Forestry Commission

Establishing and managing gene conservation units

Practice Note

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Conserving the genetic diversity within our tree species and the processes that determine it are important for sustainable forest management and increasing the resilience of Britain's forests and woodlands. The genetic diversity within a tree species at any one time is the result of many dynamic processes, and it provides the source for future adapted trees and woodlands. Its importance is recognised in *The UK Forestry Standard* and forestry practitioners are encouraged to consider genetic diversity when managing forests and woodlands. One method of genetic conservation is to manage specific areas with the intention of allowing the full cycle of natural processes to occur. These areas are called gene conservation units. This Practice Note sets out what you need to do to establish a gene conservation unit and describes the recommended management approaches. Many woodlands may already be managed in a way that would make them suitable, but a more formal recognition of a network of gene conservation units allows for a more robust and quantifiable approach. The approach described here allows for a consistent method of selecting and describing units across the full range of a species and is compatible with the approach promoted across Europe.

Introduction

Forest managers face unprecedented levels of uncertainty in the form of future climate change and the impact of new pests and diseases. Because of this uncertainty it is important to ensure that Britain's forests and woodlands are not only adapted to current conditions, but have the capacity to adapt to future conditions – as maladapted trees are less resilient to changing climatic conditions and pest and disease outbreaks. One way of achieving this is by retaining the genetic diversity and evolutionary potential of our tree populations so that natural selection and gene flow can act to allow them to adapt to new conditions.

Given the long-term nature of forestry, the adaptive genetic diversity within tree populations is important because it makes it likely that any one stand of trees will contain some individuals that will be able to respond to the changing conditions over the lifetime of the tree. Those individuals will be more successful in providing the seed source that will make up the next generation, which is crucial for the ongoing adaptation of forests and woodlands to climate change and for sustaining associated flora and fauna and wider forest ecosystems.

The need to conserve genetic diversity

There is increasing interest in developing approaches that aim to conserve the genetic diversity of trees. Most native British tree species have extensive ranges across the European continent (e.g. Figure 1) and grow in a wide range of environments (Figure 2). Therefore, our tree populations may contain a particular component of the adaptive genetic diversity that exists within the whole species. Britain's geographic position within Europe means that for many species our populations are at the edge of the natural range and, for this reason, they may be particularly important because they contain individuals that can tolerate more extreme conditions, compared with those in the centre of their natural range.

Figure 1 The distribution of wild cherry trees in Europe.

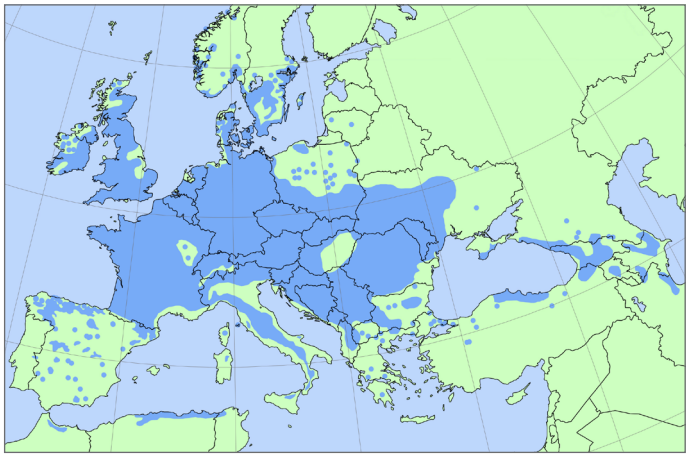
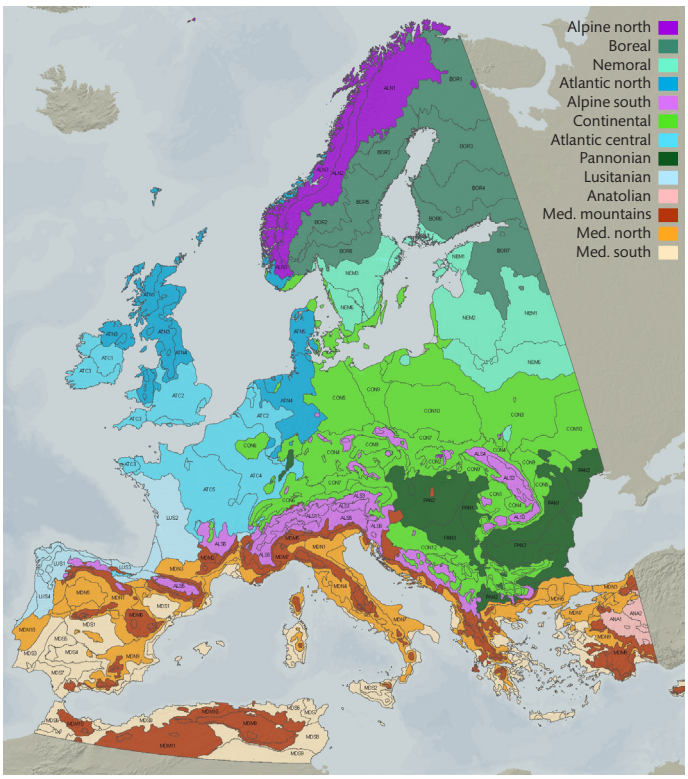


Figure 2 A climatic stratification of the environment of Europe.



Adapted from Global Ecology and Biogeography 14 (549–563) – courtesy of Dr Marc J Metzger.

In many cases forest managers are already managing sites in a way that is compatible with genetic conservation, without this necessarily being a stated objective. For example, both Sites of Special Scientific Interest and Special Areas of Conservation often have objectives consistent with gene conservation. However, a more coordinated approach within a consistent framework will be more powerful in terms of conserving genetic diversity in our trees. The concept of a network of 'gene conservation units', based on a European-wide approach, offers a practical system for conserving genetic diversity across the full range of a species without being a burden on forest managers.

The goal of dynamic genetic conservation of forest trees should be the maintenance of a diverse group of mating individuals and populations across different environmental gradients to ensure continued evolutionary processes.

The reasons for establishing gene conservation units can usefully be classified into the following two categories:

- Maintenance of genetic diversity in large tree populations.
- Conservation of adaptive or other traits in marginal or scattered populations, which often consist of only a few trees.

For example, seed stands have a role in gene conservation and they can be included in the first or second category, depending on tree species.

Box 1 Genetic conservation of trees at a European level

There has been a number of pan-European-level agreements that support the development of genetic conservation policies and the practical implementation of gene conservation for forestry purposes. The European Forest Genetic Resources Programme (EUFORGEN) was established to promote collaboration and information exchange. This programme successfully initiated the EU-funded EUFGIS project to create a pan-European network and database of gene conservation units. This approach ensures that common criteria are applied for the selection of the units and specifies that the same descriptors are used to characterise the selected populations.

The UK is committed to maintaining and encouraging genetic diversity within our tree populations and this is reflected in *The UK Forestry Standard*. Adopting the gene conservation unit approach would allow the UK to demonstrate this commitment in a more quantifiable, consistent and robust way than at present.

Scope

This Practice Note provides forest and woodland owners and managers with guidance on establishing gene conservation units and the management approaches that are acceptable within a unit. The use of the gene conservation unit strategy for genetic conservation is widely accepted within Europe and appropriate units designated within Britain could be included as part of a Europe-wide approach to genetic conservation.

Within *The UK Forestry Standard*, maintenance of genetic diversity is encouraged as an approach to adapting to the impacts of climate change and preserving the patterns of genetic diversity of our tree species.

What is a gene conservation unit?

A gene conservation unit is a clearly mapped area of forest or woodland where dynamic gene conservation is one of the main management priorities for one or more tree species. The dynamic gene conservation approach emphasises the maintenance of evolutionary processes within tree populations to safeguard their potential for continuous adaptation. This means either managing tree populations at their natural sites within the environment to which they are adapted (*in situ*), or in artificial, but dynamically evolving populations located elsewhere, for example Sitka spruce or Douglas fir in Britain (*ex situ*). The establishment of a network of gene conservation units across the natural range of a given tree species aims to ensure that the full extent of genetic diversity within that species is conserved.

Establishing gene conservation units

The management of forest trees for genetic conservation requires long-term commitment, planning and action. Although forest management plans might only operate over a 5–10 year timescale, establishing a gene conservation unit would involve a strategic management commitment for as long as possible – ideally 20 years or more. The minimum requirements for a successful gene conservation unit are summarised below:

- At least one tree species should be recognised in the management plan as the target species for genetic conservation for each unit. A unit can, however, have more than one target species within it.
- Each target species must meet the appropriate minimum population size.
- A basic management plan is needed that states that genetic conservation of forest trees is a key management goal.
- A unit should have a recognised status as a genetic conservation area and should be recorded on a central database.

Target tree species and populations

In each gene conservation unit, one or more tree species should be recognised as 'target tree species'. This means that the management efforts for the purpose of gene conservation are being carried out to favour the target species. If a gene conservation unit has several target species, each target species must meet the appropriate minimum population size, as indicated below. Units for native species should ideally be located in tree populations that have had a long history on the site, for example within ancient semi-natural woodlands.

Non-native species can also be considered within *ex situ* units if they represent well-adapted forests. *Ex situ* gene conservation units are artificially established and transplanted tree populations that are managed for gene conservation and/or seed production purposes within or outside the natural distribution range of a given species. Units of introduced tree species (i.e. species introduced to new areas from within Europe or from other regions outside Europe) will also meet the minimum requirements if they are established to conserve well-identified and differentiated characteristics, compared with their original source populations, and managed following the concept of dynamic gene conservation. An example of this could be a naturally regenerated stand of Sitka spruce or Douglas fir. The gene conservation units can consist of pure or mixed-species stands.

No genetic material of the target species of unknown origin or which is not adapted to the local conditions should be present within a unit, but natural inter-specific hybrids are allowed.

Size of the gene conservation unit

Each gene conservation unit should be defined as a fixed area within a forest or woodland (i.e. one or more compartments within a forest management plan). The unit should be large enough to contain a sufficient number of effectively mating and reproducing trees to prevent reduction of genetic diversity through demographic bottlenecks and inbreeding. Because it is often difficult to determine the number of reproducing trees in the field, more trees than the reproducing population minimum have been used to guide gene conservation unit size. A unit must meet one of the following minimum requirements in terms of population size:

(1) If the purpose of the unit is to maintain the genetic diversity of a widely occurring and stand-forming conifer or broadleaf species, the unit must consist of at least 500 reproducing trees. For example, a pure stand of oak (either *Quercus robur* or *Quercus petraea*) would need to be roughly 3–6 hectares in size to contain 500 mature trees. For Scots pine (*Pinus sylvestris*) or birch (*Betula pendula* or *Betula pubescens*) approximately half that area would be sufficient.

(2) If the objective of the unit is to conserve adaptive traits in marginal or scattered tree populations (either scattered conifers or broadleaf species), the unit must harbour a minimum of 50 trees of reproductive age of the target species or, in the case of dioecious* tree species (e.g. yew – *Taxus baccata*), 50 seed-bearing trees and 50 pollen-producing trees. The area this will require will depend on the degree to which the target species is scattered and will therefore have to be considered on a case by case basis.

Some tree species are capable of vegetative reproduction through root sprouts or partially buried shoots, for example cherry or aspen (*Prunus avium*, *Populus tremula*). Efforts should be made, when feasible, to check if there are identical genotypes (clones) of such tree species present within a unit and this should be taken into consideration when estimating the number of reproducing trees. The minimum number of reproducing trees of the target species within a unit can be temporarily lower than indicated above if natural regeneration is established and it is necessary to thin the original target tree population within the unit (or stands within the unit) or to create gaps to promote further natural regeneration. The prerequisite is that enough reproducing trees have contributed to mating (and seeding depending on the species) before the regeneration process has been initiated with silvicultural measures. Furthermore, there should be evidence that the number of reproducing trees will recover to the minimum level or above in the near future.

*Dioecious trees have male and female reproductive organs in separate individuals.

Gene conservation unit management plan

The management plan for a gene conservation unit must clearly state that dynamic genetic conservation is one of the primary objectives for the unit (i.e. it must not be compromised by other management objectives). The area of the unit should be clearly defined and one or more target species identified.

All management efforts carried out within a unit should be documented in detail and the records should be maintained either by the landowner, or the organisation responsible for the management of the unit. The management plan should be updated based on systematic field inventories conducted every 5 or 10 years, depending on the planning cycle.

Designation, data collection and storage

Any gene conservation unit established within Britain should be compatible with the European network of gene conservation units maintained by EUFGIS (www.eufgis.org). The UK National EUFGIS Co-ordinator should be informed that a gene conservation unit has been established (contact details can be found at www.eufgis.org). If the new unit fulfils the minimum requirements it will be designated as a national gene conservation unit and included in the EUFGIS database.

The minimum dataset required for a gene conservation unit to be included in the EUFGIS database is given in Tables 1 and 2. There is capacity within the database to include further details about the unit and the target species within it. Local managers may wish to record these details if they have the capacity. A full list is available from the UK National Co-ordinator.

Managing gene conservation units

The key aim for managing a gene conservation unit is to maintain and encourage the dynamic evolutionary processes for the target species within the unit. The main processes driving genetic diversity are gene flow (pollen and seed movement) and natural selection. These are most active during the stand regeneration phase when, ideally, there are high levels of natural regeneration competing for survival that have grown from seed from many mother trees. Therefore, having a minimum number of seed-bearing trees and natural regeneration are key elements to consider when managing the stand.

In terms of regenerating the stand, the aim should be to use natural regeneration, and any silvicultural intervention should have this as one of its goals. In addition, the long-term permanence and robustness of the target tree population should be considered. In most cases, some form of continuous

Table 1 Gene conservation unit (GCU) level data required for the EUFGIS database.

Data required	Data type	Comments
Country of the unit	Text (e.g. GBR)	This is supplied by the EUFGIS database.
Unit number	Text (e.g. GBR00001)	This is supplied by the EUFGIS database.
National GCU number	Free text	This can be the local reference or compartment number.
Latitude	Degrees/minutes/seconds	The location of the centre of the unit. If the data are in centesimal degrees it will be automatically converted to sexagesimal format[1].
Longitude	Degrees/minutes/seconds	The location of the centre of the unit. If the data are in centesimal degrees it will be automatically converted to sexagesimal format[1].
Minimum elevation	Number (e.g. 45)	The minimum elevation of the unit expressed in metres above mean sea level. Negative values are allowed.
Maximum elevation	Number (e.g. 138)	The maximum elevation of the unit expressed in metres above mean sea level. Negative values are allowed.
Surface area of the unit	Number (e.g. 5.1)	Area in hectares quoted to the nearest 0.1 hectare.
Data collection year	Number (e.g. 2010)	Year when the data on the unit were collected in the field.
Most recent visit	Number (e.g. 2013)	Year the unit was last inspected.
Species	Multiple choice	The scientific names of all the tree species growing in the unit, both target and non-target species. These are selected from the database list.

Table 2 Target species level data required for the EUFGIS database.

Data required	Data type	Comments
Target species	Multiple choice	The scientific name of the target species, selected from the database list.
Unit number	Text (e.g. GBR00001)	This is the unique identifier for the unit and links the species to the unit; it is repeated from Table 1.
Data collection year	Number (e.g. 2010)	Year when the data on the unit were collected in the field; again this links the species with the unit.
Most recent visit	Number (e.g. 2013)	Year the unit was last inspected.
Conservation category	1. In situ 2. Ex situ	Only one choice is allowed.
Population origin	1. Autochthonous[2] 2. Introduced 3. Unknown	Only one choice is allowed.
Justification for gene conservation unit	1. To maintain genetic diversity in large tree populations 2. To conserve specific adaptive and/or phenotypic traits[3] in marginal or scattered tree populations which are often relatively small	Only one choice is allowed.
Total number of reproducing trees in gene conservation unit	1. 51–500 2. 501–5000 3. >5000	An estimate of the number of reproducing trees of the target species in the unit. Only one choice is allowed.

Notes

1. Latitude and longitude co-ordinates can be represented using degrees, minutes and seconds (ddmmss) or decimal degrees (dd.d). Decimal degrees are called centesimal co-ordinates (meaning co-ordinates based on divisions of hundredths); degrees, minutes and seconds are called sexagesimal co-ordinates (meaning divisions based on the number 60). Since ddmmss is the preferred co-ordinate representation for maps, and decimal degrees are needed in information systems for mathematical operations, conversion from one to the other is often necessary.
2. Autochthonous describes tree populations that are indigenous to a site.
3. Phenotypic traits describe the set of observable characteristics of an individual resulting from the interaction of its genotype with the environment.

cover system would be the best method for maintaining a dynamic gene conservation unit over a long period of time.

The exact system will depend on the target species and any site constraints. If natural regeneration failed it would be acceptable to restock the unit by planting or direct seeding as long as local material was used. Ideally, this would be sourced from within the same woodland, but from a similar site within the same native seed zone would be acceptable if more local seed was unavailable. However, planting or direct seeding should be considered only as a last resort for a gene conservation unit. Wherever possible, dynamic gene conservation should involve natural processes over the whole life cycle of the unit.

Managing a gene conservation unit is compatible with other management objectives such as timber production, biodiversity, seed collection or recreation as long as the key aim of maintaining dynamic evolutionary processes is kept in mind.

Monitoring gene conservation units

In order to ensure that a gene conservation unit is fit for purpose some form of monitoring is required. The monitoring of the units should be carried out by regular visits, ideally involving an annual visual inspection, to observe that they still serve their dynamic conservation purpose and that they have not been damaged or destroyed by biological (e.g. disease outbreak) or other environmental factors.

A periodic assessment of the units should ideally be carried out through field inventories conducted every 5 or 10 years. The assessment should check the survival, health and regeneration success of the target species and confirm the details of any planting that may have been carried out. This more detailed monitoring would be compatible with the monitoring required to manage most continuous cover forestry systems and should fit most forest management planning cycles.

Useful sources of information

Forestry Commission publications

- The UK Forestry Standard (FCFC001)
- UKFS Guidelines on biodiversity (FCGL001)
- UKFS Guidelines on climate change (FCGL002)

Guidance and good practice

- Seed sources for planting native trees and shrubs in Scotland (FCFC151)
- Using local stock for planting native trees and shrubs (FCPN008)

Research

- Genetic variation and conservation of British native trees and shrubs: current knowledge and policy implications (FCTP031)
- Managing light to enable natural regeneration in British conifer forests (FCIN063)
- Selecting the right provenance of oak for planting in Britain (FCIN077)
- Choosing provenance in broadleaved trees (FCIN082)
- The role of forest genetic resources in helping British forests respond to climate change (FCIN086)
- What is continuous cover forestry? (FCIN029)
- Transforming even-aged conifer stands to continuous cover management (FCIN040)
- Monitoring the transformation of even-aged stands to continuous cover management (FCIN045)

Websites

- Continuous cover forestry research – www.forestry.gov.uk/fr/ccf
- Continuous Cover Forestry Group – www.ccfg.org.uk
- Prosilva – http://prosilvaeurope.org/home
- EUFORGEN – www.euforgen.org
- EUFGIS – http://portal.eufgis.org
- Forest Europe (was MCPFE) – www.foresteurope.org

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