and *Campylopus introflexus* are among the most commonly reported invasive species on heathland.

In Ireland, *Campylopus introflexus* is the most frequent invasive non-native species within this habitat recorded by the National Survey of Upland Habitats (NSUH). But, unless it forms extensive carpets which can suppress heather re-establishment, it is considered a mild or temporary invasive as it does not have long-term effects on biodiversity. The National Limestone Pavement Survey (NLPS) also recorded non-native invasive species at two of the four sites surveyed for 4030.

In Belgium and The Netherlands, the dominance of *Campylopus introflexus* which seems to be caused by nitrogen deposition and soil disturbance (Sparrius & Kooijman, 2011) does affect the cryptogam vegetation layer negatively and requires targeted management interventions.

There are relatively large occurrences of Campylopus introflexus also in Sweden, e.g. on the Falsterbo Peninsula in Skåne. The species is well established along the entire west coast and a bit inside it in Sweden, where the majority of 4030 habitat occurrences are located.

In Italy, the development of urbanization of the last century have caused heathland sites to be next to intensely built-up areas, with an increase in the probability of contact with exotic plants. Among introduced species, the most dangerous are those that deeply transform habitat requirements, rapidly shading and, most of all, changing soil conditions (e.g. *Robinia, Prunus serotina*).

In Poland, invasive alien species as *Prunus serotina* and *Solidago canadensis* represent a threat in some sites. In a scientifically controlled grazing project on heath and grassland in East Germany, *Prunus serotina* could be pushed back by cutting and subsequent cattle grazing (Seifert et al. 2015).

Some colonisation by non-native Sitka spruce (*Picea sitchensis*), Rhododrendron (*Rhododendron ponticum),* Shallon *(Gaultheria shallon),* sea buckthorn *(Hippophae rhamnoides)* and Japanese knotweed *(Fallopia japonica)* is reported in the UK.

3.4.7 Land use changes

Other threats and pressures reported in different countries include land use changes and consumption for residential, industrial and infrastructural developments.

In Belgium, some dry heathlands have been transformed to permanent pastures after fertilization. Nevertheless, despite the dramatic reduction of heathland area (more than 99% of heathland was destroyed In Flanders over a 230-year period), the loss of heathland species is relatively limited (11%). Heathland species that have a long-term persistent seed bank or can propagate vegetatively are least sensitive to extinction (Piessens, 2006).

Some dry heath areas have also disappeared due to urbanization in Belgium. In some sites physical destruction of habitat by mining, quarrying, sand and gravel extraction has occurred, as in other MS (e.g. Ireland, Poland and the UK).

Urbanisation is a key issue for dry heath in close proximity to urban areas in the UK, particularly the South-East. Direct loss of former heathland for housing and indirect pressure on heathland from urbanisation around Natura 2000 sites has been reported in England (Underhill-Day, 2005).

A review of Irish wind farm developments has suggested that 8% of wind farms have impacted this habitat in Ireland.

In Germany, Poland and other countries, the abandonment of military training areas can lead to the degradation and loss of huge areas of heathlands. Here the disturbance enabling heather regeneration has ceased and succession to pioneer forests proceeds rapidly. A relatively big proportion of heathland remained more or less intact on military training grounds before the reunification in Germany. Afterwards, the need for military areas was distinctly smaller and giving back these areas to public use resulted in some losses, both due to succession as well as by subsequent use for housing, industrial areas, etc.

Around 65 % of the total area of 4030 in Germany occurs on actively used or decommissioned military training areas. While 4030 in the Atlantic region occurs predominantly on actively used military training areas, around 50% of the military areas with significant occurrences of 4030 in the Continental region have been decommissioned between 1990 and 2012. The abandonment of terrestrial military or associated exercises leading to the loss of open habitats is a highly important pressure and threat for 4030 in the Continental region. It would be important to ensure the protection and maintenance of the habitat before abandoning military training (Ellwanger & Reiter 2018). Due to insufficient information on the extent and type of ammunition, however, the implementation of conservation measures for 4030 on decommissioned military areas is considerably restricted and partly prevented. Investigations into ammunition contamination and partial clearance of the areas are urgently needed as well as the development of a supra-regional concept for dealing with unexploded ordnance in Natura 2000 areas.

3.4.8 Habitat loss and fragmentation

Up to the end of the 18th century, and in some countries even until the middle of the last century, heathland formed an important component of traditional agricultural systems of Western Europe (Gimingham, 1976). As agriculture became more intensive, heathland lost its economic value and much was converted to more profitable uses such as arable cultivation or forestry. This has been observed all over north-western Europe. In Flanders and the Netherlands, for example, less than 5% of the mid-19th century heathland area is left (Ode´ et al. 2001; Piessens & Hermy 2006).

Due to the reduction and loss of this habitat area in some countries, e.g. in Belgium, Netherlands and UK, remnants are highly fragmented and isolated in a matrix of forest or rural landscape. As a consequence, biodiversity has decreased dramatically and many species have disappeared. Isolation has also deleterious effects on genetic diversity and long term viability of many species populations.

There have been significant historical losses of lowland heathland (all types) throughout its range in England. Farrell (1993) reported significant regional heathland losses from the 1800s to the mid-1980s, with an average loss of 80%, for six major heathland areas, largely

by conversion to arable or improved grassland, afforestation, lack of appropriate management and development. Over the last century other pressures have also directly or indirectly contributed to reducing the extent (both by loss and fragmentation) and quality of the remaining heathland patches (Fagúndez 2012; Diaz et al. 2013). These include increased N deposition (acidification and eutrophication), increased public access and disturbance, neglect due to low appreciation of their biological values and limited resources.

As a result, lowland heathland is severely fragmented in England (Rose et al. 2000) and a number of heathland dependent species are declining (Hayhow et al 2016). It is estimated that more than 30% of the habitat area is located in fragments that are smaller than 30 ha and relatively remote (>500 m) from associated habitats (acid grasslands, lowland fen, purple moorgrass pasture, upland heath, lowland raised bog, coastal habitats).

Farrell (1993), Webb (1986) and Rose et al (2000) demonstrated that at the same time as the area of lowland heathland decreased over decades, the size of the patches also decreased, resulting in increased fragmentation and loss of connectivity.

However, more work is required, as well as better mapping of dry heath habitat, to further study the possible negative impacts of fragmentation in other EU countries where the habitat occurs.

3.4.9 Other threats and pressures

Berry harvesting, e.g. for bilberry (*Vaccinum myrtillus)*, can represent a threat, e.g. in Romania. When blueberry and other berries are harvested, the *Calluna vulgaris* bushes are destroyed in order to increase the cover of the *Vaccinium* species.

Another threat identified in some area is the recreational use of the habitat. The pressures caused by recreation activities on some heaths, e.g. dogwalkers on lowland heaths in England are a threat for some breeding bird species like the nightjar (*Caprimulgus europaeus*) and woodlark (*Lullula arborea*), as well as leading to eutrophication from dung and urine.

3.4.10 Differences among main threats and pressures in the biogeographic regions

It seems there are no significant differences in the main threats and pressures detected and similar problems occur across the different biogeographic regions where the habitat is present.

In some countries the threats and pressures are more marked within a particular region, as, for example, the Atlantic region in Belgium. Here the total area of 4030 is currently deemed insufficient and urgent restoration works are urgently necessary.

In Italy, substantial differences are due to the intensity with which they occur, e.g. nutrient increase and alien invasive species are far more impacting on habitat in the Continental biogeographic region than in the other regions.

3.5 Climate change effects

Some studies have been published on how the climate change affects this habitat (Cook & Harrison, 2001; Wessel et al, 2004; Alonso, 2009; Natural England, 2009, 2012) but still, there is limited evidence of climate change effects on dry heaths in most of the countries or at EU level.

A first expert assessment of the sensitivity of Annex I habitat types in Germany towards climate change was carried out by Petermann et al. (2007). They classified habitat type 4030 as "medium" sensitive on a scale of three classes from "low" to "high". Pompe et al. (2010) used 474 European plant species to analyse the impacts of climate and land-use change on the composition of habitat-specific species pools in Germany. The grouping of the species by broad 'habitat types' showed that for species of all types the potential range losses were significantly greater than the potential gains. The greatest potential losses were in 'temperate heathland and bush vegetation' and 'moors' (Hanspach et al. 2013).

In Italy, in extremely hot and dry seasons at the start of this century, as in 2003, many mature individuals of *Calluna* on sites with precarious water balance were damaged and some died too. It has also been observed that *Calluna* seeds germinate and seedlings establish only in wet years, and that crucial phases of the life cycle (seed production, recruitment and survival) appear to be affected by climate anomalies concerning an increase in temperature.

In the Alpine and, to a lesser extent, in the Mediterranean Biogeographical Regions, habitat 4030 and also *Calluna vulgaris* show a wide altitudinal range encompassing several type of plant communities so that warmer and dryer climate regimes may result in the loss of some sites at lower altitudes of mountain slopes. In the Continental Biogeographical Region lowland heathlands are located in wet climates belonging to the "Cfb" Koppen climate type of the upper Po Valley, contrasting with the "Cfa" type of central Po Valley. Note that "Cfb" climate line includes almost all lowland heathlands of NW Europe (Gimingham, 1972). Therefore the effect of an increase in summer temperatures could determine the loss of survival perspective of habitat 4030 in a much wider extent, at least in theory, since here it occupies more or less flat surfaces.

In Poland, dry periods in summer may decrease *Calluna* flowering and general vitality (there is no strong scientific evidence, but some recent observations seem to confirm this). The collapse of local *Calluna* populations cannot be excluded, and in such case the whole habitat could also collapse. The habitat is single-species dependent, which makes it vulnerable to all the factors that can influence this species. Dry periods in summer decrease success of *Calluna* generative reproduction, blocking heathland regeneration (some scientific evidence is available in reports from Wrzosowisko Przemkowskie PLH020015 Natura 2000 site, one of most important heathland areas in Poland).

The assessment of alpine habitats spatial shifts in Romania based on climate change prediction scenarios by Constantinescu et al. (2014) on the 6230 *Nardus* grasslands, also reveals the climate change effects on 4030 habitat. This assessment could be valid because both habitat types are occurring in mountain areas and sub-mountain areas of the Carpathians on siliceous, nutrient poor soils with low pH substrates. The distribution maps published by Constantinescu et al. (2014) indicate that there are vulnerability areas with significant biodiversity loss due to climate change, which may lead to substantial changes in species composition. Prediction models for the year 2050 show a decrease of the area

occupied by mesophilous oligotrophic mountain pasture and subalpine oligotrophic pastures of 27% by MAXENT and 77% by BIOCLIM.

In Denmark there is some evidence of decreasing pH in soils, in areas where the habitat is present, which could be attributed to climate change or nutrient enrichment. The threat is presently categorized as "low impact"[30].

In the UK, dry heaths are sensitive to changes in hydrological conditions and the frequency of fires that may result from higher temperatures and more frequent droughts. Furthermore, warmer temperatures could cause grass species to become more dominant as a result of increased nutrient availability, leading to a shift from heathland to acid grassland. Growth of grasses and the loss of more characteristic plant species will be detrimental for some typical animal species (Natural England and RSPB, 2014).

Changes in competitive ability and distribution of species associated with the habitat can be expected as a result of climate change in the UK. These may include: increase in regeneration of trees and in gorse scrub; contraction in distribution of some heathland species, for example *Pyrola media* and *Dicranum spurium,* as an indirect consequence of climate-driven changes in land use.

Changes from climate change effects in potential area for a range of species chosen to represent lowland heath have been modelled in the UK (BRANCH Partnership, 2007). In England, the Climate Change Adaptation Manual (NE & RSPB, 2014) assessed lowland heathland's sensitivity to climate change as Medium. Climate change is likely to favour the growth of grasses leading to the loss of more characteristic plant species, which will be detrimental for some typical animal species. However, key species currently at the northern end of their range such as the smooth snake and sand lizard may benefit as the climate becomes milder.

The habitat is not expected to be lost from any of its natural areas as a result of climate change, but there may be a change in the balance of species or community composition. Addressing existing pressures on heathland (such as fragmentation, isolation, management, and hydrology) are likely to be key climate change adaptation responses in many cases.

Climate change may also have an impact on the amount of carbon stored or emitted from heathlands, and increase wildfire risk (Alonso et al, 2012).

It is important to consider how the network of sites supporting 4030 can be made more resilient to climate change, for instance bigger areas may be more robust to effects, it may be necessary to factor in possible range shifts, phenology changes and additional threats, there may be an increasing need for management as a result of increased temperatures and faster succession, spread of exotic species, increased pressure for afforestation, etc.

Some potential **adaptation options** for heathlands are identified in a Climate Change Adaptation Manual (Natural England and RSPB, 2014). This may cover also other types of heathland, not only the dry heaths 4030 focused in this document. See Box 1

[30] http://dce2.au.dk/pub/SR118.pdf, page 63).

Box 1. Adaptation options for low land and upland heathlands

Lowland heathland

- Ensuring optimal management through a combination of grazing, cutting and/or burning to achieve a diverse vegetation structure.
- Ensuring sufficient management capacity to be able to respond flexibly to changing conditions, such as a reduced window for winter management, and wetter conditions preventing winter operations.
- Consider maintaining broadleaved (not conifer) woodland in localised areas to provide a firebreak or a buffer next to urban areas.
- Within sites, identify areas that might act as potential refugia to climate change, such as areas with north facing slopes, complex micro-topography, robust hydrology and high species diversity, and ensure that these are under optimal management.
- Maintaining structural diversity in the vegetation to provide a wide range of micro habitats and niches, including, where possible, bare ground, areas dominated by mosses and lichens, herbs, dwarf shrubs of diverse age classes, wet heath and mire, and scattered trees and shrubs.
- Ensuring hydrological conditions are fully conserved, for example through blocking artificial drainage and reducing abstraction pressure.
- Increasing the area of existing habitat and reduce the effects of fragmentation through targeted re-creation and restoration around existing patches, to increase the core area and reduce edge effects.

Upland heathland

- Develop fire contingency plans across the whole upland habitat mosaic and ensure that the design and management of habitats reduces fire risk, such as by introducing firebreaks and fire ponds, and restricting access to some areas at times of high fire risk. Rewetting drier, degraded blanket bog and reducing heather cover will also help to reduce fire risk.
- Minimise erosion through the management of access, grazing and burning.
- Consider allowing an increase in scrub and woodland cover within the upland mosaic to improve habitat heterogeneity, in order to provide potential refugia for sensitive plants and invertebrates.
- Within upland sites, identify areas that might act as potential refugia to climate change, such as areas with complex micro-topography, robust hydrology, and high species diversity, and ensure that these are managed accordingly.
- Maintain structural diversity within the vegetation to provide a wide range of micro habitats and niches, including, where possible, bare ground, areas dominated by mosses and lichens, low herbs, dwarf shrubs of diverse age classes, wet heath and mire, scattered trees and shrubs.
- Consider the need to adjust designated site boundaries as habitats change (eg to create larger functional sites) and review the interest features for which the site is managed.
- Upland heath grades into various other habitat types along climatic gradients, particularly lowland heath with higher temperature, montane heath with lower temperature, and blanket bog in wetter conditions. Conservation objectives need to reflect these gradients, and build in an acceptance that there will change under a changing climate, and that the location for action to conserve particular species is likely to change.

3.6. Conclusions and recommendations

The improvement of knowledge and methodologies for assessing conservation status, threats and pressures, together with the implementation of appropriate monitoring schemes, is highly relevant for the conservation management of this habitat type.

The generic definitions of the parameters used for conservation status assessment (area, structure and function) leave a wide range of interpretation to each country and makes a serious control of trends and processes very difficult at the EU scale.

Harmonised standard criteria and procedures for the assessment and monitoring of this habitat type (variables, parameters, criteria, and thresholds) would benefit from an EU level discussion. A common methodology could be developed based on scientific evidence, adjusting variables, parameters, criteria and thresholds by biogeographical region. Nevertheless, it would be difficult or even not possible to try to impose a new standard method to replace existing methods. Instead, commonalities in existing national assessment methods should be identified, and ways of deriving comparable results sought.

Thresholds, just like FRVs, are challenging because there are not always clear references by which to set the ideal combination of traits that define the "favourable" condition. The variables and processes involved are extremely diversified.

4030 is a secondary habitat that can be replaced by (or itself replace) other Annex I habitat types. This makes setting an ideal quantification of its optimal distribution rather arbitrary, depending heavily on regional balances and strategic opportunities.

Supplementing the vegetation-oriented assessment with monitoring of fauna (in particular invertebrates typical of heathlands) would be advisable.

The following recommendations are suggested:

- Harmonisation of methods for monitoring and assessment of conservation status. The methods to assess the different parameters (range, area, structure and function, trends and future prospects) should allow comparison of conservation status assessments, at least between countries belonging to the same biogeographical region. Harmonization will need international collaboration and comparison of the methods used in different countries. The methods should also consider the different conditions and features existing for the habitat.
- Assessment of Conservation Status and regular monitoring should also take into account typical animal species (especially invertebrates), which may be essential for many ecosystem functions.
- Define Favourable Reference Values.
  Some countries are currently working on defining FRV for the EU habitat types, including heathlands. The methods recently proposed to define FRVs should be consistently applied to define FRVs for this habitat type.
- Agree on common methods to assess threats and pressures.
  In general there are no standard procedures and methodologies to determine and assess the main threats and pressures on 4030 habitat, although some countries are currently preparing standard methodologies to assess threats and pressures on habitats and species of Community interest. The methods available should be compared and

analysed in order to agree on common standards to assess threats and pressures on this habitat type.

- Improve knowledge, assessment and monitoring of habitat fragmentation
  There is not an adequate knowledge about the fragmentation of this habitat type. This gap should be tackled in order to allow for the design and implementation of appropriate measures to improve habitat connectivity where necessary.

4. HABITAT CONSERVATION AND MANAGEMENT OBJECTIVES

*European dry heaths need to be **maintained by regular management**. **Restoration actions are also necessary** to recover the area, structure and functions where these heaths are significantly degraded or have disappeared or are highly fragmented.*

Conservation objectives and priorities can be defined at EU biogeographical region level** to achieve Favourable Conservation Status, e.g. improvement of area, structure, function, and restoration needs. These need then **to be translated into specific objectives at the country level.

*Conservation objectives also **need to be set in Natura 2000 sites** in order to maximise the contribution of the sites to achieving favourable conservation status of the habitat at biogeographical scale.*

***Conservation measures for Natura 2000 sites need to be established and put in place,** to address the main threats to the habitat and achieve conservation objectives.*

***Action outside the Natura 2000 sites may also be necessary** to ensure its long-term conservation, ecological variability and adequate connectivity.*

4.1 General framework and context

The Habitats Directive requires establishing and implementing conservation measures to maintain or restore at favourable conservation status the habitat types and species of Community interest. According to the directive, the conservation status of a natural habitat will be taken as 'favourable' when:

- its natural range and areas it covers within that range are stable or increasing,
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable.

The Directive also requires setting up the Natura 2000 network of special areas of conservation, where the necessary conservation measures for the habitat types and species present in the sites shall be established and implemented, as well as a protection regime to avoid deterioration of the habitats and disturbance of the species for which the areas have been designated. It also requires assessing plans or projects to prevent adverse effects on the integrity of the sites.

4.2 Overall objective of this action plan

For the overall aim of **achieving favourable conservation status**, the plan suggests the establishment of general **objectives for the conservation and management of this habitat type at biogeographical level**, which should then be translated into **more specific objectives at country level**. The plan also suggests the identification of priority conservation measures to contribute to the objectives set at a higher level (e.g. biogeographical, national) both inside and outside the Natura 2000 network, as required.

4.3 Setting objectives at biogeographical and country level

At the biogeographical and country level, it is necessary to consider the conservation status (CS) of the habitat type and the parameters that define this status (area, structure and functions, future prospects), and to analyse the threats or combination of threats that may have caused the current status and that determine the trends.

Where conservation status is Favourable: the objectives should aim to maintain the habitat in the favourable status by maintaining an appropriate management system of the habitat and preventing possible threats and pressures that could affect its status.

Where conservation status is Unfavourable (Inadequate-U1 or Bad –U2), it should be improved. Depending on the status of the parameters that are assessed in unfavourable status, this may require:

- Maintaining the range and expanding the area where it has been reduced.
- Improving the structure and function.
- Improving future prospects.

Maintaining the range is essential to preserve the diversity of the habitat and its typical communities. It requires preventing any potential loss by ensuring appropriate management across its range.

Expanding the area is needed to counteract the habitat loss occurred in the past, and is especially important where the current extent is a reduced fraction of the historic extent leaving many small and fragmented areas. This would require restoring the habitat in suitable sites, and at the same time preventing that the total area of habitat and the number of habitat localities in the country further decrease. Appropriate sites for the restoration of the habitat should be identified and selected in the countries at the biogeographical level, with a view to ensure the long-term conservation of the habitat and its associated species, its ecological variability and adequate connectivity across its natural range.

Improving the structure and functions. The structure and functions of a habitat type concern its species composition and diversity, ecological functions and processes that sustain the habitat, as well as ecological connectivity. Improving the structure and functions may be needed in areas where the habitat is degraded. This involves restoration and preventing further degradation through the removal and reduction of the main threats and pressures acting on the habitat type. Improving the structure and functions of the habitat also needs to consider the diversity and distribution of plant communities and species characteristic of the habitat on a national level. Connectivity is also very important for the conservation of heathland. Local increases to create larger patches as part of functioning networks, are needed for long term viability of the habitat in some part of its range, especially where the habitat is highly fragmented. Defragmentation is also likely to help adaption to climate change.

Improving future prospects requires addressing underlying causes of the main threats and pressures on the habitat so that the trends in the different parameters can improve. Some examples in this regard can be: to reduce deposition of atmospheric nutrients; to stop scrub expansion and invasive species; to prevent abandonment and ensure suitable management of the areas where the habitat is present.

Increase knowledge and awareness about the importance of this habitat type

In addition to the above-mentioned objectives addressed to the conservation management of the habitat type, it is very important to communicate and transfer to the society (i.e. managers, stakeholders and, particularly, the general public) the ecological value of this habitat. Apart from the biodiversity values of the habitat itself, other ecological aspects should be emphasized, particularly those related to ecosystem services. Experiments and research should be set up to better understand the potentials for balanced ecosystem services delivery without decreasing the biodiversity value of the habitat.

General objectives

At the biogeographical and country level, the plan suggests the following general objectives:

- To maintain the **range and the area**, and, where possible, expand the area where it has decreased. Maintain or improve **the structure and function** of these heathlands (depending on current status of these parameters) and ensure **favourable future prospects** across all their area in the medium-long term.
- To maintain the **species richness** of the habitat type and its **characteristic plant communities** across its distribution area. This could involve setting specific goals for each country considering the diversity and particular features to be preserved across the region.
- To **reduce fragmentation and ensure the ecological connectivity** across the habitat range~~,~~ by increasing patch size and linking the habitat patches to form a functioning network. Creating stepping stones with targeted vegetation to improve landscape connectivity is necessary for the functioning of metapopulations of plants and animals associated with this habitat.
- To **share and harmonise knowledge and experience** in protecting and managing the habitat among countries in the same biogeographical region. Aim for the development of similar approaches in support schemes (e.g. concerning types of subsidies/incentives) in all countries of the same biogeographical region.
- **Increase knowledge and awareness about the importance of this habitat type among** land managers, spatial planners, policy makers and the general public.

4.4 Setting objectives at the national level

Specific targets for improvement of conservations status have been set in some countries, e.g. in terms of habitat area to be restored. In other cases, more general objectives are set. Some examples are given below. Quantitative values for conservation objectives could be better set when the FRV(s) for the habitat type are known.

Approaches to setting conservation objectives for dry heaths 4030 in some countries

From the expert consultation carried out during the compilation of this action plan, the following approaches were identified.

Belgium. Maintaining the existing sites in a favourable status and improving sites which are in a less favourable status by appropriate management; restoring non-managed sites and recreating or creating this habitat where it is currently missing in order to improve landscape connectivity. In Flanders, the actual surface area of habitat 4030 is 4300 - 5400 hectares and the objectives is increase of this surface with 640 – 840 hectares, which means an increase of habitat extent by 10-15%.

Denmark. The overall conservation goal is that all occurrences of 4030 should attain a FCS. Occurrences in unfavourable status (U1 and U2) should be managed to increase conservation status to favourable status FCS. The total area of 4030 should remain stable or increase if the conditions make this possible. Conservation objectives should reflect the degree of fragmentation, which in Denmark is high for 4030 in the continental region.

Poland. 1) To maintain area, structure and function status in existing large heathland areas, on active or former military training areas, by implementing conservation actions mimicking military disturbances, if necessary. 2) To maintain existing localities and patches of all bearberry heathlands (*Arctostaphylo-Callunetum*) and broom flowered heathlands (*Calluno-Genistetum*). 3) To maintain or restore connectivity between patches, enabling functioning of related species as a metapopulation.

Romania. Create an inventory regarding the structure and functions, conservation status, threats and pressures in each Natura 2000 site that is designated for 4030. The conservation objectives should consider both the areas inside and outside Natura 2000 since often the communities of this habitat extend beyond the limits of the Natura 2000 sites.

UK. Maintenance of the current range is required to maintain the range of conditions that provide for the diversity associated with this habitat. The large historical losses and continuing declines in many heathland species indicate that an increase in the overall area is required to support the diversity associated with the habitat. An increase of the area of lowland heathland by approximately 75% is considered necessary to achieve FCS. Functioning ecological networks should be created in order to reduce fragmentation and increase connectivity. Other habitats/notified features of sites may be favoured over 4030, subject to conditions regarding the status of 4030.

Italy. A main objective and priority for 4030 in Italy should be the establishment of a network of sites, which possibly includes all habitat subtypes for all the Biogeographical regions. This network of sites should be effectively managed and monitored in a coordinated and integrated way. The opportunity to relocate protected areas and/or to expand Natura 2000 should also be considered when planning the network.

4.5 Setting conservation objectives in Natura 2000 sites

As said earlier in the text, 2,095 Natura 2000 sites have been designated for the protection and conservation of this habitat type. Many of these sites have been designated as Special Areas of Conservation and conservation objectives and conservation measures have been established for these areas. Site level conservation objectives need to be set for all the SACs in view of establishing the necessary conservation measures required for the habitat types and species present on the sites[31]. Site level objectives can be an integral part of site management plans.

Site-level conservation objectives should define the condition to be achieved by the habitat type within the sites in order to maximise the contribution of the sites to achieving favourable conservation status at the national, biogeographical or European level.

Setting conservation objectives would require an assessment of the relative importance of each site for the conservation of this habitat type and of the actual potential of each site for the habitat, which requires investigation of the following aspects:

- The importance of each site for achieving biogeographical and country level objectives.
- the current conditions of the habitat in each site and the potential for its recovery or restoration
- the historical management that have maintained the habitat or the changes and the factors that may have led to habitat degradation, and possible long-lasting impacts.

Once this analysis is completed, a review of the conservation objectives already set for Natura 2000 sites where the habitat is found could be carried out in order to adjust or improve their definition where required. Furthermore, the corresponding objectives for those sites where conservation objectives have not been set yet should be established in view of their relative importance, conditions and potential for the habitat type.

When defining site conservation objectives, the following aspects should also be considered:

- The ecological requirements of the habitat in each particular site.
- The threats and pressures acting on the site that may affect the habitat.
- The conditions in the surrounding areas, including the functional relations associated with the habitat's use and which can influence the status of the habitat in the site.
- The habitat as an ecosystem services provisioning unit.

According to the above-mentioned Commission guidance on the subject, conservation objectives must be:

- ***site-specific***, i.e. set at site-level (but may need to be supplemented by a broader set of conservation targets at higher, e.g. national, regional or biogeographical, levels);
- ***comprehensive*****,** i.e. cover all species and habitat types of Community interest of the Habitats Directive that are significantly present on a Natura 2000 site (as identified in the relevant Natura 2000 Standard Date Form);

[31] Commission Note on Setting Conservation Objectives for Natura 2000 Sites (2012), available at http://ec.europa.eu/environment/nature/natura2000/management/docs/commission_note/commission_note2_EN.pdf

- ***specific as to the feature***, i.e. refer to individual habitat types or species in the site;
- ***specific as to the envisaged condition***, i.e. clearly identify the condition the habitat type and species in the site shall achieve; the desired condition must be:
    - ***quantified and measurable*** (quantitative targets possibly to be supplemented by qualitative ones, such as description of a good condition of a habitat or a population structure) as well as reportable (enabling monitoring)
    - ***consistent*** in approach (use similar structure and attributes for same features across sites)
    - ***comprehensive*** (attributes and targets should cover the properties of the interest feature necessary to describe its condition as either favourable or unfavourable)
    - be ***clear on whether "restoring" or "maintaining"*** the conservation status of the relevant feature of the site is envisaged (the respective level of ambition predetermining the necessary conservation measures)
- ***correspond to the ecological requirements*** of the natural habitat types in Annex I and the species in Annex II present on those sites;
- ***reflect the importance of the site*** for the maintenance or restoration, at a favourable conservation status of the habitat types and species present on the site and for the coherence of Natura 2000.

It may also be necessary to consider how to balance the need to maintain/restore several habitats that can all occur on the same site, e.g. heath and forest.

An example of conservation obectives set for dry heaths in a Natura 2000 site is presented below.

Conservation objectives for dry heaths (4030) in a Special Area of Conservation

- Maintain the extent (xx ha) and distribution of the habitat within the site (map provided).
- Maintain the abundance of the typical species (list provided).
- Maintain a low cover of scattered native trees and scrub (<10% cover).
- At least 1% but not more than 10% cover of the area of the habitat consist of bare ground.
- Maintain nitrogen deposition below critical load values defined for the site (e.g. 10-20 kgN/ha/yr).

Adapted from: https://www.npws.ie/protected-sites/conservation-management-planning/conservation-objectives

4.6 Setting objectives outside Natura 2000 sites

Depending on the coverage of this habitat by the Natura 2000 network, taking action outside the Natura 2000 network may be necessary to ensure the long-term conservation of the habitat, its ecological variability and adequate connectivity across its natural range,

as well as for the conservation of species associated with the habitat. This may involve sites protected under national legislation that are not part of Natura 2000 and/or areas with no formal protection.

Table 4 on page 39 provides the percentage area of this habitat type in Natura 2000 by country and biogeographical region (based on information from Art. 17 Dataset). A more detailed analysis should be carried out at national and biogeographical level, to determine the most appropriate areas to improve the conservation status or to restore the habitat outside the network.

4.7 Determining objectives and management approaches in a particular area

Depending on the condition of the habitat in a particular area and the conservation objectives set, conservation measures need to be established involving maintenance, restoration or re-creation (see definitions below).

Maintenance involves preserving and maintaining the area, species composition and structure characteristic of the European dry heaths and the ecological conditions and processes required for its maintenance in a favourable condition. It usually requires implementing recurring measures (grazing, mowing, burning, etc.) on a regular basis but in many regions this requires also immediate action for reduction of nitrogen-input and eutrophication to stop slow degradation and subsequent loss of area.

Restoration involves improving the habitat area and its condition where some of the habitat type features or processes are still present. For example, restoration of heaths overgrown with shrubs and trees where ecological conditions and processes that sustain the habitat are still present. Ecological restoration usually includes cutting trees and shrubs or removal of tree regrowth. It can also involve more intensive grazing and mowing over a certain period of time until shrub and trees regrowth is controlled and more extensive and regular maintenance can be carried out. Or, on the contrary, could involve releasing the grazing pressure to allow a diverse vegetation structure to develop.

Re-creation involves introducing the characteristic species of the habitat to a place where the habitat has disappeared and where there are the environmental conditions necessary for the habitat. Re-creation may be more relevant in countries where the current habitat area is smaller than the area that can provide favourable conservation status for its species and communities, and where the area is decreasing due to abandonment, intensification or other causes that led to the habitat disappearance. Re-creation can at least partially compensate for the consequences of habitat destruction and reduction of its area. It should aim to contribute to de-fragmentation too, i.e. linking small patches to create larger, more sustainable ones. Heaths form part of complex landscapes with sandy grasslands, older and younger stages of *Calluna*, scrub succession and acidic forests. If remnants of heathland are left and sufficient diaspores available, re-creation at least of the typical vegetation can be relatively quick, however to re-establish the typical fauna is much more challenging and takes more time.

The guiding principle is that it is always better to protect and maintain ecosystems by, wherever possible, eliminating the adverse effects and extensive pressures, as restoration of degraded ecosystems always involves the risk of failure and high costs. Many natural values may be irretrievably damaged and the resources and investments required to

restore natural ecosystems far exceed the resources needed for preserving them. The costs increase with the increase in degradation level. Thus, proper conservation and maintenance of natural ecosystems is always a priority.

In general, restoration of the former “ideal” situation (in terms of habitat area, species composition and functional processes) is only possible if there are no irreversible or significantly degraded conditions in the area and surroundings that would make the restoration of habitat and its necessary processes impossible.

Ecological restoration or the creation of habitats is a time-consuming process. Depending on the methods used, restoration of existing lowland heathland can take up to 10-15 years (Shellswell, 2016). Time scales for complete regeneration of heathland may vary from 15 to 150 years however, depending on site conditions and isolation.

Restoration can only achieve the results in a short time if most of the characteristic species are still present and all the required ecological processes are taking place.

After restoration activities have achieved their expected results, maintenance measures are usually required to keep the dry heaths in good condition. Restoration and maintenance measures are often not strictly separated, but they may occur at the same time.

5. CONSERVATION AND RESTORATION MEASURES

The maintenance of this habitat in good condition is dependent on extensive management practices including grazing by wild herbivores and domestic livestock as well as regular disturbance, for instance by fire. Where the habitat is degraded or lost, restoration is necessary.

Adapting management to the needs of particular species may be required depending on the conservation objectives of the sites.

5.1 Key management practices for maintenance of the habitat in good condition

This habitat type in general is not a climax community and relies on extensive management practices over almost all of its range. The majority of heathland sites currently require some form of conservation management to reduce succession to scrub and woodland. Management interventions include grazing by livestock, cutting and burning of vegetation (Newton et al. 2009; Diaz et al. 2013).

In general, measures that mimic relevant disturbance regime, and traditional management, preventing tree expansion and promoting heather regeneration are suitable for maintaining this habitat in good condition. The measures described below may be needed or useful depending on local conditions.

5.1.1 Grazing

In most parts of their distribution range, grazing has been historically used on heathlands, e.g. with traditional breeds of sheep, but also cattle and horses, besides wild herbivores, such as rabbits and deer. Grazing helps to control the growth of scrub and trees. Where grazing has been traditionally practiced and allowed the maintenance of the dry heaths in good condition, it can be considered a suitable management measure, provided the appropriate gazing pressure and timing are established. On the other hand grazing may not be sufficient to keep the habitat in a nutrient-poor condition, especially in regions where the airborne nitrogen input largely surpasses the critical loads (cf. Härdtle et al. 2006).

A study on the impacts of livestock grazing on lowland heathland in the UK (Lake et al. 2001) concluded the following:

- Grazing by livestock is an appropriate management for lowland heathland, to deliver conservation objectives.
- Management regimes using appropriate grazing can produce a greater diversity of habitats and thus a greater biological diversity than other management types such as burning or cutting.
- Grazing impacts must always be considered in terms of the intensity of grazing and the livestock types used; negative effects, or poor achievement of targets can arise from inappropriate grazing. The negative impact of grazing on biodiversity over much of upland heathland in Britain illustrates the consequences of overgrazing.

However, the introduction of grazing has proved controversial, especially in sites where the memory of traditional practice has disappeared and the sites are now important for access and recreation, highlighting the need for evidence regarding its effectiveness.

A systematic review of scientific literature indicated that overgrazing can result in an increase in the ratio of grassland to ericoid shrub cover (Newton et al. 2009). While a large majority of practitioners (94%) believe that grazing is an effective management option for lowland heath, evidence for a number of negative impacts on habitat attributes was recorded, highlighting the need for improved monitoring and experimental analysis of the effectiveness of management interventions. However, what is "negative" will depend on the conservation objectives. For example, in many lowland heathlands reducing the heather cover and increasing structural diversity is an objective.

On the other hand, the removal of grazing can also be used for the recovery of the habitat where grazing pressure has been too intense and has led to the degradation of heathland. Evidence on the effects of livestock grazing suppression or reduction (e.g. by fencing) is provided in Martin et al. 2017.

It is necessary to address the impacts of inappropriate grazing pressure. The production of grazing management plans, especially those relating to Natura 2000 sites, should be encouraged.

Grazing needs to be carefully controlled in relation to the set objectives. Depending on the initial situation of the habitat, its conservation status and the objectives to be achieved, the most optimal grazing regime has to be selected. Flexible stocking rates are important to prevent both over and under-grazing, which are both detrimental to heathland communities.

The type of animals used is also important, as different animals have different grazing preferences and different effects on the habitat. Sheep have been successfully used to manage heathland areas. Moreover, also cattle as well as mixed cattle and horse grazing have been successfully used to manage and restore heathland areas (Bokdam & Gleichman 2000; Henning et al. 2017a, b) and thus to enhance the local conservation status of the habitat type of community interest (Henning et al. 2017b). It is known that mixed cattle and horse grazing improves both the vegetation structure and the overall species richness in heathlands, by enhancing bare soil, rejuvenating *Calluna vulgaris* and reducing highly competitive grass species, such as *Calamagrostis epigejos*, as well as the litter and moss cover.

Lake et al. (2001) analysed the pros and cons of all types of livestock: sheep, cattle and horse, for heathland management. A study in a Continental heathland in Germany showed that cattle significantly feed more frequently on woody plants and shrubs than horses (Lorenz et al. 2016). Depending on the season, cattle took on average 3-16 % of their daily nutritional requirements from woody plants and the highest values were recorded in winter.

Timing of grazing is also important. Winter grazing of 4030 tends to favour grasses over dwarf shrubs, and particularly when combined with burning too frequently, can significantly reduce cover of dwarf shrubs.

Year-round grazing by cattle and horses can successfully reduce highly competitive grasses, such as *Calamagrostis epigejos* (Henning et al. 2017b). Also during the winter, the grazing animals favour grasses as their food (Lorenz et al. 2016). Especially horses are known for their graminoid foraging (Cosyns et al. 2001; Lamoot, Meert & Hoffmann 2005), thus they successfully reduce grass encroachment in heathlands (Lake, Bullock & Hartley 2001).

An example of seasonal sheep grazing is the so-called transhumance[32], which has been traditionally used in the Iberian Peninsula and it has been proved to be associated with the occurrence of heathland-dominated habitats. In the last century this activity has decreased exponentially and has almost disappeared. Consequently, most mountain pastures are currently abandoned or grazed by cattle and horses, which use the heath–pasture mosaic differently than sheep, feeding only on herbaceous vegetation (Osoro et al*.,* 2003; Celaya et al., 2007), leading to higher levels of shrub encroachment (Calvo et al*.,* 2002a; Morán-Ordóñez et al., 2013).

In Spain, management of the heathland communities in the northern Spanish uplands (Atlantic and Alpine region) with an appropriate stocking rate would help to maintain a young and healthy heather cover. This will then constitute an ideal habitat for a variety of wildlife and remove some of the nutrients deposited atmospherically. In Southern Spain (Mediterranean region) particular attention should be paid to dry heathlands that are rich in endemic species, particularly in the Strait of Gibraltar region (Gil-López et al. 2018).

In Atlantic heaths with less initial cover of woody species, cattle grazing successfully reduce the regrowth of woody species (Bokdam & Gleichman 2000). However, if the overall initial cover of woody species is high, manual shrub cutting is crucial since cattle and horses are not able to successfully counteract the regrowth of woody species and thus maintain the open site character of the heathland (Henning et al. 2017b). Nevertheless, in the long-term a gradual decrease of woody species regrowth as well as increased browsing of the grazing animals (grazed plots) and wild herbivores such as roe deer and rabbits (ungrazed plots) is observed (Henning et al. 2017b).

Overall, cattle significantly feed more frequently on woody plants and shrubs than horses (Lorenz et al. 2016). Depending on the season, cattle took can take on average of 3-16 % of their daily nutritional requirements from woody plants. Thereby, the highest values were recorded in winter. Moreover, cattle and horse grazing significantly reduce the re-growth of one-time cut Black Cherries (Prunus serotina), inhibit their fructification and leading to a gradual die-back of this invasive species (Lorenz et al. 2016).

In some cases, game animals (e.g. deer) may also act as significant grazers, preventing tree expansion and stimulating heather regeneration. Some game management measures, as no-hunt areas established on heathlands, may promote this positive impact. Depending on their densities, however, wild animals such as deer and even rabbits may also have a considerable impact on heath communities and may in some cases need to be controlled[33] or encouraged (e.g. Breckland, England).

5.1.2 Cutting

European dry heaths mainly originated from a long history of low-intensity grazing. This management measure was often combined with other land use practices, such as mowing or sod-cutting (Garcia et al. 2013). Heather cutting has therefore been practised since ancient times.

[32] Seasonal movements of sheep flocks across the Iberian Peninsula, to take advantage of the availability of complementary grazing resources (south-Iberian ‘‘dehesa’’ systems in winter and north-Iberian mountain pastures in summer mountain passes).

[33] For instance, on Inchnadamph SAC (UK0012787), significant improvement towards Favourable condition has been made through control of deer grazing pressure under a Section 7 Deer Act Control Scheme.

In regions where the re-introduction of livestock grazing is not viable due to socio-economic changes, mowing alone is considered to be a practical and affordable substitute (Adamowicz 2010; Diemont et al. 2013). However, studies showed that grazing creates a more open vegetation structure and reduces competing grasses (e.g. *Deschampsia flexuosa, Calamagrostis epigejos, Molinia caerulea*) more successfully than mowing, due to selective feeding (Pywell et al. 1995; Henning et al. 2017a).

The timing of cutting needs to be sensitive to animals on the heath and it should be avoided during summer breeding seasons. The cuttings should always be removed to prevent enrichment of the soil through decay.

In Poland, for instance, mowing is implemented as a conservation measure in Diabelskie Pustacie Natura 2000 site (PLH320048). The heather is mown every 3-5 years and the biomass is removed. The mowing is distributed as a mosaic of small belts and plots. There is no comprehensive scientific evidence of results, but the measure (combined with removing of trees and seedlings) seems to guarantee heather regeneration and create mosaic of heathlands with varied structure.

Felinks et al. (2013) investigated different mowing methods (mulch mowing at a height of approx. 20 cm, mowing with sickle bar mower -mowing height approx. 10 cm, flail mowing close to the ground) on dry heaths at military training areas in Germany. Whereas a high area capacity can be achieved by mulch mowing, neither an efficient regeneration of *Calluna vulgaris* nor a diverse age structure of *Calluna* stands can be assured. The use of a sickle bar mower or of a flail mower, each with removal of the cut vegetation, efficiently supports the vegetative regeneration of *Calluna vulgaris,* and mowing close to soil surface has a positive effect on the generative regeneration of the heath by generating patches of open soil.

All types of mowing are limited by surface roughness or by unexploded ordnance. To reduce the nutrient level in heathland, vegetation removal is vital (see Härdtle et al. 2006). Furthermore, woody species with rapid regrowth of shoots are facilitated whereas dynamic processes of heathlands are reduced. Thus, whenever possible all mowing techniques should be combined with other measures, such as grazing or prescribed burning (Felinks et al. 2013).

5.1.3 Burning

Prescribed burning is an established management technique to maintain heathland in several European countries (GFMC & Fire Ecology Research Group 2009).

The aim of burning is to remove above-ground vegetation cleanly, yet leave the roots unharmed for regeneration.

Controlled burning can be used to mimic the natural fire cycle of heathland and to reduce N-content. However, burning is not suitable for areas with mosaics of dry heath with other fire sensitive habitats. It needs to be very carefully controlled and it may be impossible if the area is surrounded by forestry plantations or housing. Burning may be forbidden by law in some countries, as Poland, or in particular areas.

There are different traditions with use of fire in different countries, which must be considered.

In Belgium, dry heaths were occasionally burnt but this practice has been abandoned from a long time of (since the second half of the 19th century). In some of the heathland reserves in Flanders (Belgium) small-scale prescribed burning is still successfully practised.

In Demark, small scale rotational management with different management measures including burning (or grazing, or mowing) in cycles of 20-30 years seem to work well.

In Spain, recurrent fire (during the winter) is used for the maintenance of *Calluna* heathland in a favourable status (Ojeda 2009a; Gil-López et al. 2014).

Experimental studies comparing different management alternatives in heathlands in the Cantabrian Mountains (Spain) supported repeated burning on a 15–20-year rotation to prevent the degenerate phase from occurring (Calvo et al., 2002, 2012). Results indicated that rejuvenation by prescribed burning alone may be ineffective to preserve these heathlands under elevated airborne N deposition, as fire promoted invasion by graminoid species in the experimental plots at the pioneer phase. It would be therefore necessary to complement regular burning with livestock grazing at moderately-low stocking rates before the building stage is attained (5 years after fire), allowing *Calluna* to outcompete graminoids for light. The most suitable fire frequencies could be 15-20 years to minimise the impact of N accumulation, especially regarding the most sensitive species (i.e., bryophytes and lichens)

In some countries (e.g. Germany, Poland) the larger heathlands today are linked to either active military training areas or were under former military use (Schröder et al. 2008, Ellwanger & Reiter 2018). On military training areas heavily contaminated with ammunition, prescribed burning (with armored fire ignition and suppression vehicles) may be the only practicable way to keep the areas open and restore heathland (e.g. Goldammer et al. 2016, Schleupner et al. 2016). For techniques and limitations of prescribed burning on ammunition contaminate, areas see Goldammer et al. (2016).

Controlled burning is used for heathland conservation in UK and also to create a mosaic of different patches of habitat for wildlife and/or game for hunting, e.g. for red grouse in Scotland (Bougkas et al. 2018).

Fire has different impacts in different seasons. Controlled burning is regulated in some countries (e.g. Scotland and England). The English Burning code[34] limits the dates to between early October to mid-April, depending on location), as later burning can have a more damaging effect on fauna. In Scotland, a code of good practice, the Muirburn Code, is applied (see Case Study below).

[34] http://gfmc.online/programmes/natcon/UK-DEFRA--Heather-Grass-Burning-Code-2007.pdf

The Muirburn Code. Scotland (UK)

The Muirburn Code sets out the law and good practice relating to muirburn. Its aim is to ensure that the burning occurs in the right place, avoids damage to sensitive habitats and species and does not lead to wildfire.

The burning season runs from 1 October to 15 April to avoid harm to birds and reptiles.

The general considerations when planning for burning should include:

- Reading and understanding the Code.
- Defining the land that is being considered.
- Identifying the management purpose and desired outcome, and deciding whether burning and/or cutting might meet the objective.
- Identifying all the features at risk from burning in a map.
- Identifying all protected areas, species, sensitive areas and fire-free areas.
- Checking if any consents are required.
- Reviewing the management options.
- Preparing a more detailed plan if the burning finally takes place.

A robust burning plan allows some control over the threats that can be created by burning. The plan should include:

- Objectives of burning.
- Choosing where to burn.
- Choosing when to burn.
- Choosing how to burn.
- Where and when not to burn.
- How to reduce risks.
- Equipment.
- Where and how to record what has been burnt.

The Muirburn Code provides both a detailed checklist for the preparation phase and another checklist for the actions required on the day that burning is to take place. These checklists aim to ensure that all the permits have been asked, all the warning notices, emergency plan, staff preparation, risk assessment etc. have been done.

Scottish Government. 2017. The Muirburn Code: Management of moorland by burning and cutting. https://www.nature.scot/guidance-management-moorland-muirburn-code

There are many studies of the use of controlled fires as management tool for heathland. A review of studies and evidence of the effects of prescribed burning on heathland vegetation is available in Martin et al. 2017.

The impacts of fires on soils, hydrology and biodiversity are complex and vary according to a number of interrelated factors. Characteristics of the fires are especially important, such as their frequency, temperature, ground surface intensity, residency time and size. These characteristics in turn depend on a range of factors including: fuel type and structure,

width of fire, slope, wind and moisture levels in the vegetation and soil, and burning method. Impacts also depend on soil and habitat conditions at the time of burning (which partly reflect the cumulative impacts of burning), season, weather conditions and interactions with grazing and other management practices. Fires can have significant detrimental impacts, including: ignition, combustion and loss of peat and humus layers by hot fires in dry conditions; increased rates of run-off and erosion, particularly after hot fires and where large or old stands of *Calluna* are burnt, and on steep slopes; reduction of structural and species diversity and vegetation composition changes if carried out too frequently or over large areas (Tucker, 2003).

Burning, whether accidental or controlled, can nevertheless lead to the local extinction of some animal species. Areas to be burnt should be surrounded by firebreaks for containment of the fire, as well as by older heather, to allow subsequent decolonisation of the area.

When using fire for management of heathland, particular care must be taken to consider the presence of sensitive animal species. Used with great care, burning can sometimes be useful in maintaining good vegetation condition for reptiles. However, burning too frequently, or at too large a scale, can be highly damaging to reptile populations (Edgar et al. 2010). It is often a problem to burn heathland in Denmark in spring when reptiles still hibernate and birds have not started breeding.

Heath burning at Blue pool Site of Special Scientific Interest. ©Nick Squirrell. Natural England.

5.1.4. Management of Nitrogen deposition impacts

Atmospheric Nitrogen deposition has been identified as an important threat for this habitat. Dry heaths occur on nutrient-poor acidic soils and are functionally adapted to low N content in the soil. The addition of N via deposition has therefore the potential to affect their structure, functioning and could affect the provision of regulating ecosystems services such as carbon sequestration and storage (De Vries et al. 2009).

On-site management activities such as grazing, cutting, burning, hydrological management and soil disturbance measures can mitigate the negative impacts of N on heathlands and grasslands (Jones et al. 2017). However, in places where aerial nitrogen depositions is high, often due to intensive agriculture (NH_3 in addition to NOx emissions), and N-values are well above the critical loads of the habitat 4030, traditional grazing or cutting can be no longer able to compensate the nutrient influx and other type of actions are necessary to reduce N deposition.

The removal of biomass by cutting also removes N from the system with the potential to reduce nutrient status of the soil in the long-term. However, the rate of nutrient removal by this method is usually low and so it may take some time for a significant change to be detected (Steven et al. 2011). Burning also provides a means of biomass removal and is traditionally used as a management tool in heathlands. Another method that has been tested experimentally for the removal of reactive N from soils is the addition of Carbon.

Action to remove nutrients at field level could include moving from cutting and burning to turfing to remove the accumulated nutrients where this is an issue (see e.g. Niemeyer et al. 2007).

Turf stripping or cutting is the most dramatic method for the removal of nutrients, but it also removes acidified surface soil, and so can address both acidification and eutrophication problems. Turf stripping has been used extensively in some countries, especially the Netherlands, for the restoration of heathland (De Graaf et al. 1998). Turf stripping is an expensive form of management and in addition to removing nutrients and acidified soil, it also removes the soil seed bank and organic matter, as well as reducing the water holding capacity of the soil (van den Berg and others 2003a). The removal of the soil seed bank means that if the local species pool is already depleted, appropriate species may not be able to re-colonize and may need to be reintroduced (Dorland and others 2004; van den Berg and others 2003b).

Many of these measures are unsuitable for application at a landscape scale and it would only be appropriate to apply them to sites of conservation importance or other targeted areas. Therefore a more effective way to reduce N deposition is to reduce N emissions at source.

Currently it falls to landowners to mitigate against the effects of N deposition. When conservation organizations are responsible for land management, such mitigation may be possible albeit expensive, but in many cases the land is owned by private individuals, so appropriate management needs to be promoted, e.g. through agri-environment schemes. Mitigation measures to reduce the effect of N deposition are not currently incorporated into these schemes in many parts of Europe, but some of the measures described above are feasible at different scales. Farmers need incentives to encourage appropriate management.

5.2 Heathland restoration and defragmentation

Dry heath restoration may be necessary in many EU countries and regions where the area should be expanded, to reduce fragmentation and improve the quality, structure and functions of this habitat type. Heathland restoration may involve different measures and techniques, including removal of trees, control of sprouting of scrub and trees, control and eradication of invasive species.

Given the longevity of the heathland seed bank, it is a habitat with great potential for restoration in the right conditions. Neglected heathland in unfavourable condition can be restored in many cases by introducing or adjusting to appropriate management, which is likely to include a combination of cutting, burning and grazing livestock (Symes and Day, 2003). These interventions also have the capacity to be damaging so clear site objectives are required to identify the balance of management types and intensities.

When there has been a change of land use, restoring the extent will requires removing the trees, when restoring a conifer plantation to heathland or reducing nutrient levels when converting arable land. However, restoring the structure and function is likely to be more difficult, depending on the nature of the land use change. For example, restoring a first cycle conifer plantation to heathland is likely to succeed, especially where the soil structure and nutrient composition have changed little. However, if the heathland was converted to arable land, with significant changes in the soil structure and nutrient loads, restoration is much more difficult or impossible without costly interventions.

Methods for the restoration of heathland on improved agricultural land may require a reversal of the increased soil pH and nutrient availability that is part of agricultural improvement so that ericaceous and acid grassland species are not outcompeted by large-growing mesotrophic grasses.

Successful approaches have been based on either physically removing the improved topsoil or chemically amending it by, for example, adding sulphur to reduce pH and macronutrient concentrations. However, sulphur, which is often added to decrease pH, may increase toxic cations or inhibit the development of mycorrhizal relationships (Diaz et al. 2008).

Removing the topsoil however, has extensive effects on the total mineral balance of the soil and the soil biota, which affects the success of the recovery of the heathland community (van der Bij et al., 2017; Vogels et al. 2017). Topsoil removal or sod cutting of degraded dry heath is not without problems as well. Shifts in major nutrient concentrations may occur (Härdtle et al. 2009) which also affect concentrations in plant tissues and thus in fodder quality and ammonium accumulation after sod cutting (Dorland et al. 2003) induces unfavourable conditions for seedling establishment of rare target species (van den Berg et al. 2005).

Therefore, sod cutting of degraded heath is a restoration technique that must be considered with caution, a technique that may be followed with a restoration of the mineral balance (Dorland et al., 2004) and should always be weighed up with other techniques (Wallis de Vries et al. 2014).

Heathland restoration planning should start by setting a clear objective. Objectives can differ depending on the restoration possibilities. Heathland restoration will require different effort and time depending on the degree of degradation and on the particular conditions on the site (Shellswell *et al* 2016).

When planning heathland restoration in a site, one should always consider the environmental conditions (climate, soil, geological and hydrological conditions, landscape fragmentation and its impact on species populations), economic (financial constraints) and social conditions (public, often also funders', opinion). Action will be more successful if the planning includes a risk assessment. All projects should include an evaluation plan, during the process and at the end of the project.

Recreation may be carried out by transplantation of heather turves, use of heather topsoil or heather litter as a source of propagules, harvesting and scattering of heather shoots. Each of these techniques may be useful in particular situations.

Some examples where restoration has been considered appropriate for the conservation of this habitat are summarised below:

- **Belgium**. In Wallonia, restoration of dry heaths is a priority. Inventories of potential restoration sites have been made, including where actions outside the N2000 network could be necessary to develop ecological connections between existing/restored sites.
- **Italy.** Key measures should concern the increase of areas where the habitat can develop and establish. This objective can be achieved relatively quickly within protected areas or Natura 2000 by recovering and making available to the habitat all sites which are still ecologically suitable but nowadays occupied by vegetation of poor or null conservation value, like thickets of *Betula, Populus tremula* and *Frangula alnus* or plantations of exotic species like *Pinus rigida* and *P. strobus.*

In many regions in its range, dry heath is highly fragmented and remaining patches are isolated. Enlarging and connecting them are prerequisites to ensure the survival of the populations of characteristic species.

Successful recreating or restoring dry heath and establishing functional corridors however require a thorough understanding of the landscape matrix. In intensively used landscapes with scattered habitats, mere segregation of heath and corridors on the one hand and other land use on the other will seldom result in a sustainable network.

The challenge is to establish interrelations with other land uses that facilitate the durable functionality of corridors and (newly created) heath. To achieve this, the different objectives of the land uses have to be acknowledged and a strategy to improve mutual benefits should be developed. To appreciate that heathland is in many aspects a cultural landscape, may help in this respect.

With an integrated approach, there is attention for the potentials of other land use to support the objectives to further develop and maintain the heath as an important habitat as well as for the gains this land use may obtain. Heathland may thus get a redefined role in the productive landscape. Determining this role and the linkages with other land use and developing the associated landscape pattern, will increase the chance to complete the environmental gradient that so many species depend on. Species rich acid grassland and crops with vegetal communities can be re-established, while semi-open woodland/heath corridors will allow for a higher connectivity for both heathland and forest species (Eggers et al. 2010).

Analysis of small heathland fragments can indicate where there is potential to enlarge and connect them into a functioning network by increasing their patch size in order to reduce fragmentation. Analysis of the potential heathland habitat network using soils, hydrology

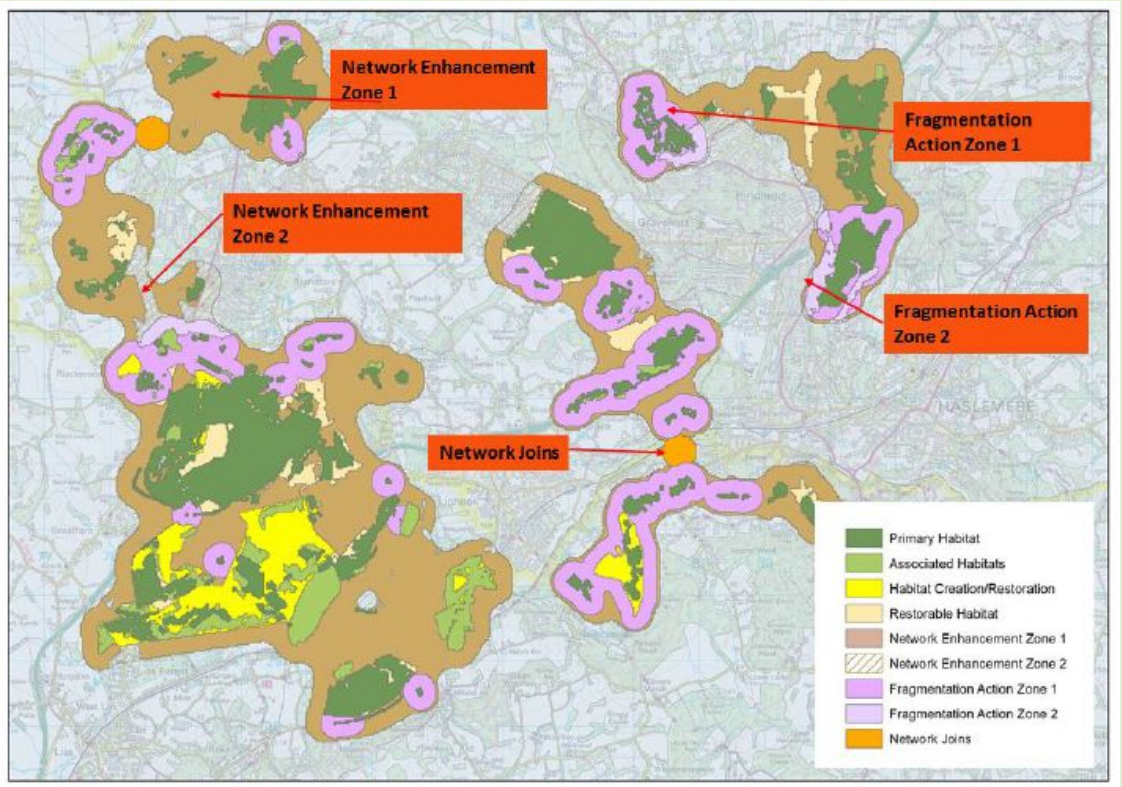
and climatic factors can indicate the areas where restoration could be carried out to increase the habitat extent although this potential can overlap with potential for other habitats and this should be fully considered.

Scottish Natural Heritage and Natural England (UK) have been looking at habitat networks mapping and connectivity in a range of habitats, including heathland. A case study on Habitat Network Mapping by Natural England is shown in Box 2 below.

Box 2. Mapping of the existing habitat and network enhancement zones[1]

Network Enhancement Zone

It identifies an area around the existing habitat (including areas which are degraded or under restoration) within which actions to enhance the resilience of the network can be targeted.



1) Enhancement Zone 1: Land connecting existing patches of primary and associated habitats which is likely to be suitable for creation of the primary habitat. Factors affecting suitability include: proximity to primary habitat, land use (urban/rural), soil type, slope and proximity to coast. Action in this zone can help to expand and join up existing habitat patches and improve the connections between them.

2) Enhancement Zone 2: Land connecting existing patches of primary and associated habitats which is less likely to be suitable for creation of the primary habitat. However, other actions that improve the biodiversity value of the land, such as increasing green infrastructure provision, in this zone can buffer existing habitat patches and improve connections between them.

3) Fragmentation Action Zone 1: Land within Enhancement Zone 1 that connects existing patches of primary and associated habitats which are currently highly fragmented and where fragmentation could be reduced by habitat creation. Action to address the most fragmented areas of habitat can be targeted here.

4) Fragmentation Action Zone 2: As above, for land within Enhancement Zone 2. Actions as described in Enhancement Zone 2 can be targeted here.

5) Network Joins: Locations where habitat creation could help to link up existing clusters of habitat patches across a landscape.

5.3 Conservation management and restoration for wildlife

An important aim of heathland conservation and restoration is often to provide habitat for protected species such as stone curlew (*Burhinus oedicnemus*), nightjar (*Caprimulgus europaeus*), sand lizard (*Lacerta agilis*) and various invertebrates that can have significant parts of their life cycles associated with heathlands. Key factors for all these species are appropriate vegetation structure and composition and the availability of food resources of sufficient quality (Diaz et al. 2011). Low concentrations of essential elements in the food may be a cause for declining predator populations (Vogels et al., 2013).

Management for birds: Stone curlew nest on open land including grass heaths and chicks usually forage within 100 m of their nest for surface-active invertebrates such as beetles, woodlice, molluscs, and worms (Green and Griffiths, 1994; Green et al. 2000). The availability of invertebrate prey has also been suggested as a possible factor affecting the recolonisation of sites by nightjar (Langston et al. 2007).

Insect-feeding birds may be affected by a decline in available insects, as food resources are then scarce and larger home ranges needed to feed their offspring. Such declines relate to changes in both vegetation structure and composition as well as more generally distributed changes.

Many of the species associated with heathland also benefit from the margins and areas of transition between one vegetation type and another, and their management requirements may vary. In the complex heathland landscape, attention should be paid to the restoration of the fertility gradient that formerly existed between the cultivated land (the 'infield') and the heath (the 'outfield').

In the following sections, habitat management requirements for three bird species closely associated with dry heathlands, Dartford Warbler (*Sylvia undata*), Woodlark (*Lullula arborea*) and Nightjar (*Caprimulgus europaeus*), are specified.

Dartford warbler *Sylvia undata* requires relatively large areas of sufficiently low heath that are managed in such a way as to maintain an appropriate level of grazing, burning and cutting of invading trees. In particular, encroachment of birch, bracken and pines needs to be resisted or even reversed on heathlands. The species also benefits from an age range of vegetation.

Woodlark *Lullula arborea* needs short turf and bare ground constantly available in areas that are free from disturbance. Areas of short turf for feeding need to be juxtaposed with areas of taller heather or tussocky grass for nesting. The species avoids areas that are overgrown, neglected or agriculturally improved. Regular mowing or burning, for example on a 20-year cycle, maintains a range of heather and should provide a continuity of short turf. Grazing helps to prolong and diversify the short structure.

Where it causes no damage to other important species, keep some areas short by a combination of grazing and mowing. It is preferred to avoid repeated burns as this will reduce invertebrate prey populations. The species needs a sparse scatter of trees as song posts and look-out posts. It is best to keep firebreaks mown short, or to have cut new ones every two years, as the old ones grow over. It is needed to control bracken (*Pteridium aquilinum*) to prevent it spreading to take over available habitat

Nightjar *Caprimulgus europaeus* needs a good proportion of old mature heather being retained for nesting with naturally occurring small gaps, in areas that are free from disturbance. Where the heather is uniform and lacks gaps, uprooting two or three plants together can create one to two metre-square gaps.

Cutting will have limited value, as the plants will regrow relatively quickly. It is useful to create a number of such gaps in each area to provide a range of options for the nightjars to choose. Keep a sparse scatter of trees as song or lookout posts. Where mature or old heather is absent or scarce, dense bracken (*Pteridium aquilinum*) may provide alternative nest sites early in the breeding season, but these are often lost as the bracken grows

It is important to prevent the bracken spreading. Avoid mechanised bracken control wherever nightjars might be nesting. Manage access, where possible, by providing defined paths that lead visitors away from nightjar nesting areas and by encouraging dog owners to keep their dogs on leads during the breeding season.

Areas of very old heaths, which tend to be more variable in structure and can include bare patches, may be important for the conservation of reptiles, invertebrates and ground-nesting birds. Such areas, which need to be managed separately for the conservation of a particular species, may need to be excluded from certain management practices as cutting or burning. They would also need a grazing Impact Assessment. Offer et al, 2003 provides a framework for considering the interaction of grazing management and the invertebrate and reptile fauna of heathlands.

Reptiles, amphibians and invertebrates often require mosaics of vegetation structure. Amphibian and Reptile Conservation has produced guidance for the conservation of reptiles and amphibians on heathland including for some UK Agri-environment schemes (e.g. HCT 2007, ARC 2011, 2016).

Burning of dry heath can be highly damaging to reptiles and their habitats (Jofre & Reading, 2012). Grazing is often promoted as a management tool with insufficient regard to the requirements of typical species. There is a need for research to document the impact of typical heathland management practices (burning, mowing, grazing) on heathland species including the herpetofauna assemblage, and for results to be incorporated into management advice.

Management for reptiles

Understanding the ecology and habitat requirements of reptiles can help in the planning and implementation of sympathetic management for these animals. Due to their need for warm sites, reptiles prefer south-facing slopes, or varied topography, usually on well-drained soils. They also need diverse vegetation structure, creating open areas and nearby cover, to provide protection from predators.

Cutting, mowing and grazing are often the most acceptable means of maintaining reptile habitat. They must, however, be applied with care, or sometimes even avoided in particular instances. Scrub and tree removal are normally essential to retain the open character of reptile habitats but management causing large-scale damage to vegetation structure can be catastrophic for local populations

It is important to implement a cutting regime that does not harm key features of a reptile site and it is essential to avoid simultaneous removal of all vegetation cover across a site, or substantial areas of it.

This can be achieved by strategic selection of limited areas of a site to be cut (for example targeting areas where scrub encroachment is most severe) or by programmed, phased cutting of a site divided into management plots. Many smaller plots are preferable to few larger ones to maintain habitat diversity at a fine scale. Two hectares is a suggested maximum plot size on large sites; smaller plots should be used for smaller sites. Interfaces between plots of differing vegetation heights create transitional zones that provide useful habitat.

Cutting should be undertaken when reptiles are least likely to be killed, ideally during the winter period of inactivity. In general, cutting should take place from November to February. However, attention should be given to weather conditions. For example, adders bask on fine spring days as early as January (in southern England) or February (elsewhere), which precludes mowing at hibernation sites at such times. Winter cutting or mowing should avoid creating large areas of very short sward vegetation around hibernation sites, where reptiles need some cover on emergence in the spring.

Heather dominated habitats should be cut on a much longer rotation of at least 25 to 30 years for reptiles, with the most sensitive areas left out of the cutting regime altogether. Gorse can be kept at an optimum state when cut on a 15-year rotation.

When using fire for management of heathland, particular care must be taken to consider the presence of sensitive animal species. Used with great care, burning can sometimes be useful in maintaining good vegetation condition for reptiles. However, burning too frequently, or at too large a scale, can be highly damaging to reptile populations. Where burning is considered, the following precautions are advised:

• Burning should be done when reptiles are in hibernation, and are thus less prone to direct mortality. The safest period is generally from November to the end of January, though local reptile activity should be taken into account.
• Burning methods should encourage a quick, cool burn rather than a slow, deep one. This promotes much better re-growth and the faster recovery of a more useful vegetation structure.
• Burning should employ as small a patch size as feasible, with a maximum of 1 ha on very large sites (>50 ha) ranging to a maximum of 0.1 ha on small (<3 ha) sites.
• Prior reptile surveys should inform the exact location of burn sites, with any particularly sensitive areas excluded (e.g. major hibernation sites or favoured basking banks).

Source: Edgar et al. 2010. Reptile Habitat Management Handbook

It is important to remember that the **historic management** at a site will have shaped the range of taxa found there and this pattern should be maintained or improved (particularly if it is an impoverished species set) where known. A rich array of species have adapted to the management regime traditionally applied in an area. Many of these species also benefit from the margins and areas of transition between one vegetation type and another, and their management requirements may vary.

When introducing management measures on heathlands, particular care should be taken to avoid possible impacts on species present in the site, e.g. by avoiding cutting during breeding seasons.

Adapting management to the needs of a particular species is not always advisable as there may be impacts on other interest features. It seems generally advisable to use management approaches that can provide a diverse vegetation structure and composition for the benefit different species groups present on the site. It is important not to manage all the area in one way at the same time.

When defining the heathlands conservation priorities from a species conservation point of view, attention should be paid to the presence of locally or nationally rare species.

The possible solutions should be considered in the context of the conservation objectives for the site. Some solutions may conflict, so action taken will be determined by overriding objectives.

A lot of species depend on the mixture of functional habitats in the heathland landscape. And thus, the main approach to achieve favourable condition of the habitat and its associated species is to ensure that there is structural diversity with different sward heights and openness, including small areas of bare ground; that there are links with adjacent habitats, such as woodlands, wetlands and temporary pools; that patches of nectar-rich flowers and uncut/ungrazed tall vegetation which provide feeding and overwintering areas for invertebrates, reptiles and other species are within reach (Alonso et al. 2018).

Some of the most important areas for invertebrates on heathland contain no heather, so it is important not to confuse heathland management with heather management (Kirby 2001).

Conserving and mainatinaing the habitat in good condition provides multiple benefits for many associated species and in particular for pollinator species, which are abundant in this habitat type. Some further recommendations to manage dry heaths in the benfit of pollinators are presented below.

Management and restoration of lowland dry heaths for pollinators

General habitat management recommendations for invertebrates (KIrby 2001):

- Maintain structural diversity (mosaic) of vegetation by ensuring all stages from bare ground to scrub are present at small scale, and including areas dominated by moss and lichen, low herbs growing on disturbed ground, and heather of a range of ages.
- Maintain artificial features and habitats such as remains of old buildings and walls, sand pits, embankments, tracks, and the enriched and disturbed ground associated with them.
- Keep paths and moderate trampling of people and livestock, as this produces hard-packed sand which is bare or sparsely vegetated, and which is a key nesting and foraging resource for invertebrates. Make sure steep slopes and south-facing slopes are kept partly bare or sparsely vegetated to ensure sunny sandy or rocky nesting habitats.
- Maintain flower-rich patches such as road verges and more intensively grazed grassland areas as foraging resources.
- Make sure there is some flowering scrub such as *Ulex* & *Cytisus* spp, and typical trees such as birch (*Betulus* spp.)

Functional pollination networks can be quite quickly restored on restored heathlands, as shown by a study of restored heathlands in the UK, mainly due to the same abundant generalist bumblebee and hoverfly species (Foriup et al 2008). However, species of conservation concern (specialist, rare and threatened species) are much less likely to colonize restored heathlands, even when there are existing habitat areas nearby. Tor example the heathland specialist butterfly Silver-studded Blue (*Plebejus argus*) is unlikely to colonize new habitat more than 1 km distant (Thomas & Harrison 1992 cited in Foriup et al 2008).

5.4 Planning for conservation management in a specific area

As the habitat features, conservation values and context (history and development) are different in the various countries and biogeographical regions, it is important, when planning the management for the habitat, to take into account the following general aspects which will allow sensible management decisions to be taken:

- Local/regional land use, livestock husbandry traditions, practices and techniques – the conservation values of today are often the result of the land use and management practices of the past. Although it is often neither possible, nor appropriate, nor necessary, to mimic historical management, it should if possible be informed by existing knowledge and experience.
- Special attention is needed when a still practised land-use is changing, e.g. military training areas are no longer needed. In these cases, concepts for both protection and establishment of long-term management are needed well before the change takes place.
- A detailed examination of the site conditions (involving experts and residents/users) will help to identify the best techniques and methods for habitat maintenance or restoration and assess their suitability for the particular situation. It is also necessary to consider the available resources and to assess the extent to which the objectives can be achieved and anticipate possible obstacles.
- Site-specific objectives and targets with reference to the conservation status of relevant species and with functional interrelations with the surrounding complex landscape mosaic.

Management aims for a particular heathland need to be clearly defined and should be accompanied by a detailed management plan. High typical heathland biodiversity requires a complex mosaic of different stages of heather, from pioneer phases to senescent phases and partial succession with shrubs and young trees.

The twin requirements of controlling tree growth and producing heather of diverse age are usually satisfied by a system of rotational management. This is done by dividing the overall area up into plots. The plots are then either cut, grazed and/or burnt on a rotational basis. This both checks tree growth and produces heather of a variety of ages on the site. The ability of heather to regenerate declines with age and this needs to be taken into account when planning the rotation (Symes & Day 2003).

Rotational management works well on large heathland areas. Small areas can be very difficult to manage because they are not big enough to divide into separate plots.

Management strategies should be developed at the landscape scale, based on explicit consideration of trade-offs associated with different management options. This will require coordination of planning and management across multiple sites, which represents a significant departure from the traditional management approach focusing on single sites in isolation.

Some examples of the measures suggested for the conservation of this habitat type in the UK are presented below.

Measures proposed for conservation and restoration of dry heaths in the UK

- *Habitat survey*. Programme(s) of habitat survey and mapping should be implemented, using aerial imagery/remote sensing in combination with field survey. If possible, land management and cultural activities should be recorded and vulnerabilities should be identified, including the presence of invasive species. These should be collaborative and involve partners where appropriate.

- *Habitat networks.* Beyond the networks of sites of European/national importance (SACs and SSSI), wider habitat networks should be identified, and restored to increase connectivity, to improve the cohesion of the Natura 2000 network.

- *Site designation.* In the light of continuing pressures on the habitat, including those outlined below that result in loss of extent, consider whether review of the current European and national site series (SAC/SSSIs) is required to achieve FCS, in particular to protect the rarest/most vulnerable types of heath and the rarest/most vulnerable typical species. Encourage local authorities to designate local nature conservation sites (LNCS) to protect rare/vulnerable types of heath and to improve the cohesion of the Natura 2000 network, for example lowland heaths, and to include appropriate policies for their protection in development and land-use plans.

- *Grazing.* Address the impacts of inappropriate grazing pressure. The production of grazing management plans, especially those relating to sites of European and national importance (SAC/SSSIs), should be encouraged.

- *Disturbance.* Measures to reduce inappropriate disturbance and damage associated with sporting and recreational activities including use of vehicles and construction of infrastructure, especially in sites of European and national importance, should be developed. This could include the implementation of agreed prescriptions/management plans in sites of European and national importance, including for example no-burn areas, and the implementation of appropriate codes of practice, for example for burning.

- *Invasive species.* Encourage land owners and managers and national and local agencies to control invasive native and non-native species on dry heaths and to produce invasive species management plans where appropriate.

- *Woodland expansion.* On SACs expansion of shrubs or woodland onto dry heath habitat should not be permitted unless scrub or woodland Annex I qualifying habitat, for example Caledonian forest and Juniper formations, has been prioritised in conservation plans. An overview of the effects of such conservation plans on the site series as a whole should be maintained. Encourage national and local agencies to consider the requirements of the Habitats Directive to maintain or restore, dry heath at FCS. This would include appropriate consultation regarding threatened areas of habitat, including with local authorities where appropriate.

- *Management schemes.* Encourage the development and subsequent uptake of Pillar 2 Rural Development Programmes, to support low intensity pastoralism and address issues such as over/under-grazing and control of invasive species, especially in sites of European and national importance.

Dry heaths management in Germany
Dry heaths should be maintained by extensive grazing especially with sheep and goats to release nutrients. Year-round grazing with cattle and horses can also be suitable. Top soil removal (Plaggen) in sections or alternatively occasional burning serve to rejuvenate the stands. The bushes should be partially removed. Keeping them open through military use may be sufficient. Buffer zones should be established to minimise nutrient inputs.

5.5 Criteria to prioritise measures and to identify priority areas for action

Prioritization can play a fundamental role for obtaining maximum effectiveness in conservation activities, optimizing costs and time for monitoring and management, and evaluating the appropriateness of management activities. With this aim, specific criteria for prioritisation of actions may be defined.

The following criteria are considered useful to prioritise conservation action on this habitat type:

- Geographical situation
- Most representative sites
- Time of abandonment
- Nature of the actual vegetation
- Degree of degradation, and/or encroachment
- Feasibility, e.g. accessibility of the area with necessary technology, ownership, etc.
- Fragmentation, lack of connectivity between sites
- Urgent needs (e.g. restoration in some regions)
- Presence of key species, both plants and animals (e.g. threatened species, pollinating insects),
- Abundance of endemic species (especially in southern Europe)
- Recognition of ecosystem services
- Threats and pressures can be quantified or qualified and this can be used to prioritise action
- Opportunities to re-establish functional relations
- Chances for improvement or completion of habitat series

5.6 Main stakeholders to define and implement the measures

In general, a broad engagement and partnership of relevant stakeholders is considered essential to effectively implement the necessary conservation measures (De Blust, 2013). Implementing participatory approaches that involve the following stakeholders are considered important for the design and implementation of the conservation measures:

- Farmers, landowners, land users.
- Site managers, public administrations (national, regional, local).
- Administrators and those responsible for military grounds.
- Nature conservation institutions and organisations.
- Agriculture, forestry and hunting institutions and organisations.
- Scientific advisors and supervisors.
- Advisory services and technical assistance to help farmers with implementation.
- NGOs.

- Local communities.
- Local tourist operators and entrepreneurs (heathlands are often attractive landscape elements, grazing animal products may be used as local products).

5.7 Challenges, difficulties and possible solutions

Important challenges and difficulties are related to the necessity of developing a self-sustaining economy in marginal areas hosting the habitat 4030. The widespread ongoing processes of abandonment are the result of the collapse of montane and rural agricultural systems, which are not competitive with the modern, large-scale productive systems. An approach to counteract this process should go through the development of sustainable production systems of which heathland is a functional component and that can guarantee the maintenance of the local population (Diemont et al. 2013a; 2013b).

Technical problems may also derive from the need of scientific supervision for a correct sustainable use of 4030 dry heaths. Appropriate management should take care of the local, ecological, floristic, biogeographic characteristics and select the most appropriate measures, e.g. amount and timing of grazing animals. All the measures should be supported by dedicated monitoring programmes, which might help the development of adaptive management.

Another important challenge is the different values that people give to this habitat: e.g., for some people the recreational values are more important than the biodiversity values.

5.8 Conclusions and recommendations

- Conservation objectives and priorities can be defined at biogeographical region level to achieve Favourable Conservation Status and to address the main threats to the habitat, including the identification of restoration needs to improve the area, structure and function, where needed.
- Conservation objectives defined at the EU biogeographical need to be translated into more specific objectives at the country level and then at site level. The action plan suggests the identification of priority sites and important areas to ensure the habitat conservation and to contribute to the objectives set at a higher level (e.g. biogeographical, national) both inside and outside the Natura 2000 network.
- Site-level conservation objectives should define the condition to be achieved by the habitat type in the respective sites in order to maximise the contribution of the sites to achieving favourable conservation status at the national, biogeographical or European level.
- Site-level conservation measures should be established in order to achieve the site-level conservation objectives, in order to address pressures and threats.
- Depending on the coverage of this habitat type by the Natura 2000 network, taking action outside protected areas may be necessary to ensure its overall long-term conservation, ecological variability and adequate connectivity across its natural range, as well as for the conservation of species associated with the habitat.

- The maintenance of this habitat in good condition is dependent on regular management practices that need to be determined depending on local conditions and historic management practices and tailored objectives.
- A detailed examination of the site conditions will help to identify the best techniques and methods for habitat maintenance or restoration and assess their suitability for the particular situation, also considering the available resources, to assess the extent to which the objectives can be achieved and anticipate possible obstacles.
- Key aspects to consider when planning for heathland conservation and management include ecological and socio-economic considerations. Restoration and management should be carried out according to an individual restoration and management plan for the particular site.
- Adapting management to the needs of particular species may be required depending on the conservation objectives of the sites, but in general the management focus should be on the habitat.
- The restoration or re-creation of heathlands may be necessary or appropriate in some situations. Its feasibility should be properly determined with the assistance of relevant experts (on soil, hydrology, ecology, vegetation, etc.). A heathland restoration plan should be developed.
- Important challenges for the conservation of this habitat are related to the difficulties for maintaining a self-sustaining economy in marginal areas hosting the habitat. A widespread process of abandonment of traditional management is ongoing. An approach to counteract this process should address the development of sustainable productive systems, of which heathland can be part, which can guarantee the maintenance of the local populations.
- Another important challenge is the different values that people give to this habitat: e.g., for some people the recreational values are more important than the biodiversity values. Therefore, the different ecosystem services of the habitat should be taken as a starting point to define balanced conservation objectives that assure the maintenance of high quality biodiversity while equally acknowledging societal demands.
- In the military use of training areas, the protection of dry heaths should be taken into account through appropriate land management. If military training areas with significant heath stands are abandoned, efforts should be made to protect them under nature conservation law. Appropriate management measures -especially on ammunition contaminated areas- should be developed and established.
- The return of the wolf (*Canis lupus*) to Central Europe requires preventive measures to protect flocks of sheep and goats, which are important for the grazing of dry heaths. Electric fences and guard dogs have proven to be particularly effective throughout Europe (BfN 2019). Government prevention and compensation payments should be offered to support livestock farmers[35].

[35] The EU Platform on Coexistence between People and Large Carnivores suggests several measures to improve coexistence of wolf and lkivestock, in addition to compensation payments. See: https://ec.europa.eu/environment/nature/conservation/species/carnivores/coexistence_platform.htm

6. COSTS, FUNDING AND SUPPORTING TOOLS

6.1 Cost of conservation measures

6.1.1 Cost assessment

Cost assessment is an important step in the preparation of heathland management plans. Cost varies over time and can rarely be generalised for specific types of work or a set of actions required to improve the habitat condition. Costs for similar works can differ greatly – depending on the geographic location, complexity of works, availability of workers and special equipment, as well as other factors. These guidelines are meant for use over an extended period of time, therefore exact costs are not given.

It is important to bear in mind that heathlands vary greatly in their accessibility for machinery, and the farmers or shepherds who manage them also vary greatly in their resources and capacity. For example, some are part of common land ownership arrangements, or they manage the land in an informal arrangement with the owner(s).

Costs must be assessed separately for each action or for the whole work in a particular place and time.

In small areas (e.g. up to 1 ha), as well as in cases where management is regular or certain parameters are known (for example: annual mowing, grazing, etc.), the cost can be generally equated to works performed elsewhere, or by interviewing the potential workers/contractors and agreeing on the total cost of all works. Usually, the bigger the area, the more cost-effective the management.

Cost information available from different countries

In **Belgium** (Wallonia) restoration of dry heath by sod-cutting cost 2000-4000 euro/ha, depending of the size of the plots. Shrubs eradication costs 500-2000 euro/ha, depending on local conditions (height and density of the shrubs). Restoration by controlled burning might be much cheaper, but is often difficult to realize. Costs of mowing are very variable depending on local conditions (stony areas, complicated topography, tussocky vegetation, dense litter layer, etc.). Land purchase of dry heath/potential dry heath areas may cost 3000-12,000 euro/ha. The management of sites is funded by local authorities and/or NGOs with help of Agri-Environment funding for local farmers or breeders for grazed habitats (650 euro/ha/year in N2000 areas).

Hungary. Shrub eradication costs 800-2000 euro/ha, depending on local conditions (height and density of the shrubs).

Italy. The cost for the recovery of habitat reported in Brusa (2015), concerning an area of about 0.2 hectares, was 4.91 euro/m^2.

6.2 Potential sources of financing

In general, the main funds that could be used for restoration, conservation management and monitoring of the habitat and to raise public awareness are the Common Agricultural Policy funds or other European funding such as the Regional Development Funds and LIFE, as well as national funds.

6.2.1 Common Agricultural Policy funding

The Common Agricultural Policy, and particularly the European Agricultural Fund for Rural Development (EAFRD), can be an important source of funding for heathland management for biodiversity, including through agri-environment measures, training and advice for implementation of measures, etc.

However, Member States make limited use of EAFRD for heathlands. There are some agri-environment schemes and heathland restoration funded though non-productive investments. On the other hand, some countries do not consider heathlands to be agricultural land and exclude them from being eligible for CAP funding.

Management of dry heaths can be made more economically viable by developing markets for the biomass produced (composting, pellets, energy production, etc.). A strong effort should be put in trying to consider these processes in CAP actions.

Heathland generally occurs in areas with poor soil quality that can be suitable for low input nature-inclusive farming systems, with mainly extensive animal husbandry as the most appropriate form of high nature value farming (Oppermann et al., 2012; Schrijver & Diemont, 2013b). Without a considerable contribution of the CAP, maintaining and restoring dry heaths appears to be unsustainable in the long-term.

Eligibility for direct payments or other forms of farm income support

Member States have taken different approaches to providing farm income support to farmers grazing heathlands. In some, the definition of land eligibility for Pillar 1 area-based payments excludes any encroachment of semi-natural vegetation on pasture, particularly scrub, heather, furze and other semi-natural habitat features, or heather that is too tall leads to proportional reductions in payments for that parcel of land. This has the perverse effect of encouraging farmers to remove heather or scrub, damaging or destroying the habitat, or accept that their direct payments will decrease, further increasing the risk of abandonment. Solutions to this include a pro rata system or increased support through other measures (see the box for some Member State examples).

Access to a combination of the direct payment and the Area of Natural Constraints payment can help farmers keep grazing these lands. However, in some situations direct payments do not provide an incentive for farmers to actively graze the land, as they can obtain the payment by burning heathland to retain eligibility whilst abandoning or decreasing livestock grazing, especially if the heaths are difficult to access and have poor or no grazing infrastructure.

Some examples of how Member States are funding heaths through CAP Pillar 1

France has extended the definition of permanent grasslands to include ligneous grazable vegetation on heaths (FR: '*landes*'), and use a pro-rata system to calculate the support taking into consideration only grazable elements, and excluding ineligible features (such as rocks and non-grazable trees and scrub). This has resulted in significant support for livestock grazing on heaths, whilst at the same time nearly all farmers are in agri-environment contracts that set stocking restrictions, so avoiding overgrazing[36].

[36] See Poux (2015) EFNCP publication at http://www.efncp.org/policy/semi-natural-pastures-meadows/

In Germany there is the possibility of recognizing various heath areas, including the dry European heaths, as eligible areas of permanent grassland under established local practices. This option was used in Baden-Württemberg, where it is necessary however to carry out mapping every three years.

The Netherlands have a voluntary coupled support scheme called 'grazing animal premium' (NL: '*Graasdierpremie*'), which supports farmers that graze cows or sheep on natural land which is otherwise not eligible for direct payments – including heaths. The premium is calculated on the average number of animals that continuously graze non-eligible land between 15 May and 15 October. Although the grazing premium represents a relatively small budget, it provides an important incentive to sheep farmers to directly contribute to biodiversity objectives most notably to reduce unwanted natural succession.

A ECJ judgment of May 15, 2019 (Case C-827/18) stated that the prerequisite for funding under the 1st pillar of the CAP is given by the agricultural use and not by the existence of agricultural land. The dry European heaths are usually originated from traditional agricultural use and rely on such use. Accordingly, it would be desirable that European dry heaths were recognized as eligible area and corresponding funding was possible via the 1st pillar of the CAP.

Agri-environment measures and non-productive investments

Ireland and the UK have agri-environment schemes tailored for heathland, and Belgium (Wallonia) has funded heathland restoration though agri-environment and non-productive investments under the regional Rural Development Programme.

A particularly relevant approach for heath is the implementation of results based schemes, which allow both a focus on achievement of positive results for biodiversity conservation and greater flexibility in management decisions adapted to each site. An example for habitat 4030 is provided in the box below.

Agri-environmental Scheme for the Hen Harrier (Ireland)

The Hen Harrier Project is a Locally Led Scheme funded by the Ireland's Rural Development Programme 2014-2020. The project is a locally targeted conservation programme building strong partnerships with farmers to deliver sustainable benefits for biodiversity, upland ecosystems and a vibrant local rural economy.

The Hen Harrier Project uses a novel 'hybrid' approach to farming for conservation which sees farmers paid for both work undertaken and, most importantly, for the delivery of defined environmental objectives. It represents a practical results based approach to farming in Special Protection Areas designated for the protection of breeding Hen Harrier, which need grazing - but not too much and not too little.

Unlike traditional agri-environment schemes, actions are not seen as an end in themselves, they serve primarily to improve the farmers' capacity to benefit from the habitats or Hen Harrier payment.

Payment types

- A points-based habitat payment - this pays for the quality of the habitat delivered at the end of each breeding season.
- A Hen Harrier payment - this represents local recognition of local success in terms of supporting breeding Hen Harrier.
- A supporting actions payment - this is an investment with the farmer in actions that improve the farmers' capacity to benefit from the other two payments.

Payment for results

All eligible land will be scored annually with a user-friendly scorecard and receive a score. Higher scores receive higher payments. This gives farmers the incentive to manage their fields in ways that will improve the habitat condition and their payment as well.

Payment for actions

An annual farm plan will contain a list of actions (jobs) that are nominated by the farmer with the aim of improving the site's management and conservation condition for the benefit of the Hen Harrier.

For more information see: http://www.henharrierproject.ie/

Advice and support to farmers

Heaths are often common land where groups of farmers share grazing rights with no fences. In Ireland, these commonage groups do not have formal governance structures, and because of the uneconomic situation, many of the farmers have stopped keeping livestock whilst continuing to claim direct payments. As a result, most commonage heaths are now undergrazed and often overburned. Advice and support can help farmer groups access and share funding and organise restoration activities, whilst improving ecosystem services and biodiversity[37].

Support under CAP for adding value to the produce of farms

Many farmers on Natura 2000 and HNV grasslands face challenges selling their products, because they are often small producers in remote areas where there are few customers who can pay premium prices. On the other hand, some are well-placed to take advantage of direct marketing to eco-tourists and tourist services such as hotels and restaurants. In some regions, farmers have built up successful direct marketing connections to supermarkets. The range of support for farmers seeking to add value to their produce includes support for setting up producer groups, developing quality schemes for agricultural products, and setting up labelling and Protected Designation of Origin designations.

Improving support to high nature value farming and the provision of ecosystem services

Large areas of heathland and grassland are abandoned in Europe. Sustainable management of these landscapes should become a priority of combined actions. Reappraisal of their (lost) services such as the provision of drinking water, the sequestration of carbon or the prevention of wildfires could revitalize these areas, conserve biodiversity and add to the local economy (Castro 2013; Ritzema et al. 2016; Siepel et al. 2013). Payment for

[37] See for example the Sustainable Uplands Agri-environment Scheme (SUAS) pilot project at http://www.wicklowuplands.ie/wicklow_mountain_views_28_suas-pilot-project/

ecosystem services has to be arranged, an objective where the Common Agricultural Policy can play a key role (Kieboom et al., 2013).

Development of new collaborations and integrated land use should be possible through concerted use of instruments of sectorial policy domains such as agriculture, environment and regional development. This may call for a revised definition of 'Utilized Agricultural Area' and the possibility to use 'Pillar I' and 'Pillar II' funding of the Common Agricultural Policy to support this new integrated land use. Pillar II is already used to pay for environmental benefits but can be optimized by reassessing the criteria for co-funding by the individual member states that is required to address major environmental issues. Besides that, Pillar I should be made more available to pay land managers for the provisioning of ecosystem and landscape public goods, in accordance with its natural and cultural values (Kieboom et al., 2013).

The farmers must be actively involved in the management and planning of nature conservation measures. However, this does not happen by itself, but needs an integrated approach in order to be effective. Therefore business and management should consider the 'whole farm system' and start from a landscape scale approach to seek synergies and match products and markets & customers.

6.2.2 LIFE projects

Over 100 LIFE projects have developed measures to improve the conservation status of the 4030 habitat, focusing on restoration, conservation measures and raising awareness, in 20 Member States across the EU[38].

In Belgium (Wallonia), seven LIFE projects have helped to restore and adequately manage a number of heaths that were used by the military over the last 20 years, and results are very encouraging (Frankard 2006, 2012, 2016).

In Slovakia, a Life project has carried out the restoration of sand dunes and dry heaths on a total area of almost 500 ha at three Natura 2000 sites in Zahorie Military Training Area (SKLIFE06 NAT/SK/000115). The ecological conditions were substantially improved on a further 200 ha of dry heath.

Afforested pine trees were removed on over 285 ha, in order to enhance the development of the native vegetation of sand dunes and dry heaths. All the woody biomass was removed from the site to avoid the development of weeds. At the most sensitive plots (e.g. with dense cover of *Cladonia* lichens) only hand-tools were used, to minimise damage to the plant communities. In addition, black locust trees (*Robinia pseudoacacia*), an alien invasive species, were eliminated on 5 ha.

Another restoration measure - sod cutting - was implemented on more than 170 ha. The purpose of this measure was to enable the development of natural sand dune pioneer vegetation on the areas of open bare sand, which in turn improves conditions for invertebrate sand specialists (e.g. ant lions). It also created fire protection belts, as large areas of bare sand functions as an efficient barrier against the spreading of forest fires.

[38] LIFE projects database, 11 October 2019, at http://ec.europa.eu/environment/life/project/Projects/index.cfm

The involvement of the Ministry of Defence in the implementation of a large-scale nature conservation project on military lands was the first such case of its kind in Slovakia, and marks a timely innovation (Sedláková and Chytrý, 1999).

Germany currently conducts an integrated IP-LIFE project (LIFE15 IPE/DE/007, Atlantic sand landscapes)[39], which will improve the conservation status of habitats and species on the sandy soils of the Atlantic biogeographic region and includes both the habitats 4030 and 4010.

In Denmark a LIFE project[40] was carried out with the aim to restore some of Denmark's large areas of heathland. Six sites of Community Importance were selected, covering a project site surface area of 66 km^2. The results were published along with a handbook in management practices.

6.2.3 Structural Funds

Structural funds (mainly ERDF) have been used for heathland restoration and management in Belgium, Bulgaria, Romania, Slovakia and other countries. European Territorial Cooperation (Interreg) projects have also provided funding for heathlands management in Hungary.

6.2.4 Other approaches and supporting tools

Many heathlands are owned and managed by the state, for example by the military. In Poland, heathland conservation is implemented voluntarily by the Army on military training areas (trees removal as part of training area maintenance) or by State Forests owning former military training areas (conservation measures as part of biodiversity care). Several examples of heath maintenance in military sites are available also from LIFE projects[41].

Dorset heaths in military sites

Of the 6,500 ha lowland heath left in Dorset after the destruction of most of its original extent by agricultural changes and urbanisation, 1,350 ha (20%) are owned by the Ministry of Defence, distributed over 5 military sites. These sites are used for live firing, which causes expanses of heath to burn off, and for tank exercises, which create deep tracks or expanses of bare sand. This mimics the traditional use, which created and maintained the heathland semi-natural habitat for many centuries. In the 19th century and before, carts and livestock etched out sandy tracks across the heaths, while areas were regularly burned for grazing and cropping. A Life project carried out in the site (LIFE92/NAT/ UK/0133) demonstrated that the armed forces had all those years been doing recurring heathland management and bare sand habitat creation on their Dorset sites, but not deliberately, simply as part of their normal activities. This conclusion was also backed up by literature.

Managing sites for hunting (e.g. grouse in Scotland) can also contribute to maintenance of heathland ion good condition.

[39] https://www.sandlandschaften.de/en/index.html
[40] https://eng.naturstyrelsen.dk/nature-protection/nature-projects/life-hedeprojektet/
[41] See LIFE, Natura 2000 and the military. Available at: https://ec.europa.eu/environment/archives/life/publications/lifepublications/lifefocus/documents/military_en.pdf

Some local communities may invest in the maintenance of heathlands as a local tourist attraction.

In some cases, voluntary effort of bee-keepers (heather honey production) is carried out.

In the UK, the National Lottery has contributed funding from their "good causes" towards heathland management and restoration projects for years, including its priority species. A recent example is the "Back from the Brink project" (https://naturebftb.co.uk/).

6.3 Main funding gaps and difficulties

It appears that there are limited financial resources to promote conservation of this habitat and it is a challenge to ensure continuity of recurrent management measures started by LIFE projects once they finish (e.g. in Belgium).

There are also difficulties to finance heathlands maintenance and restoration with RDP funds. The LIFE+ and potentially structural funds seem to be the main financial source to support restoration of valuable heathlands but resources are still limited.

There is not a good track record of expenditure of agri-environment payments related to Natura 2000 sites.

Compensatory payment systems for landowners in Natura2000 sites as well as incentives (including fiscal incentives) are insufficiently developed in most European countries.

There is in general rather low funding for 4030, which has historically been regarded as something to be reclaimed in many parts of Europe, e.g. in Italy and Spain. A full awareness of the importance of the habitat has still not been reached, and the rapid rate of decline recently suffered in some areas (e.g. lowland heathlands of Po Valley) is largely underestimated. Even locally, a key issue is to join the conservation measures of 4030 and their funding to policies and budgets of agro-forestry compartments, from which they are now excluded.

6.4 Conclusions and recommendations

- It is important that the required measures for improving the conservation status of this habitat type are properly included in the Priority Action Framework for financing Natura 2000 (PAF) and in the CAP Strategic Plans for the next financing period.
- Agricultural support schemes, including agri-environmental measures, could be used for funding the management of this habitat and could be adapted to allow for co-funding of complex habitat types, where different succession stages may form an integral part of the Annex I habitat type (without declaring part of the habitat as non-agricultural / not eligible for funding).
- Financing of preparatory actions, as habitat survey, mapping and assessment, as well as financing of continuous monitoring should be ensured.

7. MONITORING

7.1 Habitat monitoring methods

As already mentioned in the section on Conservation status assessment, habitat monitoring schemes and protocols are available or are being currently developed and improved in several EU countries. In contrast to the assessment of conservation status as part of the reporting obligations according to Article 17 of the Habitats Directive, no standardised EU guidelines exist for monitoring.

A review and analysis of habitat monitoring according to Article 11 and Article 17 of the Habitats Directive in several EU Member States has been recently carried out (Ellwanger et al. 2018). Some Member have established and already applied a special, standardised monitoring programme according to Article 11. Some have used data from existing monitoring programmes and many States are still developing or implementing their monitoring schemes or revising it.

The analysis reveals considerable differences in the quality and quantity of monitoring data used for assessment of conservation status of habitat types. Most Member States use monitoring based on samples, including field survey, but the data collection, sample sizes and level of statistical certainty differ considerably.

The analysis by Ellwanger et al. (2018) has identified some best practices implemented so far that can be considered as recommendations for sample-based habitat monitoring for the parameter 'structure and functions':

- sufficiently large sample size to be able to estimate changes in condition of a habitat type with sufficient certainty
- stratification of samples according to the areal proportion of habitat types and whether they are located within or outside the SACs
- survey of habitat types on fixed permanent sampling plots
- examination of each sampling plot at least in one year of each reporting period, several times in the case of anthropozoogenic habitat types which respond quickly to changing land use or pressures
- consideration of typical plant species at least by means of roughly quantified species lists or vegetation surveys
- consideration of typical animal species of well-known groups of species with a known indicator function in the assessment of habitat types,

Remote sensing methods are used only sporadically, apart from the use of aerial images for mapping of habitat types. On the one hand, it is almost impossible to recognise habitat types even with satellite data; on the other hand, the responsible project managers so far lack access to the necessary data, computing capacity, standardised analysing tools and specific knowledge. The rapid development in this field could lead to new possible applications to monitoring of habitats (e.g. Corbane et al. 2015, Schmidt et al. 2017).

Each Member State defines the criteria, indicators and threshold used for the assessment of the parameters that define the conservation status of each habitat (e.g. for structure and functions), the number of repetitions (in a reporting period) and the extent of tolerable changes in criteria/indicators. Thus, it is impossible to combine assessments of sample plots from different Member States at a biogeographical level or compare them directly. As

already mentioned in the section on Conservation Status (see section 3.6 on Recommendations), the harmonisation of methods and programmes for habitat monitoring in all Member States would have many advantages. It would require however a significant effort of coordination.

7.2 Monitoring effectiveness of the action plan and conservation measures

To assess the validity and effectiveness of management measures, it is necessary to carry out a serious, scientifically-supervised monitoring activity of the habitat, by applying standard scientific protocols. Habitat monitoring should provide evident indications of the results of management (effectiveness, ineffectiveness, damage).

Some possible indicators to assess the effectiveness of management measures could include the following:

- Area of habitat in favourable conservation status.
- Variation of area covered by the habitat, overall and in selected locations.
- Increase of managed areas, increase or maintenance of favourable status in managed areas, improving status of typical species, regression of unwanted species (tree species, nitrophilous species, etc.).
- Diversity of habitat-typical, endangered or rare species, occurrence of problematic species.
- Floristic composition. Species diversity (presence and status of typical plants and invertebrate species). Vegetation structure, indicator species (both positive and negative and from different groups of organisms, incl. soil biota).
- Key parameters of the successional processes (cover and height of scrub and trees).
- Area under appropriate management.
- Cost of measures and funding.

It would also be important to promote monitoring regarding some trans-national issues, such as N deposition and climate change across the habitat range.

7.3 Review of the action plan

It would seem appropriate to review and adjust the action plan every twelve years, to cover two reporting cycles (under Article 17 of the Habitats Directive), given the slow time for habitats to react to changes.

Nevertheless, the implementation of the actions could be periodically reviewed (e.g. every six-ten years) in order to check the activities implemented and intermediate results, detect possible gaps, difficulties and constraints that would need to be resolved.

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Action plan to maintain and restore to favourable conservation status the habitat type 4030 Europeran dry heaths

ANNEX

1. Habitat type definition and interpretation problems

1.1Definition across countries

In the Czech Republic, this habitat type (European dry heats) includes three formations divided according to origin and temperature/altitude (in the scope of Czech national classification system, defined in the Czech national habitat catalogue):

T8.1B Dry lowland and colline heaths without occurrence of *Juniperus communis* are semi-natural vegetation, which develop on dry, acidic and nutrient-poor soils in lower and warmer stands.

T8.2B Secondary submontane and montane heaths without occurrence of *Juniperus communis* occur on similar conditions in middle and higher altitudes.

T8.3 *Vaccinium* vegetation of cliffs and boulder screes is natural or semi-natural vegetation on similar condition as T8.2B, but is dominated by *Vaccinium* species.

In Ireland, there are six communities of dry heath vegetation in the provisional national classification all referable to the Annex I category 4030 Dry heath (Perrin et al, 2014):

- DH1 is characterised by the presence of *Ulex gallii*, generally accompanied by *Erica cinerea* or *Calluna vulgaris*; it is typically found in coastal areas.
- DH2 is a regional type of western Galway and western Mayo and is characterised by the presence of *Erica erigena* and *Calluna vulgaris*; if *Erica erigena* is present but *Calluna vulgaris* is scarce or absent and there is a peat-forming element to the vegetation, refer to PFLU4.
- DH3 is the most common community and maybe regarded as the 'standard' type of dry heath. It is usually dominated by *Calluna vulgaris* or occassionally *Erica cinerea*, but this latter species need not be present.
- DH4 is similar to DH3 and often occurs in mosaic with it. It is differentiated by the presence of *Sphagnum capillifolium* or *Sphagnum subnitens cushions* and is somewhat damper than other dry heaths, but generally it is readily identified; where other *Sphagnum* spp. occur, refer to wet heaths and blanket bogs.
- DH5 is a calcareous heath community characterised by a mixture of heath and calcareous grassland species; it would typically be only recorded in areas of outcropping limestone or rocky, shallow, base-rich soils.
- DH6 is characterised by an abundance of *Vaccinium myrtillus*, generally with *Calluna vulgaris* on rocky ground. *Vaccinium myrtillus* should account for a minimum of 20% of cover, if cover of this species is less than 20% refer to DH3.

Three main sub-types (associations) are identified in Poland, according to phytosociological system of vegetation syntaxa:

- Typical heathlands = *Pohlio-Callunetum*; in whole Poland, the most common subtype.

- Broom flowered heathlands = heathlands with *Genista germanica; Calluno-Genistetum*, very rare and endangered, with a bit bigger floristic diversity, only in Western Poland (subatlantic); "flowers-rich form".
- Bearberry heathlands = heathlands with *Arctostaphyllos uva-ursi* carpets, *Arctostaphylo-Callunetum*, rare and endangered, in Eastern and central Poland only (subcontinental-subboreal).

In Denmark, in order to recognize a particular area as 4030 the area must be characterized by a vegetation of chamaephytic dwarf shrubs (*Calluna vulgaris, Empetrum nigrum, Vaccinium vitis-idea, Vaccinium myrtillus, Genist*a spp. and/or *Cytisus scoparius*). The habitat type usually requires a sandy substrate on nutrient poor, acidic soil and it is best developed in regions with relatively high rainfall. If the substrate of an area is deposited by aeolian processes then other habitat types must be considered (2140, 2310 and 2320). If tree/bush cover of non-invasive species exceeds 50 % then a forest type must be considered, unless coverage was below 50 % in 1994 (time of coming into force of the Habitats Directive in Denmark). The habitat type has no subtypes in Denmark, nevertheless the habitat type supports quite different biodiversity depending on geographical position. Generally, 4030 are warmer and drier in eastern Denmark.

In practical mapping of this habitat type it is sometimes difficult to determine whether the sandy substrate was deposited by aeolian processes and if so then if sand is originated from the coast (2140) or from alluvial deposits (2310/20). The habitat type is dependent on management (grazing, burning, etc.) and in some periods of the management cycle a temporary decline in coverage of dwarf shrubs is to be accepted, however it is not always easy to ascribe low coverage to its exact cause.

According to Ojeda (2009a; see also Gil-López et al. 2018), the European dry heaths habitat in Spain (and Portugal) is a dense, dwarf scrub vegetation dominated by heaths (*Calluna vulgaris* and *Erica* spp.), gorse (*Genista* spp*, Pterospartum tridentatum, Stauracanthus* spp*, Ulex* spp) and rockroses (*Cistus* spp and *Halimium* spp). This habitat is relatively abundant in the western half of the Iberian Peninsula (and northwesternmost tip of Africa), both in temperate Eurosiberian and Mediterranean areas of the Iberian Peninsula. It is found on acid, sandy (or sandy-loamy), nutrient-poor soils from the sea level up to 1,900 m asl, where this habitat is replaced by alpine heathlands (habitat 4060) or oromediterranean heathlands (habitat 4090). On boggy, waterlogged soils, the European dry heathland habitat is replaced by Atlantic wet heathlands (habitat 4020).

From a floristic point of view, they are defined by the abundant presence of heath (*Calluna vulgaris, Erica* spp.) and gorse (*Genista* spp., *Ulex* spp.) species. While *Calluna vulgaris* is almost ubiquitous, *Erica australis*, *E. umbellata* and, to a lesser extent, *E. scoparia* are the dominant heath species in Mediteranean dry heathlands. In Atlantic dry heathlands, by contrast, *E. cinerea* becomes dominant, together with *Daboecia cantabrica* and *Vaccinium myrtillus*, also in the *Ericaceae* family. This marked floristic variation (Gil-López et al. 2018) determines a somewhat morphological distinction between Atlantic and Mediterranean European dry heathlands in Spain.

In the UK, European dry heaths typically occur on freely-draining, acidic to circumneutral soils with generally low nutrient content. Ericaceous dwarf-shrubs dominate the vegetation. The most common is heather *Calluna vulgaris*, which often occurs in

combination with gorse *Ulex* spp., bilberry *Vaccinium* spp. or bell heather *Erica cinerea*, though other dwarf-shrubs are important locally. Nearly all dry heath is semi-natural, being derived from woodland through a long history of grazing and burning. Most dry heaths are managed as extensive grazing for livestock or, in upland areas, as grouse moors.

Twelve NVC types in Britain meet the definition of this habitat type:

- H1 *Calluna vulgaris – Festuca ovina* heath
- H2 *Calluna vulgaris – Ulex minor* heath
- H3 *Ulex minor – Agrostis curtisii* heath
- H4 *Ulex gallii – Agrostis curtisii* heath
- H7 *Calluna vulgaris – Scilla verna* heath
- H8 *Calluna vulgaris – Ulex gallii* heath
- H9 *Calluna vulgaris – Deschampsia flexuosa* heath
- H10 *Calluna vulgaris – Erica cinerea* heath
- H12 *Calluna vulgaris – Vaccinium myrtillus* heath
- H16 *Calluna vulgaris – Arctostaphylos uva-ursi* heath
- H18 *Vaccinium myrtillus – Deschampsia flexuosa* heath
- H21 *Calluna vulgaris – Vaccinium myrtillus – Sphagnum capillifolium* heath

Not all forms of these communities are European dry heaths. For example, dry heath vegetation on deep peat is regarded as bog, while alpine forms of the last five types listed above (found at high elevations and in northern latitudes around and above the presumed natural tree-line) are referable to Annex I type 4060 Alpine and Boreal heaths. Most forms of H1 *Calluna – Festuca* heath belong within the European dry heathscategory, including those rare occurences of the *Carex arenaria* sub-community (H1d) on inland dune systems such as Breckland; but this sub-community is more usually found on the coast, when is referable to 2150 Atlantic decalcified fixed dunes. Stands of H7 *Calluna – Scilla* heath on moorland near the sea conform to European dry heaths, but most examples, together with stands of H8d *Calluna – Ulex* heath, *Scilla verna* sub-community on sea cliffs, are referable to 1230 Vegetated sea cliffs of the Atlantic and Baltic coasts. Dry heaths vary in their flora and fauna according to climate, and are also influenced by altitude, aspect, soil conditions (especially base-status and drainage), maritime influence, and grazing and burning intensity. There is a gradation from southerly to northerly kinds of dry heath, and there are also both western (oceanic) and eastern (more continental) forms.

1.2 Interpretation problems

Some examples of interpretation problems and difficulties in different EU countries are described below.

In Germany this habitat type is intermediate between the coastal heaths which are influenced by salt and wind (coastal habitat 2150 and inland dune habitats 2310, 2320) and the subalpine to alpine heaths (habitat 4060). It only includes the dry to humid facies; heather moors with Cross-leaved heath (*Erica tetralix*) for example *Ericion tetralicis*, (habitat type 4010) are excluded. The delimitation and assignment of examples of this habitat type in the field is primarily based on their phytosociological characteristics. Inland dune *Calluna*-heathland (2310, 2320) mostly do not differ from habitat 4030 floristically, therefore a decision to delimitate the inland dune habitats is necessary based on a minimum layer of aeolian sedimentation (inland dunes). Two main sub-types can be

distinguished, the *Calluna*-dominated mostly lowland heaths on sandy soils, rarely also on loamy soils, and the usually *Vaccinium*-dominated mountain heathlands. Stands which display a high degree of scrub incursion or uncontrolled grass growth can be difficult to assign. As a general rule, examples with <75% scrub or <75% uncontrolled grass growth should not be assigned to the dry heaths. Small Linear facies in secondary habitats such as along paths or on embankments should not be included. Small occurrences should only be included if their species composition is easily assignable to this habitat type. If in the shrub layer a substantial proportion of Juniperus communis occurs, these stands belong to the habitat type 5130.

Calluna heathland is an important habitat also for moss and lichen communities with can be an essential component of certain development stages, for example of the *Cladonion arbusculae* of the P*olytrichetalia piliferae*.

Any areas of wet heath with *Erica tetralix* where the proportion of *Calluna* in the dwarf shrub cover is less than 50% are to be considered under (habitat 4010) and may at most cover small areas within the site. In recording and delimiting this habitat type it is particularly important that all developmental stages of *Calluna* heaths (pioneer, building, mature, and degenerative) are considered. Many of the species inhabiting this habitat type are closely linked to particular developmental stages, or have their optimum in a particular stage, or move between the very differently structured phases. To this end the habitat type should, if possible, be delimited in such a way that all existing developmental stages are included[42].

In Hungary, it is not fully clear whether *Calluna*-stands in open forests and in very secondary places (e.g. gravel pits) belong to this type. Also stands without *Calluna* (but with acidophilous species composition) have a questionable position. However, such cases are very rare.

Interpretation of 4030 habitat at national level in Italy (Biondi et al., 2010, 2012) is not just referred to chamaephytic (low-shrub) communities (heathland formations *sensu stricto*: *Calluno-Ulicetea*), but also includes tall-shrub communities (heathland formations *sensu lato*: *Cytisetea scopario-striati*, e.g. *Telinion monspessulano-linifoliae* and *Sarothamnion scoparii*). Moreover limits towards formations scrubs rich in Mediterranean species (e.g. *Erica arborea*) are not clearly defined (Angelini et al., 2016).

However, this wide interpretation is applied in administrative regions within or neighbouring Mediterranean Biogeographical Region; for example in Liguria where communities other than *Calluno-Ulicetea*, such as *Pruno-Rubion ulmifolii, Cytision sessilifolii, Sambuco-Salicion capreae* and *Corylo-Populion tremulae* were included in habitat 4030 (Mariotti, 2009).

In Continental Biogeographical Region, specifically in Lombardy (Brusa et al., 2017a), has been specified that the tall-shrub communities could be included just in case they result by direct evolution of heath s.s. formations and still maintain typical species of 4030, other than *Molinia arundinacea* (usually occurring widespread in these stages).

In Poland, there is a problem of classification of wet form of heathlands without *Erica tetralix* (but with *Vaccinium uliginosum, Drosera rotundifolia, Pedicularis sylvatica*, some *Sphagnum; Calluna vulgaris* domination). Such wet heathlands are in Poland very rare, but

[42] https://www.bfn.de/en/lrt/natura-2000-code-4030.html

very important for biodiversity, should be interpreted as Natura 2000 habitat, but it is not clear whethet they are 4010 or 4030.

In the UK, intergradation between dry heath and other habitats can be problematic. These include (a) other habitats with high cover of dwarf shrubs, especially 4010 wet heath, 7130 Blanket bog and 4060 Alpine and Boreal heaths, (b) developing woodland/scrub including 91C0 Caledonian forest and 5130 *Juniperus* formations, and (c), to a lesser degree, related habitats with lower cover of dwarf-shrub heath, such as acidic and calcicolous grassland, including 6230 Species-rich *Nardus* grasslands and, rarely, 6210 Semi natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*).

Most interpretation problems in Spain and Portugal stem from insisting in considering different habitat types within the habitat 4030 based mainly on - sometimes subtle - floristic variations either biogeographic or anthropically driven. In that sense, dry heathlands from the Eurosiberian and Mediterranean areas of the Iberian Peninsula are often considered as different habitats. But even within Mediterranean heathlands, those from the western Iberian Peninsula are differentiated from the ones found in the area around the Strait of Gibraltar because of biogeographic considerations (e.g. Loidi et al. 2019). Although all these heathlands can certainly be differentiated from a floristic point of view, the ones from the Strait of Gibraltar area being particularly rich in endemic species (Gil-López et al. 2018), they are physiognomically similar and should be considered as a single habitat type with some morphological variations determined by floristic composition (the one distinguishing Atlantic from Mediterranean dry heathlands being the more conspicuous (Gil-López et al. 2018).

2. Methodologies for conservation status assessment in some Member States

Member States have developed methodologies for assessing conservation status of habitat types and species of Community interest or are in the process of developing/ improving such methods (see also chapter 6 on Monitoring). These methods usually define criteria and threshold values for the key parameters (range, area, structure and function, etc.) that indicate whether the habitat type is in a favourable conservation status (FCS).

The following systems are implemented by some MS:

In **Belgium**, an integrated LIFE project (LIFE BNIP – Belgian Nature Integrated Project - 20014-2020) is actually in charge of methodological definitions for the evaluation of structure and function, which are the most unfavourable parameters identified for the habitat, and develops a monitoring methodology for the conservation status of habitats and a data collection system for the Art. 17 reporting. One of the aims is to define a simple but robust methodology to detect modification (trends) with use of abiotic and biotic parameters: integrity of the habitat structure (coverage of bare ground and of ericoids, presence of the different *Calluna vulgaris* phases of growth); integrity of species composition (number of typical species, ratio of species from the series); indicators of negative trends (coverage of trees and shrubs, grasses and bracken, presence of exotic species, eutrophication indicators, soil disturbance). This methodology is currently in testing stage.

The monitoring will be based on semi-permanent (repeatable by assumption, but located only by GPS) monitoring plots (100-250 plots, depending of the size of the habitats in Wallonia – other methodology should be chosen for the very rare habitats), with observation of the plots repeated each 6 years.

Sampling plots are also monitored in restored areas of dry heath. They are set up to document the long-term development of these restored areas (initially monitored at one or two year intervals, after stabilisation of the ecology at 5 years monitoring cycle).

In **Czech Republic,** heathland habitats are monitored every 6 years. The data will be evaluated in multivariate analyses and will be available for the public in the NCA CR data warehouse. The plots of the respective habitat are always selected one year before the actual air survey. Prior field checks have to be carried out in all the plots. Those that are representative for the given habitat are selected to avoid random selection. The following criteria are taken into consideration: homogeneity of the given habitat, fair accessibility and ease to identify the plot, variability of the habitat from the phytosociological and geographical point of view, condition and stability of the habitat (priority selection of the plots within special protected areas and SCIs), level of degradation (priority selection of non-degraded plots) and elimination of edge effects. Maximum 50 plots are selected for each habitat in different altitudes all over the Czech Republic. Rare or less common habitats do not always reach the number of 50 plots.

In **Denmark**, the evaluation of the conservation status of 4030 is based on vegetation analyses of 1370 pinpoint plots (137 stations each with 10 plots). Methods to map and monitor terrestrial habitat types are available, as well as to determine the conservation value or each mapped area based on vegetation and structural indicators. The results of the monitoring activities are also available.

The mapping of the 44 habitat types occurring in the country includes recording both biotic and abiotic factors using a specific protocol (one protocol for 34 habitat types with open vegetation and another one for 10 forest habitat types[43]). Index values ranging between 0 and 1 are calculated for each area mapped of each habitat type. Calculation is based on 1) plant species present and 2) structural conditions. The two index values are weighed into a single reference value describing the conservation status of each mapped area[44]. The method thus quantify for each habitat type the fractions (surface areas) that are in good or excellent conditions and which fractions that are in medium or bad conditions. This is important knowledge when the conservation status is assessed on a national level. A multi criteria model has been developed to perform conservation status assessment[45].

In **Spain**, a methodology has been recently prepared based on the rank scoring of a series of plant diversity and functional variables to assess the conservation status of this habitat type. These variables are: (1) abundance of perennial species, (2) richness of perennial species; (3) abundance of key species (endemics or strongly associated to the habitat); (4) signs of anthropogenic disturbance; (5) soil PH; (6) abundance of post-fire recruitment, and

[43] http://bios.au.dk/fileadmin/bioscience/Fagdatacentre/Biodiversitet/TAN03_KortlaegningLysaaben_ver1.pdf (open vegetation cover types) and http://bios.au.dk/fileadmin/bioscience/Fagdatacentre/Biodiversitet/TAN04_KortlaegningSkov_220516.pdf

[44] The exact methodology for calculating these values is published in a report "Beregning af naturtilstand ved brug af simple indikatorer" available here: http://www.dmu.dk/Pub/FR599_2udgave.pdf.

[45] http://dce2.au.dk/pub/SR118.pdf.

(7) defoliation damage. Experts suggest the use of a suitable number of permanent plots of 10mx10m (both inside and outside Natura 2000 sites), in which the plant diversity and functional variables would be recorded annually.

Italy. A common and standard national monitoring system for habitats has not been adopted yet. Generic rules for all habitats and detailed rules for 4030 are provided by the Lombardy manual for habitat monitoring (Brusa et al. 2017). Two kind of monitoring strategies are proposed:
1) Advanced method (for expert in vegetation surveys): it requires selecting; arranging and collecting data in vegetation plots (phytosociological relevés). Several indicators are then estimated from field data (total % ground cover of *Calluna* and/or other typical species; number and frequency of chamaephytes and typical species; occurrence of endangered and/or protected species; indicators of the degree of forestation, of eutrophication/nitrophilous species presence, and of alien plants invasion).
2) Simplified method (for operators with a basic knowledge of the habitat): quick and efficient approach collecting few easy measurable variables (e.g. *Calluna* abundance or groundcover; presence of *Genista* species; degree of forestation; occurrence of invasive tree species)

In **Romania**, the methodologies, the specific parameters and threshold values for assessing conservation status were established during 2011-2015 within the project "Monitoring the conservation status of species and habitats in Romania under Article 17 of the Habitats Directive"[46]. Within this project, for habitat 4030 the minimal number (15 vegetation relevés) and optimal period of the Braun-Blanquet vegetation relevés are indicated. The relevés are usually performed on 200 m^2, but depending on the site situation other size or shapes may be used. For 4030 habitat monitoring it is recommended to perform at least 15 relevés within the Natura 2000 sites, every six years. The field data are stored in The National Information System for Monitoring Species and Habitats of Community Interest (SIMSHAB)[47].

In **Slovakia**, the parameters and their threshold values for assessing FCS were developed and published in 2005 (Polák & Saxa 2005, Šefferová et al. 2015). There are five main criteria for assessing favourable conservation status of a habitat type: horizontal structure, vertical structure, site area, threats on the site and distribution area. For each parameter threshold values are given which indicate whether a habitat type is in a favourable conservation status for that specific criterion on site level.

1. Horizontal structure consists of number of characteristic taxa and indication taxa based on Habitat catalogue of Slovakia (Stanová, Valachovič eds. 2002). There are four categories of the status of habitat. When number of characteristic and indication taxa is high, the status of habitat is favourable (category A - excellent, B -good). When number of characteristic and indication taxa is low the status of habitat is unfavourable (category C - disturbed, D - unsatisfactory).
2. Vertical structure represents percentage cover of four layers E0 – E3 (moss layer, herb layer, shrub layer, tree layer). For each habitat the limit values of percentage cover of layers E0 – E3 were determined (A, B – favourable status, C, D – unfavourable status).

[46] http://www.ibiol.ro/posmediu/index.htm
[47] www.simshab.ro

3. Site area - For each habitat the limit values of site area were determined (A, B – favourable status, C, D – unfavourable status).
4. Threats of the site - The criteria includes the occurrence of expansive taxa and neophyte alien taxa on the site. The abundance of expansive taxa and number and abundance of neophyte taxa on the site is crucial for habitat assessment.
5. Distribution area is defined by two criteria: changes in number and distribution of localities of habitat and changes in area of localities of habitat.

In **Poland**, there is a published methodology for monitoring 4030 (Pawlaczyk P. 2012) which includes indicators of structure & function: **Calluna* or *Calluna* & *Arctostaphyllos* coverage (positive), grass coverage (negative), *trees coverage (negative), *alien species (negative), native expansive species (negative), presence of various age stages of key species (positive), status of species important for biodiversity (positive). Value of each indicator is estimated, registered and assessed in FV-U1-U2-XX stage. The structure & function score is an expert estimation, but should not be higher that scores of "*" indicators.

In **Scotland and England (UK)**, Range and Area assessments are based on combinations of existing knowledge derived from ground survey and remote sensing data. It is recognised that these assessments are based on best estimates. Changes in these assessments can occur as a result of improved knowledge, and assessments of actual change are based on incomplete knowledge of losses and gains derived from Site Condition Monitoring (SCM, see below) and other information acquired opportunistically. More precise estimates of habitat range and extent require more precise and accurate habitat mapping as significant areas, e.g. particularly in the uplands where most 4030 is located, remain unmapped or inadequately mapped at appropriate scales and classification. A method for appropriate mapping, using stereo colour infrared aerial photography interpretation has been developed (Scobie 2018) but only applied on a tiny fraction of the relevant area. Better mapping is a pre-requisite for both determining habitat change and for developing a robust sampling system capable of adequate assessment of habitat structure and function.

Site Condition Monitoring in Scotland, which uses UK-wide common standards (Common Standards Monitoring – CSM) for monitoring dry heath and other habitats on SACs and SSSIs, has been in place since 1999. The current methodology for dry heath was revised in 2009. CSM provides standardised attributes and targets for feature extent, vegetation composition, vegetation structure and physical structure. SCM usually involves random, systematic, or targeted sampling, sometimes combined with interpretation of aerial imagery/remote sensing.

Structure and Function assessments are based on Site Condition Monitoring (SCM), Scottish Natural Heritage's programme for implementing Common Standards Monitoring (CSM).

In **Ireland**, through the National Survey of Upland Habitats (Perrin et al, 2014) typical species were assessed as an assemblage at the monitoring stop level within sites surveyed. At each monitoring stop a minimum of two indicator species were required together with a cover of ≥ 50% for siliceous heaths and 50%-75% for calcareous heaths. During the NLPS a minimum of seven indicator species were required. As both were baseline surveys trends for the assemblage and for individual species were not assessed.

Future Prospects assessments are based on changes in Range, Area, and Structure and function assessments described above, along with information on areas of habitat under assured management expected to lead to improvement in condition.

Pressure and threat assessments are derived from SCM data and wider knowledge of other impacts.

In **Germany**, already in 2007 specific assessment schemes were developed with habitat experts for every single habitat type, especially targeting the parameter structure and functions, but also giving information on threats and pressures. These assessment schemes are used for Art. 11 monitoring, as well as at local or site level to assess the degree of conservation. Major parameters used are: 1. Completeness of typical habitat structures (completeness of development phases and percentage of open patches of sandy soil); 2. Completeness of the typical species inventory (based on plant species only so far for *Calluna* heaths); and 3. Important threats. The latter include as indicators for *Calluna* heaths the percentage of negative indicator species (neophytes, ruderal species or nitrophytes), percentage of direct visible trampling, percentage of shrubs or trees, afforestation, percentage of grass dominance or invasion into heaths, but allows also to report additional negative impacts.

Both in the Atlantic and in the Continental biogeographical region a set of 63 samples each are monitored in every 6-year period of the reporting.

For all habitats the assessment schemes were revised 2010 and again in 2017 in a detailed quality check after the 2013 reports and were adapted and updated by scientific experts and agreed with the German Federal States. They are available online and include substantial lists of typical plant species (65 species), of typical mosses (8 species) and lichens (20 species) (https://www.bfn.de/themen/monitoring/monitoring-ffh-richtlinie.html; BfN & BLAK 2017). These lists include species that are only present in some subtypes and are not spread evenly over the geographic distribution of the habitat. Therefore the Federal States can use regional modifications in their assessments.

Furthermore Germany currently conducts an integrated IP-LIFE project (LIFE15 IPE/DE/007, Atlantic sand landscapes, https://www.sandlandschaften.de/en/index.html), which shall improve the conservation status of habitats and species on sandy soils of Atlantic biogeographic region and includes both the habitats 4030 and 4010.