

The conservation of juniper in Northumbria

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**The conservation of juniper
in Northumbria**

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Summary

This report summarizes a project initiated by English Nature to stimulate positive management of juniper colonies in Northumbria. This involved the comprehensive assessment of all juniper sites in County Durham and Northumberland, the identification of population trends and the development of positive management on juniper SSSIs and the wider countryside.

The 1994 surveys of juniper colonies in Northumbria (excluding the large stands of Upper Teesdale NNR) aimed to repeat surveys undertaken in 1973. This enabled the direct comparison of data from eighty-three sites to quantify demographic change and confirm suspected population trends in juniper populations across the region.

The 1994 survey highlighted a 30% decline in the juniper population over the 21 year period. Losses of 36% and 24% were recorded for County Durham and Northumberland respectively. 54% of colonies in the region had declined while 16% had been lost completely. Extant colonies were small in terms of population size and overwhelmingly even-aged, being dominated by mature and old bushes, and there were very few indications of active natural regeneration. Most sites were characterised by scattered and disjunct populations.

The main factors thought to account for this decline are considered and recent measures to promote the conservation and management of juniper stands in Northumbria are discussed.

1. Background

This report documents work carried out by English Nature in Northumbria in 1994-95 to progress the conservation of existing juniper populations on Sites of Special Scientific Interest (SSSI). There has been very little published information on juniper during the last 10-15 years and it was felt that this should be rectified in some way to promote juniper, conservation given the apparent decline of juniper in England and the listing of some types of juniper scrub under the European Habitats and Species Directive.

English Nature's initiative in Northumbria involved a number of stages:

- the assessment of all known juniper colonies in County Durham and Northumberland to establish the current status of juniper;
- the identification of population changes on juniper colonies since 1973 to confirm or refute suspected population trends;
- the implementation of positive management on juniper SSSIs in Northumbria.

1.1 Juniper and its nature conservation interest

Juniper *Juniperus communis* ssp. *communis* is a native coniferous shrub of the British Isles. Although its centre of distribution lies within the Highlands of central and eastern Scotland, juniper also occurs at scattered localities in parts of southern England, northern England and Wales (Rodwell 1991). It forms a component of a number of British plant communities as it is able to thrive on both acid and calcareous freely-drained (but moist) soils at a wide range of altitudes, ranging from sea level to montane environments where it occurs in a prostrate form as ssp. *nana*. The distribution of the lowland juniper ssp. *communis* in Britain demonstrates a distinct north-south division (Perring & Walters 1990); in southern Britain it is more or less confined to the chalk grasslands of southern counties (but occurs sporadically on sea cliffs) and is more commonly part of a seral calcareous grassland community representing a gradual transition towards beech *Fagus sylvatica* and yew *Taxus baccata* woodland. In northern Britain, juniper is often found within the field layer of open birch *Betula* spp. and pine *Pinus sylvestris* woods and on upland heaths and calcifugous grasslands. It also forms unusual thickets on the sand dunes of the northeast coast of Scotland (Dargie 1993).

Where juniper is the most dominant woody species, it can form a unique woodland vegetation type, W19 *Juniperus communis*-*Oxalis acetosella* woodland community, according to the National Vegetation Classification (Rodwell 1991). This northern juniper woodland is particularly important in terms of nature conservation, and stands in Northumbria represent southerly examples of this community. The ground layer of these woods can be species-rich, including a typical woodland ground flora with wood anemone *Anemone nemorosa*, wood-sorrel *Oxalis acetosella* and moschatel *Adoxa moschatellina*. More local species with a distinctly northern distribution such as twayblade *Listera cordata*, common wintergreen *Pyrola minor* and chickweed wintergreen *Trientalis europaea* occur occasionally in this community. Luxuriant fern-rich communities are a feature of ungrazed juniper stands. Juniper also supports a comparatively small, yet characteristic, native invertebrate fauna, including

many species with specialised habitat requirements and a restricted distribution in the UK (Ward 1977a; Ward 1977b). Juniper stands in northern England often support a mix of both northern and southern species on the edge of their range such as the Juniper Carpet *Thera juniperata* and Juniper Pug *Eupithecia pusillata*. Stands of juniper scrub can also diversify upland bird communities as bushes are an important food source for frugivorous birds such as fieldfares, song thrushes (Miles & Kinnaird 1979) and ring ouzel (Everett 1995). In the absence of native tree cover, juniper stands also provides valuable winter shelter for Black Grouse, particularly in the Pennine uplands.

1.2 Decline of juniper in England

Nationally, juniper is not a scarce plant. In England, however, there is concern that juniper is becoming increasingly scarce as a semi-natural vegetation type. The recession of juniper populations in southern England has already been well documented (Ward 1973, 1981). There juniper is in a critical state of decline in many counties with evidence of habitat fragmentation and contraction in range through extinctions. Extant sites were found to be very even-aged and dominated by mature and old plants. Many sites were suffering from a lack of natural regeneration, largely as result of intensive agricultural practices. Many juniper populations may be the products of regenerative windows associated with fluctuations in management activity and /or natural events, such as grazing pressure, ground disturbance and erosion (Ward 1973; Gilbert 1980; Rodwell 1986). The poor regenerative status of British juniper stands is widely considered to be the greatest long-term threat to this habitat type (Ward 1973; Fitter & Jennings 1975; Gilbert 1980; Ward 1981).

In northern England juniper is a restricted habitat type, but has been part of the local flora since the Ice Age. Although juniper can be locally abundant in parts of Cumbria, in County Durham it is very localised (Graham 1988) and is one of the most uncommon semi-natural vegetation types in the North Pennines (Horsfield & Thompson 1993). Most of the work on juniper in northern England has been undertaken at Upper Teesdale NNR in County Durham, which supports the largest juniper woodland in England with an estimated population of 15-20,000 bushes (Gilbert 1980). Both Pigott (1956) and Gilbert (1980) noted the apparent lack of natural regeneration of juniper within these woodlands, mainly as a consequence of changes in land use. Population decline, albeit unquantified, and local extinctions amongst juniper colonies have also been noted elsewhere from the wooded coastal dunes, sea cliffs, upland moorlands and lowland heaths of County Durham (Heslop-Harrison 1962; Dunn 1965, 1974; Mitchell *et al* 1994).

Juniper is even more localised in Northumberland. Historically, it was perhaps more abundant, occurring in the Cheviot Hills and particularly in the Allendale valleys (Baker & Tate 1868; Heslop-Harrison 1949). By 1973 juniper was no longer found in 13 one km squares and Swan (1993) found juniper to be present at scattered localities in 34 5x5km squares, noting that it had apparently become extinct at 11 locations since 1968.

2. Changes in juniper populations in Northumbria 1973-94

A major survey of juniper sites in the north-east was undertaken in 1973 by Dr L K Ward of ITE, as part of a national census of sites to compile an inventory of juniper colonies and gather baseline information to promote the long-term conservation of juniper in the UK. Amidst concern of a widespread decline in the juniper resource in the region, as demonstrated above, and confirmed trends elsewhere in Britain, this survey was repeated in County Durham and Northumberland in an attempt to simultaneously update the inventory of known sites and quantify population trends since 1973. This study coincided with renewed interest in juniper conservation following its inclusion as a habitat type of European Community Interest within Annex I of the EC Habitat and Species Directive (European Community 1992).

2.1 Methods

1973 Survey

A total of 130 sites in County Durham and Northumberland were surveyed in 1973, including sites known or presumed to be extinct. Information on these sites was derived from a variety of sources, such as published local literature, records from Biological Records Centres, information from local botanists and records from county plant recorders. Less unreliable data were gathered from placename evidence, including the word 'juniper' or earlier versions of it. In addition colonies were discovered by surveyors during days in the field.

All of the sites highlighted from this information were visited in the field, usually in the winter when the evergreen junipers were easier to detect amongst more deciduous trees and shrubs. The basic unit adopted was the colony which was defined as "an area of juniper where no sharp topographical distinction in the age structure of the bushes can be detected, and where the other vegetation is uniform. The colony may be fragmented from a larger area and it is under the same ownership and management" (Ward 1977).

Information was collected for each colony and noted on individual site record cards. Details of colony location, estimated population size and age structure were recorded. Information on solid geology, land use, associated habitats and species, aspect and altitude, stand density and the presence of male and female bushes was also collected. The age structure of each colony was recorded by defining four recognizable age categories; seedlings (<5 years), young (6-20), mature (21-50) and old (>50 years) (Ward 1973). Ill and dead bushes were also noted. On occasion, ring counts and girth measurements for particular sites were made where dead or dying specimens were available (Ward 1982). Bush age was judged on height, annual shoot growth, foliage colour, amount of dead wood and the basal girth of trunks. As in southern England, genotypic and phenotypic variation in junipers is commonly encountered amongst northern colonies and can hinder accurate recognition of bush age. On exposed sites with thin soils, individual bushes tend to be prone to dwarfing. Browsing may result in stunted growth forms and make the estimation of age more unreliable. Conversely, taller but younger bushes can be found in sheltered hollows on deeper soils.

1994 Surveys

The repeat surveys concentrated on the extant sites noted in 1973 but new sites were located as a result of fieldwork or identified from a number of new sources. These sites were also visited to establish new baseline information (Ranner 1994; Clifton & Mullinger 1995).

To allow a simple and direct comparison with baseline data of 1973, both county re-surveys recorded similar information for each colony. In Northumberland, 34 extant sites covered in 1973 were systematically revisited by two surveyors in the winter of 1994, along with an additional nine sites which had been recently identified from Phase 1 habitat surveys and National Trust biological surveys. Only two sites were not assessed (these were located within private gardens and consisted of just one bush). Additional visits to some sites were made during May 1995 to check the accuracy of the winter visits. Where sites were located away from public rights of way, permission for access was sought from landowners and local tenants. For each colony, features were recorded following the 1973 method. Age classes were estimated using the 1973 criteria although it was noted that these had since been revised slightly (Ward 1994). No girth measurements or ring counts were made although the numbers of male and female bushes were estimated at a number of sites.

A total of 49 sites were re-assessed in County Durham from April-August 1994 together with an additional 38 colonies which had been identified during fieldwork, or from recently published local Floras and information provided by local land managers. This survey did not include the extensive stands of Upper Teesdale NNR as these were already subject to regular monitoring. However, a number of outlying colonies within the NNR were included. Again the core elements of each colony were recorded as per the 1973 survey. The age structure of each population was able to be studied in greater depth and subsequent information is much more detailed.

Information from both surveys was transferred onto site record cards and distribution maps were produced.

Difficulties associated with survey methodology

Although the same parameters were applied to each of the three surveys and similar information recorded, there are some obvious difficulties associated with this methodology which may affect the overall results and conclusions. The counting methods of three independent surveyors would undoubtedly have differed and any such discrepancies would have influenced the population estimates for each colony. Similarly, classification of junipers to a defined age class could vary with the judgement and experience of each recorder. The accuracy of population estimates would be affected by the density of each colony. The higher the number of individual bushes and the greater their density and/or extent, the more difficult they were to count accurately. Errors could have occurred where juniper was found to occasionally form dense stands mixed with gorse *Ulex europaeus* as it was sometimes difficult to differentiate between the two, especially at a distance. Individual bushes could also have been missed from each survey, as a result of their location on steep terrain or their detectability as seedlings and small bushes, particularly the latter in prostrate form, are easily overlooked. Thus

they could have been excluded from both sets of counts. The failure to detect bushes may also occur through differences in fieldwork effort and intensity at each colony, as result of time constraints and adverse weather.

An extra difficulty was encountered where the vegetative reproduction of bushes via the layering of limbs had taken place. During the 1994 surveys, where bushes could be traced back to a single 'parent' they were counted as a single bush. The 1973 survey did not offer any specific definition of 'a bush' and as a result this may have led to an over-estimation of population size.

Despite these limitations, the vast majority of colonies were carefully and thoroughly searched during the 1973 and 1994 counts so bushes avoiding detection would probably be limited to very small seedlings. In addition, juniper stands in northern England are typically limited in extent and consist of small populations. All colonies were able to be searched in their entirety and there was no need to employ a system of sampling and extrapolation in order to estimate population size. Population estimates therefore were made with reasonable confidence. Similarly with the recording of age structures, each of the surveyors had some previous experience of and familiarity with the various conditions of juniper encountered.

2.2 Survey Results

Despite the pre-1973 extinctions, a total of 130 colonies were again assessed in Northumbria in 1994/95, producing an estimated regional population of 3547 bushes outside of Upper Teesdale NNR. Information on eighty-three, or 64%, of these colonies was compared for the period 1973-1994 to quantify demographic change (Clifton *et al* in prep.) and a summary is provided below.

Population change

Table 1 presents the results of these surveys in the context of Northumbria. Around 16% of colonies had been lost completely and over half (54%) of the juniper colonies were suffering from a decline in numbers. Only 11% of colonies were found to be on the increase and this figure should perhaps be lower when sites showing spurious population expansions are considered. From these eighty-three sites, the juniper population as a whole had fallen by 30% since 1973.

From a total of 49 sites re-surveyed, 49% of juniper colonies in County Durham were found to be in decline, whilst the juniper population in the county had fallen by 36% since 1973. A further twelve sites had become extinct with only 10% showing an increase in numbers. A number of sites showed apparent population increases yet no young junipers were located. Counts at a few sites are thought to have been distorted as mature bushes were probably miscounted during the 1973 survey. Four sites did however produce young bushes pointing to a genuine increase in numbers since 1973. Figure 1 illustrates this trend diagrammatically, with the diagonal line representing static populations over the 21 year period. Most sites fell below this line demonstrating a widespread fall in bush numbers at many colonies.

Table 1 : Population trends at 83 Northumbrian juniper sites

County	No. of sites	Population change	Population trend			
			Increase	Decrease	Stable	Extinct
Durham	49	-36%	5	24	8	12
Northumberland	34	-24%	4	21	8	1
TOTAL	83	-30%	9	45	16	13
			11%	54%	19%	16%

In Northumberland the pattern was found to be very similar (Figure 2). The juniper population had declined by 24% over the 21 year period. Although only one site had apparently become extinct during this period, 62% of all colonies showed a reduction in numbers. Four sites produced an apparent expansion in their populations although these positive changes can be partly explained by some of the difficulties associated with the survey methodology highlighted earlier. For example, counts from The Bog SSSI produced an increase of 18% and although there were signs of juniper regeneration within the colony, the overall cover of the population in terms of hectares does not easily correspond with the 1994 survey results. This can almost certainly be put down to differences in counting techniques; a comparison of three independent counts at this site illustrates the problem - 340, 539 and 414 in 1973, 1983 and 1994 respectively. The juniper stand here is considered to be the finest example of W19 juniper woodland in Northumberland with patches of dense juniper which does create difficulties in accurate population estimates. It was almost impossible to separate single individual bushes on some parts of the site. Nevertheless there were no indications of substantial population decline and it is likely that there may be a much smaller increase in numbers than these results suggest.

Population size

Juniper colonies in both counties were found to be typically small, usually less than 50 bushes and amounting to no more than 25 bushes on many occasions (see Figures 3 and 4). The size-class distribution illustrates this pattern and reflects the declines in population, with little or no increases showing within the defined categories since 1973. The two figures also show the cumulative loss of sites since 1973 and, in the case of County Durham, this explains the decline of colonies from the 1-50 size class in 1994. Larger populations were extremely scarce but where encountered had also suffered significant decline, for example, at Hartley Cleugh, Hisehope Burn and Bollihope Burn. Nearly all of these more extensive populations were found on SSSI.

Figure 1 :

Numbers of junipers in 49 colonies in Durham in 1994 plotted against the 1973 survey. Diagonal line no change, above increases, below decreases (log scale+1)

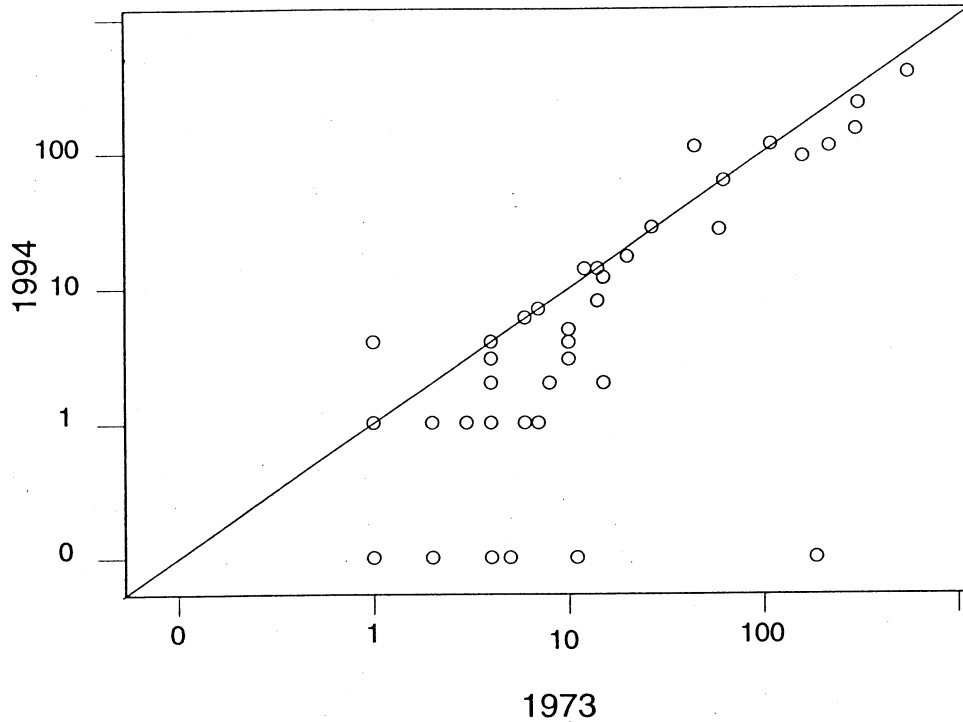


Figure 2 :

Numbers of junipers in 34 colonies in Northumberland in 1994 plotted against the 1973 survey (Diagonal line no change, above increases, below decreases) (log scale +1)

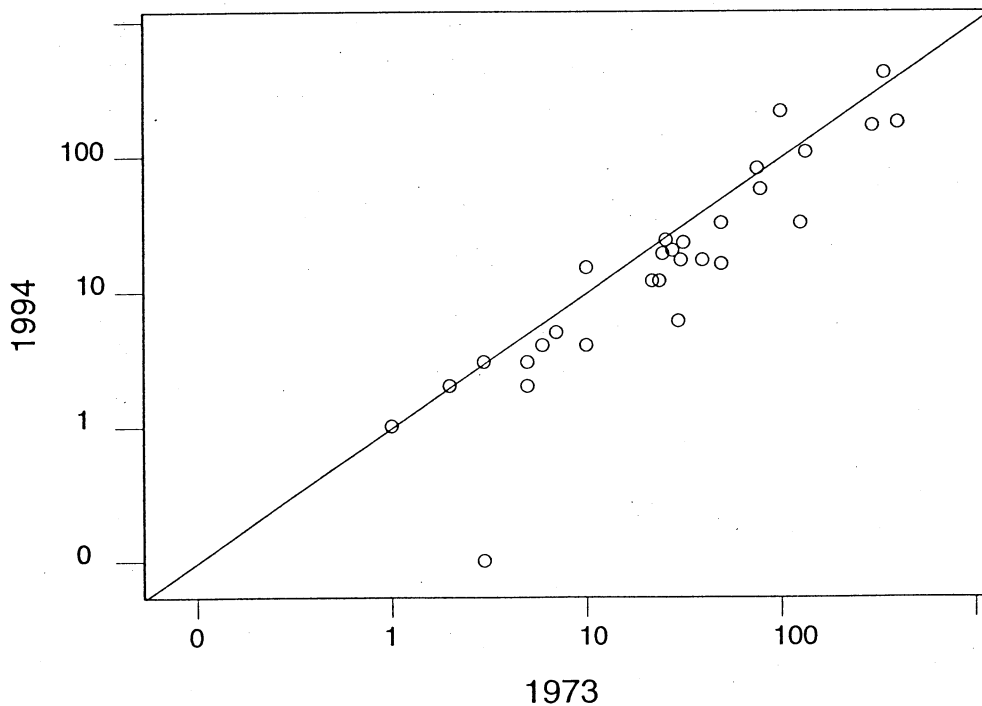


Figure 3

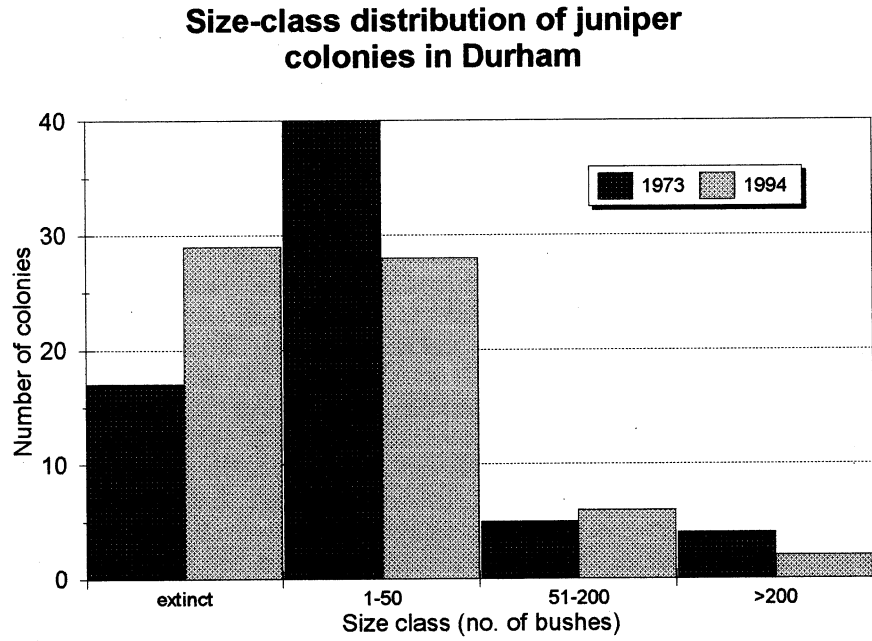
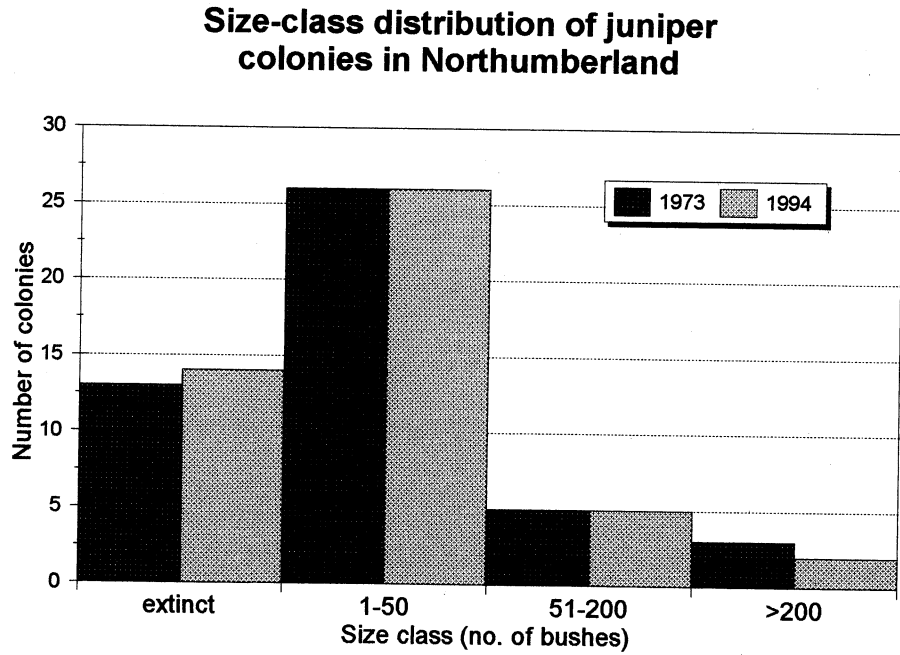


Figure 4



Distribution of colonies

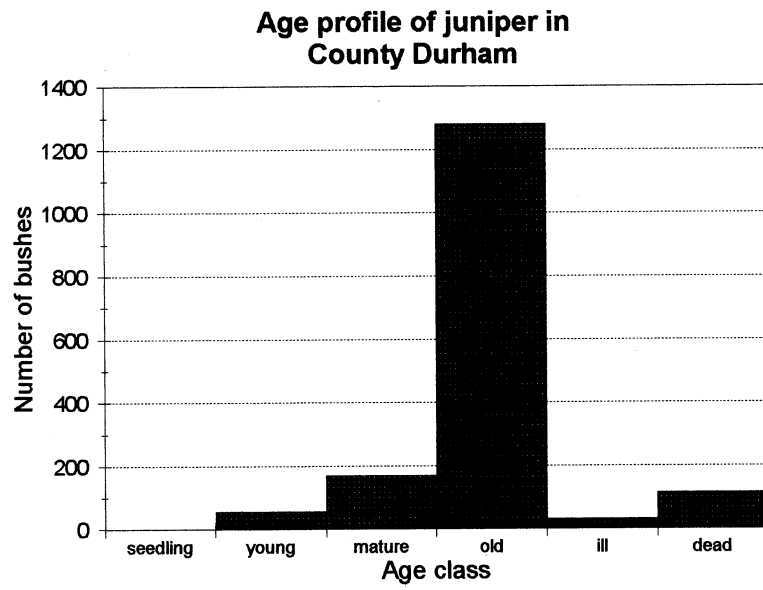
It appeared that population decline and local extinctions had not been sufficient to influence the overall distribution of colonies and there had been only minor changes in the extent of juniper colonies in the region during this period. The greatest concentration of sites were found on the Carboniferous Limestone of the North Pennines Natural Area (Table 2), with discernable linear clusters along the cleughs and burns of large moorland plateaux in west Durham and southwest Northumberland. Within the former, Teesdale and Weardale held important concentrations of juniper. However, many of the colonies on the Carboniferous Limestone were small and declining and had suffered extinctions in the past; ten sites had been lost here by 1973. By 1994, the main areas of contraction appeared to be within central and eastern Durham. By 1994 there were no remaining juniper colonies within the Northumbrian Coal Measures Natural Area and within the Durham Magnesian Limestone Natural Area, two sites, both along the Durham coast, had been lost. Only at Castle Eden Dene NNR and the sea cliffs of Blackhall Rocks did isolated junipers remain on the Magnesian Limestone.

Table 2 : Juniper population in Northumbria by Natural Area

Natural Area	% county population	
	County Durham	Northumberland
North Pennines	99.9	52
Northumbrian Coal Measures	-	-
Lower Tees	-	-
Durham Magnesian Limestone	0.1	-
Border Uplands	-	48
Northumberland Coastal Plain	-	-

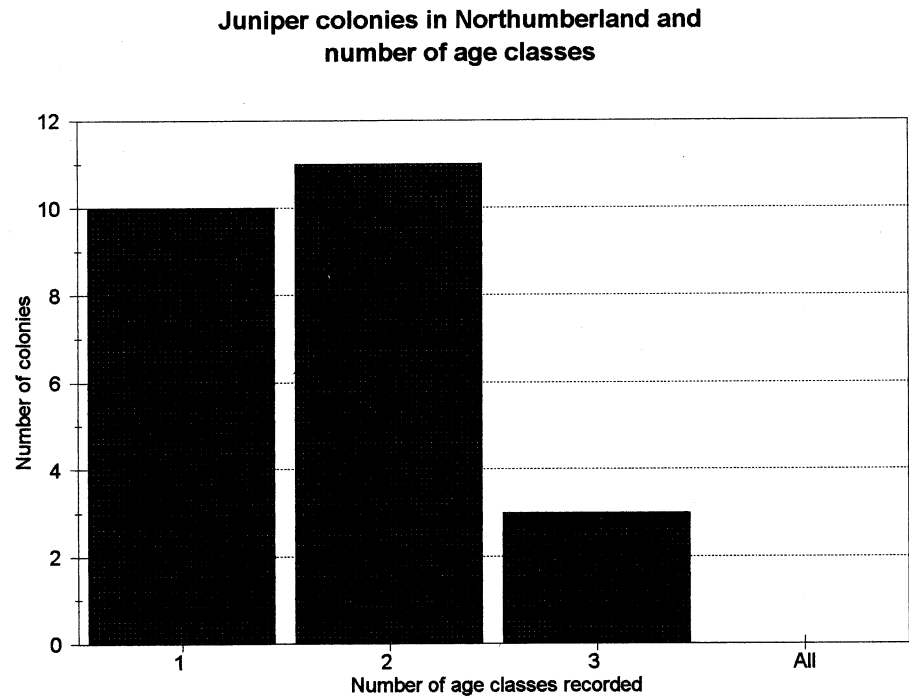
In Northumberland, juniper was again more widespread at the very extremities of the county. Colonies were largely restricted to the North Pennines (especially the Allendale and Hexhamshire moors) and the Fell Sandstone of the Border Uplands. A small number of sites were also found on acidic soils of the andesitic lavas of the Cheviots and on the crags of the Whin Sill. Sites within both counties generally occupied land subject to less intensive use and colonies were found on unenclosed marginal pasture, steep inaccessible crags and along woodland edges. The majority were typically located at moderate or high altitudes, ranging from 180 - 420m. Juniper now appears to be extinct on the Northumberland Coastal Plain. Only one site was checked and the single bush was not located.

Figure 5



Data excludes Upper Teesdale NNR

Figure 6



Based on colonies >3 bushes

Age structure and stand density

From information gathered by these surveys, juniper populations in Northumbria appear to be overwhelmingly even-aged. Age profiles at the vast majority of colonies were extremely narrow, with most dominated by mature and old bushes. There was a distinct lack of young plants and particularly seedlings. Dead junipers were often a feature of colonies and provided clear evidence of population decline. Senescent individuals, isolated by poor levels of recruitment, are left to die naturally and were distinguished by discoloured foliage, slow incremental growth of shoots and dead branches or twigs. This pattern is illustrated by the age profile of the juniper population of County Durham, which has been generated from the detailed survey of all juniper sites examined during 1994 (Figure 5). Although corresponding information for Northumberland is not as detailed, Figure 6 highlights the occurrence of age classes recorded at juniper colonies in 1994. This does point out the similarly restricted nature of age structure in these colonies and the domination of just one or two classes.

Young bushes and seedlings were rarely encountered during the surveys, although they can both be notoriously awkward to locate. Young plants were present on just 12% of colonies in County Durham in 1994 with no seedlings noted at all. During the 1994 Northumberland survey, seedlings were seldom noted and young bushes were only a feature of six colonies. The presence of young junipers would indicate a fairly recent spell of natural regeneration and this certainly appeared to be linked to the availability of bare ground. However, all Northumberland sites, with the exception of one, were generally dominated by bushes over 50 years old. Ring counts and girth measurements taken during the 1970s re-affirm this; bushes at The Bog SSSI ranged from 84-118 years of age and at Holystone Burn Woods SSSI up to 120 years old (Ward 1982).

Another typical feature of juniper colonies in the region was the scattered and very patchy distribution of bushes. Of the eighty-three sites compared in 1994, only five (6%) included areas of juniper classed as dense. Many stands showed signs of dissection by grazing animals and consisted of isolated or scattered individuals. Although northern juniper stands are characteristically patchy with a cover usually no more than 60% (Rodwell 1991), very few stands were considered to be typical examples of W19 juniper woodland; most were merely a minor component of more extensive woodland, heath and grassland communities.

Sex ratios

In a random sample of Northumberland colonies in 1995, the ratio of female junipers to males was found to average 1: 2.5 (n=8). Every site examined (except singleton sites) had a mixed population but as the sex ratio indicates, males appeared to predominate. Although very little work on this subject has been carried out on juniper stands in northern England, this trend is not unusual amongst colonies on the chalk of southern England. Here, Ward (1982) found similarly unequal ratios and an abundance of males, particularly amongst older juniper populations, and noted that old remnant bushes of numerous study sites were male. A number of others have also found that male junipers appear to live longer than females (eg Falinski 1980) although

the reasons for this are as yet unclear. Ward (1982) did however suggest the importance of land use history in explaining unequal sex ratios.

3. Factors affecting population decline

3.1 Grazing

These results appear to substantiate the widely held belief that the national trend of contraction amongst juniper populations applied to those present across much of Northumbria. This decline can be attributed to a number of factors although the outstanding factor, as elsewhere in the UK, is agricultural management practices in the form of intensive grazing.

Almost every juniper colony in the north-east of England is open to grazing animals, principally sheep but also cattle and the uncontrolled grazing of rabbits, deer and probably small mammals. Continual heavy grazing is able to open up dense stands of juniper, gradually fragmenting colonies into an open park-like community of scattered individuals. Persistent browsing also tends to affect bush physiognomy; bushes are often unnaturally stunted or prostrate and growth can be severely clipped. Features of actively grazed junipers very often include a marked browsing line (the height of which varies according to the type of grazing animal) below which the bush has been completely or partially defoliated. Gnawed bark and broken limbs are also pronounced, together with poaching of the ground and localised dunging which adversely affects the ground flora. Grazing pressure particularly in winter when junipers offer vital food and shelter exacerbates such damage. The high mortality of seedlings at this time of the year effectively eliminates colony recruitment and this persistent lack of natural regeneration is a direct threat to the long-term continuity of the juniper stand. The regeneration of other native trees amongst the juniper stands also tends to be characteristically scarce, and limited to the odd rowan *Sorbus aucuparia* or downy birch *Betula pubescens* growing from the centre of the juniper bushes.

Most stands of juniper scrub encountered during the 1994 surveys showed signs of retrogression towards heath and grassland communities as a consequence of heavy grazing. Only one site in Northumberland, The Bog SSSI, formed a significantly dense stand typical of northern W19 juniper woodland and such examples of closed canopy are particularly unusual in northern England (Rodwell 1986, 1991). The effects of grazing, as discussed previously, were evident at many sites, with a number of formerly substantial colonies heavily dissected and scattered. Even recently notified SSSIs, such as Hisehope Burn and Hunderbeck, have been subject to overgrazing for many years, particularly at the latter by rabbits. Declines of 24% and 30% respectively are the result. At the latter, bushes had been lost due to ringbarking and the undermining of roots by rabbits.

The changing density of juniper colonies was matched by the very restricted age structure of many stands. The inhibition of seedling establishment creates very even-aged juniper populations, characterised by old and senescent bushes which eventually die. Very little regeneration was noted throughout the surveys and most occurred as a result of layering, whereby lateral heavy limbs of spreading bushes, half-buried by soil, are rejuvenated and take on the persona of a group of bushes. This process whilst rare amongst southern

stands (Ward 1973) appears to be reasonably common, particularly in wetter conditions, in northern England and may well have prolonged the life of individual bushes and populations, although it is doubtful as to whether they have the ability to survive beyond the death of the parent (Ward 1982). Most of the young plants noted established themselves where access to grazers was difficult, such as amongst boulders, scree and rocky ledges, or where there had been periodic fluctuations in grazing intensity. Colonies subject to heavy grazing often already possess extensive areas of bare ground and/or short turf. A sudden lowering of the severity of grazing can very often produce a burst of juniper regeneration as seedlings colonising grazing-induced bare ground are able to grow undisturbed, as demonstrated by the effects of myxomatosis on regeneration amongst colonies in southern England (Ward 1973). The natural process of senescence does not unfortunately seem to initiate seedling growth within the centre of degenerate bushes (Gilbert 1980). Close inspection during the 1994 Northumberland survey of a number of old and dying bushes that had opened out appeared to substantiate this claim. Where regeneration had occurred, young junipers were found adjacent to the existing stand, as demonstrated by the colony at Middles West in Durham, where a phase of less intensive grazing had allowed younger plants to establish themselves and reach maturity. At Holystone Burn Woods SSSI, there has been no obvious natural regeneration since 1966 when a fenceline was cleared through birch scrub and the associated ground disturbance allowed seedling growth until ground vegetation recovered and closed (Gilbert 1980).

Upland farming practices throughout the 1970s and 1980s had been to take full advantage of production-orientated agricultural support subsidies and progress to much greater and intensive levels of stocking. Sheep numbers in the North Pennines Area of Outstanding Natural Beauty have continued to expand and are estimated to have risen by 26.7% from 1981-1988 alone (North Pennines AoNB Steering Group 1995). It is no surprise therefore that juniper scrub, along with important heather *Calluna* - dominated communities, suffers from degradation through constant overgrazing. Of the juniper colonies in the Northumbrian sector of the North Pennines, 76% were found to be in decline.

The resounding even-agedness of juniper populations has obvious implications for their long-term continuity. Age has been found to affect juniper reproductive output as the capacity of bushes to fruit diminishes as bushes grow older. Ward (1982) found that 80% of seed produced by young stands were viable, compared with just 5% from older populations. Senescent bushes also become increasingly susceptible to disease, fungal attack and windthrow. Nevertheless these old populations may well persist for a very long period of time. Junipers in northern stands can reach 200 years of age, with a 250 year old bush the oldest recorded at Upper Teesdale (Ward 1982). This is almost double the longevity associated with juniper colonies on the southern Chalk and may be related to slower growth of junipers in the north due to more extreme climatic conditions (Ward 1982). Such difficulties of reproduction associated with ageing populations often combine with adverse management activity to finally bring about the complete elimination of the population, although the strong resistance to decay of dead junipers means the remains of a stand are visible for many years after.

Many of the juniper stands in Northumbria were found in more upland localities (see Table 2) subject to intensive management regimes, with

considerable distances separating them from more extensive woodland habitat. This isolation, and the fragmentation and continual suppression of both juniper and native broadleaved woodland to complement these colonies, may, in turn, restrict the potential for seed dispersal and population recruitment through changes in local bird populations. This may be of concern particularly amongst populations of wintering thrushes *Turdus spp.* which are known to be the principal agents of juniper seed dispersal (Livingston 1972; Snow & Snow 1988). Although there has been little work to investigate this relationship in Britain, studies on the effects of forest fragmentation on Spanish juniper *Juniperus thurifera* in central Spain (Santos & Telleria 1994) suggested that the lower abundance of frugivorous birds and an increase in small mammal populations within smaller woodland fragments significantly impaired berry consumption, seed dispersal and seedling establishment. Restrictions on natural juniper regeneration were therefore much greater in smaller, more isolated patches of woodland.

3.2 Direct clearance

Juniper stands are also often removed entirely. This process of deforestation usually aims to increase the area of available pasture for livestock and it appeared that this affected a number of substantial colonies which had been largely lost since 1973. A discrete stand of 59 bushes at White House in Durham was found to have been grubbed out, while the juniper stand at Wooley Bridge in south Northumberland, consisting of over 100 bushes, was found to have been completely cleared. Its survival has been prolonged only by the natural migration of the colony downstream along the exposed banks of a small gill. Part of the scattered juniper population at Hepple Whitefield along the slopes of the Coquet valley in Northumberland were lost to the bulldozer in the 1960s. At High Jofless in Durham, a substantial area of juniper scrub (almost 200 bushes) was cleared for grazing and re-forestation with more profitable non-native conifers.

3.3 Erosion

A number of juniper colonies were located within narrow, deeply incised cleughs and burns of upland plateaux, particularly in areas of Northumberland such as South Tynedale and Allendale. These stands, though typically small populations, have been able to persist as a result of the inaccessibility of the steep slopes to grazing animals. However a number of colonies perched on steep unstable slopes had suffered a loss of population from bank erosion. The most notable example was encountered at Hartley Cleugh SSSI where the juniper population had declined by an estimated 56%, with two large landslips along the eastern slopes of the valley assumed to be contributory factors. The decline of other populations throughout the region may also be attributed to such natural processes.

By their very nature, episodes of mass movement by bank erosion provide areas of bare ground conducive to seedling establishment. It is well known that juniper requires bare ground or a short open sward in order to establish itself (Fitter & Jennings 1975; Miles & Kinnaird 1979; Ward 1982) and juniper regeneration of some stands in northern England has in some instances been traced back to periods of ground disturbance associated with management operations (Gilbert 1980). It is possible that geomorphological activity is a natural source of replicating this process. Observations during the

Northumberland survey of 1994 suggest that the presence of young plants may be related to the erodibility of some sites; 80% of colonies with young junipers were affected by bank erosion. For example, the only juniper seedlings discovered at Threestoneburn in the Cheviot Hills were associated with steep bare ground created by bank slumping. The degree to which any fresh seedlings survive and develop to the bush stage then depends upon the intensity of controlled and uncontrolled grazing. Erosion may well account for the persistence of juniper colonies in the Pennines in particular.

3.4 Decline of traditional management

This is perhaps a chronic factor affecting the juniper population in Northumbria and partially accounts for the poor regeneration of some stands this century. It is thought that the 'dual economy' of mining and farming practised in much of the North Pennines between 1600-1900 probably assisted the successful regeneration and expansion of juniper colonies during that period (Gilbert 1980). Land use fluctuated between small-scale mining activity and farming according to the economic climate and the periodic respite from farming activities would have allowed a resurgence of juniper regeneration. Until the early 20th Century, juniper was also used for firewood and to provide a base for wall tops and haystacks. Bushes were cut by hand and dragged out by pony and chain. The resulting soil disturbance provided bare ground ideal for seed germination and the fluctuating grazing levels would have allowed seedlings to establish and mature. With the cessation of this 'traditional' management, there has been little significant juniper regeneration on these sites.

3.5 Seral change

Where grazing is absent or at low levels, juniper populations revert to their natural role as seral communities in the transition towards woodland, as opposed to stands representing a relict woodland understorey isolated by tree clearance and grazing management. Juniper, as a pioneer species, rarely regenerates beneath its own canopy and the gradual successional process towards a closed woodland canopy results in naturally short-lived colonies. However, it can survive as an integral part of more open woodland communities but excessive shade can result in its often rapid disappearance from the woodland community. This process was evident at several sites in both counties such as Hannahs Hill SSSI in Northumberland and Castle Eden Dene NNR, where bushes under a fairly dense canopy are typically very leggy and moribund with discoloured foliage. Another example occurs at Oakeydean Burn in south Northumberland. Here a disused quarry is undergoing vegetation re-colonization but the juniper population is now in danger of being swamped by maturing birch and oak woodland. Coniferous afforestation schemes often allow suitable conditions for the initial invasion by juniper but populations tend to be lost very quickly on the onset of canopy closure, for example at Simonside Hills and Hamsterley Forest.

3.6 Burning

The drier unenclosed moorlands of north-east England on which heather *Calluna vulgaris* is dominant are often managed for grouse shooting and are subject to regular rotational burning as a result. This was found to have

affected several small juniper colonies. The impact of burning on juniper is somewhat contradictory; whilst it can kill or seriously damage populations in the short-term, it is often a valuable tool in the long-term rejuvenation of declining stands (Miles & Kinnaird 1979). In Northumbria, isolated individuals do appear to have been lost as a result of burning, although there may be future opportunities to redesign burning regimes and extend juniper populations on SSSI such as Simonside Hills in Northumberland.

4. Conservation management of juniper in Northumbria

The findings of the 1994 surveys suggest that, given no catastrophic events, natural or anthropogenic, and the continual absence of suitable colonization conditions, the bulk of the juniper resource in the region will be lost during the next 50-60 years. With an estimated annual rate of loss of 1.5%, continued surveillance of juniper sites, based on this accumulated information, will be invaluable in monitoring regional trends and ongoing patterns of decline. In view of the anticipated continuity of gradual decline over the next few decades, the conservation of juniper in Northumbria must now assume a much greater priority.

From information gathered during the 1970s, and with the inclusion of the juniper woods of Upper Teesdale, approximately 9% of the juniper population of England and Wales appears to be found in Northumbria (Ward 1994). The region thus makes a significant contribution to the national resource. Juniper scrub has already been recognised as a nationally scarce woodland type (Nature Conservancy Council 1989) and the inclusion of juniper formations as a habitat type of European interest within the EC Habitat and Species Directive is an extra acknowledgement of its threatened status in a much wider context (European Community 1992). The extensive juniper stand of Upper Teesdale has also been recognised as worthy of additional protection by this Directive and forms one of the principal features of the Moorhouse-Upper Teesdale candidate Special Area of Conservation .

As with any endangered habitat type, the largest populations of juniper in the region are the most important in terms of nature conservation as they are able to support good quality examples of associated flora and fauna. They also act as important reproductive sources for dispersal into the wider countryside. Ward (1973) considered that sites with populations greater than 100 bushes are ecologically more valuable in terms of maintaining their invertebrate fauna and associated vegetation communities. Juniper is only abundant on a small number of sites in Northumbria and it is likely that some of the smaller colonies are merely transient seral communities or opportunistic individuals. Conservation measures to prolong these are largely unjustified. However, the paucity of open ground conditions, subsequent poor regeneration, restricted age structure and continued high grazing levels mean that juniper has very limited opportunities to spread and maintain its current distribution in the wider countryside. Larger colonies are more resilient and offer the best sites at which to target active conservation management.

4.1 Juniper populations on SSSI and their management

The finest, and usually the largest, examples of juniper scrub and W19 woodland in Northumbria have been notified by English Nature as SSSIs, some as a direct result of the survey work noted in this report. Juniper is currently represented on seven SSSIs, which have been notified partly or wholly on account of their juniper populations (Table 3). Juniper also occurs

as small or isolated populations on five other SSSIs. The suite of Northumbrian SSSIs includes approximately 93% of the juniper population in County Durham (including Upper Teesdale NNR) and 58% of the Northumberland population, covering an estimated 120 ha ,although around 100 ha of this is found at Upper Teesdale NNR alone. This compares with an estimated 94 ha in North Yorkshire SSSIs and 250 ha in the Cumbrian SSSI series.

All of these SSSIs are now subject to positive conservation management, in partnership with landowners and site occupiers, in the form of management agreements reached through a Wildlife Enhancement Initiative (WEI). The management of these SSSIs will also be refined, given its somewhat experimental nature, through the Site Management Statement (SMS) process. The primary aims of this Initiative are to:

- Maintain and extend juniper habitats in Northumbria.
- Improve the quality of juniper habitats.
- Enhance the species interest associated with juniper habitats.
- Develop partnership , trust and respect between the farming community and English Nature.

Table 3. Juniper SSSI in Northumbria

	SSSI	Total area of site (ha)	Estimated 1994 population size (no. of bushes)	Area of juniper (ha)
County Durham	Upper Teesdale	14037	15-20,000 *	c.100
	Hunder Beck Juniper	3.4	394	1.5
	Hisehope Burn Valley	15+	242	2
Northumberland	Hannahs Hill	2.4	187	1
	The Bog	4.5	414	3
	Hartley Cleugh	2.4	177	1
	Holystone Burn Woods	110.7	213	c.11

* From Gilbert (1980)

The response from juniper SSSI owners and occupiers has been very encouraging and it is hoped that the close working relationships developed on these sites will continue as a result of the SMS programme.

Positive management agreements

The programme of practical conservation on SSSIs in the Northumbria region is currently being implemented through positive management agreements under a WEI. A series of basic management guidelines, supported by a

package of annual management and fixed cost payments, were produced to cover all of the juniper sites entered into the scheme. These are presented in Table 4. These guidelines are designed to fulfil two main objectives:

- to bolster existing juniper populations on SSSI in the short-term;
- to perpetuate juniper stands in the long-term through the promotion of natural regeneration and the establishment of self-sustaining populations;

These guidelines are readily applicable to important non-statutory sites and English Nature is presently working with local authorities and landowners on several colonies, providing management advice and promoting their conservation.

Grazing management

It is often necessary to regulate grazing levels to achieve the successful management of juniper woodland, in common with other upland woodland types (Kirby 1990). Four SSSIs have been recently fenced to exclude grazing animals and allow greater control of grazing levels in favour of natural regeneration. It is widely believed that the sudden relaxation of a heavy grazing regime will encourage a phase of regeneration, given the presence of a mixed population and fruiting bushes. At Hunder Beck Juniper SSSI, smaller rabbit-proof enclosures have also been erected inside the enclosed area. Stock are excluded during the autumn and winter to encourage seedlings to establish. The re-instatement of light sheep grazing in the summer to arrest competitive species should allow young junipers to reach maturity and new seedlings to establish. Seedling mortality and bush damage is greater in autumn and winter yet summer grazing does not appear to affect juniper seedlings, which are often ignored for more palatable vegetation (Fitter & Jennings 1975). In this situation, total exclusion of grazing animals is undesirable.

Habitat management

Cuttings and seeds from healthy bushes are to be collected over the next three years from a number of juniper SSSIs in the region to be grown on under nursery conditions. The first phase of collection was completed in the winter of 1994. Cuttings will also be taken in the summer months to vary the timing of collection and to discover whether this affects the number of plants successfully grown on. Future replanting will take place on the donor sites to bolster the existing ageing population and maintain the genetic integrity of each colony. Cuttings have already been successfully grown on and planted out as three year-old trees at Holystone Burn Woods SSSI. Each shrub is protected by guards and mesh deer fencing. Supplementary planting of other native broadleaves such as rowan, ash *Fraxinus excelsior*, holly *Ilex aquifolium* and hawthorn *Crataegus monogyna*, has also occurred to create added diversity and a more 'natural' woodland appearance.

The collection of berries in autumn was also carried out to supplement the cuttings. It is too early to judge whether the ageing nature of the donor populations has affected seed viability as previously reported (Ward 1982) but it is hoped this will provide additional material for future replanting.

A programme of bracken control is often an important precursor to this type of management on several sites. At Hannahs Hill SSSI, phased spraying with Asulox, at varying volumes depending on the proximity to juniper bushes, has been already successful in limiting bracken growth. The removal of surface litter in close proximity to fruiting bushes to expose the sparsely vegetated ground layer will follow, in an effort to encourage seedling establishment.

Monitoring of the effectiveness of this management is naturally very important, both to evaluate and revise the existing management guidelines. Annual SSSI monitoring and the renewal of management agreements offer short-term opportunities to assess the management programme, and there may be room for site-specific plots to be established to assess in greater detail the effects of grazing management under the WEI. The effects of juniper management may only be apparent in the long-term, and it will be useful to document the existing features and extent of colonies from a programme of fixed point photography.

Table 4. Juniper in Northumbria Wildlife Enhancement Initiative

Management Guidelines

<p><i>Grazing management</i></p> <ul style="list-style-type: none"> ● On land subject to grazing, a programme of grazing management is to be agreed. This may include periods of complete stock exclusion and the erection of fencing to facilitate this. ● Existing fences on ungrazed land should be maintained to exclude stock. <p><i>Habitat management</i></p> <ul style="list-style-type: none"> ● This may include: <ul style="list-style-type: none"> - Non-intervention - Tree/shrub planting (including junipers of local stock) - Protecting naturally regenerating trees and shrubs - Scarification to encourage seedling establishment - Removal of gorse ● A programme of bracken control may be necessary and should be discussed with EN. ● No fertilisers or lime to be applied to the land. ● Rabbits should be controlled to encourage natural regeneration. ● Spot treatment of weeds (nettle, dock, ragwort, creeping and spear thistles) acceptable. ● Management undertaken on the land should be recorded.

4.2 Experimental juniper management at Upper Teesdale NNR, County Durham

Over the last 30 years, experimental juniper management has taken place at Upper Teesdale NNR in an effort to identify the most effective methods of encouraging regeneration. Early experiments set up during the 1960s dealt solely with the exclusion of stock from juniper stands. Monitoring of quadrats over a 12 year period concluded that the lush growth of vegetation that followed the cessation of grazing, despite favouring some elements of the

woodland flora, was not beneficial to juniper seedling establishment. In 1990 plots were established within a single stock (and now rabbit) -proof enclosure and were subject to specific treatments. This deliberately included prescriptions designed to replicate the historical management outlined earlier. These included :

- coppicing of junipers at ground level;
- coppicing of junipers at 1m;
- the removal of junipers by winch.

Preliminary results suggest that the final treatment shows the most potential. Bare ground is created by dragging out the bushes and female junipers also shed their berries during the proceedings. Seedlings have already been noted. Coppicing allows light to reach the ground but the degree of disturbance is much more limited. These experiments are ongoing and suggestions have been made for further treatments (Ward 1991). It is envisaged that eventually the outcome of this work can be adapted to revise existing conservation management and benefit juniper populations on other sites.

4.3 Juniper in the wider countryside

Numerous juniper colonies within the region are afforded varying degrees of protection either as SSSI, County Wildlife Sites or Sites of Nature Conservation Importance, or by their location within the Pennine Dales ESA and the North Pennines AoNB. Many stands exist outside statutory sites within the wider countryside and receive little or no protection. Some stands are included within the second-tier wildlife site system with 18% of colonies designated as County Wildlife Sites (County Durham) or their Northumberland equivalent Sites of Nature Conservation Importance. The conservation of these colonies is difficult and relies on good communication and sympathetic management from landowners and land managers. The inclusion of locally important juniper colonies within the second-tier system is perhaps a start and provides some informal recognition of their local interest. A number of sites in County Durham have been recently designated as CWS following the 1994 surveys and it is hoped that a number of important Northumberland colonies currently lacking recognized status will also be selected as SNCIs in the near future. Environmentally sensitive schemes can perhaps be exploited more widely to ensure the presence of healthy juniper colonies in the wider countryside and particularly in those Natural Areas where juniper is a declining, but characteristic, feature. Although only 4% of sites fall within the Pennine Dales ESA, 11 % and 46% of juniper sites do occur within the Northumberland National Park and the North Pennines AoNB respectively. The use of Countryside Stewardship, the Forestry Authority Woodland Grant Scheme and National Park management agreements in these areas offers some scope for the integration of habitat conservation objectives within farming regimes and the provision of more favourable conditions, through changes in hill grazing practices, for juniper colonization.

5. Recommendations

- Data generated during the 1970s is now largely outdated. The implementation of baseline population surveys similar to those carried out in Northumbria is required elsewhere in England to catalogue population trends and produce more accurate information on the status of juniper in England.
- Encourage the positive management of juniper SSSIs in England.
- Continue to disseminate information on the effectiveness of regeneration/management techniques .
- Ensure that the best examples of juniper habitat which meet national or local criteria are notified as SSSI or designated as second-tier sites.

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