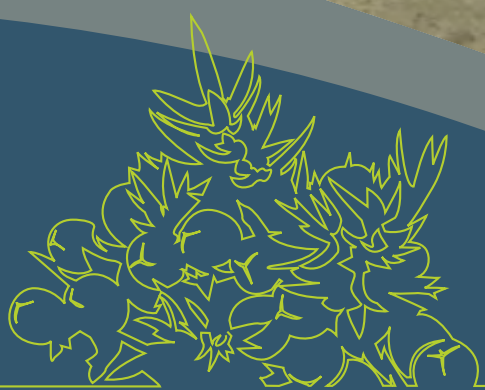
Plantlife

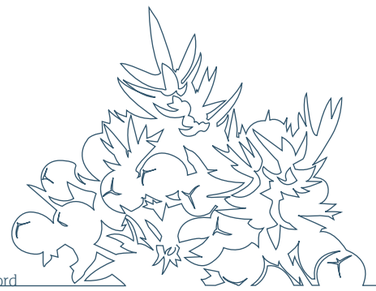
Breaking new ground for juniper

A management handbook for lowland England



Without action now juniper faces extinction across much of the English lowlands within 50 years

Juniper has declined across Britain but the problem is particularly acute in the lowlands, where it has been lost completely from 9 of its 27 lowland vice-counties, including Bedfordshire, North and South Essex, North Devon and North Somerset. Populations that are still surviving in the Chilterns, Sussex and Wiltshire have shown declines in juniper abundance of 84%, 69% and 44%. Many colonies have dwindled to such an extent that they are functionally extinct.



Front cover photograph: Calstone Down, Wiltshire.
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We are Plantlife

The UK's wild plants have been marginalised and taken for granted for too long. Wild plants clean our air and water, provide food and shelter for our insects, birds and animals and will be critical in the fight against climate change.

Plantlife is the organisation that is speaking up for nation's wild plants. We work hard to protect wild plants on the ground and to build understanding of the vital role they play in everyone's lives.

Purpose and scope

This guide contains detailed advice to aid the recovery of juniper (*Juniperus communis* subsp. *communis*) across the chalk and limestone country of lowland England. Plantlife has been piloting a series of management techniques with project partners to find out the best ways of triggering regeneration and rehabilitating functionally extinct colonies. Although these trials are still ongoing, we hope this guide will equip conservation practitioners, land managers and voluntary groups with the information they need to stem the wholesale decline of the species across southern England. In the absence of wider landscape-scale processes ushering in a whole new generation of juniper, clusters of small scale restoration projects have potential benefits beyond the level of individual sites.

This publication forms part of a two-year project 'Saving England's Lowland Juniper', funded by Natural England, Biffaward and Buckinghamshire County Council.

The guide addresses the first lowland BAP action (2008) for juniper, namely: *bring research together to establish a detailed management protocol*. In so doing, it is hoped the remaining lowland BAP actions will be achievable:

- Apply [the protocol] to key sites within core areas
- Restore and expand appropriate habitat
- Ensure grazing is at appropriate levels on all sites
- Establish ex-situ seedbank to reinforce highly isolated and edge-of-range single-sex populations with re-introductions where appropriate

For information on managing juniper in upland situations, please refer to the booklet entitled 'Managing Uplands for Juniper' which is available for download from the Plantlife website, or in hardcopy from Plantlife's head office.

Starved of light, these mangled skeletons of juniper sit beneath a dense canopy of beech.

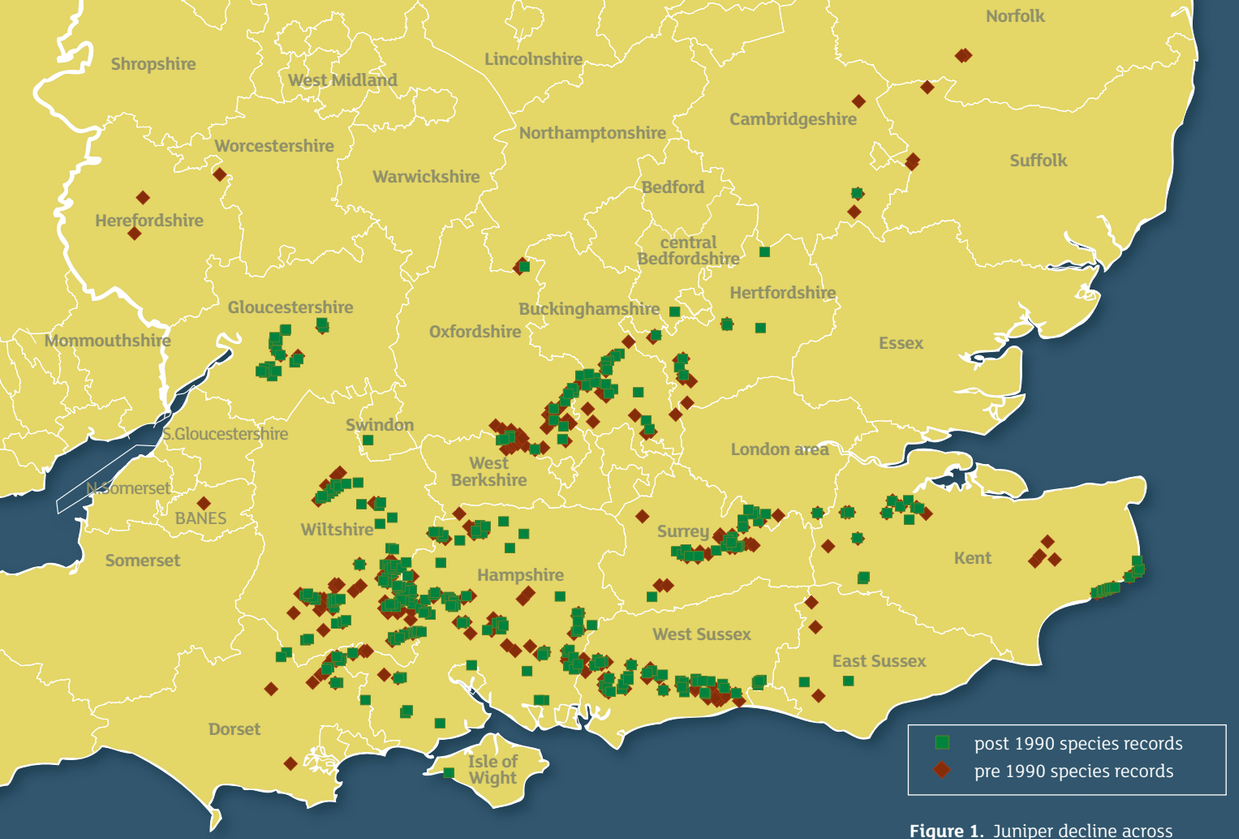

Figure 1. Juniper decline across lowland England – pre-1990 sites in red; 1990-2010 sites in blue (based on 1km square and 100m square records). Derived from MiniScale by Ordnance Survey. Reproduced from Ordnance Survey digital map data. © Crown Copyright 2011. All rights reserved.

Lowland juniper – the facts

Conservation status and distribution

Along with Scots pine and yew, juniper is one of only three conifers native to Britain. Although a long-lived perennial, in southern England there are very few sites where juniper is regenerating successfully.

Juniper's lowland headquarters lie in the South Wessex Downs, where it is particularly abundant on the military ranges of Bulford and Porton Down. These two areas support the largest remaining populations in southern England, with thousands of bushes each, and are considered to be the best remaining examples of lowland juniper scrub on chalk. Their inclusion in the Salisbury Plain Special Areas of Conservation (SAC) gives them formal recognition under the EC Habitats Directive Annex I habitat: '*Juniperus communis* formations on heaths or calcareous grasslands'.

Aston Rowant in the Chilterns is the only other SAC primarily designated for juniper scrub in southern England. Elsewhere juniper occurs more sporadically across the chalk and limestone, where the majority of good populations are either designated SSSIs or NNRs. Typical hotspots are the Cotswolds, Chilterns, and the North and South Downs (Fig. 1).

Owing to its BAP status, juniper is a Species of Principal Importance in England (S41 of NERC Act 2006). It is currently listed as 'Least Concern' in The Vascular Plant Red Data List for Great Britain but this is on account of its long lifecycle and relatively gradual decline throughout Britain as a whole.

Habitat

Juniper can be found growing on a wide variety of soil types and topographies but in lowland England today it chiefly occurs on chalk downland or limestone grassland. The grassland communities that support juniper (Box 1) are frequently species rich themselves, containing other threatened plants such as wild candytuft, musk orchid and pasqueflower. These wild flowers stand to benefit from habitat management for juniper.

Other typical habitats include: ancient trackways, paths and waysides, disused quarries, cliff faces, earthworks and rarely heathland.

Where scrub or young woodland have colonised, juniper will slowly die out. Ironically, its prickly foliage may hasten woodland development by acting as a nurse tree for other species – e.g. yew. At some Chilterns sites juniper has been lost under beech although this may be a consequence of historical plantations.

▲Pasqueflower

Box 1. Lowland plant communities

The National Vegetation Classification communities listed below reflect the diversity of calcareous grassland habitat that juniper inhabits. Remarkably, only CG2 and CG7 typically feature bare ground which is considered a prerequisite for juniper seedling establishment. The other communities may therefore be sub-optimal for recovery.

Main lowland grassland communities supporting juniper:

- CG2a *Festuca ovina – Avenula pratensis* grassland, *Cirsium acaule – Asperula cynanchica* sub-community
- CG2b *Festuca ovina – Avenula pratensis* grassland, *Succisa pratensis – Leucanthemum vulgare* sub-community
- CG3a *Bromus erectus* grassland, typical sub-community
- CG3d *Bromus erectus* grassland, *Festuca rubra – Festuca arundinacea* sub-community
- CG5a *Bromus erectus – Brachypodium pinnatum* grassland, typical sub-community
- CG7 *Festuca ovina – Hieracium pilosella – Thymus praecox/pulegioides* grassland

Wildlife dependent on juniper

Juniper is almost a habitat in its own right, supporting an impressive range of wildlife, including some species that could not survive without it. Juniper berries and shoots provide a food source for wild birds and mammals, especially during autumn and winter months and it supports over 50 insects, such as the juniper shield bug, juniper aphid and juniper carpet moth. Juniper also provides ideal habitat for spiders. Studies show that the larger the populations of juniper, the greater diversity of insect species. In addition, over 40 species of fungi are either entirely or partially dependent on juniper, and its stems and branches can support a range of lichens and bryophytes.

Bare ground around juniper can attract a variety of early successional plants and wildlife. Species such as kidney vetch and horseshoe vetch are important food plants for butterfly larvae, with the former the sole larval food plant of the small blue – a Species of Principal Importance in England (S41 of NERC Act 2006). Similarly, butterflies that require a short sparse turf stand to gain, e.g. the Near Threatened silver-spotted skipper.

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▲Figure 2. The distinctive stomatal stripes on upper sides on juniper needles.

▼Figure 3. Male flowers cones in May
Top picture – pollen sacs full; Bottom – pollen sacs empty)

Identification and life cycle

With the exception of a small population of subsp. hemisphaerica on the Lizard peninsula in Cornwall, all lowland populations comprise subsp. communis - hereafter simply referred to as juniper. Taxonomically, these subspecies may be relegated to varieties in future.

Juniper is unusual in that it has a variety of growth forms, ranging from prostrate to columnar. Upright bushes can reach four metres or more in height. Juniper's foliage is composed of small and densely packed prickly needles that grow in whorls of three. Close up, a whitish stripe of stomata (sometimes two stripes) can be seen running down the upper side of each needle (Fig. 2).

From a distance, juniper can be confused with yew or gorse but yew is generally a larger tree with comb-like shoots composed of soft, dark green needles. Female yews carry red 'berries' in the autumn. Gorse is a grey-green shrub with distinctive yellow flowers for most of the year and its spines lack the white stripes.

Be aware that there are also a great many garden varieties and non-native species of juniper which can be confused with J. communis, particularly boundary and hedgerow trees.

Juniper is dioecious – its bushes are either male or female. Female bushes are usually easy to identify because of their small blue-black or green berries (strictly speaking cones or 'galbuli'). A lack of berries is a good but not totally reliable sign that the bush is male. Young females may be berryless due to sexual immaturity and isolated females may fail to develop berries due to lack of pollination. Male bushes are generally taller and produce minute flower cones in spring with abundant pollen (Fig. 3) that are slightly different in appearance to those of females. After flowering, the remains of male cones may be seen for some time, allowing bushes to be sexed reliably.

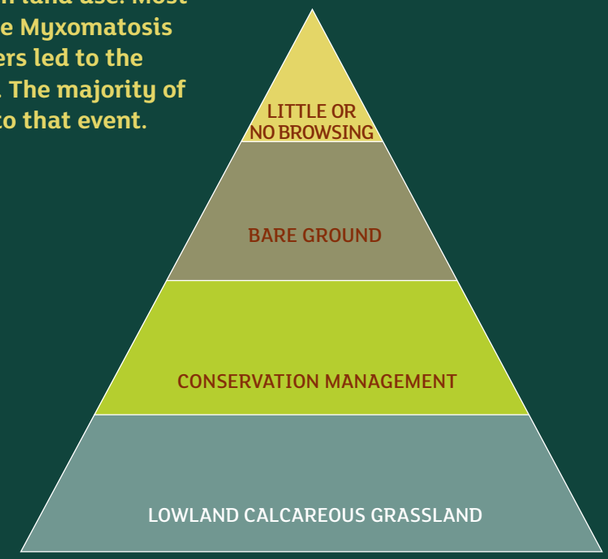
Juniper has adapted to be mobile through efficient seed dispersal. The berries on female bushes ripen two or three years after pollination which occurs by wind. In the autumn, berries fall onto the ground beneath bushes or are eaten and dispersed by birds or animals. Migrant thrushes such as fieldfare, redwing and mistle thrush are particularly responsible. Seedlings are slow-growing and take 4-9 years to reach sexual maturity. Juniper also has the facility to spread locally through layering (a means of vegetative reproduction whereby branches resting on the soil form roots). This appears to rarely happen on the dry soils of the south and its significance has yet to be determined.

Conservation challenges and solutions

After the last Ice Age, vast stony landscapes relatively free of wildlife were commonplace, providing ideal conditions for juniper to flourish. There have since been pulses of regeneration across the lowlands linked to complex changes in land use. Most recently was in the mid-1950s, in the wake of the Myxomatosis outbreak, when the sudden drop in rabbit numbers led to the emergence of a whole new generation of bushes. The majority of junipers in the south today owe their existence to that event.

Today's heavily managed countryside has little in the way of suitable habitat for juniper. Annual cycles of grassland management conflict with its reproductive strategy and, despite its prickly foliage, juniper is often damaged by livestock, rabbits and deer, with its seedlings particularly palatable.

The problem is currently perpetuated by a tendency to manage conservation grasslands uniformly, resulting in a paucity of bare ground and a seasonal risk of browsing from livestock (Fig. 4).



▲ Figure 4. Current rarity of juniper regeneration habitat

As lowland junipers typically live for 100-120 years, they have up to 100 opportunities to reproduce successfully. If each individual is survived by just one offspring, a stable population will result. For this reason, and because of juniper's tendency to reproduce episodically, the absence of seedlings at a site for a decade or more should not be a cause for great concern. However, today many populations consist entirely of old collapsing bushes which are prone to sudden die-off. Urgent intervention is clearly needed at such sites.

Although good berry years can produce prodigious quantities of seed, less than 2% may be viable. Combine this fact with the ubiquitous threats of browsing, trampling, shade, desiccation and disease, and it becomes clear why seedlings are so scarce. One study showed that out of 10,000 seeds, only 6 produced seedlings that survived their first year.

Poor seed viability occurs naturally in many small-seeded pioneer tree species. The situation is, however, exacerbated by insects and mites that hollow out the seeds. At many juniper sites in southern England, their impact is substantial. Juniper seed can also abort during development due to false pollination by air pollutants or even dust. Fragmented populations and biased sex ratios can further impede pollination through distance or barriers.

The transient nature of juniper seed means that it fails to form a persistent seed bank in the soil. This fact alone makes revival of lost populations impossible without resorting to translocation.

Juniperus communis is declining in other parts of lowland Europe. Computer modelling suggests that its European range will contract northwards as the climate warms, implying a greater international responsibility to conserve its populations in the UK. An emerging concern in Britain, is the trend for increasingly mild winters which may eventually result in a failure to break seed dormancy (juniper seed requires two cold winters to germinate). Furthermore, young seedlings are highly susceptible to summer drought.

The factors underpinning regeneration

As a pioneer species, the proximity of bare ground appears to be the most important factor responsible for seedling establishment. Areas that remain continuously open with plentiful bare ground are much more likely to support seedlings. Episodes of intense bare ground creation need to be followed by long periods of little or no disturbance. Traditional activities such as droving, shepherding, or occasional cultivation, would have created such conditions. Similarly, ancient trackways, earthworks and old quarries provided ideal habitat and are typical juniper haunts today (Table 1). Currently, regeneration is largely confined to a few roadside embankments although some of these colonies originated as introductions (Fig. 5).

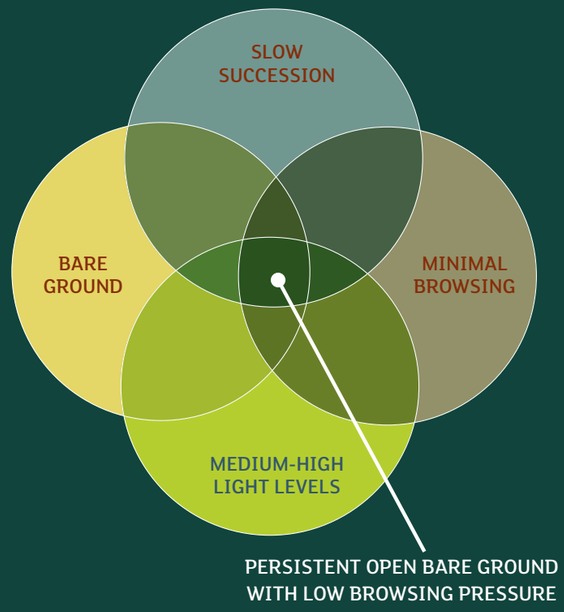
The intensity of rabbit and deer browsing in combination with livestock levels is crucial in determining seedling survival and growth. Browsing levels may need to be low for 10 to 15 years before seedlings are sufficiently robust.

▼Figure 5. Natural colonisation on a Wiltshire roadside bank

Another key condition is suppressed succession, limiting the impact of faster-growing or taller species outcompeting or overshading juniper during its development from seedling to reproductive adult. Succession is naturally slowed through a combination of impoverished skeletal soils and naturally eroding or steep slopes. Preventing soil enrichment is the key to suppressing succession.

High light levels are clearly associated with juniper establishment. Although one study has shown successful growth in 20% daylight, higher light levels tend to yield higher growth rates. Seedlings growing directly beneath parent bushes will perish in persistent deep shade.

The diagram in Fig. 6 summarises the interplay of these conditions. Note that not all need be true at the same time – e.g. a period of high grazing pressure creating bare ground may be followed by little or no grazing.



▲Figure 6. Key regeneration conditions.

Habitat	Site examples	Causal factors
Downland and grassland	Porton Down (Wilts) Bulford Down (Wilts) Rodborough Common (Gloucs)	• Fluctuating rabbit population – e.g. post-myxomatosis (1954-5) • Controlled grazing (poaching) • Terracettes on slopes (e.g. sheep paths) • Protected sites
Old/ancient quarries	Noar Hill (Hants) Painswick Beacon (Gloucs)	• Abundant bare ground • Steep slopes • Cycle of abandonment and re-use • Minimal grazing when quarried • Protected sites
Waysides, ancient routes and earthworks	Aston Rowant (Oxon) Stockton Down (Wilts) Winterbourne Downs (Wilts) Roundway Down (Wilts) Fleam Dyke (Cambs) Figsbury Ring (Wilts)	• Long-standing use • Route changes (cycle of abandonment and re-use) • Stock movements/funnelling (poaching intensity gradient; minimal browsing) • Sunkenways and slopes (natural erosion/ soil creep) • Protected sites
Wild animal tracks, burrows and diggings	Stockton Down (Wilts)	• Badger setts • Habitual animal tracks

▲Table 1. Principal lowland juniper habitats, with factors considered responsible for juniper's persistence.

Site assessment

Before management options can be considered, some key facts about the site and any surviving juniper must be known.

Site information needed:

- grazing levels
- pressure from rabbits and deer
- amount of bare ground (%)
- location of good juniper habitat (open, unshaded, thin poor soils, sloping, pockets of bare ground)
- presence/restoration potential of early successional flora and fauna
- proximity of ruderal infestations
- proximity of mixed scrub and young woodland
- proximity of field vole habitat (tall grassland)
- location of key conservation features
- location of key heritage features
- access routes for excavator
- management plan and long-term aims

Population information needed (also refer to Seedling surveys section):

- abundance: small colony <30 bushes; medium 30-100; large >100

For small and medium sized populations, try to record the location of every bush (use a GPS) along with the following attributes:

- sex
- age class (seedling, young, mature, over-mature, dying and dead)
- level of seed viability (Box 2)
- amount of disease/physical damage
- berry abundance (especially ripe berries)

For larger populations, take a representative sample from each stand/colony and record:

- a centroid grid reference
- sex ratio (% of: male and female)
- age structure (% of: seedling, young, mature, over-mature, dying and dead)

When plotted on a map, the spatial distribution of bushes/stands along with their attributes may reveal weaknesses in the population structure, allowing a more strategic conservation approach, e.g. by revealing isolated single-sex stands suitable for reinforcement.

Box 2. How to assess seed viability

The cut-test is a reliable, albeit destructive, way of determining seed viability. It can be done in the field but accurate dissection and examination is best done off site.

Equipment

Locking knife, cutting board (e.g. back of old clipboard), hand lens (x10), notebook and pen. Alternatively, if checking berries off site: sample bags or envelopes, a low-powered binocular microscope, scalpel and – if storage required – use of a domestic fridge.

Collecting

- Seed viability can vary a great deal between individuals and stands. Take small samples of berries from:
  - All females for small colonies (< 30 bushes)
  - At least 50% of females for medium colonies (30–100 bushes)
  - At least 20% of females for large colonies (>100 bushes)
- Pick no more than 20 ripe berries per bush (plump blue-black berries are ripe; leave those that are green or brown). If bushes have very few berries, collect one berry for each 10 available.
- Use a sharp knife on a flat hard surface to cut ripe berry cross-ways (equatorially), cutting through seeds.
- If you intend to collect seed for propagation afterwards, keep a record of each bush's seed viability, along with its location (GPS or sketch map) and the availability of ripe berries.
- If collecting berries for examination later, bag and label each sample.

Examination

In the field, cross-sections should be examined with a hand-lens. Off site, a low-powered binocular microscope is useful. If checking at a later date, store berries in breathable containers (e.g. paper bags) in a fridge.

Viable seed is always filled with a white/creamy interior (endosperm) – Fig. 7. If the seed is brown or hollow inside, it is almost certainly unviable. Note that not all filled seeds will germinate but the test gives a good estimation. If intermediate seed is found (e.g. incompletely filled, or endosperm slightly brown) consider these doubtfully viable.

Berries are occasionally galled by insects/mites and the seed eaten. Figure 26 shows some types of damage and the species responsible.

Results

Calculate the mean seed viability per bush and per colony and then refer to the table below. Note that some females may yield samples containing no viable seed.

<10%	poor
10-40%	moderate
40-60%	good
>60%	very good

▲ Figure 7. Typical cross-section of berries & seeds

Management options

On sites where juniper has steadily dwindled and consistently failed to regenerate, intervention is likely to be unavoidable to secure recovery. There is no silver bullet: juniper seed is slow to ripen and germinate, seedlings are slow growing and can take up to 9 years to reach sexual maturity. Ex situ techniques may decrease the recovery time but aftercare may be necessary for 5-10 years after planting. All restoration projects should run for at least 10 years.

Habitat restoration is the key to long-term recovery, without it additional measures such as reinforcement will prove unsustainable. Restoration is also likely to be of far greater ecological benefit (see Wildlife dependent on juniper). Where juniper colonies have poor seed viability, or imbalanced sex ratios, a combination of in situ and ex situ techniques can be highly effective.

There are three broad approaches to management:

1. Habitat restoration (facilitating natural regeneration)
2. Assisted regeneration (enhancing germination)
3. Reinforcement or reintroduction (transplanting)

Fig. 8 shows the pathways to regeneration for a range of lowland habitats. Under each management phase is a breakdown of the steps required. Although we have placed techniques to stimulate natural regeneration ahead of translocation, it is possible to skip or combine phases (so long as the chances of future natural regeneration are uncompromised). Where viable seed and bare ground co-occur, we advise waiting at least three years for juniper seed to germinate (see Seedling surveys) before progressing to the next phase of management.

Habitat restoration

The management sections on pages 16-25 give a broad range of options. Each option begins with a checklist of desirable attributes to help you determine its suitability.

The following are additional:

- At least one male and one female bush on site (otherwise reinforce)
- Average male:female ratio more balanced than 5m:1f (otherwise reinforce)
- Female bushes with abundant ripe berries
- Skeletal soils (poor and thin)
- Open sloping land (unshaded)
- Low risk of mixed scrub encroachment
- Low risk of ruderal infestations
- Presence or records of other important early successional species
- Other site features uncompromised (biological, archaeological, amenity, etc)

The more of these characteristics your site possesses, the greater the likelihood of achieving natural regeneration.

Juniper restoration management

Scrub / Woodland
Juniper in mixed scrub or under tree canopy

KEY THREATS
- heavy shading / succession
- impeded pollination
- impeded dispersal

PHASE I
- Scrub clearance
- Stump treatment
- Control of re-growth

MANAGEMENT PITFALLS
- accidental damage
- bushes more prone to collapse, windthrow or snow damage
- death by light shock (particularly etiolated bushes)
- increased exposure to livestock, rabbits or deer.

Long grassland
Juniper in ungrazed/uncut grassland

KEY THREATS
- insufficient bare ground (seedling habitat)
- seedlings overshaded
- deer (browsing & debarking)
- small mammals (berries, seed or seedlings eaten)

PHASE II
- Enclosure
- Stock grazing or cuttng (introduced or increased)

MANAGEMENT PITFALLS
- damage by machinery or stock (especially hardy breeds)
- hidden seedlings exposed to damage
- deer damage unchecked

Short grassland
Juniper in grassland grazed by stock and/or rabbits

KEY THREATS
- grazing animals (browsing, rubbing, trampling)
- insufficient bare ground (seedling habitat)
- soil enrichment

PHASE III
- Controlled grazing or pinch points or ground scrapes (unsown)
- Seed-shelters or seedling protection or grazing relaxed

MANAGEMENT PITFALLS
- soils too rich/deep (attracts ruderals or tree seedlings)
- insufficient seed reaches bare ground
- spiny brash piles not replenished
- seed-shelters not removed after re-vegetated
- exclosures not rabbit proof
- exclosures/shelters fail to last 5 years
- lack of monitoring (annual seedling surveys)
- problems managing site long-term for natural re-gen

SUCCESSFUL REGENERATION

Scree / Rocky ground
Juniper on/by unvegtated ground - e.g. quarries or scrapes

KEY THREATS
- low seed viability
- poor sex ratio / skewed distribution
- population small and fragmented
- single cohort of over-mature bushes
- conversion to arable or other land use

PHASE IV
- Seed sown or cultivated bushes planted
- Seedling/transplant protection (if needed)

MANAGEMENT PITFALLS
- planting/sowing area proves unsuitable
- insufficient numbers planted/sown
- unprocessed seed sown
- low survival rate due to poor planting
- planted outside of autumn
- transplants are clones of one stockplant
- bushes in cultivation too long
- sexes poorly mixed, or too few female bushes
- incorrect guard used for seedling/transplants
- lack of annual weeding
- exclosures/shelters fail to last 5 years
- lack of monitoring (annual seedling surveys)
- problems managing site long-term for natural re-gen

SUCCESSFUL REGENERATION

▲Figure 8. Management flowchart for non-regenerating stands. Select main habitat type and follow steps of management phase beneath. Prevailing threats for each habitat are listed alongside, as are potential drawbacks of each management phase.

Scrub clearance

Suitability:
- **Juniper surrounded by young woodland/mixed scrub**
- **Grassland restoration scheme ongoing**
- **Low numbers of rabbit and deer**
- **Livestock type/breed prefer broadleaf scrub to juniper**

Where the original habitat has succeeded into mixed scrub or young woodland, restoration is likely to take considerably more time and resources than on grassland. The overriding threat is lack of light, which causes a progressive weakening of shoots and stems (etiolation) and eventual death of bushes. The reproductive potential of etiolated bushes is likely to be extremely low. Furthermore, isolated females are unlikely to receive much pollen nor attract birds to disperse seed (Fig. 9). Ground conditions in mixed scrub are generally unsuitable for seedling establishment due to a thatch of organic matter and heavy shading.

Weighing up the existing ecological value of the scrub/woodland against that of liberating the juniper colony will determine the way forward. Where scrub is diverse and mature and juniper scattered and in low number, it may be of greater overall benefit to translocate the colony to nearby grassland, or another open habitat, that can be managed appropriately. The relic bushes should be used to donate cuttings and berries for ex situ propagation (see Reinforcement and reintroduction).

The removal of trees/shrubs surrounding juniper needs to be phased over two or more years, rather than clear-felled in one season. This should allay the risks of light shock and collapse. Even after gradual clearance some limbs may break under their own weight or through increased exposure to wind and snow (Fig. 10). Only prune back bushes if necessary, using sharp clean tools.

Removing the scrub barrier may expose bushes to livestock, deer and rabbits. If goats or hardy breeds are being used to control woody regrowth, monitor bushes regularly for browse damage. In cases of severe damage, some form of exclosure may be needed (see Protection).

After each round of clearance, a flush of vegetation re-growth is usual. Before controlling this, it's advisable to carry out a seedling survey (section below). In the absence of grazing, an annual 'cut and remove' regime may prove a good alternative but care should be taken to avoid damaging bushes and seedlings. If herbicide is to be used, choose equipment that eliminates the risk of drift.

◤Figure 9. Surrounded by young scrub, this healthy bush is doomed without intervention.

▲Figure 10. Sudden clearance of mixed scrub can lead to bush collapse.

Bare ground creation

Controlled grazing

Suitability:
- **Enclosed cattle-grazed grassland**
- **Cattle breeds that rarely browse**
- **Medium to large stands of male and female bushes**
- **Low numbers of rabbit and deer**
- **Seed viability moderate-very good (>10%)**

High impact cattle-grazing during the 'berry drop' period of Oct-Dec should create ideal conditions for natural regeneration through poaching (>10% bare ground cover) – Fig. 11. Afterwards the site should be allowed to recover and extensively grazed as appropriate. Seedling surveys should take place annually for the next few years (see section below). Provided the sward will sustain no permanent damage, the regime may be repeated if no seedlings appear.

Some damage to adult bushes (e.g. broken branches) may be unavoidable. If young bushes or seedlings are present and cannot be protected (see Grazing exclosures) use another technique to create bare ground.

Pinch-points

Suitability:
- **Cattle-grazed grassland**
- **Cattle breeds that rarely browse**
- **Small distinct stands of male and female bushes, or satellite females**
- **Low numbers of rabbit and deer**
- **Seed viability moderate-very good (>10%)**

Pinch-points are narrow gaps through which livestock routinely pass, creating patches of disturbed ground. They can result from natural obstructions (e.g. scrub) but are more commonly associated with gateways (Fig.12). At some sites, it may be possible to create pinch-points in the vicinity of berry-clad females using fencing, or through the strategic placement of water troughs (Fig.13). Although places where animals congregate or lay up tend to become nutrient enriched and have higher browsing pressure, the routes to these places may provide ideal habitat.

Poaching is more intense where tracks are sunken or bounded by banks, ditches or fences. Animals driven or ridden along such tracks have relatively little time to browse adjacent vegetation - including juniper. Although trampling may be too intense, and soil too compacted, for juniper seedlings to establish in the track centre,

▲Figure 11. Controlled grazing can produce copious germination microsites

▼Figure 12. Gateway pinch point

▼Figure 13. Poaching of ground around water trough

there will be a gradient of disturbance either side that may provide suitable microsites for germination and growth.

Consideration should be given to reinstating routes that have fallen into disuse such as old drove roads and sunken ways, especially where old bushes survive. Opening up routes for public recreation (e.g. as bridleways or mountain bike trails) may offer a good alternative.

Scrapes

Suitability:

- **Wide range of habitats (grassland, mixed scrub, ex-arable)**
- **Wide range of seed viability (depending on berry availability)**
- **Low numbers of rabbit and deer**
- **Compartment extensively grazed or ungrazed for a period**
- **Livestock type/breed that rarely browse**
- **Access for excavator**

Scrapes are areas that have been scarified by machine or manually (depending on size) so that no vegetation remains. They are a quick way of generating bare ground in the right place but do not persist. Careful siting of scrapes is critical to their success. Excavators are advantageous on deep soils and where arisings need to be moved, but on thinner soils ploughing or power harrowing may suffice.

Scrapes reduce the risk of berry foraging by voles and - to a lesser extent – wood mice. Protecting seedlings from small mammals may be unnecessary unless tall grassland develops harbouring field voles (Box 3).

Large scrapes are preferable to small ones as they slow down succession and discourage herbivores by offering neither food nor shelter (Fig.14). Shape is generally unimportant but long narrow scrapes are best avoided as they are less of a deterrent to herbivores and will more rapidly revegetate.

Scrapes should be as shallow as possible to expose the maximum amount of bare rock/stone (Fig. 15). A preliminary 'test dig' is highly advisable to check the soil depth, which can vary over remarkably short distances. On areas cleared of mixed scrub, stumps can be removed during scrape creation. Soil arisings should be taken away from the scrape site rather than bunded around the edge, or piled close by, because topsoil may contain ruderal seed that on flowering will seed back into the scrape.

◤Figure 14. Created for juniper, a 400m² chalk scrape on the South Wessex Downs

▲Figure 15. Newly dug, this Cotswolds limestone scrape has been sown with hundreds of seeds

Natural regeneration – On sites with acceptable seed viability (average >10%), a scrape immediately downslope of, or adjacent to, females with ripe berries should be effective. Juniper seedlings have been observed growing along fence lines and beneath trees due to bird perching, so creating bird perches over scrapes may help.

Assisted regeneration - Where it is unfeasible to create a scrape adjacent to females bushes, or seed viability is altogether poor (<10%), a good alternative is to sow the scrape by hand (Fig. 16). This has some distinct advantages over natural colonisation because scrapes can be:

- sited optimally
- located to create links between isolated colonies
- sown at other times of year (although autumn is thought best)
- sown with cleaned and screened seed (see Enhancing germination)

However, this method may be subject to translocation protocols and is more labour intensive, requiring seed harvesting, processing (see Enhancing germination) and sowing.

▲Figure 16. Sowing seed across a scrape in Wiltshire

Unlike areas subject to continual erosion, scrapes will gradually revegetate and can close over in as little as five years. Juniper's inherent slow germination and growth, means that seedling establishment is effectively a race against time. Monitor during this period to identify changing management needs (see Seedling surveys).

If a scrape has been created on heavily grazed land, or there is an acute threat from rabbits/deer, it may be necessary to install an exclosure fence. However, this should only be considered a temporary measure – see Grazing exclosures. Seed shelters may offer another alternative.

Box 3. Small mammals – friends or foes?

Field research conducted by Plantlife over 2009 and 2010 suggests that field vole, bank vole and wood mouse seldom impact negatively on juniper regeneration.

No evidence was found of these species attacking juniper seedlings nor young stems despite past reports of damage by voles (particularly field vole). However, voles did occasionally gnaw the bark of adult bushes. Damage to roots by field vole was negligible but the junipers studied rarely occurred in long grass – typical field vole habitat. Overall, rabbits and sheep were considered to have a much greater impact on seedling survival than small mammals.

Both bank voles and wood mice were found to eat juniper berries (Fig. 17) but generally only a small proportion of those available were taken (although this was expected to increase over the winter as alternative food sources diminished). Foraging by wood mice was more intense beneath bushes that provided a close sheltered environment. Nevertheless, seedlings were still noted in areas of relatively high berry foraging.

▲Figure 17. Berries de-seeded by wood mice

Berry foraging and caching may be beneficial to juniper. Seedlings were frequently found associated with bank vole tunnels and the caching of berries away from parent bushes may act as a means of seed dispersal.

Minimising browsing

Seed shelters

Suitability:
- **Stock-grazed grassland (especially sheep)**
- **Small to medium fragmented juniper colonies**
- **Large populations of rabbit, deer or small mammals**
- **Wide range of seed viability (depending on berry availability)**

Plantlife is trialling specially designed shelters to prevent berries and seedlings from being eaten (Fig. 18). The seed shelters are made of galvanised welded wire mesh (13mm - mesh size; 16g - gauge) stapled onto treated timber frames. The mesh size has been carefully chosen to keep out small mammals yet is large enough to allow juniper berries to fall through onto the ground. The shelters are hinged for flat-packing yet readily assembled on site with four bolts. The tops are removable to aid seedling monitoring. Shelter dimensions are: 120cm x 120cm x 30cm and a less conspicuous half-size version: 60cm x 60cm x 30cm. The shallow height allows shelters to be positioned close to female bushes whilst not inhibiting seedling growth. Refer to Box 4 for installation details.

▲Figure 18. Large seed shelter

Natural regeneration – This is only feasible where there is a female bush in the open with plentiful ripe berries and good seed viability (average >10%). Shelters should be installed in autumn before berry drop, September being the best time. Earlier installation is not recommended because this will reduce the window for germination and growth as the sward inside becomes a competitive threat. Assign one shelter per female bush, installing it in the berry 'drop zone' but far enough from the trunk base to avoid overshading. Sloping ground is advantageous as shelters can be sited further away downslope. On exposed sites make allowances for the prevailing wind direction.

Assisted regeneration – Where there is a lack of suitable installation sites beside female bushes, or seed viability is universally poor (<10%), shelters can be sown by hand. This has some distinct advantages over natural colonisation because shelters can be:
- sited optimally
- located to create links between isolated individuals/groups
- sown at other times of year (although autumn is thought to be optimal)
- sown with cleaned and screened seed (see Enhancing germination)

However, this method may be subject to translocation protocols and is more labour intensive, requiring seed harvesting, processing and sowing. The large Plantlife shelters were sown with 50 seeds and the small shelters with 15 but optimum sowing rates are not yet known.

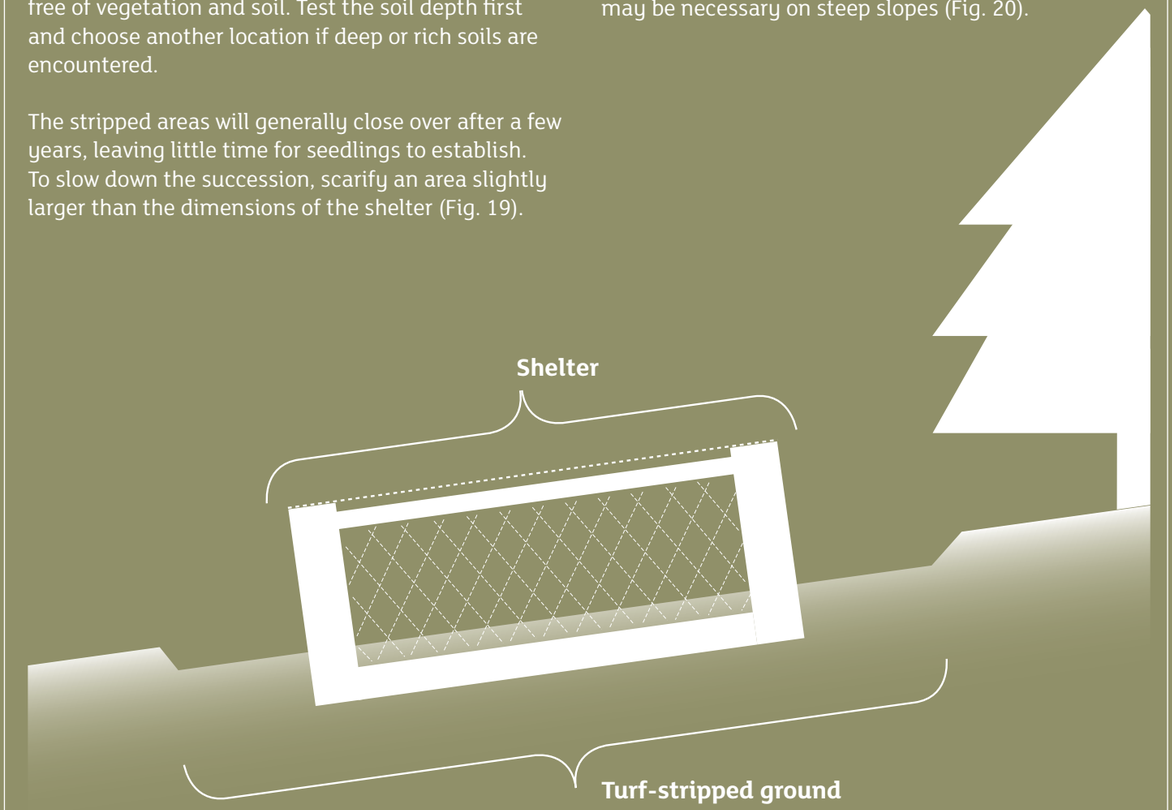
Shelters should be monitored at least annually (see Seedling surveys) and remain in situ until there is no appreciable bare ground left (usually after 3 to 4 years), after which they should be removed and if possible reused. Seedlings may need a further period of protection, depending on levels of browsing, trampling, etc until they are sufficiently robust (see Monitoring and aftercare). Field voles may pose an additional risk where seedlings occur in tall grass (Box 3).

Box 4. How to install seed shelters

Regardless of whether shelters are to be sown or not, installation sites will generally need scarifying or turf-stripping by hand (a mattock is ideal). The ground beneath shelters should be rocky and as far as possible free of vegetation and soil. Test the soil depth first and choose another location if deep or rich soils are encountered.

The stripped areas will generally close over after a few years, leaving little time for seedlings to establish. To slow down the succession, scarify an area slightly larger than the dimensions of the shelter (Fig. 19).

To prevent small mammals tunnelling under and raiding berries, it is advisable to sink shelters into the ground at least 4inches (10cm). Backfilling should help secure the shelter but anchoring posts or pins may be necessary on steep slopes (Fig. 20).



▲Figure 19. A good installation on de-turfed ground beneath adult female

▲Figure 20. Shelter with anchoring posts

Grazing exclosures

Suitability:

- **Stock-grazed grassland (especially cattle, ponies or horses)**
- **Small to large juniper colonies (clustered bushes)**
- **Large populations of rabbit or deer**
- **Wide range of seed viability (depending on berry availability)**
- **Frequent bare ground pockets, or pre-prepared scrape**
- **Absence of tall grassland in vicinity**

Fenced exclosures (Fig.21) can be expensive and are often reviled as a last resort but on heavily grazed sites they provide an effective way of facilitating natural or assisted regeneration. To be successful, they need careful siting, monitoring and maintenance.

As with shelters, areas with the thinnest poorest soils and abundant bare ground should be chosen. At least one productive female (with good seed viability) and ideally a mixed-sex group with several females should be included. If seed viability is universally less than 10%, enclosing a seeded scrape will likely yield greater success.

Several small exclosures are usually preferable to a single large one. The smaller size makes them easier to check and maintain, and if a fence is breached not all junipers will be at risk. Small exclosures can however be easily forgotten (Fig.22).

Well-sited juniper exclosures should remain beneficial for about 5 years, after which they gradually become counterproductive without some form of vegetation control. Once the exclosure vegetation has closed over, there are several options:

- remove the exclosure completely
- allow grazing animals occasional access (lightly graze)
- manually weed - carefully strip/cut back overgrowth (moss carpets can be scratched out with a spring-tine rake)

Seedling junipers will probably need guards installed before exposing them to grazing animals (see Protection). If tall grass dominates, there may be an additional risk from field voles. Maintaining a shortly mown strip around the outside of exclosures may help deter voles.

Fenced exclosures, shelters and guards may be considered eyesores or an unwanted expense. A cheap and more natural alternative is given in Box 5.

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◤Figure 21. A sown exclosure plot on the Hampshire Downs

▲Figure 22. Juniper is entombed in this long-forgotten exclosure

Box 5. A less obtrusive approach to management

Piles of spiny brushwood create a less conspicuous barrier to herbivores and can be used in two ways:

- Barriers around the bases of productive female or male bushes, mitigating browse and bark damage (Fig. 23). This approach has been successfully demonstrated at a site in Buckinghamshire, however seedlings may appear directly beneath parents.

- Loose mats or rings of spiny brash on open bare ground (scarify or deturf if necessary). Seed or berries can then be cast within, or bird perches created above. Note that juniper will not establish in deep shade, so avoid making mats too dense

Refer to the suitability criteria given for seed shelters. Brash piles should be checked and replenished from time to time to remain functional.

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▲Figure 23. Encircled by thorns, this young bush is afforded greater protection from rabbits

Seedling surveys

Seed usually starts to germinate in the second spring after reaching the ground due to the need for two winters to break seed dormancy. However, earlier germination is possible depending on when seed matured on the bush. Germination peaks after about 2.5 years but may continue for up to 5 years.

The best time to look for seedlings is in May or June although they can be inconspicuous in grassland so a thorough 'hands and knees' search is advisable (Figs. 24 & 25).

Keep a record of exact numbers and locations; if time allows note height and condition too. Shelters, guards and exclosures will help mark spots on the ground but a GPS unit is useful back-up and a means of digitising locations. Photographs are also a helpful reminder and provide a simple way of monitoring changes in the sward.

Monitor seedlings at least annually. Growth rates vary considerably but typical maximum seedling heights are: 5cm in the first year, 14cm in the second and 23cm in the third.

▼Figure 24. Prime seedling habitat

© Richard Gould

▼Figure 25. Vigorous seedling

Enhancing germination

Berry harvesting

Only ripe berries should be collected, which are smooth, plump and purple-black in appearance. Harvesting is best carried out between late-September and the end of October: too early and some berries will be unripe; too late and ripe berries will have been eaten by birds and other wildlife. Genetically, it is better to collect a few berries from a large number of bushes than many berries from a single individual. Look out for insect/mite damaged berries and avoid collecting these (Fig. 26). If there are few female bushes, or few berries on the bushes, harvest no more than 30% of the total available as they are a good food source for wildlife which consequently disperse the seed. Box 6 gives further harvesting tips.

Seed viability is easily checked in the field for each female or a representative sample of the population (Box 2). The results can be useful for estimating the number of berries required for assisted regeneration. As a guide, a one litre container holds approximately 4000 berries, with each berry containing one to three seeds (rarely four). However, the amount of viable seed may be a small fraction of this.

Seed processing

By removing the flesh of the berry and cleaning the seed, the rate of germination can be more than doubled. Germination is thought to be inhibited by chemicals in the fruit pulp, an adaptation to aid dispersal by birds and animals. Juniper tends to produce a high quantity of dead seed, although this can be readily removed through flotation. Appendix 1 gives a step by step guide to processing seed and Fig. 29 shows the finished product.

▲Figure 29. Fully processed seed

▼Figure 26. Insect and mite damage to juniper berries. Image kindly supplied by Lena Ward.

Eriophyid gall mite most serious in south

Juniper scale
Introduced in UK

Juniper seed chalcid

Juniper shield bug
also on other garden Conifers in the UK

Box 6. Top tips for collecting berries

Equipment / materials: collecting bags or containers, work gloves, eye protection (advisable), 'berry catcher' (e.g. upturned umbrella, bucket, tray or ground sheet), GPS, notebook & pen.

- Keep a record of each parent bush (GPS grid ref, age class, approximate number of berries taken, by whom); these details can be databased off site
- Label containers/bags to cross-reference with written record
- For large populations, it may be impractical to record every bush, in which case, keep separate collections for each stand or colony
- Collecting berries one at a time is impractical. A good alternative is to brush off berries with a gloved hand while holding a container beneath (Figs. 27 & 28, options listed above).
- Collect from as many different females as possible
- Ignore sickly looking bushes and those with abundant insect/mite damaged berries
- Avoid green or brown berries or those that are blue-black wrinkled
- Whilst on site, remove invertebrates and debris from the container - e.g. through winnowing.
- Process berries to remove seed as soon as possible (Appendix 1)

▼Figure 27

▼Figure 28

Storing seed and stratification

Juniper seed can be readily stored without degrading. Ensure the seed is dry (moisture can cause mould), before putting in a loosely-tied plastic bag and then in a domestic fridge (about +4°C). Stored in this way, the seed deteriorates very slowly (over a number of years).

Juniper seed is classed as 'deeply dormant' because it will only germinate after experiencing a series of seasonal temperature changes. It is possible to shorten the dormancy period by emulating the seasons. Preliminary results from Forest Research trials suggest that seed subjected to two weeks of warm temperatures followed by an indefinite cold period triggers the highest germination rate in just 40 weeks. In the absence of incubation facilities, similar conditions can be recreated using a cellar for the warm period and a fridge for the cold.

Sowing

Sowing should be undertaken in the autumn before the onset of winter. Although seed can be sown immediately after processing, without stratification germination will normally take at least 18 months.

The amount to sow will depend on the size of the scrape but also seed availability. As a rule of thumb we suggest sowing up to 30 viable seed per sq m. Only a small fraction of this is likely to germinate and survive the seedling stage. Appendix 1 includes a guide to measurement.

A record should be kept of the sowing date, the number sown, and exactly locality (use a GPS). Pass this information to your local biological records centre or the county botanical recorder (Botanical Society of the British Isles), or Plantlife.

Reinforcement and reintroduction

Attempts to trigger natural regeneration can fail for a variety of reasons such as imbalanced sex ratios or colony fragmentation impeding pollination. If restoration is impossible, or attempts have consistently failed, it may be appropriate to reinforce or reintroduce colonies. Such action should only be taken as a last resort and guided by policy - see JNCC (2003) under Useful References. Ultimately the colony created should be of sufficient size to be self-sustaining under the right management.

Translocations can generally be prioritised as follows:

1. Reinforcement of a small colony (less than 30 bushes) to address an imbalanced sex ratio, rejuvenate age structure, or link isolated stands (inter-planting)
2. Creation of a neighbouring colony when conflicting conservation interests mean that suitable habitat cannot be restored for an existing stand – e.g. over-mature bushes trapped in woodland of high conservation value
3. Reintroduction to a recently extinct site where suitable habitat exists
4. Reintroduction to a historical site where suitable habitat exists
5. Creation of a new colony within juniper's known historical range

Translocations need careful planning to be successful and to avoid damaging features of the donor site (the source of cuttings, berries or transplants) and the receptor site (the intended planting area). Although a licence from Natural England is not required to collect seed or cuttings from juniper in the wild, SSSI consents may be needed for both donor and receptor sites. Permission should also be obtained from landowners.

Site reintroduction should only be considered once the causes of loss have been identified and resolved. In cases where the original habitat has been altogether lost, severely damaged or is beyond restoration, an alternative nearby site should be sought.

Early consideration should be given to the suitability of habitat at the intended planting site. Areas recently cleared of mixed scrub/ woodland are unsuitable unless woody re-growth has been successfully controlled, or a scrape has been created. Potentially suitable planting habitat includes: stock-grazed grassland, ex-arable fields (impoverished soils only) and disused quarries (with compatible after-use). The receptor site should be agreed by all stakeholders well in advance of planting out

Propagation takes time: cuttings will need at least two years growth before they are ready for planting; seeds can take five or more years due to their inherent dormancy. Populations with low seed viability (Box 2) are better suited to propagation from cuttings. Cuttings are quicker growing but can have high failure rates and result in clones of parent bushes. Seedlings tend to have greater genetic diversity but seed is slow to germinate and seedlings slow to develop. As neither method is straightforward, higher success rates may be attained through a specialist tree nursery.

For larger projects a combination of plants from cuttings and seed is probably the best strategy, giving tangible results early on, whilst improving the future genetic diversity of the population. Aim to create a colony of at least 30 mixed-sex individuals, including any existing bushes, as this is thought to constitute a genetically robust population. Recovery may be expedited by introducing a higher proportion of females – e.g. a sex ratio of 3 females to 2 males (note that female junipers tend to die earlier than males).

To help you determine whether reintroduction or reinforcement is suitable for the recipient site, the sections below begin with a checklist of desirable attributes. The following are additional to these:

- Reasons for past decline identified and resolved
- Open habitat with at least 10% bare-ground cover
- Extensively cattle grazed most of the time; occasional mob-grazing feasible
- Low/controlled browsing pressure from rabbits and deer
- 10 year aftercare plan feasible
- Skeletal soils (poor and thin)
- Open sloping land (unshaded)
- Low risk of mixed scrub encroachment
- Lack of tall grassland in the vicinity (field vole habitat)
- Presence or records of other important early successional species
- Other site features uncompromised (biodiversity, archaeological, amenity, etc)

Box 7. Local provenance

Juniper is genetically very diverse. It appears the isolation of some populations has, over time, led to inherited traits developing. Even populations a short distance apart can be genetically and morphologically distinct. However, across subspecies communis these differences are too small to be recognised taxonomically.

There are currently two schools of thought on the importance of local provenance with respect to juniper.

1. To preserve local distinctiveness and maximise survival, planted juniper ought to originate from material collected from the same population, or in the case of re-introduction, the nearest sizeable population.

2. Under rapid climate change species will evolve. To maximise juniper's resilience and adaptability, small isolated populations ought to be linked and reinforced, 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 planted. Reintroductions should likewise originate from material collected from multiple donor sites.

Revised IUCN guidelines on translocation are due to be published in 2011. It is hoped that the guidelines will reconcile these opposing views and indicate best practice for both reinforcement and reintroduction.

Reinforcement

Suitability:

- **Functionally extinct populations (negligible chance of natural regeneration)**
- **Population 'repairable' (natural regeneration possible in future)**
- **Additional donor population/s available if needed (Box 7)**
- **Permissions obtained to supplement colony to a total size of at least 30 mixed-sex bushes**

As well as boosting numbers, reinforcement is an efficient means of diversifying age structure, balancing sex ratios, linking up isolated individuals/groups and generally enriching the gene pool. Nevertheless it should be undertaken sparingly, just enough to 'repair' the population and kick-start natural regeneration.

Use the information gathered in the Site Assessment to produce a planting plan. If you are planting to improve pollination rates, take into account the prevailing wind direction.

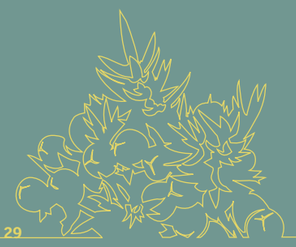
If existing bushes cannot provide sufficient material for propagation (e.g. if only one sex is present), donor material from additional site/s should be sought - see Box 7.

Reintroduction

Suitability:

- **Juniper known to occur at site in the past, or site within known historical range**
- **Donor population/s identified (Box 7)**
- **Permissions obtained to create a colony of at least 30 mixed-sex bushes**

The decision to reintroduce a BAP species should not be taken lightly; consultation will be needed with site stakeholders and a management plan in place to facilitate long-term recovery.



Propagation from cuttings

The processes of ageing in plants grown from cuttings are not known. Such plants are in reality as old as those from which the cuttings were taken and they may suffer from reduced fertility associated with older plants. For the same reason, cuttings have a distinct time advantage over seedlings in that they are already sexually mature.

Cuttings usually take two growing years before they are ready to be planted out. Keeping bushes in cultivation for an extended period (e.g. 5 years) so that they are larger and more resilient is likely to reduce survivorship in the wild because of increased transplant shock and a prolonged need for aftercare. Conversely planting them young results in more rapid establishment; two years ex situ is probably the optimum.

If time isn't a constraint, stock plants can be raised from the most vigorous cuttings that in later years will supply numerous cuttings. However, entire colonies created this way may be less adaptable to climate change because they are clones of a few individuals. The effect may be less significant when reinforcing populations, depending on the number of clones introduced.

Guidance on taking cuttings is given in Box 8. Under ideal conditions good quality cuttings will start to root in as little as 6 weeks. Good rooting has been obtained with heel cuttings in sharp sand (Fig.30). Nonetheless some batches of cuttings inexplicably fail and for this reason we recommend using a specialist nursery.

Alternatively follow the propagation protocol given in Appendix 2. This was produced by the Eden Project for subsp. *hemisphaerica* and its suitability for subsp. *communis* remains untested. Due to the ongoing destruction of peatlands, Plantlife strongly advocates the use of peat-free compost - e.g. Peat Free T2 – produced by Petersfield Growing Mediums www.peatfreecompost.co.uk

The use of 'air root pruning' pots for propagation may accelerate growth and increase survivorship after planting out. The technique produces a dense fibrous root system that prevents roots coiling and plants becoming pot bound. There is no need to tease out roots during planting, lowering the risk of damage to root hairs. A well developed root system will also aid establishment in impoverished soils. Air-Pots (Figs. 31 & 32) are made from recycled plastic and are available from The Caledonian Tree Company: www.airpotgarden.com/

▲Figure 30. Preparation of heel cutting – lower leaves are removed in readiness for striking

▲Figure 31. Air-Pot grown bush

▼Figure 32. The Air-Pot range

Propagation from seed

Reliably raising juniper plants from seed is difficult. If results are needed within a predetermined timescale, it is advisable to use a specialist. Pretreatment is necessary to break dormancy but even then germination times tend to be sporadic. It can take five years or more before bushes a large enough to be planted out. Information on berry harvesting, seed processing, storage and sowing is given in the Enhancing germination section. Detailed guidance on propagation from seed is available from Forest Research – see Broome (2003) in Useful References.

Box 8. Top tips for taking cuttings

Equipment / materials: work gloves, secateurs, cleaning solution, plastic bags, marker pen, water-filled mist sprayer, cool box/bag, GPS, notebook & pen.

Collect over the winter (ideally before year-end but no later than mid-February). To capture the genetic diversity, ideally take about 4 cuttings per bush (depending on size of cutting) from at least 30 bushes, representing both sexes and the full range of growth forms. Collect extra cuttings to compensate for likely losses during propagation. If there are fewer than 30 bushes, avoid over-pruning by collecting from a neighbouring colony as well (note translocation protocols may apply).

Additional considerations:

- Use only clean sharp secateurs (sterilise blades by wiping with methylated spirits)
- Wear thorn-proof gloves
- Select branches with strong leading shoots and few berries (avoid sickly shoots)
- Collect long shoots in the field that can be expertly dissected at the nursery
- Prevent cuttings from drying out (even on cool days) – keep them out of direct sunlight, in plastic bags and use a mist sprayer
- Keep a record of each parent bush (number of cuttings taken, GPS grid ref, sex, age, etc); this may be impractical with large populations, instead keep tallies of male and female cuttings collected; these details can be databased at the nursery
- Label bags with site name, date and a cross-reference to written record

It's vital that cuttings are potted up straightaway. If delayed, wrap the cut end of each shoot in damp tissue, with an elastic band to hold in place. Then store cuttings in plastic bags in a cool dry place – e.g. a cellar. In so doing they should remain viable for several days.

Planting

Whether you are planning on re-establishing a colony, or expanding an existing one, careful selection of the planting area will pay dividends later. Protected areas and nature reserves may provide ideal receptor sites, although undesignated sites that appear unsuitable may still be worth considering if suitable habitat can be restored. Programmes of vegetation clearance and nutrient stripping can in time produce good planting areas.

To maximise the beneficial effects of planting, prepare a detailed planting plan. This will later serve as a useful record of the introduction. Adopt a naturalistic planting pattern, mixing sexes and ages. Reinforcement should be more targeted, addressing imbalances and discontinuities in the population.

In the wild, juniper tends to form thickets that are generally lacking other shrub or tree species (Fig. 33). For this reason and its susceptibility to competition, the planting of mixed-species stands is inadvisable. However, broadleaf shrubs are frequently browsed in preference to juniper so the presence of other shrub species in the same compartment may prove not entirely negative.

Ideally plant in locations that provide good regeneration habitat – e.g. the top of steep slopes (Fig. 34), beside pinch points, or along the edges of a well used paths or tracks (unmetalled). Also consider at this stage preventing damage from herbivores – see sections on Protection and Grazing exclosures.

Cultivated bushes are ready for planting when they reach at least 20cm in height (depending on their shape) – see Box 9.

▲Figure 33. Natural juniper scrub at Calstone Down, Wilts

▼Figure 34. Bush cascade, the result of berries tumbling down from an upslope female

Box 9. Top tips for planting

Equipment / materials: work gloves, mattock or spade, trowel, bucket (to collect leaf litter), shrub shelters/guards, stakes, ties (to fix guard to stake), mulch mats & anchoring pegs (optional).

Great care should be taken when planting out. Bushes will grow less quickly than during propagation and their roots need to able to spread into the surrounding soil. Planting methods will vary according to whether bushes have been container or cell grown (e.g. in rootrainers) and a host of other factors. The following advice is general; ask your nursery for detailed instruction.

To establish readily, transplants need to be young with a high proportion of roots to shoots. Well before planting out, 'harden off' the young bushes to acclimatize them to growing outdoors. Over several weeks, move them from the greenhouse to a sheltered location outside for increasingly longer periods.

Aim to plant out in October-November to allow some root development before winter and in readiness for the surge of root growth in early spring. Planting in February-March leaves less time for roots to establish, imparting a higher risk of desiccation and failure over the summer. The problem is more acute on poor chalky soils and south-facing slopes.

Adopt a varied spacing pattern that mimics wild populations. Competition between bushes will be reduced by planting at least two metres apart which may be critical when young bushes are of varied height/vigour (e.g. when grown from seed). Where interstitial grassland exists – e.g. glades – allow sufficient access for grazing stock.

A step-by-step guide to planting a container-grown bush:

1. Choose a calm cloudy day
2. Ensure bush is well watered before planting
3. Dig a square-sided hole slightly wider and deeper than the pot
4. Mix organic matter such as leaf litter, or chopped turves, with the soil
5. Keeping the bush in its container, adjust the planting depth so that the top of root ball will be just covered with soil once planted (exposed compost will increase water loss)
6. Only expose the root ball at the moment of planting, disturbing the roots as little as possible
7. Badly pot-bound plants have stiff spiralled roots; return them to the nursery for replacement
8. In less severe cases, gently tease out coiled roots so that they point away from root ball when planting
9. Keep the bush vertical whilst backfilling the mixture
10. Firm backfill around root ball, gently heel in and water thoroughly
11. Fit a mulch mat, or place upturned sods around the base of plant but ensuring the stem itself is kept entirely clear
12. Take care not to skewer the root ball when staking the guard

Protection

Choose guards that will be effective against the biggest and smallest herbivores on site. Preformed shrub-shelters with a diameter of 20-30cm and height of 60cm should suit most circumstances, providing adequate protection against rabbits, rodents and deer. Tree guards tend to be too narrow resulting in die-back and unnatural bush shapes that may reduce survivorship once the guards are removed (Fig. 35).

The ideal shrub-shelter material is a fine mesh that allows light and air to penetrate but prevents shoots growing through. If herbicide is to be used to control weed growth, take precautions against spray drift. Avoid solid guards and fake meshes coated in plastic as they create warm humid conditions that may be suboptimal for juniper.

Climatic Plus shelters (Figs. 36 & 37) have a proven track record for juniper and are available from Trees Please (Northumberland): http://www.treesplease.co.uk/
These guards are UV-biodegradable but are stated to last more than 10 years.

Fitting a mulch mat /sheet will reduce root desiccation (the main reason for transplant failure) and reduce competition from weeds (Fig. 37). Without mats, it may be necessary to manually weed shelters although this can be a difficult and time consuming task.

Shelters should be double-staked and fitted tight to the ground to exclude voles. After 5 years, shelters and mulch-mats should generally be removed and if necessary replaced with another means of protection.

As well as presenting a barrier to herbivores, guards stifle the wind. Buffeting of transplants can prevent root establishment. This is a particular problem on exposed sites with thin rocky soils where bushes may be poorly anchored after planting. To prevent guards being blown over, ensure stakes are aligned with the prevailing wind.

A good bespoke alternative is a post and rail triangle or square with toughened plastic/wire netting that can be dug into the ground. Chicken wire should be avoided because shoots grow through and become trapped (Fig. 38). Although post and rail constructions are more sturdy and stock-proof, considerable time and resources are needed, making them less practical for large planting schemes. On sites where guards are likely to attract complaints or vandalism, mounds of encircling spiny twigs offer a less conspicuous alternative (Box 5).

On stock-grazed land, a sturdy fenced exclosure or electric fence is best to eliminate the possibility of trampling and rubbing. When multiple threats exist, combinations of rabbit netting and vole guards have been shown to be highly effective (see Grazing exclosures).

▲Figure 35. Tree guards encourage top-only growth, leading to a less resilient bush later on.

▲Figure 36. Climatic Plus shrub shelter installed with two stakes and a mulch mat.

▲Figure 37. View of mulch mat inside shelter

▼Figure 38. Chicken wire provides some protection but is difficult to remove in later years as shoots become entangled.

Monitoring and aftercare

Bushes should be checked regularly during the first year after planting, and annually thereafter for at least five years.

Aftercare has three key components:
1. Removal of competitive vegetation
2. Maintenance of grazing protection
3. Prevention of desiccation

The control of weeds surrounding planted bushes has been shown to be a major factor determining growth rates and survival. Mulch mats will give transplants a head start but may be considered unsightly. Weed in the spring, clearing a 50cm swathe around the stem of each bush. Most sites will require annual weeding but on fertile soils more frequent weeding is advisable. Where guards are fitted, manually remove detritus and rank vegetation from inside.

The careful application of an appropriate herbicide may offer an efficient alternative particularly for larger planting schemes but should only be used where there is negligible chance of damaging juniper.

Check bushes are still firm in the ground (tread them in as necessary), re-stake loose shrub-shelters and replace torn mulch mats. Check the integrity of exclosure fences; grazed or browsed vegetation inside would indicate a breach.

Although juniper is well adapted to dry conditions, emergency watering during droughts, especially in the first year after planting, is likely to greatly increase survival rates. Spring-planted bushes are particularly vulnerable to desiccation.

Depending on their size at planting, subsequent root development and situation, bushes can take many growing seasons to become strong enough to survive in the wild unaided. Before removing guards or dismantling exclosures, test the browsing impact by exposing one or two bushes.

Documenting

Recording the numbers, sex and exact locations of planted bushes is important. When evaluating the national status of juniper in the wild, or the conservation value of a particular site, we need to know to what degree populations are natural as opposed to introduced or enhanced. Please ensure records are passed to your Local Record Centre, Vice County Recorder or Plantlife.

Appendix 1

Step-by-step guide to seed processing

Equipment / materials: food processor, several bowls, spoon or egg-whisk, kitchen sieve, tea strainer, paper towels. You will also need access to cold running water and, if storing seed afterwards, use of a domestic fridge.

1. Sort through berries one container at a time, discarding any green, brown or wrinkled ones.

2. Mash blue-black berries to release the seed. Small numbers of berries can be processed by rubbing off the pulp by hand using a fine-gauze sieve but this can be messy and time consuming. Instead, use a food processor or electric mincer with a medium mincing screen (5mm holes) – anything finer will destroy the seed.

3 Put the result into a large bowl and fill with cold water. Stir the mixture with a whisk or spoon to release trapped air, then allow to settle. This can be done in stages if large numbers of berries are being processed.

4. Seed that floats is empty and should be skimmed off and discarded (a tea strainer is ideal for this purpose). Conversely seed that has sunk to the bottom is mainly viable, and can be sieved off afterwards.

5. Flush the good seed under cold running water until clean.

6. Allow to drain before tipping onto absorbent kitchen towelling.

7. Leave at room temperature until dry (do not oven-dry).

8. Estimate the number of seed by volume. One level teaspoon (5ml) = about 200 seeds. Alternatively, 100 seeds weighs approximately 1gram.

9. Keep seed in a household fridge.

Appendix 2

Propagation protocol for *Juniperus communis* subsp. *hemisphaerica*

Juniperus communis subsp. *hemisphaerica* is a dwarf evergreen dioecious shrub. For finished 5L pot plant.

Propagules

Stage 1 (unrooted cuttings)
Cutting material taken from Gew Graze in early February and/or October from one year old semi-ripewood tip cuttings or semi ripewood cuttings with ripe heel, 6-9cm in length resulted in over 80% rooting success. Cuttings taken at the end of February had a higher rooting success. The bottom leaves of cuttings should be carefully removed with a sharp propagation knife before the base of cutting is dipped for five seconds in Synergol 10000ppm IBA. Diluted 1:5.6 giving a 1500ppm IBA and placed into modules compost mixture 25% to 75% grit (higher percentage of grit is a necessity for high percentage rooting as Juniper dislikes being waterlogged.) Cuttings were watered in and placed on a gravel based mist bed in a Venlo glasshouse with bottom heat of 20°C, on electronic leaf activated keeping the leaves just moist. It is crucial at all times not to let the cuttings dry out as this will significantly reduce percentage rooting success. Do not propagate in direct sunlight as can cause scorching. Growing temperatures: Nights: 8-10 ° C Days: Max 16°C. Cuttings taken in Feb take up to three months to root. Cuttings taken in October take up to six months to root.

Stage 2
Once rooted, wean off cuttings for two weeks by reducing mist bursts followed by removal from mist bed and pot on into 9 cm square pots (during potting on ensure that root disturbance is kept to a minimum.) Place on mypexed floor in glasshouse with growing temperatures of minimum 8-10 °C and maximum 20°C.

Stage 3
Pot on 9 cm to 2L pot (during potting on ensure that root disturbance is kept to a minimum.). Remain in glasshouse on floor in Venlo glasshouse with growing temperatures of minimum 8-10 °C and maximum 20°C. When outside temperatures reach above 5°C place outside on hard standing. Ensure the plants remain outside and fleece if temperatures go below -2°C.

Stage 4
Pot on 2L into 5L pots (during potting on ensure that root disturbance is kept to a minimum.). Place outside on hard standing with shade. Keep the plants outside above -2°C and fleece if temperatures go below this.

Preparation for Transplantation
Slightly reduce irrigation of plants over a five month period to prepare for planting out. Ensure that the plants are checked with regards to pests, diseases and viruses and that these are treated before the transplantation process occurs.

Potting Media
80% Vapogrow seed and modular compost, 10% Perlite standard and 10% sterilised Loam.

Fertilization
No fertilisation required in stage 1. In stages 1-4 use 1 gram per litre of Osmocote, 12-14 months 15-9-11 +2Mgo + TE in growing media. Supplement with a liquid feed with half strength Peters Excel, 15:5:15 Mgo + TE 0.3g/l on a fortnightly basis.

Temperature
Juniper will survive temperatures of -5°C. At temperatures below -2°C ensure that plants are protected by fleece.

Light
Ensure cuttings and plants are shaded and away from direct sunlight. Junipers grow well under glass and when large enough can be moved outside with up to 20 percent shading in the UK.

Irrigation
It is crucial at all times not to let the plants dry out as this will significantly reduce percentage survival success. The media requires to be free draining as the roots do not like to be waterlogged.

Spacing
Throughout all stages space so that the plants do not overlap.

Crop Schedule (Last week in February)

Rooting stage: Up to 90 days (3 months)
Weaning: Up to 14 days (2 weeks)
Stage 2- Stage 3: Up to 364 days (12 months)
Stage 3 – Stage 4: Up to 364 days (12 months)
Stage 4 – Transplantation: Up to 90 days (5 months)

Total Time: Up to 980 days (33 months)

Crop Schedule (October)

Rooting stage: Up to 180 days (6 months)
Weaning: Up to 14 days (2 weeks)
Stage 2- Stage 3: Up to 240 days (8 months)
Stage 3 – Stage 4: Up to 364 days (12 months)
Stage 4 – Transplantation: Up to 90 days (5 months)

Total Time: Up to 980 days (33 months)

Pests and diseases
Keep vigilant at all times with regards to monitoring for Pests, Diseases and Viruses. Plants have been attacked by Totrix moth.

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