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The conservation status of juniper formations in Ireland

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The conservation status of juniper formations in Ireland

Fiona Cooper[1], Richard E. Stone[2], Peter McEvoy[3], Tim Wilkins[4] & Neil Reid[1].

1 *Quercus*, School of Biological Sciences, Queen's University Belfast, MBC, 97 Lisburn Road, BELFAST. BT9 7BL. Northern Ireland. http://www.quercus.ac.uk

2 *Giorria Environmental Services*, Ardacarha, Bohola, Co. Mayo. Republic of Ireland. www.giorria.com

3 *Dept. of Environment, Food & Agriculture*, Thie Slieau Whallian, Foxdale Road, St. Johns, Isle of Man, IM4 3AS. http://www.gov.daff

4 *Plantlife International*, 14 Rollestone Street, Salisbury. Wiltshire. SP1 1DX. England. http://www.plantlife.org.uk

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Executive Summary

1. This is the first study to make a quantitative assessment of the conservation status of the EU Annex I Habitat 5130 *Juniper communis formations on heaths or calcareous grasslands* throughout Ireland based on survey data.

2. A total of 125 locations were found to support juniper but many consisted of isolated small groups or individual shrubs. Following Plantlife (UK) criteria, a '*formation*' was taken as any discrete cluster of ≥50 shrubs which was judged the minimum number likely to be capable of recruitment and long-term persistence whilst avoiding inbreeding depression. A total of 51 formations were identified.

3. Formations occurred in a total of 36 x $10km^2$ squares with a favourable reference range judged to be 68 x $10km^2$ squares. Whilst this appeared to represent a substantial long-term decline (-74%) this may be spurious as the previously reported range was derived from single species records spanning the period 1800-2005 (NPWS, 2008). Formations were found to cover a total of $47.3km^2$ within their range. Conversely, this represented a substantial long-term increase (+436%) from that previously reported but again this change is likely to be spurious for similar reasons (NPWS, 2008). Thus, any change in distribution, range and the area covered by the habitat is entirely due to improved knowledge and more accurate data. Consequently, the results of this survey should be taken as a new baseline against which future change can be measured.

4. The total population within formations was estimated at approximately 20,036 individuals. Formations with notably large populations exist at Cruit Island and around Dawros Head (Co. Donegal), with approximately 3,000 and 3,500 shrubs respectively.

5. Intensive grazing pressure significantly reduced recruitment success presumably because small seedlings are more vulnerable to domestic stock than mature shrubs.

6. The age structure of juniper formations remains unknown as various methods of estimating and measuring age indirectly resulted in poor reliability.

7. Juniper was mostly associated with lowland dry calcareous and neutral grassland, exposed calcareous rock, dry siliceous heath, exposed siliceous rock and dry calcareous heath. However, it also occurred on coastal dunes and at higher altitudes.

8. A total of 5 phytosociological groupings were derived from vegetation analysis to describe indicative plant communities characterising juniper scrub throughout Ireland.

9. Following EU guidelines the current conservation status of *J. communis formations on heath and dry grasslands* was assessed as Unfavourable Inadequate U1 or poor (amber). This is considered to be a baseline assessment as the data supporting the amber assessment submitted in 2007 were based on a desk study of Juniper records.

10. A future monitoring protocol is outlined and site-specific recommendations are made to ensure conservation status remains stable or at sites were the status was determined as poor or bad can be restored.

11. Further research is required to elucidate the importance of habitat quality on the structure of juniper formations and also the impacts of livestock and climate on juniper recruitment.

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1.0 Introduction

Juniper (*Juniperus* sp.) is a slow-growing coniferous shrub belonging to the family Cupressaceae, found mainly in temperate and subtropical regions of the northern hemisphere. The genus is taxonomically complex, consisting of between 68 and 80 species (Thomas *et al*., 2007); however, only common juniper (*Juniperus communis* L.) is found throughout Ireland (Perring & Walters, 1990).

Juniper was one of the first woody species to colonise Great Britain and Ireland post-glacially about 15,000 years ago (Bennett *et al*., 1997; Pilcher & Hall, 2001). Pollen analysis suggests that juniper expanded its range about 12,400 years ago and would have formed shrub-dominated heath throughout Ireland (Nelson & Walsh, 1993). Due to its former widespread distribution juniper is associated with a rich folklore and diverse ethnobotanical uses, including medicinal, veterinary and culinary uses (see Appendix I). Today, juniper is found in a wide range of open habitats, at varying altitudes and growing in a wide range of soil types. It favours free-draining soils, rocky outcrops and rarely inhabits wet conditions, although it is occasionally found in well-drained locations within bogs, e.g. islands in pools (Thomas *et al*., 2007). The species has a low tolerance to shade (Grubb *et al*. 1996) and is gradually excluded from woodland (Ward, 1973). As an early coloniser, the presence of bare ground for seedling establishment is an important factor (Ward, 1973; Banks, 2001; Wilkins *et al*., 2011a; 2011b).

1.1 Sub-specific identification

Field botanists generally support the identification of three subspecies of *Juniperus communis* in Britain and Ireland; an upright form (ssp. *communis*) and a prostrate form (ssp. *nana*) are native to Ireland and a third ssp. *hemisphaerica* is probably known from just one location in Great Britain (Squirrell & Hollingsworth, 2008). Many authors accept that differentiating the subspecies based on morphology can be difficult (Clapham *et al*., 1987; Stace, 1991; Sullivan, 2001) whilst molecular and biochemical analyses have failed to convincingly discriminate between ssp. *communis* and ssp. *nana* (Vines 1998; Filipowicz *et al*. 2006; Appendix II). Moreover, there is substantial variation in the degree to which each individual can be upright or prostrate due to environmental conditions, for example, windward exposure (Elwes & Henry, 1906) or through putative hybridisation (Stace, 1991; Khantemirova & Semerikov, 2009). Even without environmental influences there can be a large degree of variation (Fig. 1). Nevertheless, it has been suggested that the length of the leaves and leaf-to-stem angle may be used to separate the putative subspecies; 8-20mm long at 90^{o} in ssp. *communis* and 4-10mm long at 45^{o} in ssp. *nana*. Praeger (1934) also suggested that both subspecies occupied different landscapes with ssp. *communis* being 'calcicole and lowland' and ssp. *nana* 'calcifuge and upland'. However, ssp. *communis* clearly straddles both lowland and upland situations, including a handful of lowland heath sites in southern England (Ward, 2004). To create yet further confusion, the subspecies have undergone frequent name changes and reclassification, most notably ssp. *nana* (Table 1). Where subspecies assignment is difficult the epithet *J. communis* ssp. *communis* is usually applied as suggested by Sullivan (2001).

Adams & Pandey (2003) and Adams (2004) used DNA fingerprinting to conclude that there was little evidence to support separation at sub-species level. The recognition of *J. communis* var. *saxatilis* sensu stricto (aka ssp. *nana*) was not supported by their analysis. Vines (1998) has also cast doubt on the authenticity of ssp. *nana*; there appears to be some blurring of distinctions at the extremes of morphological ranges. Adams (2004) further relegated ssp. *communis* to a variety. In future, the three sub-species that occur in Britain and Ireland may be generally treated as varieties of *Juniperus communis*. However, Stace (2010) currently maintains the three sub-species.

Fig. 1 Variation in Juniper communis grown from cuttings taken from various UK sites and planted at Cambridge Botanic Garden (Photo © J.A. Grant 1980).

Table 1 Frequent reclassification of juniper in the historical literature may have lead to confusion over sub-specific identification (Thomas et al., 2007).

Modern classification	Description	Historical classification	Authority
J. communis ssp. *communis*	Generally upright (though can be spreading), leaves 8-20mm long at 90° to stem, calcicole and lowland	ssp *eu-communis*	Syme
(Thomas *et al*., 2007)		var. *Arborescens*	Gaud.
		var. *Montana*	Nielr. – non-Ait.
		var. *vulgaris*	Ait.
J. communis ssp. *nana*	Generally prostrate, leaves, 4-10mm long at 45° to stem, calcifuge and upland	ssp *nana*	Willd.: Syme
(Thomas *et al*., 2007)		ssp *alpina*	Sm.; Celak.
		ssp. *alpina*	S.F. Gray; Celak; Neilr.
		var *Montana*	Ait.
		var *Saxatilis*	Pall.
		J. alpina	Sm.; S.F. Gray
		J. densa	Gord.
		J. pygmaea	K.Koch.
		J. sibirica	Burgsf
		J. nana	Willd.
		J. vulgaris	Kohler no. nud.

1.2 Species biology and ecology

Juniper is a wind-pollinated, dioecious species, with male and female flowers growing on separate plants. The female produces fleshy cones (galbulae; commonly referred to as berries, due to their fleshy texture), that are green in colour at first and take 2-3 years to mature, when they attain a distinctive purple colour (Ward, 2010). Germination requires passage through the gut of a bird, or if falling onto the ground, 1-2 years exposure to allow the cones to break down to expose the seed (Thomas, 2000). The seeds are classed as deeply dormant requiring a seasonal pattern of temperature changes before germination (Gosling, 2007). Germination times are long and highly variable, perhaps due to ecological adaptation, which aids seedling establishment in 'unpredictable habitats or those prone to catastrophic events' (Moore, 2001). Broome (2003) found that the earliest germination took place 18 months after sowing, peaking after 2.5 years and continued up to 5 years after sowing.

Seed viability is also highly variable ranging from nearly zero to 75–80% germination in ssp. communis (Ward, 1982) and approximately 60–75% in ssp. nana (Sullivan, 2001). Geographic location appears to influence germination rate, with greatest viability in the core of the species' central European range, notably at high altitudes. Viability decreases towards the species' range edge, notably in southern Mediterranean areas (Garcia et al., 2000a; Garcia et al., 2000b), indicating that juniper reproduction is climate dependent and is favoured by cooler environments. Juniper seed is prone to insect predation (Thomas et al., 2007), and abortion due to false pollination by dust or other airborne particles (Mugnaini et al., 2007). The latitudinal variation in seed viability may relate to the range of seed-eating insect species or pathogens (Verheyen, 2009).

Juniper is an important food plant for invertebrates supporting 32-35 species in Great Britain (Ward, 1977) and 3 species of moth in Ireland are known to feed exclusively upon it (A Tyner, pers comm.); the juniper pug moth (Eupithecia pusillata), juniper carpet moth (Thera juniperata) and chestnut-coloured carpet moth (T. cognata). Ward (1977) showed a strong relationship between the size of juniper populations and the diversity of insect fauna. Small juniper stands, e.g. of ≤10 shrubs, are likely to support few juniper-specific insect species unless they are close to large juniper populations.

Juniper has adapted to be mobile through efficient seed dispersal. In autumn, berries fall onto the ground beneath bushes or are eaten and dispersed by birds or other animals (Ward, 2004). Migrant thrushes such as fieldfare, redwing and mistle thrush are particularly responsible for dispersal. Seedlings are slow-growing and take 4-9 years to reach sexual maturity (Ward, 2004). Juniper also has the facility to spread locally through layering to form clones (Ward, 2004). The significance of this as a means of reproduction has yet to be determined.

1.3 Genetic structuring

Juniper populations are generally characterised by high genetic diversity (Oostermeijer & de Knegt, 2004). Adams *et al.* (2002) showed that Juniper colonised much of its current distributional range by spreading from glacial refugia since the end of the late Pleistocene ice age. Colonization within the Britain Isles followed a similar pattern (Van der Merwe *et al.*, 2000; Vines, 1998). These studies, and also Marsden (1997), Borders Forest Trust (1997) and Greeve *et al.*, (1998) found that all populations studied retained a high degree of genetic variability which probably relates to the juniper's mobility via seed dispersal by birds (Ward, 2004).

In the Scottish borders up to 93% of genetic diversity is within-populations and only 7% between-populations (Anon, 1997). Populations are generally fragmented and isolated which may eventually lead to inbreeding depression, although stands with inherently high genetic diversity will be more resilient. In Ireland, significant genetic differentiation of populations has been found using both chloroplast and nuclear DNA markers, indicating restricted gene flow, particularly over larger geographic scales (Appendix II). For conservation purposes, the existence of genetically distinct clusters and geographically localised haplotypes suggests that the concept of provenance should be taken into account when formulating conservation strategies, such as population augmentation or reintroductions. To maximise juniper's resilience and adaptability, small isolated populations should be linked through population supplementation and re-introductions, thereby enhancing gene flow and broadening gene pools. To allay the risk of outbreeding depression (reduced fitness caused by crossing between two genetically distinct populations), multiple donor sites should be used and sufficient numbers of individuals planted. The overall intention is to maximise the potential for juniper to adapt to the changing environment (Wilkins & Duckworth, 2011a).

Revised IUCN guidelines on translocation should be consulted to ensure best practice for both reinforcement and reintroduction is undertaken.

1.4 Associated vegetation

Juniper is widespread throughout Europe and Ireland and occurs in many habitat types. Whilst Annex I of the EU Habitats Directive (92/43/EEC) lists 5 habitats associated with juniper (Table 2) the specific habitat category *'J. communis formations on heaths or calcareous grasslands'* (#5130) is the most directly relevant to Ireland (NPWS, 2008).

Table 2 EU Annex I habitats associated with juniper.

EU Habitats Directive Code	Description
4030	European dry heath
4060	Alpine and sub-Alpine heath
5130	*J. communis* formations on heaths or calcareous grasslands
6210	Semi-natural dry grasslands and scrub facies on calcareous substrates
8240	Limestone pavement

Fossitt (2000) lists three habitats with which juniper is associated and that also have relevance to the EU Habitats Directive categorisation, namely: *'dry calcareous and neutral grassland (GS1)'*, *'dry calcareous heath (HH2)'* and *'scrub (WS1)'*. However, it may also be included under *'dry siliceous heath (HH1)'* and *'montane heath (HH4)'*. Although not specifically listed by Fossitt (2000), juniper is also associated with *'exposed siliceous rock (ER1)'* and *'exposed calcareous rock (ER2)'* in the forms of siliceous scree and limestone pavement respectively.

White & Doyle (1982) specify two distinct phytosociological units in which juniper assemblages occur in Ireland; those found in Counties Donegal and Mayo were referred to as *'Lycopodio alpine-Rhacomitrietum lanuginosi'* and those in County Clare were referred to as *'Arctostaphylo-Dryadetum'*. They also cite an account by Praeger (1934) which refers to *'groves of Taxus and luxuriant Juniperus communis'* around the shores of Lough Derg (White & Doyle, 1982).

1.5 National Conservation Assessment

The EU Habitats Directive (92/43/EEC) requires that habitats listed under Annex 1 are maintained in *'favourable conservation status'* throughout member states; a habitat's status is taken as *favourable* only when:

- *its natural range and the area 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*
- *the conservation status of its typical species is favourable.*

The '*Assessment, Monitoring and Reporting under Article 17 of the Habitats Directive'* report (European Commission, 2006) provided the first basic guidelines to assess the conservation status of juniper habitats. In addition, the Joint Nature Conservation Council (JNCC) produced *'Common Standards Monitoring Guidelines'* in order to monitor designated sites in the UK (Williams, 2006). The *'Status of EU Protected Habitats and Species in Ireland'* report (NPWS, 2008) provided the first baseline assessment of juniper scrub throughout Ireland.

To assess a habitat's conservation status, 4 parameters are objectively scored, namely; i) *range*, ii) *area and population*, iii) *structure and function*, and iv) *future prospects*. The conservation status of a habitat is defined as the sum of the influences acting on the habitat that may affect its long-term persistence. Updated methods for assessing conservation status have been drawn up by the European Topic Centre for Nature Conservation (ETCNC) in conjunction with EU Member States represented on the Expert Reporting Group for the Nature Directives (Evans & Arvela, 2011).

The format for the assessment of conservation status involves the application of a "traffic-light" system and brings together information on the four parameters for any habitat. Each parameter is classified as being "favourable FV" or good, "unfavourable inadequate U1" or poor, "unfavourable bad U2" or bad and "unknown" or grey.

Favourable reference values are set as targets against which future values can be judged. These reference values have to be at least equal to the value when the EU Habitats Directive came into force, i.e. in 1994. For habitats, favourable reference values are set for range and area. Favourable Reference Range is the geographic range within which all significant ecological variations of a habitat are included and which is sufficiently large to allow the long-term persistence of that habitat. The favourable reference value for the area covered by the habitat is the minimum value required for the long-term survival of the habitat.

For habitats, the assessment of structure and function includes an assessment of the condition and the typical species that characterize the habitat.

The major pressures and threats are also listed for each assessment. The impacts of these pressures and threats are used to determine the future prospects.

If any one of the four parameters i) *range*, ii) *area and population*, iii) *structure and function*, and iv) *future prospects* are assessed as "red", the overall assessment is also "red" (i.e. unfavourable – bad).

1.5.1 Current status

The range of juniper in the Republic of Ireland (defined as the number of occupied 10x10km Irish grid squares or cells) declined by 35% between 1987 and 1999 and was reported to be 108 cells during 1999 (Preston *et al*., 2007). Similar declines are known from Great Britain (Anon, 2007), specifically 46.3% in England, 29.9% in Scotland and 17.9% in Wales (Ward, 2004) whilst its European status is also under threat (Verheyen *et al*., 2009).
The last National Conservation Assessment (NPWS, 2008) for *'J. communis formations on heaths or calcareous grasslands'* (#5130) listed the habitat as in POOR (amber) status (Fig. 2a) and evaluated the habitat's current distribution as 141 x 10km squares with a favourable reference range of 191 x 10km squares (Fig. 2b). The previous assessment was based on 281 *J. communis* records collated from the period 1800-2005 (each of which was assumed to be a discrete stand, otherwise known as a *formation*; a sub-unit within a wider national meta-population). A single 8.8ha polygon of habitat was also identified which, taken together with each formation (each of which was assumed to be 1ha in area), totalled to 289.9 ha of remaining habitat (NPWS, 2008). However, the quality of the data was reported as "poor" given that each record was not surveyed to ensure it constituted a '*formation*', while the area of each site was not accurately measured.

1.5.2 Monitoring

The EU Habitats Directive requires '*surveillance*' of listed habitats by Member States under Article 11. In the first instance (and in the absence of other data), member states compile historical data on the distribution and extent of a listed habitat (for example, the collation of juniper records from 1800-2005 for the last Article 17 report). However, once the historical context is established a baseline survey is generally required to update the information with verified data collected in a standardised fashion. Thereafter, a subset of sites and key features of the habitat (generally selected after rigorous statistical analysis) are 'monitored' and reported on a six yearly cycle to establish the temporal trends in the habitat's conservation status. After the first cycle in which survey data are collected clear monitoring guidelines for each designated habitat are drawn up so that each Member State has a bespoke procedure for ensuring consistency of reporting to the EU commission. However, there are no such guidelines for the surveillance of juniper formations in Ireland.

1.6 Aims of the current study

Due to the general paucity of data on juniper formations in Ireland the current project aimed:

1. To define the term 'juniper formation'.
2. To establish the current distribution and extent of juniper formations
3. To establish the habitat and species associations of juniper formations.
4. To determine the condition and future prospects for each juniper formation
5. To assess the conservation status of the habitat throughout Ireland
6. To propose management recommendations to ensure favourable conservation status
7. To propose a monitoring prescription for juniper formations

The principal drivers of juniper decline are not well understood and undoubtedly vary geographically and between sites but contributing factors are likely to include (Thomas *et al*., 2007; Ward, 2004; Wilkins *et al*., 2011b):

1. Inappropriate management by over-grazing

2. Abandonment of grazing regimes, or low grazing pressure

3. Lack of suitable soil conditions preventing seedling establishment

4. Competition and shading by invasive native and non-native species (the former including natural successional change)

5. Low levels of seed viability

6. Population fragmentation resulting in reduced pollination (poor distribution or isolation of sexes)

7. A male-skewed sex ratio resulting in low reproductive success

8. Soil nutrient enrichment and aerial nitrogen deposition

9. Climate change

10. Habitat destruction

The current study also aimed to examine the prevalence of impacts and threats to juniper formations and the likely cause of their decline.

JUNIPERUS COMMUNIS formations on heaths or calcareous grasslands (5130)	
Range	Good
Area	Poor
Structure & Function	Poor
Future prospects	Poor
OVERALL	POOR

(b)

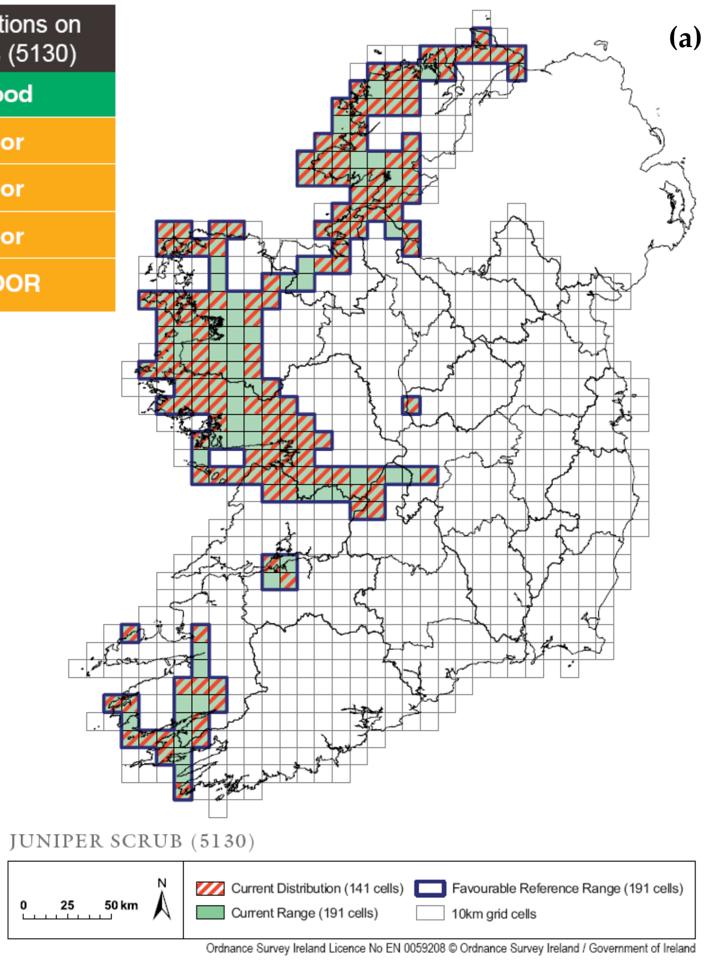


Fig. 2 (a) *A 10km atlas of known juniper distribution and* **(b)** *the most recent conservation assessment of juniper scrub during the last Article 17 report to the European Commission* (NPWS, 2008).

2.0 Methods

2.1 National juniper survey

Juniper records were collated from the UK National Biodiversity Network (NBN) Gateway, the Irish National Biodiversity Data Centre, Botanical Society of the British Isles (BSBI) and the National Parks & Wildlife Service (NPWS) database as well as individual Conservation Ranger records. MothsIreland (www.mothsireland.com) also provided records of three species of juniper-feeding moth. County floras and juniper-related papers in *The Irish Naturalist* (and subsequently the *Irish Naturalist's Journal*) were also used to identify potential species' locations where details were provided.

Juniper records with grid references <6 figures were not surveyed (i.e. 10km and 1km grid references) as they were too coarse to resolve the locations of individual juniper shrubs. This included the pre-1987 records (Preston *et al*. 2002). Duplicate records and those that were clearly incorrectly geo-referenced were also discarded (established by examining their distribution using ArcGIS v9.3 (ESRI, California, USA) and rejecting those that fell outside Ireland). Records sharing the same geo-reference but listed under different names or sharing the same name but marginally different geo-references were collapsed into the same site.

All sites identified were surveyed for juniper between May to September during 2008, 2009 and 2010.

2.2 General site surveys

Area and population

The extent of juniper scrub at each site was established by walking around the perimeter of all extant shrubs and geo-referencing the enclosing boundary using a Garmin 60 GPS. A Minimum Convex Polygon (MCP) was created for each site using ArcGIS v9.3. Where boundaries were inaccessible, or it was impractical to walk the perimeter, a visual assessment was conducted and co-ordinates were subsequently obtained from publicly available aerial photographs online at Ordnance Survey Ireland (www.osi.ie). If a site contained a very small population (i.e. <10 shrubs), the total area was taken as the number of shrubs multiplied by 1m^2 per shrub expressed in hectares (i.e. 0.001 – 0.009ha).

The total population, i.e. number of shrubs, (if >25 individuals) was estimated by counting the number in a random sample plot (which varied in area proportionally with the total extent of the population) which was then extrapolated upwards (using a similar rule of thumb to ornithological estimation of bird flock size). Populations consisting of <25 individuals were enumerated accurately. Initial population enumeration was conducted between May and September from 2008 to 2010 for all sites. It was noted that shrubs at some sites were low growing and prostrate in nature making it difficult to enumerate populations accurately due to long grass or other tall vegetation. Thus, those sites that were defined as '*non-formations*' (i.e. <50 shrubs) were revisited during November 2011 to February 2012 for reassessment when ground vegetation had died back.

Structure and function

A sample of shrubs was selected at random to estimate a suite of parameters throughout each site. The sub-specific identify of each shrub within this sample was determined as spp. *communis* or spp. *nana* using the length of the leaves and leaf-to-stem angle taken as 8-20mm long at 90^{o} in ssp. *communis* and 4-10mm long at 45^{o} in ssp. *nana*. The morphometrics of each shrub identified to subspecies were taken as height and width (on both a north-south and east-west axis) measured to the nearest 0.1 metres.

Active reproduction at each site was taken as an estimate of the percentage of shrubs with galbulae (% coned) and the number of shrubs classed as seedlings (% seedlings). Seedlings are typically <15cm tall and generally consisted of a single upright, thin (<0.75cm wide) stem.

Age structure was taken as the total number of shrubs at each site that were perceived as a) young, b) mature, c) senescent (i.e. post-maturity) and d) dead expressed as a percentage of the total number of shrubs. Estimation of age by eye is highly subjective, thus a number of other measurements were also taken. Dichotomous classification of age structure using Plantlife (2005) criteria was used to estimate the number of shrubs with less than ten (<10) or greater than ten (>10) dead stems expressed as a percentage of the total number of shrubs. It was assumed that aging populations may have a larger proportion of shrubs with >10 dead stems than younger populations. The diameter of the main stem of each shrub at ground level was recorded assuming that older plants had thicker stems than younger plants and that a frequency distribution may indicate whether a population was predominately young or old. To verify subjective measures of age a number of stem cores were taken for dendrochronological aging and a small sample of shrubs were destructively sampled by cutting them down at ground level to extract a complete stem disc. Obviously, it was not desirable to conduct destructive sampling at each site. Thus, only a small sample was taken at those sites with very large populations that were judged as being in relatively favourable conservation status and were not classified as Special Areas of Conservation (SAC), potential National Heritage Areas (pNHA) or Special Protection Areas (SPA). Cores and stem discs were prepared in the laboratory following Baillie (1982). Their surfaced was flattened using a razor blade and finely-ground chalk was rubbed onto the surface to define tree rings and facilitate accurate measurement. The tree-ring pattern on the samples was measured to an accuracy of 0.01mm using a microcomputer-based travelling stage and the age of each plant recorded as the total number of growth rings visible.

Impact and threats

The impacts and threats present at each site were categorised according to the standardised EU reference list (Ssymank, 2011; examples listed in Table 3). The extent of each threat was estimated as the proportion of the entire site that was affected by each impact. The intensity of each impact and threat was also evaluated on a relative scale. A site unaffected by any impact or threat was scored zero (0). Positive impacts were scored as minor influences (1), moderate influences (2) and strong influences (3) whilst negative impacts and threats were scored as minor (-1), moderate (-2) or severe (-3). It should be noted that some sites may have had multiple impacts and threats.

Table 3 Descriptive of each impact or threat using the EU Habitat Directive codes relevant to juniper.

High-level description		Impact or threat code	Specific-description
A	Agricultural	A03.01	Intensive mowing or intensification
		A03.02	Non-intensive mowing
		A04.01.01	Intensive cattle grazing
		A04.01.02	Intensive sheep grazing
		A04.01.03	Intensive horse grazing
		A04.01.05	Intensive mixed animal grazing
		A04.02.01	Non-intensive cattle grazing
		A04.02.02	Non-intensive sheep grazing
		A04.02.04	Non-intensive horse grazing
		A04.02.05	Non-intensive mixed animal grazing
		A04.03	Abandonm't of pastoral systems, lack of grazing
		A11	Agricultural activities not referred to above
C	Mining, extraction of materials	C01	Mining and quarrying
D	Transportation and service corridors	D01.01	Paths, tracks and cycling tracks
		D03.01.01	Slipways
E	Urbanisation, residential and commercial development	E01.03	Dispersed habitation
		E02.01	Factory
		E03.01	Disposal of household waste
		E04.01	Agricultural structures, building in the landscape
G	Human intrusions and disturbances	G05.01	Trampling, overuse
I	Invasive, other problematic species and genes	I01	Invasive non-native species
		I02	Problematic native species
J	Natural systems modification	J01.01	Burning
K	Natural biotic and abiotic processes	K01.01	Erosion
		K01.03	Drying out
		K04.01	Competition (flora)
		K04.05	Damage by herbivores
M	Climate change	M01.03	Flooding and rising precipitation

Associated vegetation

The habitats present throughout the entirety of each site were classified *in situ* using Fossitt (2000) categories in the field (Table 4). Some large sites contained multiple habitat types and were attributed multiple Fossitt codes.

Table 4 Description of Fossitt (2000) habitat codes used to classify juniper sites in the field.

Fossitt code	Description
BL3	Buildings and artificial structures
CD2	Marram dunes
CD3	Fixed dunes
CD6	Machair
CS1	Rocky sea cliffs
ED2	Spoil and bare ground
ED3	Recolonising bare ground
ED4	Active quarries and mines
ER1	Exposed siliceous rock
ER2	Exposed calcareous rock
GA1	Improved agricultural grassland
GM1	Marsh
GS1	Dry calcareous and neutral grassland
GS2	Dry meadows and grassy verges
GS3	Dry-humid acid grassland
GS4	Wet grassland
HH1	Dry siliceous heath
HH2	Dry calcareous heath
HH3	Wet heath
PF1	Rich fen and flush
WS1	Scrub

2.3 Relevé survey

At each site where juniper was found a sample of 2x2m relevés (quadrats) were placed throughout the site, centred on randomly selected juniper shrubs. For each relevé, a 10 figure grid reference was taken using a handheld Garmin 60 GPS. Altitude (metres above sea level), slope (estimated by eye to the nearest 5^{o}) and aspect (categorised into 9 discrete classes including north, north-east, north-west, east, west, flat, south-east, south-west and south) were also recorded. A soil sample was collected for pH analysis in the laboratory. Distilled water was added to each soil sample in a 2:1 ratio and pH values were measured using a handheld Hanna pHep pH meter. pH analysis was completed within one week of sample collection. All vascular plant species present within each relevé were recorded (following the nomenclature of Stace, 1991) and the extent of their coverage was judged on the traditional Domin scale (Kent & Coker, 1992). Bryophytes and lichens were not recorded.

Domin scores were converted to mean percentage cover values using the 'Domin 2.6' conversion method (Currall, 1987). The estimates of percentage cover on the Domin scale in the range 4-10 approximate to the square-root of the cover value, however this function does not adequately describe the lower Domin scores. A much closer approximation to the functional relationship between Domin scores and actual percentage cover values throughout its range is best described using the formula:

$$\% \, cover = \frac{Domin \, score^{2.6}}{4}$$

Equation 1
(Currall, 1987)

Consequently, the percentage cover range of traditional Domin scores was converted to a more accurate mean associated with Domin 2.6 (Table 5).

Table 5 The relationship between the Domin scale, percentage cover and the calculated parameter 'Domin 2.6' (Currall, 1987).

Domin score	% cover range	Mean of % cover range	'Domin 2.6'
10	95 – 100	97.5	99.5
9	75 – 94	84.5	75.7
8	50 – 74	62.0	55.7
7	33 – 49	41.0	39.4
6	25 – 32	28.5	26.4
5	10 – 24	17.0	16.4
4	5 – 9	7.0	9.2
3	1 – 4	2.5	4.3
2	<1	0.5	1.5
1	<1	0.5	0.3
+	<1	0.5	-

Ellenberg (1979; 1988) and Ellenberg *et al*. (1991) scored vascular plant species on how they 'behave' with respect to a range of environmental parameters. Originally such scores were based on European conditions but Hill *et al*. (1999) recalibrated them for the British Isles. Mean Ellenberg values were calculated for each relevé and used as proxies of environmental parameters, namely, light and four soil metrics including reaction (pH), moisture, nitrogen (fertility) and salinity. Mean values were derived from the scores for each plant species present (following Hill *et al*. 1999) weighted by their abundance (in this case, Domin 2.6 scores).

Total species richness was expressed as the total number of plants (identified to species level) present in each relevé minus negative indicator species (in this case, those species deemed to qualify for the EU Habitats Directive impact and threat codes I01 invasive non-native species (for example, *Rhododendron ponticum*) and I02 native problematic species (for example, *Pteridium aquilinum*). Sward height was measured in centimetres and taken as a mean from 4 locations selected at random within each relevé. Where relevés fell on limestone pavement or expanses of bare rock sward height was recorded as zero (0).

The total area of each relevé which was unvegetated was estimated as the percentage of bare rock or bare soil. Detailed soil analysis was beyond the scope of the current study but data on parent materials were nonetheless attributed to each relevé using the TEAGASC/EPA DIGITAL SOILS AND SUBSOILS database for Ireland (http://www.teagasc.ie), specifically, the presence (1) or absence (0) of calcareous parent material (RcKCa) and non-calcareous parent material (RcKNCa). The coarse resolution of ArcGIS landscape variables may raise difficulties with the precision of its attribution to individual relevés. However, in the case of parent materials the presence or absence of calcareous rock may give a *broad* indication of the type of soil, pH and plant community likely to be present.

2.3.1 Vegetation Analysis

Preparation of vegetation data

Initially, all species and sites were included in analyses but there was very poor concurrence on the resulting number of habitat types. Thus, rigorous data preparation was required to achieve any level of concurrence. For example, species identified to *Genus* level only were removed including young tree seedlings and saplings belonging to *Betula* sp., *Pinus* sp. and *Quercus* sp. and species subject to taxonomic difficulties including *Dryopteris* sp. and *Sagina* sp. Species occurring in 1 or 2 relevés cannot be indicators as they yield non-significant *p* values i.e. their occurrence cannot be distinguished from random chance (McClune & Grace, 2002; Murphy & Fernandez, 2009). Thus, rare and uncommon species, i.e. those occurring in ≤3 relevés were excluded as they were likely to have provided little leverage when assigning parent relevés to descriptive groups (McCune & Grace, 2002). Moreover, one relevé (representing a site) contained species data but environmental data were missing and was also removed.

Preparation of environmental data

Insufficient soil at a number of relevés, which fell on limestone pavement or expanses of bare rock, prevented the collection of soil samples and consequently pH values were missing. Missing values were interpolated using linear regression at those sites where pH values were known and where a suitable surrogate predictor variable was available (in this case, mean Ellenberg reaction scores). As pH and Ellenberg Reaction scores were co-linear, only pH was retained for analysis.

Initially, aspect was included in the analysis as a 9 factor but it provided poor analytical leverage. Thus, aspect was recoded into a continuous scalar variable representing an index of exposure where north = 0, north-west and north-east = 0.25, east, west and flat areas = 0.5, south-east and south-west = 0.75 and south = 1.

Outlier analysis

This is an essential step in cleaning any dataset as outliers can profoundly affect the output of multivariate analyses such as those used to determined plant community composition (McCune & Grace, 2002). Outlier Analysis was initially performed to remove any relevés ≥3 standard deviations away from the grand mean (following Murphy & Fernandez, 2009). This resulted in no sites being removed and initial runs of the analysis provided very poor concurrence on the resulting number of habitat types. Thus, Outlier Analysis was re-run removing sites ≥2 standard deviations away from grand mean.

Ordination

Ordination aims to simplify complex noisy multivariate datasets into a highly reduced set of hypothetical dimensions or axes that capture the majority of the variation in the response variables. In this case, the main objective was to describe plant community structure by grouping relevés using a measure of dissimilarity in hypothetical ordination space and to define communities using a list of species that acted as indicators within the community to which they had been assigned. Four complimentary approaches were used:

Hierarchical Cluster Analysis

Polythetic agglomerative cluster analysis was used to define discrete groups of relevés (i.e. habitat types) that provided a means of plant community classification. Using a matrix of n relevés x p species, a distance matrix was constructed by measuring the degree of dissimilarity, based on Sørensen or Bray-Curtis metrics, between pairs of relevés. The minimum distance (or linkage) method was taken as flexible β = -0.25 (Lance & Williams, 1967). Therefore, each relevé was assigned to a habitat type representing clusters of relevés with similar plant communities. We performed this procedure at every level of putative clustering from a minimum of 2 groups to a maximum of 10 groups.

Indicator Species Analysis

This method was used to identify species indicative of habitat types that differed sufficiently as to be used to differentiate between them reliably (Dufrene & Legendre, 1997). Specifically, information was combined on species abundance (i.e. Domin 2.6 scores) in a particular habitat type and the reliability of the occurrence of that species within that habitat type (McCune & Grace, 2002). In principal, a predetermined habitat type will have an ideal indicator species that belongs exclusively to that habitat and will be found in all relevés at maximum abundance. However, in reality Indicator Species Analysis assigns a percentage Indicator Value (IV) to each species to represent the likelihood that that species is the best indictor for a given habitat. Indicator Values were tested for significance using a randomised Monte Carlo technique based on 1000 iterations. The latter allows mean Indicator Values to be associated with probability or *p*-values against a null hypothesis of no difference between habitat types (McCune & Grace, 2002).

Indicator Species Analysis was performed for each grouping obtained from Hierarchical Cluster Analysis (ranging from 2 groups to 10 groups). The sum of the Indicator Values (IVs) for all species and their mean p values were obtained for each putative grouping and plotted. The grouping that provided the highest summed Indicator Value and the lowest mean p value was chosen as the most parsimonious means by which to differentiate between indicator species groups and, therefore, habitat types (Perrin *et al*. 2008; Murphy & Fernandez, 2009).

Multi-Response Permutation Procedure Analysis

This is a non-parametric test for the null hypothesis that final indicator species groups (i.e. habitat types) did not differ significantly (i.e. were poor clusters). The Multi-Response Permutation Procedure provided an A statistic which described within-group environmental heterogeneity compared to random expectation. If all relevés within a habitat were identical $A = 1$, if variation equalled random expectation $A = 0$ and when all relevés varied less than expected $A < 0$. It was inappropriate to test between groups using the same variables that were originally used to define them (i.e. species abundances), thus the Multi-Response Permutation Procedure was run using a matrix of 12 environmental variables including altitude, slope, index of exposure, pH, Ellenberg scores (moisture, nitrogen, light and salinity), the extent of bare rock and bare soil and the presence or absence of calcareous parent material (RcKCa) and non-calcareous parent material (RcKNCa).

Non-metric Multidimensional Scaling Analysis

This method was used to determine relationships between groups of relevés (i.e. habitat types) and the 12 environmental parameters listed above by reducing them to ordination axes. Initially, 3 axes were used, however, 2 axes provided the same result in a clearer format, and thus a 2-dimensional solution was used. Similar to Hierarchical Cluster Analysis, this procedure used Sørensen or Bray-Curtis metrics to assess the n x n distances calculated from an n x p-dimensional matrix where n was the number of relevés and p was the number of environmental parameters. Monotonicity in the distance between p-dimensional space (environmental parameters) and the final reduced k-dimensional space (the two ordination axes) was kept to a minimum (using varimax rotation) and was described by a measure of 'stress' expressed as a percentage. Significance testing was based on Monte Carlo randomisation using 100 iterations in each of 100 runs (i.e. 100 x 100 = 10,000 permutations). Pearson correlation coefficients described the relationship between the final two axes and the environmental variables using an r^2 cut-off value = 0.200. Thus, all relevés were assigned to a discrete habitat type which was described using a combination of plant community structure and associated environmental parameters.

All outlier and ordination analyses were conducted using PC-ORD v3.2 (MjM Software, Oregon, USA).

2.4 Conservation value

The relative '*conservation value*' of each formation was assessed using methods modified from Martin *et al*. (2005) and Perrin *et al*. (2008). Conservation value was judged under three main attributes including i) *Area and population*, ii) *Structure and function* and iii) *Future prospects*. A number of criteria (i.e. features indicative of the three main attributes, for example, the percentage of shrubs bearing cones under *Structure and function*) were scored within each attribute by either dividing their observed values into discrete scoring bands or by rescaling their variance to represent a percentage ranging from 0-100% (for details see Perrin *et al*. 2008). As the scoring bands or scores were dependent on the observed values, further details with respect to juniper are given in the Section 3.4 (pages 55-58).

2.5 Conservation assessments

Site-by-site conservation assessments are required to develop specific management plans tailored to the idiosyncratic features of each site. Conservation assessments were judged using the same attributes as conservation value including i) *Area and population*, ii)

Structure and function and iii) *Future prospects*. A number of criteria within each attribute were assessed and objective targets established using observed data. Criteria either passed or failed these targets and the number of criteria passing or failing determined whether individual sites were classified as being "favourable FV" or good, "unfavourable inadequate U1" or poor, "unfavourable bad U2" or bad or "unknown" i.e. grey. As the targets were dependent on the observed values, further details with respect to juniper are given in the Section 3.5 (page 62).

2.6 National conservation assessment

An overall National Assessment for the *conservation status* of *'J. communis formations on heaths or calcareous grasslands'* (EU Annex I Habitat #5130) was conducted following the most recent EU guidelines for the period 2007-2012 (dated February 2011). The habitat was assessed using standard Annex D criteria at 1) a National Level (including distribution and range) and 2) a Biogeographical level (including short-term and long-term trends in surface area covered by the habitat and its favourable reference range plus the main pressures on the habitat). The overall assessment used the same parameters as those used to assess individual sites (i.e. *Area and population, Structure and function* and *Future prospects*) with the addition of an extra parameter (i.e. *Range*). The standard "traffic-light" system was used. If any one of the four parameters i) *range*, ii) *area and population*, iii) *structure and function*, and iv) *future prospects* was assessed as "red", the overall assessment was also "red" (i.e. unfavourable – bad). Favourable reference values (based on observed values) were set as targets against which future changes could be judged.

3.0 Results

3.1 National juniper survey

A total of 837 juniper records with grid references were collated. Those consisting of 2 - 4 figure grid references were too coarse for practical application and were removed along with those with incorrect grid reference formatting (i.e. falling outside Ireland). Duplicates, including those sharing the same site name but having slightly different spatial references or *vice versa* were collapsed into a single site (for example, Cruit Island and the Dawros Head Complex, Donegal). Thus, a total of 178 sites were identified for survey.

Juniper was determined as present at a total of 129 sites (72%), absent at 42 sites (24) and its status was unknown at a further 7 sites (4%) due to their inaccessiblity, either due to health and safety concerns or denial of access. A conservation assessment was made at a total of 125 sites at which juniper was present (4 sites were not assessed as they were not adequately surveyed due to their inaccessiblity, either due to health and safety concerns or denial of access despite juniper being observed at a distance). Not all 125 sites at which juniper was assessed were surveyed using relevés as many consisted of isolated shrubs or were in inaccessible locations; thus a total of 194 relevés (Table 6) were surveyed at 98 sites.

Table 6 Number of sites with juniper present and number of relevés surveyed.

County	No. of sites with juniper present	No. of relevés surveyed
Clare	20	23
Cork	9	7
Donegal	29	63
Galway	20	35
Kerry	11	3
Leitrim	2	5
Limerick	3	6
Mayo	8	13
Offaly	1	0
Sligo	18	31
Tipperary	4	8
TOTAL	**125**	**194**

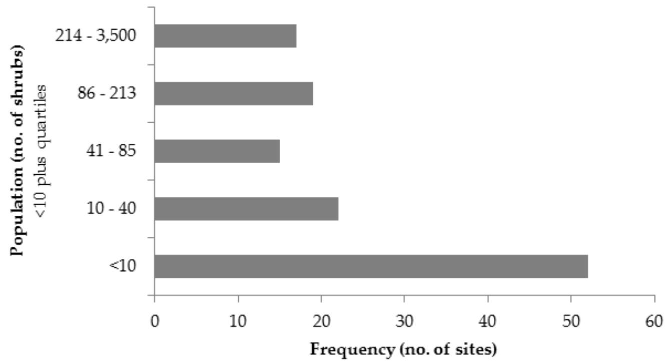
3.2 General site surveys

Area and population

The total area of juniper recorded throughout Ireland was 4,756.5 ha (excluding unsurveyed sites, which were estimated to cover approximately 18ha). The mean area of all sites was 38.1 ha but ranged from 0.001ha (sites with only one shrub covering approximately 1m^2) to 2,673.7 ha (a widespread population of >3,500 shrubs at the Dawros Head Complex, Co. Donegal). The majority of sites were small in total area (Fig. 3a).

The total population was estimated at approximately 21,036 individual shrubs (the sum of estimates for individual sites). The mean population across all sites was 168.3 shrubs but ranged from 1 shrub to >3,500 shrubs. The majority of sites consisted of small populations only (Fig. 3b).

A total of 7 sites had populations >1,000 shrubs (Fig. 4a) including the Dawros Head Complex, Cruit Island and Lough Nagreany (Co. Donegal), Cappacasheen (Co. Galway), Corraun Hill/Clew Bay (Co. Mayo), Barrigone (Co. Limerick) and Caherbannagh (Co. Clare).



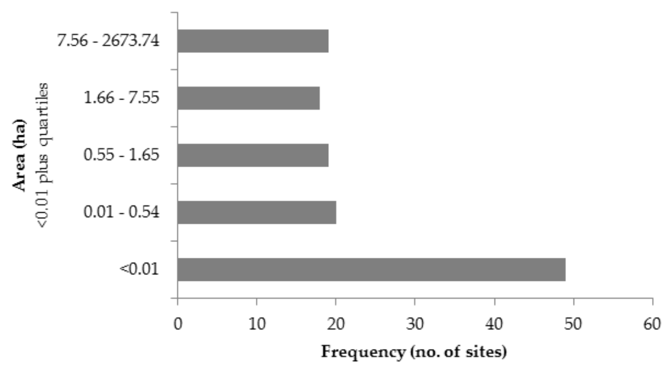


Fig. 3 Frequency distribution of the area covered by each site (a above) and the estimated number of individual shrubs at each site (b below)

Structure and function

Sub-specific identity

The sub-specific identity of juniper was established at 102 sites with half or 51 sites (50%) dominated by subspecies *communis*, 44 sites (43%) dominated by subspecies *nana* and 7 sites (7%) were mixed populations of both subspecies. Both subspecies were widespread but *communis* was generally distributed in the mid-west whilst *nana* was generally characteristic of sites on the Atlantic fringe (Fig. 4b). Mixed populations occurred in counties Donegal and Sligo only.

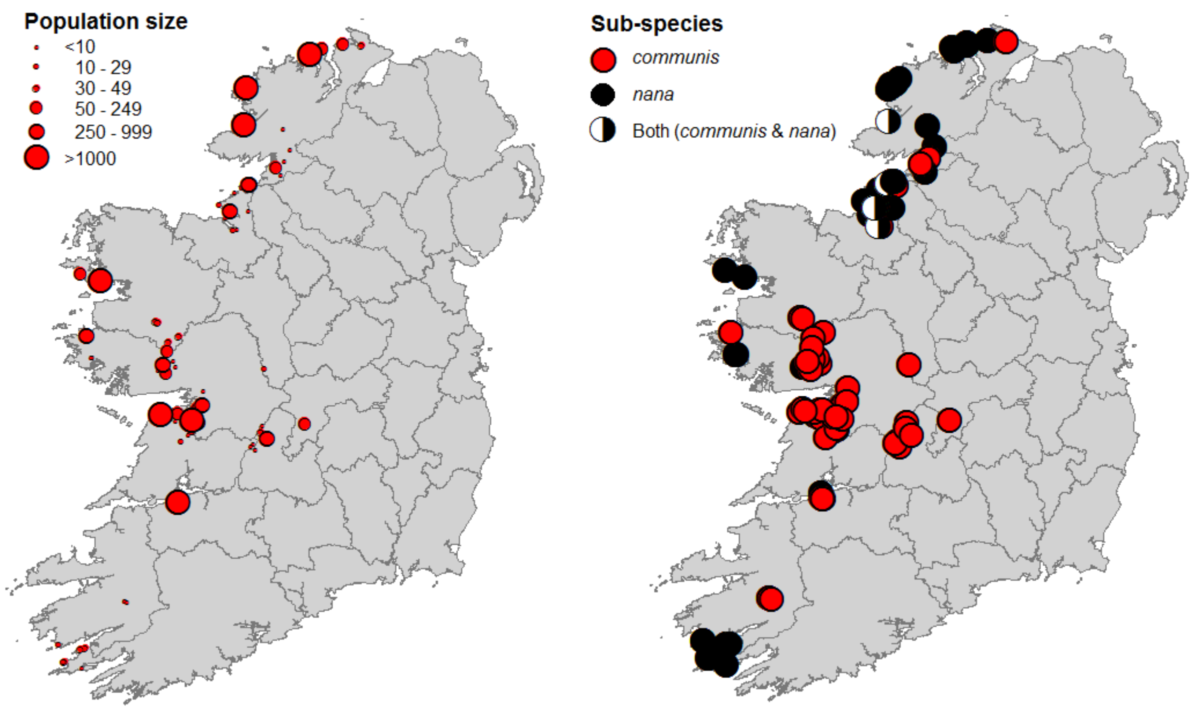


Fig. 4 Juniper population size throughout Ireland and distribution of sub-species communis and nana.

Plant size

Plant size was highly variable. Shrub height varied from 1 - 350cm depending on subspecies (Table 7). In addition, it seemed that local environmental factors influenced shrub morphology, for example, shrubs at altitude and on wind exposed sites were typically smaller than those in less exposed sites. Mean height, north-south width and east-west width of putative mature shrubs at Corraun Hill, Co. Mayo (mean altitude 300m), was 9.8 x 80.7 x 76.5cm, whilst the same dimensions of putative mature shrubs at

Kincasslough, Co. Donegal (mean altitude 11.5m) were 14.4 x 166.6 x 184.8cm respectively, despite both populations being ssp. *nana.*

Table 7 Summary of shrub morphology by perceived subspecies for all individuals measured.

Mean	**ssp. *communis*** cm (range)	**ssp. *nana*** cm (range)
Height	73.7 (3-800)	23.1 (2-100)
NS width	219.4 (3-918)	137.1 (1-600)
EW width	224.9 (3-877)	131.5 (1-650)

Reproduction and recruitment

Across all sites there was a modal sex ratio of 3:1 (assumed male: coned female), however, it was impossible to accurately assign sex ratios to individual sites as small populations biased identification to non-cone bearing shrubs which were assumed male. For those sites where data were available (n=103), a total of 74 sites (72%) were sexually reproductive with female shrubs bearing cones. The percentage of shrubs bearing cones exhibited a Poisson distribution approximating a normal distribution for those sites with sexually reproductive individuals but with a high number of sites with no sexual reproduction (Fig. 5a). A total of 22 sites (21%) exhibited signs of active recruitment i.e. seedlings. The frequency distribution of the percentage of plants classed as seedlings was highly left-skewed (Fig. 5b) with the majority of individuals on the majority of sites classed as adult. Evidence of recruitment was difficult to find as seedlings tended to be small and generally grew in sheltered rock crevices. Active recruitment, i.e. the presence of seedlings, was significantly associated with reproductive effort, i.e. the presence of cones ($\chi^2_{d.f.=1} = 7.98$, p=0.005; Table 8).

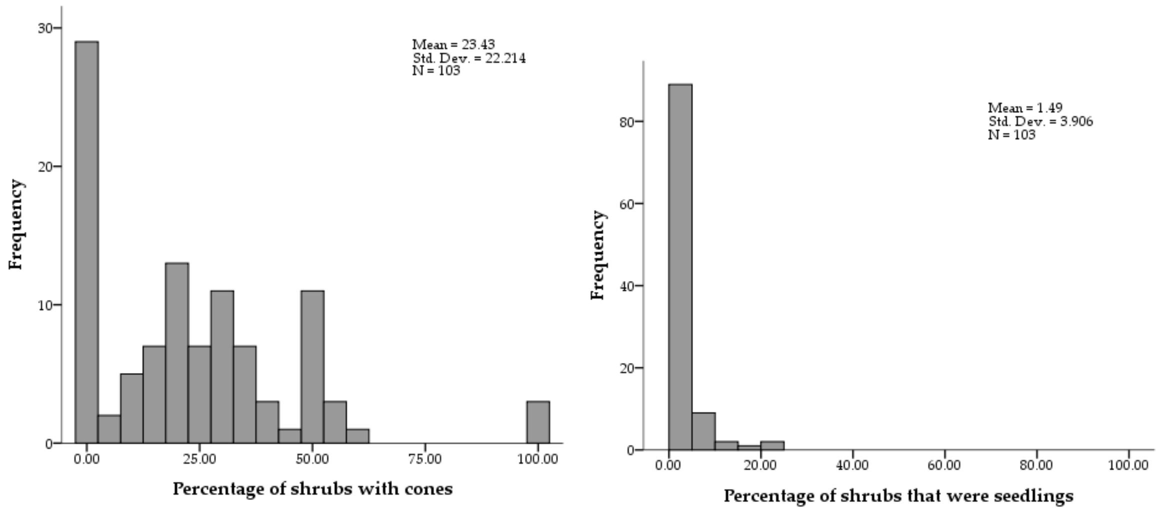


Fig. 5 Frequency distribution of sites that were reproductively active with female plants bearing cones (a left) and sites that were actively recruiting (b right).

Table 8 2 x 2 contingency table of the number of sites that were reproductively active (i.e. had cones present) and those that were actively recruiting (i.e. had seedlings present).

No. of sites	Seedlings absent	Seedlings present	**TOTAL**
Cones absent	29	0	**29**
Cones present	57	17	**74**
TOTAL	**86**	**17**	**103**

Age structure

Visual assessment suggested that approximately 77.5% of shrubs per site were perceived as mature, a significantly greater proportion than those perceived as seedlings, young, senescent or dead (Fig. 6).

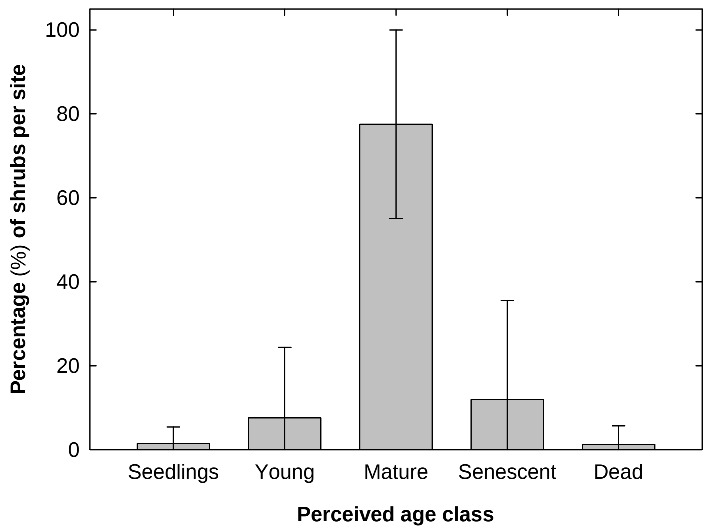


Fig. 6 Frequency distribution of the perceived age of juniper shrubs at all sites surveyed (n=103).

Dichotomous classification of the age structure of each individual shrub using Plantlife (2005) criteria suggested that 70.8% of shrubs possessed <10 dead stems and 29.2% of shrubs possessed >10 dead stems (n=431). Plantlife criteria ignored plant size; for example, a shrub with a total of 5 stems, four of which were dead would be classified in the same <10 dead stem category as a shrub of 20 stems, four of which were dead despite the former small shrub being 80% dead and the latter large shrub being 20% dead. Thus, due to the arbitrary nature of this criterion this measurement was abandoned after the first year of survey (2008) and replaced with an estimate of the percentage of each shrub that was dead (2009 and 2010). However, these data (n=962) supported the previous observation that the majority of plants possessed relatively little dead material and were predominately '*in-the-green*' (Fig. 7).

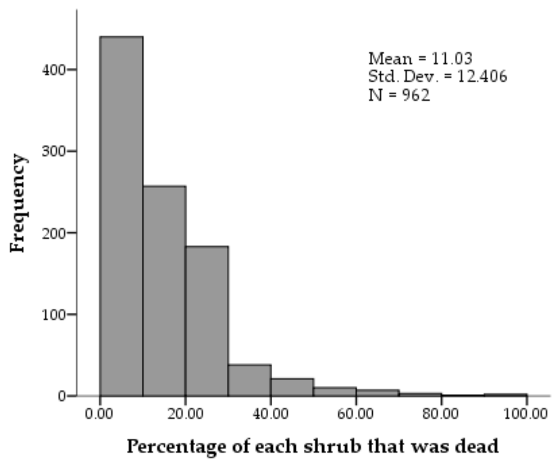


Fig. 7 Frequency distribution of the percentage of each shrub that was dead estimated during 2009 and 2010 (n=962).

Stem diameters were collected from a total of 387 shrubs; however, the main stem was assessable at ground level in only 194 cases (50.1%). The frequency distribution of main stem diameters was highly left-skewed suggesting that the majority of the plants may have been younger than originally perceived (Fig. 8). In those cases where the main stem could not be measured a secondary stem diameter was taken (n=193). These values were significantly smaller than those from main stems ($t_{d.f.=385}$ = 6.227, p<0.0001) and were therefore rejected as non-informative. Dearnley & Duckett (1999) suggested that stem measurements are generally a poor indicator of age. Given the difficulty in obtaining measurements at ground level due to the prostrate nature of many shrubs this method of aging was also abandoned after the first year of survey (2008).

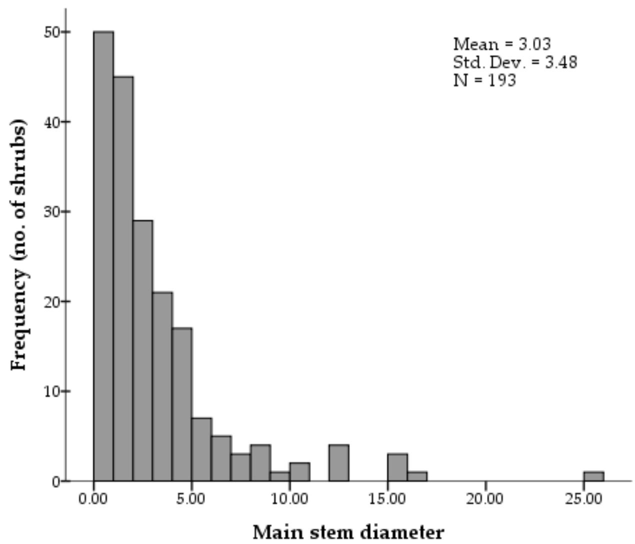


Fig. 8 Frequency of main stem diameters of shrubs surveyed during 2008.

Stem coring (Fig. 9a) was trialled during the second year of fieldwork (2009) at 2 sites at the Upper Lake and Muckross Lake, in Co. Kerry. However, all shrubs sampled had hollow stems and it was impossible to age them with any degree of accuracy.

Finally, destructive sampling was employed during the third year of fieldwork (2010) to obtain stem cores (Fig. 9a) and stem discs (Fig. 9b). A total of 26 samples were taken from perceived young, mature, senescent and dead shrubs (Table 9). Actual dendrochronological age was determined by counting annual growth rings which ranged from 0.01mm to 6.20mm wide indicating highly irregular growth patterns (Table 9). Whilst the perceived age classes varied significantly in actual age ($F_{d.f.=1,22}$ = 246.576, p<0.0001) only dead shrubs were significantly older than living shrubs (Fig. 10). Shrubs perceived as young, mature and senescent did not differ significantly in actual age. Thus, estimation of age by surveyors in the field was deemed highly unreliable.

There was a positive significant relationship between the maximum stem diameter and actual age ($F_{d.f.=1,23}$= 20.167, p<0.001; Fig. 11). However, only 47% of the variation in age was accounted for by stem diameter. Consequently, the 95% prediction limits of the equation for the line were notably wide (Fig. 11) suggesting that using stem diameter for interpolating age would yield inaccurate predictions (i.e. 53% of variance in age was accounted for by other unknown factors). Thus, estimation of age using stem diameter was deemed unreliable for practical purposes.

Accurate assessment of age was therefore problematic. Thus, original estimates of the percentage of each population which was perceived as young, mature and senescent were rejected as potential parameters by which to assess the conservation value and status of each site.

Fig 9 (a) Stem section from a perceived mature shrub from Lough Mask, Co. Mayo and **(b)** stem disc from a perceived mature shrub from Fanad, Co. Donegal.

Table 9 Summary of stem disc ring widths and dendrochronological age.

Perceived age class	Sample	Range (mm)	Mean (mm)	SD	Approx. max stem diameter (mm)	Total (yrs)
Young	Q11257	0.16-1.18	0.52	0.11	16.52	12
	Q11265	0.07-0.33	0.17	0.02	8.14	12
	Q11255	0.08-0.40	0.23	0.03	9.92	13
	Q11259	0.07-0.69	0.31	0.04	13.98	16
	Q11256	0.07-0.73	0.29	0.04	18.32	25
Mature	Q11262	0.35-1.39	0.83	0.09	22.18	11
	Q11261	0.16-2.14	0.7	0.15	40.32	13
	Q11254	0.17-1.93	0.84	0.14	32.56	17
	Q11260	0.20-0.99	0.5	0.04	22.82	20
	Q11263	0.10-1.48	0.56	0.08	30.88	24
	Q11273	0.10-4.85	2.12	0.2	110.24	25
	Q11264	0.02-1.47	0.24	0.02	17.64	28
	Q11253	0.07-1.01	0.47	0.05	34.74	33
	Q11272	0.11-2.86	1.38	0.13	94.86	33
	Q11258	0.10-1.02	0.31	0.03	26.04	35
	Q11252	0.01-2.53	1.18	0.11	89.06	36
Senescent	Q11267	0.13-3.06	1.15	0.24	6.08	13
	Q11275	0.35-3.04	1.69	0.19	54.82	15
	Q11268	0.45-3.72	1.69	0.27	58.14	16
	Q11266	0.32-2.02	1.13	0.12	42.38	17
	Q11270	0.18-2.46	1.09	0.17	43.14	18
	Q11271	0.32-2.73	1.34	0.12	73.62	26
	Q11269	0.88-1.99	0.69	0.1	51.60	33
Dead	Q11274	0.16-2.88	1.27	0.13	100.52	38
	Q11277	0.10-6.20	1.08	0.17	109.88	49
	Q11276	0.10-2.56	0.95	0.09	100.68	51

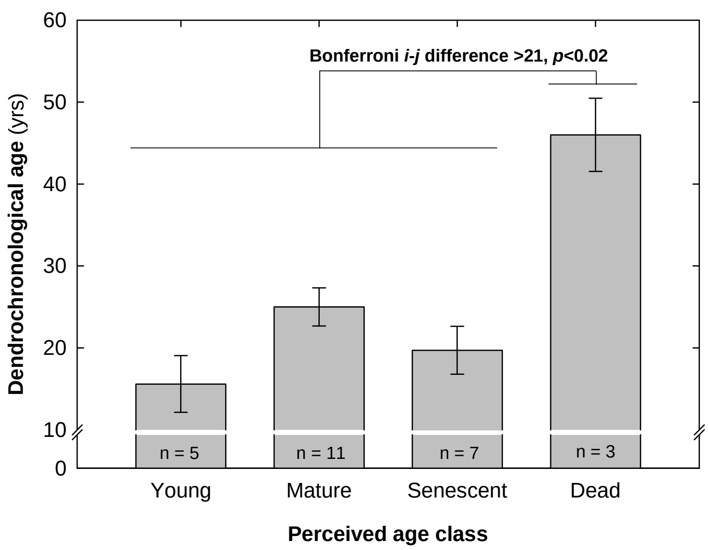


Fig. 10 Mean age of juniper shrubs sampled using stem discs ± standard errors.

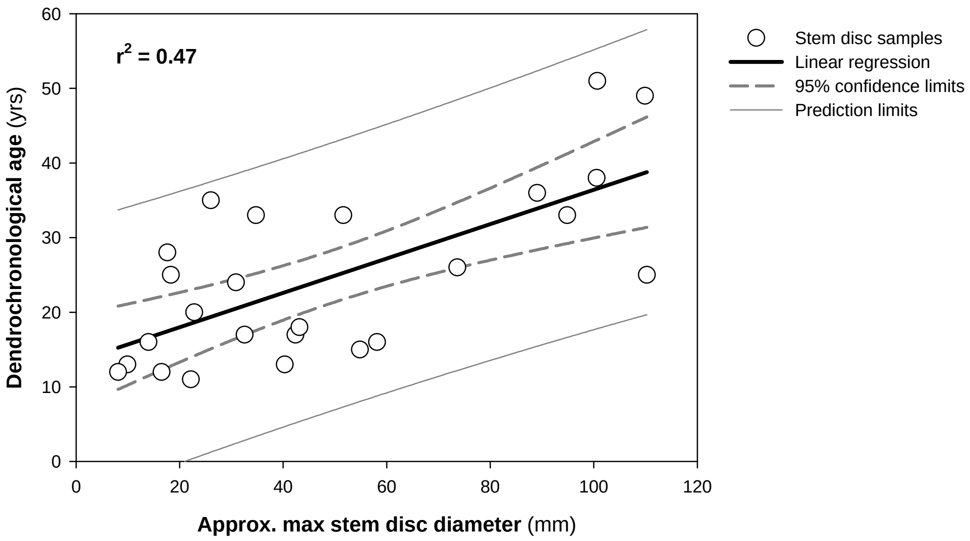


Fig. 11 The relationship between the estimated maximum stem diameter (mm) and actual dendrochronological age ($F_{d.f.=1,23}$= 20.167, p<0.001). Note that many points lie outside the 95% confidence limits and that the predicted limits are notably wide.

Associated vegetation

Juniper occurred on sites with no fewer than 21 distinct habitat types determined using Fossitt (2000) criteria (Table 10). In the majority of cases each site was associated with only one habitat type, however, in some cases (usually large sites) a second, third or fourth habitat type was also recorded.

Overall, there were five main Fossitt (2000) habitat types associated with juniper (Fig. 12):

1. Dry calcareous and neutral grassland (GS1)
2. Exposed calcareous rock (ER2)
3. Dry siliceous heath (HH1)
4. Exposed siliceous rock (ER1)
5. Dry calcareous heath (HH2)

Table 10 Frequency of Fossitt (2000) habitat types at sites where juniper was surveyed (n=103). Note that some sites have multiple habitats present.

Fossitt code	Description	No. of sites (%)				
		Primary habitat type	Secondary habitat type	Third habitat type	Fourth habitat type	Total
GS1	**Dry calcareous and neutral grassland**	19 (18.4)	12 (23.5)	1 (25.0)		**32 (20.0)**
ER2	**Exposed calcareous rock**	22 (21.4)	5 (9.8)			**27 (16.9)**
HH1	**Dry siliceous heath**	14 (13.6)	3 (5.9)	2 (50.0)		**19 (11.9)**
ER1	**Exposed siliceous rock**	13 (12.6)	5 (9.8)			**18 (11.3)**
HH2	**Dry calcareous heath**	7 (6.8)	5 (9.8)	1 (25.0)		**13 (8.1)**
GS4	Wet grassland	3 (2.9)	5 (9.8)			8 (5.0)
HH3	Wet heath		6 (11.8)		2 (100)	8 (5.0)
GS3	Dry-humid acid grassland	4 (3.9)	3 (5.9)			7 (4.4)
PF1	Rich fen and flush	4 (3.9)	1 (2.0)			5 (3.1)
CD2	Marram dunes	4 (3.9)				4 (2.5)
CD6	Machair	1 (1.0)	2 (3.9)			3 (1.9)
GA1	Improved agricultural grassland		3 (5.9)			3 (1.9)
CD3	Fixed dunes	2 (1.9)				2 (1.3)
CS1	Rocky sea cliffs	2 (1.9)				2 (1.3)
GS2	Dry meadows and grassy verges	2 (1.9)				2 (1.3)
WS1	Scrub	1 (1.0)	1 (2.0)			2 (1.3)
GM1	Marsh	1 (1.0)				1 (0.6)
ED4	Active quarries and mines	1 (1.0)				1 (0.6)
ED2	Spoil and bare ground	1 (1.0)				1 (0.6)
ED3	Recolonising bare ground	1 (1.0)				1 (0.6)
BL3	Buildings and artificial structures	1 (1.0)				1 (0.6)
	Total	**103** (100)	**51** (100)	**4** (100)	**2** (100)	**160** (100)

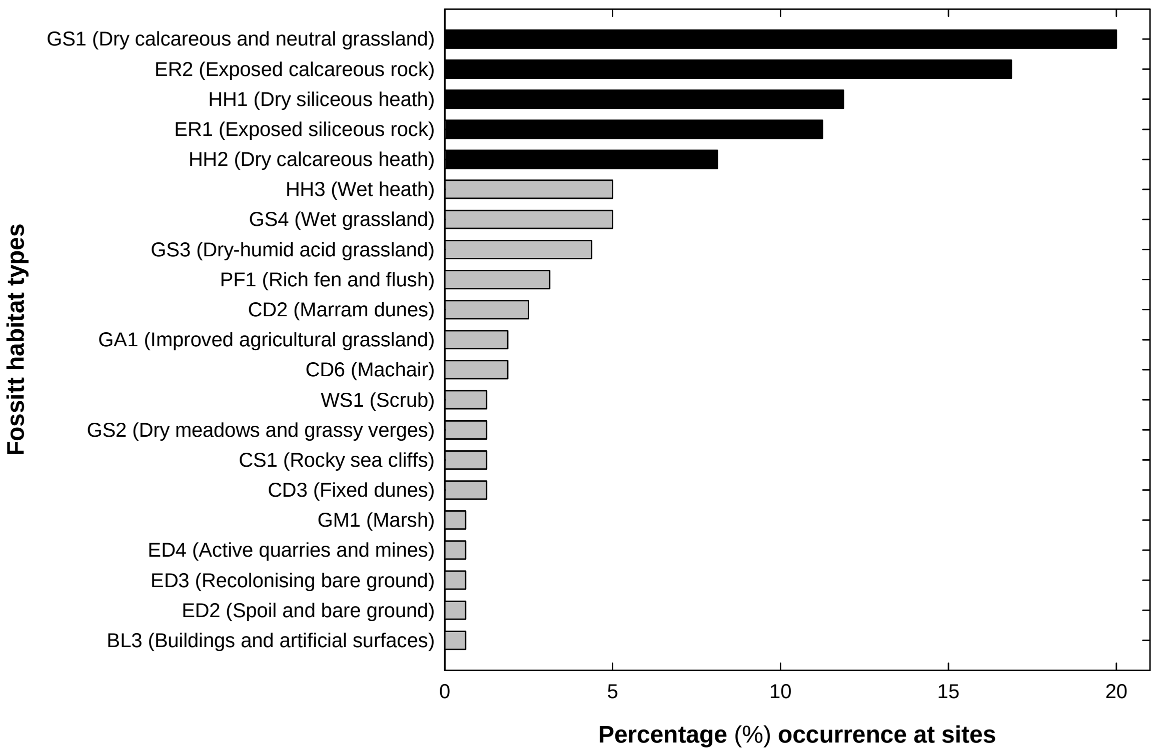


Fig. 12 Overall frequency of Fossitt (2000) habitat types listed in descending rank order.

3.3 Relevé survey

A total of 194 relevés containing a total of 235 plant species from 98 sites were recorded. After rigorous data preparation (see Section 2.3.1, pages 21-22), a total of 193 relevés containing a total of 127 plant species from 97 sites remained for analysis. Prior to analyses traditional Domin scores were converted to mean percentage cover values using the 'Domin 2.6' conversion method (Currall, 1987).

A total of 37 out of 193 relevés (19%) had no pH values as measured in the field as they fell on limestone pavement or expanses of bare rock that could not be sampled. The 156 relevés (81%) which possessed pH values exhibited a strong positive relationship with the mean Ellenberg reaction scores for each relevé as calculated from area-weighted means from plant species coverage data ($F_{d.f.=1,154}$= 295.734, p<0.0001; Fig. 13). Thus, the missing pH values were interpolated using the formula for the line $y = (1.0608 * x) + 2.0222$) where x equalled the mean Ellenberg reaction score and y equalled the predicted pH value.

Aspect was recoded onto a an index of exposure where north = 0, north-west and north-east = 0.25, east, west and flat areas = 0.5, south-east and south-west = 0.75 and south = 1.

The utility of an index of exposure was demonstrated by its strong positive relationship with the mean Ellenberg light scores for each relevé ($F_{d.f.=1,3}$= 12.918, p=0.037; Fig. 14).

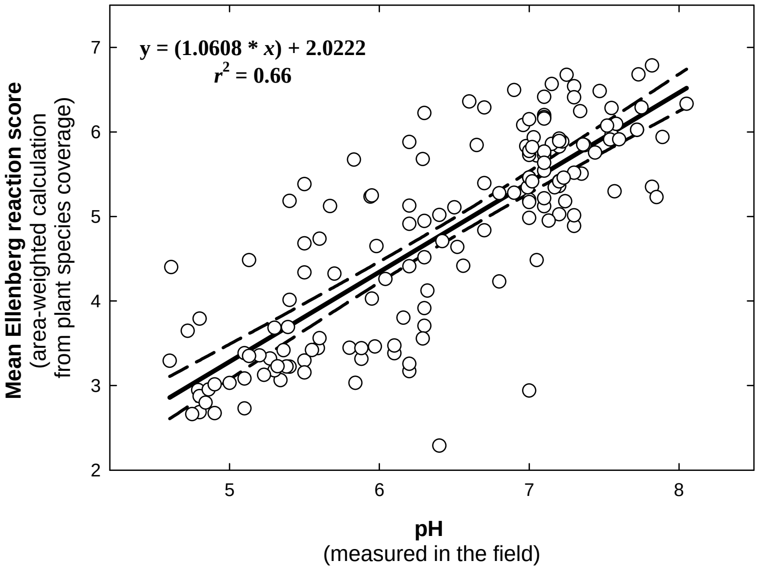


Fig. 13 The relationship between pH values (measured in the field) and mean Ellenberg reaction scores per relevé provided a means by which interpolate missing pH values for relevés which fell on limestone pavement.

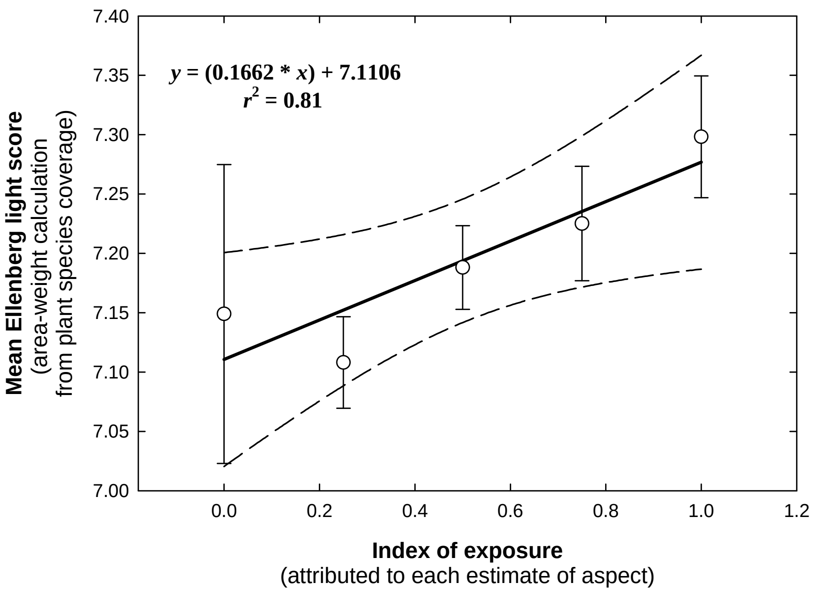


Fig. 14 Mean Ellenberg light scores ± s.e. for relevés were aspect was recoded into a continuous scalar index of exposure.

3.3.1 Vegetation Analysis

Outlier Analysis resulted in the removal of 2 outlying relevés (TP04DRM1 and TP04DRM2). These were located at a single site at Dromineer, Co. Tipperary and were located on a narrow strip of verge between Lough Derg and a roadside. Consequently, they were not typical juniper habitat and were identified by the analysis as sufficiently unusual to remove. Thus, a total of 191 relevés containing a total of 127 plant species from 96 sites remained for analysis.

Indicator Species Analysis within each grouping obtained from Hierarchical Cluster Analysis (ranging from 2 groups to 10 groups) indicated that 5 groups provided optimum discrimination based on the sum of the Indicator Values for all species and their mean *p* values (Fig. 15). A multi-response permutation procedure (MRPP) supported the significant differentiation of the five groups based on 19 environmental variables (A = 0.11, p<0.0001). Non-metric multidimensional scaling (NMS) ordination was initially used to assess a 3-dimensional solution but a 2-dimensional solution provided the clearest separation of the five groups (Fig. 16). Axis 1 (r^2 = 0.265) was positively correlated with pH and negatively correlated with Ellenberg moisture scores and the presence of non-calcareous parent materials and bedrock (RcKNCa). Axis 2 (r^2 = 0.273) was positively correlated with exposed bare rock and calcareous parent materials and bedrock (RcKCa) and negatively associated with Ellenberg light scores (Table 11). Taken together, both axes accounted for 53.8% of variance in dissimilarity with stress minimised at 28.2%.

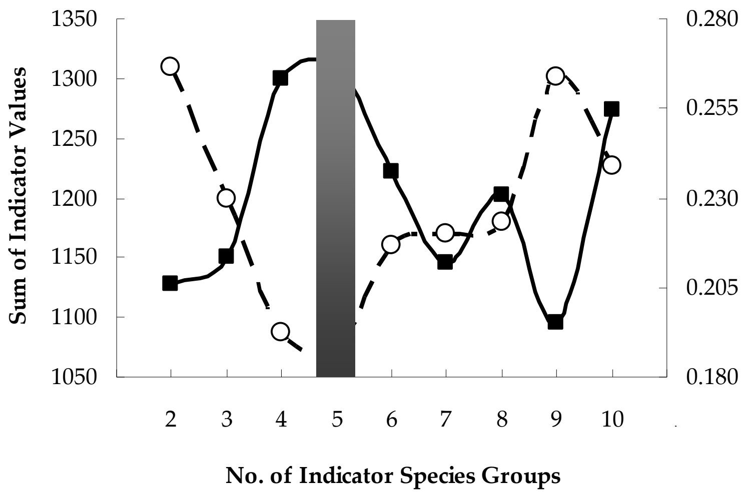


Fig. 15 Variation in the sum of Indicator Values (closed squares) determined by Indicator Species Analysis (ISA) and their mean p values (open circles) for each number of putative groups derived from hierarchical cluster analysis. Five groupings (grey shading) provided the optimum discrimination between indicator species.

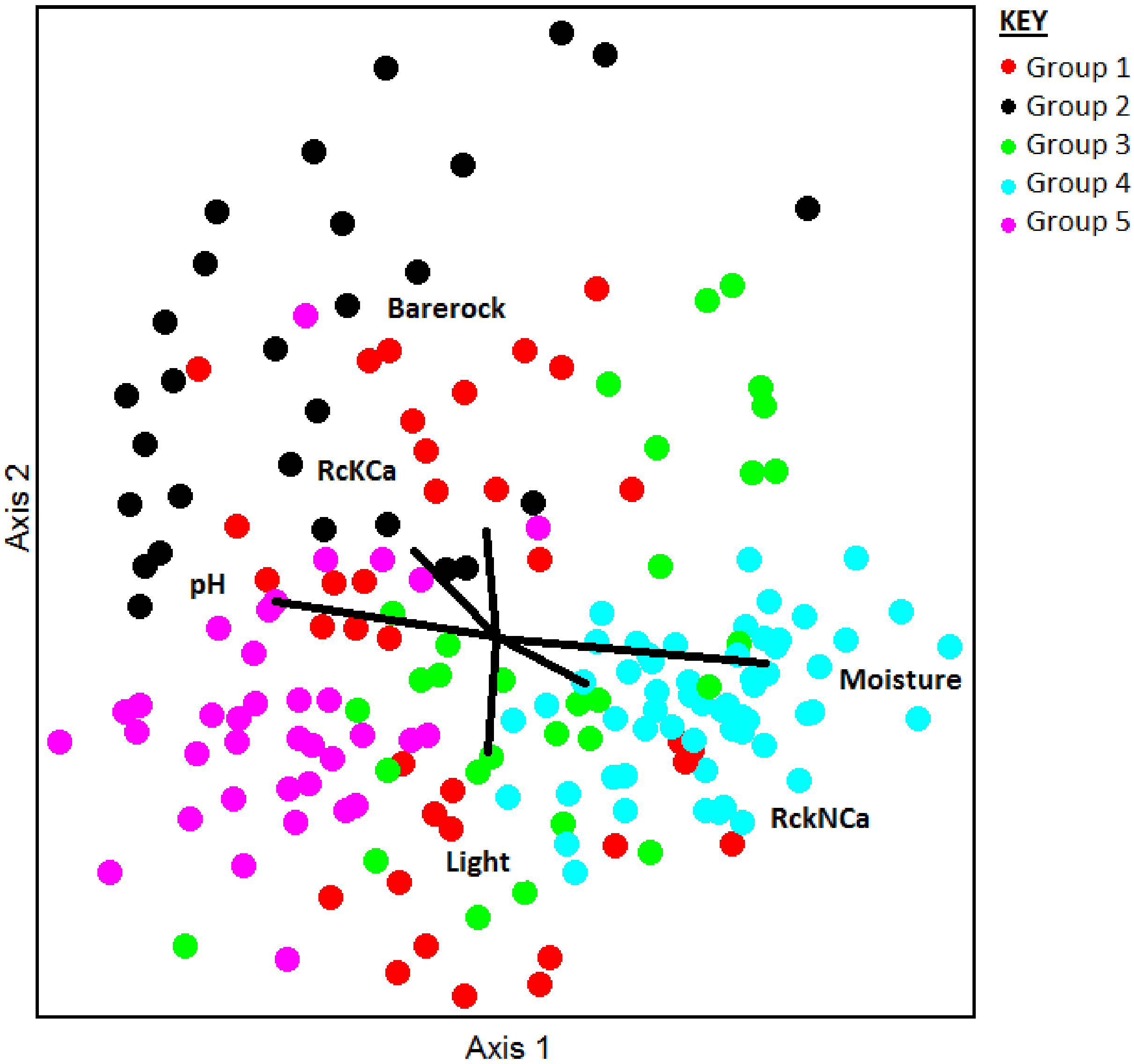


Fig. 16 Non-metric multidimensional scaling ordination biplot showing five groups of 191 relevés separated along two environmental axes with the direction of the bold black lines showing correlations and their relative length indicating the strength of each relationship. Moisture and Light were mean Ellenberg scores and RcKCa and RcKNCa were both presence and absence of calcareous and non-calcareous parent material and bedrock respectively.

Table 11 Correlation coefficients between Axes 1 and 2 and environmental variables determined by non-metric multidimensional scaling (NMS) analysis using five groups of indicator species.

Environmental variables	Axis 1		Axis 2	
	r	r^2	r	r^2
Altitude	0.199	0.039	0.079	0.006
Slope	0.015	0.000	-0.148	0.022
Exposure	0.111	0.012	-0.098	0.010
pH	**-0.679**	0.461	0.272	0.074
Moisture	**0.748**	0.559	-0.231	0.053
Nitrogen	-0.308	0.095	0.257	0.066
Salinity	-0.359	0.129	-0.114	0.013
Light	-0.136	0.019	-0.490	0.240
Bare soil	0.103	0.011	0.061	0.004
Bare rock	-0.149	0.022	**0.473**	0.224
RcKCa	-0.407	0.166	**0.415**	0.172
RcKNCa	**0.428**	0.183	-0.299	0.089

Three discrete groups (Groups 2, 4 and 5) separated out neatly along both environmental axes whilst two groups (Groups 1 and 3) were relatively poorly differentiated being largely central and widely dispersed on both axes (Fig. 16). Juniper was present in all relevés and significant positive indicators for each habitat group and mean values for key environmental variables are listed in Tables 12-16.

Group 1 Wet grassland, heath or bog

***Carex flacca* – *Succisa pratensis* group** (Table 12)

This group was poorly defined on the ordination plot and possessed a diverse community characterised by upland, basic species (e.g. *Dryas octopetala*) but also moisture dependent species (e.g. *Schoemus nigricans* and *Juncus articulatus*). The group did not correspond closely to any one Fossitt (2000) habitat. An example of this group was found at Ballybornagh (site code CE06), Co. Clare which was a mixed grassland site on limestone pavement with neutral to high pH. In addition, an alkaline fen at Carney Commons (site code TP01), Co. Tipperary was also included in this group.

Group 2 Exposed calcareous rock aka limestone pavement

***Teucrium scorodonia* – *Geranium sanguineum* group** (Table 13)

A well-defined group on the ordination plot directly equating to the Fossitt (2000) ER2 (exposed calcareous rock) habitat, otherwise known as limestone pavement. However, none of the positive indicators listed here were included by Fossitt as indicators yet all four significant indicators occurred frequently in relevés in The Burren, Co. Clare and areas close to Lough Corrib, Co. Galway accurately reflecting the known distribution of limestone pavement (Fig. 17).

Group 3 Dry calcareous heath and grassland (associated with succession)

***Lotus corniculatus - Trifolium pratensis* group** (Table 14)

This group was poorly defined on the ordination plot dominated by legumes but directly equated to the Fossitt (2000) HH2 (dry calcareous heath) with elements of GS1 (dry calcareous or neutral grassland). The presence of common ash (*Fraxinus excelsior*) may suggest ecological succession.

Group 4 Dry siliceous heath and raised bog

***Calluna vulgaris – Erica cinerea* group** (Table 15)

A well-defined group on the ordination plot directly equating to the Fossitt (2000) HH1 (dry siliceous heath) habitat characterised by nutrient-poor, low pH, well-drained soils. Key sites in this group included Fanad A and B (site codes DL05 and DL06) and Melmore Head (site code DL31), Co. Donegal and Dawros More (site code GY24, Galway).

Group 5 Dry calcareous or neutral grassland including coastal dune grassland

***Galium verum – Pilosella offcinarum* group** (Table 16)

A well-defined group on the ordination plot directly equating to the Fossitt (2000) GS1 (dry calcareous or neutral grassland) habitat characterised by nutrient rich, high pH, well-drained soils. Typical examples of this group were found at Illaunavee (site code GY04) and Cloghboley B (site code GY10), Co. Galway or Cloughmoyne (site code MO06), Co. Mayo. However, the group also contained elements of the CD3 (fixed dune) including the presence of *Ammophila arenaria* and *Jasione montana,* for example, the mixed site found at Rosses Point (site code SO01), Co. Sligo.

Table 12 Floristic table for **Group 1** with significant indicator species listed in descending order of Indicator Values (IV) as defined by Indicator Species Analysis with mean values for key environmental variables listed below. For further explanation see Perrin *et al*. (2008).

	Frequency (% relevés)	**Abundance** (% coverage)	**Domin score**	**IV**	***p***
Group 1 - *Carex flacca - Succisa pratensis* group					
Carex flacca	78	43	7	33.4	0.01
Succisa pratensis	67	31	6	20.9	0.01
Carex nigra	33	61	8	20.3	0.01
Dryas octopetala	19	98	10	19.1	0.01
Pedicularis palustris	17	88	9	14.6	0.02
Cynosurus cristatus	28	51	8	14.2	0.01
Dachtylorhiza maculata	19	73	8	14.1	0.01
Juncus articulatus	14	100	10	13.9	0.01
Anagallis tenella	14	97	10	13.5	0.01
Schoenus nigricans	17	73	8	12.2	0.01
Prunella vulgaris	11	99	10	11.0	0.01
Carex viridula	8	99	10	8.2	0.01
Agrostis stolonifera	14	56	8	7.8	0.04

Other key metrics		**Topography**	
Species richness (#)	15.5 ± 5.6	Altitude	61.4 ± 79.7
Sward (cm)	30.3 ± 19.8	Slope (°)	1.0 ± 3.3
pH	6.9 ± 0.9		
		Parent material (%)	
Ellenberg scores		Bare rock	21.8 ± 31.6
Moisture	5.8 ± 0.7	RcKCa	38.9 ± 49.4
Nitrogen	2.8 ± 0.6	RcKNCa	13.9 ± 35.1
Light	7.3 ± 0.2		
Salinity	0.2 ± 0.2		

Frequency = % frequency occurrence at relevés within the group
Abundance = % coverage (as associated with the Domin score) within relevés
Domin scores are indicative of abundance values.
Mean values for environmental variables are ± 1 standard deviation (SD)
Species richness excluded negative indicators (invasive non-native species and problematic native species)
n = 36 relevés

Table 13 Floristic table for **Group 2** with significant indicator species listed in descending order of Indicator Values (IV) as defined by Species Indicator Analysis with mean values for key environmental variables listed below. For further explanation see Perrin *et al*. (2008).

	Frequency (% relevés)	Abundance (% coverage)	Domin score	IV	*p*
Group 2 - *Teucrium scorodonia - Geranium sanguineum* group					
Teucrium scorodonia	55	56	8	31.0	0.01
Geranium sanguineum	31	57	8	17.8	0.01
Mycelis muralis	14	100	10	13.8	0.01
Geranium robertianum	21	42	7	8.6	0.04
Other key metrics			**Topography**		
Species richness (#)	10.1 ± 4.7		Altitude (m)	32.1 ± 26.3	
Sward (cm)	19.3 ± 10.4		Slope (°)	5.9 ± 20.0	
pH	7.3 ± 0.9				
			Parent material (%)		
Ellenberg scores			Bare rock	64.3 ± 35.6	
Moisture	4.9 ± 0.5		RcKCa	75.9 ± 43.5	
Nitrogen	3.2 ± 0.9		RcKNCa	10.3 ± 31.0	
Light	6.9 ± 0.6				
Salinity	0.2 ± 0.2				

Frequency = % frequency occurrence at relevés within the group
Abundance = % coverage (as associated with the Domin score) within relevés
Domin scores are indicative of abundance values.
Mean values for environmental variables are ± 1 standard deviation (SD)
Species richness excluded negative indicators (invasive non-native species and problematic native species)
n = 29 relevés

Table 14 Floristic table for **Group 3** with significant indicator species listed in descending order of Indicator Values (IV) as defined by Species Indicator Analysis with mean values for key environmental variables listed below. For further explanation see Perrin *et al*. (2008).

	Frequency (% relevés)	**Abundance** (% coverage)	**Domin score**	**IV**	***p***
Group 3 - *Lotus corniculatus - Trifolium pratensis* group					
Lotus corniculatus	58	39	7	22.9	0.04
Trifolium pratensis	29	53	8	15.3	0.02
Viola riviniana	29	48	7	13.8	0.04
Fraxinus excelsior	16	83	9	13.5	0.01
Polygala vulgaris	19	69	8	13.3	0.05

Other key metrics		**Topography**	
Species richness (#)	10.9 ± 4.9	Altitude (m)	34.9 ± 42.1
Sward (cm)	35.9 ± 29.2	Slope (°)	13.4 ± 25.4
pH	6.8 ± 0.8		
		Parent material (%)	
Ellenberg scores		Bare rock	22.9 ± 30.8
Moisture	5.3 ± 0.3	RcKCa	45.2 ± 50.6
Nitrogen	3.4 ± 0.6	RcKNCa	29 ± 46.1
Light	7.2 ± 0.5		
Salinity	0.3 ± 0.4		

Frequency = % frequency occurrence at relevés within the group
Abundance = % coverage (as associated with the Domin score) within relevés
Domin scores are indicative of abundance values.
Mean values for environmental variables are ± 1 standard deviation (SD)
Species richness excluded negative indicators (invasive non-native species and problematic native species)
n = 31 relevés

Table 15 Floristic table for **Group 4** with significant indicator species listed in descending order of Indicator Values (IV) as defined by Species Indicator Analysis with mean values for key environmental variables listed below. For further explanation see Perrin *et al*. (2008).

	Frequency (% relevés)	**Abundance** (% coverage)	**Domin score**	**IV**	***p***
Group 4 - *Calluna vulgaris - Erica cinerea* group					
Calluna vulgaris	100	69	8	69.0	0.01
Erica cinerea	83	59	8	49.1	0.01
Potentilla erecta	84	35	7	29.6	0.01
Anthoxanthum odoratum	55	44	7	24.5	0.01
Carex panicea	36	63	8	22.8	0.01
Molinia caerulea	53	41	7	22.0	0.01
Carex binervis	21	100	10	20.7	0.01
Erica tetralix	31	59	8	18.2	0.01
Danthonia decumbens	33	46	7	15.1	0.02
Polygala serpyllifolia	16	93	9	14.4	0.01
Empetrum nigrum	22	63	8	14.2	0.01
Luzula multiflora	24	56	8	13.6	0.03
Nardus stricta	12	100	10	12.1	0.01
Agrostis canina	19	57	8	10.8	0.03
Narthecium ossifragum	10	92	9	9.6	0.05
Eriophorum angustifolium	7	100	10	6.9	0.04

Other key metrics		**Topography**	
Species richness (#)	12.1 ± 5.1	Altitude (m)	58.9 ± 90.2
Sward (cm)	32.1 ± 16.0	Slope (°)	14.9 ± 19.0
pH	5.6 ± 0.7		
		Parent material (%)	
Ellenberg scores		Bare rock	14.2 ± 24.1
Moisture	6.1 ± 0.5	RcKCa	0.0 ± 0.0
Nitrogen	2.4 ± 0.4	RcKNCa	79.3 ± 40.9
Light	7.2 ± 0.2		
Salinity	0.1 ± 0.1		

Frequency = % frequency occurrence at relevés within the group
Abundance = % coverage (as associated with the Domin score) within relevés
Domin scores are indicative of abundance values.
Mean values for environmental variables are ± 1 standard deviation (SD)
Species richness excluded negative indicators (invasive non-native species and problematic native species)
n = 58 relevés

Table 16 Floristic table for **Group 5** with significant indicator species listed in descending order of Indicator Values (IV) as defined by Species Indicator Analysis with mean values for key environmental variables listed below. For further explanation see Perrin *et al*. (20086).

	Frequency (% relevés)	**Abundance** (% coverage)	**Domin score**	**IV**	***p***
Group 5 - *Galium verum - Pilosella officinarum* group					
Galium verum	65	88	9	56.8	0.01
Pilosella officinarum	54	89	9	48.0	0.01
Thymus polytrichus	86	52	8	44.9	0.01
Ammophila arenaria	35	100	10	35.1	0.01
Daucus carota	41	75	9	30.4	0.01
Anthyllis vulneraria	51	57	8	29.1	0.01
Koeleria macrantha	38	70	8	26.6	0.01
Campanula rotundifolia	32	78	8	25.2	0.01
Festuca rubra	68	36	7	24.1	0.01
Plantago lanceolata	70	34	7	24.1	0.01
Senecio jacobea	27	88	9	23.9	0.01
Arrentherum elatius	22	95	10	20.6	0.01
Hypochaeris radicata	51	35	7	18.2	0.03
Linum catharticum	43	42	7	18.1	0.01
Holcus lanatus	46	37	7	17.2	0.01
Ranunculus bulbosus	19	90	9	17.0	0.01
Briza media	30	52	8	15.6	0.03
Trifolium repens	30	49	7	14.6	0.02
Dactylis glomerata	22	67	8	14.5	0.01
Polygala vulgaris	27	50	8	13.6	0.03
Carex arenaria	14	96	10	12.9	0.01
Hypericum perforatum	24	45	7	11.1	0.04
Jasione montana	14	76	9	10.3	0.01
Anacamptis pyramidalis	8	97	10	7.8	0.04
Plantago coronopus	8	91	9	7.4	0.04

Other key metrics		**Topography**	
Species richness (#)	18.0 ± 4.9	Altitude (m)	28.8 ± 53.2
Sward (cm)	38.0 ± 22.2	Slope (°)	19.5 ± 29.9
pH	7.4 ± 0.5		
		Parent material (%)	
Ellenberg scores		Bare rock	5.5 ± 12.5
Moisture	4.8 ± 0.3	RcKCa	27.0 ± 45.0
Nitrogen	3.1 ± 0.5	RcKNCa	32.4 ± 47.5
Light	7.5 ± 0.2		
Salinity	0.3 ± 0.2		

Frequency = % frequency occurrence at relevés within the group
Abundance = % coverage (as associated with the Domin score) within relevés
Domin scores are indicative of abundance values.
Mean values for environmental variables are ± 1 standard deviation (SD)
Species richness excluded negative indicators (invasive non-native species and problematic native species)
n = 37 relevés

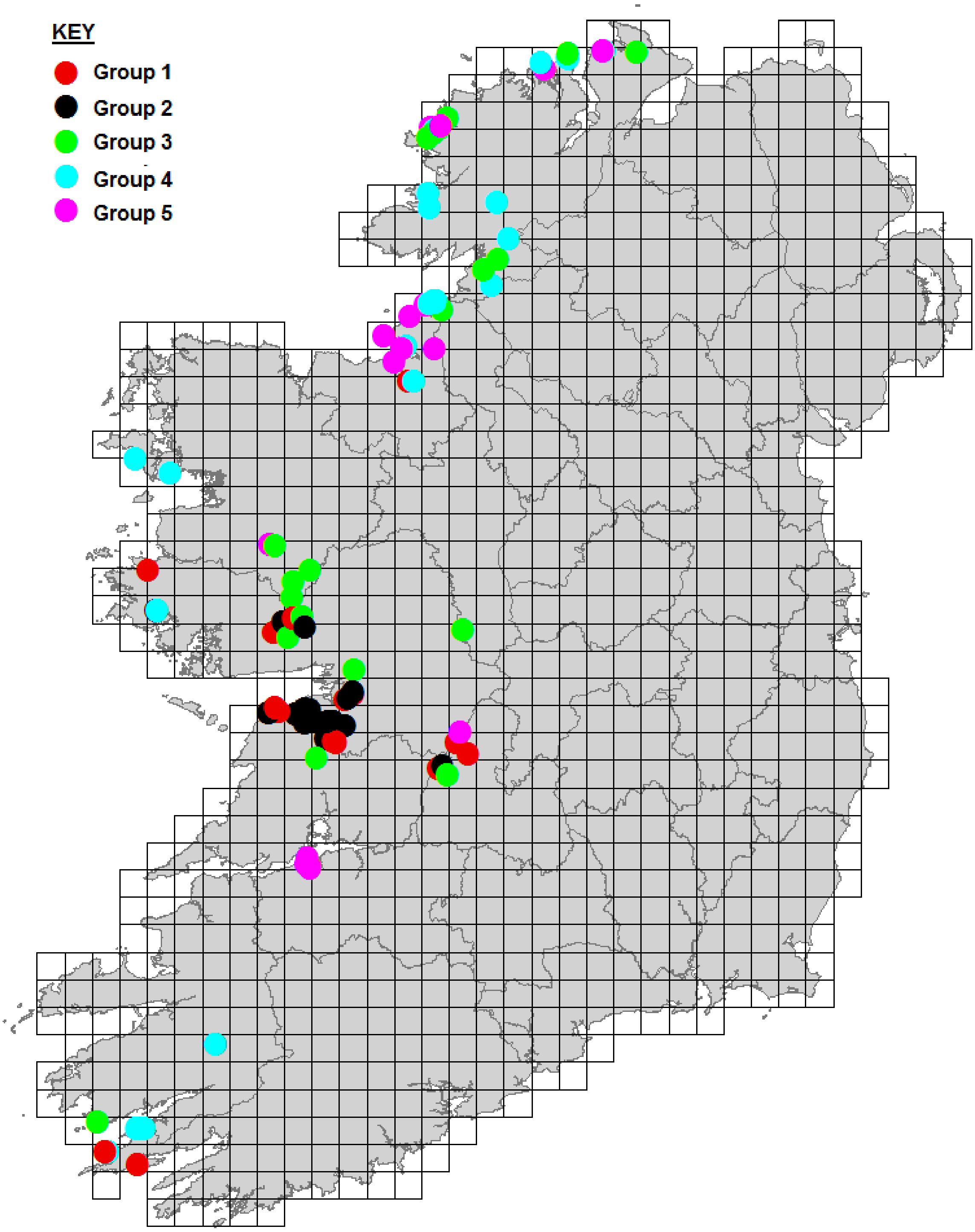


Fig. 17 Distribution of each habitat type (Groups 1-5) as defined by Cluster Analysis. For example, Group 2 (exposed calcareous rock aka limestone pavement) was accurately restricted to the habitats known distribution in The Burren, Co. Clare and areas near Lough Corrib, Co. Galway.

Structural data

There was no statistical differences in the mean area of sites between habitat types ($F_{d.f.=4,92}$=0.917 p=0.458) due to overlapping standard errors for most groups. Nevetheless, sites in Group 1 and 3 were generally smaller than sites in Groups 2 and 5 whilst sites in Group 4 were generally larger but had a high degree of variance (Fig. 18a). Population numbers were generally similar between habitat types ($F_{d.f.=4,92}$=0.685 p=0.604) but Group 3 had densities generally lower than in any other habitats (Fig. 18b). Shrub density also did not vary between the groups ($F_{d.f.=4,92}$=0.606 p=0.659) but the large numbers of individual shrubs scattered throughout The Burren, Co. Clare resulted in Group 2 having a typically lower density of plants per unit area (Fig. 18c).

Sub-species *communis* generally dominated Groups 1, 2 and 3 while sub-species *nana* dominated Groups 4 and 5 (Fig. 18d).

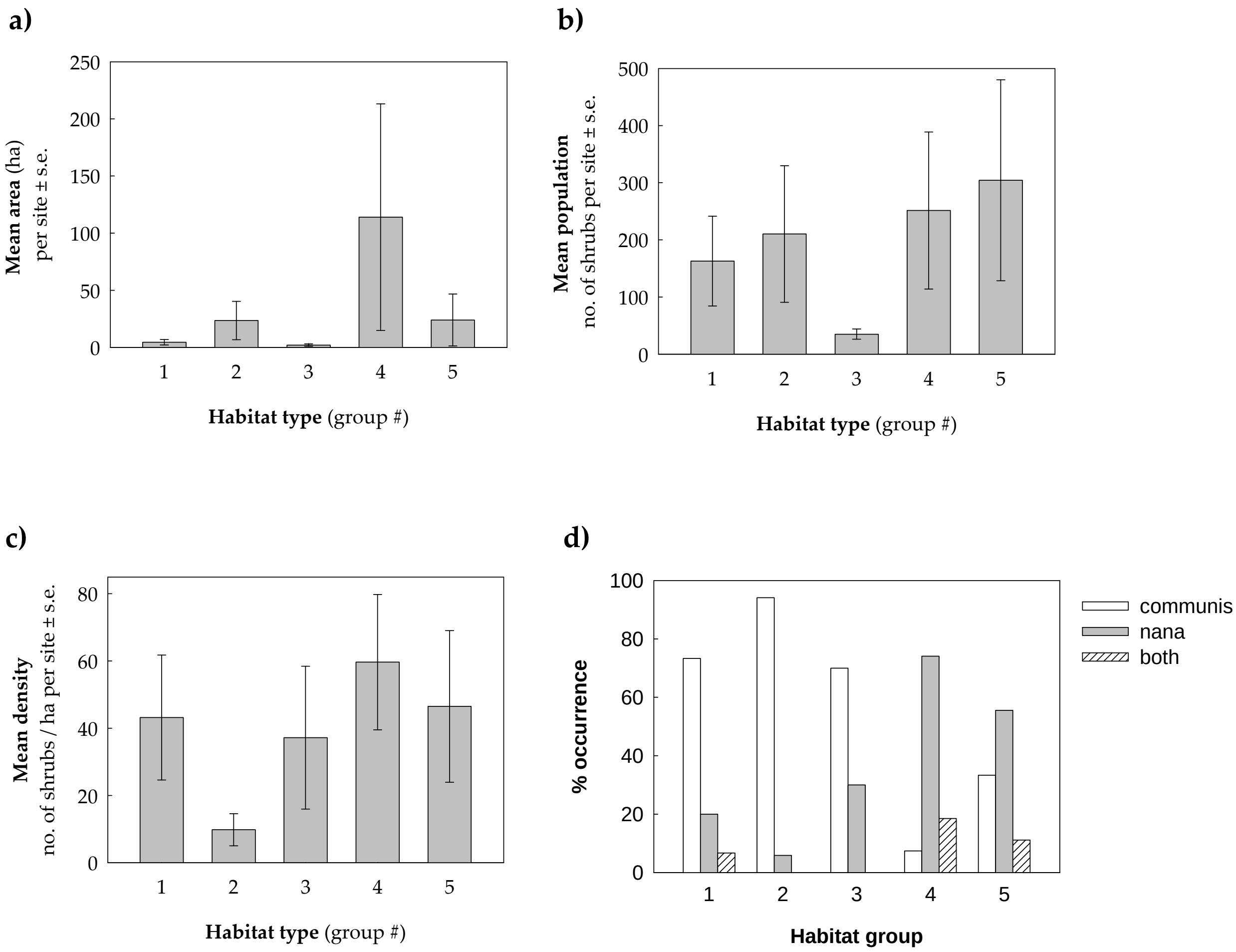


Fig. 18 Mean **a)** area, **b)** population size, **c)** shrub density and **d)** percentage occurrence of sub-species per site within each habitat group defined by Cluster Analysis.

There was no difference in the percentage of shrubs bearing cones between the habitat types (Fig. 19a), but Group 2 (limestone pavement) was notable in having the lowest levels of recruitment (i.e. % seedlings; Fig. 19b). This may be that it was more difficult to locate small seedlings between the crevices in limestone pavement and the fact that large expanses of bare rock cannot support seedling recruitment. Groups 1 and 5 had higher species richness than Groups 2, 3 and 4 values (Fig. 19c).

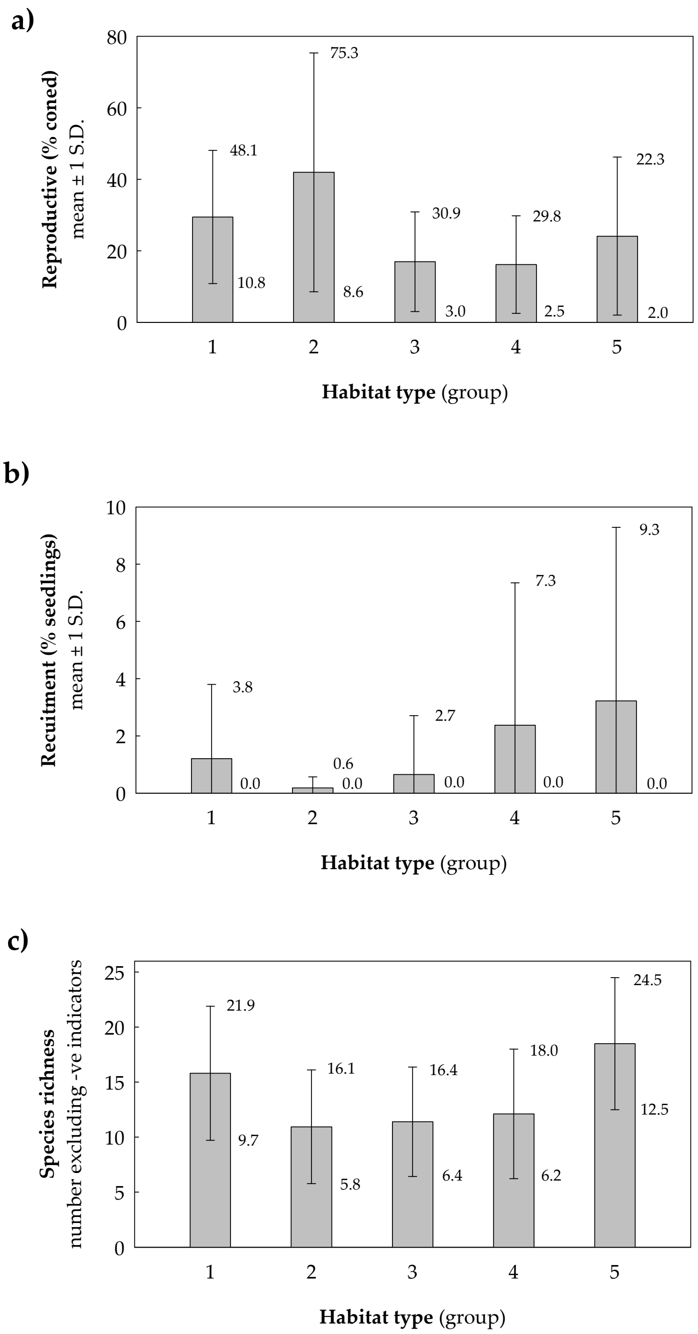


Fig. 19 Mean **a)** reproductive (% coned), **b)** recruitment (% seedlings), and **c)** species richness showing the values for the mean + 1SD (these are used later for conservation assessments).

Impacts and threats

The majority of sites surveyed showed some sign of negative impact or threat. In total, 28 separate threats were listed, five of which were notably prevalent (Table 17). 'Intensive sheep grazing' was typical in upland areas, however, 'non-intensive mixed animal grazing', usually sheep and cattle was also common. Invasive non-native species and problematic native species were listed as negative indicators (Table 18). Invasive non-native species did not represent a significant threat but problematic native species negatively impacted upon many sites (Table 17). Bracken (Pteridium aquilinum) was widespread (occurring at 20.4% of sites) with a mean coverage of 9.6% of relevés surveyed but often covered large areas at some sites out-competing juniper and shading younger shrubs, perhaps reducing the chances of successful recruitment. Grazing by naturally occurring herbivores, notably rabbits and to a lesser extent hares, was also noted on a substantial number of sites. Trampling and overuse of some sites by walkers and ramblers, at times resulting in soil erosion on higher ground, was a problem at a minority of sites.

Table 17 Threats to juniper formations with their respective EU impact and threat codes

Threat code	Description	# sites	% occurrence	x̄ intensity score	x̄ area affected (%)
A03.01	Intensive mowing or intensification	4	3.9	-2.0	100.0
A03.02	Non-intensive mowing	1	1.0	-2.0	100.0
A04.01.01	Intensive cattle grazing	2	1.9	-2.5	100.0
A04.01.02	**Intensive sheep grazing**	31	**30.1**	-2.0	71.9
A04.01.03	Intensive horse grazing	1	1.0	-3.0	50.0
A04.01.05	Intensive mixed animal grazing	6	5.8	-2.3	100.0
A04.02.01	Non-intensive cattle grazing	5	4.9	-1.8	100.0
A04.02.02	Non-intensive sheep grazing	1	1.0	-2.0	100.0
A04.02.04	Non-intensive horse grazing	2	1.9	-1.5	100.0
A04.02.05	**Non-intensive mixed animal grazing**	15	**14.6**	-1.7	90.7
A04.03	Abandonment of pastoral systems, lack of grazing	6	5.8	-1.5	91.7
A11	Agricultural activities not referred to above	1	1.0	-1.0	10.0
C01	Mining and quarrying	5	4.9	-1.8	90.0
D01.01	Paths, tracks and cycling tracks	1	1.0	-3.0	25.0
D03.01.01	Slipways	1	1.0	-2.0	100.0
E01.03	Dispersed habitation	5	4.9	-2.4	82.4
E02.01	Factory	4	3.9	-2.0	100.0
E03.01	Disposal of household waste	1	1.0	-1.0	5.0
E04.01	Agricultural structures, building in the landscape	1	1.0	-2.0	10.0
G05.01	**Trampling, overuse**	13	**12.6**	-1.8	84.2
I01	Invasive non-native species	7	6.8	-1.6	46.1
I02	**Problematic native species**	26	**25.2**	-1.7	51.7
J01.01	Burning	4	3.9	-1.3	8.8
K01.01	Erosion	4	3.9	-2.5	100.0
K01.03	Drying out	3	2.9	-1.0	76.7
K04.01	Competition (flora)	1	1.0	-3.0	100.0
K04.05	**Damage by herbivores (natural)**	24	**23.3**	-1.1	97.9
M01.03	Flooding and rising precipitation	4	3.9	-2.0	92.5

Table 18 List of negative indicator species.

EU code	Impact or threat	Species
I01	Invasive non-native species	*Cotoneaster integrifolius* *Rhododendron ponticum*
I02	Problematic native species	*Corylus avellana* *Molinia caerulea* *Pteridium aquilinum* *Rubus fruticosus*

The overall *impact and threat* score per site (intensity multiplied by the proportion of the site affected) of each of the five most prevalent threats varied between habitat types (Fig. 20a-e) as did the overall score (Fig. 20f).

Grazing (both A04.01 non-intensive and A04.02 intensive) was of particular interest (Figs. 20g & h) most notably with respect to recruitment. A Generalized Linear Model (GLM) of % seedlings suggested that many factors influenced recruitment (Table 19). Large populations (high numbers of shrubs) were strongly associated with seedling prevalence, but seedlings were negatively associated with site area (i.e. large sites had fewer seedlings). Nevertheless, there was a positive interaction between area*population suggesting that it was shrub density that was important (i.e. seedlings were associated with populations at higher densities). Seedlings were also strongly associated with actively reproducing populations (i.e. those with females bearing cones).

Accounting for variance in these factors, recruitment was not affected by levels of non-intensive grazing (A04.01) but was significantly negatively affected by intensive grazing (A04.02) pressure (Fig. 21). This is further demonstrated through a positive relationship with sward height, i.e. seedlings were present at sites with longer swards indicative of lower levels of grazing (Table 19).

Accounting for variance in the levels of non-intensive (A04.01) and intensive grazing (A04.02), recruitment was significantly higher at sites within Groups 4 and 5 and lower in Groups 2 and 3 than Group 1 (Fig. 22).

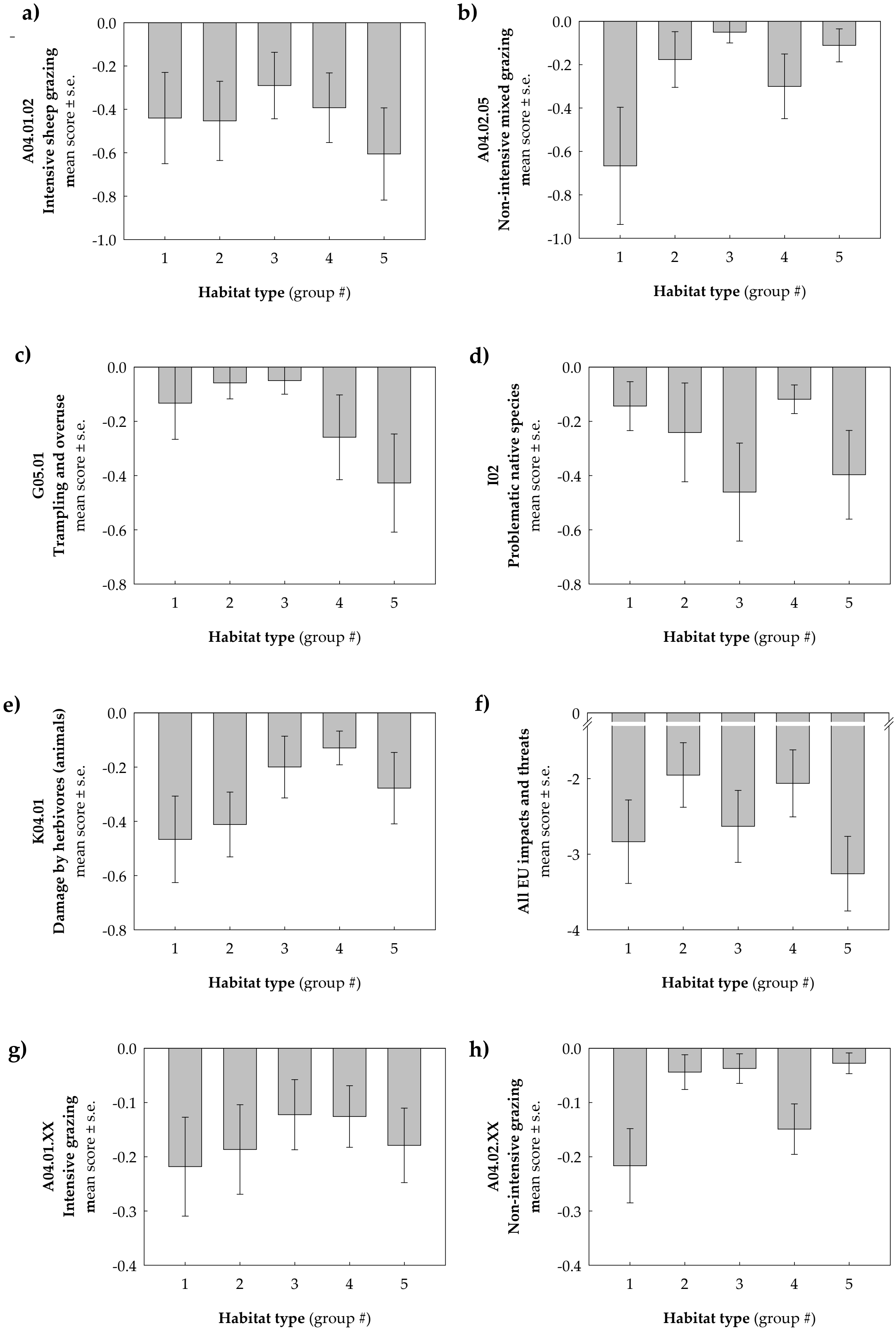


Fig. 20 *Mean impact and threat scores within each habitat type (Group) for the top five most prevalent impacts and threats from Table 17 (a-e) and the mean overall score for all impacts and threats taken together (f). As the principal impact and threat, all intensive and non-intensive grazing categories were collapsed to provide a mean score for each (g-h).*

Table 19 Generalized linear model (GLM) of juniper recruitment (i.e. % seedlings). Beta values are directly comparable as all variables were standardised before analysis.

Explanatory variables	β ± s.e.	χ^2 Wald	df	p
Group	Factor	51.643	4	<0.0001
Sward height	0.509 ± 0.105	23.470	1	<0.0001
% coned	0.581 ± 0.122	22.879	1	<0.0001
Population	0.598 ± 0.152	15.608	1	<0.0001
Area	-3.699 ± 1.599	5.353	1	0.021
Intensive grazing	-0.179 ± 0.079	5.191	1	0.023
Area*population	0.553 ± 0.256	4.662	1	0.031
Non-intensive grazing	-0.066 ± 0.083	0.636	1	0.425

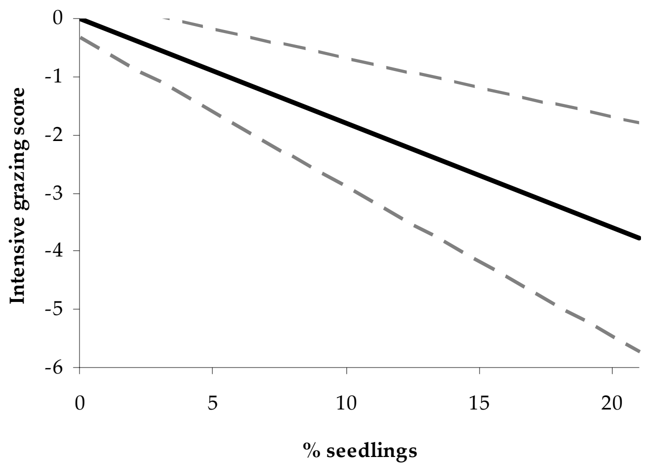


Fig. 21 Linear relationship between active recruitment (i.e. % seedlings) and intensive grazing (EU code A04.01) ± s.e. plotted from the beta value extracted from the Poisson generalized linear model (GLM) presented in Table 19.

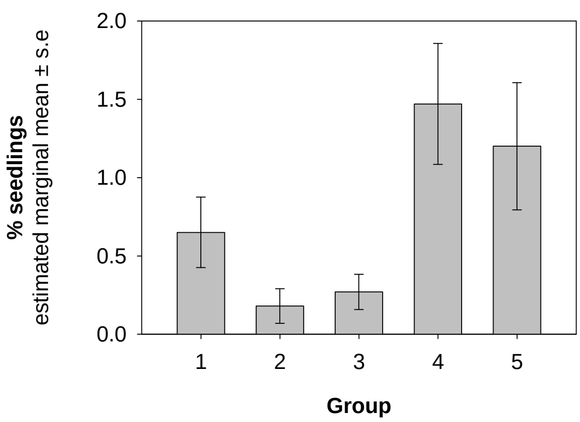


Fig. 22 Estimated marginal mean values for recruitment (i.e. % seedlings) of juniper populations at sites in each habitat (i.e. group) after accounting for variation in population, area, density, sward height and reproduction.

Sward height

Sward height varied significantly between habitat types ($F_{d.f.=4,91}$ = 5.5683, p<0.0001), with *Group 2* (ER2 exposed calcareous rock or limestone pavement) having significantly shorter swards than any other group (Fig. 23).

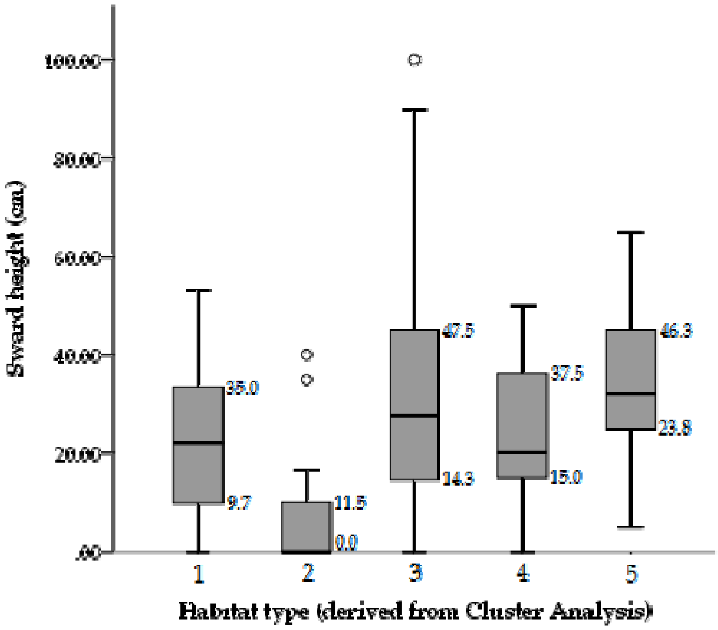


Fig. 23 Boxplot of sward heights within habitat types (Groups) as derived by cluster analysis.

Definition of a J. communis formation

Ideally, a juniper *'formation'* would be considered as any geographically discrete population of individuals with the current or future capacity of reproduction *in situ* (i.e. a mixed sex population showing no signs of inbreeding depression). This would be evaluated using a composite of variables for each site including the number of individuals and their frequency distribution of age and reproduction, specifically the proportion of young shrubs with berries and/or the presence of seedlings. We have demonstrated here that the age of any population is *very* difficult to estimate with any accuracy. The Borders Forest Trust (1997) suggested that a sample of 20-30 individuals is required to retain sufficient genetic diversity within a population. Plantlife's 2004/05 survey of juniper across uplands in Great Britain concluded that populations of fewer than 50 plants were essentially unviable unless there were other juniper populations growing close by (Long & Williams, 2007). Conservation assessments should adopt a methodology which is as simple as possible. This project adopted the general criteria used by Plantlife when defining a formation as "*any one site supporting ≥50 individual shrubs taken as the minimum* *threshold below which isolated groups are unlikely to reproduce in any sufficient numbers to bring about recovery without inbreeding depression being a significant risk*" (Tim Wilkins, Plantlife, *pers. comms*.). Hereafter, sites with ≥50 individual shrubs will be referred to as '*formations*' and those with <50 individual shrubs will be referred to as '*non-formations*'. The national conservation assessment for the habitat is concerned with formations only. However, non-formations may have many of the same attributes as formations (*structure & functions* or *impact & threats*) and may become formations in the future should conditions change and the number of individuals increase to >50 individuals.

According to these criteria, a total of 51 sites (40.8%) from the 125 sites which had juniper present were defined as *formations*. A total of 36 x $10km^2$ Irish grid squares were occupied by formations. The total population within formations was estimated at approximately 20,295 individuals presenting 96% of the total number (i.e. non-formations covered 4% of the total number). The total area covered by formations was 4,726.0 ha ($47.3km^2$) representing 99% of the total coverage of juniper sites (i.e. non-formations covered <1% of the total habitat). A total of 56.5% of formations were perceived to consist of sub-species *communis*, 37.0% were sub-species *nana* and 6.5% were mixed populations with both sub-species.

A total of 74 sites were idenitifed as *non-formations* with most comprising fewer than 10 shrubs and many being isolated individuals.

3.4 Site conservation value

Area and population

Very small sites (<0.01ha) were scored lowest with a conservation value = 0 whilst very large sites (>7.6ha) were scored highest with a conservation value = 4. Remaining sites were divided into statistical quartiles and scored 0, 1, 2 and 3 from lowest to high quartile respectively. An identical approach was taken with population, where very small populations (<10 shrubs) scored lowest with a conservation value = 0 whilst very large populations (<3,500 shrubs) were scored highest with a conservation value = 4. Remaining sites were divided into statistical quartiles and scored 0, 1, 2 and 3 respectively as above. For the overall attribute, the scores for both criteria were combined. Thus, sites that scored 0 out of 8 were assigned a percentage conservation value of 0% and those that were scored 8 out of 8 were assigned a conservation value of 100% (Table 20).

Table 20 Criteria used in the calculation of the area (including population size) element of conservation value scores for each site. See text for explanation.

Attribute	Criteria	Values	Conservation scores	Max. score
Area and population	Area (ha)	<0.01	0 (0%)	
		0.01-0.54	1 (25%)	
		0.55-1.65	2 (50%)	
		1.66-7.55	3 (75%)	
		7.56-2673.74	4 (100%)	100%
	Population (shrubs)	<10	0 (0%)	
		10-40	1 (25%)	
		41-85	2 (50%)	
		86-213	3 (75%)	
		214-3500	4 (100%)	100%
	TOTAL	**N/A**	**8 (100%)**	**100%**

Structure and function

There were a total of 7 criteria for evaluation within this attribute (Table 21). Where multiple relevés were taken at any one site mean values were scored. The percentage of shrubs at any one site that were reproductive (% coned), actively recuiting (% seedlings), the percentage coverage of baresoil within reléves (% baresoil) and the mean percentage of each shrub that was alive (% alive) were scored by giving the lowest value a minimum score of 0% and the highest value a maximum score of 100%. Species richness and the total number of significant indicator species were scored by giving the lowest value in each habitat type a minimum score of 0% and the highest value in each habitat type a maximum score of 100%. Sward height was scored unfavourably (0%) if sward heights were either shorter than the lower (25th) quartile (i.e. at the lowest end of the distribution perhaps due to overgrazing) or longer than the upper (75th) quartile (i.e. at the highest end of the distribution perhaps due to undergrazing) and favourably (100%) if sward heights were within the range of the lower (25th) and upper (75th) quartiles (i.e. in the centre of the distribution and thus typical for that habitat).

Future prospects

Only 1 criterion was evaluated within this attribute. However, it was a composite of the number of impacts and threats present per site, the area of each site affected by each impact or threat and their relative intensities. The area of each site affected was estimated as a proportion of its total area for each impact or threat present. This was then multiplied by the relative intensity of each impact or threat scored as 0 where no impact or threat was present, -1 (relatively minor), -2 (moderate) or -3 (severe). Sites with a value of 0 had no impacts or threats present. It should be noted that whilst the minimum score for the intensity of any one threat was -3, a site with multiple threats which covered large areas of the site resulted in a lower total minimum score (for example, -9.0). Conservation values were attributed with values of 0 scoring 100% and the maximum value (-9.0) scoring 0% (Table 22).

Table 21 Criteria used in the calculation of the structure & functions element of conservation value scores for each site. See text for explanation.

Attribute	Criteria	Values	Conservation score	Max. score
Structure and function	% reproductive (coned)	Min. = 0% (i.e. absent)	0%	
		Max. = 100%	100%	100%
	% recruitment (seedlings)	Min. = 0% (i.e. absent)	0%	
		Max. = 21%	100%	100%
	% baresoil	Min. = 0%	0%	
		Max. = 30%	100%	100%
	% alive	Min. = 0%	0%	
		Max. = 30%	100%	100%
	Species richness (n)	*Group 1*		
		Min. = 10	0%	
		Max. = 33	100%	100%
		Group 2		
		Min. = 3	0%	
		Max. = 20	100%	100%
		Group 3		
		Min. = 5	0%	
		Max. = 23	100%	100%
		Group 4		
		Min. = 4	0%	
		Max. = 25	100%	100%
		Group 5		
		Min. = 10	0%	
		Max. = 32	100%	100%
	Sward height (cm)	*Group 1*		
		≤9.6 or ≥35.1	0%	
		9.7-35.0	100%	100%
		Group 2		
		≥11.6	0%	
		0.0-11.5	100%	100%
		Group 3		
		≤14.2 or ≥47.6	0%	
		14.3-47.5	100%	100%
		Group 4		
		≤14.9 or ≥37.6	0%	
		15.0-37.5	100%	100%
		Group 5		
		≤23.7 or ≥46.4	0%	
		23.8-46.3	100%	100%
	Indicator species (n)	*Group 1*		
		Min. = 1	0%	
		Max. = 13	100%	100%
		Group 2		
		Min. = 0	0%	
		Max. = 4	100%	100%
		Group 3		
		Min. = 1	0%	
		Max. = 6	100%	100%
		Group 4		
		Min. = 1	0%	
		Max. = 16	100%	100%
		Group 5		
		Min. = 2	0%	
		Max. = 25	100%	100%
	TOTAL	**N/A**	**100%**	**100%**

Table 22 Criteria used in the calculation of conservation value scores for each site under Impacts and threats.

Area affected (*p*)	**Intensity (*i*)**	**Total score per site**	**Values**	**Conservation score**	**Max. score**
Estimate of the area of each site affected by each impact or threat expressed as a proportion of the total area (**0-1**)	**0** = Site unaffected **-1** = Impact judged as minor (low level threat) **-2** = Impact judged as moderate (intermediate level threat) **-3** = Impact judged as severe (high level threat)	∑*pi* for all impacts and threats	Min. = 0 (i.e. no threat) Max. = -9.0 (i.e. highest value)	100% 0%	 100%

Total conservation value and rank

Each attribute category (*area and population, structure and function* and *impact and threats*) was weighted equally and total conservation scores were taken as the mean value across each of the three attributes.

Generally conservation scores corresponded broadly to a site's perceived value: 0-20% (*very poor*), 20-40% (*poor*), 40-60% (*moderate*), 60-80% (*good*) and 80-100% (*excellent*). Conservation scores for sites determined as formations exhibited a normal distribution (Kolmogorov-Smirnov Z = 0.960, p=0.315, n=51; see Fig. 24) and were ranked in descending order of conservation value (Table 23). Cruit Island, Co. Donegal was ranked 1st and was the only site with a conservation score >80% and therefore classed as 'excellent'. However, there were a further 25 sites were classed as 'good', 17 sites as 'moderate' and 8 as 'poor'. No formations were classed as 'very poor'.

Mean conservation scores within each assessed parameter are provided for each habitat type for comparison in Fig. 25.

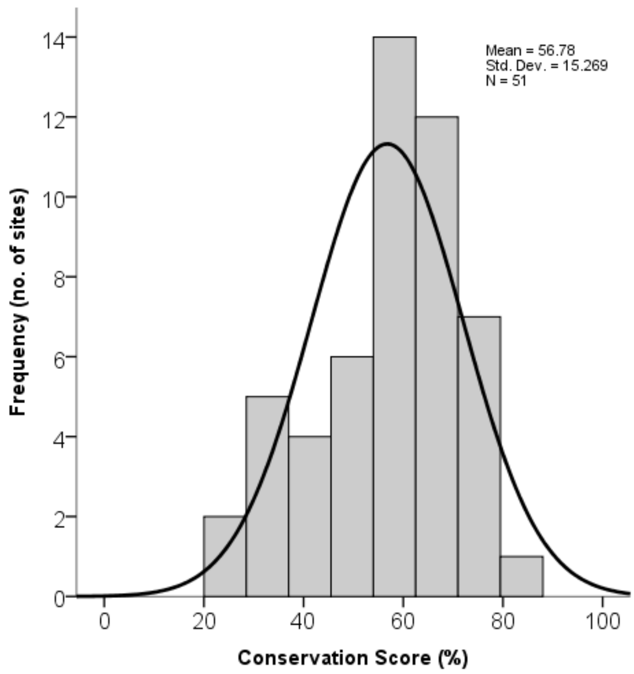


Fig.24 Frequency distribution of conservation value scores among formations (>10 shrubs).

Evaluation of the current SAC network

Formations fell entirely within, partly within or adjacent and close to 30 existing Special Areas of Conservation or SACs (Table 24). A total of 23 formations fell entirely within the existing SAC network. A further 10 formations fell mostly within existing SACs but with some shrubs falling beyond the SAC boundary thus we recommend extending the boundary to include the entire formation. A further 6 formations were adjacent or close to an existing SAC and consideration should be given to extending the SAC boundary on a site-by-site basis where its inclusion is merited. A further 9 formations were beyond the current SAC network, however, of these 5 fell within 500m to 2km of an existing SAC. Designation of these sites will also need site-by-site consideration.

Table 23 Conservation scores for each formation (n=51). Data were not available for all attribute criteria and missing values were left as blanks. The scores are listed under each criterion as described in Section 3.4. Each attribute is summarized with a mean percentage value where the lowest score = 0% and the highest score = 100%. Each attribute was weighted equally and a total score represents the mean across the three attribute categories. Sites were listed in descending rank order i.e. those at the top of the list are perceived as having the highest conservation value and those at the bottom are perceived as having the lowest conservation value.

						Area & Population			**Structure & Function**								**Future prospects**			**Current Conservation Value**		
Code	**Site**	**County**	**X**	**Y**	**Habitat group**	*Area*	*Population*	**Sub-total**	*% reproductive (coned)*	*% recruitment (seedlings)*	*% baresoil*	*% alive*	*Spp. richness*	*Sward height*	*+ve indicators spp.*	**Sub-total**	*Pressures & threats*	**Sub-total**	**TOTAL SCORE**	**Status**	**Rank**	**Formation**
DL12	Cruit Island	Donegal	172997	420445	5	100	100	100.0	37	9	0	99	69	100	68	54.5	-0.8	90.7	81.7	Excellent	1	Formation
GY07	Tirneevin	Galway	142086	202286	2	100	100	100.0	36	0	0	70	85	100	75	52.3	-1.3	85.8	79.4	Good	2	Formation
GY08	Cappacasheen	Galway	138186	203727	2	100	100	100.0	55	1	10	100	85	0	75	46.6	-1.0	88.9	78.5	Good	3	Formation
GY24	Dawros More, Letterfrack	Galway	70303	259058	1	100	100	100.0	25	0	0	100	36	100	23	40.6	-1.0	88.9	76.5	Good	4	Formation
DL09	Dawros Head Complex	Donegal	167970	396929	4	100	100	100.0	30	3	0	98	100	0	81	44.6	-1.5	83.1	75.9	Good	5	Formation
DL08	Lough Nagreany	Donegal	215315	441678	5	100	100	100.0	35	11	0	94	69	0	56	37.8	-2.1	77.2	71.7	Good	6	Formation
SO14	Bunduff Sligo C	Sligo	175326	357427	4	75	100	87.5	18	1	0	100	76	100	44	48.4	-2.0	77.8	71.2	Good	7	Formation
SO11	Skerrydoo 4	Sligo	174686	357236	4	75	100	87.5	10	1	0	99	44	100	50	43.4	-1.6	82.2	71.0	Good	8	Formation
GY27	Lavally	Galway	145400	222700	3	75	75	75.0	20	0	0	100	65	100	50	47.9	-1.0	88.9	70.6	Good	9	Formation
DL14	Kincasslough/Mullaghderg	Donegal	174976	420227	4	100	100	100.0	12	0	0	100	60	100	56	46.9	-3.2	64.4	70.4	Good	10	Formation
MO06	Cloghmoyne	Mayo	122577	249502	3	100	75	87.5	30	5	0	100	74	100	83	56.0	-3.0	66.7	70.1	Good	11	Formation
CK01	Cappul Bridge 1	Cork	69058	55887	4	75	75	75.0	17	6	0	94	48	100	31	42.3	-1.3	85.6	67.6	Good	12	Formation
GY16	Caherateige	Galway	144675	213502	1	100	100	100.0	15	0	0	100	36	100	23	39.2	-3.5	61.1	66.8	Good	14	Formation
DL06	Fanad B	Donegal	223038	446040	4	50	75	62.5	27	15	13	100	24	100	25	43.4	-0.5	94.4	66.8	Good	14	Formation
GY05	Corranellistrum	Galway	119670	240385	2	100	100	100.0	18	1	0	99	60	0	50	32.6	-3.0	66.7	66.4	Good	15	Formation
LK01	Barrigone	Limerick	129561	150795	5	75	100	87.5	42	0	0	98	63	0	32	33.4	-2	77.8	66.2	Good	16	Formation
MO04	Corraun Hill/Clew Bay	Mayo	78121	294235	4	100	100	100.0	45	0	13	100	28	0	25	30.1	-3.0	66.7	65.6	Good	17	Formation
CE13	Corcomroe	Clare	129326	208336	2	75	75	75.0	50	1	3	99	55	0	50	36.8	-2.0	77.8	63.2	Good	18	Formation
CE10	Caherbannagh	Clare	118216	207478	1	100	100	100.0	21	0	0	100	39	0	31	27.3	-3.4	62.2	63.2	Good	19	Formation
SO01	Rosses Point A	Sligo	163040	340227	5	50	100	75.0	55	21	0	100	78	100	76	61.4	-4.3	52.8	63.1	Good	20	Formation
MO07	Lough Carra	Mayo	116516	267920	3	50	75	62.5	15	0	0	100	35	100	17	38.1	-1.3	86.1	62.2	Good	21	Formation
DL05	Fanad A	Donegal	223034	445654	4	75	75	75.0	30	3	0	100	44	0	56	33.3	-2.0	77.8	62.0	Good	22	Formation
MO03	Dooega Head	Mayo	65561	299484	4	100	50	75.0	20	0	0	100	24	100	25	38.4	-2.5	72.2	61.9	Good	23	Formation
SO12	Skerrydoo 2	Sligo	174421	357219	4	25	50	37.5	4	0	0	100	60	100	56	45.8	0.0	100.0	61.1	Good	24	Formation
MO08	Mocorha Lough	Mayo	123312	255093	3	50	75	62.5	25	0	0	100	48	0	33	29.5	-1.0	88.9	60.3	Good	25	Formation
CE06	Ballybornagh	Clare	135928	204151	2	75	100	87.5	30	0	0	100	80	0	50	37.1	-4.0	55.6	60.1	Good	26	Formation

						Area & Population			Structure & Function								Future prospects			Current Conservation Value		
Code	**Site**	**County**	**X**	**Y**	**Habitat group**	*Area*	*Population*	**Sub-total**	*% reproductive (coned)*	*% recruitment (seedlings)*	*% baresoil*	*% alive*	*Spp. richness*	*Sward height*	*+ve indicators spp.*	**Sub-total**	*Pressures & threats*	**Sub-total**	**TOTAL SCORE**	**Status**	**Rank**	**Formation**
DL02	Binnion A	Donegal	236308	448509	4	75	50	62.5	10	6	0	96	84	100	38	47.6	-2.8	68.9	59.7	Moderate	27	Formation
GY10	Cloghboley B	Galway	142318	212070	1	50	50	50.0	60	0	0	100	64	100	31	50.6	-2.0	77.8	59.5	Moderate	28	Formation
GY23	Rineen	Galway	121309	235417	3	100	75	87.5	30	0	0	100	48	0	50	32.5	-4.0	55.6	58.5	Moderate	29	Formation
MO01	Carrowaneeragh	Mayo	114768	268786	5	50	50	50.0	36	0	0	100	69	0	44	35.5	-1.0	88.9	58.1	Moderate	30	Formation
DL11	Mullaghdoo B	Donegal	176577	420329	3	25	75	50.0	16	8	0	84	83	0	50	34.4	-1.0	88.9	57.8	Moderate	31	Formation
DL31	Melmore Head	Donegal	213359	444321	4	50	50	50.0	30	0	0	100	32	100	19	40.1	-2.0	77.8	56.0	Moderate	32	Formation
OY01	Island Fen, Birr	Offaly	212106	201476	-	75	50	62.5	25	0	-	90	-	-	-	16.4	-1.1	88.3	55.8	Moderate	33	Formation
DL21	Malin	Donegal	248605	448019	3	50	50	50.0	23	0	0	100	35	100	33	41.6	-2.3	75.0	55.5	Moderate	34	Formation
DL15	Viking House	Donegal	174328	418540	3	100	50	75.0	30	0	0	100	48	100	17	42.1	-5.2	42.2	53.1	Moderate	35	Formation
CE01	Church Bay	Clare	175910	186500	1	50	50	50.0	33	0	0	100	33	100	8	39.1	-3.0	66.7	51.9	Moderate	36	Formation
TP02	Kilgarvan Quay	Tipperary	182853	196517	1	50	75	62.5	50	0	0	100	100	0	77	46.7	-5.0	44.4	51.2	Moderate	37	Formation
TP01	Carney Commons	Tipperary	187062	192043	1	75	100	87.5	31	4	0	99	36	0	46	30.9	-6.5	27.6	48.7	Moderate	38	Formation
TP03	Cornalack	Tipperary	184054	199941	5	75	75	75.0	0	0	0	100	41	100	8	35.5	-6.0	33.3	48.0	Moderate	39	Formation
CK05	Black Rock, Allihies	Cork	55938	47141	4	25	50	37.5	0	0	0	100	68	100	56	46.3	-4.0	55.6	46.5	Moderate	40	Formation
GY09	Cloghboley A	Galway	142976	212615	2	75	50	62.5	20	0	3	99	100	0	25	35.2	-5.9	34.4	44.1	Moderate	41	Formation
TP04	Dromineer	Tipperary	178674	185191	3	75	75	75.0	0	0	0	100	39	0	33	24.6	-6.2	31.1	43.6	Moderate	42	Formation
CE31	Lough Cullan	Clare	131608	190768	3	25	50	37.5	10	0	0	95	43	0	67	30.7	-4.0	55.6	41.3	Moderate	43	Formation
CK07	Cod's Head, Allihies	Cork	55218	47335	1	25	75	50.0	0	0	0	76	42	0	31	21.3	-5.0	44.4	38.6	Poor	44	Formation
DL30	Ballynacarrick	Donegal	193116	368634	3	50	50	50.0	20	0	0	95	61	0	67	34.6	-7.3	18.7	34.4	Poor	45	Formation
SO16	Rosses Point C	Sligo	162777	339952	5	25	50	37.5	0	0	0	100	38	0	16	21.9	-6.0	33.3	30.9	Poor	46	Formation
GY29	Catherweelder	Galway	145427	215799	-	100	75	87.5	-	-	-	-	-	-	-	-	-	-	29.2	Poor	47	Formation
SO19	Ballinderreen	Sligo	138937	314192	-	100	75	87.5	-	-	-	-	-	-	-	-	-	-	29.2	Poor	48	Formation
MO02	Aghinish	Mayo	115764	268257	-	100	75	87.5	-	-	-	-	-	-	-	-	-	-	29.2	Poor	49	Formation
GY28	Sillhouse Lough	Galway	141862	214602	-	50	75	62.5	-	-	-	-	-	-	-	-	-	-	20.8	Poor	51	Formation
CE32	Poulataggle 1	Clare	139943	201134	-	50	75	62.5	-	-	-	-	-	-	-	-	-	-	20.8	Poor	51	Formation

Table 24 List of juniper formations (>50 shrubs) idenitifying whether they are **a)** entirely within an SAC, **b)** mostly within an SAC, **c)** adjacent or close to an SAC or **d)** not within any SAC. A total of 30 different SACs are listed where designation for juniper may be an issue.

#	Code	Site name	SAC name	Recommendation
a) Formation entirely within SAC				
1	CE01	Lough Cullan	East Burren Complex SAC	None
2	CE02	Poulataggle 1	East Burren Complex SAC	
3	CE10	Caherbannagh	Black Head-Poulsallagh Complex SAC	
4	CK05	Black Rock Allihies	Kenmare River SAC	
5	CK07	Cod's Head Allihies	Kenmare River SAC	
6	DL02	Binnion A	North Inishowen Coast SAC	
7	DL11	Mullaghdoo B	Gweedore Bay and Islands SAC	
8	DL12	Cruit Island	Gweedore Bay and Islands SAC	
9	DL31	Melmore Head	Tranarossan and Melmore Lough SAC	
10	GY05	Corranellistrum	Gortnandarragh Limestone Pavement SAC	
11	GY07	Tirneevin	Coole-Garryland Complex SAC	
12	GY08	Cappacasheen	East Burren Complex SAC	
13	GY16	Caherateige	Ardarhan Grassland SAC	
14	GY24	Dawros More, Letterfrack	Twelve Bens/Garraun Complex SAC	
15	GY29	Catherweelder	Castletaylor Complex SAC	
16	MO01	Carrowaneeragh	Lough Carra/Mask Complex SAC	
17	MO03	Dooega Head	Keel Machair/Menaun Cliffs SAC	
18	MO04	Corraun Hill - Clew Bay	Corraun Plateau SAC	
19	MO07	Lough Carra	Lough Carra/Mask Complex SAC	
20	MO08	Mocorha Lough	Mocorha Lough SAC	
21	SO19	Ballinderreen	Lough Hoe Bog SAC	
22	TP02	Kilgarvan Quay	Lough Derg, North-East Shore SAC	
23	TP03	Cornalack	Lough Derg, North-East Shore SAC	
b) Formation mostly within SAC				
24	CE13	Corcomroe	East Burren Complex SAC	Adjust SAC boundary to include entire formation
25	CK01	Cappul Bridge	Kenmare River SAC and Glanmore Bog SAC	
26	DL08	Lough Nagreany	Lough Nagreany Dunes SAC	
27	DL09	Dawros Head Complex	West of Ardara/Maas Road SAC	
28	GY28	Sillhouse Lough	Lough Fingall Complex SAC	
29	LK01	Barrigone	Barrigone SAC	
30	MO02	Aghinish	Lough Carra/Mask Complex SAC	
31	MO06	Cloghmoyne	Cloughmoyne SAC	
32	OY01	Island Fen Birr	Island Fen SAC	
33	SO01	Rosses Point A	Cummeen Strand/Drumcliff (Sligo Bay) SAC	
34	SO14	Bunduff Sligo C	Bunduff Lough and Machair/Trawalua/ Mullaghmore SAC	
c) Formation adjacent or close to SAC				
35	CE06	Ballybornagh	East Burren Complex SAC	Consider adjusting SAC boundary to include formation
36	DL14	Kincasslough - Mullaghderg	Gweedore Bay and Islands SAC	
37	DL15	Viking House	Gweedore Bay and Islands SAC	
38	DL30	Ballynacarrick	Ballintra SAC	
39	SO08	Rosses Point C	Cummeen Strand/Drumcliff (Sligo Bay) SAC	
40	SO11	Skerrydoo 4	Bunduff Lough and Machair/Trawalua/ Mulaghmore SAC	
41	SO12	Skerrydoo 2	Bunduff Lough and Machair/Trawalua/ Mulaghmore SAC	
d) Formation not within or close to any SAC				
42	DL05	Fanad A	1km from Ballyhoorisky Point to Fanad Head SAC	Consider adjusting SAC boundary to include formation or create new SAC
43	DL06	Fanad B	1km from Ballyhoorisky Point to Fanad Head SAC	
44	DL21	Malin	700m from North Inishowen Coast SAC	
45	GY09	Cloghboley A	500m from Ardrahan Grassland SAC	
46	GY10	Cloghboley B	1km from Ardrahan Grassland SAC	
47	GY23	Rineen	1-2km from Ross Lake and Woods SAC and Lough Corrib SAC	
48	CE01	Church Bay	None nearby	Create new SAC
49	GY27	Lavally	None nearby	
50	TP01	Carney Commons	None nearby	
51	TP04	Dromineer	None nearby	

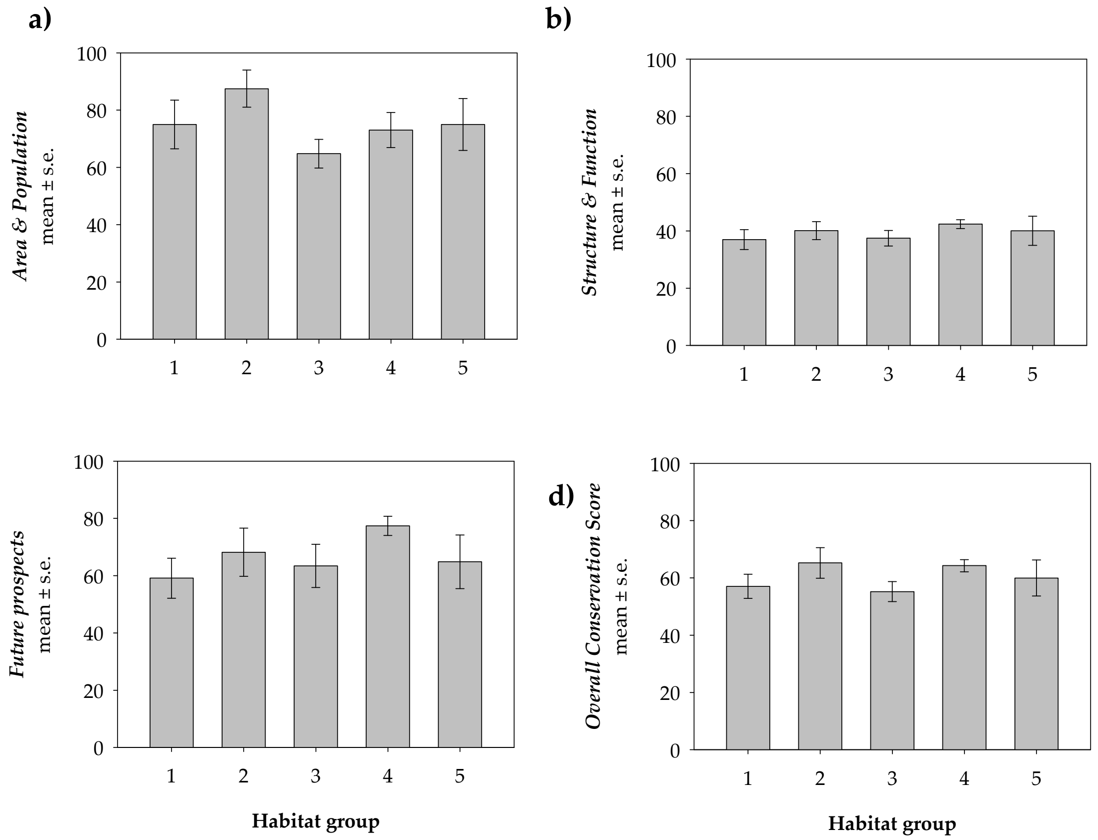


Fig. 25 Mean conservation value scores ± standard error showing differences between habitat types in **a)** Area and population, **b)** Structure and function, **c)** Im pacts and threats and **d)** overall conservation score for assessed formations.

3.5 Site conservation assessments

Each indicator within the parameters of i) *area and population*, ii) *structure and function* and iii) *future prospects* was given a target, usually within each habitat type identified from analysis of vegetation. The criteria to *Pass* or *Fail* each target is listed in Table 25 as are the criteria for assessing the overall status of each attribute to be assessed using the standard traffic light system (good, poor or bad).

Individual site assessments are given along with the actual data values in ***Appendix VIII*** of this report which includes specific site management recommendations (for example, proposed designation of sites or a change in existing designation boundaries to include currently undesignated formations).

Due to improved knowledge and more accurate data this survey was taken as a new baseline against which future change could be measured. Consequently, the conservation status under the parameter of *Area and population* for all 51 formations (100%) was determined as Favourable FV or good (green) as there is no evidence of decline since the Directive came into force. Consequently, the overall assessment under *Area and population* was considered Favourable FV or good (green). See Table 26.

Under the parameter of *Structure and function* a total of 13 formations (25%) were determined as Favourable FV or good (green), 29 formations (57%) as Unfavourable Inadequate U1 or poor (amber) and 4 formation (8%) as Unfavourable Inadequate U2 or bad (red). A total of 5 formations (10%) were not assessed under this parameter due to lack of data. Consequently, the overall assessment under *Structure and function* was considered Unfavourable Inadequate U1 or poor (amber). See Table 26.

Under the parameter of *Future prospects* a total of 9 formations (17%) were determined as Favourable FV or good (green), 20 formations (40%) as Unfavourable Inadequate U1 or poor (amber) and 17 formations (33%) as Unfavourable Inadequate U2 or bad (red). A total of 5 formations (10%) were not assessed under this parameter due to lack of data. Consequently, the overall assessment under *Future prospects* was considered Unfavourable Inadequate U1 or poor (amber). Site specific recommendations have been made to ensure that the *impacts and threats* identified can be mitigated at these sites in the future (see Appendix III – Site Assessments). See Table 26.

At those site where any one parameter could not be adequately assessed due to missing data the assessment for that criteria was listed as Unfavourable Inadequate U1 or poor (amber).

If any one of the three parameters was assessed as Unfavourable Inadequate U2 or bad (red) for any one site then the overall assessment for that site was also considered Unfavourable Inadequate U2 or bad (red). A total of 4 formations (8%) were determined as Favourable FV or good (green), 29 formations (57%) as Unfavourable Inadequate U1 or poor (amber) and 18 formations (35%) as Unfavourable Inadequate U2 or bad (red). As the conservation status of the majority formations was considered poor or above, the overall assessment for the habitat was considered poor (amber).

The *conservation value* and subsequent *conservation status* of a formation were significantly associated (ANOVA $F_{d.f.=2,48}$= 4.615, p=0.015; Fig. 26). Thus, there was good congruence between the evaluation of perceived conservation value (and site rank) with conservation status for each formation.

Table 25 Site conservation assessment criteria including indicators and their objective targets (these may vary between habitat types) including the definition of Favourable FV or good ('green), Unfavourable Inadequate U1 or poor ('amber') and Unfavourable Inadequate U2 or bad ('red').

Attribute	Indicator	Target	Pass	Fail	Status
Area & population	1. Area	Maintain 2008/10 area	Yes	No	GOOD = Both indicators pass POOR = One indicator fails BAD = Both indicators fail
	2. Population	Maintain 2008/10 population	Yes	No	
Structure & function	1. % coned	>10% coned	Yes	No	GOOD = 5-7 indicators pass (i.e. 71-100% pass) POOR = 3-4 indicators pass (i.e. 43-57% pass) BAD = 0-2 indicators pass (i.e. 0-29% pass)
	2. % seedlings	>10% seedlings	Yes	No	
	3. % baresoil	>10% baresoil	Yes	No	
	4. % alive	>90% alive	Yes	No	
	5. Spp. Richness[1]	>1 SD below the 2008/10 mean within each habitat type	Yes	No	
	6. Sward height	< lower quartile or > upper quartile from the 2008/10 within each habitat type	Yes	No	
	7. Indicator species	≥50% of positive indicator species for within each habitat type	Yes	No	
Impacts and threats	1. Overall site score	Pass or fail target not applicable			GOOD = 0 POOR = -0.1 to >-3.0 BAD = <-3.0 (max. = -9.0)
				OVERALL ASSESSEMENT	GOOD = All 3 attribute are good POOR = 1-3 attributes are poor BAD = 1of 3 attributes are bad

[1] Species richness scores exclude negative indicators (invasive species and native problematic species)

Table 26 A summary of the conservation status of each formation (n=51). Data for each attribute is provided for each site in **Appendix VIII**. The standard "traffic-light" system was used. If any one of the three parameters i) area and population, ii) structure and function, and iii) future prospects was assessed as Unfavourable Inadequate U2 or bad ('red'), the overall assessment was also "red". Where data were not available for any attribute criteria cells were left blank and highlighted in grey as unknown. It should be noted that Species Richness scores did not include byrophytes or lichens which may disadvantage some sites.

Rank	Formation	Conservation Score	County	Code	Site	X	Y	Area	Population	*Area & Population status*	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	No. of positive indicators	*Structure & Function status*	*Future Prospects*	OVERALL ASSESSMENT
1	Formatio	**81.7**	Donegal	DL12	Cruit Island	17299	42044	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	GOO	GOO
2	Formatio	**79.4**	Galway	GY07	Tirneevin	14208	20228	Pas	Pas	GOO	Pas	Fail	Fail	Fail	Pas	Pas	Pas	POOR	POOR	POOR
3	Formatio	**78.5**	Galway	GY08	Cappacasheen	13818	20372	Pas	Pas	GOO	Pas	Fail	Pas	Pas	Pas	Pas	Pas	GOO	GOO	GOO
4	Formatio	**76.5**	Galway	GY24	Dawros More, Letterfrack	70303	25905	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	GOO	POOR
5	Formatio	**75.9**	Donegal	DL09	Dawros Head Complex	16797	39692	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Fail	Pas	POOR	POOR	POOR
6	Formatio	**71.7**	Donegal	DL08	Lough Nagreany	21531	44167	Pas	Pas	GOO	Pas	Pas	Fail	Pas	Pas	Fail	Pas	GOO	POOR	POOR
7	Formatio	**71.2**	Sligo	SO14	Bunduff Sligo C	17532	35742	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
8	Formatio	**71.0**	Sligo	SO11	Skerrydoo 4	17468	35723	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	POOR	POOR
9	Formatio	**70.6**	Galway	GY27	Lavally	14540	22270	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	GOO	GOO
10	Formatio	**70.4**	Donegal	DL14	Kincasslough/Mullaghder	17497	42022	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	BAD	BAD
11	Formatio	**70.1**	Mayo	MO0	Cloghmoyne	12257	24950	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	POOR	POOR
12	Formatio	**67.6**	Cork	CK01	Cappul Bridge 1	69058	55887	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
14	Formatio	**66.8**	Donegal	DL06	Fanad B	22303	44604	Pas	Pas	GOO	Pas	Pas	Pas	Pas	Fail	Pas	Fail	GOO	GOO	GOO
14	Formatio	**66.8**	Galway	GY16	Caherateige	14467	21350	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	BAD	BAD
15	Formatio	**66.4**	Galway	GY05	Corranellistrum	11967	24038	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	POOR	POOR
16	Formatio	**66.2**	Limerick	LK01	Barrigone	12956	15079	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
17	Formatio	**65.6**	Mayo	MO0	Corraun Hill/Clew Bay	78121	29423	Pas	Pas	GOO	Pas	Fail	Pas	Pas	Pas	Fail	Fail	POOR	POOR	POOR
18	Formatio	**63.2**	Clare	CE13	Corcomroe	12932	20833	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	POOR	POOR
19	Formatio	**63.2**	Clare	CE10	Caherbannagh	11821	20747	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	BAD	BAD
20	Formatio	**63.1**	Sligo	SO01	Rosses Point A	16304	34022	Pas	Pas	GOO	Pas	Pas	Fail	Pas	Pas	Pas	Pas	GOO	BAD	BAD
21	Formatio	**62.2**	Mayo	MO0	Lough Carra	11651	26792	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
22	Formatio	**62.0**	Donegal	DL05	Fanad A	22303	44565	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Fail	Pas	POOR	POOR	POOR
23	Formatio	**61.9**	Mayo	MO0	Dooega Head	65561	29948	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Fail	Pas	Fail	POOR	POOR	POOR
24	Formatio	**61.1**	Sligo	SO12	Skerrydoo 2	17442	35721	Pas	Pas	GOO	Fail	Fail	Fail	Pas	Pas	Pas	Pas	POOR	GOO	POOR
25	Formatio	**60.3**	Mayo	MO0	Mocorha Lough	12331	25509	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Fail	Fail	POOR	GOO	POOR
26	Formatio	**60.1**	Clare	CE06	Ballybornagh	13592	20415	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	BAD	BAD
27	Formatio	**59.7**	Donegal	DL02	Binnion A	23630	44850	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR

Rank	Formation	Conservation Score	County	Code	Site	X	Y	Area	Population	*Area & Population status*	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	No. of positive indicators	*Structure & Function status*	*Future Prospects*	OVERALL ASSESSMENT
28	Formatio	**59.5**	Galway	GY10	Cloghboley B	14231	21207	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
29	Formatio	**58.5**	Galway	GY23	Rineen	12130	23541	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Fail	Pas	POOR	BAD	BAD
30	Formatio	**58.1**	Mayo	MO0	Carrowaneeragh	11476	26878	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Fail	Fail	POOR	GOO	POOR
31	Formatio	**57.8**	Donegal	DL11	Mullaghdoo B	17657	42032	Pas	Pas	GOO	Pas	Fail	Fail	Fail	Pas	Fail	Pas	POOR	GOO	POOR
32	Formatio	**56.0**	Donegal	DL31	Melmore Head	21335	44432	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
33	Formatio	**55.8**	Offaly	OY01	Island Fen, Birr	21210	20147	Pas	Pas	GOO	Pas	Fail		Fail				BAD	POOR	BAD
34	Formatio	**55.5**	Donegal	DL21	Malin	24860	44801	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
35	Formatio	**53.1**	Donegal	DL15	Viking House	17432	41854	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	BAD	BAD
36	Formatio	**51.9**	Clare	CE01	Church Bay	17591	18650	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	POOR	POOR
37	Formatio	**51.2**	Tipperar	TP02	Kilgarvan Quay	18285	19651	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Fail	Pas	POOR	BAD	BAD
38	Formatio	**48.7**	Tipperar	TP01	Carney Commons	18706	19204	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Fail	Pas	POOR	BAD	BAD
39	Formatio	**48.0**	Tipperar	TP03	Cornalack	18405	19994	Pas	Pas	GOO	Fail	Fail	Fail	Pas	Pas	Pas	Fail	POOR	BAD	BAD
40	Formatio	**46.5**	Cork	CK05	Black Rock, Allihies	55938	47141	Pas	Pas	GOO	Fail	Fail	Fail	Pas	Pas	Pas	Pas	POOR	BAD	BAD
41	Formatio	**44.1**	Galway	GY09	Cloghboley A	14297	21261	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Fail	POOR	BAD	BAD
42	Formatio	**43.6**	Tipperar	TP04	Dromineer	17867	18519	Pas	Pas	GOO	Fail	Fail	Fail	Pas	Pas	Fail	Fail	BAD	BAD	BAD
43	Formatio	**41.3**	Clare	CE31	Lough Cullan	13160	19076	Pas	Pas	GOO	Fail	Fail	Fail	Pas	Fail	Pas	Pas	POOR	BAD	BAD
44	Formatio	**38.6**	Cork	CK07	Cod's Head, Allihies	55218	47335	Pas	Pas	GOO	Fail	Fail	Fail	Fail	Pas	Fail	Fail	BAD	BAD	BAD
45	Formatio	**34.4**	Donegal	DL30	Ballynacarrick	19311	36863	Pas	Pas	GOO	Pas	Fail	Fail	Pas	Pas	Pas	Pas	GOO	BAD	BAD
46	Formatio	**30.9**	Sligo	SO16	Rosses Point C	16277	33995	Pas	Pas	GOO	Fail	Fail	Fail	Pas	Fail	Fail	Fail	BAD	BAD	BAD
47	Formatio	**29.2**	Mayo	GY29	Catherweelder	14542	21579	Pas	Pas	GOO										POOR
48	Formatio	**29.2**	Sligo	SO19	Ballinderreen	13893	31419	Pas	Pas	GOO										POOR
49	Formatio	**29.2**	Mayo	MO0	Aghinish	11576	26825	Pas	Pas	GOO										POOR
51	Formatio	**20.8**	Clare	CE32	Poulataggle 1	13994	20113	Pas	Pas	GOO										POOR
51	Formatio	**20.8**	Mayo	GY28	Sillhouse Lough	14186	21460	Pas	Pas	GOO										POOR

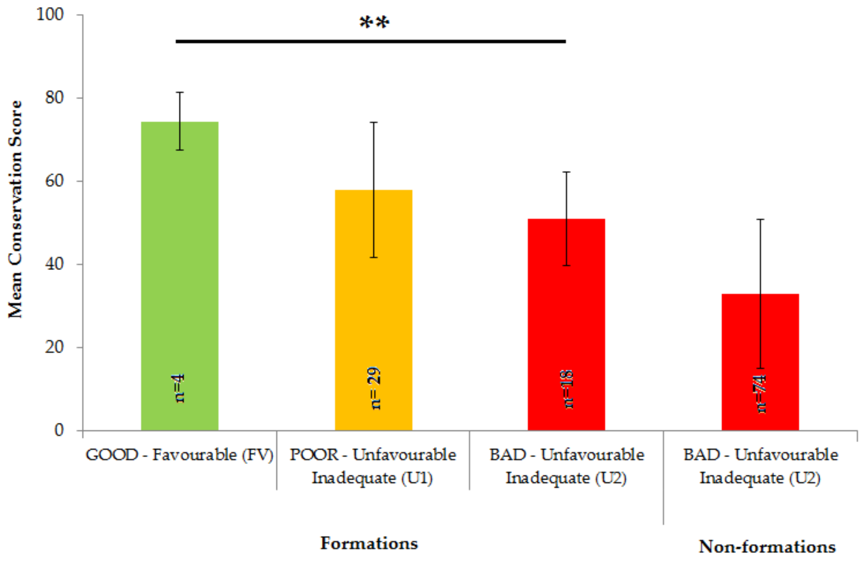
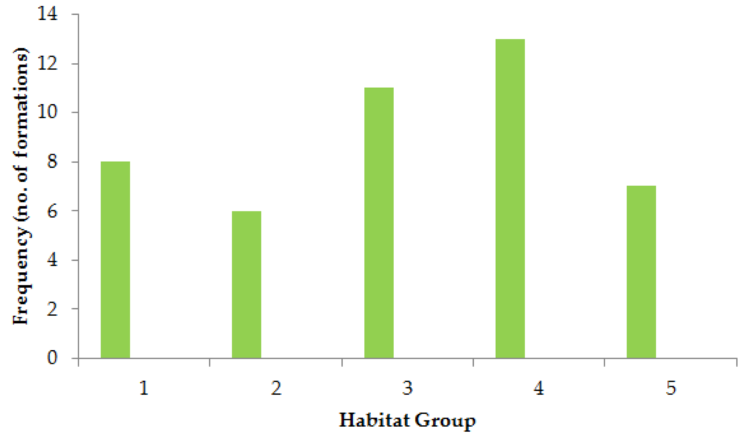


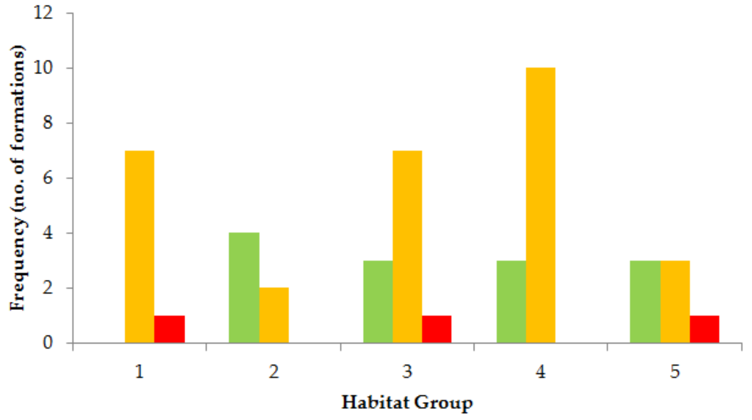
Fig. 26 The relationship between conservation status and mean conservation value ± 1 S.D. (** denotes signficiant variation between categories ANOVA $F_{d.f.=2,48}$= 4.615, p<0.015).

The frequency of formations evaluated under each parameter that was determined as in *good*, *poor* or *bad* conservation status is shown in Fig. 27. All formations within each habitat group were determined as in *good* conservation status under *area and population*. Under *structure and function,* habitat group 1 was notable as all formations were determined to be in *poor* or *bad* conservation status while habitat groups 3 and 4 had a substantially higher numbers of *poor* formations than *good* formations. *Future prospects* may provide the most meaningful interpretation where habitat groups 1 and 3 had the highest frequency of formations in *bad* conservation status indicating greater *pressures and threats* than at those present in habitat groups 2, 5 and 5.

Area & Population



Structure & Function



Pressures & threats

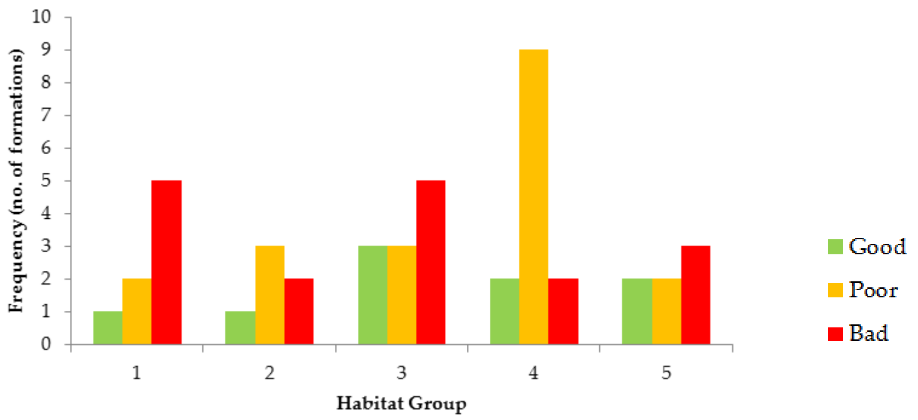


Fig. 27 The frequency of good, poor and bad conservation status at formations attributed to each habitat group.

3.6 National conservation assessment

An overall national assessment of the *conservation status* was determined using the same parameters as those used to assess individual sites (i.e. *area and population, structure and function* and *future prospects*) with the addition of an extra parameter (i.e. *range*) for the purposes of updating the last Article 17 assessment from 2008 (Table 27).

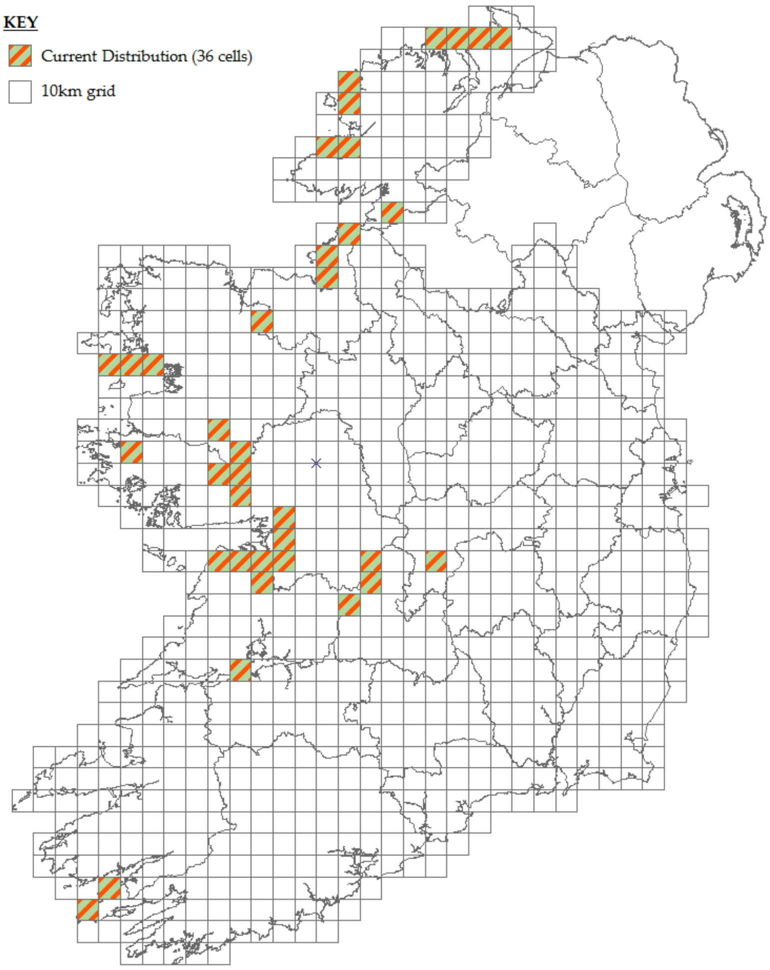
Table 27 Conservation status of EU Annex 1 Habitat 5130 as reported in the 2008 Article 17 report.

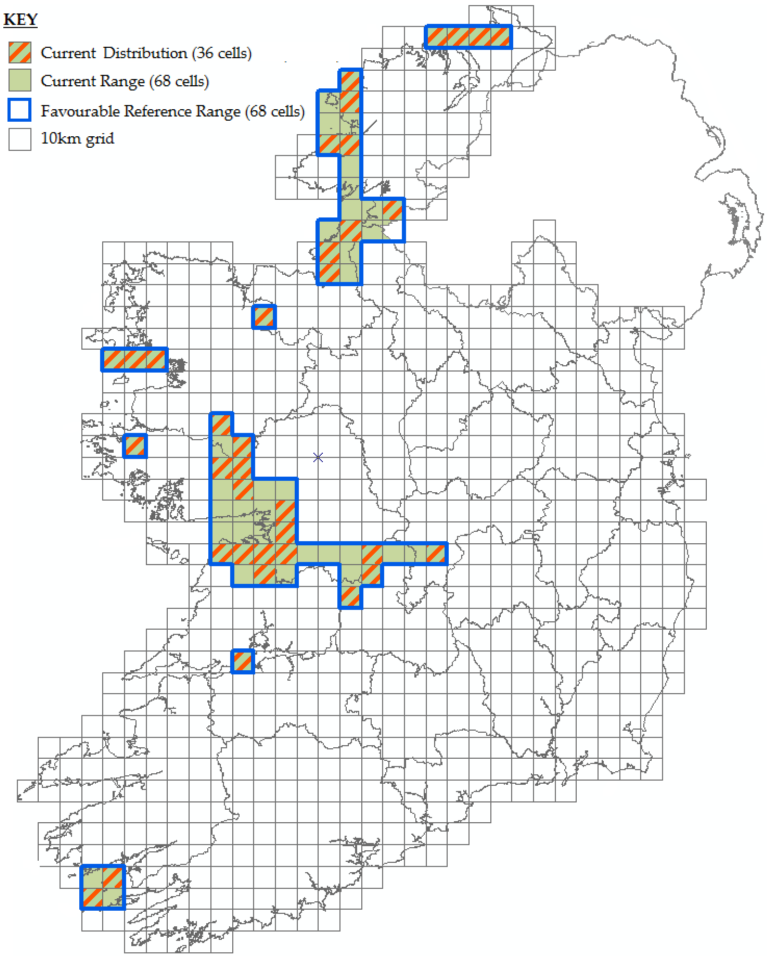
2.6 Conclusions ***(assessment of conservation status at end of reporting period)***	
Range	Favourable (FV) or good (green) **Explanatory note** There is some uncertainty due to uncertainty over the comprehensiveness of the recording time, and reliance on single species records.
Area	Unfavourable Inadequate (U1) or poor (amber)
Specific structures and functions (incl. typical species)	Unfavourable Inadequate (U1) or poor (amber)
Future prospects	Unfavourable Inadequate (U1) or poor (amber)
Overall assessment of Conservation Status	Unfavourable Inadequate (U1) or poor (amber)

The main results of surveillance under Article 11 of the EU Habitats Directive for Annex I habitat types must be provided in a standard reporting format known as Annex D (Table 28).

Table 28 The current conservation status of EU Annex 1 Habitat 5130 as determined during this study.

Field definition	***Brief explanations***
0.1 Member State	IE
0.2 Habitat code	5130

1 National level	
1.1. Maps	Distribution and range within the country concerned
1.1.1. Distribution map	 **Map 1.1.1** *Current Distribution (based on a 10km grid) of* Juniperus communis <u>formations</u> *(i.e. only those sites with ≥50 shrubs) on heaths or calcareous grasslands (5130) during 2008-10.* **Explanatory note** Juniper formations occupied a total of 36 cells (10km² grid squares).
1.1.2. Method used - map	3 = complete survey
1.1.3. Year or period	2008-2010
1.1.4. Additional distribution map	N/A

1 National level	
1.1.5. Range map	 **Map 1.1.5** *Current Range (based on a 10km grid) of* Juniperus communis *formations (i.e. only those sites with ≥50 shrubs) on heaths or calcareous grasslands (5130) during 2008-10.* **Explanatory note** Gaps in the range were filled assuming suitable habitat was present within 3 cells distant between occupied cells (in a straight line) or within 2 cells at right angles in the oblique.

2. Biogeographical level	
2.1. Biogeographical region	Atlantic (ATL)
2.2. Published sources	Cooper, F., Stone, R.E., McEvoy, P., Wilkins, T. & Reid, N. (2012) The conservation status of juniper formations in Ireland. *Irish Wildlife Manuals*, No. XX. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.
2.3. Range	Range within the biogeographical region concerned.
2.3.1. Surface area	6,800 km² **Explanatory note:** 68 x 10km cells multiplied by 100km² per cell = 6,800km² for the total surface area of the range.
2.3.2. Short-term trend Period	2001-2013 (rolling 12-year time window)

2.3.3. Short-term trend Trend direction	x = unknown
2.3.4. Short-term trend Magnitude Optional	x = unknown
2.3.5. Long-term trend Period Optional	
2.3.6 Long-term trend Trend direction Optional	
2.3.7 Long-term trend Magnitude Optional	
2.3.8 Favourable reference range	a) 6,800 km². A GIS file has been provided.
	b) N/A
	c) N/A
	d) The reference value is set as the current value as there is no evidence of a decline since the Directive came into force.
2.3.9 Additional information Is the difference between the reported value in 2.3.1. and the previous reporting round mainly due to:	a) genuine change? *NO*
	b) improved knowledge/more accurate data? *YES* **Explanatory note:** The current study is the first survey of juniper formations in Ireland and updates the previous distribution and range derived from unverified records from 1800-2005.
	c) use of different method (e.g. "Range tool")
2.4 Area covered by habitat	Area covered by habitat within the range in the biogeographical region concerned (km²)
2.4.1 Surface area	47.3 km² (may increase further if more formations are discovered) **Explanatory note:** 4,726.0 ha was the total summed area for all 51 formations, as defined by the minimum convex polygon that completely enclosed all juniper records at each formation.
2.4.2 Year or period	2008 - 2010
2.4.3 Method used	3 = full ground survey
2.4.4 Short-term trend Period	2001-2012 (rolling 12-year time window)
2.4.5 Short-term trend Trend direction	x = unknown
2.4.6 Short-term trend Magnitude Optional	x = unknown
	Confidence interval - N/A
2.4.7 Short-term trend Method used	0 = absent data

2.4.8 Long-term trend Period Optional	
2.4.9 Long-term trend Magnitude Optional	a)
	b) *Confidence interval* - N/A
2.4.10 Long-term trend Method used	
2.4.11. Favourable reference area	a) 47.3 km². A GIS file has been provided.
	b) N/A
	c) N/A
	d) N/A
2.4.12 Additional information Is the difference between the reported value in 2.4.1. and the previous reporting round mainly due to:	a) genuine change? *NO*
	b) improved knowledge/more accurate data? *YES* **Explanatory note:** The current study is the first survey of juniper formations in Ireland and updates the previous distribution and range derived from unverified records from 1800-2005.
	c) use of different method (e.g. "Range tool")

2.5 Main pressures

a) Pressure (20 max.)		b) Ranking	c) Pollution qualifier
A03.01	Intensive mowing or intensification	L	N/A
A04.01.01	Intensive cattle grazing	L	
A04.01.02	**Intensive sheep grazing**	**H**	
A04.01.05	Intensive mixed animal grazing	M	
A04.02.01	Non-intensive cattle grazing	M	
A04.02.04	Non-intensive horse grazing	L	
A04.02.05	**Non-intensive mixed animal grazing**	**H**	
A04.03	Abandonment of pastoral systems, lack of grazing	M	
C01	Mining and quarrying	M	
E01.03	Dispersed habitation	M	
E02.01	Factory	L	
G05.01	**Trampling, overuse**	**H**	
I01	Invasive non-native species	M	
I02	**Problematic native species**	**H**	
J01.01	Burning	L	
K01.01	Erosion	L	
K01.03	Drying out	L	
K04.01	Competition (flora)	L	
K04.05	**Damage by herbivores (natural)**	**H**	
M01.03	Flooding and rising precipitation	L	

Explanatory note: The top five pressures (see Table 10, page 36) have been listed as high impact pressures whilst those present at <10% of sites were listed as low impact pressures and those of intermediate prevalence were listed as medium impact pressures based exclusively on real data from site occurrences.

2.5.1 Method used – pressures	3 = based exclusively or to a larger extent on real data from sites *occurrences* or other data sources

2.6. Main threats		
a) Pressure	b) Ranking	c) Pollution qualifier
As listed in 2.5. There is no evidence to suggest that any of these pressures will decline in the near future.		N/A
2.6.1. Method used –threats	3 = based exclusively or to a larger extent on real data from sites *occurrences* or other data sources	

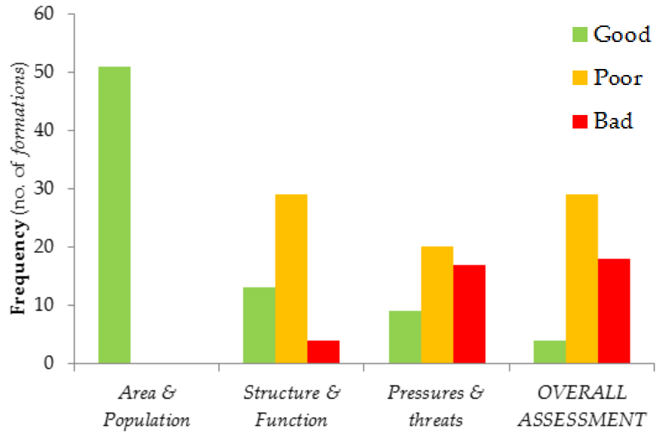
2.7 Complementary information	
2.7.1 Typical species	**Wet grassland, heath or bog** *Carex flacca* *Succisa pratensis* *Carex nigra* *Dryas octopetala* *Pedicularis palustris* *Cynosurus cristatus* *Dactylorhiza maculata* *Juncus articulatus* *Anagallis tenella* *Schoenus nigricans* *Prunella vulgaris* *Carex viridula* *Agrostis stolonifera* **Exposed calcareous rock** *Teucrium scorodonia* *Geranium sanguineum* *Mycelis muralis* *Geranium robertianum* **Dry calcarerous heath and grassland** *Lotus corniculatus* *Trifolium pratensis* *Viola riviniana* *Fraxinus excelsior* *Polygala vulgaris* **Dry siliceous heath and raised bog** *Calluna vulgaris* *Erica cinerea* *Potentilla erecta* *Anthoxanthum odoratum* *Carex panicea* *Molinia caerulea* *Carex binervis* *Erica tetralix* *Danthonia decumbens* *Polygala serpyllifolia* *Empetrum nigrum* *Luzula multiflora* *Nardus stricta* *Agrostis canina* *Narthecium ossifragum* *Eriophorum angustifolium*

	Dry calcareous/neutral grassland inc coastal dunes *Galium verum* *Pilosella officinarum* *Thymus polytrichus* *Ammophila arenaria* *Daucus carota* *Anthyllis vulneraria* *Koeleria macrantha* *Campanula rotundifolia* *Festuca rubra* *Plantago lanceolata* *Senecio jacobea* *Arrhenatherum elatius* *Hypochaeris radicata* *Linum catharticum* *Holcus lanatus* *Ranunculus bulbosus* *Briza media* *Trifolium repens* *Dactylis glomerata* *Polygala vulgaris* *Carex arenaria* *Hypericum perforatum* *Jasione montana* *Anacamptis pyramidalis* *Plantago coronopus*
2.7.2 Typical species – method used	**Explanatory note** Typical species have been listed under each habitat type identified by Hierarchical Cluster Analysis of relevé data and Indicator Species Analysis.
2.7.2 Justification of % thresholds for trends	1% per year when assessing trends.
2.7.3 Structure and functions - Methods used	3 = based exclusively or to a larger extent on real data from sites/occurrences or other data sources
2.7.4 Other relevant information	See explanatory notes in each section.
2.8. Conclusions *(assessment of conservation status at end of reporting period)*	
2.8.1. Range	Favourable (FV) or good (green) **Explanatory note** The current study has established a new baseline of improved knowledge/more accurate data and therefore all 51 formations (100%) were determined as favourable (green).
2.8.2. Area	Favourable (FV) or good (green) **Explanatory note** The current study has established a new baseline of improved knowledge/more accurate data and therefore all 51 formations (100%) were determined as favourable (green).

2.8.3. Specific structures and functions (incl. typical species)	Unfavourable Inadequate (U1) or poor (amber) **Explanatory note** A total of 13 formations (25%) were assessed as favourable (green), 29 formations (57%) as inadequate U1 or poor and only 4 formation (8%) was inadequate (U2) or bad. A total of 5 formations (10%) were not assessed uner this parameter due to lack of data. Consequently, the overall assessment of *structure and function* was determined as inadequate U1 or poor.
2.8.4. Future prospects	Unfavourable Inadequate (U1) or poor (amber) **Explanatory note** A total of 9 formations (17%) were assessed as favourable (green), 20 formations (40%) as inadequate U1 or poor and 17 formations (33%) as inadequate (U2) or bad. A total of 5 formations (10%) were not assessed under this parameter due to lack of data Thus, the majority of sites were either green or amber (57%) and not all those sites classified as red were subject to the 'main threat' of intensive grazing. Thus, the overall assessment of *future prospects* was determined as inadequate U1 or poor (amber).
2.8.5. Overall assessment of Conservation Status	Unfavourable Inadequate (U1) or poor (amber) **Explanatory note** A total of 4 formations (8%) were determined as favourable (green), 29 formations (57%) as inadequate U1 or poor and 18 formations (35%) as inadequate (U2) or bad. Consequently, the overall assessment of was determined as inadequate U1 or poor.
2.8.6 Overall trend in Conservation Status	= (stable) **Explanatory note** The overall conservation status of each parameter has remained the same as during the last Article 17 assessment with the exception of Area and population which was previously assessed as inadequate U1 or poor and has now been revised to favourable or good. Nevertheless, the overall assessment remains inadequate U1 or poor and thus the general trend is stable.

The distribution of formations and their conservation status is shown in Fig. 28a & b.

a)



b)

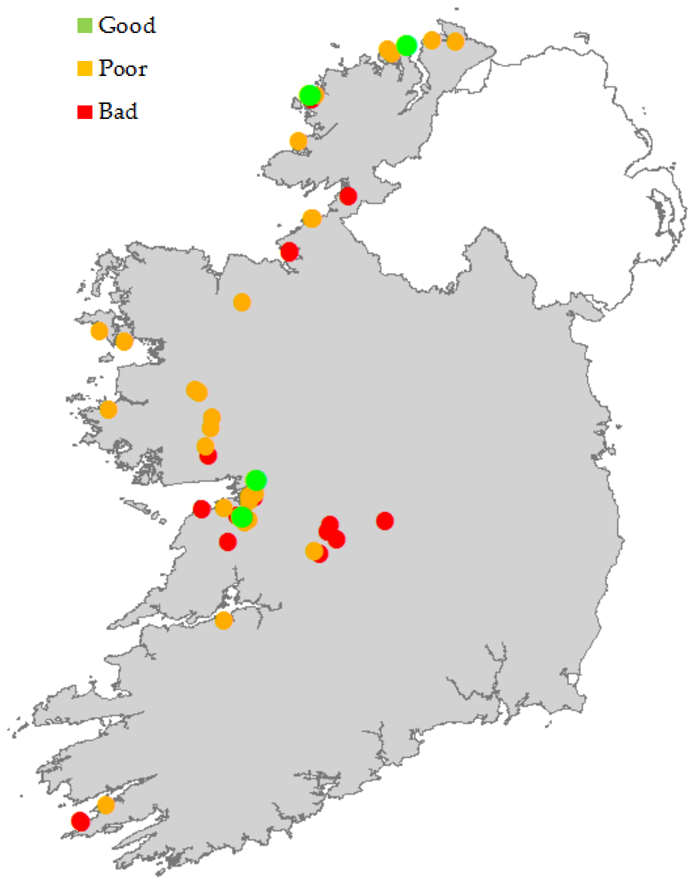


Fig. 28 Summary of the frequency of conservation status assessments within a) formations (n=51) and b) the geographical distribution of sites and their overall conservation status.

4.0 Discussion

4.1 National juniper survey

This is the first study to make a quantitative assessment of the conservation status of the EU Annex I Habitat 5130 (juniper scrub) throughout Ireland based on survey data. The status of juniper was assessed at a total of 125 sites but many consisted of individual shrubs or small isolated groups.

Juniper stands have been variably defined by others. The Borders Forest Trust (1997), University of Edinburgh (1997) and Broome (2003) considered that 20 bushes exhibiting the full range of growth forms could provide seed to adequately represent the genetic diversity of a population, whilst this number was increased to 30 individuals if cuttings were to be taken for population supplementation. Juniper is known to support a diverse and specialised insect fauna, some of which are host specific (Ward, 1977). In southern England, there is a strong significant relationship between the number of bushes per site and the number of juniper-specific insect species (Ward & Lakhani, 1977). Large juniper populations generally supported the most diverse insect fauna whilst fruit-feeding species are soon lost at smaller sites. Thus, only extensive areas of juniper scrub provide important insect habitat. Plantlife's 2004/05 public survey of juniper across the uplands in Great Britain also concluded that populations of fewer than 50 plants were essentially unviable unless there were other juniper populations growing close by (Long & Williams, 2007). Consequently, we defined a '*formation*' as any discrete cluster of more than 50 shrubs likely to be capable of recruitment and long-term persistence whilst avoiding inbreeding depression to be consistent with accepted Plantlife criteria. Consequently, a total of 51 formations were identified.

Formations occurred in a total of 36 x $10km^2$ squares with the current range judged to be 68 x $10km^2$ squares. Whilst this appeared to represent a substantial long-term decline (-74%) this may be spurious as the previously reported range was derived from single species records spanning the period 1800-2005 (NPWS, 2008). Formations were found to cover a total of $47.3km^2$ within their range. Conversely, this represented a substantial long-term increase (anywhere between +436%) from that previously reported but again this change is likely to be spurious for similar reasons (NPWS, 2008). Thus, any recorded change in distribution, range and the area covered by the habitat is entirely due to improved knowledge and more accurate data. Consequently, the results of this survey should be taken as a new baseline against which future change can be measured.

For comparison, a range decline of 49% (10km square units) has been calculated recently for ssp. *communis* in lowland England when measured against all historical records (Wilkins *et al.*, 2011b). In England, juniper has become extinct in nine vice-counties and declined by over 50% in a further six counties, generally retreating to its strongholds. At the 1km square level these declines were more pronounced. For example on the Chiltern Hills, 10km square losses were estimated at 14% but 56% in 1 km squares. Populations had also greatly dwindled in size (i.e. shrub abundance).

In Ireland, the total population within formations was estimated at approximately 20,295 individuals. However, the majority of formations supported only small numbers (50-250 shrubs). Formations with notably large populations exist at Cruit Island and around Dawros Head (Co. Donegal), with approximately 3,000 and 3,500 shrubs respectively. *Juniperus communis* ssp. *communis* was present at 56.5% of formations, *Juniperus communis* ssp. *nana* at 37.0% and mixed populations at 6.5%.

In Ireland, a total of 74 sites were idenitifed as non-formations comprising fewer than 50 shrubs with most consistng of fewer than 10 shrubs and many being isolated individuals. A similar pattern of abundance has been observed in Great Britain. In lowland England, Wilkins *et al.* (2011b) found that in 2010 nearly a quarter of ssp. *communis* sites comprised just one bush and over half of sites supported fewer than 10 bushes. In Scotland, Plantlife (2007) estimated 40% of sites to have 10 or fewer individuals (Long & Williams, 2007). In Northern England (County Durham and Northumberland, excluding Upper Teesdale), Clifton *et al*. (1997) recorded declines over the 21 years up to 1994. Surviving colonies were mostly small (79% had < 50 bushes and 61% < 25 bushes). All authors found that large populations were comparitively rare.

In general, the sex ratio of juniper populations in Ireland were highly male skewed; however, the majority of sites possessed reproductively active individuals i.e. coned females. The predominance of males appears commonplace for ssp. *communis* in Great Britain. Recent data for lowland England populations of ssp. *communis* show that males clearly outnumbered females by a factor of over two in larger populations i.e. >60 shrubs (Wilkins *et al.*, 2011b). In a long term study by Ward (2007), the sex ratio of a population changed over time, with more females dying due to attacks by rabbits and later by fungus disease in the roots. This trend continued into senescence until males outnumbered females by 2 to 1. Males had a greater resistance to terminal disease and were slightly older than females at death. Male plants, therefore, appeared better able to withstand stresses, particularly with age. Females may be more intensively grazed than males owing to the extra nutritional value conferred by their fleshy fruits. Grazing may result in physical damage providing vectors for disease. A study by McGowan *et al*. (2004) in northern Scotland found that female plants of ssp. *nana* suffered more winter grazing than male plants.

As males produce copious quantities of pollen, it can be assumed that the number of females will be more critical in determining the amount of regeneration from seed. Isolated stands predominantly composed of males e.g. 1:5 (F:M) will have limited reproductive potential. Manual reinforcement by population supplementaton may offer a way of conserving isolated single-sex stands (Wilkins & Duckworth, 2011a).

Seed viability remains uncertain (Appendix IV) and should be further investigated. Low seed viability is evidently a problem in British and European sites where species of seed-eating insect and unviable seeds can vastly limit the reproductive potential of populations (Bristow, 1981; Ward, 1977; Garcia *et al.* 2000, 2001, 2002; Verheyen *et al.* 2009). The effect is more severe the further south the population, hence populations in lowland England tend to have poorer seed viability than in Scotland. Seed viability can vary a great deal, ranging from ca. 1-90%. The average for nine lowland England sites assessed in 2010 was approx. 20% (Wilkins *et al.*, 2011b). Site level variation is probably more important than individual bush variation where populations of juniper are of similar ages, health, etc.

Active recruitment (the presence of seedlings) was relatively rare, reflecting poor regeneration levels known from throughout the UK (Dearnley & Duckett, 1999; Verheyen *et al.*, 2005; Ward, 2004). We cannot infer from the observation of seedlings that a population is regenerating adequately (i.e. birth rate equals or exceed death rate). It can take up to 10 years for seedlings to reach sexual maturity in which time they may succumb to other hazards. In Spain, Garcia *et al.* (2001) estimated that 10,000 seeds are likely to produce only one successful sapling.

Recruitment was directly associated with reproductive effort (i.e. the presence of coned adults) and was positively associated with population density (high numbers restricted to small sites). Intensive grazing pressure significantly reduced recruitment success presumably because small seedlings are more palatable to domestic stock than mature shrubs (Thomas *et al.*, 2007) and are, therefore, more vulnerable due to their lack of protective spines and small size. Seedlings can also be destroyed through stock trampling. Seedlings were generally located in rocky crevices in the vicinity of suspected mother plants, possibly as a result of avian delivery or protection from grazers (Garcia *et al.* 2001b). This may affect detectability in landscapes such as the Burren, Co. Clare (Habitat Group #2), were rocky crevices are particularly common. The presence of pockets of bare ground as germination microsites has been well documented as being a *critical* factor in seedling establishment (Vedel, 1961; Fitter, 1968, Ward, 1973; Sutherland, 1993; Banks, 2001). Concomitant with bare ground, is reduced competition from other vegetation and a lack of heavy shading. Where shallow mineral soils exist, areas can remain open for prolonged periods of time allowing juniper to regenerate continuously (Ward, 1973), although browsing must remain at a low level for 10 years or more to allow young bushes to become sufficiently robust.

Whilst recruitment varied between floristic communities this may be as much a function of detectability as variance in the quality of populations or site conditions. Seedling presence was lowest on limestone pavement sites despite small seedlings being likely to take hold in grykes where they would be concealed from view. Alternatively, low light levels, seed predation by small mammals, and/or the low production or quality of seed may account for the dearth of seedlings.

The age structure of juniper formations remains unknown as various methods of estimating and measuring age indirectly resulted in poor reliability of estimates. Visual estimates of age, Plantlife criteria estimating the number of dead stems, estimates of the percentage of dead material and measuring stem diameter are all uninformative (Dearnley & Duckett 1999; Thomas *et al*. 2007). Stem coring was not effective as many plants were hollow. From limited destructive sampling, it was clear that shrubs may '*look*' old and gnarled and may be subjectively classed as mature or senescent but may be actually be quite young. The width of growth rings indicated a highly irregular pattern of growth. Rings within the same plant may be thick indicating rapid growth and others thin indicating slow growth at different times whilst the width of the same ring, indicative of a single year, may vary between one side of the plant and the other. It is likely that the shallow impoverished soils on which juniper occurs and the levels of exposure that exist on some sites (for example, limestone pavement or coastal cliffs) result in many plants taking on the resemblance of a bonsai tree early in life. Plants destructively sampled were notably younger than anticipated with a maximum age of 51 years. Ward (1982) found that the lifespan of common juniper on chalk substrate in southern England was about 100 years and in northern England 'exceptional individuals reach over 200 years', whilst Cedro, *et al*. (2007) found shrubs in Poland were aged no more than 98 years. Thus, in contrast, juniper in Ireland was comparatively young. This may be due to a milder maritime climate encouraging rapid growth in a shrub's early years, which results in unusually early development and premature appearance of senescence. Nevertheless, age structure was not included in the conservation assessment as no reliable non-destructive method was found.

In Great Britain, populations are generally dominated by mature bushes (Ward, 1973; Ward & King, 2006; Long & Williams, 2007; Dines & Daniels, 2006; Wilkins *et al*., 2011b) although determination of age was by non-destructive methods in almost every case, thus a degree of subjective error is likely. Stands that are predominantly even-aged appear characteristic of recent establishment following ground disturbance or a sudden decline in grazing pressure e.g. post myxomatosis (Wells *et al.*, (1976); Thomas *et al.*, 2007). In the absence of seedlings, even-aged colonies are highly susceptible to rapid die-off through natural senescence. This is a concern at many British sites.

In Ward (1973), the age of bushes was judged by their height, basal girth of trunks, amount of annual growth of shoots, amount of dead wood and foliage colour but site characteristics were also taken into account. The relationship between the annual rings and basal girth was known to be only a rough correlation and differed from site to site according to the soil and other conditions influencing growth rates (Malins-Smith, 1935). Ward (1973) acknowledged that as well as complications due to variable growth forms, on exposed sites and poor shallow soils dwarfing occurred, while bushes growing on good soils in sheltered places and those growing in dense older stands of scrub tended to be taller. Grazing could also make age estimation unreliable, especially when the whole bush was affected.

Shrub longevity appears to increase with latitude, probably due to more extreme climatic conditions leading to slower growth rates (Ward 1982; Clifton *et al*. 1997).

The majority of formations showed some sign of direct or indirect anthropogenic damage with grazing and browsing by domestic stock being the most significant, however, trampling was notable on high ground. Invasive non-native species did not represent a significant threat but problematic native species including *Corylus avellana, Molinia caerulea, Pteridium aquilinum* and *Rubus fruticosus* were significant problems at a large number of sites. Damage by naturally occurring herbivores (rabbits and possibly hares) was also noted.

Our findings reflect British surveys. In Scotland, subspecies *nana* appears to respond least favourably to grazing. McGowan *et al*. (1998) found most plants and the largest plants were in areas with little grazing. In lowland England, the principal threat is scrub encroachment from lack of grazing and management (Wilkins *et al.*, 2011b; Walker, 2011). However, overgrazing (particularly by rabbits) was considered an issue at 25% of sites. Soil enrichment and deficiency of bare ground may also be cause for concern, the latter affecting 75% of sites in England. In Snowdonia, high numbers of sheep coupled with the tradition of burning heathland have probably contributed to the dramatic reduction in juniper populations (Dines & Daniels, 2006).

Native plants that could impact negatively on juniper have recently been elucidated in a survey of lowland England populations (Walker, 2011). The current study identified

Corylus avellana, Molinia caerulea, Pteridium aquilinum and *Rubus fruticosus* be be 'problematic native species' in an Irish context (as defined by the EU Habitats Directive *impact and threat* code I02). Of the top 10 species most frequently associated with juniper in England (Walker, 2011), six are species of shrubs or trees, namely *Rubus fruticosus, Ligustrum vulgare, Crataegus monogyna, Fraxinus excelsior, Viburnum lantana and Cornus sanguinea.* Some Welsh juniper populations are threatened by encroaching alien species, principally *Rhododendron ponticum*.

Regarding bracken, Sutherland (1993) reported that following an experiment at Upper Teesdale which involved cutting and dragging out mature juniper, seedling emergence was strongest under bracken cover. Subsequent experimentation showed that shade from older juniper shrubs was also beneficial. However, only seedlings protected from sheep and rabbit grazing survived the winter. The apparent benefits of shade contradict research that suggests that juniper is light-demanding (Grubb *et al*. 1996) although it can survive and grow in as little as 20.5% daylight (Humphrey 1996). Shading vegetation may effectively nurse seedlings, providing shelter and a degree of protection from grazing. *Rubus fruticosus* and broom are thought to act in this way at Burnham Beeches NNR, Buckinghamshire (H. Read, 2010, pers. comm.).

4.2 Vegetation classifications

Juniper was largely associated with dry calcareous and neutral grassland, exposed calcareous rock, dry siliceous heath, exposed siliceous rock and dry calcareous heath. However, it also occurred on coastal dunes and, in the case of sub-species *nana* at higher altitudes. Colonies in Snowdonia, Wales have similar habitat preferences; most frequently, they occur in a matrix of moderately sloping rocks and grassland, on cliffs faces and in heathland (Dines & Daniels, 2006).

It should be noted that the bulk of the analysis presented in the current study is a vegetation classification *not* a habitat classification and, as such, has a lot in common with the National Vegetation Classification (NVC) system used to define phytosociological groups in Great Britain (Rodwell, 1991). The 5 groupings devised to describe plant communities characterising juniper scrub throughout Ireland were determined using floristic data only. Environmental data including topography, pH, ground conditions and parent material were used to interpret the groupings as ecologically relevant plant communities but were *not* used to define them. Typical species within each group were derived objectively from percentage occurrence and coverage data using Indicator Species Analysis. Thus, no weighting was applied to any species which may *a priori* have been regarded as a putative indicator of juniper occurrence. It must be acknowledged that the protocols used were entirely prescriptive with the aim of reducing a highly complex and often noisy dataset for the applied purpose of conservation assessment. Therefore, relationships should not be taken as definitive.

Nevertheless, of the 5 vegetation groups identified 3 equated directly to Fossitt (2000) habitat types, principally, ER2 exposed calcareous rock or limestone pavement (the *Teucrium scorodonia – Geranium sanguineum* group), HH1 dry siliceous heath (the *Calluna vulgaris – Erica cinerea* group) and GS1 dry calcareous or neutral grassland (the *Galium verum – Pilosella offcinarum* group) whilst another possessed elements of HH2 dry calcareous heath (the *Lotus corniculatus - Trifolium pratensis* group). The fifth group (the *Carex flacca – Succisa pratensis* group) was poorly defined and appeared to be a 'mosaic' group containing relevés from a mixture of different habitat types possessing a diverse community of moisture dependent and upland species.

It is important to acknowledge that relevé surveys may be compromised by the subjectivity of the surveyor who may overemphasise the occurrence or coverage of species perceived to be typical of a particular habitat (Jörg, 2003). Consequently, less well defined transitional vegetation may be overlooked. McCune & Grace (2002) make it clear that it is improper to draw conclusions about the discrete nature of the vegetation groupings derived from such an overly simplified dataset.

4.3 Current conservation status

The overall conservation status of the Annex I Habitat 5130 *J. communis formations on heath or calcareous grasslands* was determined as Unfavourable Inadequate U1 or poor (amber). Consequently, the overall trend in conservation status was determined as stable as the previous Article 17 assessment also reported the conservation status of the habitat as Unfavourable Inadequate U1 or poor (amber).

Formations fell entirely within, partly within or adjacent and close to 30 existing *Special Areas of Conservation* or *SACs*. A total of 23 formations fell entirely within the existing SAC network. A further 10 formations fell mostly within existing SACs but with some shrubs falling beyond the SAC boundary thus we recommend extending the boundary to include the entire formation. A further 6 formations were adjacent or close to an existing SAC and consideration should be given to extending the SAC boundary on a site-by-site basis where its inclusion is merited. A further 9 formations were beyond the current SAC network, however, of these 5 fell within 500m to 2km of an existing SAC. Designation of these sites will also need site-by-site consideration. We make explicit site-specific recommendations for each formation in *Appendix VIII – Site Assessments*.

4.4 Conclusions

The main conclusions from this survey were:

- Following Plantlife (UK) criteria, a '*formation*' was taken as any discrete cluster of ≥50 shrubs and a total of 51 formations were identified.
- Formations occurred in a total of 36 x $10km^2$ squares with a favourable reference range judged to be 68 x $10km^2$ squares.
- Formations were found to cover a total of $47.3km^2$ within their range.
- The total population within formations was estimated at approximately 20,295 individuals.
- Intensive grazing pressure significantly reduced recruitment success presumably because small seedlings are more vulnerable to domestic stock than mature shrubs.
- The age structure of juniper formations remains unknown as various methods of estimating and measuring age indirectly resulted in poor reliability.
- Juniper was mostly associated with lowland dry calcareous and neutral grassland, exposed calcareous rock, dry siliceous heath, exposed siliceous rock and dry calcareous heath. However, it also occurred on coastal dunes and at higher altitudes.
- A total of 5 phytosociological groupings were derived from vegetation analysis to describe indicative plant communities characterising juniper scrub.
- Following EU guidelines the current conservation status of *J. communis formations on heath and dry grasslands* was assessed as Unfavourable Inadequate U1 or poor (amber). This is considered to be a baseline assessment as the data supporting the amber assessment submitted in 2007 were based on a desk study of Juniper records.

Two aspects not fully addressed in this report are i) genotypic diversity at the population level and ii) the potential impact of climate change. Appendix II suggests that there is significant population differentiation within juniper throughout Ireland using both chloroplast and nuclear markers, indicating restricted gene flow, particularly over larger geographic scales. For conservation purposes, the existence of genetically distinct clusters and geographically localised chloroplast haplotypes suggests that the concept of provenance should be taken into account when formulating population augmentation or reintroduction strategies. Furthermore, the potential lack of seed dispersal and seedling establishment means that *ex-situ* approaches to seed and seedling management may have to be considered. However, more research on seed viability is needed (Appendix IV).

Climate change in an emerging issue in global change biology and it has the potential to alter species' distributions. Juniper is known to favour cooler environments (Garcia *et al*., 2000a; Garcia *et al*., 2000b) and preliminary work suggests that in Ireland it may be highly vulnerable to increasing temperatures and irregular rainfall with models predicting a significant and substantial range contraction by 2080 (Appendix V).

Other modelling studies predict that the European range of juniper will contract northwards as the climate warms (BRANCH partnership, 2007). This suggests that Great Britain and Ireland will have a greater international responsibility to conserve juniper in the future.

Forestry Commission Scotland (2009) identified the following threats to juniper from climate change:

- *Drier spring weather in the east may restrict seedling establishment and growth;*

- *Protracted waterlogging in autumn and winter in the west, coupled with milder winters, will cause water-table fluctuation and more unsuitable growing conditions, stress and disease;*

- *More frequent mild winters in which temperatures rarely drop below 4°C may reduce germination rates in some areas, because juniper seeds need cold weather to break dormancy;*

- *Increased variability of annual weather may reduce pollen dispersal in wet summers and reduce berry production on more isolated bushes.*

Recent harsh winters with greater than usual numbers of sub-zero days and snowfall (2008/09, 2009/10 and 2010/11) may have increased seed germination and subsequent recruitment. Nevertheless, long-term trends in climate cannot be ignored and climate change adaptation may be necessary when implementing conservation strategies.

To maximise juniper's resilience and potential for adaption under climate change, small isolated populations could be linked through strategic reinforcement and re-introduction of populations, thereby enhancing gene flow and broadening gene pools (Wilkins & Duckworth, 2011a). To reduce the risk of outbreeding depression, multiple donor sites could be used. However, these actions go against the notion of local provenance (Appendix II). Revised IUCN guidelines on translocation are awaited to inform best practice and to resolve the issue between preserving local provenance and aiding the defragmentation of populations.

4.5 Proposed monitoring protocol

To ensure that future Article 17 reports are consistent with the current baseline and are simplified to ensure ease of reporting, a protocol for assessing the conservation status of *J. communis on heaths and calcareous grasslands* has been outlined:

Survey teams

Future monitoring can be achieved most easily by co-opting the field support of NPWS Conservation Rangers. Formations can be allocated to pairs of NPWS Conservation Rangers based on their inclusion within the districts for which those rangers are responsible. As many juniper formations are highly localised and concentrated in the west and north it may be that surveying all formations within one district is beyond the capacity of the resident team. Thus, thought may need to be given to sharing the workload more evenly among adjacent teams.

Health & Safety

Survey teams should consist of a minimum of two persons for Health & Safety reasons. Juniper formations are frequently in areas of upland were conditions underfoot may be difficult to traverse or may be located on coastal cliffs or limestone pavement where walking conditions may be treacherous. It is important to carry a handheld GPS device (with spare batteries) and a 1:10,000 map to aid navigation and a mobile phone for communication should surveyors get into any difficulties. A Health & Safety risk assessment should be carried out in accordance with NPWS standard guidelines (or those of any contractor undertaking the work). Outdoor clothing is essential including waterproofs and sufficient water must be carried to remain hydrated as some sites are a considerable distance from the road.

Site access

Many juniper formations are located in rural areas of low human population density. Therefore, it is important to respect people's rights and employ good practise to raise awareness of future surveys and to make contact with local people, landowners and farmers prior to accessing each site. Whilst locals may not be the owners of the land to be surveyed it may be important to make contact to allay any fears within Community Watch groups.

Technical support

Field teams should be supported by at least one person with appropriate IT skills including GPS and GIS expertise. Hardware required includes a laptop (preferably a notebook suitable for use in the field), Personal Digital Assistants (PDAs) and a handheld GPS device whilst software required includes Microsoft Excel, Microsoft Access (i.e. Microsoft Office), ArcGIS 10 (ESRI, California, USA). It is essential that data are collected in a fashion compatible with standard methods of data storage (principally Microsoft Access).

Training

Training for potential field surveyors is essential. Fieldworkers should be familiar with the habitats that contain juniper formations (uplands, coastal cliffs, limestone pavement etc) and the associated Health & Safety hazards. Familiarisation with the classification systems of such habitats in Fossitt (2000) is desirable as well as the 5 phytosociological groupings identified here.

Generally, two training days are required; one located in the south and one in the north to enable access to training by all NPWS Conservation Rangers. An inventory should be kept of attendance as the quality of the data returns may vary and this is likely to be associated with whether a surveyor attended a training session. It is recommended that each training event has an indoor session to cover the theoretical basics including the layout of survey sheets, how they should be completed, relevant equipment, software etc and an outdoor session at a juniper formation to demonstrate the field methods to ensure consistency between surveyors. The length of the training session should be tailored to the previous experience of the surveyors.

Training should include basic identification of vascular plants, covering as many of those identified as typical species within the 5 phytosociological groupings as possible. If specimens are not available at the chosen outdoor training site, specimens should be collected and brought to the training session in preference to reliance on field guide books. Consideration should be given to collecting data on bryophytes (mosses, liverworts and lichens) to ensure that future surveys are consistent with the national relevé survey for vegetation. Identification, taxonomy and systematic of bryophytes is a highly specialised subject and thought should be given to holding a separate training course specifically on this topic. This could be part of a wider training exercise associated with the national relevé survey for vegetation rather than for assessing juniper conservation status alone.

Timing

Whilst juniper shrubs are evergreen and can be surveyed at any time of year, the vegetation associated with the phytosociological groups associated with juniper is seasonal with many species being herbaceous or annual. Consequently, all vegetation surveys should be restricted to between May and August, although May and June are best to determine sex by observing flowering (however, the remains of male cones can be observed for some time afterwards). Should it be convenient, juniper populations can be enumerated, boundaries of formations and individual shrubs suitable for relevé surveys identified between September and April whilst vegetation surveys can be conducted during the summer month assisted by prior knowledge of each site.

Quality assurance and data manipulation

It is a frequent problem in large, national surveys involving multiple surveyors that data quality may vary. Each surveyor should be individually responsible for ensuring that all their data are clear, complete, correct and in the right format prior to the end of the field season and returning the data for analysis. Any abbreviations used should be fully explained in accompanying notes and should follow accept standards e.g. Fossit (2000) for habitat codes or EU Habitat Directive *impact and threat* codes.

Conservation assessments

Area and population

Future conservation assessments should focus on the 51 *formations* identified in the current survey. These should be taken as the baseline survey against which all future surveys should be compared.

The extent of each juniper formation should be established by walking around the perimeter of all extant shrubs and geo-referencing the enclosing boundary using a handheld GPS device. A Minimum Convex Polygon (MCP) should be created to enclose each formation and the area calculated to the nearest 0.1 ha. Where boundaries are inaccessible, or it is impractical to walk the perimeter, a visual assessment should be conducted and co-ordinates subsequently obtained from aerial photographs obtained from Ordnance Survey Ireland. Formations that are equal to or greater than (≥) the area recorded during the baseline (this survey) *pass* and those than are smaller than (<) that area *fail* the assessment (accounting for potential variation due to GPS accuracy and mapping errors).

The total population, i.e. number of shrubs, should be established by direct enumeration up to 50-100 shrubs. Populations numbering >50-100 shrubs should be estimated within the following number classes, e.g. 101-300, 301-500, 501-1000, 1001-3000, 3001-10000, >10000 (following Plantlife criteria) Populations that are equal to or greater than (≥) the number of shrubs recorded during the baseline (this survey) *pass* and those than are smaller than (<) that population size *fail* the assessment.

The overall status of *Area and population* should be determined as Favourable FV or good (green) if both criteria within the parameter (i.e. area *and* population) *pass*, Unfavourable Inadequate U1 or poor (amber) if only one criteria *passes* and Unfavourable Inadequate U2 or bad (red) if both criteria *fail*.

Structure and function: Releve/Monitoring Stop level

The grid references of each relevé sampled during the current survey will be held by NPWS and future surveyors could aim to revisit the same relevés for comparability. A database of digital photographs associated with each formation is also available to allow between-survey comparisons. However, it should be expected that there would be difficulties in re-locating some relevés, thus a random sample within the formation would suffice. A minimum of 4 relevés should be undertaken, however the number should reflect the the heterogeneity of the site. Relevés are 2 x 2m quadrats placed around each juniper shrub to be surveyed with the shrub placed in the centre. Future surveys may consider using a large size quadrat.

Species richness (i.e. the number of species) at each relevé should be recorded minus those species identified here as negative indicators, namely, invasive non-native species including *Cotoneaster integrifolius* and *Rhododendron ponticum* and problematic native species including *Corylus avellana*, *Molinia caerulea*, *Pteridium aquilinum* and *Rubus fruticosus*. Species richness should be based on the total number of species present and not just positive indicator species. The mean number per formation should be compared to the current survey to establish if there has been any change in the total plant community. The range of values determining whether a formation *passes* or *fails* depends on which of the 5 phytosociological groupings dominates each formation. The lower range value above or below which a formation *passes* or *fails* are given in Fig, 19c, page 52.

The number of positive indicator species present in each relevé should be recorded. This has been simplified by their inclusion on template survey sheets specific to each of the 5 phytosociological groupings identified here (Appendix VI). Assuming that the same relevés are surveyed as those contained within the current study, then the phytosociological group to which each belongs can be identified from the existing database. However, where a new relevé is used a species list should be compiled and compared to the lists of typical species for each phytosociological group. The relevé should be attributed to whichever group it shares the most species. A site *passes* the assessment if it contains ≥50% or *fails* if it contains <50% of the typical species listed for its phytosociological group.

Sward height should be measured in centimetres and taken as a mean from 4 locations selected at random within each relevé. Where relevés fall on limestone pavement or expanses of bare rock sward height should be recorded as zero. The range of values determining whether a formation passes or fails depends on which of the 5 phytosociological groupings dominates each formation. The mean values above or below which a formation *passes* or *fails* are given in Fig, 23, page 57.

Bare ground should be estimated for each relevé (% bare ground) as unvegetated areas are critical for active recruitment. If the mean area of bareground within relevés from a formation is >10% of the the formation *passes* the assessment and if <10% it *fails* the assessment.

Structure and function: Site level

Active reproduction at each site should be estimated as the percentage of shrubs with galbulae (% coned). If >10% of shrubs bear cones then the formations *passes* the assessment and if <10% it *fails* the assessment.

Active recruitment at each site should be estimated as the percentage of shrubs classified as seedlings or saplings (% seedlings/saplings). Seedlings are typically <15cm tall and generally consisted of a single upright, thin (<0.75cm wide) stem. If >10% are seedlings/saplings the formation *passes* the assessment and if <10% it *fails* the assessment. Habitat Group #2 (limestone pavement) mostly located in the Burren, Co. Clare had the lowest prevalence of seedling perhaps due to lower detectability within rocky crevices. Consideration might be given to lowering future thresholds for % seedling subject to further research.

The total number of shrubs within each formation that are determined as dead should be recorded and those alive should be expressed as a percentage (% alive). If >90% are alive the formation *passes* the assessment and if <90% it *fails* the assessment.

In future, consideration should be given to assessing seed viability by using the "cut-test" (for details see Wilkins & Duckworth 2011a, page 13) on a small sample of berries from a representative sample of females from each formation. Seed viability levels < 10% should *fail*.

No attempt should be made at estimating the age structure of formations unless future research provides a reliable method for doing so. There is a great deal of difficulty in the accurate identification of the putative sub-species (spp. *communis* or spp. *nana*.). Considering the difficulties and confusion it is also recommended that future surveyors should simply identify each shrub as *J. communis* and avoid separating the sub-species. This problem was also encountered by juniper surveyors in Snowdonia, Wales (T. Dines, pers. comm.). Classifying upright or prostrate forms may be useful.

It should be noted that criteria for species richness, sward height and positive indicator species are based on observed values from the current baseline survey. In accordance with the EU Habitats Directive, such criteria assume that formations should not deteriorate from baseline values. However, baseline values are probably not the same as *ideal* values. Thus, future assessments should refer to the caveats associated with these prescribed methods.

The overall status of *Structure and function* should be determined as Favourable FV or good (green) if ≥5 of the criteria pass (i.e. 83-100%), Unfavourable Inadequate U1 or poor (amber) if 2-4 of the criteria pass or fail (i.e. 33-66%) and Unfavourable Inadequate U2 or bad (red) if ≥5 of criteria fail (i.e. 83-100%).

Future prospects

The *impacts and threats* present at each site should be categorised according to those listed on the template survey form (Appendix VII).

The extent of each threat should be estimated as the proportion of the entire site that is likely to be affected. The intensity of each impact and threat should also be recorded as minor (-1), moderate (-2) or severe (-3) depending on the perception of the surveyor. The surveyor should multiply the proportion of the site affected, by the intensity score, for each impact or threat and sum all the values for the site to derive the overall impact or threat score. A certain degree of expert judgement can be used particularly in the case of the perceived impact of non-intensive grazing. The impacts of activities on the Area and Stucture & Functions should be considered when assessing the severity of the impact.

The overall status of *Future prospects* should be determined as Favourable FV or good (green) if the total impact and threat score of a formation is zero (0), Unfavourable Inadequate U1 or poor (amber) if -0.1 to <-3.0 and Unfavourable Inadequate U2 or bad (red) >3.0.

Overall assessment

The overall status conservation assessment should be determined as Favourable FV or good (green) if all three parameters (i. *Area and population*, ii. *Structure and function* and iii. *Future prospects*) are determined as Favourable FV or good (green). The overall assessment should be determined as Unfavourable Inadequate U1 or poor (amber) if 1-3 of the parameters are also Unfavourable Inadequate U1 or poor (amber). The overall assessment should be determined as Unfavourable Inadequate U2 or bad (red) if any 1 parameter is also determined as Unfavourable Inadequate U2 or bad (red).

Reporting

Future conservation assessment should be reported using the standard Annex D format as presented in the most up-to-date EU Habitats Directive Conservation Assessment Guidelines.

4.6 Recommendations

The main recommendations from this survey are to:

- Follow the site specific recommendations made to improve the conservation status of Unfavourable Inadequate U2 or bad (red) and Unfavourable Inadequate U1 or poor (amber) formations (see Appendix VIII – Site assessments).

- Establish additional means by which to improve the overall conservation status of the habitat by encouraging reproduction and recruitment (perhaps utilising population augmentation) at those sites determined as non-formations on the grounds of notably small populations and therefore at greater risk of extinction. Increasing their population size above the threshold for them to be considered formations would increase the total number of formations in Ireland, thus increasing the habitats distribution, range and the total area covered by the habitat this would contribute to a positive or increasing trend at the next assessment, assuming the conservation status of the formations does not substantially alter.

- Create seedling habitat at selected formations to halt potential decline and catalyse natural regeneration. For sustainable outcomes, long-term management tenures need to be in place and other competing features of interest reduced or absent. Grazing pressure may need to be controlled for 10 or so years before seedlings have developed sufficiently to withstand herbivory e.g. through exclosures or shrub guards. Colonies with low levels of seed viability may be helped through assisted regeneration techniques (see Wilkins & Duckworth, 2011a) involving harvesting and processing of seed cones.

- Determine seed viability levels at all sites visited (formation and non-formation) and if possible the likely causes of inviability.
- Develop and test a simplified age strucuture system that can be applied to both sub-species to give a relative and crude indication of age.

We suggest that all formations that are not already within the designation site network are included by making modifications to existing Special Areas of Conservation (SAC) boundaries or by creating new SACs specifically for those sites not adjacent to existing SACs.

A certain number of targets were permitted to fail and still result in a Green assessment for Structure & Functions. This was due to uncertainty surrounding the ecology of Juniper. Future monitoring surveys should attempt to clarify the uncertainties, some of which are listed below, and refine the targets where appropriate:

- The possibility of enhanced recruitment following cold snaps.
- The impact of non-intensive grazing on recruitment
- The possibility that some populations are naturally aging.
- The fact that perceived negative species may in fact be good nursery plants e.g. bracken/bramble
- The importance of the quality of the habitat for the survival of the Juniper population

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Appendix I – Ethnobotany & folk lore

Integrating ethnobotany, folk lore and conservation: IS juniper a culturally undervalued shrub?

Abstract

The juniper genus has undergone dramatic population and range declines throughout Europe, including Great Britain and Ireland. Consequently, juniper-scrub is listed in Annex I of the EU Habitats Directive. Whilst juniper has intrinsic conservation value and the maintenance of ecosystem integrity and services is the main driving force behind contemporary conservation efforts, its perceived low economic value may well be a historically significant factor contributing to its decline. This review examines the ethnobotanical and historical significance of juniper in Europe and provides a substantial body of evidence for its medicinal, veterinary, culinary and cultural importance. We argue that such perspectives may provide useful tools in generating public interest in the species, by increasing its use as a garden plant and through use of its timber in artisanal crafts, further raising its profile and offering a new angle for conservation of natural populations of juniper and their genetic diversity.

Introduction

The juniper genus belongs to the Cupressaceae family and is found mainly in temperate and subtropical regions of the northern hemisphere; the genus consists of between 68 and 80 species (Thomas *et al.*, 2007). *Juniperus communis* L is native to Great Britain and Ireland and consists of three distinct subspecies: *communis*, *nana* and *hemisphaerica,* the latter being restricted to only two locations in Great Britain.

Juniper is a dioecious shrub, with male and female flowers growing on separate individuals. The female produces fleshy cones (galbulae; commonly referred to as berries due to their fleshy texture), which slowly ripen over a 2 to 3 year period, attaining a distinctive purple colour. As a hardy shrub, juniper was one of the first woody species to colonise Ireland (Pilcher & Hall, 2001) and Great Britain (Bellamy, 1993) after the last ice age approximately 15,000 years before present. Post-glacially the British Isles were dominated by juniper-scrub prior to ecological succession leading to widespread afforestation by deciduous species (Nelson & Walsh, 1993). Juniper is host to a wide range of insects with at least 35 species of invertebrate known to use the shrub as a primary food source (Ward, 1977).

Due to dramatic population and range declines throughout Europe (Ward, 2007), juniper-scrub is currently listed on Annex I of the EU Habitats Directive (92/43/EEC). The principal drivers of such declines are not well understood but contributing factors are likely to include a male-skewed sex ratio resulting in low reproductive success (Thomas *et al.,* 2007), inappropriate management by over-grazing, abandonment of grazing regimes, lack of suitable soil conditions preventing seedling establishment, competition and shading by invasive native and non-native species, climate change and habitat destruction (Thomas *et al.,* 2007; Ward, 2007; F.M. Cooper, pers. Obs.).

Juniper has intrinsic conservation value and the maintenance of the ecosystem integrity of juniper-scrub is the main driving force behind contemporary conservation efforts. However, its perceived low economic value in Great Britain and Ireland may well be a historically significant factor contributing to its decline. This review examines the cultural and historical significance of juniper and its many uses in medicine and craftwork. We provide a substantial body of evidence for its historical, medicinal, veterinary, culinary and cultural importance and argue that such perspectives may provide useful tools in generating public interest in the species, further raising its profile and offering a new angle for species conservation in the wild.

History

One of the earliest references to juniper comes from the Judeo-Christian Bible; it is recorded in 1 Kings, Ch. 19v4 that the prophet Elijah took refuge under a juniper shrub in the wilderness of Beersheeba, whilst avoiding persecution by Jezebel (King James Version, 1998). However, more recent editions of the Bible suggest that it was a broom, rather than a juniper shrub (New International Version, 2008). According to Italian legend, after the birth of Jesus, he and his family fled to Egypt to escape Herod’s assassins. Tradition records that trees stretched out their branches and enlarged their leaves to afford the fleeing family safety and, as a result of this, juniper boughs were used as Christmas decorations (Folkard, 1892). As the Italians believed that juniper was dedicated to the Virgin, they considered that it was juniper which acted as the saviour for Mary, Joseph and Jesus. Thus the species was seen as ‘a symbol of succour or an asylum’ as a result of its provision of refuge and sanctuary (Folkard, 1892). Italians also believed that it had the power to drive away evil spirits and destroy magical spells (Folkard, 1892). It is believed by some that the cross upon which Jesus was crucified was constructed from juniper timber (Folkard, 1892). However, although the species is not given for any of these references, it is unlikely to be *J. communis* L, because, other than Italy, areas discussed are outside its natural range.

Medicinal uses

Pliny, writing in approximately AD77-79, suggested a multitude of medicinal uses for juniper seed (although he does not define species, and could be referring to *J. communis* or *J. sabina*): berries mixed with *Sphagnos* and wine 'draws off the water in dropsy' (Pliny, AD77-79a); he added that it aided stomach, chest and side pains, diuretic, soothed sprains, ruptures, colic, uterine disorders, sciatica, flatulence, feelings of chill and it checked tumours and berries taken in wine bound the bowels. When set on fire it allegedly deterred snakes and seed extract smeared on skin was supposed to protect against venomous bites (Pliny, AD77-79b). Many European ethnobotanists held juniper properties in high regard. Gerarde (1597) listed a multitude of medicinal uses: cleansing of the liver and kidneys; as a diuretic; 'infirmities of the chest', coughs, cramps, snake bites (when mixed with wine); ashes of burnt bark clean 'scurffe and filth of the skinne' and effective against worms, haemorrhoids, ulcers and cuts. The German botanist and physician Tragus (Hieronymus Bock 1498-1554) believed that 'its berries will cure all diseases' (Loudon, 1844), whilst the Italian doctor and naturalist Mathiolus (1501-1577) maintained that 'its virtues are too numerous to mention' (Loudon, 1844). Its properties were believed to be cleansing, detoxifying, fortifying, astringent and stimulating for the skin. Poor toxic elimination was thought to contribute to rheumatism, gout and arthritis. Thus, juniper oil was used in the belief that it improved elimination of toxins and aided management of the condition (Boizot, 2010). Culpeper regarded juniper oil as the finest remedy for wind or colic. He also listed its virtues as a counter-poison and in treating dropsy, respiratory problems, dysenteries, belly pains, ague (shaking fever), gout, sciatica, scurvy, worm infestations in children, palsies and falling sickness (Culpeper, 1653). Weiss recommended the use of juniper tea or juniper oil for chronic arthritis, gout and rheumatic diseases, but warned of its potential to damage the kidneys (Weiss, 1988). Evelyn (1679) described the berries as 'one of the most universal remedies in the world to our crazy forester' and suggested that swallowing berries instantly cured colic, whilst in decoction he maintained that they were 'most sovereign against an inveterate cough'. In Ireland, it was believed that juniper berries expelled wind and were useful against the gravel (kidney stones) and stoppage of urine (Threlkeld, 1727). 'The juice of the berries has been a traditional diuretic' brought to bear specifically on dropsy in County Cavan (Hart, 1898). In County Donegal, a juniper concoction was favoured as a stimulant or cleanser of the system properties that are still thought to be effective today (Garrad, 2003). The gathering of berries in their white unripe state (caora aitinn), for bottling in whiskey and keeping on hand for 'ailments', was even the subject of a special tradition among children on Achill Island, County Mayo, and the neighbouring Corraun Peninsula, on the coast of Co. Mayo (Mabey 1998), reserved for the last Sunday in July (known as Reek Sunday) when Christian pilgrims traditionally climb Croagh Patrick, County Mayo.

Knight (2002) reported the former use of juniper syrup by women following labour, to aid sleep and ease pain, made from the berries and included cowslip flowers, anise seed and liquorice which were boiled in milk and beer. Juniper oil was also recommended as a treatment for amenorrhoea or absence of periods in women (Hallowell, 1996), but warnings were given that it should not be used by pregnant women as it induces uterine contractions and could cause miscarriage (Weiss, 1988). Berries were also used to deliberately induce abortion, earning it the name 'bastard killer' in Somerset (Grigson, 1975), due to high levels of isocupressic acid found therein (Gupta, 2007). It should be noted that *J. sabina* is also used as an abortifacient in Italy (Idolo, *et al.*, 2009). These qualities also made it suitable to aid childbirth as it induced stomach contractions (Grigson, 1975). Until the early-1990s it was possible to purchase juniper pills, under the brand name *The Lady's Friend,* in the classified section of ladies' journals (Mabey, 1998).

Juniper is still used in aromatherapy as a stimulant and a detoxification agent (Anon, 2010b). Other modern uses include as an antiseptic, diuretic, in treating cystitis and as a carminative (Grigson, 1975; Hallowell, 1996). It is also recommended as a urinary remedy to be combined in equal parts with parsley piert *(Alchemilla arvensis* (L.) Scop.) (Culpeper, 1653). Wong (2010) gives a recipe for ivy *(Hedera helix* L), juniper and grapefruit cream to be used for aching legs as it is thought to improve circulation. Recent research suggests that the anti-bacterial and anti-fungal properties of juniper oil are due to α-pinene, p-cymene and β—pinene (Filipowicz *et al.*, 2003). Juniper contains a strong antiviral compound, known as deoxypodophyllotoxin, and it is recommended for inhibiting viruses such as flu and herpes (Duke, 2003).

Veterinary uses

During the 17th and 18th centuries, sheep were fed juniper berries, as they were believed to prevent and cure dropsy (Drury, 1985). The burning of juniper berries was thought to prevent general infection and juniper fire and smoke were employed frequently as a fumigant and as a remedy for contagious diseases in cattle (Loudon, 1844). Animals were repeatedly driven through the smoke to 'cure them'. Grigson (1975) quotes the name of 'horse saving' (from which the name 'savin' may be derived, a name whereby juniper is sometimes known) as juniper was said to have been employed as a horse medicine used for the purpose of 'gingering them up'. However, the name savin is also applied to *J. sabina,* found in the mountains of central and southern Europe. More recently, for domestic animals, including household pets, juniper was used as an ectoparasite (flea and tick) repellent (Boizot, 2010). In Estonia, juniper is used to control sarcoptic mange mites in pigs (Magi *et al*., 2006).

Fumigation

Threlkeld states that juniper wood cut in March smells sweet and was reputedly good to burn in 'times of contagious distempers' (Threlkeld, 1727). Edlin (1956) reported that juniper timber and twigs make good kindling. Juniper foliage was also used for kindling in Ireland (Wyse Jackson, 1994). Furthermore, there was a tradition in central Europe of burning juniper berries in houses three days prior to Beltane (the mid-point between spring equinox and summer solstice) to purify the house and welcome summer (Frazer, 1922). In Scotland, juniper wood was burned in houses and outbuildings at New Year to purify the buildings and their inhabitants (MacNeill, 1968). In Norway, juniper branches are still used at funerals and in houses to protect against evil spirits (Folkard, 1892). Juniper and broom *(Cytisus* sp.) were burnt on Lenten (the first day of Lent) fires in Belgium, probably for fumigation purposes (MacCoitir, 2003). In Tudor and Elizabethan times, twigs were strewn across floors to disinfect rooms while the air in Queen Elizabeth I's bedchamber was sweetened using juniper (Miles, 1999).

Culinary uses

The most well-known culinary use for juniper berries is for flavouring gin and it is the oils found in the berries that gives gin its distinctive aroma. The name gin derives from the French word *genievre*, which in turn derived from the name *juniperus* (Miles, 1999). A juniper-based spirit was first produced in Holland in the mid-16th century, whilst production of the gin we are familiar with today commenced in England in the late 17th century, which is when the so-called 'gin epidemic' began (Anon, 2010f). Excessive gin consumption led to social problems; it was estimated that the average Londoner consumed 14 gallons of gin per year (Anon, 2010e). This resulted in record levels of public drunkenness and begging for gin money; consequently, it became known as 'Mother's Ruin' (Anon, 2010e). This epithet could be attributed equally to its abortificient qualities or to the fact that women drank excess amounts and subsequently neglected their children, as depicted in Hogarth's famous work, *Gin Lane* (Hogarth 1751).

The gin industry in Ireland dates back to 1798, when apprentice distiller William Caldwell first produced Cork Dry Gin at Watercourse Distillery, using imported botanicals, which arrived at Cork harbour (Anon, 2010c). Edlin (1956) records that the cones were once gathered in quantity around Inverness, Scotland, for gin making. However, berries are now sourced from Eastern Europe (Miles, 1999), particularly Hungary (Grieve, 1976) and from Tuscany for premium quality Cork Crimson Gin (Anon, 2010c).

According to herbalists, juniper oil instils a depressant effect in gin, which possibly explains the old wives' tale that gin brings on depression and perhaps also explains its use as a sedative in ancient Greece and Arabia (Hallowell, 1996). Juniper seeds provide a peppery sauce and can be added to casseroles, marinades and stuffing (Wyse Jackson, 1994). The flavour complements pork, rabbit, venison, beef and duck and a range of savoury and dessert recipes (Anon, 2010d). An alcoholic beer-like beverage known as 'genevrette' was made from barley *(Hordeum* sp.) and juniper berries in France (Loudon, 1844) and in Scandinavia, a juniper-flavoured beer is produced, which is regarded as a health drink (Grieve, 1976).

Other cultural uses and significance

The earliest record of juniper timber utilisation was by Pliny, who suggested that the timber was useful for vine props (Pliny, AD77-79c) and also stated that the beams in the Temple of Diana in Spain were constructed from juniper (Pliny, AD77-79d). It was reported by Larsen (1991) that juniper rope and juniper wickerwork were found by archaeologists in the Faroe Islands dating back to AD850, together with a plate made of pine, but repaired with juniper. Timber from the shrub was also used by the Faroe islanders as fuelwood (Larsen, 1991). Juniper was reported as being excellent for cupboard and wardrobe linings, as it deterred moths and it was also useful for pencils (when straight-grained and knot-free) and for fence posts (Boulton & Jay, 1947). Polunin (1976) described the wood as durable, with a delicate and lasting fragrance and reported that it was used for making small objects; for example, small bowls or the handles of dirks (Edlin, 1956). Indeed, it is still possible to buy small artefacts, such as knives and pot stands, crafted from juniper (Anon, 2010a). Juniper was also fashionable as a garden plant from the 17th century, utilised as a topiary shrub. The brother of the famous diarist John Evelyn (1620-1706) formed an arbour from a single tree, under which three people could be seated (Loudon, 1844; Miles, 1999). Juniper is still popular as a garden plant, with most garden centre and nurseries stocking as least one species (Cooper, pers. Obs).

Under early Irish law, there were penalties for the destruction of juniper, which was regarded as a member of the 'lower divisions of a wood' (MacCoitir, 2003). Base-cutting of a shrub resulted in the fine of a two-year-old heifer (*colpthach*) whilst a fine of a year-old heifer (*dairt*) was the penalty for total removal. Colgan (1893) tells of a juniper shrub on the Irish island of Inisheer (one of the Aran Islands, Co. Galway), which had been severely decimated as a result of its use as a representation of an emblematic palm on Palm Sunday. It was employed as a substitute for yew which was more traditionally used, but was not found on the islands (Colgan, 1893). Miles (1999) reported that it was thought to be unlucky to cut down a juniper tree as the perpetrator would die within a year and MacCoitir (2003) associated this belief with Welsh superstition.

Juniper has been used in place names; for example, Juniper Hill is a road in Glenrothes, Scotland, an elevation near Portrush, Northern Ireland and a small hamlet in Oxfordshire, the latter being immortalised in Flora Thompson's *Lark Rise to Candleford* (Mabey, 1998). Indeed, a solitary juniper shrub still exists outside what used to be the Fox Inn (referred to as the Waggon and Horses in *Lark Rise to Candleford*), and the shrub is probably a relic of a previous population (Mabey, 1998). There is an area named Juniper Green in Edinburgh and a village named Juniper in Northumberland.

Juniper in literature

In what is possibly the most gruesome of the fairy tales by The Brothers Grimm is *The Juniper Tree*, which tells of a pregnant woman who ate juniper berries; these induced illness and she only lived long enough to give birth to a son. She was buried beneath a juniper bush in the garden and after a period of mourning the boy's father remarried and a daughter was born. The avaricious stepmother became jealous and sought to gain all of the father's wealth for her daughter. She first physically abuses and then kills her stepson by beheading him with the lid of a chest as he chose an apple from within and feeds his flesh in the form of a soup to his father. His half-sister collected his bones and buried them with his mother beneath the juniper bush. The bush mysteriously burst into flames and a bird flew from the flaming bush, revealing the story of his murder via song throughout the countryside and finally kills his stepmother by dropping a millstone onto her head. He was then transformed back into a boy who returned to live with his father (Skinner, 1911); however, no mention was made of his half-sister, or whether everyone lived happily ever after.

In 7th century Ireland, the hermit, Marbán, wrote a poem relating the flora and fauna of his natural surroundings and told of the fruits that nourished him, which included juniper berries (MacCoitir, 2003).

A poem entitled *The Juniper Tree* tells of a 'bent and broken shrub' and is used as an analogy to the author's childhood, damaged as a result of her father's alcoholism, which (somewhat ironically) resulted from his alleged gin addiction (Leeder, 2010).

European juniper folklore

Italians believed that juniper was dedicated to the Virgin Mary; they considered that it was juniper which acted as the saviour for Mary, Joseph and Jesus. Thus the species was seen as 'a symbol of succour or an asylum' as a result of its provision of refuge and sanctuary (Folkard, 1892). As a result of juniper acting as a saviour, Mary is alleged to have given the shrub her blessing, which invested the species with the power of despatching evil spirits and destroying the powers of magicians (Friend, 1883).

The juniper was reputed to serve as a thief-catcher; a young juniper was bent towards the earth and held down with two weights; a big stone and the brain-pan (skull) of a murderer. The following words were spoken: 'juniper, I [will] bend and squeeze you till the thief (name) returns what he has taken, to its place'. The thief is allegedly seized with a compulsion to return that which he stole and you may then release the tree from its constraints (Skinner, 1911).

Greeks regarded juniper as 'a tree of the Furies' (the three goddesses of vengeance) and its berries were burned at funerals to ward off demons and protect the departing spirit; its green roots were smoked as incense on 'offerings to the god of hell' (Skinner, 1911, Loudon, 1844). Medea, one of the three classical witches in ancient Greece, was 'specially cognisant' of a number of herbs, one of which was juniper, and as result it was 'persistently sought' by witches through the ages (Folkard, 1892).

More recently, throughout Europe, juniper sap was smeared over dwellings and stables to keep off evil spirits (Skinner, 1911) and the burning of juniper was also believed to ward off witches and demons, a practice which was still conducted as recently as the mid-19th century in Europe (Loudon, 1844). Stable buildings in Italy are 'preserved from the power of demons and thunderbolts' by a sprig of juniper (Friend, 1883).

It is reported that rosemary and thyme were burnt with juniper for the dual purpose of warding off witches and bad spirits and cleaning the air in sick rooms (Anon, 2010g).

In central Europe, juniper berries and rue are used to clean and fumigate houses during the last three days of April (Frazer, 1922), perhaps in preparation for Beltane celebrations.

British and Irish juniper folklore

The festival of Beltane (the mid-point between spring and summer equinoxes, but usually celebrated on Mayday) was seen as a time of saining (making a cross as a blessing or protection against evil) and whilst rowan was seen as the great protector, juniper was sometimes substituted and hung above doors and windows (McNeill, 1959). At Hogmanay, juniper was burned in byres and houses in the highlands of Scotland, as part of a saining rite (McNeill, 1961). In addition, a 'juniper and water rite' was conducted; juniper was collected after sunset on Hogmanay and dried overnight. 'Magic water' was drawn from 'the dead and living ford' in a pitcher, from which each household member drank; the remaining water was sprinkled on the beds. Then, all windows and doors were sealed and the dried juniper set alight and carried throughout the house, so the fumes could purify the building (McNeill, 1961).

Juniper is reputed to be potent when dreamt about; whilst it is considered unlucky to dream of the shrub itself, particularly when unwell, dreaming of collecting berries, especially in winter, suggests prosperity. Dreaming of berries also indicates that personal importance and 'great honours' will happen, but if married, it was seen as a prediction of the birth of a son (Thistleton-Dyer, 1889).

In Scotland, juniper was believed to have protective powers; when a branch was placed before cattle or attached to their tails it afforded protection against witches; no house in which juniper was placed would take fire. However, shrubs had to be harvested in a certain manner; they had to be held by the roots, with branches put into four bundles, which were placed between four fingers and thumb; presumably their protective powers were thought to be less efficacious if harvested incorrectly. The following charm was recited whilst shrubs were collected (mountain yew is a name for juniper in Scotland):

> *'I will pluck the bounteous yew**
> *Through the five bent ribs of Christ*
> *In the name of the Father, the Son and Holy Ghost*
> *Against drowning, danger and confusion'* (MacCoitir, 2003).

According to Irish mythology, juniper is linked with wind, and the combination of the two corresponds with the west, the direction which is associated with death, magic and wisdom (MacCoitir, 2003); as most juniper populations in Ireland are located in the west, this could possibly explain how the link arose in Ireland.

Discussion

We provide a substantial body of historical evidence for the cultural, medical, veterinary and culinary significance and, to a lesser degree, economic importance of juniper throughout the Middle East, Europe and particularly Great Britain and Ireland. The uses of juniper were practical and medicinal, as a panacea for all ills, an enduring religious emblem and as a symbol to ward off evil. Whilst many of its medicinal properties are likely to be erroneous or over-exaggerated, it is still used by aromatherapists and herbalists as an antioxidant and stimulant and is readily available as an essential oil and as dried berries (F.M. Cooper, pers. Obs.). Consequently, its varied therapeutic properties should not be overlooked. Neither should its many culinary applications, both in food and beverages.

Despite its obvious importance, juniper is notably absent from the Celtic Tree Calendar and there are two possible reasons for this. Firstly, it may have been omitted to avoid confusion with the yew, as the Irish names for yew translate to rock yew, mountain yew and ground yew (MacCoitir, 2003). Secondly, it is perhaps due to its status as a shrub rather than as a tree, even though it can grow to 8m tall in its upright form. This may also be the reason why the shrub does not feature strongly in British or Irish folklore.

We suggest that juniper's cultural significance and historical uses are just as important for contemporary conservation as its current ecological status. It is an attractive garden shrub, with growth forms to suit most garden types and its timber can be utilised for small artefacts, produced by artisanal craft, and could be used to re-engage the interest of the public. *Ex situ* conservation measures, such as the provision of clone banks, which would have the additional benefit of preserving rare genotypes, could also be implemented to supply not only gardeners but also population supplementation or reintroduction schemes. Conservation strategies, notably those dealing with species not necessarily perceived as charismatic, for example, woody plants, would benefit from a multidisciplinary approach and we propose that cultural history is an area frequently overlooked.

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Appendix II – Population genetics

Restricted gene flow in fragmented populations of a wind-pollinated tree: a case study using Juniper in Ireland

Provan, J., Beatty, G.E., Hunter, A.M., McDonald, R.A., McLaughlin, E. **Preston, S.J.**, Wilson, S. (2008) Restricted gene flow in fragmented populations of a wind-pollinated tree. *Conservation Genetics* 9: 1521-1532.

Abstract

Fragmentation of natural populations can have negative effects at the genetic level, thus threatening their evolutionary potential. Many of the negative genetic impacts of population fragmentation can be ameliorated by gene flow and it has been suggested that in wind-pollinated tree species, high or even increased levels of gene flow are a feature of fragmented populations, although several studies have disputed this. We have used a combination of nuclear microsatellites and allele-specific PCR (AS-PCR) analysis of chloroplast single nucleotide polymorphisms (SNPs) to examine the levels and patterns of genetic diversity and population differentiation in fragmented populations of juniper (Juniperus communis) in Ireland and inform conservation programs for the species. Significant population differentiation was found for both chloroplast and nuclear markers, indicating restricted gene flow, particularly over larger geographic scales. For conservation purposes, the existence of genetically distinct clusters and geographically localised chloroplast haplotypes suggests that the concept of provenance should be taken into account when formulating augmentation or reintroduction strategies. Furthermore, the potential lack of seed dispersal and seedling establishment means that ex-situ approaches to seed and seedling management may have to be considered.

Introduction

Habitat loss and fragmentation is one of the greatest threats to global biodiversity (Wilcox and Murphy 1985; Saunders et al. 1991). The potentially deleterious ecological effects of fragmentation on species and communities include changes in resource availability, reduction in population numbers and loss of connectivity leading to population isolation. Within species, fragmentation of natural populations can have negative effects at the genetic level, thus threatening their evolutionary potential (Young et al. 1996). Theoretical and empirical population genetic studies have predicted that fragmentation will lead to a loss of genetic diversity due to inbreeding (Keller and Waller 2002), population isolation and restricted gene flow (Schaal and Leverich 1996; Couvet 2002) and small effective population sizes (Ellestrand and Elam 1993) and that these may lead to a decline in fitness or even, ultimately, extinction (Newman and Pilson 1997; Frankham and Ralls 1998; Keller and Waller 2002).

Many of the negative genetic impacts of population fragmentation can be ameliorated by gene flow (Allendorf 1983). In tree species, which are generally believed to harbour high levels of within-population genetic diversity, studies on impacted populations have yielded conflicting results regarding the effects of fragmentation. It has been suggested using both direct and indirect estimates of gene flow that the removal of potential physical barriers to pollen movement allows for high or even increased levels of gene flow in wind-pollinated tree species (Foré et al. 1992; White et al. 2002; Dick et al. 2003; Bacles et al. 2005) but other studies have suggested that this is not always the case (Sork et al. 2002; Koenig and Ashley 2003; Jump and Peñuelas 2006).

In this study, we have examined the genetic diversity in fragmented populations of juniper (*Juniperus communis*) in Ireland. Coniferous trees are generally highly heterozygous, outbreeding and wind-pollinated, and thus should exhibit high levels of intrapopulation genetic diversity but low levels of genetic differentiation between populations. Information on the genetic diversity of extant juniper populations and how this diversity is partitioned is important for conservation purposes, since many extant populations exhibit a highly fragmented distribution. This is exemplified by the distribution of juniper in Ireland, where the majority of populations are restricted to the extreme western regions of the island (Figure 1). The species is one of only three native conifers in Britain, the others being yew (*Taxus baccata*) and Scots pine (*Pinus sylvestris*), and one of only two in Ireland since natural populations of Scots pine became extinct on the island several hundred years ago (Bradshaw & Browne 1987). Juniper exhibits a variety of morphological forms ranging from prostrate and creeping to erect, tree-like shrubs and two subspecies, ssp. *communis* and ssp. *nana*, are currently believed to exist in the UK, although previous molecular and biochemical analyses failed to discriminate between the two (Vines 1998; Filipowicz et al. 2006). Plants are dioecious, with wind-pollinated female cones, or "berries", producing seeds that are primarily dispersed by birds. Despite the potential for high levels of dispersal of both pollen and seeds, the species has shown a serious reduction in distribution across the UK and Ireland and populations are believed to have declined by up to 60% since 1960 (Ward 1973; Preston et al. 2002; Thomas et al. 2007). This decline can be attributed to a wide range of factors including climate change, intensification of agriculture, especially grazing, and urbanisation (Clifton et al. 1997; Sanz-Elorza et al. 2003; Verheyen et al. 2005). Recruitment levels appear to be low, with a recent survey of juniper in Northern Ireland finding an age structure highly skewed towards mature and old trees with very little evidence of berries

(Preston et al. 2007). As a consequence of population decline, juniper is protected under Section 8 of the Wildlife and Countryside Act in Britain and corresponding legislation in Northern Ireland.

The aims of the present study were to use biparentally inherited nuclear markers and paternally inherited chloroplast markers (Neale and Sederoff 1989; Neale et al. 1992; Wagner 1992) to elucidate the levels and patterns of genetic diversity in juniper in Ireland to inform conservation and management strategies. We utilised a combination of nuclear microsatellites and a cheap, high-throughput method of analysing single nucleotide polymorphisms (SNPs) in the chloroplast genome to assess the effects of gene flow patterns in shaping the present-day genetic architecture of extant juniper populations throughout its known Irish range.

Materials and methods

Sampling and DNA extraction

Samples were obtained from 19 populations in 12 regions representing the majority of the distribution of juniper in Ireland (Table 1). Where sample numbers within populations are small, these reflect small numbers of accessible plants. Samples were stored at -20 ^{o}C and DNA was extracted from needle tissue using the Qiagen DNeasy Plant Mini Kit, after an initial 8 min grinding at 30 Hz using a Retsch MM300 mixer mill. DNA was quantified visually on 1% agarose gels stained with ethidium bromide and diluted to a concentration of 50 ng μl^{-1} for subsequent PCR.

Nuclear microsatellite analysis

All samples were genotyped for nuclear microsatellite loci JC16, JC32 and JC35. Primer sequences and PCR protocols are given in Michalczyk et al. (2006). The other two primers described in the same paper, JC31 and JC37, could not be reliably amplified and thus were not used in the present study. PCR was carried out on an MWG thermal cycler in a total volume of 10 μl containing 100 ng genomic DNA, 10 pmol of ^{32}P-end labelled forward primer, 10 pmol of reverse primer, 1x PCR reaction buffer (5 mM Tris-HCl [pH9.1], 1.6 mM $[NH_4]_2SO_4$, 15 μg/μl BSA), 2.5 mM $MgCl_2$ and 0.5 U *Taq* polymerase (Genetix). Products were resolved on 6% denaturing polyacrylamide gels containing 1X TBE and 8 M urea after addition of 10 μl of 95% formamide loading buffer. Gels were run at 70 W constant power for 2 h, transferred to 3MM Whatman blotting paper and exposed to Xray film overnight at -20 ^{o}C. In all cases, previously analysed samples were included as controls to compare product sizes across gels.

Table 1 Locations of sampled sites and sample numbers

Region	Population	Code	Grid Ref.	*n*
Fanad Head, Co. Donegal	Fanad Head	FAN	C 235 458	22
Portnoo, Co. Donegal	Portnoo	PNO	B 696 000	20
Monawilkin, Co. Fermanagh	Monawilkin	MON	H 090 535	22
Cuilcagh, Co. Fermanagh	Marlbank	MAR	H 093 359	13
	Trien	TRI	H 151 335	14
	Brookfield	BRO	H 145 334	14
	Gortmaconnell Rock	GOR	H 132 335	21
Mournes, Co. Down	The Castles	CAS	J 344 280	32
	The Gully	GUL	J 345 279	8
	Annalong River	ANN	J 343 265	19
Rosses Point, Co. Sligo	Rosses Point	ROS	G 629 403	10
Curraun, Co. Mayo	Curraun	CUR	L 769 924	11
Moycullen, Co. Galway	Moycullen	MOY	M 191 406	5
Ardrahan, Co. Galway	Ardrahan	ARD	M 459 154	10
Lough Derg, Co. Tipperary	Commons of Carney	CAR	R 873 919	7
	Portumna Forest Park	PMN	M 851 037	10
Barrigone, Co. Limerick	Barrigone	BAR	R 295 507	10
Cappul Bridge, Co. Cork	Cappul Bridge	CAP	V 691 558	34
	Cleanderry Wood	CLE	V 662 555	14
Total n =				**309**

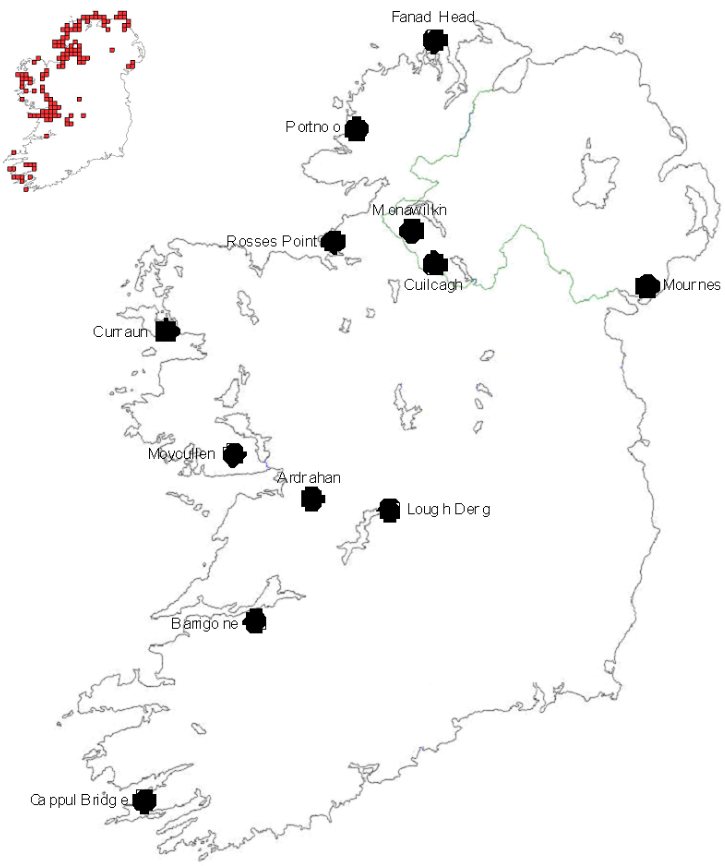

Fig. 1 Map showing locations of populations sampled. Inset map shows distribution of juniper in Ireland.

Chloroplast single nucleotide polymorphism allele-specific PCR (SNP AS-PCR) analysis

An initial screen for chloroplast variation was carried out using a single individual from each of the populations studied (Table 2). The following eight regions were analysed: *trn*T-*trn*F (Taberlet et al. 1991); *trn*D-*trn*T, *psb*C-*trn*S (Demesure et al. 1995); *atp*H-*atp*I, *atp*I-*rpo*C2, *pet*B-*pet*D (Grivet et al. 2001); *trn*V intron (Wang et al. 2003); *trn*G-*trn*S (Zhang et al. 2005). PCR was carried out on a MWG Primus thermal cycler using the following parameters: initial denaturation at 94 ^{o}C for 3 min followed by 35 cycles of denaturation at 94 ^{o}C for 1 min, annealing at 55 ^{o}C for 1 min (48 ^{o}C for *pet*B-*pet*D), extension at 72 ^{o}C for 2 min and a final extension at 72 ^{o}C for 5 min. PCR was carried out in a total volume of 20 µl containing 200 ng genomic DNA, 20 pmol of forward primer, 20 pmol of reverse primer, 1x PCR reaction buffer (7.5 mM Tris-HCl [pH9.0], 2.0 mM $[NH_4]_2SO_4$, 5.0 mM KCl, 2.0 mM $MgCl_2$) and 2.0 U BIOTOOLS DNA polymerase. 5 µl PCR product was resolved on 1.5% agarose gels and visualised by ethidium bromide staining and the remaining 15 µl sequenced commercially (Macrogen, Korea). Sequences were aligned using the CLUSTALW program in the BioEdit software package.

To facilitate inexpensive, large-scale genotyping of single nucleotide polymorphisms (SNPs), mutations detected in the chloroplast sequences were converted into allele-specific PCR (AS-PCR) primer sets. These mainly used the nested competitive primer approach of Soleimani et al. (2003) but a pair of specific PCR primers was also used to screen for length variation in the *trn*T-*trn*D region using standard PCR. For nested competitive primer design, the selective primer was designed so that the 3′ nucleotide of the primer was the SNP position and had an annealing temperature of 58 ^{o}C. Compatible flanking primers, also with annealing temperatures of 58 ^{o}C , were designed approximately 100 bp upstream and downstream of the SNP. In total, five SNPs were assayed in all samples using these approaches (Table 2). The AS-PCR protocol was as follows: initial denaturation at 94 ^{o}C for 3 min followed by 11 touchdown cycles of denaturation at 94 ^{o}C for 60 s, annealing at 65 ^{o}C for 60 s (-0.7 ^{o}C per cycle), extension at 72 ^{o}C for 60 s followed by 24 cycles of denaturation at 94 ^{o}C for 60 s, annealing at 58 ^{o}C for 60 s, extension at 72 ^{o}C for 60 s and a final extension at 72 ^{o}C for 5 min. PCR was carried out in a total volume of 10 µl containing 100 ng genomic DNA, 10 pmol of forward primer, 10 pmol of reverse primer, 10 pmol SNP-selective primer, 1x PCR reaction buffer (5 mM Tris-HCl [pH9.1], 1.6 mM $[NH_4]_2SO_4$, 15 µg/µl BSA), 200 µM each dNTP, 2.5 mM $MgCl_2$ and 0.5 U *Taq* polymerase (Genetix). The *trn*T-*trn*D PCR protocol was as follows: initial denaturation at 94 ^{o}C for 3 min followed by 35 cycles of denaturation at 94 ^{o}C for 30 s, annealing at 58 ^{o}C for 30 s, extension at 72 ^{o}C for 30 s and a final extension at 72 ^{o}C for 5 min. For both assays, PCR products were resolved on a 2% agarose gels and visualised by ethidium bromide staining.

Table 2 Juniper chloroplast SNP allele-specific PCR (AS-PCR) primers

Name	Region	SNP	Flanking primers	Selective primer
IC-61	*atp*I – *rpo*C2	C → G	GCGAGTTTTCAAGAAACTGCTCG ATTTCAAGAAAAAATCTTTCACTT	TTTCGGATCTATTTTACTCCC
VV-435	*trn*V intron	T → G	ATCTATATATTATGAACCGAATG CTAAATTCTAGGCATAATTAGAC	GAAAGTGATCTATTTTATTAGTC
VV-449	*trn*V intron	A → C	Same as VV-435 Same as VV-435	ATCATCTTGACAGAAAGTGAG
BD-616	*pet*B – *pet*D	C → T	GGGAAATGCATGCATTTTCAT CAGATCGAAATGTGTCTCTGT	AAGAGAATTATTTCTATGATCA
TD	*trn*T – *trn*D	2 x 20 bp indels	GTAATAGAGAAAGAATCGGAA GCCGGGTCGTATTTTGAA	No selective primer – indel mutations

Data analysis

Nuclear microsatellite allele sizes were scored using a 10 bp ladder and were checked by comparison with previously sized control samples. Levels of polymorphism measured as allelic richness (A_R) and expected heterozygosity (H_E) were calculated using the FSTAT software package (V2.9.3.2; Goudet 2001) and the POPGENE software package (V1.32; Yeh et al. 1997) respectively. Polymorphisms at the five chloroplast SNPs were combined to give multi-locus haplotypes. For both nuclear and chloroplast markers, interpopulation differentiation and differentiation between regions (see Table 1) were estimated from allele and haplotype frequencies using Φ-statistics, which give an analogue of *F*-statistics (Weir and Cockerham 1984) calculated within the analysis of molecular variance (AMOVA) framework (Excoffier et al. 1992), using the ARLEQUIN software package (V3.01; Excoffier et al. 2005). To facilitate comparisons with future studies, we also calculated a standardized value of population differentiation, $F'_{ST(N)}$, from the nuclear microsatellite data set, as this statistic is independent of the levels of variation detected within populations (Hedrick 2005). Population pairwise estimates of gene flow based on nuclear microsatellites were calculated using the private alleles method (Slatkin 1985; Barton and Slatkin 1986) as implemented in the GENEPOP software package (V3.4; Raymond and Rousset 1995). Population pairwise F_{ST} values were also calculated using GENEPOP and significance of population differentiation was estimated using the genic differentiation option in GENEPOP after sequential Bonferroni correction for multiple tests. To further identify possible spatial patterns of gene flow, the software package BAPS (V3.2; Corander et al. 2003) was used to identify clusters of genetically similar populations using a Bayesian approach. Ten replicates were run for all possible values of the maximum number of clusters (K) up to $K = 19$, the number of populations sampled in the study, with a burn-in period of 10,000 iterations followed by 50,000 iterations. Multiple independent runs always gave the same outcome. Finally, a test for isolation by distance (IBD; Rousset 1997) was carried out using a Mantel test to assess the relationship between genetic distance, measured as $F_{ST}/(1- F_{ST})$, and geographical distance in GENEPOP.

Results

Levels of within-population genetic variation

The three microsatellite loci used in this study were moderately to highly polymorphic, with numbers of alleles ranging from eight (JC16) to 35 (JC32). Within-population levels of expected heterozygosity averaged across loci ranged from 0.460 in the ROS population to 0.765 in the PNO population (Table 3). Levels of allelic richness averaged across loci ranged from 2.733 in the MOY population to 4.265 in the PNO population.

Analysis of a total of 4,735 bp of sequence from eight regions of the chloroplast genome in one individual per population revealed only four substitutions and two indel mutations (Table 2). AS-PCR analysis of these mutations in the complete sample gave rise to six haplotypes (Figure 2). All populations were variable and within-population chloroplast diversity values ranged from 0.200 in the BAR population to 0.600 in the MOY population (Table 4).

Population structuring and levels of gene flow

The analysis of molecular variance (AMOVA) revealed significant differences between populations for both nuclear ($\Phi_{ST(N)} = 0.0957$; $P < 0.001$) and chloroplast ($\Phi_{ST(C)} = 0.2491$; $P < 0.001$) markers (Table 5). The standardised estimate of population differentiation based on nuclear microsatellite markers, $F'_{ST(N)}$, was 0.429. The three-level AMOVA suggested that the majority of between-population variation for nuclear markers was due to differences between regions ($\Phi_{CT(N)} = 0.0755$; $P < 0.001$) but that between-region differentiation was not a significant factor for chloroplast markers ($\Phi_{CT(C)} = 0.0526$; NS). Despite this, there was evidence of some geographical substructuring of chloroplast haplotypes: Haplotype 3 was found only in the three populations from the Mournes area in the northeast (CAS, GUL and ANN), Haplotype 4 was restricted to the far northwest populations (FAN and PNO) and Haplotype 6 was only found in one population (CAP) from the far southwest.

Table 3 Nuclear microsatellite diversity statistics: A_R – allelic richness; H_E – expected heterozygosity.

Population	**Locus**						**Mean**	
	JC16		**JC32**		**JC35**			
	AR	***HE***	***AR***	***HE***	***AR***	***HE***	***AR***	***HE***
FAN	1.643	0.172	5.524	0.881	4.362	0.794	3.843	0.615
PNO	3.392	0.704	5.812	0.904	3.591	0.686	4.265	0.765
MON	2.670	0.429	4.953	0.836	4.049	0.763	3.891	0.676
MAR	2.452	0.351	4.353	0.735	2.372	0.397	3.059	0.494
TRI	2.221	0.319	5.356	0.873	3.377	0.686	3.651	0.626
BRO	1.783	0.204	5.409	0.878	2.664	0.554	3.285	0.546
GOR	1.863	0.257	4.976	0.841	3.286	0.627	3.375	0.575
CAS	1.882	0.232	5.190	0.866	2.474	0.562	3.182	0.553
GUL	1.500	0.125	5.776	0.901	1.987	0.458	3.088	0.495
ANN	2.308	0.366	4.318	0.791	1.948	0.413	2.858	0.523
ROS	1.000	0.000	4.655	0.842	2.749	0.537	2.801	0.460
CUR	2.833	0.515	5.796	0.896	3.427	0.710	4.019	0.707
MOY	2.800	0.600	3.400	0.533	2.000	0.429	2.733	0.521
ARD	3.399	0.706	3.186	0.549	3.631	0.621	3.405	0.625
CAR	2.670	0.484	5.356	0.889	2.979	0.714	3.668	0.696
PMN	2.453	0.363	5.186	0.863	2.550	0.484	3.396	0.570
BAR	1.889	0.216	4.927	0.843	4.284	0.817	3.700	0.625
CAP	2.981	0.571	4.861	0.839	4.176	0.780	4.006	0.730
CLE	2.128	0.362	5.103	0.865	3.207	0.712	3.479	0.646
Mean	**2.309**	**0.367**	**4.955**	**0.822**	**3.111**	**0.618**	**3.458**	**0.602**

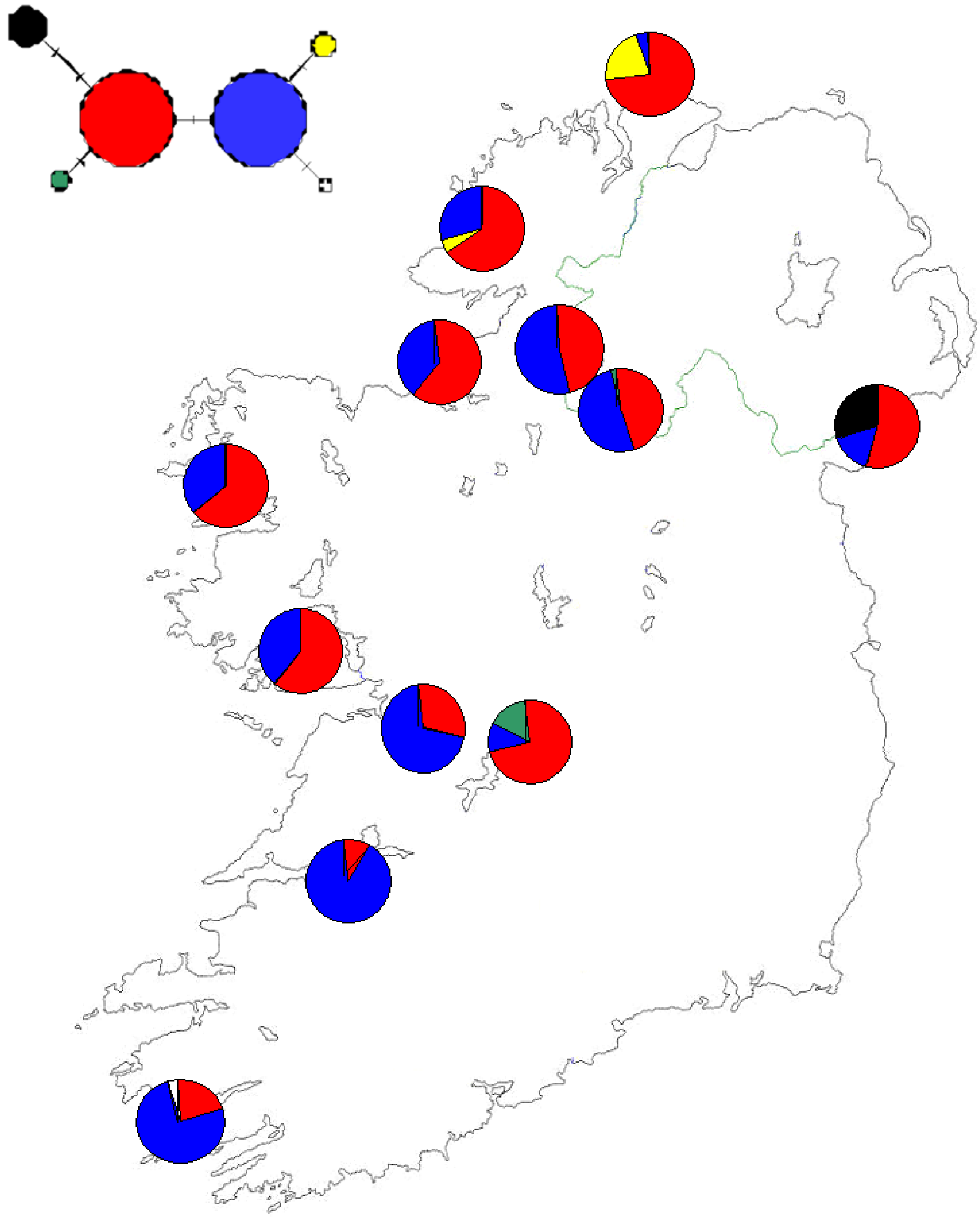

Fig. 2 Distribution of chloroplast AS-PCR haplotypes.

Table 4 Distribution and frequency of chloroplast AS-PCR haplotypes. H – gene diversity.

Population	**Haplotype**						***H***
	1	**2**	**3**	**4**	**5**	**6**	
FAN	0.727	0.046	-	0.227	-	-	0.437
PNO	0.650	0.300	-	0.050	-	-	0.511
MON	0.455	0.545	-	-	-	-	0.520
MAR	0.154	0.769	-	-	0.077	-	0.410
TRI	0.294	0.647	-	-	0.059	-	0.522
BRO	0.357	0.643	-	-	-	-	0.495
GOR	0.882	0.118	-	-	-	-	0.221
CAS	0.656	0.188	0.156	-	-	-	0.526
GUL	-	0.250	0.750	-	-	-	0.557
ANN	0.579	0.053	0.368	-	-	-	0.429
ROS	0.600	0.400	-	-	-	-	0.533
CUR	0.636	0.364	-	-	-	-	0.509
MOY	0.600	0.400	-	-	-	-	0.600
ARD	0.300	0.700	-	-	-	-	0.467
CAR	0.571	-	-	-	0.429	-	0.571
PMN	0.800	0.200	-	-	-	-	0.356
BAR	0.100	0.900	-	-	-	-	0.200
CAP	0.147	0.794	-	-	-	0.059	0.355
CLE	0.357	0.643	-	-	-	-	0.495

Table 5 Analysis of molecular variance (AMOVA)

Genome	**Source of variation**	**d.f.**	**Variance components**	**Percentage of variation**	**Fixation indices**
Nuclear	Between populations	18	0.0939 Va	9.57	Φ_{ST} = 0.0957 ***
	Within populations	575	0.8869 Vb	90.43	
	Between regions	11	0.0745 Va	7.55	Φ_{CT} = 0.0755 ***
	Between populations within regions	7	0.0251 Vb	2.54	Φ_{SC} = 0.0275 ***
	Within populations	575	0.8869 Vc	89.91	Φ_{ST} = 0.1009 ***
Chloroplast	Between populations	18	0.0754 Va	24.91	Φ_{ST} = 0.2491 ***
	Within populations	276	0.2272 Vb	75.09	
	Between regions	11	0.0160 Va	5.26	Φ_{CT} = 0.0526 NS
	Between populations within regions	7	0.0606 Vb	19.94	Φ_{SC} = 0.2105 ***
	Within populations	276	0.2272 Vc	74.80	Φ_{ST} = 0.2520 ***

Levels of gene flow between pairs of populations calculated from private alleles at nuclear microsatellite loci ranged from 0.38 (GUL/BAR) to 3.95 (FAN/MON) with a mean value of 1.15 (Table 6) and a global value (i.e. across all populations) of 1.09. Although it has been suggested that calculation of *Nm* values gives an indirect estimate of historical, rather than contemporary, levels of gene flow, the approach has been widely used and comparison with other studies in outcrossing coniferous tree species may be informative (see Discussion). Over half (87 of 171) of the values were less than 1.00, which represents the theoretical threshold for population differentiation due to genetic drift (Wright 1931). 162 of 171 population-pairwise F_{ST} values were significantly different from zero, with values ranging from 0.002 (CAP/CAR) to 0.453 (ROS/CUR) and a mean of 0.103. Six of the nine non-significant F_{ST} values were between populations from the same region. No evidence for isolation by distance was detected.

The BAPS analysis identified nine genetic clusters (Figure 3a). In general, populations from the same region were assigned to the same cluster with the exception of the Lough Derg populations, where the PMN population was assigned to a cluster of its own whereas the CAR population was grouped with the FAN and MON populations. The Voronoi tessellation (Figure 3b) further highlights the spatial organisation of the genetic clusters, with clusters containing multiple populations usually comprising geographically proximal populations. The only exceptions to this are the grouping of the PNO and CUR populations, and the grouping of the CAR, FAN and MON populations as described above.

Table 6 Above diagonal: population pairwise estimates of gene flow (Nm) calculated from nuclear microsatellite data using the private alleles method of Barton and Slatkin (1986). Below diagonal: population pairwise F_{ST} values calculated from nuclear microsatellite data. NS – non-significant F_{ST} value.

	FAN	PNO	MON	MAR	TRI	BRO	GOR	CAS	GUL	ANN	ROS	CUR	MOY	ARD	CAR	PMN	BAR	CAP	CLE
FAN	-	1.71	3.95	2.33	2.42	1.19	2.87	1.60	1.55	1.18	0.90	1.34	0.91	1.46	1.28	0.86	0.94	1.38	0.74
PNO	0.147	-	1.90	0.78	1.35	0.59	1.04	2.45	0.67	1.07	0.82	2.15	0.99	1.35	0.94	1.38	0.72	1.17	1.60
MON	NS	0.124	-	2.44	2.44	1.34	3.28	1.23	1.29	1.36	1.00	1.08	1.04	1.20	1.02	0.79	0.73	0.86	1.01
MAR	0.102	0.199	0.086	-	0.88	1.58	1.54	2.37	0.85	0.77	1.16	1.30	0.84	0.74	0.63	0.94	0.83	0.55	0.44
TRI	0.043	0.111	0.045	0.042	-	1.51	2.80	1.84	0.86	0.98	1.51	1.39	0.78	0.74	1.04	1.39	1.15	0.94	0.66
BRO	0.076	0.187	0.062	0.028	NS	-	2.20	0.82	0.58	0.65	1.58	0.78	1.03	0.96	0.60	1.16	0.79	0.65	0.60
GOR	0.050	0.154	0.041	0.026	NS	NS	-	1.22	1.08	1.09	1.62	1.02	1.39	0.95	1.03	0.97	1.04	0.83	0.66
CAS	0.038	0.186	0.041	0.083	0.075	0.078	0.057	-	2.57	3.22	0.66	1.45	1.01	2.48	1.39	0.70	0.61	0.66	1.01
GUL	0.026	0.203	0.045	0.209	0.136	0.177	0.139	NS	-	3.93	0.47	1.11	0.72	1.07	0.90	0.48	0.38	0.91	0.65
ANN	0.103	0.189	0.096	0.112	0.101	0.087	0.073	NS	NS	-	0.53	1.35	0.72	2.23	0.91	0.68	0.45	0.98	0.56
ROS	0.100	0.214	0.087	0.061	0.040	0.003	0.009	0.088	0.207	0.103	-	0.59	0.71	0.70	0.58	0.80	0.75	0.52	0.42
CUR	0.049	0.061	0.038	0.089	0.033	0.067	0.055	0.032	0.065	0.051	0.453	-	1.29	1.84	1.13	0.91	0.69	0.80	0.84
MOY	0.172	0.167	0.135	0.178	0.143	0.110	0.092	0.137	0.255	0.082	0.141	0.074	-	1.76	0.77	1.03	0.85	1.41	0.45
ARD	0.216	0.115	0.164	0.216	0.178	0.179	0.166	0.187	0.260	0.131	0.203	0.094	NS	-	0.72	1.46	0.52	1.58	0.72
CAR	0.013	0.054	0.023	0.132	0.018	0.095	0.042	0.037	NS	0.055	0.118	NS	0.078	0.124	-	0.79	0.59	1.00	0.77
PMN	0.113	0.140	0.114	0.075	0.039	0.047	0.042	0.074	0.175	0.064	0.065	0.034	0.102	0.145	0.057	-	1.08	0.75	0.63
BAR	0.058	0.146	0.078	0.144	0.059	0.076	0.077	0.124	0.160	0.167	0.118	0.331	0.159	0.216	0.073	0.069	-	0.63	0.46
CAP	0.065	0.104	0.068	0.132	0.058	0.092	0.064	0.086	0.108	0.081	0.111	0.034	0.062	0.094	0.002	0.076	0.081	-	1.24
CLE	0.078	0.068	0.096	0.157	0.059	0.103	0.080	0.094	0.134	0.099	0.120	0.050	0.139	0.166	0.019	0.065	0.098	0.040	-

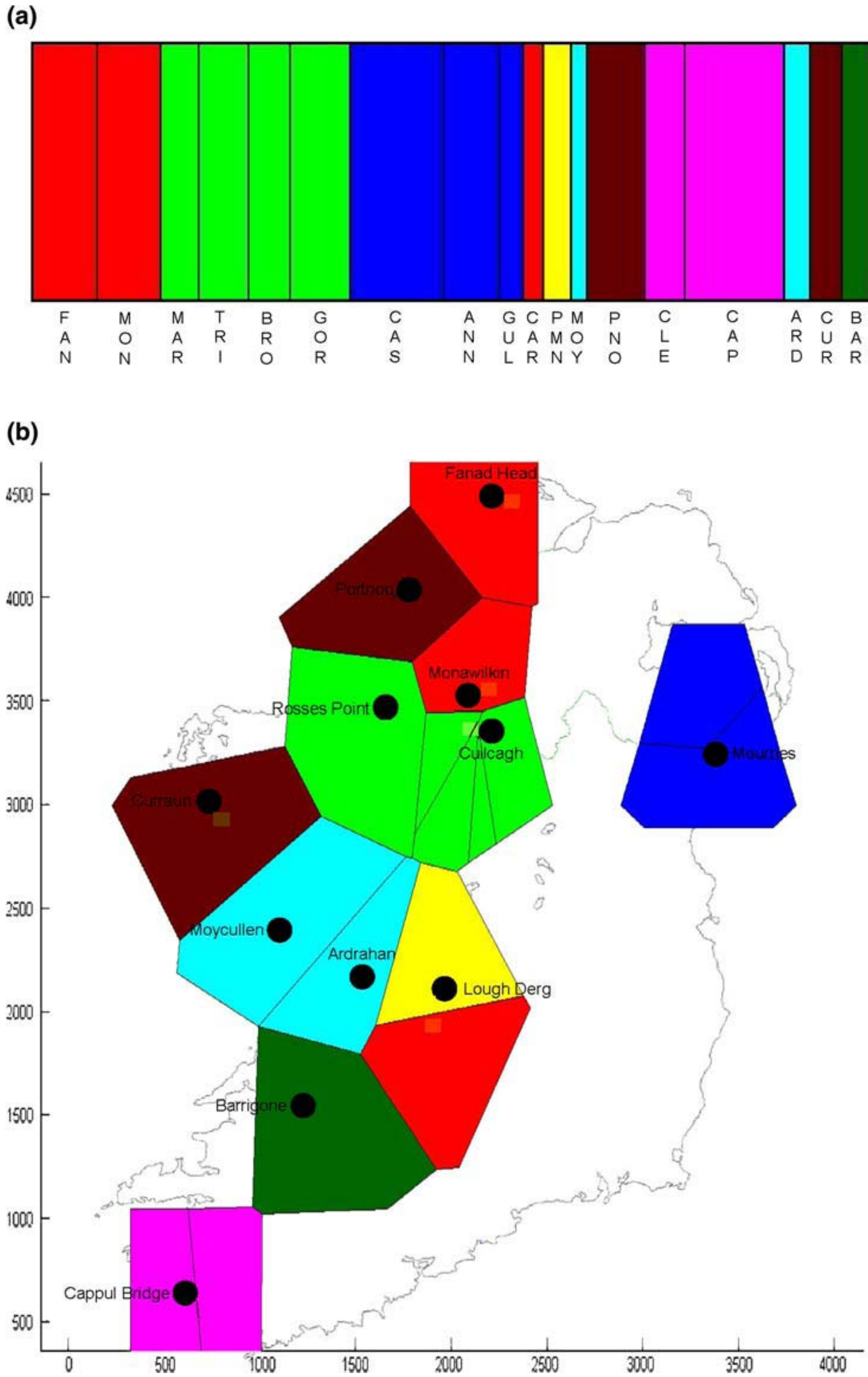

Fig. 3 (a) Colour-coded assignment of populations to nine clusters using the BAPS software package. **(b)** Voronoi tessellation showing spatial organisation of populations in nine clusters delineated by BAPS. Colours as in **(a)**.

Discussion

Allele-specific PCR as a tool for population and conservation genetics

To our knowledge, this represents the first population genetics study to utilise allele-specific PCR (AS-PCR) for high-throughput screening of SNP variation. SNP genotyping techniques range from simple, PCR-based assays that can be resolved on standard agarose gels such as PCR-RFLP, to more complicated methods requiring the use of fluorescently labelled primers and/or dideoxynucleotides and polyacrylamide gel or capillary electrophoresis such as single base extension (SBE) or allele-specific primer extension (ASPE; Morin et al. 2004). Although PCR-RFLP approaches are cheap and technically simple, only a small fraction of SNPs give rise to restriction site changes. Whilst not as amenable to multiplexing as other SNP assays and not as straightforward when applied to diploid nuclear genes, the three-primer AS-PCR technique allows reliable and cost-effective genotyping of organellar SNP variation for large-scale population genetic analyses, particularly where the SNP does not result in a restriction site gain or loss.

Population differentiation and restricted gene flow

Although levels of gene flow in outcrossing, wind-pollinated tree species such as juniper are expected to be high, the findings of the present study are contrary to this. Our value for population differentiation based on nuclear loci ($\Phi_{ST(N)}$ = 0.0957) is slightly higher than the average value for outcrossing gymnosperm species (0.073) quoted by Hamrick and Godt (1996) but slightly lower than the mean value quoted for biparentally inherited markers in conifers (0.116) by Petit et al. (2005). The standardised value of population differentiation, $F'_{ST(N)}$, was much higher (0.429), reflecting the high levels of within-population variation detected by microsatellites. Population differentiation based on chloroplast markers was also high ($\Phi_{ST(C)}$ = 0.2491). Previous studies using chloroplast markers in conifers have tended to find around 10% or less of the total genetic variation partitioned between populations (e.g. Provan et al. 1998 [$\Phi_{ST(C)}$ = 0.032 in *Pinus sylvestris*]; Vendramin et al. 2000 [$R_{ST(C)} \approx 0.1$ in *Picea abies*]; Richardson et al. 2002 [$\Phi_{ST(C)}$ = 0.046 in *Pinus albicaulis*]; Robledo-Arnuncio et al. 2005 [$\Phi_{ST(C)}$ = 0.031 in *Pinus sylvestris*]; Naydenov et al. 2005 [$\Phi_{ST(C)}$ = 0.110 in *Pinus banksiana*], 2006 [$\Phi_{ST(C)}$ = 0.061 in *Pinus nigra*]) and in cases where high levels of population differentiation have been reported, these inflated values tend to be the result of long-term isolation of populations (e.g. Vendramin et al. 1998 [$\Phi_{ST(C)}$ = 0.254 in *Pinus pinaster*]; Jaramillo-Correa et al. 2006 [$\Phi_{ST(C)}$ = 0.295 in *Picea chihuahuana*]). Where data are available for both the nuclear and chloroplast genomes in gymnosperms, as is the case in this study, differentiation between populations is expected to be more marked for chloroplast markers than for nuclear markers (Ennos 1994; Hu and

Ennos 1997, 1999). Empirical studies, however, have generally found comparable levels of differentiation in both classes of markers which have been attributed to the high dispersal capabilities of pollen in conifers (Dong and Wagner 1994; Latta and Mitton 1997; Viard et al. 2001; Ribeiro et al. 2002). In the present study, differentiation based on chloroplast markers ($\Phi_{ST(C)}$ = 0.2491) was much higher than that calculated for nuclear markers ($\Phi_{ST(N)}$ = 0.0957), which is consistent with the action of genetic drift on the smaller effective population size of the uniparentally transmitted, haploid chloroplast genome. The limited dispersal suggested by both the nuclear and chloroplast Φ_{ST} values is also reflected in the BAPS analysis, which delineated nine genetic clusters that are largely congruent with the spatial organisation of populations studied.

To date, there have only been two published population-level genetic studies on *Juniperus communis*. Oostermeijer and de Knegt (2004) used allozymes to assess the levels and distribution of genetic diversity in twelve populations from fragmented heathlands in the Netherlands and found low ($F_{ST(N)}$ = 0.026) levels of population differentiation. In contrast, a study using AFLPs on eight populations from England and Wales suggested a high level of genetic structuring, although summary statistics for population differentiation (e.g. F_{ST} / G_{ST} / Φ_{ST}) were not calculated (van der Merwe et al. 2000). Of particular note, though, is a study on the congeneric *J. przewalskii*, which revealed very high levels of differentiation using chloroplast markers (G_{ST} = 0.772; Zhang et al. 2005). Although no evidence of isolation by distance was evident at the global scale (i.e. across all populations) in the present study, suggesting the predominance of genetic drift over gene flow, individual values for inter-population differentiation and gene flow suggest that there may be adequate gene flow at local scales to prevent population divergence. Six of the nine non-significant pairwise F_{ST} values were between populations from the same geographical region and the average value of Nm between populations from the same region (1.94) was almost double that of the average figure between populations from different regions (1.09). Values of Nm in conifers tend to be much higher, with values of $Nm > 3$ being the norm (Ledig 1998). Although Nm values give an indication of historical gene flow, the decline in juniper populations over the last few hundred years means that these values probably overestimate contemporary levels of gene flow and thus the degree of connectivity between extant populations is even lower. Zhang et al. (2005) reported that field studies on *J. tibetica* revealed no wind-mediated pollen dispersal beyond 2 km and in all six cases in the present study where populations were separated by less than this distance (BRO vs TRI, GOR vs TRI, BRO vs GOR, GUL vs CAS, ANN vs CAS and GUL vs ANN), population-pairwise F_{ST} values were non-significant. Seeds in juniper are primarily dispersed by thrushes of the genus *Turdus* (Livingston 1972, Snow and Snow 1988) but a study on thrush communities in fragmented *Juniperus thurifera* populations has suggested that a decrease in abundance of frugivorous birds from smaller patches of woodland has had a negative impact on dispersal and seedling recruitment (Santos and Telleria 1994; Santos et al. 1999). Taken together, the potentially limited capacity for dispersal within and between fragmented populations via both pollen and seeds may explain the high levels of genetic differentiation found in Irish juniper populations. Ennos (1994) described a method to calculate the relative rates of interpopulation seed and pollen flow using a combination of maternal and biparentally inherited markers. In conifers, this generally uses data from the mitochondrial genome since the chloroplast genome is almost always transmitted paternally, unlike in angiosperms where maternal inheritance of the chloroplast genome occurs in the vast majority of taxa. Such calculations are unlikely to be feasible for the present study, however, since previous evidence suggests that the mitochondrial genome may be paternally inherited in the Cupressaceae, which includes juniper. Neale et al. (1989) described paternal inheritance of mitochondrial DNA in the coast redwood *Sequoia sempervirens* and cytological studies have shown the cytoplasmic inheritance of paternal mitochondria in other members of the Cupressaceae (Camefort 1970; Chesnoy 1973).

Conservation implications

Juniper populations in both the UK and Ireland have been in decline for many years now and one of the goals of the Species Action Plan is to maintain and re-establish natural populations. Information from population genetic studies is now considered an integral part of conservation programmes (Haig 1998) and the findings of this study are particularly relevant to the conservation of juniper in Ireland, where populations tend to be highly fragmented. The relatively high levels of genetic differentiation between populations and the apparent geographical structuring of this variation coupled with the occurrence of geographically localized haplotypes suggest that the concept of provenance should be taken into account when formulating conservation strategies for Irish populations of juniper. One obvious starting point for the designation of distinct management units would be the genetic clusters identified by the BAPS analysis which tend to reflect the limited levels of gene flow at larger geographic scales as described above. Of particular note for conservation purposes are the populations from the Mournes area: the region is geographically distinct and isolated from the remainder of the populations in Ireland, which have a predominantly western distribution, and almost a third (18 of 59) plants studied from this area exhibited an endemic chloroplast haplotype.

One of the main perceived threats to juniper populations is the lack of recruitment from seed (reviewed in Thomas et al. 2007) and establishment of seedlings has been shown to be negatively affected by both grazing (Ward 1973; Gilbert 1980) and climatic factors (Rosen 1988, 1995; Garcia et al. 1999). Overgrazing may present a particular problem to many of the populations examined in this study, particularly those occurring in montane and rough pasture hillsides where effective fencing is problematic. Coastal populations tend to be out of the reach of many grazing animals but their persistence on cliff faces exposes them to windthrow and, consequently, many of these populations comprise limited numbers of stunted trees. These threats to seedling establishment are further exacerbated by low levels of seed viability coupled with limited dispersal. Verheyen et al. (2005) showed that only 3% of seeds collected from a managed nature reserve in Belgium were viable and seed viability may be even more limited for Irish populations, which have an age structure skewed towards mature and old plants, since older stands tend to have lower reproductive capacity (Dearnley and Duckett 1999; Preston et al. 2007). The limited dispersal suggested by the findings of the present study is reflected by field observations which suggest that thrushes responsible for seed dispersal in juniper tend to favour larger, berry-rich populations over smaller, isolated populations even where individual plants within smaller populations produce large numbers of berries (Garcia et al. 2001). Consequently, the small, isolated populations comprising mainly senescent plants examined in this study may be at particular risk of ongoing loss of diversity and extinction. Conservation efforts aimed at the maintenance and reintroduction of these populations may be most effective when ex-situ management of seed and seedlings is implemented.

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Appendix III – Site species frquencies

Site species frequency (tabulated in ascending order)

#	Species	No. of relevés (n)	% occurrence
1	*Acer pseudoplatanus*	1	0.5
2	*Alnus glutinosa*	1	0.5
3	*Arabis hirsuta*	1	0.5
4	*Arum maculatum*	1	0.5
5	*Asperula cynanchica*	1	0.5
6	*Brachythecium rutabulum*	1	0.5
7	*Calystegia sepium*	1	0.5
8	*Cardamine pratensis*	1	0.5
9	*Carex distans*	1	0.5
10	*Carex elata*	1	0.5
11	*Carex flava*	1	0.5
12	*Carex hirta*	1	0.5
13	*Carex paniculata*	1	0.5
14	*Carex vesicaria*	1	0.5
15	*Cirsium arvense*	1	0.5
16	*Cochleria officinalis*	1	0.5
17	*Conopodium majus*	1	0.5
18	*Crocosmia x crocosmiiflora*	1	0.5
19	*Cuscuta epithymum*	1	0.5
20	*Equisetum arvense*	1	0.5
21	*Equisetum telmateia*	1	0.5
22	*Equisetum variegatum*	1	0.5
23	*Eupatorium cannabinum*	1	0.5
24	*Euphorbia hyberna*	1	0.5
25	*Filipendula ulmeria*	1	0.5
26	*Filipendula vulgaris*	1	0.5
27	*Galium aparine*	1	0.5
28	*Galium odoratum*	1	0.5
29	*Gentianella amarella*	1	0.5
30	*Geranium molle*	1	0.5
31	*Heracleum sphondylium*	1	0.5
32	*Honckenya peploides*	1	0.5
33	*Hydrocotyle vulgaris*	1	0.5
34	*Ilex aquilfolium*	1	0.5
35	*Iris pseudacorus*	1	0.5
36	*Juncus inflexus*	1	0.5
37	*Juncus subnodulosus*	1	0.5
38	*Lathyrus pratensis*	1	0.5
39	*Ligustrum ovalifolium*	1	0.5
40	*Lythrum salicaria*	1	0.5
41	*Menyanthes trifoliata*	1	0.5
42	*Ophioglossum vulgatum*	1	0.5
43	*Ophyrys apifera*	1	0.5
44	*Phyllitis scolopendrium*	1	0.5
46	*Populus tremula*	1	0.5
47	*Potentilla palustris*	1	0.5
48	*Potentilla reptans*	1	0.5
49	*Rumex crispus*	1	0.5
50	*Sagina spp.*	1	0.5
51	*Schoenoplectus lacustris*	1	0.5
52	*Scrophularia nodosa*	1	0.5
53	*Senecio aquaticus*	1	0.5

#	Species	No. of relevés (n)	% occurrence
54	*Silene uniflora*	1	0.5
55	*Sorbus aucuparia*	1	0.5
56	*Sorbus spp.*	1	0.5
57	*Stellaria holostea*	1	0.5
58	*Tussilago farfara*	1	0.5
59	*Umbilicus rupestris*	1	0.5
60	*Vaccinium vitis-idaea*	1	0.5
61	*Valeriana officinalis*	1	0.5
62	*Viola palustris*	1	0.5
63	*Alchemilla alpina*	2	1.0
64	*Bromus hordaceous*	2	1.0
65	*Carex caryophylla*	2	1.0
66	*Carex pilulifera*	2	1.0
67	*Cirsium vulgare*	2	1.0
68	*Cladium mariscus*	2	1.0
69	*Coeloglossum viride*	2	1.0
70	*Crepis capillaris*	2	1.0
71	*Dryopteris spp.*	2	1.0
72	*Equisetum fluviatile*	2	1.0
73	*Festuca vivipara*	2	1.0
74	*Hypochaeris glabra*	2	1.0
75	*Juncus bufonius*	2	1.0
76	*Juncus squarrosus*	2	1.0
77	*Phragmites australis*	2	1.0
78	*Pinus spp.*	2	1.0
79	*Plantago major*	2	1.0
80	*Poa trivialis*	2	1.0
81	*Primula veris*	2	1.0
82	*Quercus spp.*	2	1.0
83	*Rhododendron ponticum*	2	1.0
84	*Rubia peregrina*	2	1.0
85	*Salix cinerea*	2	1.0
86	*Sambucus nigra*	2	1.0
87	*Sonchus arvensis*	2	1.0
88	*Veronica chamaedrys*	2	1.0
89	*Veronica officinalis*	2	1.0
90	*Angelica sylvestris*	3	1.5
91	*Bromus hordeaceus*	3	1.5
92	*Carex echinata*	3	1.5
93	*Epipactis palustris*	3	1.5
94	*Festuca ovina*	3	1.5
95	*Fragaria vesca*	3	1.5
96	*Hyacinthoides non-scripta*	3	1.5
97	*Lathyrus linifolius*	3	1.5
98	*Leontodon autumnalis*	3	1.5
99	*Lotus pedunculatus*	3	1.5
100	*Mentha aquatica*	3	1.5
101	*Myrica gale*	3	1.5
102	*Parnassia palustris*	3	1.5
103	*Ranunculus flammula*	3	1.5
104	*Rumex acetosella*	3	1.5
105	*Taxus baccata*	3	1.5
106	*Vaccinium myrtillus*	3	1.5
107	*Vicia sativa*	3	1.5
108	*Anacamptis pyramidalis*	4	2.1
109	*Asplenium ruta-muraria*	4	2.1
110	*Betula spp.*	4	2.1
111	*Carex hostiana*	4	2.1

#	Species	No. of relevés (n)	% occurrence
112	*Carex viridula*	4	2.1
113	*Cirsium dissectum*	4	2.1
114	*Deschampsia flexuosa*	4	2.1
115	*Equisetum palustre*	4	2.1
116	*Eriophorum angustifolium*	4	2.1
117	*Gentiana verna*	4	2.1
118	*Ilex aquifolium*	4	2.1
119	*Juncus effusus*	4	2.1
120	*Leontodon hispidus*	4	2.1
121	*Mycelis muralis*	4	2.1
122	*Plantago coronopus*	4	2.1
123	*Ranunculus repens*	4	2.1
124	*Trichophorum cespitosum*	4	2.1
125	*Trifolium dubium*	4	2.1
126	*Asplenium trichomanes*	5	2.6
127	*Blechnum spicant*	5	2.6
128	*Carex pulicaris*	5	2.6
129	*Cotoneaster integrifolius*	5	2.6
130	*Festuca gigantea*	5	2.6
131	*Juncus acutiflorus*	5	2.6
132	*Juncus articulatus*	5	2.6
133	*Lolium perenne*	5	2.6
134	*Pinguicula vulgaris*	5	2.6
135	*Potentilla anserina*	5	2.6
136	*Primula vulgaris*	5	2.6
137	*Ranunculus acris*	5	2.6
138	*Rumex acetosa*	5	2.6
139	*Carex arenaria*	6	3.1
140	*Cirsium palustre*	6	3.1
141	*Filipendula ulmaria*	6	3.1
142	*Galium saxatile*	6	3.1
143	*Gymnadenia conopsea*	6	3.1
144	*Sanguisorba minor*	6	3.1
145	*Solidago virgaurea*	6	3.1
146	*Ulex gallii*	6	3.1
147	*Anagallis tenella*	7	3.6
148	*Jasione montana*	7	3.6
149	*Lonicera periclymenum*	7	3.6
150	*Nardus stricta*	7	3.6
151	*Narthecium ossifragum*	7	3.6
152	*Sedum anglicum*	7	3.6
153	*Vicia cracca*	7	3.6
154	*Agrostis capillaris*	8	4.1
155	*Arctostaphylos uva-ursi*	8	4.1
156	*Armeria maritima*	8	4.1
157	*Brachypodium sylvaticum*	8	4.1
158	*Rhinanthus minor*	8	4.1
159	*Ulex europaeus*	8	4.1
160	*Dactylorhiza fuchsii*	9	4.6
161	*Dryas octopetala*	9	4.6
162	*Ranunculus bulbosus*	9	4.6
163	*Corylus avellana*	10	5.2
164	*Geranium robertianum*	10	5.2
165	*Leucanthemum vulgare*	10	5.2
166	*Polygala serpyllifolia*	10	5.2
167	*Schoenus nigricans*	10	5.2
168	*Arrhenatherum elatius*	11	5.7
169	*Blackstonia perfoliata*	11	5.7

#	Species	No. of relevés (n)	% occurrence
170	*Carlina vulgaris*	11	5.7
171	*Listera ovata*	11	5.7
172	*Orchis mascula*	11	5.7
173	*Agrostis stolonifera*	12	6.2
174	*Carex binervis*	12	6.2
175	*Centaurium erythraea*	12	6.2
176	*Fraxinus excelsior*	12	6.2
177	*Ammophila arenaria*	13	6.7
178	*Cerastium fontanum*	13	6.7
179	*Crataegus monogyna*	13	6.7
180	*Prunus spinosa*	13	6.7
181	*Dactylis glomerata*	14	7.2
182	*Agrostis canina*	15	7.7
183	*Geranium sanguineum*	15	7.7
184	*Pedicularis palustris*	15	7.7
185	*Salix repens*	15	7.7
186	*Carex nigra*	16	8.2
187	*Senecio jacobea*	16	8.2
188	*Achillea millefolium*	17	8.8
189	*Bellis perennis*	17	8.8
190	*Antennaria dioica*	18	9.3
191	*Dactylorhiza maculata*	18	9.3
192	*Hypericum perforatum*	18	9.3
193	*Daucus carota*	19	9.8
194	*Empetrum nigrum*	20	10.3
195	*Koeleria macrantha*	20	10.3
196	*Campanula rotundifolia*	21	10.8
197	*Cynosurus cristatus*	21	10.8
198	*Prunella vulgaris*	22	11.3
199	*Hedera helix*	23	11.9
200	*Luzula multiflora*	23	11.9
201	*Taraxacum officinale*	24	12.4
202	*Polygala vulgaris*	25	12.9
203	*Erica tetralix*	26	13.4
204	*Linum catharticum*	27	13.9
205	*Carex panicea*	29	14.9
206	*Pilosella officinarum*	29	14.9
207	*Plantago maritima*	29	14.9
208	*Teucrium scorodonia*	29	14.9
209	*Centaurea nigra*	30	15.5
210	*Danthonia decumbens*	30	15.5
211	*Pteridium aquilinum*	31	16.0
212	*Rosa pimpinellifolia*	31	16.0
213	*Sesleria caerulea*	32	16.5
214	*Viola riviniana*	32	16.5
215	*Trifolium repens*	33	17.0
216	*Euphrasia salisburgensis*	34	17.5
217	*Rubus fruticosus*	34	17.5
218	*Trifolium pratense*	34	17.5
219	*Galium verum*	36	18.6
220	*Anthyllis vulneraria*	39	20.1
221	*Briza media*	39	20.1
222	*Holcus lanatus*	43	22.2
223	*Molinia caerulea*	49	25.3
224	*Hypochaeris radicata*	55	28.4
225	*Erica cinerea*	68	35.1
226	*Succisa pratensis*	72	37.1
227	*Plantago lanceolata*	73	37.6

#	Species	No. of relevés (n)	% occurrence
228	*Festuca rubra*	77	39.7
229	*Anthoxanthum odoratum*	79	40.7
230	*Thymus polytrichus*	81	41.8
231	*Calluna vulgaris*	87	44.8
232	*Carex flacca*	90	46.4
233	*Lotus corniculatus*	108	55.7
234	*Potentilla erecta*	108	55.7
235	*Juniperus communis*	124	63.9

Appendix IV – Seed viability experiment

Juniper seed viability in the short-term: an experimental approach

Abstract

An attempt was made to assess juniper seed viability using a germination experiment over a 12 month period. Regardless of treatment (avicory, scarification or control) no seeds germinated within the duration of the experiment. Juniper is, therefore, highly unlikely to actively recruit within one year of reproduction. Juniper seed can germinate up to 5 years after sowing. Consequently, seed viability in the long-term remains unknown.

Methods

A selection of ripe galbulae (cones) were collected from each site surveyed in order to examine seed viability using germination experiments. Previous studies suggest that juniper cones may require digestion by a bird prior to germination. Thus cones were divided into three groups. Approximately 150 cones underwent avicory (digestion by a chicken) before being scarified; 50 were subjected to -20^{o}C, 50 to 4^{o}C and 50 were left unscarified as a control group. A further 150 cones did not undergo avicory but were scarified as above except for a control group. Finally, 50 cones were immersed in vinegar for 48 hours to mimic the stomach conditions of a bird. All cones were planted and germination rates were evaluated after 6 and 12 months.

Results

No seeds were recovered from cones which underwent avicory (digestion by a chicken). The reason for lack of transit is unknown; it is possible that the birds retained the seeds in their crop longer than anticipated or that the digestion by domestic chickens was more efficient than expected. No seeds of any of the other experimental groups (scarified seeds, those subject to artificial digestion or the control group) germinated within the 12 month duration of the seed viability experiment.

Discussion

Juniper is highly unlikely to actively recruit within one year of reproduction. Broome (2003) suggested that juniper germination peaks between 18 months and five years. Thus, this experiment may have been too short to effectively assess seed viability.

Appendix V – Climate change impacts

Assessing the potential impact of climate change on juniper distribution in Ireland

Abstract

A GIS-based approach was used to assess the potential impact of likely changes in climate (maximum and minimum annual temperatures and total precipitation) on the distribution of juniper throughout Ireland under the commonly accepted "business as usual" model of CO_2 emissions. Maximum entropy analysis (using MaxEnt) was highly successful (93.6%) at predicting the current distribution of juniper. Models predicted that the suitability of the Irish landscape for the species will substantially and significantly decrease by 2020, 2050 and 2080. The majority of the change is likely to occur in the early decades of the 21st century with models predicting near total extinction of the species in Ireland by 2080. Due to uncertainty in predicting climate and likely changes in the past climate which juniper evidently survived, these results should be treated with caution but the potential threat posed by climate change should not be underestimated.

Introduction

Climate change is an emerging threat to biological diversity. The conservation assessments of the *impacts and threats* to juniper throughout Ireland, made within the main report, did not consider the potential impact of climate change on the species' distribution. Thus, to augment the national assessment, we quantified the potential impact of likely changes in maximum and minimum temperatures and precipitation predicted to occur throughout Ireland over the next century. Early attempts to evaluate the impact of climate change utilised GIS-based climate envelope modelling only. However, more sophisticated attempts have been made recently to also include landscape variables including topography and land cover (Lundy *et al.* 2010).

Methods

We used a GIS-based approach where data were extracted for each 1km square throughout Ireland (n=71,492). The climate characteristics of each 1km square were described using data from WORLDCLIM (http://www.worldclim.org/) for maximum annual temperature, minimum annual temperature and total annual precipitation. Current climate conditions were defined as the mean for the period 1950-2000. To evaluate the potential impact of global climate change on the distribution of juniper in Ireland, we used predicted changes in the three climate variables taken from the Canadian Centre for Climate Modelling and Analysis (CCCMA) model based on the a2a carbon dioxide (CO_2) emissions scenario, derived from the Intergovernmental Panel on Climate Change (IPCC, 2007) for 2020, 2050 and 2080. This scenario is commonly referred to as the "*business as usual*" model of climate change and assumes that recent trends in CO_2 emissions will continue at a similar rate with no major technological advances in energy production or coordinated international effort to reduce carbon emissions.

We also included three other categories of candidate variables. Topography was described as the mean altitude derived from a global DIGITAL ELEVATION MODEL (DEM) downloaded from WORLDCLIM (http://www.worldclim.org/). The TEAGASC/EPA DIGITAL SOILS AND SUBSOILS database for Ireland (http://www.teagasc.ie) was used to establish the parent materials and soils on which the greatest proportion of juniper records occurred. Specifically, the total area of calcareous bedrock (RcKCa) and non-calcareous bedrock (RcKNCa) was calculated per 1km square and expressed as a percentage. In addition, the area of shallow, well-drained mineral soils derived from basic parent materials (BminSW), shallow, lithosolic-podzolic type soils, derived from non-calcareous rock or gravel (AminSRPT) and shallow, lithosolic-podzolic type soils, derived from calcareous rock or gravel (BminSRPT) were calculated per 1km square and expressed as a percentage. The TEAGASC/EPA DIGITAL LAND COVER AND HABITAT MAP of Ireland (http://www.teagasc.ie) was used to calculate the area and percentage of each 1k square which was bare rock, bog and heath, coastal habitat or dry grassland. All variables were projected as an ArcGIS raster file.

Presence-only maximum entropy analysis was performed using the programme MAXENT 3.2.1 (Phillips *et al.*, 2006; Phillips & Dudík, 2008) to examine the current associations of juniper with remote sensed climate, topography, soil and land cover data. This allowed the maximum number of 1km squares suitable for the species to be identified and compared to the total number from which records were known (i.e. occupied squares). To minimise problems with over-fitting, linear and quadratic functions were the only responses considered for each environmental parameter (Phillips & Dudík, 2008). A total of 75% of the data was used to create the predictive model whilst a random sample of 25% of the data was retained for independent model testing. Global model performance was judged using the area under the receiver operating characteristic (ROC) curve (Liu *et al.*, 2005). Predicted presence of juniper was based on the predicted probability value for the minimum training presence (MTP). The final model built under current climate conditions was projected into future climate change scenarios for 2020, 2050 and 2080 and the number of 1km squares predicted as suitable for juniper was assessed using the minimum training presence (MTP) value as the cut-off value. Change in the number of suitable 1km squares was plotted against time and maps of spatial projections were drawn using ArcGIS v9.3.

Results

Juniper occurrence was negatively correlated with maximum annual temperature and was greatest in areas intermediate in the range of minimum annual temperatures (i.e. the species did not occur in the coldest or mildest areas). Occurrence was greatest in areas with high annual rainfall.

A further 10 topographic and landscape variables were used to refine suitable landscapes including information on soils and their parent materials (Table 1). The probability of juniper presence was greatest at low and high altitudes (areas with coastal habitats and high mountains). Areas of exposed bedrock, typically calcareous in nature (for example, limestone pavement), were favoured as were landscapes with shallow well-drained soils. Juniper was negatively correlated with areas predominated by bog, heath and dry grasslands.

Under current conditions the MaxEnt model predicted 93.6% of juniper records (using 75% of the dataset as a training model). A random sample of 25% of records was held back as an independent test dataset with 89.8% of records being correctly classified (Fig. 1).

Future climate predictions suggest that maximum and minimum temperatures will increase and rainfall will become more unpredictable. Thus, maintaining current values for all topographic and landscape variables and varying the three climatic variables only, the predicted suitability of the Irish landscape for juniper presence substantially and significantly decreased between current conditions and 2020, 2050 and 2080 (Fig. 2). Specifically, under current conditions a total of 643 x 1km squares were predicted as being suitable to support juniper. Indeed, the model correctly identified west Donegal and the Burren as the remaining strongholds for the species with the largest areas of suitable contiguous landscape (Fig. 2). However, juniper records were only recorded from 129 x 1km squares suggesting that only 20% of the areas suitable for the species are presently occupied. The impacts and threats identified at each site (see Section 3.10 above) may reflect the stresses which have contributed to the species' historical decline within landscapes otherwise suitable for the species. Under predicted climate conditions for 2020, a total of 196 x 1km squares were predicted as being suitable for juniper which further declined to 16 x 1km squares in 2050 and 7 x 1km squares (all in west Donegal) during 2080 (Fig. 3). Thus, the majority of the predicted decline of juniper, due to putative climate change, is likely to occur during the next few decades (early 21st century). Assuming that occupancy rates remain at 20% of suitable squares (which may not be a realistic assumption) juniper is predicted to be remain in just 1 x 1km square by 2080.

Discussion

Future climate predictions suggest that juniper will not cope well with increasing temperatures and increasingly unpredictable rainfall. The most commonly accepted model of potential climate change, the CCCMA a2a or '*business as usual*' model, suggests that the predicted suitability of the Irish landscape for juniper will substantially and significantly decrease between current conditions and 2020, 2050 and 2080. Despite assuming that parent materials, soil and land cover will remain unchanged (the latter seems highly unlikely), predictions based on climate alone suggest near total extinction of the species in Ireland by 2080 with the majority of the decline occurring in the early decades of the 21st century. Climate change may, therefore, be the single greatest challenge to the conservation status of juniper formations in Ireland and active site management to combat anthropogenic threats may not be sufficient to arrest the observed historical decline in the species range and abundance. The caveat to this conclusion is that climate predictions are highly variable and the degree to which the impact of rising CO_2 emission might be offset is unknown. Moreover, there have been brief periods since the last glacial maximum in which Ireland's climate was as warm, if not warmer, than it is today, however, juniper evidently survived. Consequently, the results of this analysis should be treated with caution but the potential threat from climate change should not be underestimated.

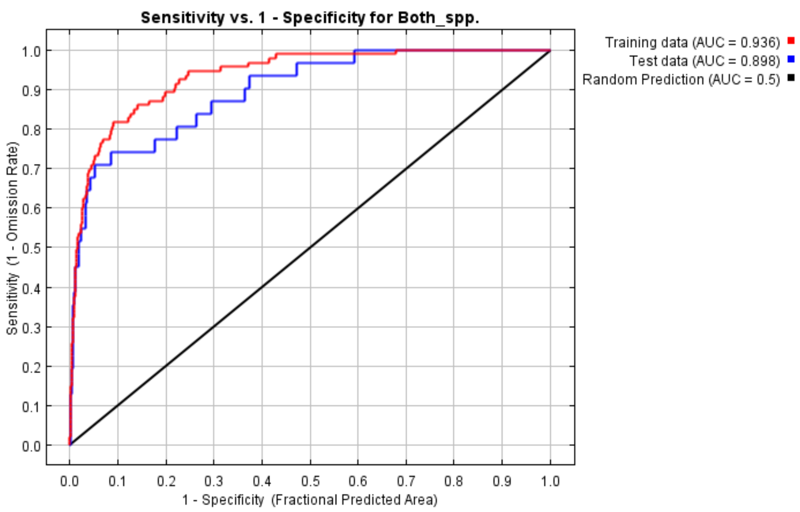
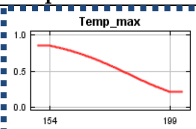
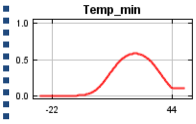
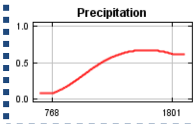
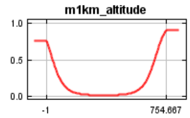
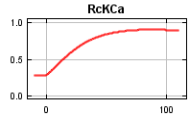
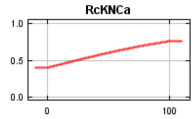
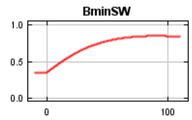
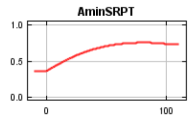
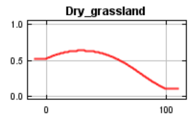
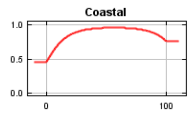
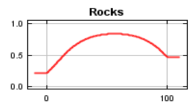
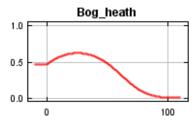


Fig. 1 *The receiver operating characteristic (ROC) curve for predictions of juniper occurrence within 1km2 squares using variables listed in Table 22 under current climate conditions (1950-2000).*

Table 1 Description of variables used to model juniper distribution showing the predicted probability response curve for each. Climate variables are bordered by a blue dashed line.

Type	#	Variable	Units	Description	Response curves
Climate	1	$Temp_{max}$	°C	Maximum temperature per $1km^2$ derived from *WorldClim* data	
	2	$Temp_{min}$	°C	Minimum temperature per $1km^2$ derived from *WorldClim* data	
	3	Precipitation	mm	Total annual precipitation per $1km^2$ derived from *WorldClim* data	
Topography	4	Altitude	m	Mean altitude per $1km^2$ derived from a *Digital Elevation Model (DEM)* of Ireland	
Parent material	5	RcKCa	%	Calcareous bedrock derived from the *National Soils Database* of Ireland *(Teagasc & EPA)*	
	6	RcKNCa	%	Nitrogenous or nutrient rich calcareous bedrock taken from the *National Soils Database* of Ireland *(Teagasc & EPA)*	
Soils	7	BminSW	%	Shallow well-drained mineral soils derived from mainly basic parent materials taken from the *National Soils Database* of Ireland *(Teagasc & EPA)*	
	8	AminSRPT	%	Shallow, lithosolic-podzolic type soils, derived from non-calcareous rock or gravels taken from the *National Soils Database* of Ireland *(Teagasc & EPA)*	
	9	BminSRPT	%	Shallow, lithosolic-podzolic type soils, derived from calcareous rock or gravels taken from the *National Soils Database* of Ireland *(Teagasc & EPA)*	
Landcover	10	Dry grassland	%	Area of dry grassland per $1km^2$ expressed as a percentage taken from the *Teagasc Landcover Map*	
	11	Coastal habitats	%	Area of coastal habitats per $1km^2$ expressed as a percentage taken from the *Teagasc Landcover Map*	
	12	Bare rock	%	Area of exposed bare rock per $1km^2$ expressed as a percentage taken from the *Teagasc Landcover Map*	
	13	Bog & Heath	%	Area of bog and heath per $1km^2$ expressed as a percentage taken from the *Teagasc Landcover Map*	

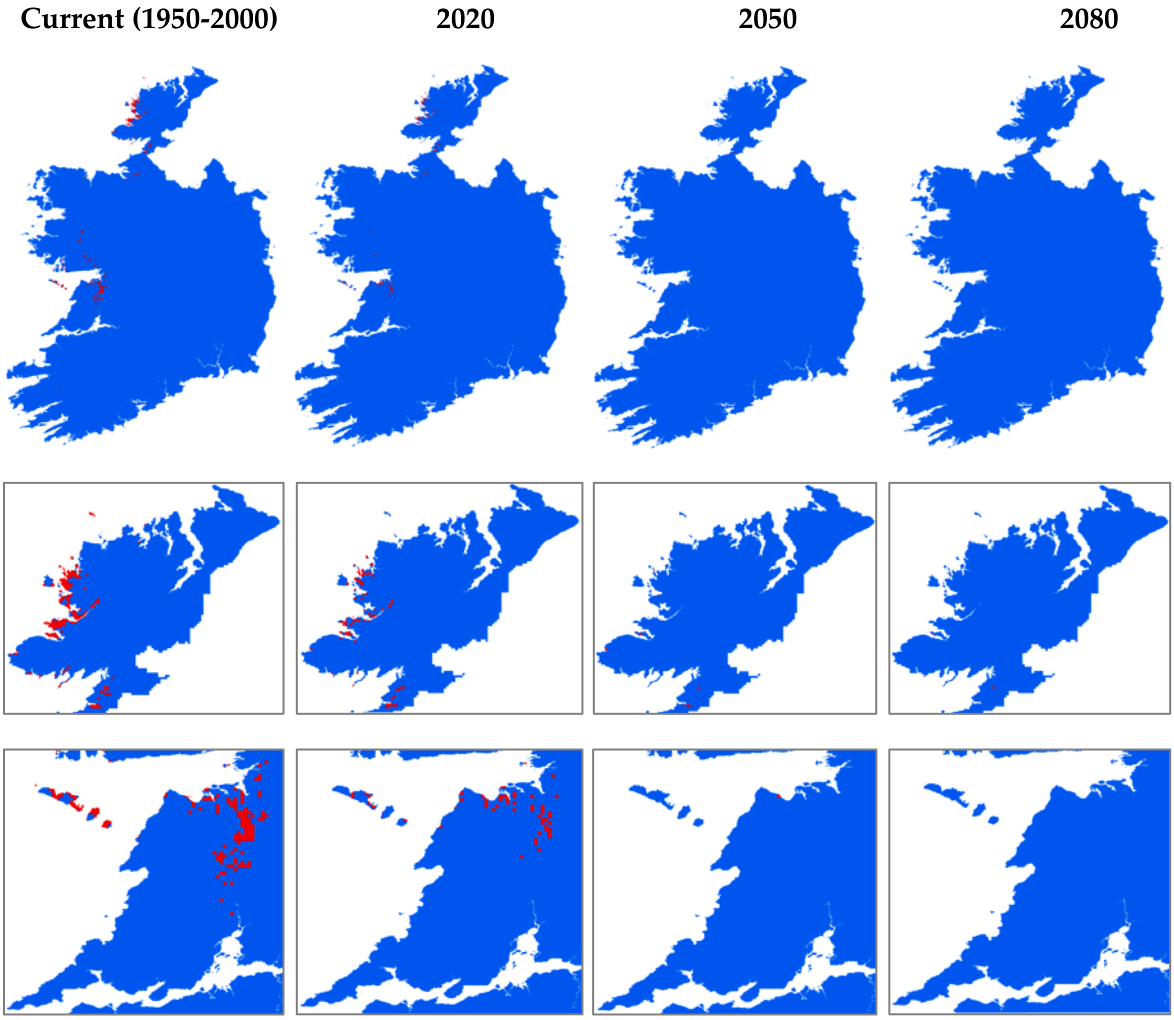


Fig. 2 *The predicted distribution of juniper (assuming a Minimum Training Presence or MTP = 0.688) under current climate conditions (1950-2000), and future predicted conditions (2020, 2050 and 2080) throughout Ireland (red = suitable and blue = unsuitable). Inserts show the predicted distribution in the two remaining strongholds for the species in west Donegal (upper insert) and the Burren (lower insert).*

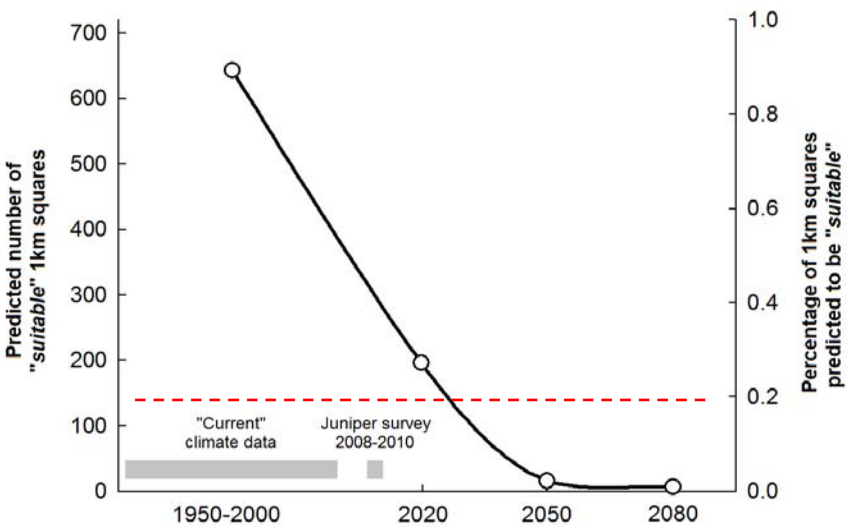


Fig. 3 *The predicted change in the suitability of the Irish landscape for juniper given future climate change predictions (2020, 2050 and 2080). Note that under current conditions juniper does not occupy all 1km squares predicted as "suitable" (a total of 129 x 1km squares were recorded as occupied during 2008-2010 – shown as a red dashed line).*

Appendix VI – Template datasheets for habitat assessment

Table 1 *Assessment sheet for sites in GROUP 1* Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Site code		**Date**	
Site name			

	Value	**Score**	**Tick**
Area (ha)	<0.01 0.01-0.57 0.58-1.41 1.42-6.40 6.5-53.8 >53.9	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	
Population (no. shrubs)	<10 10-29 30-49 50-549 250-999 >1,000	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	

	% est.
% coned	
% seedling	
% dead	

	No.	**Score (%)**
Species richness (no.) ≤10 = 0% and ≥33 = 100%		
Sward height (cm) ≤9.6 or ≥35.1 = 0% 9.7-35.0 = 100%		

Positive indicator species	**Tick**
Vascular plant sp. *Carex flacca* *Succisa pratensis* *Carex nigra* *Dryas octopetala* *Pedicularis palustris* *Cynosurus cristatus* *Dactylorhiza maculata* *Juncus articulatus* *Anagallis tenella* *Schoenus nigricans* *Prunella vulgaris* *Carex viridula* *Agrostis stolonifera*	
Pass = >6 species	

Negative indicator species	**Tick**
I01 Non-native sp. *Cotoneaster integrifolius* *Rhododendron ponticum* **I02 Problematic native sp.** *Corylus avellana* *Pteridium aquilinum* *Molinia caerulea* *Rubus fruticosus*	

Table 2 *Assessment sheet for sites in GROUP 2* Exposed calcareous rock *Teucrium scorodonia – Geranium sanguineum* group

Site code		**Date**	
Site name			

	Value	**Score**	**Tick**
Area (ha)	<0.01 0.01-0.57 0.58-1.41 1.42-6.40 6.5-53.8 >53.9	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	
Population (no. shrubs)	<10 10-29 30-49 50-549 250-999 >1,000	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	

	% est.
% coned	
% seedling	
% dead	

	No.	**Score (%)**
Species richness (no.) ≤3 = 0% and ≥20 = 100%		
Sward height (cm) ≥11.6 = 0% 0.0-11.5 = 100%		

Positive indicator species	**Tick**
Vascular plant sp. *Carex flacca* *Teucrium scorodonia* *Geranium sanguineum* *Mycelis muralis* *Geranium robertianum*	
Pass = >2 species	

Negative indicator species	**Tick**
I01 Non-native sp. *Cotoneaster integrifolius* *Rhododendron ponticum* **I02 Problematic native sp.** *Corylus avellana* *Pteridium aquilinum* *Molinia caerulea* *Rubus fruticosus*	

Table 3 *Assessment sheet for sites in GROUP 3* Dry calcareous heath and grassland
Lotus corniculatus - Trifolium pratensis

Site code		**Date**	
Site name			

	Value	Score	Tick
Area (ha)	<0.01 0.01-0.57 0.58-1.41 1.42-6.40 6.5-53.8 >53.9	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	
Population (no. shrubs)	<10 10-29 30-49 50-549 250-999 >1,000	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	

	% est.
% coned	
% seedling	
% dead	

	No.	Score (%)
Species richness (no.) ≤5 = 0% and ≥23 = 100%		
Sward height (cm) ≤14.2 or ≥47.6 = 0% 14.3-47.5 = 100%		

Positive indicator species	Tick
Vascular plant sp. *Lotus corniculatus* *Trifolium pratensis* *Violoa riviniana* *Fraxinus excelsior* *Polygala vulgaris*	
Pass = ≥3 species	

Negative indicator species	Tick
I01 Non-native sp. *Cotoneaster integrifolius* *Rhododendron ponticum* **I02 Problematic native sp.** *Corylus avellana* *Pteridium aquilinum* *Molinia caerulea* *Rubus fruticosus*	

Table 4 *Assessment sheet for sites in GROUP 4* Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Site code		**Date**	
Site name			

	Value	Score	Tick
Area (ha)	<0.01 0.01-0.57 0.58-1.41 1.42-6.40 6.5-53.8 >53.9	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	
Population (no. shrubs)	<10 10-29 30-49 50-549 250-999 >1,000	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	

	% est.
% coned	
% seedling	
% dead	

	No.	Score (%)
Species richness (no.) ≤4 = 0% and ≥25 = 100%		
Sward height (cm) ≤14.9 or ≥37.6 = 0% 15.0-37.5 = 100%		

Positive indicator species	Tick
Vascular plant sp.	
Calluna vulgaris	
Erica cinerea	
Potentilla erecta	
Anthoxanthum odoratum	
Carex panicea	
Molinia caerulea	
Carex binervis	
Erica tetralix	
Danthonia decumbens	
Polygala serpyllifolia	
Empetrum nigrum	
Luzula multiflora	
Nardus stricta	
Agrostis canina	
Narthecium ossifragum	
Eriophorum angustifolium	
Pass = >8 species	

Negative indicator species	Tick
I01 Non-native sp.	
Cotoneaster integrifolius	
Rhododendron ponticum	
I02 Problematic native sp.	
Corylus avellana	
Pteridium aquilinum	
Molinia caerulea	
Rubus fruticosus	

Table 5 *Assessment sheet for sites in GROUP 5* Dry calcareous/neutral grassland inc coastal dunes

Galium verum – Pilosella offcinarum group

Site code		**Date**	
Site name			

	Value	**Score**	**Tick**
Area (ha)	<0.01 0.01-0.57 0.58-1.41 1.42-6.40 6.5-53.8 >53.9	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	
Population (no. shrubs)	<10 10-29 30-49 50-549 250-999 >1,000	0 (0%) 1 (20%) 2 (40%) 3 (60%) 4 (80%) 5 (100%)	

	% est.
% coned	
% seedling	
% dead	

	No.	**Score (%)**
Species richness (no.) ≤10 = 0% and ≥32 = 100%		
Sward height (cm) ≤23.7 or ≥46.4 = 0% 23.8-46.3 = 100%		

Positive indicator species	**Tick**
Vascular plant spp. *Galium verum* *Pilosella officinarum* *Thymus polytrichus* *Ammophila arenaria* *Daucus carota* *Anthyllis vulneraria* *Koeleria macrantha* *Campanula rotundifolia* *Festuca rubra* *Plantago lanceolata* *Senecio jacobea* *Arrhenatherum elatius* *Hypochaeris radicata* *Linum catharticum* *Holcus lanatus* *Ranunculus bulbosus* *Briza media* *Trifolium repens* *Dactylis glomerata* *Polygala vulgaris* *Carex arenaria* *Hypericum perforatum* *Jasione montana* *Anacamptis pyramidalis* *Plantago coronopus*	
Pass = >13 species	

Negative indicator species	**Tick**
I01 Non-native spp. *Cotoneaster integrifolius* *Rhododendron ponticum* **I02 Problematic native spp.** *Corylus avellana* *Pteridium aquilinum* *Molinia caerulea* *Rubus fruticosus*	

Appendix VII – Impact & threat datasheets

Table 1 *Impact and threat monitoring sheet for all sites.*

Threat code	Description	Proportion of area affected (*p*)	Intensity score (*i*)	*pi*
A03.01	Intensive mowing or intensification			
A03.02	Non-intensive mowing			
A04.01.01	Intensive cattle grazing			
A04.01.02	**Intensive sheep grazing**			
A04.01.03	Intensive horse grazing			
A04.01.05	Intensive mixed animal grazing			
A04.02.01	Non-intensive cattle grazing			
A04.02.02	Non-intensive sheep grazing			
A04.02.04	Non-intensive horse grazing			
A04.02.05	**Non-intensive mixed animal grazing**			
A04.03	Abandonment of pastoral systems, lack of grazing			
A11	Agricultural activities not referred to above			
C01	Mining and quarrying			
D01.01	Paths, tracks and cycling tracks			
D03.01.01	Slipways			
E01.03	Dispersed habitation			
E02.01	Factory			
E03.01	Disposal of household waste			
E04.01	Agricultural structures, building in the landscape			
G05.01	**Trampling, overuse**			
I01	Invasive non-native species			
I02	**Problematic native species**			
J01.01	Burning			
K01.01	Erosion			
K01.03	Drying out			
K04.01	Competition (flora)			
K04.05	**Damage by herbivores (natural)**			
M01.03	Flooding and rising precipitation			
		TOTAL SITE SCORE (∑*pi*) =		

p = ranges from 0 (absent) to 1 (100% of site affected)
i = 0 (absent), -1 (low), -2 (moderate) and -3 (severe)

Negative indicator species	Tick
I01 Non-native sp. *Cotoneaster integrifolius* *Rhododendron ponticum* **I02 Problematic native sp.** *Corylus avellana* *Pteridium aquilinum* *Molinia caerulea* *Rubus fruticosus*	

Appendix VIII – Site Assessments

1. This Appendix contains the individual site assessments for each *formation* identified in the main report.

2. Conservation criteria and targets are listed in accordance with the results of analyses presented in the main report.

3. Each site is described and a site map is provided. The *Impacts and threats* identified are listed and the data under each criteria within the parameters of i) *Area & population*, ii) *Structure & functions* and iii) *Future prospects* are evaluated using the standard traffic light system.

4. Sites are listed in descending order of conservation rank.

5. Site specific recommendations are provided based on the outcome of the conservation assessment including identifying sites suitable for designation or inclusion within existing designations should site boundaries be redefined.

6. Non-formations are also listed in tabular form. Whilst these are not returnable under Article 17 of the EU Habitats Directive for 5130 they may become relevant in the future should their status change.

Table 1 Definition of conservation targets within assessment parameters defining a pass or fail and Favourable FV (good), Unfavourable Inadequate U1 (poor) or Unfavourable Inadequate U2 (bad) status .

Parameter	Criteria	Target	Pass	Fail	Status
Area & population	1. Area	Maintain 2008/10 area	Yes	No	GOOD = Both indicators pass POOR = One indicator fails BAD = Both indicators fail
	2. Population	Maintain 2008/10 population	Yes	No	
Structure & function	1. % coned	>10% coned	Yes	No	GOOD = 5-7 indicators pass (i.e. 71-100% pass) POOR = 3-4 indicators pass (i.e. 43-57% pass) BAD = 0-2 indicators pass (i.e. 0-29% pass)
	2. % seedlings	>10% seedlings	Yes	No	
	3. % bare ground	>10% bare ground	Yes	No	
	4. % alive	>90% alive	Yes	No	
	5. Spp. Richness[1]	>1 SD below the 2008/10 mean within each habitat type	Yes	No	
	6. Sward height	< lower quartile or > upper quartile from the 2008/10 within each habitat type	Yes	No	
	7. Indicator species	≥50% of positive indicator species for within each habitat type	Yes	No	
Impacts and threats	1. Overall site score	Pass or fail target not applicable			GOOD = 0 POOR = -0.1 to >-3.0 BAD = <-3.0 (max. = -9.0)
				OVERALL ASSESEMENT	GOOD = All 3 attribute are good POOR = 1-3 attributes are poor BAD = 1of 3 attributes are bad

[1] Species richness scores exclude negative indicators (invasive species and native problematic species)

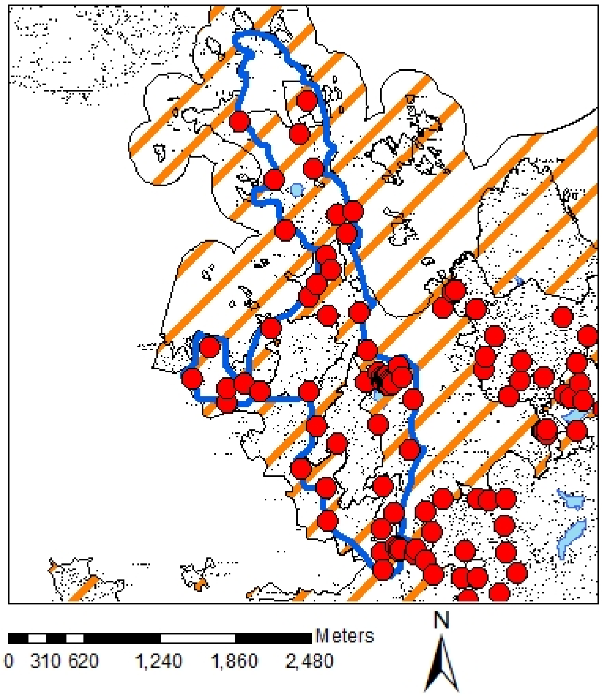
Table 2 Values for the conservation targets within assessment parameters defining a pass or fail between the 5 vegetation groups identified during analysis.

Parameter	**Criteria**	**Targets**				
		Vegetation group				
		1	**2**	**3**	**4**	**5**
Area	Area (ha)	*	*	*	*	*
	Population (numbers)	†	†	†	†	†
Structure & function	Reproductive (cones)	>10%	>10%	>10%	>10%	>10%
	Recruitment (seedlings)	>10%	>10%	>10%	>10%	>10%
	% bare ground	>10%	>10%	>10%	>10%	>10%
	% alive	>90%	>90%	>90%	>90%	>90%
	Spp. richness	≥10	≥6	≥6	≥6	≥13
	Sward height (cm)	9.7 - 35.0	<11.5	14.3 - 47.5	15.0 - 37.5	23.8 - 46.3
	Indicator species	≥6	≥2	≥3	≥8	≥13
Future prospects	Overall score	‡	‡	‡	‡	‡

* Targets for *Area* equalled the area covered by the habitat during the current baseline assessment (2008-2010)
† Targets for *Population* equalled the number of shrubs enumerated during the current baseline assessment (2008-2010)
‡ Targets for *Future Prospects* were taken as 0.0 if the *Impact and threat* score was > -1.0, > -1.0 if the *Impact and threat* score was < -1.0 but > -3.0 and > -3.0 if the *Impact and threat* score was < -3.0.

Vegetation groups:
1 = Wet grassland, heath or bog (*Carex flacca – Succisa pratensis* group)
2 = Exposed calcareous rock *aka* limestone pavement (*Teucrium scorodonia - Geranium sanguineum* group)
3 = Dry calcareous heath and grassland (*Lotus corniculatus – Trifolium pratensis* group)
4 = Dry siliceous heath and raised bog (*Calluna vulgaris – Erica cinerea* group)
5 = Dry calcareous or neutral grassland including coastal dunes (*Gallium verum – Pilosella offcinarum* group)

FORMATION – Cruit Island (DL12)
(entirely within Gweedore Bay and Islands SAC)



County: Donegal
Central Grid Ref: B732206

Conservation rank: 1
Conservation value: 81.7% (Excellent)

Fossitt (2000): Predominantly HH2
Secondary CD6

Vegetation group: 5
Dry calcareous or neutral grassland including coastal dunes
Gallium verum – Pilosella offcinarum group

Current designations: SAC

Recommendations:
- Reduce sheep grazing pressure

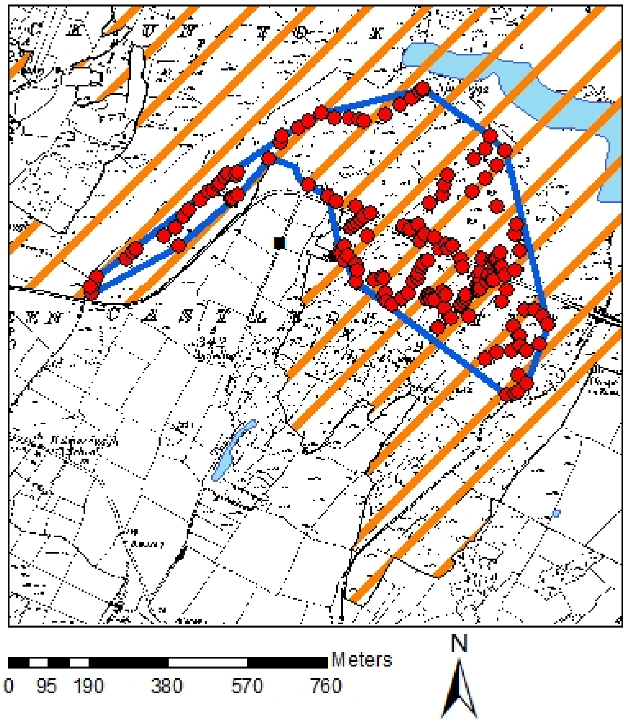
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate	ca. 62.5	20%
E01.03	Dispersed habitation	Negative	Moderate	ca. 37.5	12%
G05.01	Trampling, overuse	Negative	Minor	ca. 62.5	20%

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area	Area (ha)	312.4	312.7	Pass
	Population (numbers)	3000	3000	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	37	Pass
	Recruitment (seedlings)	>10%	9	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	99	Pass
	Spp. richness	≥13	22	Pass
	Sward height (cm)	23.8 - 46.3	26.7	Pass
	Indicator species	≥13	17	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-0.8	FAVOURABLE (FV)
OVERALL ASSESSMENT				FAVOURABLE (FV)

FORMATION – Tirneevin (GY07)
(entirely within the Coole-Garryland Complex SAC)



County: Galway
Central Grid Ref: M422023

Conservation rank: 2
Conservation value: 79.4% (Good)

Fossitt (2000): Predominantly GS1
Secondary ER2

Vegetation group: 2
Exposed calcareous rock *aka* limestone pavem
Teucrium scorodonia - Geranium sanguineum grc

Current designations: SAC

Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants
- Reduce grazing pressure

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	2.38	5
E03.01	Disposal of household waste	Negative	Minor (-1)	2.38	5
I02	Problematic native species	Negative	Minor (-1)	4.76	10
J01.01	Burning	Negative	Minor (-1)	1.43	3
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	47.6	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	47.6	47.6	Pass
	Population (numbers)	300	300	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	36	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	70	Fail
	Spp. richness	≥6	17	Pass
	Sward height (cm)	<11.5	16.7	Pass
	Indicator species	≥2	3	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.3	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Cappacasheen (GY08)
(entirely within East Burren Complex SAC)

County: Galway
Central Grid Ref: M378041

Conservation rank: 3
Conservation value: 78.5% (Good)

Fossitt (2000): Predominantly ER2

Vegetation group: 2
Exposed calcareous rock *aka* limestone pavemen
Teucrium scorodonia - Geranium sanguineum grouր

Current designations: SAC

Recommendations:
- Consider designating this site as an NHA

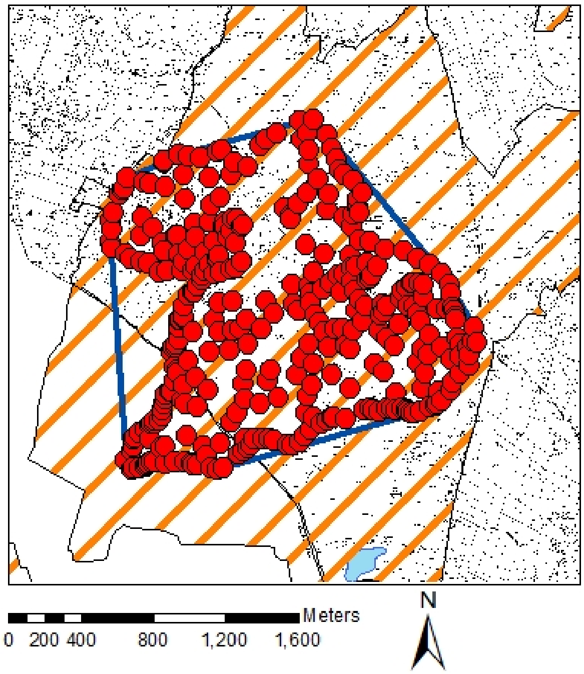


Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
K04.05	Damage by herbivores (natural)	Negative	Minor	ca. 285.4	100%

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	285.4	285.4	Pass
	Population (numbers)	2000	2000	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	55	Pass
	Recruitment (seedlings)	>10%	1	Fail
	% bare ground	>10%	10	Pass
	% alive	>90%	100	Pass
	Spp. richness	≥6	17	Pass
	Sward height (cm)	<11.5	3.3	Pass
	Indicator species	≥2	3	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-1.0	FAVOURABLE (FV)
OVERALL ASSESSMENT				FAVOURABLE (FV)

FORMATION – Dawros More, Letterfrack (GY24)
(entirely within Twelve Bens/Garraun Complex SAC)

County: Galway
Central Grid Ref: L702591

Conservation rank: 4
Conservation value: 76.5 (Good)

Fossitt (2000): Predominantly HH1
Secondary ER1

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: SAC

Recommendations:

- Consider designating this site as an NHA
- Consider creating patches of bare soil to aid recruitment and combat agricultural abandonment

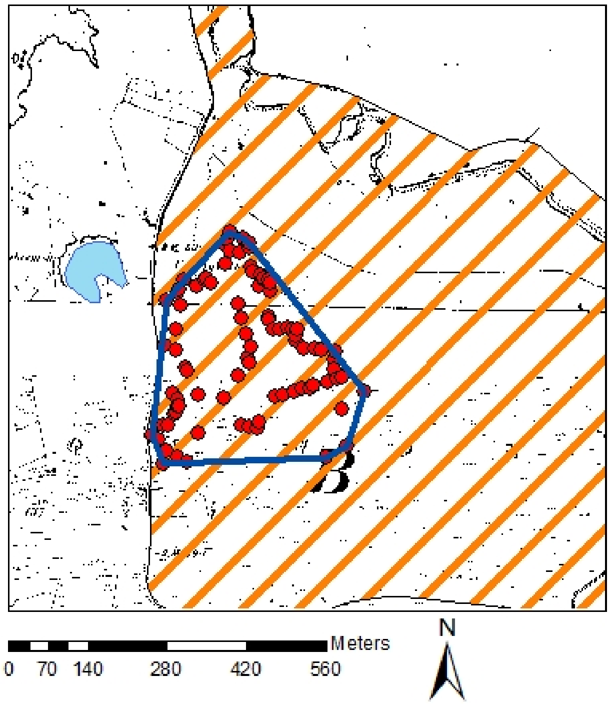


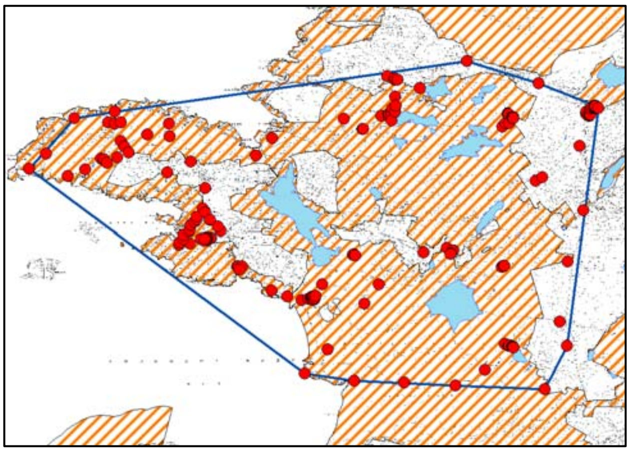
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.03	Abandonment of pastoral systems	Negative	Minor (-1)	10.5	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	10.5	10.5	Pass
	Population (numbers)	250	250	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	25	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥10	12	Pass
	Sward height (cm)	9.7 - 35.0	23.3	Pass
	Indicator species	≥6	3	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.0	**FAVOURABLE (FV)**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – DL09 Dawros Head Complex
(mostly within West of Ardara/Maas Road SAC)



County: Donegal
Central Grid Ref: B722966

Conservation rank: 5
Conservation value: 75.9 (Good)

Fossitt (2000): Predominantly ER1
Secondary GS3
Also HH1 & HH3

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: SAC

Recommendations:
- Consider designating this site as an NHA
- Reduce sheep grazing pressure

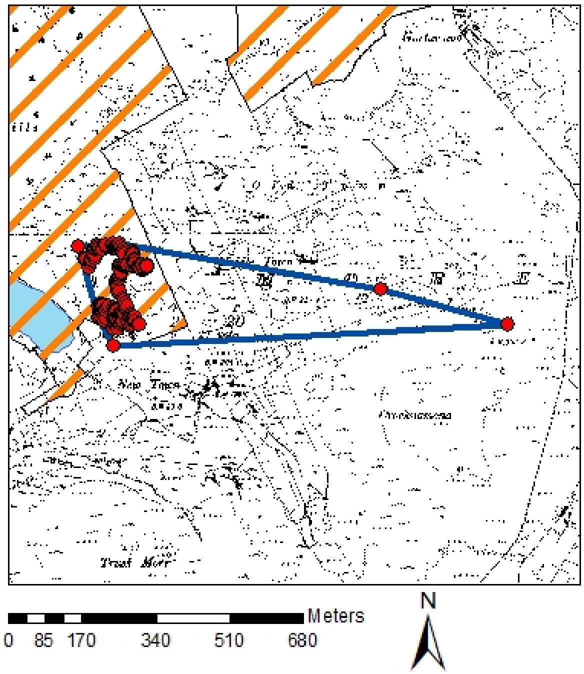
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate	ca. 534.6	20
A04.02.05	Non-intensive mixed animal grazing	Negative	Minor	ca. 267.3	10
J01.01	Burning	Negative	Minor	ca. 53.5	2
K04.05	Damage by herbivores (natural)	Negative	Minor	ca. 2673.0	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	2673.0	2673.0	Pass
	Population (numbers)	4250	4250	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	30	Pass
	Recruitment (seedlings)	>10%	3	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	98	Pass
	Spp. richness	≥6	25	Pass
	Sward height (cm)	15.0 - 37.5	42.6	Fail
	Indicator species	≥8	13	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.5	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Lough Nagreany (DL08)
(mostly within Lough Nagreany Dunes SAC)



County: Donegal
Central Grid Ref: C149416

Conservation rank: 6
Conservation value: 71.7 (Good)

Fossitt (2000): Predominantly HH2
Secondary GS1

Vegetation group: 5
Dry calcareous or neutral grassland
including coastal dunes
Gallium verum – Pilosella offcinarum group

Current designations: pNHA
SAC

Recommendations:
- Consider designating this site as an NHA
- Reduce grazing pressure

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.05	Non-intensive mixed animal grazing	Negative	Minor (-1)	13.0	100
I02	Problematic native species	Negative	Minor (-1)	0.65	5
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	13.0	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	13.0	13.0	Pass
	Population (numbers)	1000	1000	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	35	Pass
	Recruitment (seedlings)	>10%	11	Pass
	% bare ground	>10%	0	Fail
	% alive	>90%	94	Pass
	Spp. richness	≥13	22	Pass
	Sward height (cm)	23.8 - 46.3	57.5	Fail
	Indicator species	≥13	14	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-2.1	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – SO14 Bunduff Sligo C
(mostly within Bunduff Lough and Machair/Trawalua/Mullaghmore SAC

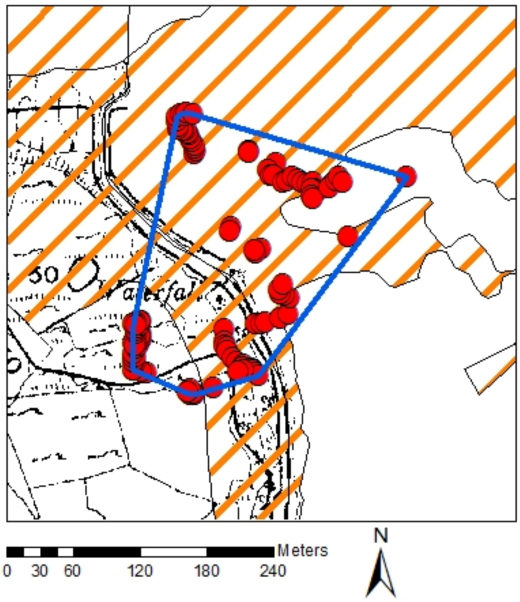
County: Sligo
Central Grid Ref: G753574
XY: 175326, 357427

Conservation rank: 7
Conservation value: 71.2 (Good)

Fossitt (2000): Predominantly GS1
Secondary HH2

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: SAC



Recommendations:
- Consider extending Bunduff Lough and Machair/Trawalua/Mullaghmore SAC
- Consider designating this site as an NHA
- Reduce grazing pressure on part of the site

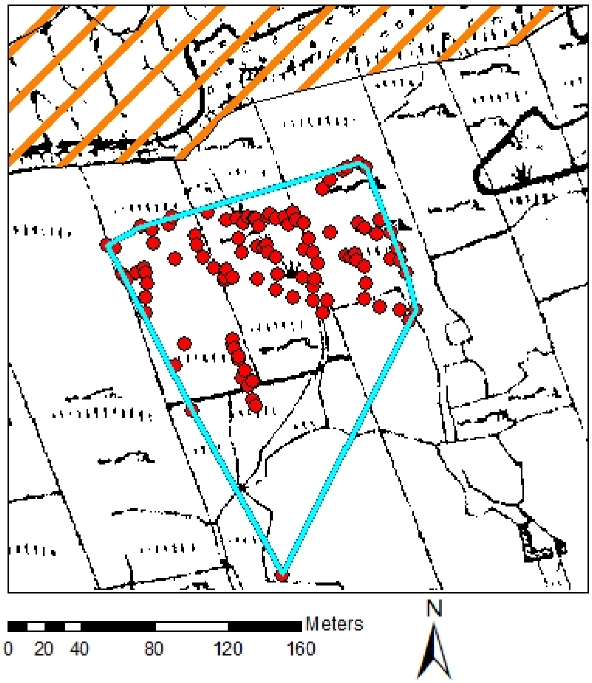
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	1.887	50
A04.02.01	Non-intensive cattle grazing	Negative	Moderate (-2)	3.774	100
G05.01	Trampling, overuse	Negative	Moderate (-2)	1.887	50

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	3.774	3.774	Pass
	Population (numbers)	318	318	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	18	Pass
	Recruitment (seedlings)	>10%	1	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	19	Pass
	Sward height (cm)	15.0 - 37.5	30.0	Pass
	Indicator species	≥8	7	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.0	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Skerrydoo 4 (SO11)
(within 260m of the Bunduff Lough and Machair/Trawalua/Mulaghmore SAC)



County: Sligo
Central Grid Ref: G746572

Conservation rank: 8
Conservation value: 71.0 (Good)

Fossitt (2000): Predominantly GS1
Secondary HH1

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: SAC

Recommendations:
- Consider extending the boundary of the
- Bunduff Lough and Machair/Trawalua/ Mulaghmore SAC by 260m southward beyon the foreshore to include formation
- Consider designating this site as an NHA
- Consider active control of invasive non-native and problematic species on part of the site

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
I01	Invasive non-native species	Negative	Moderate (-2)	1.1	50
I02	Problematic native species	Negative	Moderate (-2)	0.66	30

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	2.2	2.2	Pass
	Population (numbers)	300	300	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	10	Pass
	Recruitment (seedlings)	>10%	0.6	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	99	Pass
	Spp. richness	≥6	11	Pass
	Sward height (cm)	15.0 - 37.5	30.0	Pass
	Indicator species	≥8	8	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-1.6	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – GY27 Lavally
(not within any SAC)

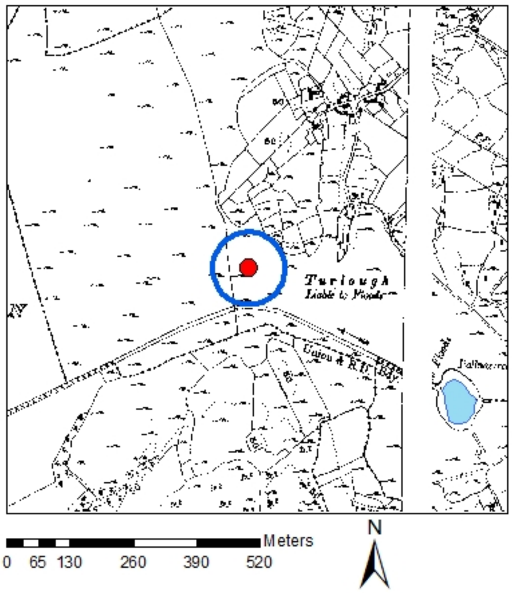
County: Galway
Central Grid Ref: M454227
XY: 145400, 222700

Conservation rank: 9
Conservation value: 70.6 (Good)

Fossitt (2000): Predominantly ER2

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: None



Recommendations:
- Delineate the exact boundary of the formation
- Assist recruitment by planting cones from reproductively active adult plants
- Raise awareness of the conservation status of juniper with the quarrying company

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
C01	Mining and quarrying	Negative	Minor (-1)	1.738	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.738	1.738	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	20	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	15	Pass
	Sward height (cm)	14.3 - 47.5	15.0	Pass
	Indicator species	≥3	3	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-1.0	**FAVOURABLE (FV)**
OVERALL ASSESSMENT				**FAVOURABLE (FV)**

FORMATION – Kincasslough - Mullaghderg (DL14)
(adjacent or close to Gweedore Bay and Islands SAC)

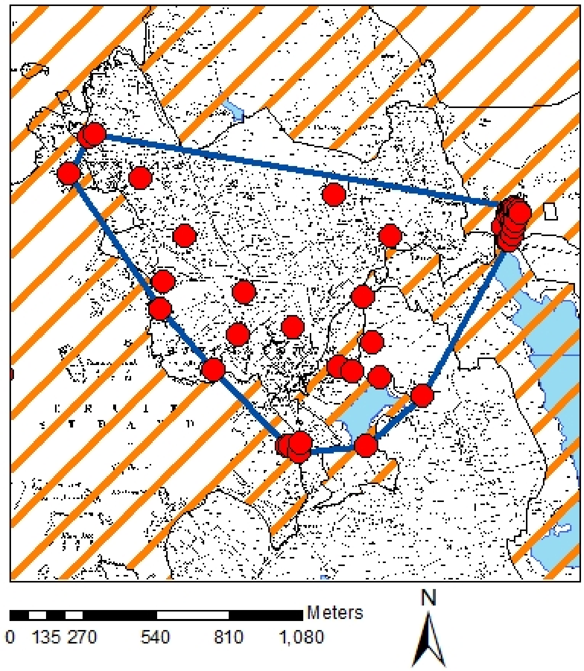
County: Donegal
Central Grid Ref: B749196

Conservation rank: 10
Conservation value: 70.4 (Good)

Fossitt (2000): Predominantly ER1
Secondary GS3
Also HH1 & HH3

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: pNHA
SAC



Recommendations:

- Consider designating this site as anNHA
- Raise awareness of the conservation status of juniper within the local community
- Reduce sheep grazing pressure

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	11.3	10
E01.03	Dispersed habitation	Negative	Severe (-3)	113.2	100
I02	Problematic native species	Negative	Minor (-1)	7.9	0.7

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	113.2	113.2	Pass
	Population (numbers)	500	500	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	12	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	15	Pass
	Sward height (cm)	15.0 - 37.5	37.5	Pass
	Indicator species	≥8	9	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -3.0	-3.2	**UNFAVOURABLE BAD U2**
OVERALL ASSESSMENT				**UNFAVOURABLE BAD U2**

FORMATION – Cloghmoyne (MO06)
(mostly within the Cloughmoyne SAC)

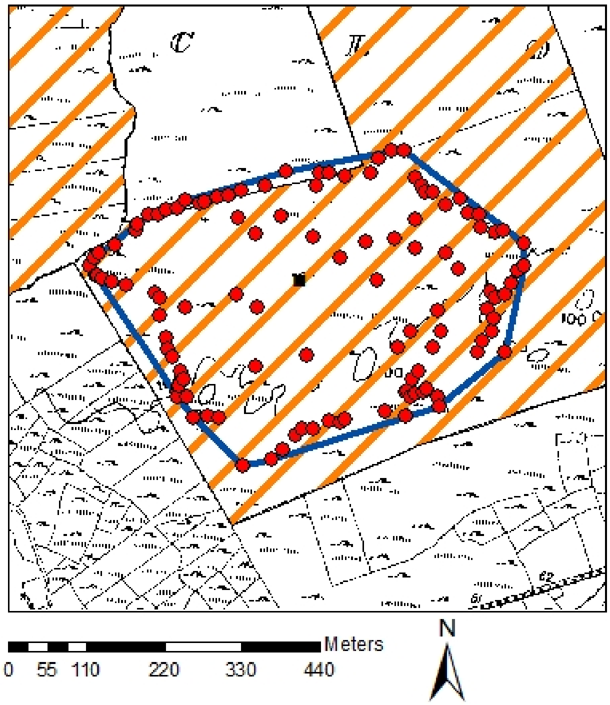
County: Mayo
Central Grid Ref: M227494

Conservation rank: 11
Conservation value: 70.1 (Good)

Fossitt (2000): Predominantly GS1
Secondary ER2

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: pNHA
SAC



Recommendations:
- Consider extending the inner boundary of tl Cloghmoyne SAC northward by 20m to include shrubs at the northern most parame of the formation
- Reduce sheep grazing pressure

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	18.2	100
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	18.2	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	18.2	18.2	Pass
	Population (numbers)	150	150	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	30	Pass
	Recruitment (seedlings)	>10%	5	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	17	Pass
	Sward height (cm)	14.3 - 47.5	18.0	Pass
	Indicator species	≥3	5	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-3.0	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – CK01 Cappul Bridge
(mostly within the Kenmare River SAC and Glanmore Bog SAC)

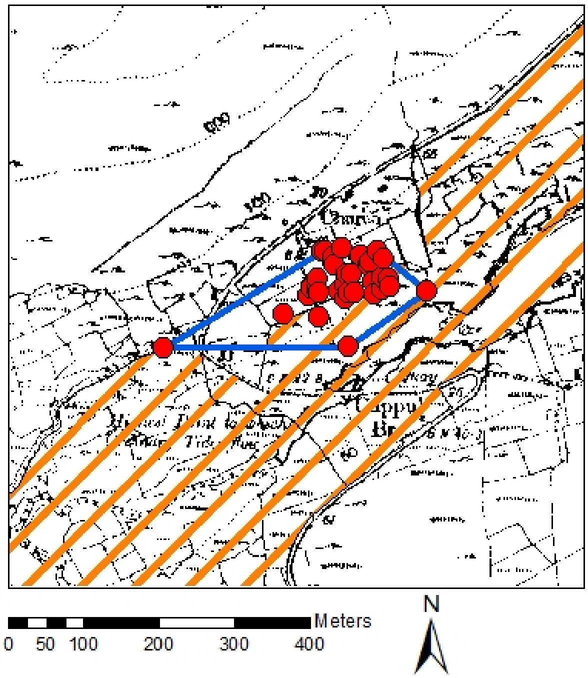
County: Cork
Central Grid Ref: V690558
XY: 069058, 055887

Conservation rank: 12
Conservation value: 67.6 (Good)

Fossitt (2000): Predominantly ER1
Secondary HH3

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: SAC



Recommendations:

- Monitor the prevalence of problematic native species

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.03	Abandonment of pastoral systems, lack of grazing	Negative	Minor (-1)	2.541	100
I02	Problematic native species	Negative	Minor (-1)	0.762	30

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	2.541	2.541	Pass
	Population (numbers)	87	87	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	17	Pass
	Recruitment (seedlings)	>10%	6	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	94	Pass
	Spp. richness	≥6	12	Pass
	Sward height (cm)	15.0 - 37.5	23.0	Pass
	Indicator species	≥8	5	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.3	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Caherateige (GY16)
(entirely within the Ardarhan Grassland SAC)

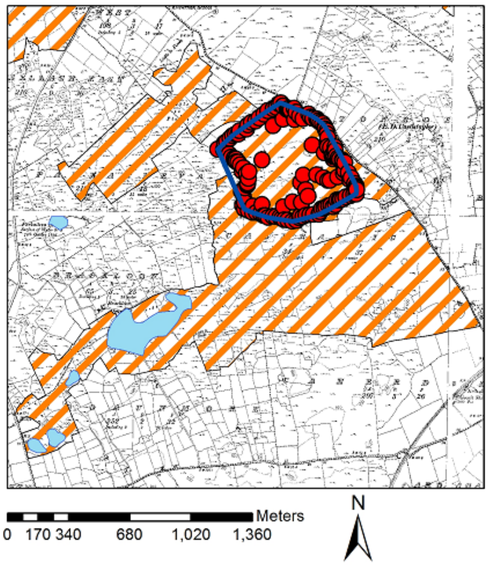
County: Galway
Central Grid Ref: M449139

Conservation rank: =14
Conservation value: **66.8** (Good)

Fossitt (2000): Predominantly GS1

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: SAC



Recommendations:

- Consider designating this site as an NHA
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce the number of horses on the site
- Consider active control of problematic native species on part of the site

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.03	Intensive horse grazing	Negative	Severe (-3)	16.9	50
A04.03	Abandonment of pastoral systems	Negative	Moderate (-2)	16.9	50
I02	Problematic native species	Negative	Moderate (-2)	16.9	50

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	33.7	33.7	Pass
	Population (numbers)	>750	>750	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	15	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥10	12	Pass
	Sward height (cm)	9.7 - 35.0	31.7	Pass
	Indicator species	≥6	3	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -3.0	-3.5	**UNFAVOURABLE BAD U2**
OVERALL ASSESSMENT				**UNFAVOURABLE BAD U2**

FORMATION – Fanad B (DL06)
(approx. 1km from Ballyhoorisky Point to Fanad Head SAC)

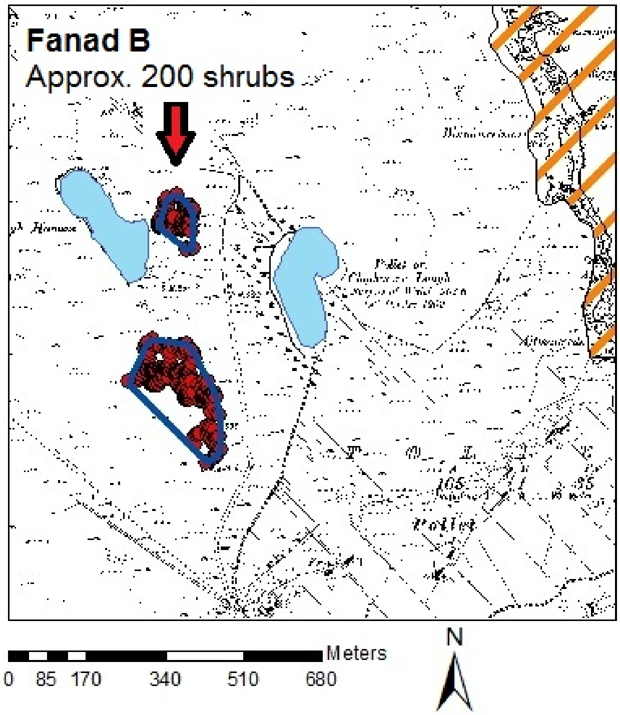
County: Donegal
Central Grid Ref: C234456

Conservation rank: =14
Conservation value: 66.8 (good)

Fossitt (2000): Predominantly HH1
Secondary ER1

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: None



Recommendations:
- Consider designating this site as an NHA

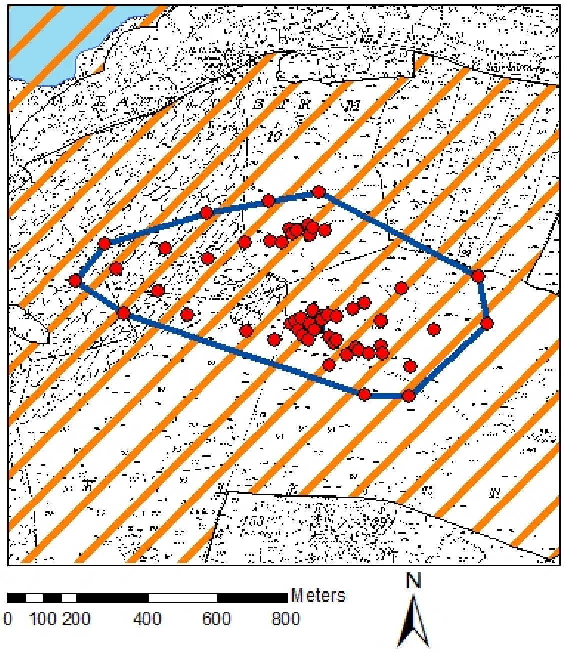
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
E01.03	Dispersed habitation	Negative	Moderate (-2)	0.62	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.62	0.62	Pass
	Population (numbers)	200	200	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	27	Pass
	Recruitment (seedlings)	>10%	15	Pass
	% bare ground	>10%	12.5	Pass
	% alive	>90%	100	Pass
	Spp. richness	>6	6	Fail
	Sward height (cm)	15.0 - 37.5	35.0	Pass
	Indicator species	≥8	4	Fail
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-0.5	FAVOURABLE (FV)
OVERALL ASSESSMENT				FAVOURABLE (FV)

FORMATION – Corranellistrum (GY05)
(entirely within the Gortnandarragh Limestone Pavement SAC)



County: Galway
Central Grid Ref: M197403

Conservation rank: 15
Conservation value: 66.4 (Good)

Fossitt (2000): Predominantly ER2
Secondary GS1

Vegetation group: 2
Exposed calcareous rock *aka* limestone pavement
Teucrium scorodonia - Geranium sanguineum group

Current designations: pNHA
SAC

Recommendations:
- Consider designating this site as an NHA
- Reduce grazing pressure especially numbers of sheep on the site

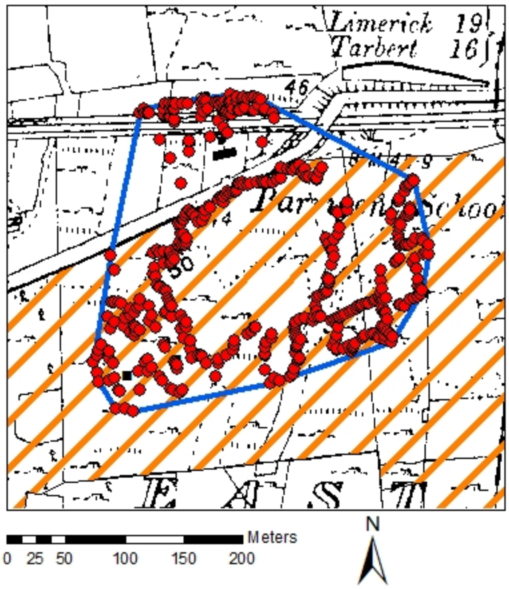
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	21.1	50
A04.02.05	Non-intensive mixed animal grazing	Negative	Minor (-1)	42.2	100
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	42.2	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	42.2	42.2	Pass
	Population (numbers)	500	500	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	18	Pass
	Recruitment (seedlings)	>10%	1	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	99	Pass
	Spp. richness	≥6	12	Pass
	Sward height (cm)	<11.5	0.0	Pass
	Indicator species	≥2	2	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-3.0	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Barrigone (LK01)
(mostly within Barrigone SAC)



County: Limerick
Central Grid Ref: R295507
XY 129561, 150795

Conservation rank: 16
Conservation value: 66.2 (Good)

Fossitt (2000): Predominantly ER2
Secondary GS1 & BL3

Vegetation group: 5
Dry calcareous or neutral grassland including coastal d
Gallium verum – Pilosella offcinarum group

Current designations: SAC

Recommendations:

- Consider extending the boundary of the Barrigone SAC approx. 100m northward to include northern most shrubs within the formation
- Consider designating this site as an NHA
- Assist recruitment by planting cones from reproductively active adult plants or seed
- Reduce grazing pressure
- Raise awareness of the conservation status of juniper with the quarrying company
- Consider control of problematic native species on part of the site

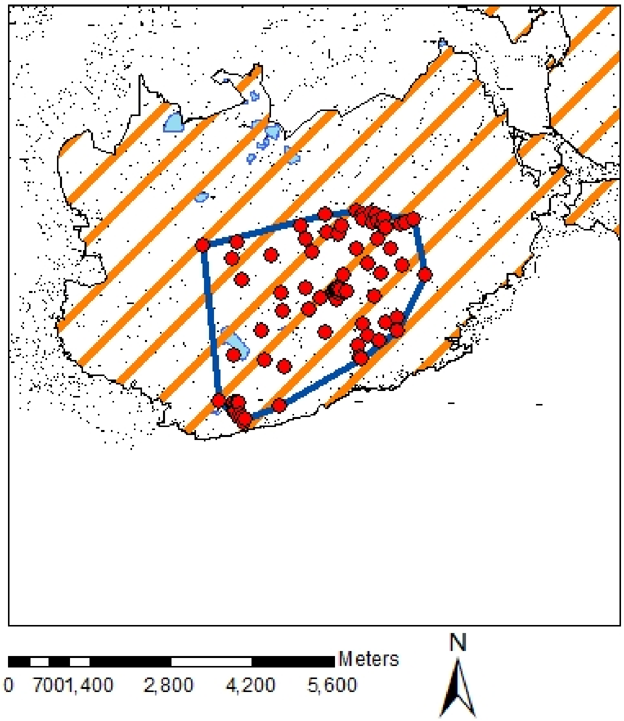
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.05	Non-intensive mixed animal grazing	Negative	Moderate (-2)	2.823	50
C01	Mining and quarrying	Negative	Moderate (-2)	2.823	50
I02	Problematic native species	Negative	Moderate (-2)	2.823	50

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	5.645	5.645	Pass
	Population (numbers)	1100	1100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	41.5	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	98	Pass
	Spp. richness	≥13	20.0	Pass
	Sward height (cm)	23.8 - 46.3	52.5	Fail
	Indicator species	≥13	8	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.0	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Corraun Hill – Clew Bay (MO04)
(entirely within Corraun Plateau SAC)



County: Mayo
Central Grid Ref: L785946

Conservation rank: 17
Conservation value: 65.6 (Good)

Fossitt (2000): Predominantly HH1

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: pNHA
SAC

Recommendations:
- Consider designating this site as an NHA
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce the number of sheep on the site

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Severe (-3)	961.2	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	961.2	961.2	Pass
	Population (numbers)	500	500	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	45	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	12.5	Pass
	% alive	>90%	100	Pass
	Spp. richness	≥6	12	Pass
	Sward height (cm)	15.0 - 37.5	0.0	Fail
	Indicator species	≥8	2	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-3.0	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Corcomroe (CE13)
(mostly within East Burren Complex SAC)

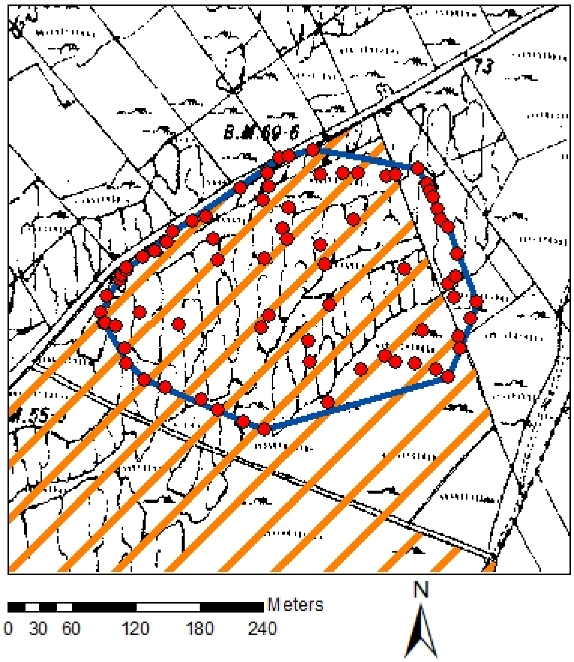
County: Clare
Central Grid Ref: M293083

Conservation rank: 18
Conservation value: 63.2 (Good)

Fossitt (2000): Predominantly ER2
Secondary GS1

Vegetation group: 2
Exposed calcareous rock *aka* limestone pavement
Teucrium scorodonia - Geranium sanguineum group

Current designations: pNHA
SAC



Recommendations:

- Extend boundary of East Burren Complex SAC by 25m north-east and 10m north to include shrubs at the formations parameter
- Consider active control of problematic native species on part of the site

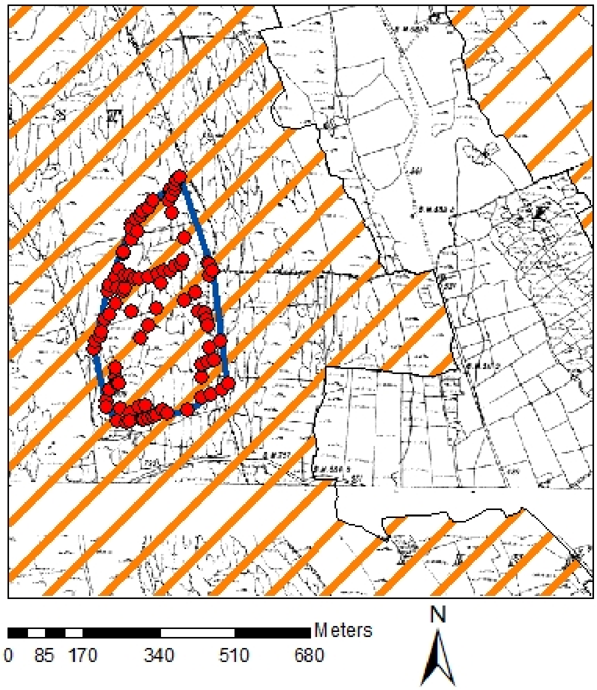
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
I02	Problematic native species	Negative	Moderate (-2)	3.2	50
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	6.4	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	6.4	6.4	Pass
	Population (numbers)	200	200	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	50	Pass
	Recruitment (seedlings)	>10%	1	Fail
	% bare ground	>10%	2.5	Fail
	% alive	>90%	99	Pass
	Spp. richness	≥6	11	Pass
	Sward height (cm)	<11.5	8.5	Pass
	Indicator species	≥2	2	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -1.0	-2.0	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Caherbannagh (CE10)
(entirely within the Black Head-Poulsallagh Complex SAC)



County: Clare
Central Grid Ref: M182077

Conservation rank: 19
Conservation value: 63.2 (Good)

Fossitt (2000): Predominantly ER2
Secondary GS1

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: pNHA
SAC

Recommendations:

- Consider designating this site as an NHA
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce grazing pressure to encourage active recruitment

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	2.2	20
A04.02.05	Non-intensive mixed animal grazing	Negative	Moderate (-2)	11.2	100
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	11.2	100

Table 2 *Formation attributes*

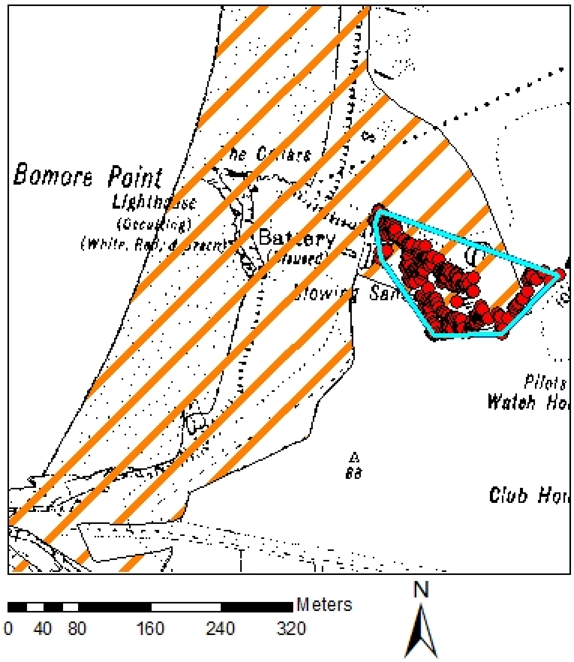
Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	11.2	11.2	Pass
	Population (numbers)	1000	1000	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	21	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥10	13	Pass
	Sward height (cm)	9.7 - 35.0	8.3	Pass
	Indicator species	≥6	4	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -3.0	-3.4	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – Rosses Point A (SO01)
(mostly within Cummeen Strand/Drumcliff (Sligo Bay) SAC)

County: Sligo
Central Grid Ref: G629420

Conservation rank: 20
Conservation value: 63.1 (Good)

Fossitt (2000): Predominantly CD3
Secondary GS1
Vegetation group: 5
Dry calcareous or neutral grassland including coastal dunes
Gallium verum – Pilosella offcinarum group



Current designations: SAC
Recommendations:

- Consider extending SAC boundary 50m west t include western most shrubs
- Consider designating this site as an NHA
- Reduce grazing pressure
- Ensure farmers and landowners are aware of the conservation status of juniper
- Consider active control of invasive native species on part of the site

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A03.01	Intensive mowing or intensification	Negative	Severe (-3)	1.62	100
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	0.41	25
G05.01	Trampling overuse	Negative	Moderate (-2)	0.41	25
I01	Invasive non-native species	Negative	Minor (-1)	0.41	25

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.62	1.62	Pass
	Population (numbers)	350	350	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	55	Pass
	Recruitment (seedlings)	>10%	21	Pass
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥13	25	Pass
	Sward height (cm)	23.8 - 46.3	33.8	Pass
	Indicator species	≥13	19	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -3.0	-4.3	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – MO07 Lough Carra
(entirely within the Lough Carra/Mask Complex SAC)

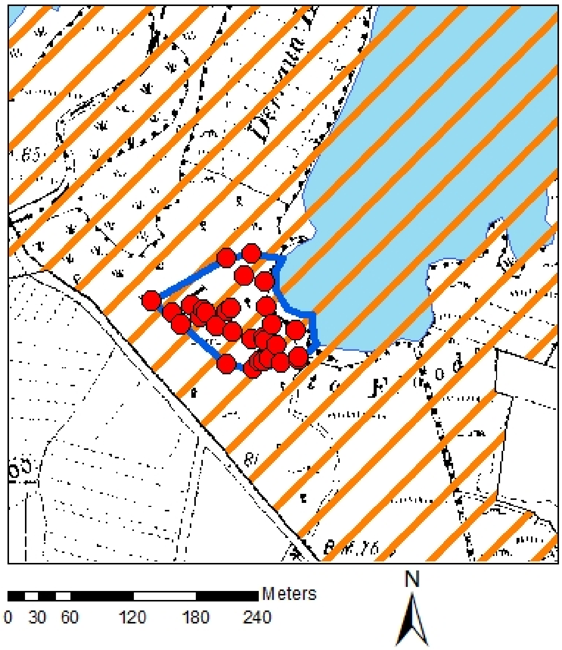
County: Mayo
Central Grid Ref: M165679
XY: 116516, 267920

Conservation rank: 21
Conservation value: 62.2 (Good)

Fossitt (2000): Predominantly GS1
Secondary GS4

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: SAC



Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants
- Consider control of problematic native species on part of the site reproductively active adult plants
  or import seed

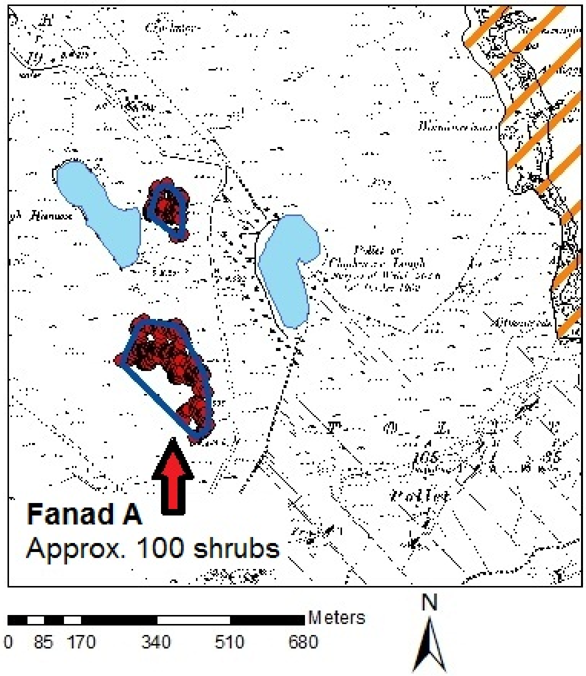
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.05	Intensive mixed animal grazing	Negative	Minor (-1)	1.040	100
I02	Problematic native species	Negative	Minor (-1)	0.260	25

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.040	1.040	Pass
	Population (numbers)	~100	~100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	15	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	8	Pass
	Sward height (cm)	14.3 – 47.5	30.0	Pass
	Indicator species	≥3	1	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.3	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Fanad A (DL05)
(⚜pprox.. 1km from Ballyhoorisky Point to Fanad Head SAC)



County: Donegal
Central Grid Ref: C231460

Conservation rank: 22
Conservation value: 62.0 (Good)

Fossitt (2000): Predominantly HH1
Secondary GS3

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: None

Recommendations:
- Raise awareness of the conservation status of juniper within the local community

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
E01.03	Dispersed habitation	Negative	Moderate (-2)	3.0	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	3.0	3.0	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	30	Pass
	Recruitment (seedlings)	>10%	3	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	11	Pass
	Sward height (cm)	15.0 – 37.5	45.0	Fail
	Indicator species	≥8	9	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.0	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Dooega Head (MO03)
(entirely within Keel Machair/Menaun Cliffs SAC)

County: Mayo
Central Grid Ref: L657995

Conservation rank: 23
Conservation value: 61.9 (Good)

Fossitt (2000): Predominantly HH1

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: SAC

Recommendations:
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce grazing pressure

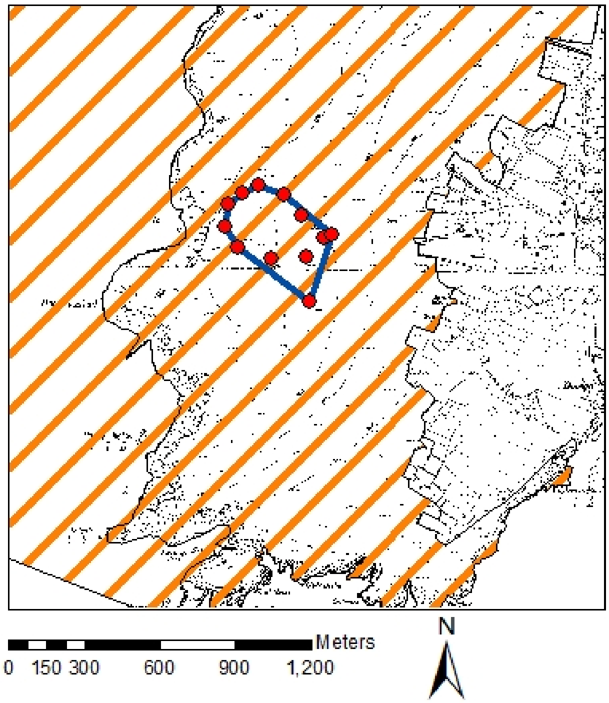


Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.05	Non-intensive mixed animal grazing	Negative	Moderate (-2)	11.2	100
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	5.8	50

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	11.2	11.2	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	20	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	>6	6	Fail
	Sward height (cm)	15.0 – 37.5	15.0	Pass
	Indicator species	≥8	4	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.5	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Skerrydoo 2 (SO12)
(within 110m of the Bunduff Lough and Machair/Trawalua/Mulaghmore SAC)

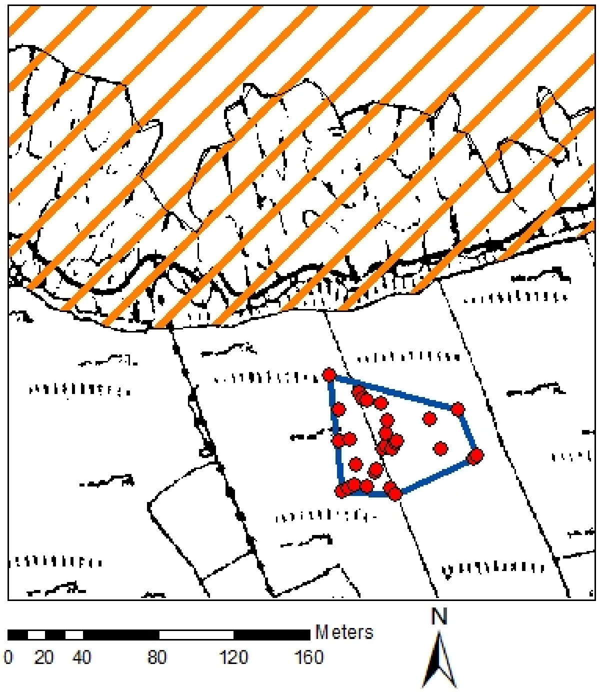
County: Sligo
Central Grid Ref: G744572

Conservation rank: 24
Conservation value: 61.1 (Good)

Fossitt (2000): Predominantly HH1

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: SAC



Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
None					

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.33	0.33	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	4	Fail
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	15	Pass
	Sward height (cm)	15.0 - 37.5	35.0	Pass
	Indicator species	≥8	9	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	0.0	FAVOURABLE (FV)
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – MO08 Mocorha Lough
(entirely within Mocorha Lough SAC)

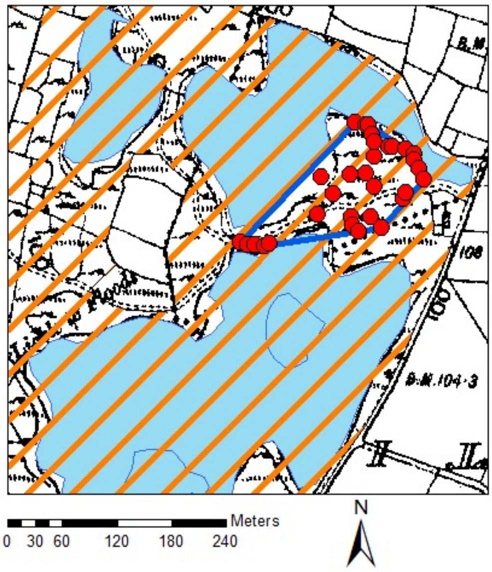
County: Mayo
Central Grid Ref: M233550
XY: 123345, 255091

Conservation rank: 25
Conservation value: 60.3 (Good)

Fossitt (2000): Predominantly GS1

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: SAC



Recommendations:
- Assist recruitment by planting cones from reproductively active adult plants

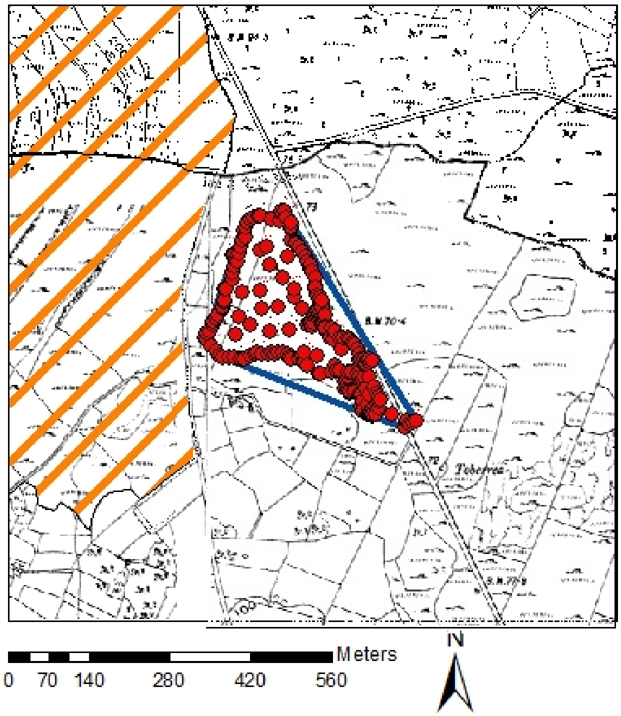
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
K04.05	Damage by herbivores	Negative	Minor (-1)	1.394	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.394	1.394	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	25	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	11	Pass
	Sward height (cm)	14.3 - 47.5	10.0	Fail
	Indicator species	≥3	2	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.0	**FAVOURABLE (FV)**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Ballybornagh (CE06)
(adjacent or close to the East Burren Complex SAC)



County: Clare
Central Grid Ref: M361039

Conservation rank: 26
Conservation value: 60.1 (Good)

Fossitt (2000): Predominantly ER2
Secondary GS1
Also HH2

Vegetation group: 2
Exposed calcareous rock *aka* limestone paveme
Teucrium scorodonia - Geranium sanguineum gro

Current designations: pNHA
SAC

Recommendations:
- Extend western boundary of the East Burre SAC by approx. 400m to include formation
- Consider designating this site as an NHA
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce grazing pressure to encourage active recruitment

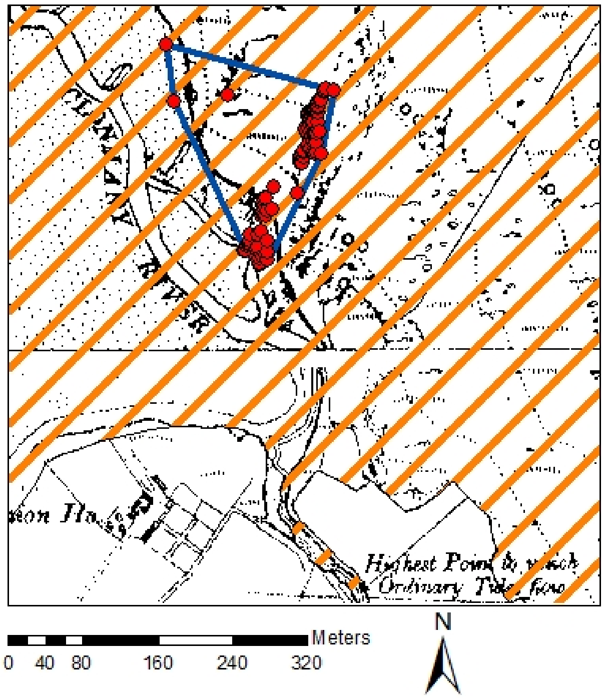
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	3.2	50
A04.01.05	Intensive mixed animal grazing	Negative	Moderate (-2)	6.4	100
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	6.4	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	6.4	6.4	Pass
	Population (numbers)	500	500	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	30	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	16	Pass
	Sward height (cm)	<11.5	8.7	Pass
	Indicator species	≥2	2	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -3.0	-4.0	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Binnion A (DL02)
(entirely within North Inishowen Coast SAC)



County: Donegal
Central Grid Ref: C364484

Conservation rank: 27
Conservation value: 59.7 (Moderate)

Fossitt (2000): Predominantly GS1
Secondary HH2

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: pNHA
SAC

Recommendations:
- Reduce numbers of horses on the site
- Consider active control of problematic native species on part of the site

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.04	Non-intensive horse grazing	Negative	Moderate (-2)	2.33	100
I02	Problematic native species	Negative	Moderate (-2)	0.93	40

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	2.33	2.33	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	≥10%	10	Pass
	Recruitment (seedlings)	>10%	6	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	96	Pass
	Spp. richness	≥6	21	Pass
	Sward height (cm)	15.0 - 37.5	30.0	Pass
	Indicator species	≥8	6	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.8	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Cloghboley B (GY10)
(1km from south-western edge of Ardrahan Grassland SAC)

County: Galway
Central Grid Ref: M422119

Conservation rank: 28
Conservation value: 59.5 (Moderate)

Fossitt (2000): Predominantly GS1

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: None

Recommendations:
- Import cones from geographically adjacent populations to stimulate recruitment
- Ensure grazing pressure remains relatively low to stimulate recruitment

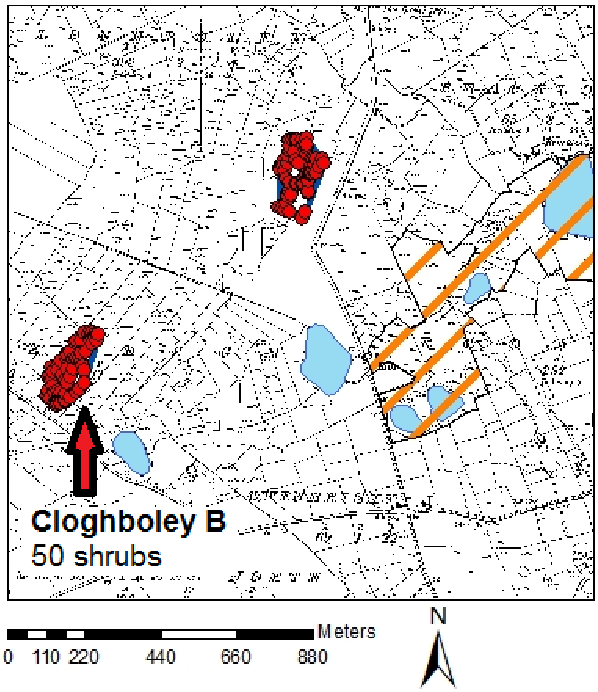


Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.05	Non-intensive mixed animal grazing	Negative	Minor (-1)	1.6	100
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	1.6	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.6	1.6	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	60	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥10	21	Pass
	Sward height (cm)	9.7 - 35.0	35.0	Pass
	Indicator species	≥6	4	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.0	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Rineen (GY23)
(1-2km from the Ross Lake and Woods SAC and Lough Corrib SAC)

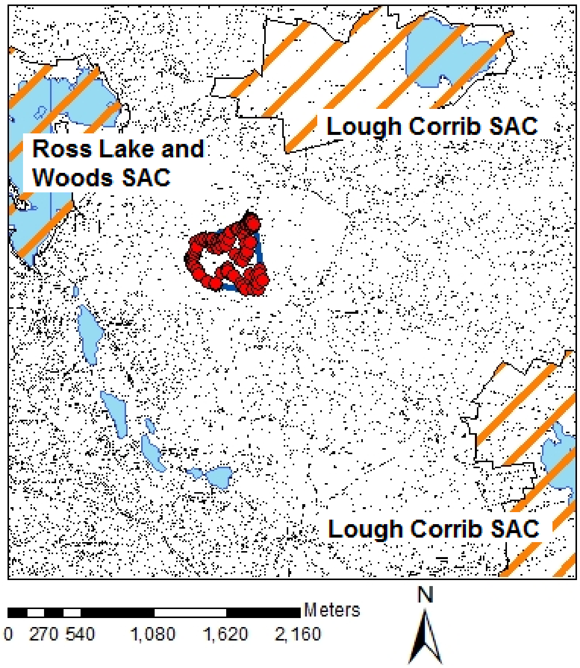
County: Galway
Central Grid Ref: M213345

Conservation rank: 29
Conservation value: 58.5 (Moderate)

Fossitt (2000): Predominantly ER2

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: None



Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants
- Ensure the site is grazed to restore plant communities to favourable status
- Consider active control of problematic native species on part of the site

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.03	Abandonment of pastoral systems	Negative	Moderate (-2)	19.5	100
I02	Problematic native species	Negative	Moderate (-2)	19.5	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	19.5	19.5	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	30	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	11	Pass
	Sward height (cm)	14.3 - 47.5	0.0	Fail
	Indicator species	≥3	3	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -3.0	-4.0	**UNFAVOURABLE BAD U2**
OVERALL ASSESSMENT				**UNFAVOURABLE BAD U2**

FORMATION – MO01 Carrowaneeragh
(entirely within the Lough Carra/Mask Complex SAC)

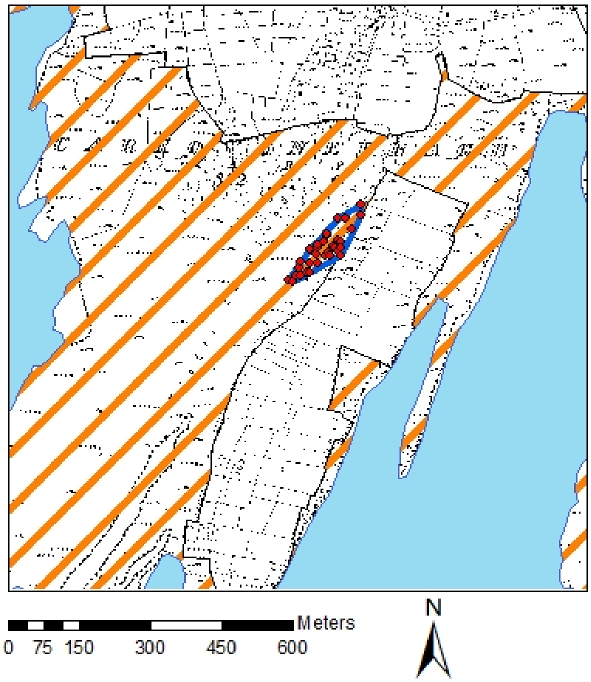
County: Mayo
Central Grid Ref: M147687
XY: 114768, 268786

Conservation rank: 30
Conservation value: 58.1 (Moderate)

Fossitt (2000): Predominantly ER2

Vegetation group: 5
Dry calcareous or neutral grassland including coastal dunes
Gallium verum – Pilosella offcinarum group

Current designations: SAC



Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants
- Elevate grassing pressure from wild rabbits to increase sward height

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
K04.05	Damage by herbivores	Negative	Minor (-1)	0.791	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.791	0.791	Pass
	Population (numbers)	73	73	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	36	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥13	22	Pass
	Sward height (cm)	23.8 - 46.3	5.0	Fail
	Indicator species	≥13	11	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.0	FAVOURABLE (FV)
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Mullaghdoo B (DL11)
(entirely within the Gweedore Bay and Islands SAC)

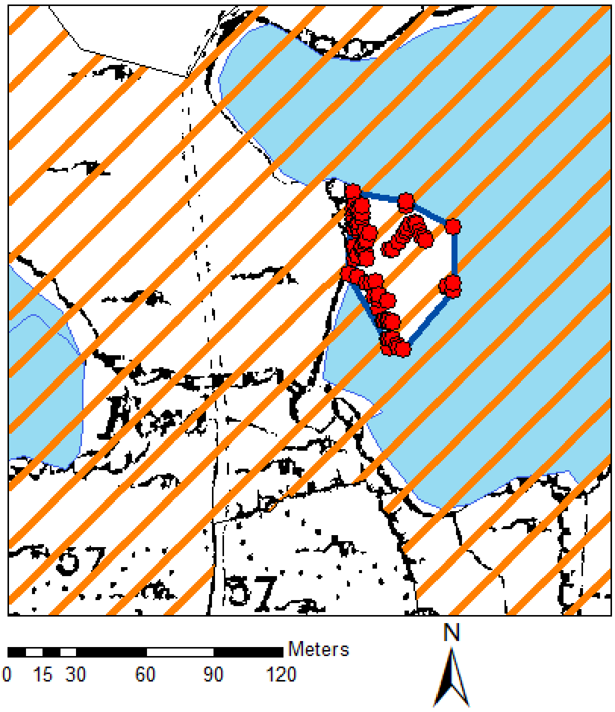
County: Donegal
Central Grid Ref: B765203

Conservation rank: 31
Conservation value: 57.8 (Moderate)

Fossitt (2000): Predominantly HH1
Secondary CD6

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: pNHA
SAC



Recommendations:

- Ensure site is grazed to restore vegetation communities to favourable status

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.05	Non-intensive mixed animal grazing	Negative	Minor (-1)	0.23	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.23	0.23	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	16	Pass
	Recruitment (seedlings)	>10%	8	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	84	Fail
	Spp. richness	≥6	19	Pass
	Sward height (cm)	14.3 - 47.5	80.0	Fail
	Indicator species	≥3	3	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-1.0	**FAVOURABLE (FV)**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Melmore Head (DL31)
(entirely within Tranarossan and Melmore Lough SAC)

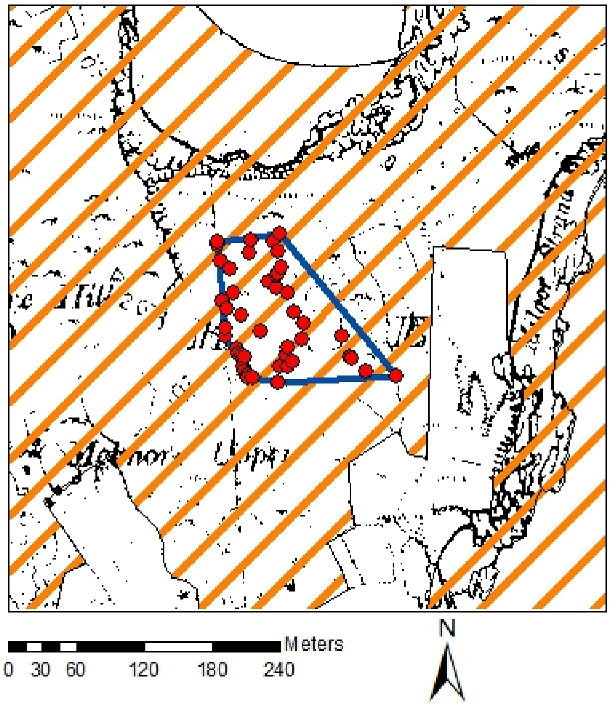
County: Donegal
Central Grid Ref: C133442

Conservation rank: 32
Conservation value: 56.0 (Moderate)

Fossitt (2000): Predominantly HH1

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: pNHA
SAC
SPA



Recommendations:
- Assist recruitment by planting cones from reproductively active adult plants

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.05	Non-intensive mixed animal grazing	Negative	Minor (-1)	1.3	100
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	1.3	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.3	1.3	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	30	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	8	Pass
	Sward height (cm)	15.0 - 37.5	20.0	Pass
	Indicator species	≥8	3	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.0	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**UNFAVOURABLE INADEQUATE U1**

FORMATION – Island Fen Birr (OY01)
(mostly within the Island Fen SAC)

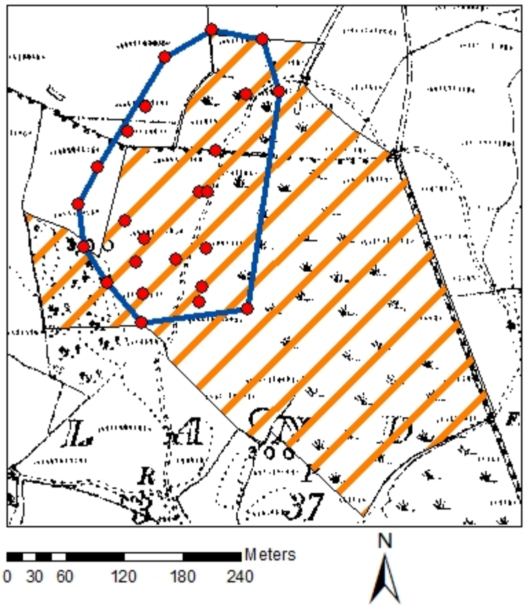
County: Offaly
Central Grid Ref: N120014

Conservation rank: 33
Conservation value: 55.8 (Moderate)

Fossitt (2000): Predominantly GS4
Secondary PF1

Vegetation group: No data

Current designations: SAC



Recommendations:

- Extend Island Birr SAC boundary approx.. 60m north-west to include shrubs outside the designated area
- Assist recruitment by planting cones from reproductively active adult plants
- Make site developers aware of the conservation status of juniper
- Assess site drainage

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
D01.01	Paths tracks and cycling tracks	Negative	Severe (-3)	1.1	25
K01.03	Drying out	Negative	Minor (-1)	1.3	30

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	4.4	4.4	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	25	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	-	Unknown
	% alive	>90%	90	Fail
	Spp. richness	-	-	Unknown
	Sward height (cm)	-	-	Unknown
	Indicator species	-	-	Unknown
				UNFAVOURABLE BAD U2
Future prospects	Overall score	≥ -1.0	-1.1	**UNFAVOURABLE INADEQUATE U1**
OVERALL ASSESSMENT				**Assumed UNFAVOURABLE BAD U2**

FORMATION – DL21 Malin
(outside the boundary of the North Inishowen Coast SAC)

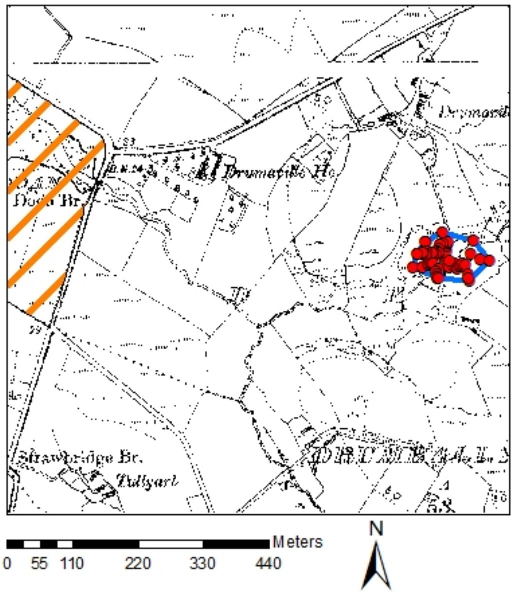
County: Donegal
Central Grid Ref: C486480
XY: 248605, 448019

Conservation rank: 34
Conservation value: 55.5 (Moderate)

Fossitt (2000): Predominantly GS3
Secondary ER1

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: None



Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants
- Ensure site is grazed to restore vegetation communities to favourable status
- Consider active control of problematic native species on a quarter of the site
- Extend the boundary of the North Inishowen Coast SAC by approx. 600m to the eastExtend boundary of North Inishowen Coast SAC approx. 700m east to include formation

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.03	Abandonment of pastoral systems, lack of grazing	Negative	Moderate (-2)	0.709	100
I02	Problematic native species	Negative	Minor (-1)	0.177	25

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.709	0.709	Pass
	Population (numbers)	60	60	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	23	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	8	Pass
	Sward height (cm)	14.3 - 47.5	35.0	Pass
	Indicator species	≥3	2	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-2.3	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – Viking House (DL15)
(adjacent or close to the Gweedore Bay and Islands SAC)

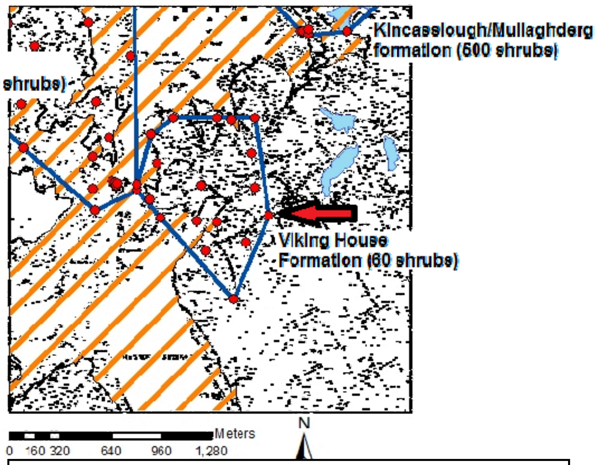
County: Donegal
Central Grid Ref: B744184

Conservation rank: 35
Conservation value: 53.1 (Moderate)

Fossitt (2000): Predominantly HH1
Secondary ER1

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: pNHA
SAC



This formation was judge separate from Cruit Island due to its separation by the Cruit Strait and it was >600m distant from the Kincasslough /Mullaghderg formation

Recommendations:

- Extend the Gweedore Bay and Islands SAC approx.. 700m westward to include formation
- Consider active control of problematic native species on a small area of the site
- Raise awareness of the conservation status of juniper within the local community
- Reduce sheep grazing pressure

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	6.2	10
E01.03	Dispersed habitation	Negative	Severe (-3)	62.3	100
I02	Problematic native species	Negative	Moderate (-2)	62.3	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	62.3	62.3	Pass
	Population (numbers)	79	79	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	30	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	11	Pass
	Sward height (cm)	14.3 - 47.5	30.0	Pass
	Indicator species	≥3	1	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -3.0	-5.2	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – CE01 Church Bay
(not within any SAC)

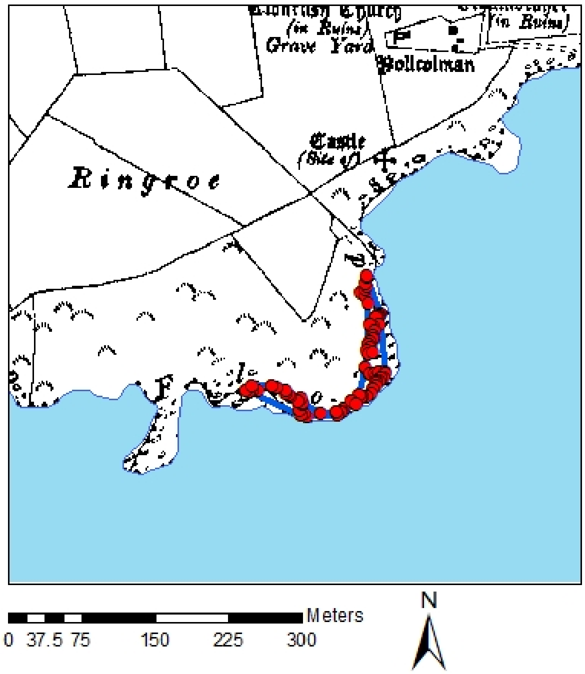
County: Clare
Central Grid Ref: R759865
XY: 175910, 186500

Conservation rank: 36
Conservation value: 51.9 (Moderate)

Fossitt (2000): Predominantly GM1

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: SAC



Recommendations:
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce sheep grazing pressure to encourage active recruitment

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	1.086	100
A04.02.01	Non-intensive cattle grazing	Negative	Minor (-1)	1.086	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.086	1.086	Pass
	Population (numbers)	82	82	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	33	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥10	11	Pass
	Sward height (cm)	9.7 - 35.0	14.0	Pass
	Indicator species	≥6	1	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-3.0	UNFAVOURABLE INADEQUATE U1
OVERALL ASSESSMENT				UNFAVOURABLE INADEQUATE U1

FORMATION – TP02 Kilgarvan Quay
(entirely within Lough Derg, North-East Shore SAC)

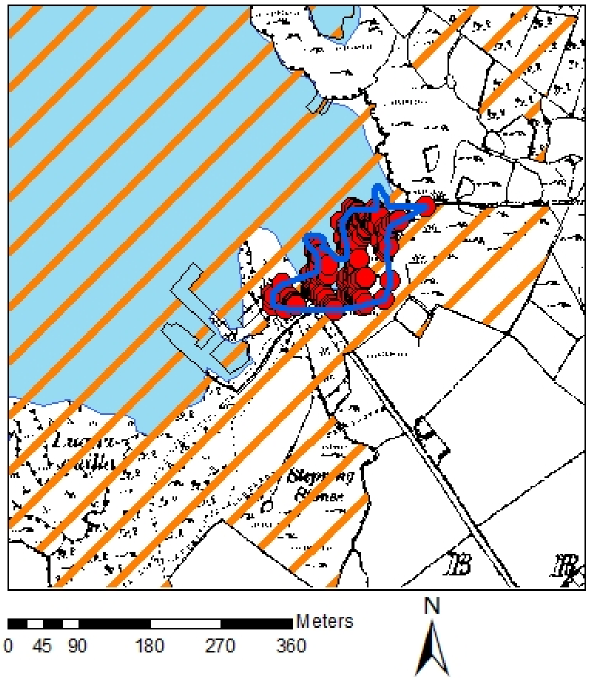
County: Tipperary
Central Grid Ref: R828965
XY: 182853, 196517

Conservation rank: 37
Conservation value: 51.2 (Moderate)

Fossitt (2000): Predominantly PF1
Secondary GS4

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: SAC



Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants or import se
- Reduce grazing pressure
- Assess site drainage

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A03.02	Non-intensive mowing	Negative	Moderate (-2)	1.250	100
A04.02.05	Non-intensive mixed animal grazing	Negative	Moderate (-2)	1.250	100
I01	Invasive non-native species	Negative	Minor (-1)	1.250	100
K01.03	Drying out	Negative	Minor (-1)	1.250	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.250	1.250	Pass
	Population (numbers)	>100	>100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	50	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥10	33	Pass
	Sward height (cm)	9.7 - 35.0	40.0	Fail
	Indicator species	≥6	10	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-5.0	**UNFAVOURABLE BAD U2**
OVERALL ASSESSMENT				**UNFAVOURABLE BAD U2**

FORMATION – Carney Commons (TP01)
(not within any SAC)

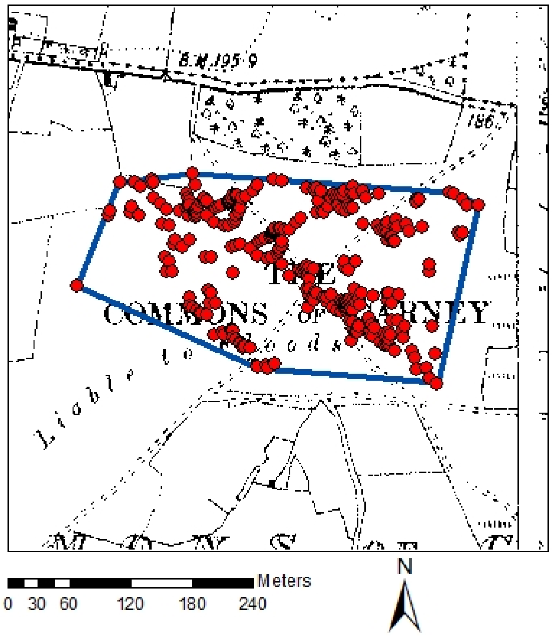
County: Tipperary
Central Grid Ref: R874920

Conservation rank: 38
Conservation value: 48.7 (Moderate)

Fossitt (2000): Predominantly PF1
Secondary GS1

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: None



Recommendations:
- Consider designating this site as an NHA
- Reduce grazing pressure
- Consider active control of invasive non-native and problematic native species on part of the site

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	0.6	10
A04.02.05	Non-intensive mixed animal grazing	Negative	Moderate (-2)	6.0	100
G05.01	Trampling overuse	Negative	Moderate (-2)	6.0	100
I01	Invasive non-native species	Negative	Moderate (-2)	4.8	8
I02	Problematic native species	Negative	Moderate (-2)	4.8	8
K04.05	Damage by herbivores (natural)	Negative	Moderate (-2)	6.0	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	6.0	6.0	Pass
	Population (numbers)	250	250	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	31	Pass
	Recruitment (seedlings)	>10%	4	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	99	Pass
	Spp. richness	≥10	12	Pass
	Sward height (cm)	9.7 - 35.0	53.3	Fail
	Indicator species	≥6	6	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -3.0	-6.5	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – TP03 Cornalack
(entirely within Lough Derg, North-East Shore SAC)

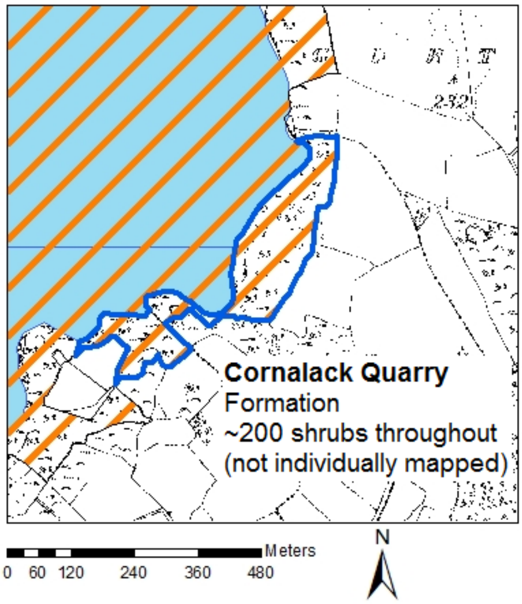
County: Tipperary
Central Grid Ref: R841999
XY: 184114, 199995

Conservation rank: 39
Conservation value: 48.0 (Moderate)

Fossitt (2000): Predominantly ER2

Vegetation group: 5
Dry calcareous or neutral grassland including coastal dunes
Gallium verum – Pilosella offcinarum group

Current designations: SAC



Recommendations:

- Assist recruitment by planting cones from reproductively active adult plants or import seeds
- Raise awareness of the conservation status of juniper with the quarry owners
- Reduce grazing pressure
- Consider active control of invasive non-native and problematic native species on part of the site
- Raise awareness of the conservation status of juniper with site owners and farmers

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A03.01	Intensive mowing or intensification	Negative	Minor (-1)	5.427	100
C01	Mining and quarrying	Negative	Moderate (-2)	5.427	100
I02	Problematic native species	Negative	Moderate (-2)	5.427	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	5.427	5.427	Pass
	Population (numbers)	~200	~200	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	0	Fail
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥13	13	Pass
	Sward height (cm)	23.8 - 46.3	40.0	Pass
	Indicator species	≥13	2	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-6.0	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – CK05 Black Rock Allihies
(entirely within Kenmare River SAC)

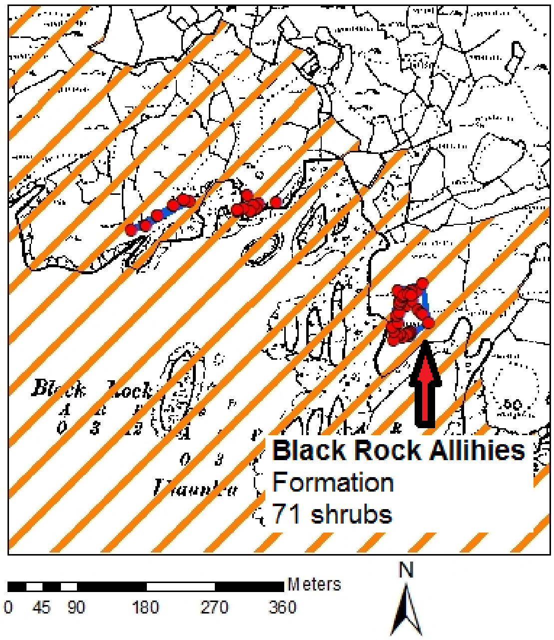
County: Cork
Central Grid Ref: V559471
XY: 055938, 047141

Conservation rank: 40
Conservation value: 46.5 (Moderate)

Fossitt (2000): Predominantly ER1
Secondary HH3

Vegetation group: 4
Dry siliceous heath and raised bog
Calluna vulgaris – Erica cinerea group

Current designations: SAC



Recommendations:
- Import cones from neighbouring populations and plant to assist recruitment
- Reduce grazing pressure

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	0.248	100
A04.02.01	Non-intensive cattle grazing	Negative	Moderate (-2)	0.248	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.248	0.248	Pass
	Population (numbers)	71	71	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	0	Fail
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	17	Pass
	Sward height (cm)	15.0 - 37.5	17.5	Pass
	Indicator species	≥8	9	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-4.0	**UNFAVOURABLE BAD U2**
OVERALL ASSESSMENT				**UNFAVOURABLE BAD U2**

FORMATION – Cloghboley A (GY09)
(500m from south-western edge of Ardrahan Grassland SAC)

County: Galway
Central Grid Ref: M429125

Conservation rank: 41
Conservation value: 44.1 (Moderate)

Fossitt (2000): Predominantly GS1
Secondary ER2

Vegetation group: 2
Exposed calcareous rock *aka* limestone pavement
Teucrium scorodonia - Geranium sanguineum group

Current designations: None

Recommendations:
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce grazing pressures
- Consider extending the boundary of the Ardrahan Grassland SAC to include this site

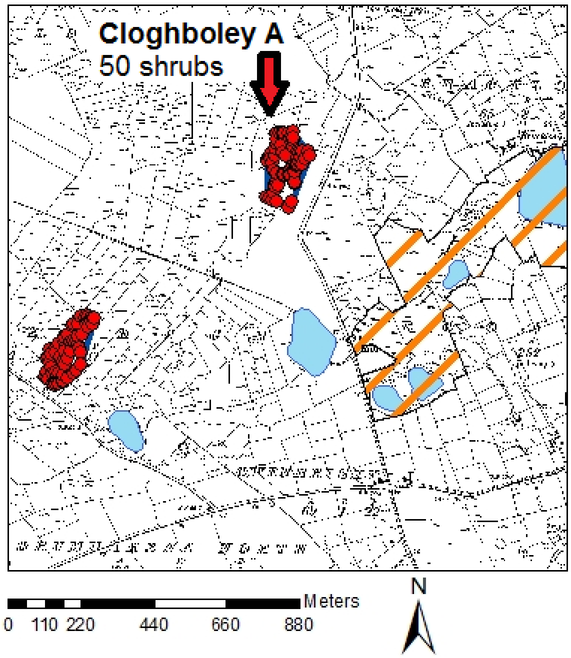


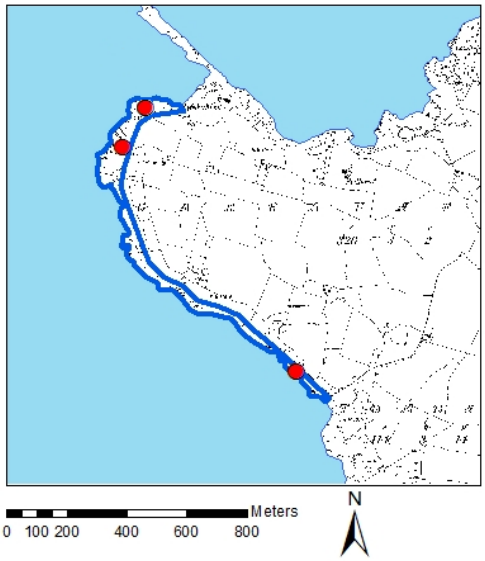
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	1.68	80
A04.01.05	Intensive mixed animal grazing	Negative	Severe (-3)	2.10	100
A11	Agricultural activities	Negative	Minor (-1)	0.21	10
E04.01	Agricultural structures building in the landscape	Negative	Moderate (-2)	0.21	10
K04.05	Damage by herbivores (natural)	Negative	Minor (-1)	2.10	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	2.1	2.1	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	20	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	2.5	Fail
	% alive	>90%	99	Pass
	Spp. richness	≥6	20	Pass
	Sward height (cm)	<11.5	10.0	Pass
	Indicator species	≥2	1	Fail
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -3.0	-5.9	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – TP04 Dromineer
(not within any SAC)



County: Tipperary
Central Grid Ref: R786851
XY: 178674, 185191

Conservation rank: 42
Conservation value: 43.6 (Moderate)

Fossitt (2000): Predominantly GS2

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: None

Recommendations:
- Assist recruitment by planting cones from reproductively active adult plants or import seeds
- Raise awareness of the conservation status of juniper with the factory owners
- Reduce grazing pressure
- Consider active control of invasive non-native and problematic native species on part of the site
- Raise awareness of the conservation status of juniper with site managers including farmers

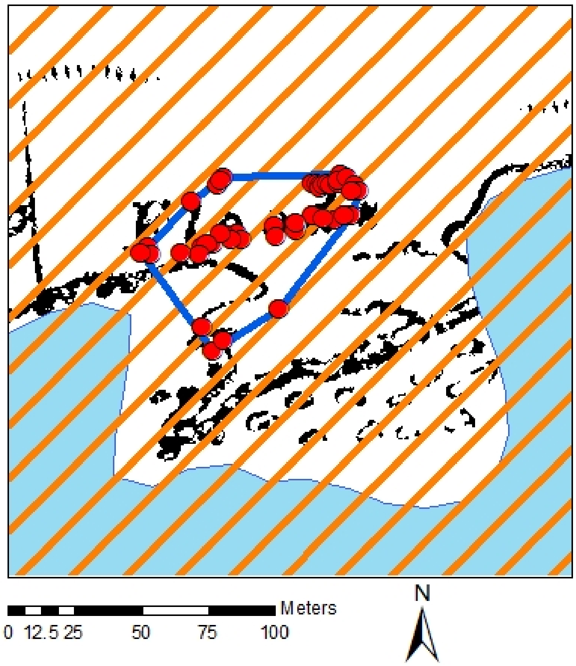
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A03.01	Intensive mowing or intensification	Negative	Minor (-1)	6.041	100
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	6.041	100
E02.01	Factory	Negative	Moderate (-2)	6.041	100
G05.01	Trampling, overuse	Negative	Minor (-1)	6.041	100
I01	Invasive non-native species	Negative	Minor (-1)	1.208	20

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	6.041	6.041	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	0	Fail
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥6	9	Pass
	Sward height (cm)	14.3 - 47.5	100.0	Fail
	Indicator species	≥3	2	Fail
				UNFAVOURABLE BAD U2
Future prospects	Overall score	≥ -1.0	-6.2	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – CE31 Lough Cullan
(entirely within the East Burren Complex SAC)



County: Clare
Central Grid Ref: R316907
XY: 131608, 190768

Conservation rank: 43
Conservation value: 41.3 (Moderate)

Fossitt (2000): Predominantly GS4

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: SAC

Recommendations:
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce cattle grazing pressure to encourage active recruitment
- Assess site drainage

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.02.01	Non-intensive cattle grazing	Negative	Moderate (-2)	0.315	100
M01.03	Flooding and rising precipitation	Negative	Moderate (-2)	0.315	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.315	0.315	Pass
	Population (numbers)	61	61	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	10	Fail
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	95	Pass
	Spp. richness	≥6	10	Pass
	Sward height (cm)	14.3 - 47.5	14.0	Fail
	Indicator species	≥3	4	Pass
				UNFAVOURABLE INADEQUATE U1
Future prospects	Overall score	≥ -1.0	-4.0	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – CK07 Cod's Head Allihies
(entirely within Kenmare River SAC)

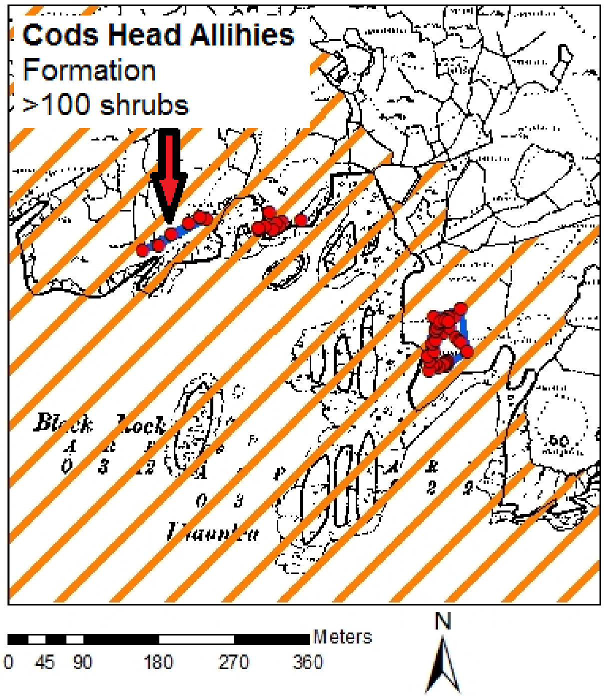
County: Cork
Central Grid Ref: V556472
XY: 055615, 47267

Conservation rank: 44
Conservation value: 38.6 (Poor)

Fossitt (2000): Predominantly HH1

Vegetation group: 1
Wet grassland, heath or bog
Carex flacca – Succisa pratensis group

Current designations: SAC



Recommendations:
- Assist recruitment by planting cones from reproductive individuals or import cones
- Reduce grazing pressure to encourage active recruitment and restore vegetation communities

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	0.042	100
A04.02.05	Non-intensive mixed animal grazing	Negative	Severe (-3)	0.042	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.042	0.042	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	0	Fail
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	76	Fail
	Spp. richness	≥10	14	Pass
	Sward height (cm)	9.7 - 35.0	7.0	Fail
	Indicator species	≥6	4	Fail
				UNFAVOURABLE BAD U2
Future prospects	Overall score	≥ -1.0	-5.0	**UNFAVOURABLE BAD U2**
OVERALL ASSESSMENT				**UNFAVOURABLE BAD U2**

FORMATION – Ballynacarrick (DL30)
(adjacent or close to the Ballintra SAC)

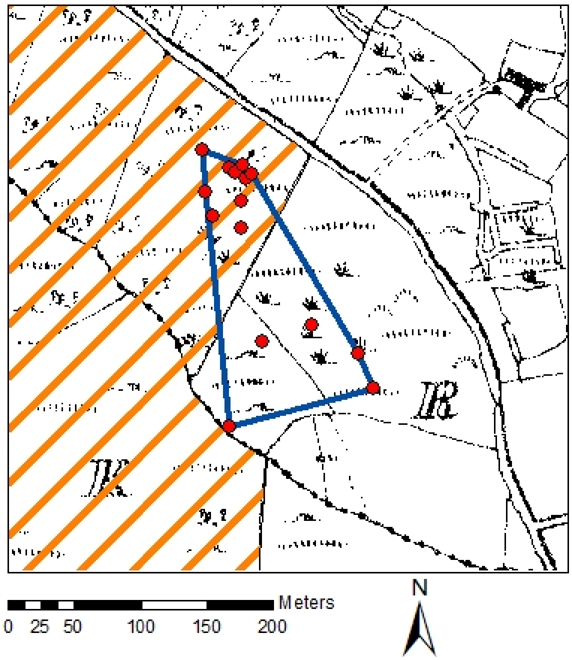
County: Donegal
Central Grid Ref: G929685

Conservation rank: 45
Conservation value: 34.4 (Poor)

Fossitt (2000): Predominantly GS1
Secondary HH2

Vegetation group: 3
Dry calcareous heath and grassland
Lotus corniculatus – Trifolium pratensis group

Current designations: pNHA
SAC



Recommendations:

- Extend boundary of Ballintra SAC approx.. 140m westward.
- Assist recruitment by planting cones from reproductively active adult plants
- Reduce grazing pressure
- Consider protecting propagated seedlings using rabbit proof covering
- Consider active control of problematic native species on part of the site

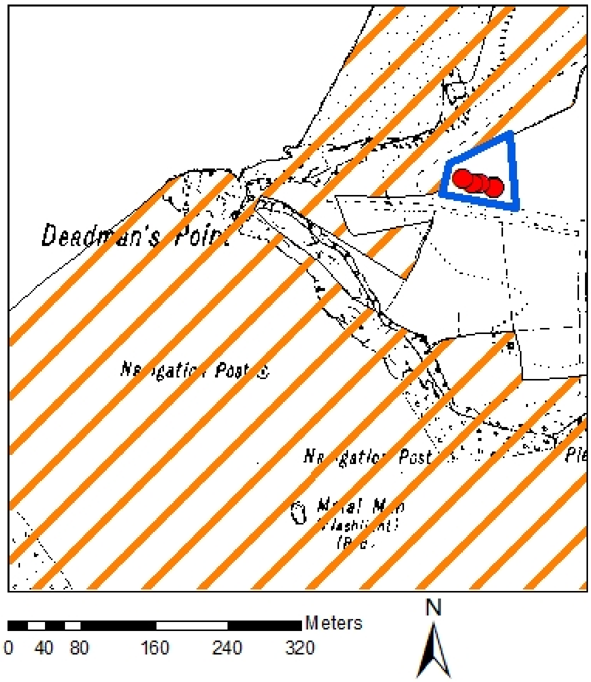
Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	1.1	80
A04.01.05	Intensive mixed animal grazing	Negative	Severe (-3)	1.4	100
I02	Problematic native species	Negative	Moderate (-2)	0.5	36
K04.05	Damage by herbivores (natural)	Negative	Moderate (-2)	1.4	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.4	1.4	Pass
	Population (numbers)	50	50	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	20	Pass
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	95	Pass
	Spp. richness	≥6	14	Pass
	Sward height (cm)	14.3 - 47.5	10.0	Pass
	Indicator species	≥3	4	Pass
				FAVOURABLE (FV)
Future prospects	Overall score	≥ -3.0	-7.3	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – SO08 Rosses Point C
(adjacent to the Cummeen Strand/Drumcliff (Sligo Bay) SAC)



County: Sligo
Central Grid Ref: G627399
XY: 162761, 339956

Conservation rank: 46
Conservation value: 30.9 (Poor)

Fossitt (2000): Predominantly CD2
Secondary GS1

Vegetation group: 5
Dry calcareous or neutral grassland including coastal dunes
Gallium verum – Pilosella offcinarum group

Current designations: None

Recommendations:

- Import cones from geographically adjacent pop
- Reduce grazing pressure
- Restrict site access
- Raise awareness of the conservation status of juniper with the factory owners
- Extend boundary of Cummeen Strand/Drumcliff (Sligo Bay) SAC approx. 60-70m east to include formation

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
A04.01.02	Intensive sheep grazing	Negative	Moderate (-2)	0.423	100
E02.01	Factory	Negative	Moderate (-2)	0.423	100
G05.01	Trampling, overuse	Negative	Moderate (-2)	0.423	100

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.423	0.423	Pass
	Population (numbers)	64	64	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	0	Fail
	Recruitment (seedlings)	>10%	0	Fail
	% bare ground	>10%	0	Fail
	% alive	>90%	100	Pass
	Spp. richness	≥13	12	Fail
	Sward height (cm)	23.8 - 46.3	50.0	Fail
	Indicator species	≥13	4	Fail
				UNFAVOURABLE BAD U2
Future prospects y	Overall score	≥ -1.0	-6.0	UNFAVOURABLE BAD U2
OVERALL ASSESSMENT				UNFAVOURABLE BAD U2

FORMATION – GY29 Catherweelder
(entirely within Castletaylor Complex SAC)

County: Galway
Central Grid Ref: M454157
XY: 145427, 215799

Conservation rank: 47
Conservation value: **29.2** (Poor)

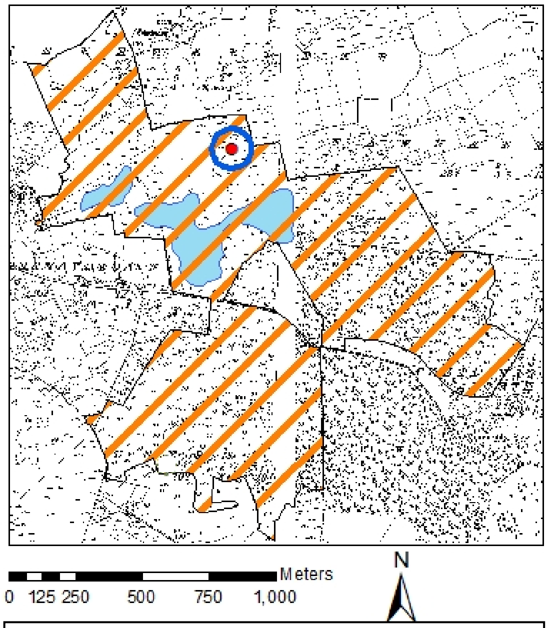
Fossitt (2000): Unknown

Vegetation group: Unknown

Current designations: SAC

Recommendations:

- Complete plant surveys to determine phytosociological associations and assess pressures and threats to complete assessment of *Structure & Function* and *Future Prospects* criteria.



NB: No access to site, not mapped. Observed from a distance.

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
-	Not surveyed	-	-	-	-

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	1.717	1.717	Pass
	Population (numbers)	150	150	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	50	Unknown
	Recruitment (seedlings)	>10%	0	Unknown
	% bare ground	>10%	0	Unknown
	% alive	>90%	96	Unknown
	Spp. richness	≥13	17	Unknown
	Sward height (cm)	23.8 - 46.3	18.0	Unknown
	Indicator species	≥13	5	Unknown
				UNKNOWN
Future prospects	Overall score	≥ -1.0	-3.0	**UNKNOWN**
OVERALL ASSESSMENT				***Assumed*** **UNFAVOURABLE INADEQUATE U1**

FORMATION – Ballinderreen (SO19)
(entirely within the Lough Hoe Bog SAC)

County: Sligo
Central Grid Ref: G389141
XY: 138937, 314192

Conservation rank: =49
Conservation value: **29.2** (Poor)

Fossitt (2000): Unknown

Vegetation group: Unknown

Current designations: SAC

Recommendations:

- Complete plant surveys to determine phytosociological associations and assess pressures and threats to complete assessm of *Structure & Function* and *Future Prospect* criteria.

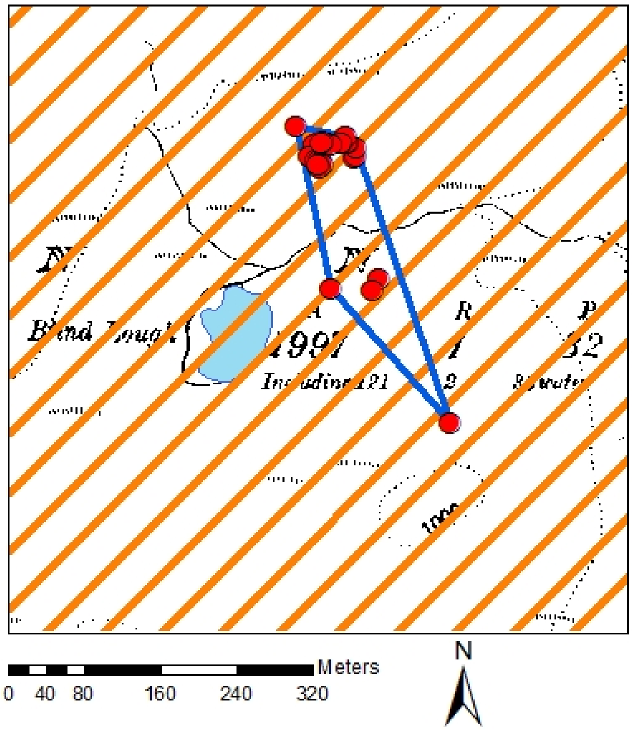


Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
-	No surveyed	-	-	-	-

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	16.3	16.3	Pass
	Population (numbers)	>100	>100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%		Unsurveyed
	Recruitment (seedlings)	>10%		Unsurveyed
	% bare ground	>10%		Unsurveyed
	% alive	>90%		Unsurveyed
	Spp. richness			Unsurveyed
	Sward height (cm)			Unsurveyed
	Indicator species			Unsurveyed
				UNKNOWN
Future prospects	Overall score	≥ -3.0		**UNKNOWN**
OVERALL ASSESSMENT				***Assumed*** **UNFAVOURABLE INADEQUATE U1**

FORMATION – Aghinish (MO02)
(mostly within Lough Carra/Mask Complex SAC)

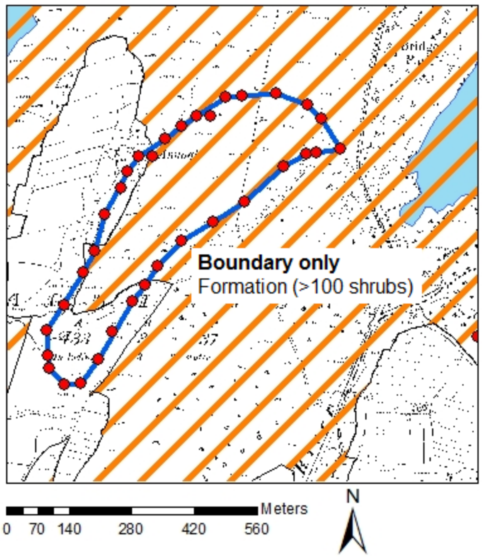
County: Mayo
Central Grid Ref: M157682
XY: 115764, 268257

Conservation rank: =49
Conservation value: 29.2 (Good)

Fossitt (2000): Unknown

Vegetation group: Unknown

Current designations: pNHA
SAC
SPA



Recommendations:

- Extend Lough Carra/Mask Complex SAC boundary south-westward to include whole formation
- Complete plant surveys to determine phytosociological associations and assess pressures and threats to complete assessment of *Structure & Function* and *Future Prospects* criteria.

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
-	No surveyed	-	-	-	-

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	18.4	18.4	Pass
	Population (numbers)	>100	>100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%		Unsurveyed
	Recruitment (seedlings)	>10%		Unsurveyed
	% bare ground	>10%		Unsurveyed
	% alive	>90%		Unsurveyed
	Spp. richness			Unsurveyed
	Sward height (cm)			Unsurveyed
	Indicator species			Unsurveyed
				UNKNOWN
Future prospects	Overall score	≥ -3.0		**UNKNOWN**
OVERALL ASSESSMENT				***Assumed*** **UNFAVOURABLE INADEQUATE U1**

FORMATION – CE02 Poulataggle 1
(entirely within East Burren Complex SAC)

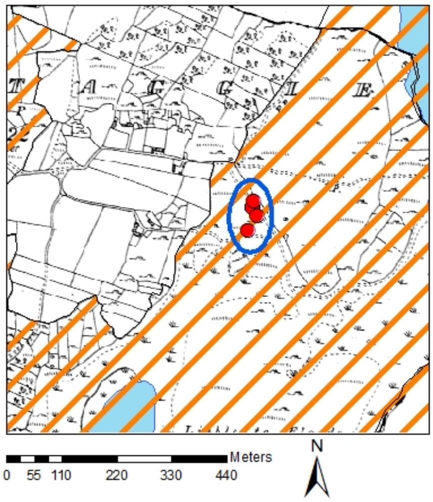
County: Clare
Central Grid Ref: M399011
XY: 139943, 201134

Conservation rank: =51
Conservation value: **20.8** (Poor)

Fossitt (2000): Unknown

Vegetation group: Unknown

Current designations: SAC



Recommendations:

- Complete plant surveys to determine phytosociological associations and assess pressures and threats to complete assessment of *Structure & Function* and *Future Prospects* criteria.
- Import cones from neighbouring populations and plant to assist recruitment.

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
-	Not Surveyed	-	-	-	-

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.966	0.966	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	-	Unknown
	Recruitment (seedlings)	>10%	-	Unknown
	% bare ground	>10%	-	Unknown
	% alive	>90%	-	Unknown
	Spp. richness	-	-	Unknown
	Sward height (cm)	-	-	Unknown
	Indicator species	-	-	Unknown
				UNKNOWN
Future prospects	Overall score	≥ -1.0	-	**UNKNOWN**
OVERALL ASSESSMENT				***Assumed*** **UNFAVOURABLE INADEQUATE U1**

FORMATION – Sillhouse Lough (GY28)
(entirely within the Lough Fingall Complex SAC)

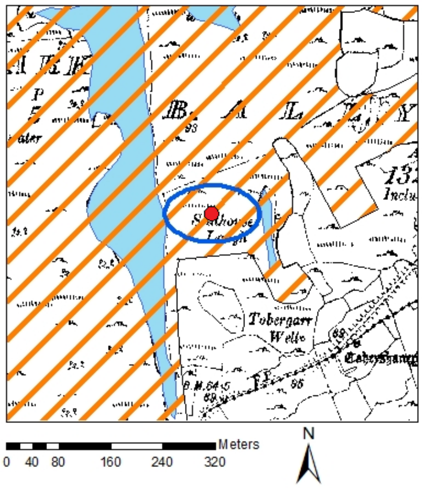
County: Galway
Central Grid Ref: M418146
XY: 141862, 214602

Conservation rank: =51
Conservation value: **20.8** (Poor)

Fossitt (2000): Unknown

Vegetation group: Unknown

Current designations: SAC



Recommendations:

- Complete plant surveys to determine phytosociological associations and assess pressures and threats to complete assessment of *Structure & Function* and *Future Prospects* criteria.

Table 1 *Future prospects*

Code	Description	Influence	Intensity	Area affected (ha)	% affected
-	Not Surveyed	-	-	-	-

Table 2 *Formation attributes*

Parameter	Criteria	Target	Result	Assessment
Area & population	Area (ha)	0.979	0.979	Pass
	Population (numbers)	100	100	Pass
				FAVOURABLE (FV)
Structure & function	Reproductive (cones)	>10%	-	Unknown
	Recruitment (seedlings)	>10%	-	Unknown
	% bare ground	>10%	-	Unknown
	% alive	>90%	-	Unknown
	Spp. richness	-	-	Unknown
	Sward height (cm)	-	-	Unknown
	Indicator species	-	-	Unknown
				UNKNOWN
Future prospects	Overall score	≥ -1.0	-	**UNKNOWN**
OVERALL ASSESSMENT				*Assumed* **UNFAVOURABLE INADEQUATE U1**

Table 3 Conservation rank and values with associated data describing juniper stands determined as non-formations (i.e. <50 shrubs per discrete site). These are not returned under Article 17 of the EU Habitats Directive for 5130, however, may be relevant should their populations increase sufficiently in the future to warrant being reclassified.

Classification	Code	Site name	X	Y	County	Rank	Conservation Score	Status	Dominant Fossitt habitat	Secondary Fossitt habitt	Habitat group	Area (ha)	Population	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	Future prospects	SAC
Non-Formation	GY01	Portumna	185126	203759	Galway	52	**57.1**	Moderate	PF1	GS4	3	0.849	25	20	0	0	100	19	90.0	2	0.0	✓
Non-Formation	CE03	Nr Tubber	138800	196100	Clare	53	**56.4**	Moderate	ER2	GS1	1	3.756	29	40	0	0	100	14	10.0	1	-2.0	✓
Non-Formation	DL33	Keadew	172260	417202	Donegal	54	**55.6**	Moderate	HH1	HH3	3	8.700	30	30	0	0	100	5	0.0	2	-2.0	✓
Non-Formation	KY01	Abbey Island	51807	57982	Kerry	55	**55.3**	Moderate	GS1		3	0.010	10	0	0	0	100	12	20.0	2	0.0	✓
Non-Formation	SO09	Corhawnagh	165559	328140	Sligo	56	**55.0**	Moderate	PF1	GS4	1	0.127	14	54	0	0	100	24	45.0	7	0.0	
Non-Formation	CK04	Cleanderry track	66311	55584	Cork	57	**54.7**	Moderate	ER1	HH3	4	1.416	30	6	0	0	100	10	19.0	3	-1.0	✓
Non-Formation	CE04	Moneen mountain	127300	208700	Clare	58	**54.2**	Moderate	GS1	ER2	2	5.422	40	100	0	0	100	15	13.0	1	-4.0	✓
Non-Formation	CK06	Dunboy Castle	66600	42600	Cork	59	**53.7**	Moderate	ER1	HH3	1	0.519	13	0	0	0	100	15	22.0	1	0.0	✓
Non-Formation	GY02	Doon	116300	236600	Galway	60	**52.3**	Moderate	GS3		1	0.122	6	50	0	0	100	15	30.0	2	0.0	✓
Non-Formation	CE09	Lough Bunny	138072	196872	Clare	61	**52.1**	Moderate	ER2	GS1	1	1.335	39	19	6	0	100	13	9.7	3	-2.0	✓
Non-Formation	GY25	Luimnagh	129649	241204	Galway	62	**51.0**	Moderate	GS1		3	0.128	39	20	0	0	100	8	25.0	3	-1.4	✓
Non-Formation	KY02	Derrynane	51900	58300	Kerry	63	**50.6**	Moderate	GS1			0.857	23	0	0		100				0.0	
Non-Formation	SO08	Rosses Point B	164403	340701	Sligo	64	**50.2**	Moderate	CD2	GA1	4	0.160	40	22	7	0	99	16	20.0	10	-2.3	
Non-Formation	DL45	Gortnasate	174428	421004	Donegal	65	**50.0**	Moderate				1.817	21									
Non-Formation	SO10	Carricknagat	167202	327979	Sligo	66	**49.5**	Moderate	HH2	GA1	4	0.003	3	0	0	0	100	19	15.0	10	0.0	
Non-Formation	CE11	Skaghard	134872	197921	Clare	67	**48.1**	Moderate	ER2		2	0.001	1	100	0	0	100	12	0.0	2	0.0	✓
Non-Formation	DL23	Loughnabrackbradan	195700	362900	Donegal	68	**47.9**	Moderate	GS3		4	0.003	3	33	0	0	100	9	20.0	6	0.0	
Non-Formation	DL19	Dunmore	179500	424100	Donegal	69	**46.3**	Moderate	CS1	HH1	3	0.001	1	0	0	0	100	9	20.0	2	0.0	✓
Non-Formation	KY03	Muckross A	94900	86400	Kerry	70	**45.7**	Moderate	ER1		2	0.001	1	100	0	20	100	8	0.0	0	0.0	
Non-Formation	SO07	Bunduff Sligo B	172900	356400	Sligo	71	**45.7**	Moderate	CD6	GA1	5	0.002	2	0	0	0	100	26	40.0	14	-1.0	✓
Non-Formation	CE05	Tonarussa	124000	206700	Clare	72	**45.0**	Moderate	ER2		2	0.002	2	50	0	0	100	9	0.0	2	0.0	✓
Non-Formation	LM01	Uragh Lough	177381	354100	Leitrim	73	**42.6**	Moderate	ED4		3	0.002	2	0	0	0	100	23	30.0	3	-2.0	✓
Non-Formation	DL25	Clogher Hill	201637	380015	Donegal	74	**42.1**	Moderate	ER1	HH3	4	0.001	1	0	0	0	100	10	50.0	7	0.0	
Non-Formation	GY12	Roundstone Bog B	73000	244600	Galway	75	**41.7**	Moderate	ER1		2	0.002	2	50	0	0	100	5	0.0	0	0.0	✓
Non-Formation	CE08	Keelhilla	133173	203538	Clare	76	**41.4**	Moderate	ER2		2	0.002	2	0	0	0	100	9	0.0	1	0.0	✓
Non-Formation	CK02	Cappul Bridge 2	68800	55800	Cork	77	**41.2**	Moderate	ER2		4	0.003	3	25	0	0	100	7	0.0	2	0.0	✓
Non-Formation	SO17	Glackbaun	174964	340059	Sligo	78	**41.1**	Moderate	ER2	GS1	5	0.163	40	0	0	0	100	10	50.0	3	-2.0	✓
Non-Formation	GY11	Roundstone Bog A	73692	244277	Galway	79	**39.9**	Poor	ER1		4	0.001	4	0	0	0	100	5	0.0	3	0.0	✓
Non-Formation	DL29	Glascarns Hill	197600	393300	Donegal	80	**39.8**	Poor	GS3		4	0.003	3	0	0		100	4	10.0	3	0.0	✓
Non-Formation	GY03	Corrib East	127554	238404	Galway	81	**39.7**	Poor	ER2		2	0.123	23	0	0	0	100	3	0.0	0	-2.0	✓
Non-Formation	SO18	Skerrydoo 3	174527	357294	Sligo	82	**39.5**	Poor	HH1			0.007	7	30	0		100				0.0	✓
Non-Formation	CE14	Deelin More	127543	203457	Clare	83	**39.2**	Poor	ER2		2	0.001	1	0	0	0	100	15	0.0	1	-1.0	
Non-Formation	SO06	Bunduff Sligo A	171554	356031	Sligo	84	**38.7**	Poor	CD3		5	1.979	19	50	5	0	100	32	28.3	15	-8.4	✓

Non-Formation	LK03	Aughinish 2	128397	154315	Limerick	85	**38.4**	Poor	GS2		5	0.002	2	0	0	0	100	12	30.0	6	-2.0	✓
Non-Formation	SO04	Knocklane	156371	344443	Sligo	86	**38.2**	Poor	GS1		5	0.258	17	16	0	0	100	19	25.0	12	-5.1	✓
Non-Formation	CK03	Cleanderry harbour	67100	56300	Cork	87	**38.1**	Poor	ER1	WS1		0.001	1	0	0		100				0.0	✓
Non-Formation	GY21	Keekill 1	126462	241999	Galway	88	**38.1**	Poor	GS1	GS4	3	0.001	1	0	0	0	100	5	40.0	2	-2.0	✓
Non-Formation	DL43	Ardara 6996	169900	396900	Donegal	89	**37.5**	Poor				1.473	22									
Non-Formation	SO15	Bunduff Sligo D	175035	357456	Sligo	90	**37.4**	Poor	HH2		4	0.013	13	38	0	0	88	16	50.0	5	-4.0	✓
Non-Formation	DL03	Binnion B	236286	448573	Donegal	91	**36.9**	Poor	HH1	ER1	5	0.002	2	50	0	0	100	11	30.0	6	-3.0	
Non-Formation	KY04	Muckross B	94800	86500	Kerry	92	**36.9**	Poor	ER1		4	0.006	6	0	0	30	100	4	0.0	1	-1.0	✓
Non-Formation	GY13	Gregmore	145200	214600	Galway	93	**36.3**	Poor	WS1		2	0.005	5	40	0	0	100	6	40.0	1	-3.0	
Non-Formation	LK02	Aughinish 1	128177	151735	Limerick	94	**35.2**	Poor	ED2		5	0.001	1	0	0	0	100	19	20.0	9	-2.0	
Non-Formation	DL29	Ardara sewage works	173050	391550	Donegal	95	**35.0**	Poor	GS3		4	0.003	4			0		4	10.0	3	0.0	
Non-Formation	CE02	St Philip's Point	177700	188000	Clare	96	**34.8**	Poor	ED3		2	0.002	2	50	0	0	100	3	35.0	0	-3.0	✓
Non-Formation	DL10	Mullaghdoo A	176940	420870	Donegal	97	**34.8**	Poor	HH2		5	0.009	9	22	12	0	100	19	45.0	12	-4.0	✓
Non-Formation	GY04	Illaunavee	123362	241782	Galway	98	**33.7**	Poor	GS1	HH2	1	0.293	33	29	8	0	100	18	10.0	2	-6.1	✓
Non-Formation	CE07	Fanore	114500	207300	Clare	99	**31.9**	Poor	ER2		2	0.007	7	14	0	0	100	8	0.0	2	-3.0	✓
Non-Formation	CE28	Ballyeighter upper	135800	194200	Clare	100	**31.2**	Poor	GS4			0.009	9	10	0		100				-2.0	✓
Non-Formation	CE12	Aillwee mountain	124310	204675	Clare	101	**30.7**	Poor	GS1			0.001	1	0	0		100				-2.0	✓
Non-Formation	SO03	Strandhill	159910	335077	Sligo	102	**30.7**	Poor	CD2		5	0.002	2	50	0	0	100	17	20.0	13	-4.0	✓
Non-Formation	CE29	Caher Lower	116600	209100	Clare	103	**30.2**	Poor	ER2		1	0.009	9	15	0	0	100	10	0.0	3	-3.0	
Non-Formation	SO05	Streedagh	165710	351603	Sligo	104	**30.1**	Poor	CD2		5	0.001	1	0	0	0	100	12	5.0	7	-3.0	
Non-Formation	DL26	Pettigo - Loughy	197969	372431	Donegal	105	**27.9**	Poor	ER1	HH1	3	0.002	2	50	0	0	100	7	70.0	1	-4.0	✓
Non-Formation	KY05	Boathouse	96200	85600	Kerry	106	**27.0**	Poor	ER2			0.002	2	0	0		100				-3.0	✓
Non-Formation	DL46	Kincaslough Island	174452	419412	Donegal	108	**25.0**	Poor				0.010	10									
Non-Formation	DL48	Mullaghdoo 2	176936	421416	Donegal	108	**25.0**	Poor				0.562	4									
Non-Formation	DL07	Pincher Bay	223144	447299	Donegal	109	**21.8**	Poor	CS1	HH2	3	0.004	4	0	0	0	100	7	50.0	1	-5.0	✓
Non-Formation	LM02	Bunduff Leitrim A	175448	357063	Leitrim	110	**20.8**	Poor	HH2		4	0.210	34	20	0	0	100	20	40.0	10	-9.0	✓
Non-Formation	SO13	Skerrydoo 1	173029	356483	Sligo	111	**17.6**	Very poor	HH1		4	0.002	2	0	0	0	100	15	20.0	5	-8.0	
Non-Formation	DL47	Mullaghdoo 1	176941	420873	Donegal	112	**12.5**	Very poor				0.019	9									
Non-Formation	KY07	Juniper Island	90050	81850	Kerry	113	**0.0**	Very poor				0.009	9									✓
Non-Formation	CK08	Black Rock 2	55750	47250	Cork	125	**0.0**	Very poor				0.009	9									
Non-Formation	DL44	Benbeg	179869	422987	Donegal	125	**0.0**	Very poor				0.005	5									
Non-Formation	CK10	Cleanderry roadside	66350	55650	Cork	125	**0.0**	Very poor				0.001	5									
Non-Formation	GY20	Cregballymore	140350	215450	Galway	125	**0.0**	Very poor				0.003	3									✓
Non-Formation	CE25	Murrooghkilly	116250	209750	Clare	125	**0.0**	Very poor				0.003	3									✓
Non-Formation	CE33	Poulataggle 2	139950	201150	Clare	125	**0.0**	Very poor				0.003	3									✓
Non-Formation	DL43	Ardara_6696_B	169400	396600	Donegal	125	**0.0**	Very poor				0.003	3									
Non-Formation	KY08	Eagle Island	89850	81950	Kerry	125	**0.0**	Very poor				0.002	2									✓
Non-Formation	KY06	Ronayne's Island	89750	81750	Kerry	125	**0.0**	Very poor				0.002	2									✓
Non-Formation	KY09	Upper Lake shore 1	89750	81550	Kerry	125	**0.0**	Very poor				0.002	2									✓
Non-Formation	KY10	Upper Lake shore 2	90150	81650	Kerry	125	**0.0**	Very poor				0.001	1									✓
Non-Formation	KY11	Upper Lake shore 3	90750	81950	Kerry	125	**0.0**	Very poor				0.001	1									

Table 4 Conservation rank and values with associated data describing juniper stands determined as non-formations (i.e. <50 shrubs per discrete site). These are not returned under Article 17 of the EU Habitats Directive for 5130, however, may be relevant should their populations increase sufficiently in the future to warrant being reclassified.

Classification	Code	Site name	Area	Population	***Population* status**	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	***Structure & Function* status**	***Impact & threat*status**	**OVERALL ASSESSMENT**	**Comments**	**Recommendations**
Non-Formation	GY01	Portumna	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Fail	Fail	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants • Ensure site is grazed to restore vegetation communities to favourable status
Non-Formation	CE03	Nr Tubber	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Fail	POOR	POOR	BAD	• Moderate intensive mixed animal grazing (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Reduce grazing pressure to encourage active recruitment
Non-Formation	DL33	Keadew	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Fail	Fail	Fail	BAD	POOR	BAD	• Moderate dispersed habitation (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Examine the potential causes for poor *Structure & function* and implement appropriate mitigation • Raise awareness of the conservation status of juniper within the local community • Extend the boundary of the Rutland Island and Sound SAC by approx. 300m
Non-Formation	KY01	Abbey Island	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants
Non-Formation	SO09	Corhawnagh	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Fail	Pass	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants
Non-Formation	CK04	Cleanderry track	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• Minor abandonment of pastoral systems, lack of grazing (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Ensure site is grazed to restore vegetation communities to favourable status

Classification	Code	Site name	Area	Population	*Population* status	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	*Structure & Function* status	*Impact & threat* status	OVERALL ASSESSMENT	Comments	Recommendations
Non-Formation	CE04	Moneen mountain	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Fail	POOR	BAD	BAD	• Moderate intensive sheep (100% of site) • Moderate non-intensive mixed animal grazing (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Reduce grazing pressure to encourage active recruitment
Non-Formation	CK06	Dunboy Castle	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• No impacts or threats	• Ensure site is grazed to restore vegetation communities to favourable status
Non-Formation	GY02	Doon	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants • Ensure site is grazed to restore vegetation communities to favourable status
Non-Formation	CE09	Lough Bunny	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Fail	POOR	POOR	BAD	• Moderate problematic native species (50% of site) • Minor damage by natural herbivores e.g. rabbits or hares (100% of site)	• Consider active control of problematic native species on part of the site
Non-Formation	GY25	Luimnagh	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	POOR	BAD	• Moderate flooding and rising precipitation (70% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Assess site drainage
Non-Formation	KY02	Derrynane	Fail	Fail	BAD	Fail	Fail	Fail	Pass				BAD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	SO08	Rosses Point B	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	POOR	BAD	• Moderate non-intensive sheep grazing (100% of site) • Minor burning (25% of site)	• Reduce grazing pressure
Non-Formation	DL45	Gortnasate	Fail	Fail	BAD										BAD		• Survey *Structure & function* and *Pressures & Threats*
Non-Formation	SO10	Carricknagat	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Pass	POOR	GOOD	BAD	• No impacts or threats	• Import cones from geographically adjacent populations to stimulate recruitment
Non-Formation	CE11	Skaghard	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants

Classification	Code	Site name	Area	Population	***Population* status**	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	***Structure & Function* status**	***Impact & threat*status**	**OVERALL ASSESSMENT**	Comments	Recommendations
Non-Formation	DL23	Loughnabrackbradan	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductive individuals or import cones
Non-Formation	DL19	Dunmore	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductive individuals or import cones
Non-Formation	KY03	Muckross A	Fail	Fail	BAD	Pass	Fail	Pass	Pass	Pass	Pass	Fail	GOOD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants
Non-Formation	SO07	Bunduff Sligo B	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Pass	POOR	GOOD	BAD	• Minor problematic native species (100% of site)	• Import cones from geographically adjacent populations to stimulate recruitment
Non-Formation	CE05	Tonarussa	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants
Non-Formation	LM01	Uragh Lough	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Pass	POOR	POOR	BAD	• Moderate mining and quarrying (100% of site)	• Import cones from geographically adjacent populations to stimulate recruitment • Raise awareness of the conservation status of juniper with the quarrying company
Non-Formation	DL25	Clogher Hill	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Fail	Fail	BAD	GOOD	BAD	• No impacts or threats	• Import cones from geographically adjacent populations to stimulate recruitment • Ensure the site is grazed to restore the vegetation community to favourable status
Non-Formation	GY12	Roundstone Bog B	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Fail	Pass	Fail	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants or import seed
Non-Formation	CE08	Keelhilla	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• No impacts or threats	• Import cones from nearbouring populations and plant to assist recruitment
Non-Formation	CK02	Cappul Bridge 2	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Fail	Fail	POOR	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants

Classification	Code	Site name	Area	Population	*Population* status	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	*Structure & Function* status	*Impact & threat*status	OVERALL ASSESSMENT	Comments	Recommendations
Non-Formation	SO17	Glackbaun	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Fail	Pass	Fail	BAD	POOR	BAD	• Moderate erosion (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Assess reasons for soil erosion to implement mitigation measures
Non-Formation	GY11	Roundstone Bog A	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Fail	Fail	Fail	BAD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants or import seed
Non-Formation	DL29	Glascarns Hill	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Fail	Pass	Fail	BAD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductive individuals or import cones • Monitor *Structure & function*
Non-Formation	GY03	Corrib East	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Fail	Pass	Fail	BAD	POOR	BAD	• Moderate flooding and rising precipitation (100% of site)	• Import cones from geographically adjacent populations to stimulate recruitment • Ensure the site is grazed to restore the vegetation community to favourable status • Assess site drainage
Non-Formation	SO18	Skerrydoo 3	Fail	Fail	BAD	Pass	Fail	Fail	Pass				BAD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductively active adult plants • Monitor *Structure & function*
Non-Formation	CE14	Deelin More	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	GOOD	BAD	• Minor damage by natural herbivores e.g. rabbits or hares (100% of site)	• Import cones from nearbouring populations and plant to assist recruitment
Non-Formation	SO06	Bunduff Sligo A	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	BAD	BAD	• Moderate intensive cattle grazing (100% of site) • Moderate intensive sheep grazing (100% of site) • Moderate trampling and overuse (100% of site) • Moderate damage by natural herbivores e.g. rabbits (100% of site) • Moderate invasive non-native species (20% of site)	• Montior the number of threats present at the site and generally attempt to reduce their intensity • Reduce grazing pressure • Consider active control of invasive native species on part of the site

Classification	Code	Site name	Area	Population	***Population* status**	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	***Structure & Function* status**	***Impact & threat*status**	**OVERALL ASSESSMENT**	Comments	Recommendations
Non-Formation	LK03	Aughinish 2	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Fail	Pass	Fail	BAD	POOR	BAD	• Moderate factory (100% of site)	• Import cones from geographically adjacent populations to stimulate recruitment • Raise awareness of the conservation status of juniper with the factory owners
Non-Formation	SO04	Knocklane	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	BAD	BAD	• Moderate intensive sheep grazing (100% of site) • Moderate erosion (100% of site) • Minor damage by natural herbivores e.g. rabbits or hares (100% of site) • Minor problematic native species (10% of site)	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Reduce the number of sheep on the site • Restrict site access and assess reasons for soil erosion • Consider active control of invasive native species on part of the site
Non-Formation	CK03	Cleanderry harbour	Fail	Fail	BAD	Fail	Fail		Pass				BAD	GOOD	BAD	• No impacts or threats	• Import cones from nearbouring populations and plant to assist recruitment • Monitor *Structure & function*
Non-Formation	GY21	Keekill 1	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Fail	Pass	Fail	BAD	POOR	BAD	• Moderate slipways (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants or import seed
Non-Formation	DL43	Ardara 6996	Fail	Fail	BAD										BAD	• Not surveyed	• Survey *Structure & function* and *Pressures & Threats*
Non-Formation	SO15	Bunduff Sligo D	Fail	Fail	BAD	Pass	Fail	Fail	Fail	Pass	Fail	Fail	BAD	BAD	BAD	• Severe non-intensive mixed animal grazing (100% of site) • Minor drying out (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Reduce grazing pressure • Assess site drainage
Non-Formation	DL03	Binnion B	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Fail	Pass	Fail	POOR	POOR	BAD	• Severe erosion (100% of site)	• Assist recruitment by planting cones from reproductive individuals or import cones • Examine causes of soil erosion and implement appropriate mitigation measures

Classification	Code	Site name	Area	Population	*Population* status	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	*Structure & Function* status	*Impact & threat*status	OVERALL ASSESSMENT	Comments	Recommendations
Non-Formation	KY04	Muckross B	Fail	Fail	BAD	Fail	Fail	Pass	Pass	Fail	Fail	Fail	BAD	GOOD	BAD	• Minor damage by natural herbivores e.g. rabbits or hares (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants or seed • Assess the reasons for poor *Structure & function* and implement appropriate mitigation
Non-Formation	GY13	Gregmore	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Fail	Fail	POOR	POOR	BAD	• Severe flora competition (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants
Non-Formation	LK02	Aughinish 1	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	POOR	BAD	• Moderate factory (100% of site)	• Import cones from geographically adjacent populations to stimulate recruitment • Raise awareness of the conservation status of juniper with the factory owners
Non-Formation	DL29	Ardara sewage works	Fail	Fail	BAD					Fail	Pass	Fail	BAD	GOOD	BAD	• No impacts or threats	• Assist recruitment by planting cones from reproductive individuals or import cones • Monitor *Structure & function*
Non-Formation	CE02	St Philip's Point	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Fail	Fail	Fail	BAD	POOR	BAD	• Severe problematic native species (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Consider active control of problematic native species around the remaining shrubs
Non-Formation	DL10	Mullaghdoo A	Fail	Fail	BAD	Pass	Pass	Fail	Pass	Pass	Pass	Pass	GOOD	BAD	BAD	• Moderate mining and quarrying (100% of site) • Moderate problematic native species (100% of site)	• Ensure the quarrying firm at the site are aware of the conservation status of juniper • Consider active control of problematic native species
Non-Formation	GY04	Illaunavee	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Fail	POOR	BAD	BAD	• Moderate intensive sheep grazing (100% of site) • Severe intensive mixed animal grazing (100%) • Minor damage by natural herbivores e.g. rabbits (100% of site) • Moderate burning (5% of site)	• Montior the number of threats present at the site and generally attempt to reduce their intensity • Reduce grazing pressure

Classification	Code	Site name	Area	Population	*Population* **status**	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	***Structure & Function* status**	***Impact & threat*status**	**OVERALL ASSESSMENT**	Comments	Recommendations
Non-Formation	CE07	Fanore	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	POOR	BAD	• Moderate intensive sheep grazing (100% of site) • Minor trampling and overuse (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Reduce sheep grazing pressure to encourage active recruitment
Non-Formation	CE28	Ballyeighter upper	Fail	Fail	BAD	Pass	Fail		Pass					POOR	BAD	• Moderate flooding and rising precipitation (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Assess site drainage
Non-Formation	CE12	Aillwee mountain	Fail	Fail	BAD	Fail	Fail		Pass				BAD	POOR	BAD	• Moderate intensive sheep grazing (100% of site)	• Import cones from nearbouring populations and plant to assist recruitment • Reduce sheep grazing pressure
Non-Formation	SO03	Strandhill	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	BAD	BAD	• Moderate intensive sheep grazing (100% of site) • Moderate trampling and overuse (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants or seed • Reduce the number of sheep on the site • Restrict site access
Non-Formation	CE29	Caher Lower	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Fail	Fail	POOR	POOR	BAD	• Moderate non-intensive cattle grazing (100% of site) • Minor damage by natural herbivores e.g. rabbits or hares (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Reduce cattle grazing pressure to encourage active recruitment and increase sward height
Non-Formation	SO05	Streedagh	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Fail	Fail	Fail	BAD	POOR	BAD	• Moderate intensive sheep grazing (100% of site) • Minor trampling and overuse (100% of site)	• Import cones from geographically adjacent populations to stimulate recruitment • Reduce the number of sheep on the site • Restrict site access
Non-Formation	DL26	Pettigo - Loughy	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Fail	Fail	POOR	BAD	BAD	• Minor non-intensive horse grazing (100% of site) • Moderate invasive non-native species (100% of site) • Moderate problematic native species (100% of site)	• Assist recruitment by planting cones from reproductive individuals or import cones • Consider active control of invasive and problematic native species

Classification	Code	Site name	Area	Population	*Population* status	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	*Structure & Function* status	*Impact & threat* status	OVERALL ASSESSMENT	Comments	Recommendations
Non-Formation	KY05	Boathouse	Fail	Fail	BAD	Fail	Fail		Pass				BAD	POOR	BAD	• Moderate intensive sheep grazing (100% of site) • Minor trampling and overuse (100% of site)	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Assess the reasons for poor *Structure & function* and implement appropriate mitigation
Non-Formation	DL46	Kincaslough Island	Fail	Fail	BAD										BAD	• Not surveyed	• Survey *Structure & function* and *Pressures & Threats*
Non-Formation	DL48	Mullaghdoo 2	Fail	Fail	BAD										BAD	• Not surveyed	• Survey *Structure & function* and *Pressures & Threats*
Non-Formation	DL07	Pincher Bay	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	BAD	BAD	• Moderate problematic native species (100% of site) • Severe erosion (100% of site)	• Assist recruitment by planting cones from reproductive individuals or import cones • Consider active control of problematic native species • Examine causes of soil erosion and implement appropriate mitigation measures
Non-Formation	LM02	Bunduff Leitrim A	Fail	Fail	BAD	Pass	Fail	Fail	Pass	Pass	Pass	Pass	GOOD	BAD	BAD	• Severe intensive cattle grazing (100% of site) • Severe trampling and overuse (100% of site) • Moderate intensive sheep grazing (100% of site) • Moderate problematic native species (50% of site)	• Assist recruitment by planting cones from reproductively active adult plants • Reduce grazing pressure on part of the site • Consider control of probelmatic native species on part of the site
Non-Formation	SO13	Skerrydoo 1	Fail	Fail	BAD	Fail	Fail	Fail	Pass	Pass	Pass	Fail	POOR	BAD	BAD	• Severe intensive mowing or intensification (100% of site) • Severe trampling and overuse (100% of site) • Moderate intensive sheep grazing (100% of site)	• Import cones from geographically adjacent populations to stimulate recruitment • Ensure farmers and landowners are aware of the conservation status of juniper • Restrict site access • Reduce the numbers of sheep
Non-Formation	DL47	Mullaghdoo 1	Fail	Fail	BAD										BAD	• Not surveyed	• Survey *Structure & function* and *Pressures & Threats*

Classification	Code	Site name	Area	Population	***Population* status**	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	***Structure & Function* status**	***Impact & threat*status**	**OVERALL ASSESSMENT**	Comments	Recommendations
Non-Formation	KY07	Juniper Island	Fail	Fail	BAD									BAD	BAD	• Not surveyed	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	CK08	Black Rock 2	Fail	Fail	BAD									BAD	BAD	• Not surveyed	• Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	DL44	Benbeg	Fail	Fail	BAD										BAD	• Not surveyed	• Survey *Structure & function* and *Pressures & Threats*
Non-Formation	CK10	Cleanderry roadside	Fail	Fail	BAD										BAD	• Not surveyed	• Assist recruitment by planting cones from reproductive individuals or import cones • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	GY20	Cregballymore	Fail	Fail	BAD									BAD	BAD	• Not surveyed	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	CE25	Murrooghkilly	Fail	Fail	BAD										BAD	• Not surveyed	• Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	CE33	Poulataggle 2	Fail	Fail	BAD										BAD	• Not surveyed	• Import cones from nearbouring populations and plant to assist recruitment • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	DL46	Ardara_6696_B	Fail	Fail	BAD										BAD	• Not surveyed	• Survey *Structure & function* and *Pressures & Threats*
Non-Formation	KY08	Eagle Island	Fail	Fail	BAD									BAD	BAD	• Not surveyed	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	KY06	Ronayne's Island	Fail	Fail	BAD									BAD	BAD	• Not surveyed	• Assist recruitment by planting cones from reproductively active adult plants or seed • Monitor *Structure & function* and assess *Impacts & threats*

Classification	Code	Site name	Area	Population	*Population* status	% reproductive (coned)	% recruitment (seedlings)	% baresoil	% alive	Species richness	Sward height	+ve indicator spp.	*Structure & Function* status	*Impact & threat* status	OVERALL ASSESSMENT	Comments	Recommendations
Non-Formation	KY09	Upper Lake shore 1	Fail	Fail	BAD									BAD	BAD	• Not surveyed	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	KY10	Upper Lake shore 2	Fail	Fail	BAD										BAD	• Not surveyed	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Monitor *Structure & function* and assess *Impacts & threats*
Non-Formation	KY11	Upper Lake shore 3	Fail	Fail	BAD										BAD	• Not surveyed	• Assist recruitment by planting cones from reproductively active adult plants or import seed • Monitor *Structure & function* and assess *Impacts & threats*