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Juniper in the Lake District National Park. A review of condition and regeneration

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ABSTRACT

Juniperus communis L. (Common Juniper) (Cupressaceae) is a native British species of evergreen dioecious conifer, threatened by extensive grazing, competing tree species and lack of sites to colonise. This study assesses the present status of juniper in the Lake District. Ten large stands recorded as in good condition in 1975 were compared to five smaller stands, and a reference stand protected from grazing for 70 years. Recorded values of the number of berries produced by large stands and seed viability of these berries were combined as a seed viability index. Analysis showed that the seed viability indices of large stands were significantly higher than the small stand values, but significantly lower than the reference stand. These results suggest low reproductive potential may be indicative of a senescing population, and that grazing pressure is limiting reproduction. The absence of regeneration is attributed to stands becoming substantially moribund at a similar time without replacement. Seedling propagation and planting in fenced areas is suggested as the best strategy for juniper conservation.

KEYWORDS: reproductive potential, seed viability index, stand size, grazing pressure.

INTRODUCTION

Juniperus communis L. is a characteristic shrub of varied morphology. It is one of three native species of Coniferae in the British Isles (Humphries 1981), well established in the Lake District where it is mainly found on scree slopes and exposed regions. Throughout the country *J. communis* exhibits variation in population structure existing sometimes as large stands, sometimes as individual bushes, and has been observed to show differences in life history, genetic constitution and morphology, particularly between southern and northern Britain. The north/south divide is also apparent from the distribution map of the species (see Fig. 1).

Two subspecies of *J. communis* are recognised, *J. communis* subsp. *nana* Syme which is usually prostrate, small and slow growing, and *J. communis* subsp. *communis* the commoner, larger subspecies. However there is some doubt as to the distinction between subspecies due to the highly variable morphology (Ward pers. comm.).

Evidence from Upper Teesdale Nature Reserve, North Pennines and Tynron Juniper Wood, Dumfries and Galloway shows that there has been active management of *J. communis* in this country for a considerable period (Piggott 1956). By continuously disturbing the ground over a large area, substantial quantities of *J. communis* have been maintained which would otherwise have been outshaded by successional species such as *Betula pendula* (Clifton, Ranner & Ward 1997). In the Lake District particularly, the wildly fluctuating mining and quarrying industries which were a feature of the area for several hundred years up until this century (Gilbert 1980), and the lack of any regulated grazing regime are thought to have encouraged colonisation by continuous disturbance of the ground (Milner 1992). The large quantity of *J. communis* in the Lake District is therefore thought to be due to two main influences: (1) active management and (2) conditions which are conducive to repeated colonisation.

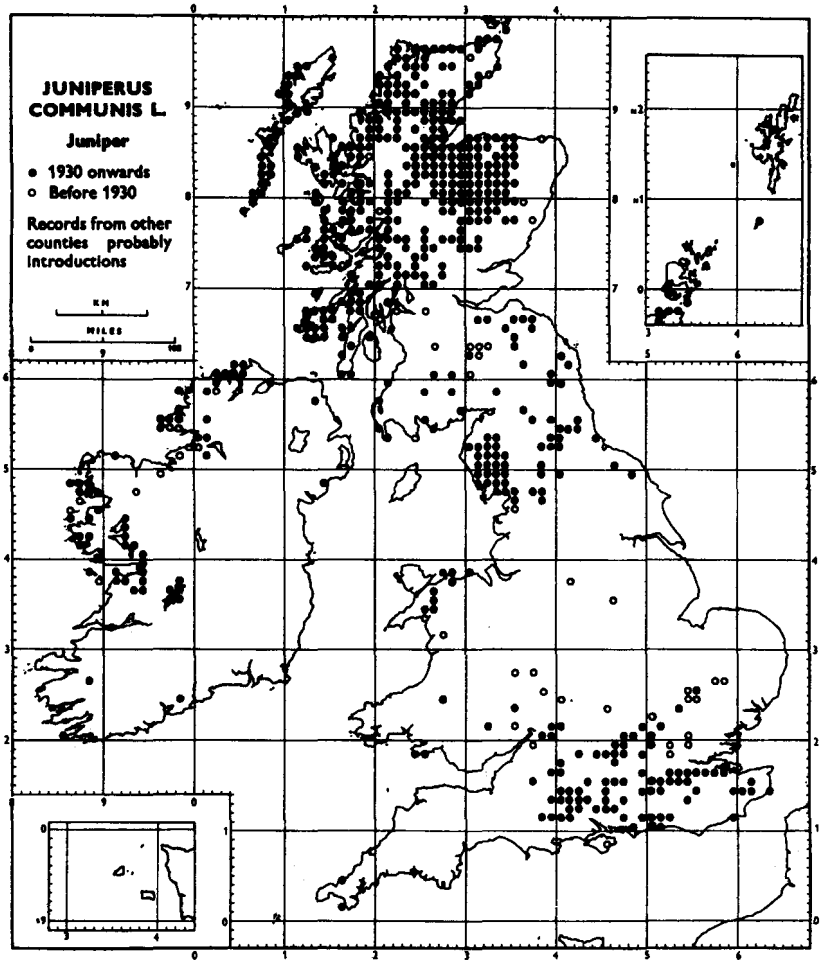

FIGURE 1. National distribution of *Juniperus communis*

The vast majority of research into British *J. communis* has been carried out in Southern England. As far as we are aware there are no published papers relating to *J. communis* in the Lake District, and while Miles & Kinnard (1979a; b) have researched *J. communis* in the Scottish Highlands, and Ward has made maps of distribution over the Lake District (Ward pers.comm.), there remains a gap in our knowledge of *J. communis* in this region. It is recognised however that *J. communis* is declining in the area and has been for most of this century, as it is over the majority of the country (Ward 1973).

There has been speculation over the reasons for the present decline in *J. communis* but Ward (1977), Gilbert (1980) and Clifton, Ranner & Ward (1997) have all suggested that lack of suitable sites to colonise and intensive grazing of any regeneration are the principal causes. Ward (1982) has conducted surveys of the age of *J. communis* and results show that most stands have a very even age structure. This is taken as evidence of the colonising nature of *J. communis* and also suggests that without further colonisation, individual stands will tend to become universally moribund at a particular age. Evidence that *J. communis* declines in seedling viability with age of parent means that if stands are allowed to become moribund, the potential for natural regeneration will also decline (Raatikainen & Tanska 1993).

In the Lake District particularly, the grazing and mining regimes used until the end of the last century, are thought to have been beneficial for recolonisation. At present any mining is done on a

more long term basis and is less disturbing to the local community. The widespread change of farming practice from arable to livestock following the agricultural depression of 1870–1940 seems to coincide with the start of the *J. communis* decline in the area (Milner 1992). Grazing would appear to play an important role in *J. communis* colonisation, as noted by Thomas (1960; 1963) when the widespread outbreak of myxomatosis in the 1950s was followed by an unprecedented period of regeneration. Rabbit grazing seems to bare the ground sufficiently to allow *J. communis* growth, if the grazing pressure from rabbits and other herbivores is then reduced. However Fitter & Jennings (1975) found that the removal of grazing altogether allows other species to overshadow *J. communis* seedlings within three years. Thus some grazing appears to be essential.

Several other suggestions have been made as to the conditions necessary for regeneration, including fire to bare the ground, death of other plants, trampling by farm animals and disturbance by moles (Miles & Kinnard 1979a; 1979b), which all assist the colonising nature of *J. communis*. Few experiments have been conducted to test these theories, with the exception of sheep grazing experiments by Fitter & Jennings (1975).

This paper presents the results of a 1995 survey of *J. communis* in the Lake District. The aims were (1) to assess the status and (2) to propose recommendations for future management. As this survey did not record variables over a period of time, substantial sites of juniper were compared with smaller sites, to discover whether there were differences in seed viability and berry abundance. Results of the present survey are compared with others carried out in 1975 (Ward pers. comm.) and in 1995 (Sear 1995), which had similar aims to the present study.

METHOD

Ten substantial stands > 1000 of *J. communis* were chosen which were in good condition in 1975. As these large stands were recognised as worth conserving in 1975, but had not been actively managed since this time, any change in their condition was likely to be apparent in September 1995 when the survey was conducted (see Table 1). The ten large stands were compared with five smaller stands of < 1000 bushes (small stands). The stands selected for this survey encompass the range of habitats occupied by *J. communis* throughout the Lake District (Table 1).

An area of *J. communis* which had not been recorded in 1975 known as Juniper Scar was also examined. This had been documented for several years and more importantly, surrounded by a sheep proof fence for the last seventy years. This stand was therefore examined to assess how protection from grazing might influence the ecology of *J. communis*.

Three 100 m^2 quadrats per stand were examined. The quadrats were distributed over the stand at three points, representing the variations in physical condition and exposure of the site. Notes were taken on the general appearance of each stand, and appearance of individual quadrats.

Perhaps the most useful variable which could have been recorded in this survey was the age of stands. However *J. communis* is a notoriously difficult species to age without cutting live samples of the stem, for two reasons. The first is that the stem diameter of *J. communis* is not closely related to age. The second is that *J. communis* stems are usually eccentric in shape and therefore their girth is difficult to record with any accuracy; this also precludes accurate core sampling (Fitter & Jennings 1975).

Seed viability has obvious implications for the reproductive potential of a stand of *J. communis*, and is therefore an important indicator of present and future condition which may not be obvious to the eye. Ten mature, purple berries were collected in each quadrat using random number tables to select the nearest female bush to given co-ordinates. Viability was determined by sectioning berries. Seeds are viable "where the internal tissues fill the seed completely and are white/off white in colour" (Ward 1989). Viability was then recorded as a mean of the three samples out of a possible thirty seeds. A seed production index was obtained using the abundance of berries on bushes at each site. This was calculated by multiplying the number of bushes with a limited number of berries by one, the bushes with abundant berries by ten, and the bushes with very abundant berries by one hundred. Together these values gave the mean seed production index for each site (from Sear 1995).

The seed viability index is the mean proportion of a possible 30 seeds at each site which were viable, multiplied by the seed production index to show how many of the seeds produced were viable, as sites may have produced many berries but these may have contained very few viable seeds. This value demonstrates the condition of the stand and the likely regeneration potential, as far

TABLE 1. SITES STUDIED WITH GRID REFERENCES

Site	Grid Reference	Habitat	Altitude m	Geology
Large sites				
Place Fell	NY/396.180	Rough fell	210	Volcanic
Mardale Banks	NY/482.124	Grazing	290	Volcanic
Carrock Fell	NY/329.327	Grazing	310	Volcanic
Dovedale	NY/380.116	Scree	610	Volcanic
Blind Tarn Moss	NY/314.070	Fell	270	Volcanic
Blea Tarn	NY/295.037	Grazing	350	Volcanic
Thwaites Fell	SD/177.904	Grazing	190	Volcanic
Yew Barrow	SD/354.871	Woodland	230	Volcanic
Bradleyfield	SD/489.921	Grazing	190	Carboniferous limestone
Whitbarrow	SD/442.893	Grazing	200	Carboniferous limestone
Small sites				
Whitbarrow N.	SD/443.889	Fell	140	Carboniferous limestone
Lingmore Oak	NY/300.057	Fell & grazing	190	Volcanic
Broad Hollins	SD/299.914	Bog	150	Valley bog
Blea Tarn S.	NY/298.836	Fell	320	Volcanic
High Harsop	NY/393.105	Fell & grazing	410	Volcanic
Reference site				
Juniper Scar (Staveley Head Fell)	NY/476.012	Nature reserve	260	Volcanic

TABLE 2. SEED VIABILITY INDICES OF JUNIPERUS COMMUNIS IN THE THREE SITE CATEGORIES

Site	Seed Viability	Seed Viability Index
Large sites		
Place fell	14·00	29·73
Mardale Banks	15·00	83·84
Carrock Fell	16·67	200·25
Dovedale	12·33	9·86
Blind Tarn Moss	15·33	5·47
Blea Tarn	15·00	2·65
Thwaites Fell	14·33	6·05
Yew Barrow	9·33	0·52
Bradleyfield	10·00	18·67
Whitbarrow	11·67	3·90
Small sites		
Whitbarrow N.	5·33	1·24
Lingmore Oak	15·00	13·49
Broad Hollins	11·33	5·67
Blea Tarn S.	11·67	4·67
High Harsop	17·33	7·32
Reference site		
Juniper Scar (Staveley Head Fell)	17·33	243·39

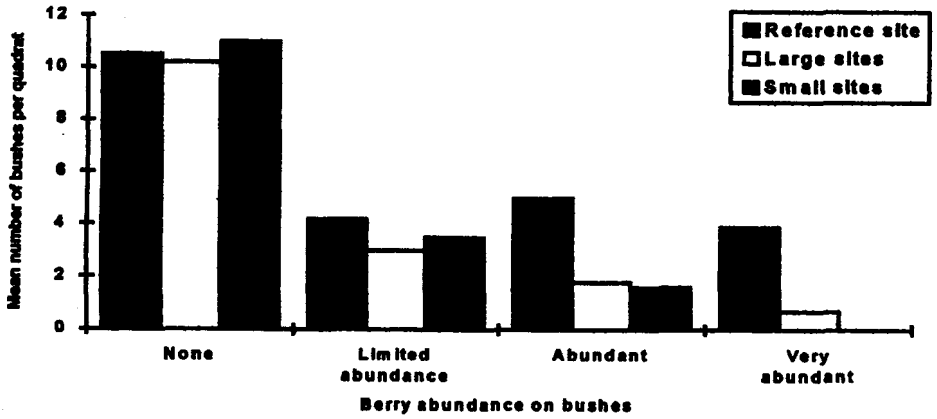

FIGURE 2. Berry abundance on bushes at each site category.
None - No berries. Limited abundance - Few berries on some branches. Abundant - Berries on most branches, some in clumps. Very abundant - Bushes laden with berries, most in large clumps.

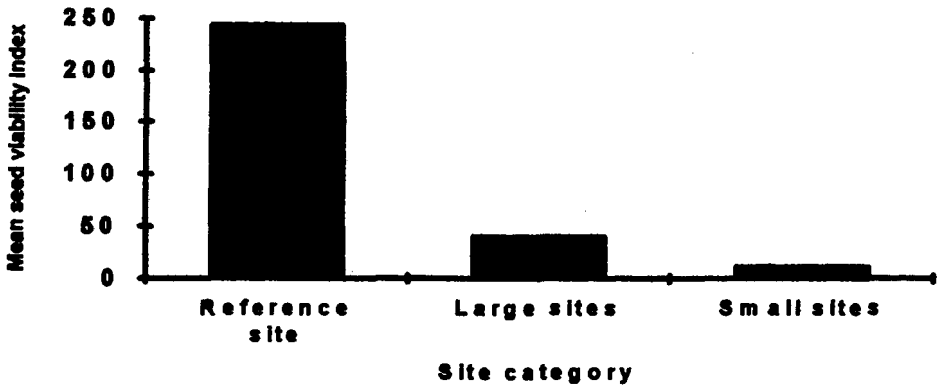

FIGURE 3. Mean seed viability of *Juniperus communis* L. at each site category.

as seed production and viability are concerned. Values are recorded in Table 2. The seed viability index for each site category were then compared using a one-way ANOVA test.

RESULTS

The null hypothesis that there is no difference in seed viability index between the site categories was rejected at the 5% significance level. The average seed viability indices were: Small Sites = 6·478, Large Sites = 36·094 and Reference Site = 243·39. The calculated F value was greater than the tabulated F value as $F_{calc} = 8{\cdot}6063 > F_{tab} = 4{\cdot}75$ for 2 degrees of freedom between groups and 13 error degrees of freedom within groups.

As the large sites had significantly higher seed viability indices than the small sites, there is a > 95% probability that large sites produce more viable seeds than small sites. Large sites also produce significantly less viable seeds than the reference site (Juniper Scar). Berry abundance and seed viability indices at each category of site are illustrated in Figs 2 & 3 respectively.

In addition to the 16 sites recorded in this survey, an example of attempts to encourage *J. communis* regeneration was visited at Greenside Mines. Although the ground was heavily

polluted with lead, *J. communis* seedlings were growing well within protective tubes. However, these will have to remain protected for at least eight more years before they are able to resist grazing (Ward & Lakhani 1977), particularly from sheep which occupy the surrounding land. This regeneration experiment provided a useful example of how conservation measures could be implemented to propagate *J. communis* in the Lake District.

DISCUSSION

The seed viability indices found in this survey are consistent with data obtained by Ward (1989) at Teesdale National Nature Reserve, which showed that the maintenance of a high seed viability is important for the conservation of *J. communis*. This suggests that the sites recognised as good in 1975 producing adequate quantities of berries, are still in a more reproductively viable condition than the small sites in this survey. However the much higher viability index recorded at Juniper Scar may be an indication of the seed reproductive potential and berry production necessary to maintain regeneration, as recommendations for the maintenance of viability such as disturbance and fencing (Miles & Kinnard 1979a) are found at this site. In this case the ten large sites may be in worse condition than in 1975, but have experienced a viability decline in parallel with the small sites. Without long-term experimental evidence that seed viability and berry production correlates with regeneration, it is not possible to suggest a limit at which regeneration is endangered, but the evidence from these three categories of sites would seem to suggest a decline over the last 20 years at least.

CONSERVATION AND FUTURE RECOMMENDATIONS

The situation at Greenside mines is characteristic of the problems of conservation schemes in the Lake District. Such is the need for plant cover on steep slopes of the area, that the National Parks have sometimes had to implement emergency action to stop intense erosion (Harding, pers. comm.), but long term schemes are often restricted by land ownership complications. Several authors have drawn attention to the need for long term surveys to be conducted into the causes of declining *J. communis* in Britain including Ward (1987) and Ranner (1994), who also used Ward's 1975 survey as a baseline for his own study. With the exception of regeneration experiments at Teesdale National Nature Reserve (Findley, pers. comm.) which are at present unpublished, there have been few studies which have been conducted thoroughly enough and over a long enough period to suggest techniques which may be employed to encourage regeneration.

The problem with long term experiments at present is that the decline of *J. communis* may be extremely severe before conclusions can be put into practice. Also, the range of morphologies and possibly genealogy of *J. communis* in the Lake District alone, may mean that *J. communis* varies in the conditions needed for regeneration between regions, and possibly between stands. Milner (1992) underlines that *J. communis* propagation should use cuttings from local sources as the species has a wide genetic diversity. Although historical aerial or terrestrial photographs were not used for our study, this source of information on past populations and colonisation could be invaluable for rapidly establishing changes in population density in other regions.

As intense grazing seems to be one of the central causes of *J. communis* decline, controlled grazing regimes should be put into practice as soon as possible, perhaps using the collapsible fences recommended by Miles & Kinnard (1979a). These authors suggest other means of encouraging regeneration such as felling mature trees and sowing seed, but these are experimental techniques not yet investigated for the conservation of *J. communis*. Propagating seedlings and planting in fenced areas seems to be the best immediate approach to *J. communis* conservation. The National Parks Centre at Brockhole have found that propagating cuttings is an effective way to grow stock. Roughly 60% of Greenside Mines cuttings were successfully grown in greenhouse conditions (Tasker, pers. comm.), which also preserves genetic diversity.

Long term studies of reproductive condition in parallel with planting are urgently required. Unless these are instigated, young or small populations of *J. communis* face great danger through population fluctuation in the near future.

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