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MANAGEMENT of Natura 2000 habitats

* Species-rich *Nardus* grasslands

6230

Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora

EUROPEAN COMMISSION

environment

The European Commission (DG ENV B2) commissioned the Management of Natura 2000 habitats. 6230 *Species-rich *Nardus* grasslands

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Contents

6230 | *Species-rich *Nardus* grasslands

Species-rich Nardus *grassland in Western Carpathians – Velka Raca. Photo: J. Seffer.*

62 – Semi-natural dry grasslands and scrubland facies

EUNIS classification:

E4.3 Acid alpine and subalpine grassland
E1.7 Non-Mediterranean dry acid and neutral closed grassland

* Priority habitat

Summary

Species-rich *Nardus* grasslands are some of the most widespread habitats in the EU, occurring in 24 Member States and 6 different bioregions. They include a huge variety of sub-types, which may be found in very different ecological situations. It is generally an oligotrophic habitat, typical found mostly on species-poor soils throughout Europe. In spite of the fact that some types of *Nardus* grasslands can be considered as climax vegetation which do not require active ongoing management, the long-term existence of the habitat is in general closely with pastoral traditions and with extensive agriculture. The area of the habitat in Europe has declined in the last decades because of the intensification of agricultural practices on the one hand and land abandonment and too low an intensity of the use on the other. Mountain types are also threatened by tourism and skiing activities.

Grazing and mowing are the most frequent recommendations for the management of the habitat. 'Appropriateness' as regards grazing intensity and organisation varies considerably in different European regions and countries. The habitat in general requires extensive grazing which prevents invasion by trees and scrub, but which is not so intensive as to cause the eutrophication of the habitat. Mowing is also feasible technique which is applied mostly on the lower altitude sites. In some regions there is also usual to combine both grazing and mowing. Additional fertilization is usually prohibited on the habitat or is very restricted, because it can cause the eutrophication of the habitat and may induce a change towards mesic grasslands. Other measures like cutting and chopping of biomass with a flail or rotary mower, or burning can be also used for the maintenance of the habitat, but their regular application is not recommended.

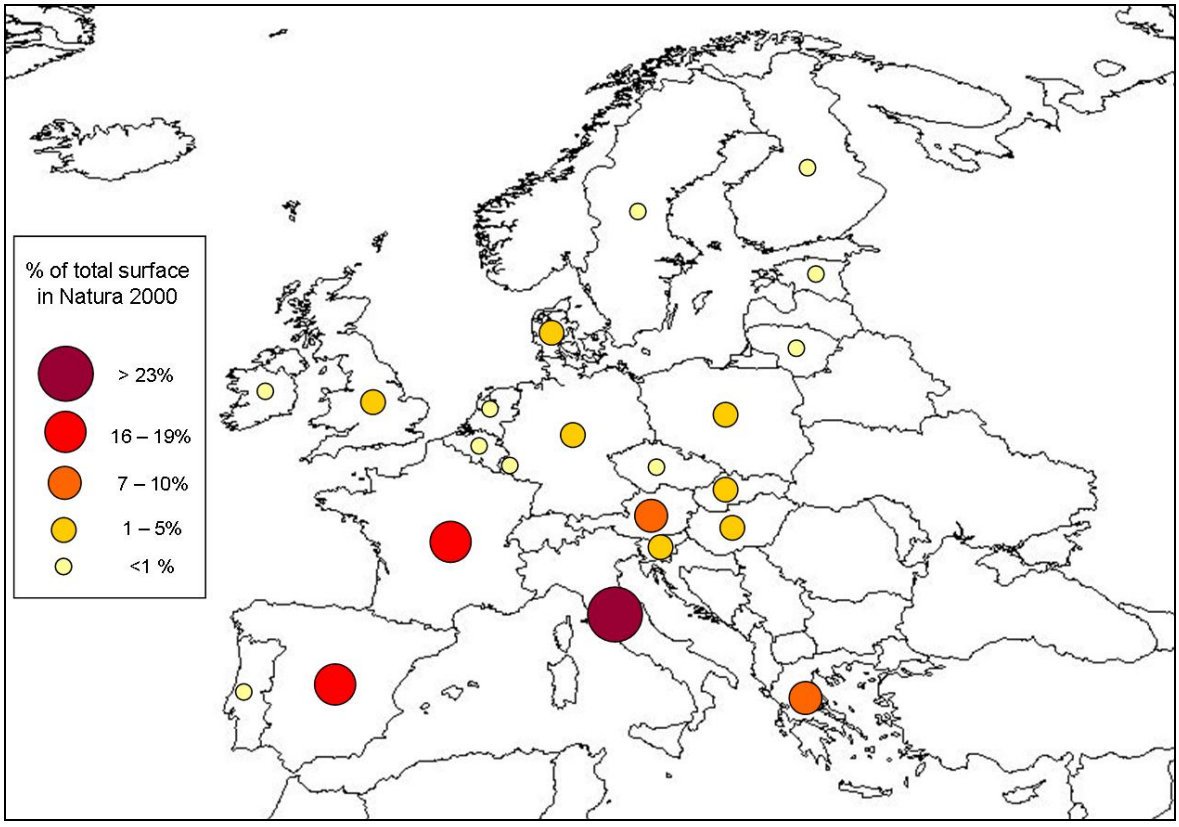
If necessary, several restoration measures may be applied together and their application is generally much more complicated than regular management. The most frequently-employed measure is the removal of the trees and shrubs by the machines or by hand. If the habitat was totally destroyed and afforested, restoration is still possible, but relatively costly. Restoration in such conditions has been carried out in some areas, e.g. in Belgium, where sod cutting techniques were used. Where the habitat is seriously damaged also by skiing activities, turf transplantation and the application of hay or mulch from species-rich grasslands may be used to restore the habitat. Probably the best way to finance the positive ongoing management on the habitat is the use of the funds from European Agricultural Fund for Rural Development (EAFRD). Restoration measures are usually much more costly, so they are usually not eligible for EAFRD funds and may be financed for instance through LIFE+ projects.

1. Description of habitat and related species

The habitat consists of closed, dry or mesophile perennial *Nardus* grasslands, which can occur from the lowlands to more mountainous areas (European Commission 2007). It is mostly a mountain habitat in Continental Europe, and it is more frequent in lowland areas in the Atlantic and Boreal parts of Europe.

Distribution

The habitat occurs in almost all the EU member states, except for Estonia, Malta and Cyprus. However, a major proportion of its area is located within the Alpine bioregion (Alps, Pyrenees and the Carpathian region). It is also relatively frequent in the Mediterranean, Continental and Atlantic bioregions. A small portion of the habitat is distributed in the Pannonian and Boreal bioregions.



Percentage distribution of the total surface of Nardus grasslands in Natura 2000

Nardus grasslands in Natura 2000 sites

The following data have been extracted from the Natura 2000 Network database, elaborated by the European Commission with data updated on December 2006. The surface was estimated on the basis of the habitat cover indicated for each protected site and should be considered only as indicative of the habitat surface included in Natura 2000.

Biogeographical region	Nº of sites	Estimated surface in Natura 2000 (ha)	% of total surface in Natura 2000
Alpine	236	80,703	42.08
Mediterranean	91	38,311	19.98
Continental	858	34,629	18.06
Atlantic	201	27,895	14.54
Panonic	5	9,232	4.81
Boreal	212	1,014	0.53
Countries	**Nº of sites**	**Estimated surface in Natura 2000 (ha)**	**% of total surface in Natura 2000**
Italy	190	44,959	23.44
France	128	35,915	18.73
Spain	63	31,484	16.42
Austria	32	17,423	9.08
Greece	24	13,904	7.25
Hungary	5	9,232	4.81
Denmark	91	8,431	4.40
Germany	615	8,308	4.33
Poland	17	4,623	2.41
United Kingdom	22	4,194	2.19
Slovakia	19	3,494	1.82
Slovenia	5	2,785	1.45
Czech Republic	22	1,661	0.87
Netherlands	22	1,290	0.67
Sweden	223	1,101	0.57
Portugal	5	978	0.51
Belgium	60	940	0.49
Ireland	9	698	0.36
Lithuania	10	236	0.12
Latvia	15	112	0.06
Finland	19	15	0.01
Luxemburg	7	<0,1	0.00
TOTAL	**1,603**	**191,782**	**100**

Note: According to the national lists of habitats included in the Habitats Directive (92/43/EEC), the Nardus grasslands are also present in Bulgaria and Romania. Nevertheless, the corresponding data are not included in the table because the standard data forms for those countries were not available during the preparation of this document.

Main habitat features, ecology and variability

The habitat consists of closed, dry or mesophile perennial *Nardus* grasslands, which can occur from the lowlands to more mountainous areas (European Commission 2007). It is mostly a mountain habitat in Continental Europe, and it is more frequent in lowland areas in the Atlantic and Boreal parts of Europe.The habitat is found on nutrient-poor soils on various types of siliceous rocks (mostly crystalline slides, granite, but also volcanic rocks). In some countries (e.g. France or Slovakia) the habitat is also found on calcareous rocks where the calcium content is highly decreased in the upper layers of the soil because of high precipitation (Bensettiti *et al.* 2005, Stanová and Valachovič 2002). A few countries only include substrates with some content of silica in this habitat type (e.g. the U.K.).

The interpretation manual of EU habitats (European Commission 2007) defines the habitat types as *species-rich* grassland, so that habitats with a decreased number of species due to overgrazing should not be included. For example in Denmark, the interpretation is even further restricted, stating that the flora must not have suffered any kind of enduring damage from fertilisation or intensive agricultural practices (Miljø- og Energiministeriet 2000).

The fact that a habitat can be present from lowland areas in Atlantic Europe to the alpine areas in European mountains, and that it can be in contact with *Festuco-Brometea* dry grasslands as well as

Caricion fuscae fen grasslands, induces very high variability with respect to altitude and the moisture gradient.

Variability of the habitat

Acidophilous Nardus grasslands in Atlantic zone (alliances *Agrostion curtisii* B. Foucault 1986 and *Galio saxatilis-Festucion filiformis* B. Foucault 1994)

This sub-type occurs within the lowland areas of the Atlantic bioregion, often on plains or on small hills. The geological substrates are usually acidic (sandstone, granite), but also acidic sands. The soils are oligotrophic, with various moisture regimes. Extensive trampling by grazing animals can influence the habitat (Bensettiti *et al.* 2005). It is typically found in Western Europe along the Atlantic coast.

Characteristic species: *Agrostis curtisii, Pseudarrhenatherum longifolium, Avenula lodunensis subsp. lodunensis, Polygala serpyllifolia, Viola lactea, Scilla verna, Carex binervis, Agrostis capillaris, Gladiolus illyricus, Jasione montana, Hypericum linariifolium, Sedum anglicum, Centaurea nigra, Danthonia decumbens, Hieracium pilosella, Festuca filiformis, Festuca rubra, Galium saxatile, Luzula campestris, Luzula multiflora, Nardus stricta, Potentilla erecta*

Acidophilous psamophytic Nardus grasslands (alliance *Carici-areanariae-Festucion filiformis* B. Foucault 1994)

This sub-type occurs on sand dunes in the Atlantic bioregion (e.g. in northern France) (Bensettiti *et al.* 2005). The sands are decalcified by various moisture regimes. Extensive trampling by grazing animals influences the vegetation.
Characteristic species: *Festuca rubra, Carex trinervis, Carex arenaria, Luzula campestris, Nardus stricta*

Dry or mesophile sub-mountain and mountain Nardus grasslands (alliance *Violion caninae* Schwickerath 1944)

This sub-type is probably the most frequent type of *Nardus* grasslands in Europe. It occurs from Northern Spain (San Miguel 2008) through the mountains of the Massif Central and the Vosges in France (Bensettiti *et al.* 2005), the mountains and lowlands of central Europe (Krahulec 2001, Stanová and Valachovič 2002, Grabherr and Mucina 1993, Fekete *et al.* 1997, Ministry of Environment of Poland 2008, Kaligaric *et al.* 2003) and of the Balkans (Sarbu *et al.* 2004), to the Baltic countries (Rasomavicius *et al.* 2006, Kabucis *et al.* 2003).

It is mostly typical of lower and middle altitudes in mountainous areas, but it can also occur in Atlantic and Sub-Atlantic lowlands in areas with relatively high precipitation. The substrate is usually of acidic, on various types of rock (mostly granite, crystalline slides, sandstone and volcanic rocks). The habitat is usually either grazed or mown or both. A low input of manure may also be applied, especially in areas with traditional agriculture.

Characteristic species: *Danthonia decumbens, Festuca filiformis, Nardus stricta, Polygala multicaulis, Scorzonera humilis, Viola canina, Antennaria dioica, Arnica montana, Calluna vulgaris, Coeloglossum viride, , Festuca ovina, Pimpinella saxifraga, Polygala vulgaris, Agrostis capillaris, Briza media, Solidago virgaurea, Genista tinctoria, Potentilla erecta, Dianthus armeria, Dianthus deltoides, Calluna vulgaris, Centaurea nigra, Galium saxatile, Genista sagittalis, Anemone nemorosa, Prunella hastifolia, Meum athamanticum, Viola lutea*

Sub-continental mountain Nardus grasslands (*Nardo-Agrostion tenuis* Sillinger 1933)

This sub-type occurs mostly in the continental part of Europe (Carpathians, eastern Alps, the Bohemian massif) and represents a transition between *Violion* and *Nardion* grasslands (Krahulec 2001, Grabherr and Mucina 1993). It is typical for mountainous areas below or around the tree-line. Substrates are usually acidic or moderately acidic on various rocks (mostly granite, sandstone, volcanic rocks). The grasslands are used as pastures; less often they are also mown.

Characteristic species: *Agrostis capillaris, Campanula bohemica, Festuca rubra agg., Hieracium iseranum, Nardus stricta, Silene vulgaris, Carex leporina, Gnaphalium sylvaticum, Pseudorchis albida, Gentiana asclepiadea, Veratrum album, Carex pallescens, Arnica montana, Carlina acaulis, Campanula barbata, Hieracium aurantiacum, Gentiana pannonica, Avenula planiculmis, Campanula serrata.*

High-altitude mountainous *Nardus* grasslands (*Nardion strictae* Br.-Bl. 1926, *Plantaginion thalackeri* Quézel 1953, *Campanulo-Nardion* Rivaz-Martinez 1963, *Potentillo ternatae-Nardion* Simon 1958, *Trifolion parnassi* Quézel 1964, *Nardo-Caricion rigidae* Nordhagen 1937)

This sub-type is typical of the highest mountains in Europe, mostly in the sub-alpine and alpine zones. Its occurrence at lower altitudes below the tree line is dependent on high precipitation. Due to the fact that its distribution is in small pockets on high mountains, its flora is very specific, with a high level of endemism. High-altitude montane *Nardus* grasslands are therefore classified into several alliances: *Plantaginion thalackeri* (Sierra Nevada in southern Spain), *Campanulo-Nardion* (mountains of the central Iberian peninsula), *Nardion strictae* (from the Pyrenees, Auvergne to Western and the Eastern Carpathians), *Potentillo ternatae-Nardion* (the Southern Carpathians, Pirin, Rila), *Trifolion parnassi* (Southern Greece), and *Nardo-Caricion rigidae* (Scotland, Scandinavia, Western Sudeten) (Krahulec 1985).

The soils are acidic and lie on various substrates including limestone, but due to high annual rainfall, the upper layer of the soil is decalcified. Some types of this vegetation are strongly chionophile, located in areas with high and long-term snow cover.

Characteristic species: *Nardus stricta, Geum montanum, Meum athamanticum, Plantago atrata, Phleum alpinum, Gentiana lutea, Pseudorchis albida, Hieracium alpinum, Hypochoeris uniflora, Pulsatilla scherfelii, Solidago virgaurea subsp. minuta, Campanula abietina, Ligusticum mutellina.*

Hygrophytic Nardus grasslands (*Violion caninae* Swickenrath 1944 p.p., *Nardo-Juncion squarrosi* (Oberdorfer 1957) Passarge 1964)

This sub-type occurs in moist habitats with poor and highly acidic soils (pH about 4), which are influenced by the groundwater and high precipitation. It is often found in the vicinity of fen grasslands and bogs, or it occurs on their edges. The optimum area is the sub-Atlantic part of Europe, reaching as far as Eastern Europe.

Characteristic species: *Gentiana pneumonanthe, Juncus squarrosus, Pedicularis sylvatica, Polygala serpyllifolia, Anthoxanthum odoratum, Carex nigra, Deschampsia cespitosa, Festuca ovina, Galium uliginosum, Potentilla erecta, Aulacomnium palustre, Carex panicea, Eriophorum angustifolium, Juncus filiformis, Sphagnum sp.*

Species that depend on the habitat

Different types of species-rich *Nardus* grasslands host important populations of butterflies. Warm, sun-exposed, extensively-grazed pastures on hillsides with short vegetation support the Habitats Directive Annex II species *Maculinea arion* (Large Blue butterfly). Caterpillars of this species feed mostly on *Thymus praecox* or other thyme (*Thymus* spp.) species. The presence of these plants within the vegetation is however not the only prerequisite for the persistence of the species. Just like other *Maculinea* species, *Maculinea arion* caterpillars go through some stages of their life cycle within colonies of *Myrmica* ants (in this case namely *Myrmica sabuleti*). The presence of these ant colonies thus determines the suitable habitat for the species and is responsible for a patchy structure of local (meta-) populations of the Large Blue, consisting of small micro- populations (Konvička *et al.* 2005).

More humid oligotrophic meadows and pastures on the transition to *Molinia* meadows are a habitat for *Maculinea alcon* (Alcon large blue butterfly), which is considered to be critically endangered in many European countries (for example Hungary and the Czech Republic). *Gentiana pneumonanthe*, which is a diagnostic species for some types of *Nardus* grasslands, is the caterpillars' food plant. The species *Maculinea alcon* is also myrmecophilous, using several *Myrmica* ant species as hosts for its larvae during certain stages of their life cycle (Beneš and Konvička 2008).

Mountainous and sub-mountainous *Nardus* grasslands are also inhabited by specific fauna such as grasshoppers and crickets (*Orthoptera*). Among others, the Habitats Directive Annex II and IV species *Pholidoptera transilvanica* can also be found (Kelemen ed. 1997).

High-altitude montane *Nardus* grasslands host specific bird communities. The most significant are *Tetrao tetrix* (black grouse), *Lagopus mutus* (Rock Ptarmigan), *Alectoris graeca* (Rock Partridge), and passerines such as *Prunella collaris* (Alpine Accentor) and *Anthus spinoletta* (Water Pipit) (Bensettiti *et al.* 2005). *Alectoris graeca* is endemic to Europe, occurring only in the Alps and in mountainous parts of Italy and the Balkans (BirdLife International 2004). It occurs patchily in dry rocky sub-alpine zones on mountains, mainly between 900 and 1,500 m a.s.l., but exceptionally down to 100 m in Greece and up to 3,000 m in the Alps (Johnsgard 1988). Mountainous and sub-mountainous grasslands established as a result of centuries of agricultural use and livestock grazing are one of its traditional habitats (Randi 2006). The species *Tetrao tetrix* is the Northern Eurasian species. It has broad habitat preferences, from heaths to forest clearings, alpine pastures and meadows. In central Europe the largest and most stable population is found in the Alps (Suchant and Braunisch 2004).

Nardus grasslands in lowland locations are a key habitat for various wide-spread passerine bird species that have suffered from a general decline related to changes in agricultural practices during recent decades. Examples are *Oenanthe oenanthe* (northern wheatear) and *Carduelis cannabina* (Eurasian linnet) - both have an unfavourable conservation status in Europe due to a moderate recent decline (BirdLife International 2004).

On the plant side, *Nardus* grasslands (a sub-type of *Violion caninae* grasslands) may host some species requiring special management measures, such as specific timing of mowing and grazing. A good example is the small gentian *Gentianella praecox subsp. bohemica* (Habitat Directive Annex II species) occurring in the Czech Republic and in adjacent countries (Austria, Germany, Poland) (Marhoul and Turoňová 2007).

Related habitats

Nardus grasslands can be in contact with a relatively high variety of habitats at different gradients.

The types found on sand dunes are part of the dune complex within other habitats occurring there (mostly hab. 2130, 2150, 2190). *Nardus* grasslands are relatively closed vegetation areas compared to other habitats. Sub-types in lowland areas can also be in contact with some border types of calcareous dry grasslands and pioneer habitats on calcareous substrates, (hab. 6210 and 6110) as well as the initial vegetation on siliceous substrates (hab. 8230) (Bensettiti *et al.* 2005). Wet *Nardus* grasslands may be in contact with various wetland habitats: non-alkaline fens and transitional mires (hab. 7140), alkaline fens (7230), bogs, both active and degraded (hab. 7110, 7120), *Molinia* meadows (hab. 6410), and alder carr.

High-altitude mountainous types may be in contact with different sub-alpine and alpine habitat types, especially alpine grasslands (hab. 6150 and 6170), and habitats with dwarf willows such as *Salicion herbacae*.

In areas used for agriculture, *Nardus* grasslands are very frequently in a mosaic with more eutrophic hay meadows (hab. 6510 and 6520), as well as *Cynosurion* pastures, which are used more intensively than *Nardus* grasslands, because they are more productive. On the Iberian Peninsula, communities are also in contact with habitats 6140 and 6160 (San Miguel pers. comm.).

In places with a lower agricultural intensity, *Nardus* grasslands may be found in mosaic with habitats of dry heaths at lower altitudes (hab. 4030), or Alpine heaths at higher altitudes (hab. 4060). They can be frequently in contact with *Pinus mugo* scrub (hab. *4070) and habitats 4090 and 5120 in sub-alpine zones.

Nardus grasslands may also be in contact with various forest types: with oak and oak-hornbeam forests in particular at lower alttudes (hab. 9230); at higher altitudes with beech forests (hab. 9110, 9120, 9130, 9150, 9160), and with spruce forests (hab. 9430). Less frequent contact habitats are different pine forests (e.g. *Pinus uncinata* forests (hab. 9430)), Charente pine, holm oak forests, and Samartic steppe pine forests.

Ecological services and benefits of the habitat

Nardus grasslands in mountainous areas are very often located on relatively steep slopes, but they may sometimes occur on flat areas or gentle slopes e.g. in the Pyrenees. Their closed canopy may significantly contribute to the prevention of soil erosion, as well as the prevention of avalanches in high-altitude mountainous areas. Research from the Italian and Austrian Alps shows that soil erosion is reduced on managed alpine grasslands (Tasser *et al.* 2003).

When *Nardus* grasslands are regularly managed, they can also contribute to flood prevention. The regular removal of biomass may prevent the so-called "roof effect", which is the quick run-off of rainwater on lodged grass.

Nardus grasslands belong to habitats closely connected with old pastoral traditions and transhumance practices throughout Europe (Institute for European Environmental Policy 2007). They are often managed by traditional pasturing methods, which are a part of the European cultural heritage. They have great pastoral importance, especially in Mediterranean regions (e.g. in Spain), because they do not suffer from summer droughts as much as other pasture habitats (San Miguel pers. comm.).

Nardus grasslands, especially high-altitude mountain types, host high numbers of endemic and threatened plant taxa. Their conservation and, where necessary, their regular management can contribute very significantly to the protection of the nature value of European mountains.

Trends

There are some types of *Nardus* grasslands which are considered to be climax vegetation, meaning they do not require regular management (e.g. alpine *Nardus* grasslands). However, most *Nardus* grasslands are semi-natural habitats, where regular active management is the ultimate condition of their sustainable existence.

Nardus grasslands are low productivity grasslands, which persist due to extensive farming with low inputs. Most probably, they were in the past widespread on poorer soils in all parts of Europe. However their extent decreased significantly with the intensification of agriculture during the 20th century. The Common Agricultural Policy encouraged production in Western Europe and the state subsidised agricultural intensification in Eastern Europe. Both promoted the conversion of low-productive *Nardus* grasslands into grassland types with a higher biomass production.

On the other hand, there is also the problem of land abandonment. A substantial part of *Nardus* grasslands is located in remote mountainous areas. They are used as seasonal pastures, and transhumance is also frequent. The marginalisation of rural areas and land abandonment in mountainous areas has led to the deterioration of large areas of mountainous *Nardus* grasslands, which either transformed into heath or shrub communities, or have become overgrown by forests. Some countries also implemented afforestation programmes, and as a result, *Nardus* grasslands, with their limited agricultural value, are among the most afforested habitats.

Threats

Eutrophication

The habitat occurs on less fertile soils in oligotrophic or lightly mesotrophic conditions. An increased input of nutrients may cause relatively fast deterioration. Nutrient limitation is weakened; plants are taller, and light becomes a limiting factor (Lepš 1999). Eutrophication can be caused by the addition of mineral or organic fertilisers, but it can also be the result of intense grazing.

Inappropriate grazing practices

Nardus grasslands are usually highly dependent on regular grazing. The organization of grazing in different localities may strongly affect the quality of the habitat. The concentration of animals on small

patches of pasture may cause eutrophication, and may destroy the grassland canopy and accelerate invasion by weeds. On the other hand, pasture edges are often undergrazed and may be overgrown with trees and shrubs.

Especially in the Eastern part of Europe, sheep and cattle are usually shut into fenced areas, such as sheep-folds, during the night to protect them from predators. However, if this is practised inappropriately, it may cause a near total destruction of grass cover where folds are located and may result in strong eutrophication which is later followed by an invasion by nitrophilous species.

Land abandonment or low management intensity

Nardus grasslands are very often situated in remote mountainous areas. This means that they can be threatened by land abandonment and a lower intensity of land use. This can lead to a secondary succession, an invasion by tall herbs and the establishment of trees and shrubs on grassland areas.

Afforestation

Nardus grasslands belong to habitats which are unattractive for agricultural use because of their low biomass production. They were therefore very often targeted by afforestation programmes, especially in some parts of Western Europe (e.g. Life project LIFE02 NAT/B/008595 Minerotrophic mires and heath ecosystems in the Zuiderkempen).

Tourism and skiing activities

High-altitude mountain areas are highly attractive tourist destinations. The development of tourism infrastructure may lead to a total destruction of the habitat or can strongly influence its structure and species composition (e.g. weed invasion on disturbed patches). The grasslands can also be negatively influenced by artificial snow and by machine-grading (Wipf *et al.* 2005).

Climate change effects

The optimum condition for the existence of *Nardus* grassland is low trophic status of the substrate. Hence it is believed that climate change should not cause total destruction of the habitat. However, it may lead to substantial changes in the species composition of different subtypes. Sub-types in transition from wet grasslands, and those occurring in high-altitude mountainous areas, especially chionophile types, are probably the most vulnerable. Pauli *et al.* (2007) reported a slow shift of the species of alpine communities into nival and subnival habitats. Experiments by Herben *et al.* (2003) in the Krkonoše (Czech republic), demonstrated that the weather may strongly influence competition among species on mountainous *Nardus* grasslands, and thus changes in weather resulting from climate change could lead to changes in species composition.

2. Conservation management

General recommendations

Alpine *Nardus* grasslands, and types only occurring on Atlantic sand dunes, may be considered not to require any active management and can continue without any human intervention. All other types of *Nardus* grasslands are semi-natural habitats that are the result of human activities in the past and persist due to regular agricultural activities.

Managed *Nardus* grasslands are mostly used for extensive grazing, but they can also be mown. The minimum given intensity for the management of mown types of *Nardus* grassland is at least once every 2-3 years (Háková *et al.* 2004, Ministry of Environment of Poland 2008).

Háková *et al.* (2004) recommend grazing as being suitable mostly for mountainous habitats, while sub-mountainous areas prefer mowing combined with a short grazing period. Combinations of different approaches are also very welcome, because they promote diverse conditions.

For Sweden, grazing and mowing are the main recommended management measures, but should be adjusted according to previous land-use practices and specific flora and fauna values. The use of fertilisers, foddering of livestock and the introduction of non-native species are not allowed (Naturvårdsverket 2005).

Active management

Grazing

Grazing Intensity is probably the most decisive factor determining the quality of the habitat. Too high an intensity of grazing may cause the spreading of *Nardus stricta* in the canopy, which is hard to reverse. Grazing can also promote local disturbances which may affect the roots of the typical habitat species. On the other hand, too low an intensity of grazing, a late start to grazing, or badly organised grazing may lead to the spreading of small shrubs, *Vaccinium myrtillus* and *V. uliginosum,* which may significantly decrease the habitat's pasturing value (Bensettiti *et al.* 2005).

The recommended livestock density differs between regions and sub-types. The Polish Agri-environmental programme requires a livestock density between 0.4-0.6 LU/ha with a maximum pasture load of 5LU/ha (Ministry of Agriculture and Rural Development of Poland 2007). Slovak RDP allows a wider range of 0.3-1.0 LU/ha (Ministry of Agriculture of Slovakia 2007). The recommendations for *Violion* grasslands in Eastern France prescribe the range between 0.5-1.0 LU/ha, but for the Massif Central region it is only 0.2-0.4 LU/ha (Bensettiti *et al.* 2005). Such low figures (about 0.2-0.4 ha) might also be adequate for summer grazing in high-altitude mountainous areas of Spain (*Nardion, Campanulo-Nardion, Plantaginion nivalis*) (San Miguel, pers. comm.).

A slightly different approach may be applied in conditions where *Nardus* grasslands are part of dune systems in lowland areas. The existence of bare spots is a normal part of dune dynamics, but it is necessary to alternate the zones for grazing and leave some time for recovery. Grazing by cattle is usually recommended, because of their intensive trampling which creates open patches, but young stock are nevertheless preferred to dairy cows, which are heavier and may cause substantial damage to the habitat (Bensettiti *et al.* 2005).

The length of the pasturing season is usually limited by local climatic conditions. In the Atlantic part of Europe, animals can graze during the whole season, while only seasonal use is possible in the continental part of Europe. Pastures on higher altitudes are only used during summer months.

Traditions of keeping cattle in enclosed or fenced areas differ between various countries and regions of Europe, and can sometimes be very difficult to organise. In some countries (e.g. Slovakia) grazing in fenced areas is prohibited by agro-environmental programmes (Ministry of Agriculture of Slovakia 2007).

Háková *et al.* (2004) recommend rotation of the area used for grazing, as continuous grazing is less suitable. They suggest that animals should be divided into small herds of up to 15 LU and that any are be grazed for a maximum of 10 days. Three grazing cycles should be applied annually, but when the number of animals is higher, the cycle would be shorter. Unpalatable species like *Rumex sp. div.* have to be topped at the end of the grazing season. However, it is sometimes very difficult to carry out such a scheme because of the higher costs of this system (Ministry of Environment of Poland 2008).

Mountainous habitats are usually grazed by sheep, but cattle can also be used in some areas; they consume a wider range of grass species, such as *Festuca rubra* or *Carex sempervirens*. Grazing by horses is also feasible, but it can cause soil erosion in wet conditions (Bensettiti *et al.* 2005). *Nardus stricta* has a high silica content and is unpalatable to livestock. Grazing by sheep only may lead to a dominance of *Nardus stricta* in the canopy, because the sheep avoids it . If cattle or goats graze the pastures, *Nardus stricta* is controlled more effectively (Grant *et al.* 1996). Háková *et al.* (2004) recommend sheep for high-altitude mountainous types of *Nardus* grasslands, but not at lower altitudes. Cattle are generally recommended, horses are also possible, but they are less suitable than cattle. Horse is a suitable species, but its market demand is very low. The usual livestock in Spain is cattle, although sheep are used especially in Mediterranean Spain (San Miguel *pers. comm.*).

The timing of the start of grazing is also very important. Late grazing is not very suitable, because some grass species may lose their nutrient value and will not be consumed by the animals (Bensettiti *et al.* 2005). On the other hand, grazing too early during the spring and summer, e.g. before the flowering and seeding of vascular plants of conservation value, must also be carefully considered.

The directing of the sheep by a shepherd in order to avoid selective grazing, which promoted the spreading of *Nardus,* should also be considered (Bensettiti *et al.* 2005).

Grazing can also be considered as a potential tool for the restoration of species-rich grasslands. But experimental experience from the Czech Republic shows that the restoration potential of this habitat may be limited. The grazing of grasslands dominated by *Deschampsia cespitosa* by cattle with a pressure of 0.7 LU/ha did not lead to the enrichment of their species composition (Matějková *et al.* 2003).

Overnight staying of the animals on the pastures

A concentration of animals in closed or fenced off areas during the night is a typical practice used in mountainous areas of Europe (e.g. Alps, Carpathians). It was used in the past to increase habitat productivity. It is necessary to ensure a maximum density of animals in an area. One sheep per $1m^2$ (1.5 LU/$10m^2$) for 2 nights is the maximum recommended for *Nardus* grasslands in the French Alps (Bensettiti *et al.* 2005). In Slovakia, regulations require a maximum density of 1 LU/$10m^{2,}$ and that sheep-folds must be relocated every day. (Ministry of Agriculture of Slovakia 2007). In some countries, for example Poland, sheep-folding is not recommended at all on *Nardus* grasslands (Ministry of Environment of Poland 2008).

To avoid possible damage to places with high animal concentrations, it is better to allocate them to peripheral parts of the pastures to avoid the spreading of nitrophilous species (Bensettiti *et al.* 2005).

Mowing

Mowing is usually employed in regions where there is a lack of more productive habitats. The hay is sometimes not used for feeding, but only for littering e.g. on sand dune *Nardus* grasslands in France (Bensettiti *et al.* 2005).

A combination of mowing and pasturing is the traditional method employed on semi-natural grasslands in large parts of Europe. It is highly recommended, because mowing as a non-selective method of biomass removal promotes different species from selective grazing.

Despite frequent mowing being the practice recommended for *Nardus* grasslands of high nature value, the traditional method is no longer feasible due to high costs. So alternative measures have to be considered. Experiments in the Krkonoše in the Czech Republic have shown it can be altered with the grazing of sheep (Krahulec *et al.* 2001).

Mowing itself, with the regular removal of biomass, may lead in some cases to gradual oligotrophisation of *Nardus* grasslands, mostly on very poor soils, and it results in a decreased number of species (Krahulec *et al.* 1996, Halada *et al.* 2001). An experience from Czech Republic shows that when mowing is employed without the use of manure, *Avenella flexuosa* and *Luzula luzuloides* tend to dominate (Krahulec *et al.* 2007).

Therefore some use of manure, or occasionally leaving the cut and chopped grass on the ground (see below), may be recommended in such cases together with regular mowing (Háková *et al.* 2004). However, several important aspects, especially overall of nutrients and local soil conditions have to be taken into consideration in order to avoid eutrophication.

If the habitats are only mown, artificial disturbances to promote space for the recruitment of some less competitive plant species are recommended (Háková *et al.* 2004).

Cutting and chopping of biomass with a flail or rotary mower, leaving the cuttings spread on the ground[1], is widely used for restoration purposes where insufficient domestic animals are available, and it has become very popular in some parts of Central Europe as an alternative to the removal of biomass by mowing and grazing. This practice, when regularly applied, may lead to a change of species composition and the dominance of grasses such as *Avenella flexuosa* and *Holcus mollis* (Krahulec *et al.* 2007). Therefore, repeating such practice over several years is not recommended. The Czech management manual recommends that it should be done before the end of July to promote better biomass decomposition (Háková *et al.* 2004). But some managers recommend an even earlier date, i.e. before the middle of July (Jiřiště pers. comm.).

This practice is used very often in combination with grazing, when unconsumed vegetation on pasture is cut and chopped in the autumn. Such management may lead to the accumulation of biomass on the site, especially when used as a restoration measure on abandoned grasslands (Jiřiště pers. comm.).

Fertilization

Eutrophication is one of the biggest threats for a habitat. Therefore, recommendations for habitat management very often do not recommend any kind of additional fertilisation (e.g. Ministry of Agriculture and Rural Development of Poland 2007, Naturvårdsverket 2005 Sweden). Nevertheless, limited fertilization may be allowed in some circumstances, e.g. in Central Europe, where overall level of nutrients in the soils is generally lower.

Some countries, for example Slovakia, allow limited organic fertilization, e.g. 50 kg of N/ha once every 2 years (Ministry of Agriculture of Slovakia 2007).

Regular fertilization together with regular grazing may transform the habitat into mesic grassland (Bensettiti *et al.* 2005). On the other hand, additional fertilizing may help in sustaining species diversity, when only mowing is utilised.

The type of fertilizer used is also very important, because especially phosphorus is strongly persistent in the soil and may cause a long-term increase in productivity (Hejcman *et al.* 2007a).

Some countries propose liming as a measure for the improvement of *Nardus* grasslands, e.g. Romania (Barbos pers. comm.). An increased calcium level may promote higher species diversity (Common *et al.* 1991, Bărbos 2007), but it has to be carefully assessed, since liming has long-term effects on species composition (Hejcman *et al.* 2007b).

Burning

Burning is another management measure applied to the habitat. It was used during the LIFE project in the military camps in Wallonia, Belgium. Some fires were started by land managers, some were caused by military activity in the area (Pirard 2007). However, it is a relatively controversial measure, which may

[1] This practice is referred to in some countries as "mulching".

lead to changes in species composition, and if applied regularly, it may promote the spreading of invasive species like *Pteridium aquillinum* or *Molinia sp. div.* (Bensettiti *et al.* 2005).

Control of invasive grass and weed species

The cessation of grazing practices may lead to the expansion of tall grasses like *Deschampsia cespitosa, Calamagrostis sp. div., Molinia caerulea* or species like *Pteridium aquillinum, Bistorta major, Senecio sp. div.*. Most of these species are grazing-intolerant, but if they spread over the grassland, restoration is very complicated. Restoration mowing itself may not be sufficient to suppress them, because they can store a high amount of nitrogen within their root systems. Experiments with *Nardus* grasslands overgrown by *Bistorta major* showed that better results can be achieved if the sites are not only mown, but also manured, or mown and grazed. Species-rich grassland can then be restored within 3-5 years (Pecháčková and Krahulec 1995).

An experiment in the East Carpathians biosphere reserve found that the vitality of invasive species may be suppressed by regular restoration mowing, and that gaps in the community are open. However, due to limited seed dispersal, no target endemic species were able to colonize the gaps (Halada *et al.* 2001).

An unpalatable invasive species like *Deschampsia cespitosa* may spread even on regularly-grazed localities. It is therefore beneficial to alternate between grazing and mowing to control such species (Krahulec *et al.* 2001).

Other relevant measures

Restoration of the stands overgrown by trees and shrubs

There are several methods used to restore habitats degraded by secondary succession. If the locality is not heavily overgrown, cutting and chopping of biomass with a flail or rotary mower can be used. If the stage of degradation is higher, that practice is not feasible and a cultivator has to be applied (Pirard 2007). Manual cutting by brush cutter is also a suitable but costly method (Marques 2006). Cutting scrub is always an effective measure, but only if it is followed by regular management. If it is not possible to ensure frequent mowing or grazing after restoration, it is better to skip restoration (Bensettiti *et al.* 2005), because scrub encroachment may be even more vigorous after cutting.

It is possible to use herbicide to control scrub encroachment after restoration, but it can be a somewhat risky. To avoid double application of herbicide, the treated areas can be colour-marked. The application of herbicide to freshly cut scrub in the autumn is also effective. Such application kills their root systems, preventing further invasion, and is not harmful to other vegetation or the soil (Jiřiště pers. comm.).

Turf stripping

Turf stripping is a restoration method used mostly in cases where the upper horizons of the soil are suffering from eutrophication. Through the removal of nutrients from the upper soil layer, an oligotrophic habitat, such as *Nardus* grasslands, may be restored. The method was used especially for the restoration of grasslands in areas which used to be coniferous plantations, which are clear-cut, and then sod cutting is applied (LIFE project LIFE04 NAT/BE/000010 Habitat restoration in Landschap De Liereman).

Land acquisition

The principle that farmers should take care of the habitat is applied in most cases. However, if the area is of no interest to farmers, or the habitat is threatened by different economic activities, land acquisition is relevant means of ensuring its proper management. It was used in Belgium as part of the LIFE project in Zuiderkempen, where land was purchased by the NGO Natuurpunt (Life project LIFE02 NAT/B/008595 Minerotrofic mires and heath ecosystems in the Zuiderkempen) and in the Rhön Biosphere reserve in Germany, where support from the LIFE programme was also used (Life project LIFE98 NAT/D/005064 Rhön Biotope region - Building Block for Natura 2000).

Practices connected with grazing management

Some practices connected with grazing management may be extremely important for habitat conservation. For instance, the use of chemicals for the removal of worms from cattle is not recommended, because it is harmful for coprophag insects which play a very important role in the decomposition of dung (Bensettiti *et al.* 2005).

Grazing on *Nardus* grasslands at higher altitudes may be connected with traditional transhumance practices. Maintenance of the infrastructure for transhumance may be an ultimate condition for the maintenance of habitats in remote mountain areas. For example, in Portugal, "canhadas" - typical pathways in the Iberian Peninsula for the migration of animals with shepherds, were restored to promote traditional pastoral activities (Marques 2006).

The purchase of animals or equipment necessary for grazing, such as electric fences, may also be an important part of conservation management. Resources from the LIFE programme were used in the Alpe Veglio area of Italy for the purchase of 5 horses and for electric fencing. Mixed groups of cattle and horses organised by local farmers were used to improve the management of *Nardus* grasslands in the area (Life project LIFE02 NAT/IT/008574 Alpe Veglia and Alpe Devero: conservation activities on mountain grasslands and peatlands).

The restoration of grasslands damaged by ski activities

The construction of ski infrastructure may in some cases be harmful to *Nardus* grasslands, because of large-scale disturbance and the dispersal of weed species. Several methods can be applied to restore such sites. Dispersal of hay from species-rich grasslands over disturbed places, in combination with the relocation of turves from species-rich grasslands, which are laid on the open land in a chessboard arrangement, appear to be effective. Such a solution promotes seed dispersal and recruitment, and leads to the fast recovery of disturbed habitats. Turf also prevents soil erosion (Stanová *et al.* 2007).

Special requirements driven by relevant species

The extinction of *Maculinea arion* (large blue) in England during the mid 1980's gained the attention of researchers and conservation biologists. As a result, the complicated biology and habitat requirements of the species were discovered. In Britain, the species is found on tightly-grazed, warm, sun-exposed pastures. Once the grazing pressure decreases and the vegetation becomes taller and denser, *Myrmica* ant colonies are replaced by other species. Populations of *Maculinea arion* resisted the encroachment of woods on pastures, but the restriction of grazing in nature reserves resulted in their rapid extinction. Only the revival of grazing on a large scale enabled the successful restoration of their population.

In other parts of Europe (such as the Czech Republic) *Maculinea arion* inhabits landscapes with a mosaic of differently-mown meadows, extensively-used pastures, hedgerows and small woodlands. The intensification of grassland use and the substitution of sheep grazing by cattle, and the afforestation of abandoned grasslands have destroyed many traditional habitats of the species. Intensified pastures lack the characteristic flora which is the nectar source for adult butterflies. Grazing by cattle creates a very different structure of turf which is not suitable for *Myrmica* ant colonies (Konvička *et al.* 2005). As local populations have the usual structure of sedentary metapopulations, local extinctions in altered habitats have often lead to the extinction of *Maculinea arion* in entire regions.

Experience from the Czech Republic suggests that the re-introduction of non-intensive grazing by small numbers of sheep or mixed sheep-cattle herds is recommended in locations with *Maculinea arion* (max. 2-3 LU per hectare with a predominance of sheep). A shorter grazing period is to be preferred; a combination of mosaic mowing once per year before the 15th of June or after the 10th of September, with short-term autumn grazing, is also acceptable. Grazing on locations with *Maculinea arion* should be done in a rotational manner, leaving 50% of the area without intervention in year 1, then swapping grazing to the other part in year 2, and back in year 3. Intensive large-scale grazing, and mowing the entire plot twice or even once a year should not be allowed under any circumstances.

Locations left abandoned for longer periods of time, and thus not suitable for the species, can be burnt (with small-scale surface fires set each year on different parts of the site) and then grazed. A suitable season for burning, as well as for the use of heavy machinery, is the winter season, when ants and caterpillars hibernate underground (Beneš and Konvička 2008).

Maculinea alcon (alcon large blue) is a near-threatened species on the IUCN red list (Gimenez Dixon, 1996). The most important threats to it are land improvement and the abandonment of traditional land use, which leads to scrub encroachment on the remaining sites, and a decrease in food plant populations. A suitable restoration method, which can be applied in locations unmanaged for a long period, is mowing with a brush cutter and non–intensive grazing with cattle, which consumes tussocks of dominant grasses (such as *Molinia caerulea, Deschampsia cespitosa*).

More suitable is short-term grazing at the beginning of the summer (before the flowering of *Gentiana pneumonanthe*) or during the autumn after seed ripening. In many protected areas, the traditional management of grasslands is replaced by one-off mowing. In such cases, the dominant grasses do not create tall tussocks, but the turf is dense and litter accumulates, which limits the barer patches needed for seeding. Late summer or early autumn mowing has proven to be insufficient, as it is unable to suppress dominant grass species. Colonies of host ant species are usually present in most gentian localities. Regular mowing can however become a significant stress factor. Taking this into account, mosaic hand mowing, instead of mowing with machinery, should be used (Beneš and Konvička 2008).

The *Pholidoptera transilvanica* grasshopper also requires special attention within habitat management. The species is threatened by spring grassland fires and early mowing, and the critical period is from April to June (Kelemen ed., 1997).

The decline in grazing and mowing on alpine summer pastures; reforestation, loss and degradation of habitats due to tourism developments, such as expansion of ski resorts; disturbance by tourism and leisure activities (such as hiking, skiing, mountain biking, snowshoeing and snowboarding); collisions with wires and fences, and overhunting have been reported as threats to *Tetrao tetrix* (black grouse) and *Lagopus mutus* (rock ptarmigan) (Storch, 2000). For *Alectoris graeca* (rock partridge), genetic pollution by captive-bred rock partridges, is also a serious threat and has even led to the eradication of many local populations, particularly in the Apennines and Greece (Randi, 2006).

In cultural landscapes, where traditional human land use techniques supported grouse species (such as *Tetrao tetrix* or *Alectoris graeca*), the habitat quality can often be maintained or restored only by continuing these activities. In the Alps many alpine pastures have been abandoned in recent years due to poor economic returns. This has led to the spontaneous colonisation of these areas by scrub and the loss of grouse habitat.

The extensive use of pastures and other historic land use techniques that favour grouse habitat needs should be continued. If possible, favourable habitat conditions can also be maintained with appropriate modern techniques. Collisions with wire fences, overhead wires and ski wires often kill birds. Wires and fences should not be erected within key areas for grouse, and existing ones should be removed or their visibility increased (e.g. wooden slats or plastic coverings). Alpine grasslands are an ideal landscape for alpine tourism. Management measures for grouse should therefore include visitor management (Suchant and Braunisch, 2004).

Gentianella praecox subsp. bohemica is a species which was relatively widely distributed in the Czech Republic in the past, but is very rare now, occurring only in 64 locations within the Czech Republic and in adjacent parts of Germany, Austria and Poland. It suffers from changes in agricultural practices from small-scale farming to large-scale farming. The optimum conditions for its presence are the removal of biomass from the grassland and disturbances allowing seedling recruitment. The timing of grazing and mowing is extremely important for the species. It should be done before the end of June, because later on it can harm the flowering and ripening of plants. Mowing and grazing in very late autumn is also suitable. Grazing should be extensive, and high livestock densities should be avoided. The removal of biomass in late autumn (second half of October) is also very important for the creation of gaps for seedling recruitment (Marhoul and Turoňová 2007).

Cost estimates and potential sources of EU financing

Active recurring management may be financed using the European Agricultural Fund for Rural Development (EAFRD), through agri-environment schemes. Broad farming activity may be supported by payments for Less Favoured Areas (LFA). When dealing with special schemes for maintaining species-rich *Nardus* grasslands, there are two main tasks in determining the calculation of costs. The first one is income foregone due to limits placed on fertilization. It can be calculated as the income lost because of lower biomass production comparing to average or reference production.

There are also additional costs connected with special grazing practices. This may include, for example, the cost for shepherds guarding their animals on the pastures (number of workdays x number of grazing days x rate for shepherd work), higher costs because of the dividing of animals into several herds (estimated increased costs as a percentage when compared with grazing with one herd, higher costs because of daily translocation of sheep-folds, costs of acquisition of electric fence systems as protection against predators etc.).

The calculated payments vary widely between countries depending on the methodology used for the calculation and depending on the conditions of particular schemes. It is interesting to mention examples from some countries which have special schemes for the management of semi-natural and natural grasslands. The Slovak RDP payment (Ministry of Agriculture of Slovakia 2007) is 74.57 EUR/ha, but *Nardus* grasslands are classified in the same group as all relatively common mesic grasslands within the country. In addition, agri-environmental payments can be combined with LFA payments and direct payments, so the real payment per hectare for *Nardus* grasslands may be about 200-300 EUR/ha depending on the location of the site within LFAs. The Polish RDP payment (Ministry of Agriculture and Rural Development of Poland 2007) is 204.9 EUR/ha and the calculation was tailored for *Nardus* grasslands only. For Sweden, the current compensation levels (February 2008) are at 120-270 €/ha for grazing and 120-375 €/ha for mowing; the highest for land with high nature conservational value. Compensation for restoration of overgrown grasslands may in single cases qualify for a maximum of 390 €/ha or a maximum of 90% of eligible costs.

If we compare regular active management with restoration measures, we may conclude that restoration is much more costly than regular management. The main EU fund for restoration management is the LIFE+ programme, but also sources from other programmes are eligible for such activities (e.g. non-profit investments from EARDF). Probably the highest investments for the restoration of the habitat, with a budget of several millions of EUR, were LIFE projects in Belgium for the restoration of different habitats including *Nardus* grasslands in the area of former coniferous plantations (e.g. Life project LIFE02 NAT/B/008595 Minerotrofic mires and heath ecosystems in the Zuiderkempen). The project included such costly measures as the clear-cutting of coniferous plantations and subsequent turf removal.

If scrub encroachment is not serious, less costly methods such as cutting and chopping of biomass with a flail or rotary mower, or cutting with a brush cutter are possible. The involvement of farmers in clearing is also very effective, because they can do the job at low prices compared with specialised companies. This was found to be the case during the LIFE project "The protective management of moors and short grass prairies in the Mediteranean" in France (Life project LIFE98 NAT/F/005200 the protective management of moors and short-grass prairies in the Mediterranean).

To identify to what extent management measures required for a specific site are eligible for financial support from various EU funds, further consultation of the "Financing Natura 2000 Guidance Handbook" (Torkler 2007) is recommended. Furthermore an IT-tool is available on the EC web site:
http://ec.europa.eu/environment/nature/natura2000/financing/index_en.htm

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