COST Action E42

Growing valuable broadleaved tree species

Final Report

October 2008

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On behalf of the Management Committee
Heinrich Spiecker
Chair of Action E42

Front cover images: [left] Cherry plantation trial, Tuscany, Italy (credit Igor Stefancik), [centre] considering management options, Hardwick Estate, England, [right] fruit of *Sorbus domestica* (credit Robert Brus)

1 Executive Summary

Images: [top] birch forest and logs, Finland (credit Gabriel Hemery), [left] flowers of *Ulmus carpinifolia* (credit Robert Brus), [right] *Acer pseudoplatanus*, Slovenia (credit Robert Brus)

Valuable broadleaved tree species are important across Europe; economically, environmentally and culturally. Independent approaches to supporting and developing this valuable resource across the different countries of Europe has meant that knowledge and experience is widely dispersed and often inaccessible to a wider audience.

COST Action E42 brought together over 100 forestry scientists and practitioners from 25 countries to share their expertise and experience in growing and caring for valuable broadleaves trees and forests in Europe. Over a period of four years, meetings were held in 11 different countries and a great deal of information exchanged, resulting in the publication of a dedicated website and numerous publications. A public conference in September 2008 marked the end of the Action.

This Final Report of the Action summarises the results of this work. It highlights the basic knowledge required for growing valuable broadleaves and presents a summary of available improved material available for growers. The impacts and opportunities of climate change in Europe are reviewed. Silvicultural options are explained and a new approach that recognises the unique factors of growing valuable broadleaves is presented. The quality criteria for these species are defined. Finally, the non-wood benefits associated with valuable broadleaves across Europe are presented.

Figure 1 Members of COST Action at the Hardwick Estate Woodlands, Oxfordshire, England in October 2006. (credit Gary Kerr).

2 Valuable broadleaves in Europe

Today, valuable broadleaved tree species are an increasingly important element of forest production in Europe. However, valuable broadleaves have been neglected over time, firstly having been removed from natural sites during the historical period of forest clearance and later, as sites were afforested with other species. A shortage of timber in Europe favoured fast growing and less demanding species and this substantially affected the composition of European forests. The proportion of high forest consisting of coniferous species such as Norway spruce and Scots pine increased continuously, while forest consisting of broadleaved species decreased. The area of broadleaved forest consisting of coppice and coppice with standards decreased on many sites, and these forest types often included many valuable broadleaved tree species.

Figure 2 Wild cherry orchard in flower.

A combination of a lack of knowledge and understanding of the value of these broadleaved species has led to a lack of willingness to cultivate them and an inconsistent supply of timber. This contributed to the expansion of European monoculture forests with little diversity of habitats. However, ecological and economic considerations have recently increased interest in growing valuable broadleaved tree species. The high-quality timber of these tree species can realise high market prices and demand often exceeds supply. Demand for valuable timber has increased recently and there is a notable interest among forest owners and farmers to grow valuable broadleaved species but the current level of knowledge of these species and how to grow them is insufficient.

More information on how to grow valuable broadleaved species to obtain high-quality wood is urgently needed. With the right management valuable broadleaves can yield high quality timber within relatively short production times. These species also increase the attractiveness of forests and the landscape through their diversity, their special characteristics and aesthetic features. Valuable broadleaved forests may form important habitats for numerous plants, insects, fungi and animals, some of them endangered. Table 1 presents the main species studied by COST E42.

The main objective of the Action was **to increase the knowledge of growing valuable broadleaved tree species**, with an emphasis on the **production of valuable wood** and with the intent to **promote non-wood products** that can be produced in conjunction with the main product. Such non-wood products include biodiversity, nature conservation, habitat values, landscape and recreational values, and products that can be collected or gathered as by-products alongside the main product, namely timber. Valuable broadleaved tree species offer options for increasing ecological, economic and social values and therefore contribute to multi-purpose forestry.

Table 1 Valuable broadleaved tree species considered by COST Action E42

Common name	Latin name
sycamore maple	*Acer pseudoplatanus* L.
black alder	*Alnus glutinosa* L.
birches	*Betula pendula* L., and *B. pubescens* Ehrh.
common ash	*Fraxinus excelsior* L.
walnuts	*Juglans regia* L. and *J. nigra* L. and hybrids
wild cherry	*Prunus avium* L.
wild service tree	*Sorbus torminalis* L.
lime	*Tilia cordata* Miller
elms	*Ulmus laevis* Pallas and *U. carpinifolia* Gled.

3 The work of COST Action E42

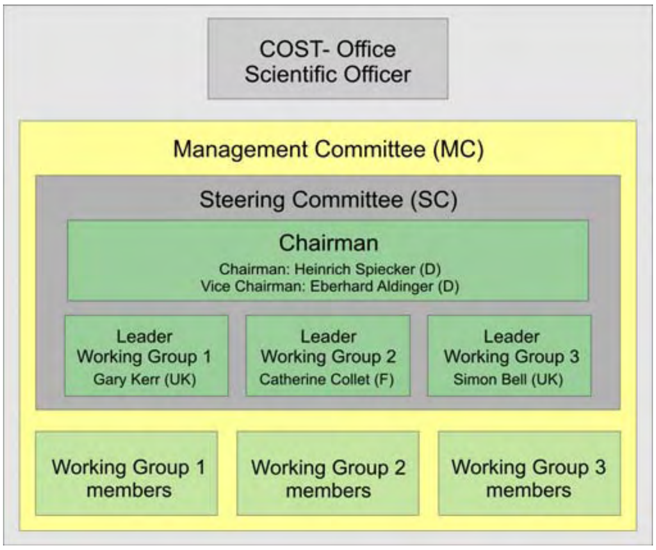

Figure 3 Organisational structure of COST E42

The organisational structure of COST Action E42 consisted of a steering committee, a management committee and three working groups (Figure 3).

In total, 110 members took part in the Action, representing the interests of 25 European countries; making E42 one of the largest Actions to be supported by COST.

Eleven main meetings took place in different host countries where all working groups and their members met together. These typically took the form of two days of meetings and presentations, and a day excursion into local forests.

Working Group 1
***Basics of growing valuable broadleaved tree species*:**

- Selection of species and provenances while considering site conditions and management targets;
- Harmonisation of terms, units, methods and practices for research;
- Identification of value-relevant wood properties;
- Identification of non-wood goods and services;
- Spacing, species mixture, weed control and tending the stands;
- Interspecific and intraspecific competition
- Growth dynamics in respect to site and species.

Working Group 2
***Management for quality wood production*:**

- Controlling diameter growth;
- Crown architecture;
- Natural and artificial pruning;
- Stem form development and control;
- Selection and management of future crop trees;
- Controlling volume growth of high value timber;
- Final cutting systems;
- Regeneration practices according to species, mixture and site.

Working Group 3
***Management for non-wood goods and services*:**

- Public perception;
- Aesthetic values;
- Biodiversity and habitats;
- Identification of new non-wood goods and services.

4 Basics of growing valuable broadleaved trees - Working Group 1

4.1 Introduction

There are many silvicultural guides available in Europe that offer guidance to forest managers on how to grow trees for different management objectives. Close investigation of these guides reveals that the basic principles of growing trees are the same whether they are conifers or broadleaved. However, there are differences in how to manipulate forests to achieve different management objectives. An extreme example of this would be a management objective of 'production of constructional timber from an ash woodland' compared to the 'conservation of veteran trees to enhance biodiversity and social values'.

The main principles of growing trees can be summarised by five points:

1. Making the correct choice of species dependent on site conditions, climate and soil (water and nutrition supply).
2. Ensuring that the genotype of the trees is appropriate for the site and management objectives.
3. In the regeneration phase, control competing vegetation and mammal damage.
4. Achieving a minimum stocking density that will create a robust woodland environment.
5. Thinning the woodland according to management objectives and the silvicultural characteristics of the species.

Figure 4 *Betula pendula* in Finland showing good characteristics for the production of quality timber. (credit Gary Kerr)

1. ***Species choice***
Suitable choice of species is fundamental to the growing of broadleaved trees and is possible only if the characteristics of the site and species are properly understood. If the wrong decision is made the effects of this will be apparent for many years; a good analogy is a financial investment where the money is tied in for 50-100 years but the performance of the investment is very poor. The limiting site and environmental factors for valuable broadleaved species are reasonably well known and good information exists to allow species to be matched to site.

2. ***Genotype***
The question of the genotype of the trees is equally important as matching the species to the site. It is possible to get the species choice correct but the genotype wrong. For example, the natural distribution of ash (*Fraxinus excelsior*) covers most of Europe except most of the Iberian Peninsula and northern Scandinavia. However, plants raised from seed collected in Greece are very unlikely to grow well if planted on sites in Scotland. An important aspect of selecting the genotype is to consider future changes in the climate.

3. ***Regeneration***
If the species and genotype are suitable then it is important to have enough trees so that the site is converted to woodland conditions quickly and there are enough trees for later manipulation of the stand to achieve management objectives. For valuable timber production the minimum number of trees per hectare required is 2500. However, there are some situations, such as growing trees in silvo-pastoral systems or where improved plant material is used, where initial planting densities will be lower - and in these cases getting the correct species and genotype is crucial.

4. ***Stocking density***
In order for the trees to be given maximum opportunity to dominate the site quickly it is essential to control competing vegetation and the impact of mammals such as deer, rabbits and hares.

5. ***Thinning***
Lastly, once trees are dominating the site they must be thinned in accordance with the silvicultural requirements of the species and management objectives.

4.2 Improvement of valuable broadleaved species

Working Group 1 adopted a very simple model to guide and focus their work. This was:

$$P = G \times E$$

where P is phenotype, G is genotype, and E environment.

In simple terms this means that how you see a tree (its phenotype) is a product of how the tree is programmed to grow (its genotype) and where it is growing and how it is managed (its environment). It was not possible to fully consider all of these factors for all of the tree species considered in the Action. One topic was therefore selected for 'G' and one topic for 'E'. For the genetic aspect it was agreed to produce an inventory of all the improved valuable broadleaved forest reproductive material in Europe. This was the first time such an ambitious undertaking had been attempted. For the environmental aspect of their work the group investigated the possible impacts of climate change on valuable broadleaves and any likely changes in their distribution (Section 5.3).

Figure 5 Controlling pollination in a wild cherry orchard.

The objective of the improvement work was to evaluate the Europe-wide resource of improved varieties of the valuable broadleaved species considered by the Action. It is important to note that the interest of the Action in 'improved varieties' only included the use of traditional methods of improving plant genetic material. Genetically modified forest tree species were not considered. According to the European Council Directive 1999/105/EC on the marketing of forest reproductive material (FRM), improved material belongs to the categories 'Qualified' and 'Tested' and hence work on the inventory covered three types of basic material:

- tested seed stands;
- seed orchards;
- clones and clonal mixes.

A questionnaire enquiring about a standard set of descriptors for each type of material was distributed to each of the 25 European countries in the Action. It was not always easy to obtain the information required! In some countries, responsibility for implementing the Directive had been delegated to federal governments and it was difficult to obtain a national view. In other countries it was difficult to find out who had responsibility for ensuring compliance with the Directive in the national government. However, eventually good quality information was obtained from 18 countries.

Results from the survey showed that none of the responding countries used material from tested seed stands. In addition, clonal material was only available for four species in five of the countries as shown in Table 2.

Table 2 Clonal material available for valuable broadleaved species in EU

Species	Number of clones	Country
Alnus glutinosa	126	Lithuania
Betula pendula	45	Lithuania
Betula pendula var *carelica* ('curly birch')	30	Finland
Prunus avium	10	France
Prunus avium	10	United Kingdom
	221	

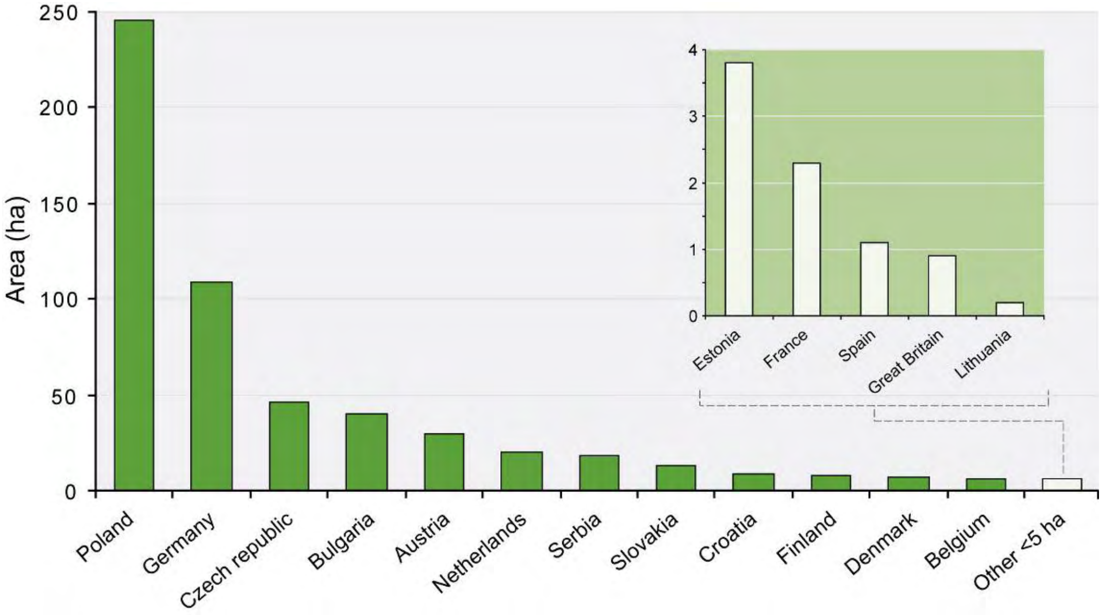

Figure 6 Area of seed orchards in those European countries that responded to the questionnaire.

The main finding of the study was that the majority of improved material of valuable broadleaved tree species is produced from 256 seed orchards that are mainly located in Central and Eastern Europe (Table 3 and Figure 6). The main species are *Alnus glutinosa*, *Tilia cordata* and *Betula pendula*; however, most of the orchards have been established only recently and have not yet reached full commercial productivity.

Table 3 Number and area of seed orchards for valuable broadleaves

Species	Number	Area (ha)
Acer platanoides	3	6.7
Acer pseudoplatanus	26	47.1
Alnus glutinosa	51	135.6
Betula pendula	34	66
Betula pendula var. *carelica*	1	0.04
Betula pubescens	2	3.1
Fraxinus angustifolia	1	3.5
Fraxinus excelsior	24	43.4
Prunus avium	31	47.8
Robinia pseudoacacia	16	43
Sorbus aucuparia	2	3.2
Sorbus domestica	1	0.9
Sorbus torminalis	2	1.7
Tilia cordata	44	136.7
Tilia platyphyllos	1	1.2
Ulmus glabra	10	12
Ulmus laevis	4	4.4
Ulmus minor	3	2.6
	256	**559**

A strong view from members of the Action was that the success of *Alnus glutinosa*, *Tilia cordata* and *Betula pendula* had been achieved where a decision had been made to give long-term commitment to this type of work. Unfortunately the present approach to much pan-European research is short-term and will not encourage further work on the genetic improvement of valuable broadleaved species.

4.3 Species distributions and likely impacts of climate change

The main objective of this work was to describe objectively species and provenance distributions and to assess the likely effects of predicted global climate change on them. This study was led by Dr. Gabriel Hemery undertaking a short-term scientific mission at the University of Bordeaux, France. The main output from this was a report '*Forest management and silvicultural responses to predicted climate change impacts on valuable broadleaved species*'. Further meetings of the Action refined the ideas formulated in this mission and a scientific paper was produced that has been submitted to a peer-reviewed journal for publication.

The first question that the project addressed was: what are the main factors influencing valuable broadleaved tree species that will be affected by climate change? The second question posed was:

how will the above changes influence the species and provenance distributions of valuable broadleaved species. As expected the results are complex but summarised in Table 4.

In conducting this study it is interesting to compare and contrast the situation in Europe with that in eastern part of the United States. For example, in the United States a Climate Change Tree Atlas has been produced that shows how the current and future distributions of 134 trees species could be affected by climate change. The web-based model allows the user to select one of two emission scenarios and vary predictions according to three different climate change models. If such a project was attempted in Europe a major hurdle would be the obtaining of appropriate tree data from European countries. The work in the United States is based on tree data obtained from more than 100,000 plots for the eastern part of the country and the plots represent data for nearly 3 million trees!

Table 4 Summary of climate change impacts on European forests

Factor	Impacts
Temperature	Photosynthesis and respiration, soil organic matter decomposition and mineralisation, phenology and frost hardiness, species distributional changes, and adaptation and evolution are affected by temperature.
CO_2	Increases in CO_2 not only affect the global climate but directly impact plant photosynthesis and respiration. Research has indicated increased growth rates but with impacts on water use, carbon, nutrient allocation and timber quality.
Wildfires	The European forest resource, in the most part, is neither adapted (e.g. serotinous) nor dependent on wildfires. Native species will be poorly adapted and changes to forest ecology difficult to predict, although it is likely that fast colonizers and non-native invasive species may alter existing communities.
Drought	Generally drought will impact by negatively affecting ecosystem productivity and increasing mortality. Competitive species, those adapted to cold and wet conditions, as well as species with low reproduction rates and/or limited mobility, seem to be the most affected. Evidence was found for intraspecific variation in response to drought conditions and consequently more frequent exceptionally dry summers could have a more serious impact than a single event and would give certain species a competitive advantage. Indeed, relictual taxa appear more drought tolerant than extinct taxa. Therefore in the long run, a change in the frequency of hot and dry years could affect tree species composition and diversity.
Wind	Windthrow damage in Europe increased in the 20^{th} Century but loss of timber was typically smaller than annual timber harvests. Windthrow can also have positive ecological effects but where damage levels exceed harvesting or salvage harvesting, costs are high, e.g. in mountainous terrain.
Precipitation	Heavy precipitation can be associated with high costs, both in terms of financial and human life, it can also impact the environment; e.g. through loss of fertile topsoil by soil erosion. Simulations suggest that a climate warming could be associated with a substantial increase in atmospheric moisture content of about 7% per degree of warming. Changes to forest cover, tree health and the rainfall climate will also impact water flow.
Chilling	For species with a large chilling requirement, milder winters might result in inadequate chilling and hence delayed and erratic bud burst in spring. For example, climatic warming has been linked to premature bud burst of trees in Finnish conditions during mild spells in mid-winter, resulting in heavy frost damage during subsequent periods of frost.
Pests and Pathogens	Future pest and pathogen trends will relate to relationships between pest/pathogen, the health of the host tree species and any natural defence mechanisms/pest predators. However, stressed trees are more susceptible to insect pests and diseases, and many insect pests are likely to benefit from climate change as a result of increased breeding activity and reduced winter mortality. Climate change has been linked with range expansion, northward and upward, of several insect species of northern temperate forests. Impacts on broadleaved species are uncertain as much of the current scientific work in this area has focussed on coniferous species. The impact of facultative pathogens such as sooty bark disease of sycamore may worsen, while some insect pests that are present at low levels, or currently not considered important, may become more prevalent.

5 Management and Silviculture - Working Group 2

5.1 Introduction

It is impossible to define a single silvicultural approach that would be applicable to all species of valuable broadleaves. However, they share a similar economic context and can be grouped according to growth patterns to define some general principles to guide silviculture. These principles can then be applied flexibly to different systems used to grow valuable broadleaves, from natural regeneration to plantations. These general rules apply to the different systems used to grow valuable broadleaves, from natural regeneration to plantation conditions.

Working Group 2 focussed on identifying the growth patterns of valuable broadleaves and identified silvicultural approaches for their management. The wood quality criteria for the various species were also identified.

5.2 Growth pattern of valuable broadleaved species

Most valuable broadleaves have a wide natural distribution and grow well under markedly different climates, from oceanic to continental regions and across large latitudinal gradients. All these species are site demanding, as they require high nutrient levels and good water supply. Although some species (*Prunus avium*, *Sorbus torminalis*) tolerate drier conditions, adequate silviculture for these species requires a high growth rate that can only be achieved under a continuous supply of moisture, which restricts their use to the best sites. In addition, most species do not tolerate stagnant water conditions or compact soils, with the notable exception of *Alnus glutinosa*.

In continuously moist and fertile sites, valuable broadleaves show rapid growth, at least in their early stages. Specific height growth curves exist for *Fraxinus excelsior*, *Acer pseudoplatanus*, *Alnus glutinosa*, and *Prunus avium*. For these species, height growth peaks between 10 and 20 years of age. After this period, height growth tends to slow and, at 50 to 70 years of age, it declines rapidly. These species are often found in mixture with beech *Fagus sylvatica* L. In these mixtures, valuable broadleaves usually outgrow beech until the age of 40 to 60; after this beech catches up and becomes dominant. *Sorbus torminalis* has a very different growth pattern and shows slower height growth at all ages. In order to take advantage of this fast initial growth of valuable broadleaves it is best to grow them on a short rotation, which ranges from 50 to 80 years for the different species

In the young growth stages, these species have extremely different light requirements: *Juglans regia*, *Betula spp.* and *Alnus glutinosa* are classified as strictly shade intolerant. *Prunus avium* and *Sorbus torminalis* are intermediate, and *Fraxinus excelsior*, *Acer pseudoplatanus*, and *Tilia spp*. are shade tolerant species. However, as they grow larger, all species become strongly light demanding, and their survival and growth are dramatically reduced if they are not released from competition from neighbouring trees. In the adult stage, maximum diameter growth can only be achieved with frequent heavy thinning that maintains final crop trees in a position of minimal competition. Generally, valuable broadleaves respond poorly to late thinning.

The crown architecture is markedly different among valuable broadleaved species. *Fraxinus excelsior*, *Prunus avium*, *Sorbus torminalis*, and *Betula spp.* have light crowns, whilst *Acer pseudoplatanus*, *Juglans regia* and *Tilia spp.* have large and dense crowns. However, for all species, rapid growth is associated with the development of large branches, and most of them are prone to forking. For most species, branches rapidly decline and die as soon as they are deprived of light, and self-pruning may be evident even for large branches and forks. However, the heavy thinnings required to achieve good growth induces high light levels around the crowns and slows the process of self pruning, leading to the presence of large branches that must be artificially pruned. At the adult stage, when crowns reach their full width and enter into contact with each other, rapid shedding of the lower branches may occur if insufficient light passes through the canopy.

Valuable broadleaves are classified as pioneer or post-pioneer species. They regenerate in open stands but this much less frequent in dense climax forests of central and western Europe. With the exception of *Betula spp.* and *Fraxinus excelsior*, valuable broadleaved species are rarely found in pure stands to any extent, and more often grow according to the very local site conditions in mixture with other broadleaves or with conifers, with a few individuals scattered among the other species or in small groups.

Figure 7 A tree improvement field experiment of ash *Fraxinus excelsior*, Little Wittenham, England (credit Igor Stefancik)

A series of review papers on the growth pattern of the main valuable broadleaved species (*Fraxinus excelsior*, *Acer pseudoplatanus*, *Alnus glutinosa*, *Sorbus torminalis*, *Juglans regia*, *Betula spp.* and *Tilia spp.*) were written (see Section 8.1), and are freely available on the ValBro website.

5.3 *Silvicultural practice*

The silviculture of valuable broadleaves aims at producing high quality (see Section 5.4) timber for the veneer and furniture industries. In the present economic context, these high quality trees must be produced with a minimum number of silvicultural interventions in order to reduce costs, and on a short rotation to reduce the payback period. These economic constraints demand that all silvicultural operations are focused on a small number of selected trees that have the potential to produce high quality timber in a short period of time. These "tree oriented" methods are very different to more traditional management methods, which are more "stand-oriented" and focus on the size and structure of the whole stand

A set of silvicultural rules adapted to valuable broadleaves may be described by considering three phases of stand development, characterised by distinctive silvicultural objectives:

1. **stand initiation phase;**
2. **bole formation and pruning phase;**
3. **diameter growth and crown thinning phase.**

5.3.1 Stand Initiation - phase 1

The objective of the *stand initiation* phase is to establish a sufficient number of vigorous young trees of the desired species, regularly spaced in the stand. The view to what constitutes a 'sufficient number' varies considerably with local practices but is usually between 800 and 2500 stems per hectare. However, attention should be paid to avoid wasting effort by establishing too many seedlings. In plantation systems, total costs increase rapidly with the number of planted seedlings, especially on sites where individual protection against browsing is needed. Similarly, in naturally regenerated systems, tending operations may be needed at a high frequency in early years and operations should be targeted on a small number of seedlings to reduce overall costs. Considering that only 40 to 60 crop trees per hectare may remain at the end of the rotation, a density of 400 to 1200 potential future crop trees per ha at the end of the *stand initiation* phase should be aimed at, irrespective of the regeneration system. These potential future crop trees should be regularly spaced among the other trees of the stand, which will be more numerous but not be considered as future crop trees.

Establishing a single species or mixed-species stand of valuable broadleaved by planting requires the implementation of a suite of silvicultural operations which are common to all tree species and must be adapted to the local site conditions, including: soil preparation, vegetation control and protection against browsing (p. 4).

On suitable sites, most valuable broadleaved species regenerate easily, and the main difficulty when using natural regeneration is to acquire the desired species mixture. The species constituting a mixture often have different height growth dynamics and show striking differences in their competitive abilities. This usually leads to a rapid loss in the mixture if regular tending operations do not strictly control the growth of the different species.

5.3.2 Bole formation and pruning - phase 2

The objective of the second phase is to obtain a sufficient number of high quality trees, i.e. a straight, defect free stem with no branches up to the final log length. These characteristics may be obtained either by natural pruning, which is induced by competition, or artificial pruning when competition is low.

Using natural processes to allow self-pruning should be preferred whenever possible. It is based on the maintenance of neighbouring plants around the target tree, which reduce the amount of light reaching branches on the stem, which then decline and die. The technique requires a good knowledge of the growth dynamics and architectural development of the target tree and its competitors. These methods maintain the target trees under strong competition from neighbours, and a major difficulty is to maintain the less competitive tree species throughout this phase. The best species for this are those that are shade tolerant, including the valuable broadleaves *Acer pseudoplatanus* and *Fraxinus excelsior*, which also tolerate relatively high levels of lateral competition. Species such as *Prunus avium, Alnus glutinosa, Betula spp.* do not tolerate competition from neighbours.

Artificial pruning may be necessary in situations were trees are not able to self-prune. This could be due to an absence of competition from neighbours or in low density plantations where no nurse trees appear naturally or were planted. Pruning is best done early, when the forks and branches to be removed are still small, in order to minimise the size of wounds and maximise the final knot-free volume.

5.3.3 Diameter growth and crown thinning – phase 3

The objective of the third phase is to maximize the diameter growth of the selected final crop trees. Rapid diameter growth must be obtained as soon as the target log length is reached, and then maintained until final harvest. This is an important difference with traditional silviculture, where diameter growth peaks early and then decreases until the end of the rotation (Figure 8). In broadleaves, stem diameter is closely related to crown width, at all growth stages. Sustained diameter growth requires a constant low level of crown competition, which is obtained by regular heavy thinning. Thinning operations should aim strictly at favouring the final crop trees. In stands where the density of the final crop trees is low, the unselected trees may be managed for different management objectives such as biodiversity preservation and fuel wood production.

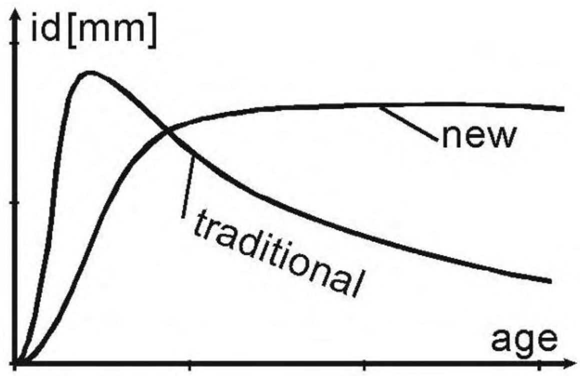

Figure 8 Current diameter increment (id) of future crop trees in a naturally regenerated stand, in the new 'tree-orientated' system and in a traditional 'stand orientated' system (from Spiecker 2003).

Regular and heavy thinning prevents dieback of lower branches and maintains the crown base of final crop trees at a constant height throughout the whole phase (Figure 9). The maintenance of a large live crown (60% of total tree height at the end of the rotation) is a second major difference with traditional 'stand orientated' silviculture, where the crown base usually rises up to the end of the rotation. In the new system, the crown base is settled at the end of the bole formation phase when the branch-free part of the stem of a final crop tree has reached its target length. It is therefore necessary for the manager to have a clear idea of the final objective (in terms of target bole length) when deciding upon the transition from the bole formation phase to the diameter growth phase, and ensuring the release the final crop trees from competing neighbours.

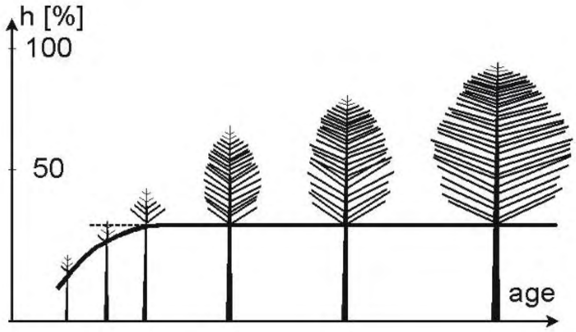

Figure 9 Crown base height (h) in the proposed system, increased rapidly during the bole formation phase, and is maintained constant through the diameter growth phase (from Spiecker 2003).

5.4 Quality requirements for valuable broadleaved trees

The economic returns from growing valuable broadleaved trees depend on the quality of the wood produced. Quality reflects the utility of the wood and therefore is defined by the end user. Quality criteria can only be applied for the specific purpose for which the wood is used. However, some general quality requirements exist which may be applied for various purposes. The most important requirements are described in the following short review.

Figure 10 A future crop tree of *Acer pseudoplatanus* (credit Anne Oosterbaan)

Diameter of the log and branchiness are the most important criteria which can be directly influenced by silviculure. Due to a positive relationship between the volume of valuable wood and **diameter**, the price per cubic metre increases with increasing diameter. **Stem taper** reduces veneer output and therefore a cylindrical, untapered stem is preferred. The most commonly preferred length **of log** for veneer is about 2.8 m or a multiple of it.

The most significant fault in the timber of valuable broadleaves is **knots**. Knots reduce the strength of wood, may lead to discolouration and may adversely influence the surface quality and appearance. The value of **swept** (or curved) logs is reduced if sweep exceeds 5 cm per m. **Spiral grain** causes problems during manufacturing processes and should therefore not exceed 15 cm per m for high quality logs.

Discoloration has an adverse impact on wood quality. Certain market demands affect judgements as to whether a discoloration, such as olive core of ash, is considered undesirable or not. Other discolorations such as black heart in ash, always decrease wood value. **Ring width** is often cited as relevant. However, the importance of a uniform ring width is generally overstated and is almost impossible to achieve as growing conditions change from year to year.

Based on these rather general criteria a survey was undertaken to evaluate the most important criteria at a species level for Europe. Experts from eight European countries (Germany, Italy, Switzerland, Finland, Poland, France, Slovakia and Netherlands) were questioned on the relevance of quality factors (i.e. not relevant, relevant and highly relevant), concerning:

- **Stem form:** forked tree (over butt log), sweep, taper, spiral grain, eccentricity, ovality and uneven stem surface.
- **Branches on the butt log:** living, dead, hidden knots and burrs or epicormic branches.
- **Wood structure:** ring width, regularity of ring widths, grain deviation, gum pockets, tension wood, ring shake and frost crack.
- **Discoloration:** positive or negative impact.
- **Stem damage:** damage originating from roots, mammals or mechanical damage, infestation with mistletoe, or insects or fungi.

The results of this work are presented in Table 5.

Table 5 Priority quality requirements for each assessment criterion. Brackets denote number of experts.

	Acer pseudo-platanus	***Betula pendula***	***Alnus glutinosa***	***Castanea sativa***	***Fraxinus excelsior***	***Prunus avium***
Stem form	spiral grain(2), forked tree(2), sweep(1)	sweep(2), spiral grain(1), uneven stem surface(1)	spiral grain(2), uneven stem surface(1), sweep(1)	uneven stem surface(1), spiral grain(1), sweep(1)	spiral grain(3), forked tree(3), sweep(2)	spiral grain(2), forked tree(1), sweep(1)
Branches on the butt log	hidden knots(4), dead(4), living(2)	hidden knots(4), dead(3), epicormic branches(2)	dead(3), hidden knots(3), epicormic branches(2)	dead(2), hidden knots(2), epicormic branches(1)	hidden knots(3), dead(3), living(3)	dead(3), living(2), hidden knots(2)
Wood structure	grain deviation (2), ring width(1), frost crack(1)	grain deviation(1), tension wood(1), frost crack(1)	---	ring shake(2), frost crack(1)	ring shake(2), frost crack(2), tension wood(1)	gum pocket(1), grain deviation(1), frost crack(1)
Discolo-ration	negative(1)	negative(1)	negative(1)	---	negative(3)	negative(1)
Stem damages	browsing or mechanical damage (1), insects(1), from roots(1)	browsing or mechanical damage(3), from roots(3), insects(1)	browsing or mechanical damage(2), from roots(2), insects(1)	browsing or mechanical damage(1), from roots(1)	browsing or mechanical damage(3), from roots(2), mistletoe(1)	from roots(3), browsing or mechanical damage(1)

6 Non-wood goods and services – Working Group 3

6.1 Introduction

As well as the timber and silvicultural aspects considered by Working Groups 1 and 2, there are other values associated with valuable broadleaved trees. They have often been strongly associated with traditional rural ways of life, providing a range of different uses, especially non-wood products. Moreover, they have many cultural associations, ranging from myths and legends to superstitions. Within the rural landscape they also often play a major role, contributing to local distinctiveness and landscape character as well as fulfilling ecological roles when found in small woods, along hedges or streams or along forest edges, for example. New forms of intensive silviculture are also under consideration which, if applied over large areas could have a significant impact on the landscape quality.

For these reasons, Working Group 3 considered a range of mainly non-wood goods and services. Surveys were undertaken of literature and through visits to different areas. Amongst the experts who comprised the working group, each was asked to assemble information from a range of sources on the subject, in order to sample some of these values for the countries represented in the working group. Not all species are found in each country and in some they are planted but not native. The cultural values and associations therefore vary but there are also many similarities in the way trees have played a role in culture:

- **economically** in providing a range of special or local non-wood products;
- sources of **folklore**, myths, legends and superstitions.
- As part of the composition of the cultural landscape, imparting a **sense of place**
- As elements of the **ecological landscape**

These values are on the point of being lost to most cultures because they are associated with traditional, rural ways of life. As Europe becomes more urbanised such cultural heritage is at risk of becoming lost forever. Fewer people know about these special values or how to use the trees for making special products. In the case of medicinal products there is a risk that potentially useful compounds may be missed.

6.2 Non-wood products

This aspect studied traditional products derived from the non-woody parts of the trees used in the study: bark, flowers, fruit, sap and seeds. The main traditional use common to most countries appears to be their use to produce dyes. Many of the trees were and still are used for medicinal purposes and the fact that they are recorded and still in use indicates their importance to society over the centuries.

Table 6 presents a comparison of the species where most parts of the trees are used frequently for different purposes.

Figure 11 ***Juglans regia*** **in the Trenta valley, Slovenia (credit Robert Brus)**

Table 6 Non wood uses of valuable broadleaves, for species common across Europe

Tree species	Medicinal	Dye production	Food	Fodder	Drink	Domestic use
Alder	Germany Poland Portugal Switzerland	Finland Germany		Finland Poland France Germany	Switzerland	Poland Switzerland Portugal
Ash	Portugal France Poland	Poland		Finland Poland France Germany		Greece Switzerland Germany
Birch	Portugal UK Germany France	Poland		Finland	Germany France Poland Switzerland	Finland France Ireland Poland
Elm	Portugal France		Switzerland	Switzerland France Germany Portugal	France	
Lime	France Portugal		Switzerland	Switzerland France Germany Portugal	France	
Sycamore			France Germany		Switzerland	
Walnut	France Portugal Germany	Switzerland Germany Portugal	France Greece UK Portugal Switzerland			France Greece Germany Portugal
Wild service tree	France Germany		France Switzerland			
Wild cherry			Germany France Switzerland		Germany Switzerland	Greece

The pattern of uses shown in Table 6 illustrates that some trees are used for more products than others. A key example is walnut which produces nuts which can be used in many ways and is economically important in countries such as Greece. Lime, which has a fibrous cambium layer (bast), is also used quite widely. Another aspect relates to the countries with low numbers of tree species but large amounts of specific species, Finland and the use of birch being a prime example of this.

6.3 Cultural associations

The cultural associations of the selected species examined here are broad and have persisted for many centuries. Cultural associations include the relationship of the tree or products from the tree in folklore, mythology, in religious practices, in symbolism and as a sign of good or ill luck.

Comparing the cultural associations with tree species in the different countries (Table 7), it can be observed that:

- there are some tree species with strong symbolic aspects which are found across several countries;
- there are the same issues (religious, superstitions) connected with different tree species in different countries;
- the cultural/religious importance of a tree species often determined the place where these trees could (or still can) be found. In Greece, for example, lime (tree of Virgin Mary) and walnut (its leaves are used in Orthodox Christian ceremonies) are associated with religion. This is enhanced by the fact that these trees are very often growing in front of churches.

Figure 12 ***Acer pseudoplatanus*** **in Julian Alps, Slovenia (credit Robert Brus)**

Figure 13 ***Sorbus domestica*** **in the Vipava valley, Slovenia (credit Robert Brus)**

Cultural associations are one way in which people identify themselves with a particular place. This place attachment is an important facet of the way that people belong to the landscape. This is usually a strong element of rural communities and societies and tends to persist in places where the rural community is still vital. In many places in Europe migration from rural areas to cities the and resulting depopulation is weakening the attachment of the population to the countryside and the survival of knowledge of cultural associations with these and other trees, plants and other landscape elements can be seen as an important part of heritage. This is the same for the traditional products noted in the previous section.

Figure 14 Birch along a frozen lake shore in Finland (credit Kisis Makinen)

Table 7 Main cultural associations in relation to particular tree species (CH – Switzerland, D – Germany, FI- Finland, F – France, GR-Greece, IR – Ireland, P – Portugal, PL – Poland, UK – United Kingdom)

Tree species	Cultural association (country of evidence)
Alder	Evil tree (FI), tree of evil ghosts, the devil and witches (D); tree of war and death (IR)
Ash	Divine (F); tree in holy groves, sacred (PL)
	Fertility, healing, regeneration (IR, PL)
	Predict weather (D, CH & UK)
	(young) men (F, D)
	Human strength, mythical and legendary weapons, divine retribution and punishment (GR); symbol of fearless warriors (F)
	Keeps snakes away (F, GR)
Birch	Emergence of spring (D, CH, UK)
	Joy, happiness (FI, PL)
	Connected with love (D, CH, UK)
Cherry	Connected with love / marriage and beauty (F, D, IR), hope, optimism (GR)
Elm	Death and sorrow (D, CH), death and transition into the Underworld (UK)
	Fertility and love (D, CH); family protection (PL), female ancestor of human race, tree of Virgin Mary (GR)
Lime	Hospitability, quietness (trees on farms) (F, CH)
Sycamore	Symbol of fear or horror (GR)
Walnut	Fertility (D, CH)
	Shape of the tree supposed to bring illness and bad luck (GR, D)

6.4 Landscape

The European Landscape Convention defines landscape as "an area, as perceived by people, whose character is the result of action and interaction of natural) and/or human factors". Both urban and rural landscapes are considered in the convention. One of the main components of the rural landscape are trees – as single trees, in clumps, avenues, along roadsides, next to houses, in small woods or in forests. One of the aims of the convention is to identify characteristic landscapes and to protect, manage or enhance them by appropriate action. As part of this it is necessary to be able to understand the main elements that make up a particular landscape type of which the species, distribution pattern, form of management and cultural associations of trees is frequently an important aspect.

The working group visited a number of locations and used this experience to compare the character of different areas and the way that trees play a role in landscape character. The members also collected typical examples from each country in order to show how the trees are found in a sample of landscapes.

Some examples of the different patterns of valuable broadleaved trees in Europe are as follows:

- ash and elm are common throughout the French "bocage" or English hedgerows throughout agricultural or pastoral landscapes (although the elm has been largely wiped out due to Dutch elm disease, which dramatically changed the character of the landscape);
- cherry and birch colonise woodland edges of more wooded landscapes;
- ash or sycamore are commonly associated with farmsteads on mountain and hill landscapes.

Figure 15 Cherry trees in flower form a characteristic scene in this area of southern France (credit Andre Gavaland)

Trees contribute strongly to the landscape character of each of these regions. Each tree in each place, whether planted or spontaneously growing, has been chosen and managed by its specific properties (such as the type of wood and bark or fodder value of leaves) but also by its morphological features (enclosure capacity, shade potential) or aesthetic aspects (form, size, autumn colour). Agricultural and forestry intensification or abandonment, an increase in timber production and adoption of new forms of silviculture, may affect landscape character. Landscapes with a strong character derived from valuable broadleaves in hedges, clumps of woods need to be considered and new silvicultural approaches may be necessary where intensive management is proposed so that the valued landscape character is not compromised.

Figure 16 *Sorbus domestica* in autumn colours (credit Robert Brus)

6.5 Ecology

The ecology of landscapes – the functioning of the ecosystem in terms of continuing ecosystem processes – depends in part on the pattern and structure of the elements that make up the landscape. In forests the mosaic of stand types of different species and ages helps to determine functioning while in the agricultural landscape it is the pattern of trees, hedges, small woods and so on that create the structure. Thus, the same structure that is characteristic of the cultural landscape can also be analysed in terms of it ecological values. Although not a major aspect of the working group, nevertheless, some of the ecosystem functions were reviewed by comparing the role of different tree species in connection with their typical locations.

Figure 17 A landscape in France where hedgerows have been removed but the remaining woods still form a connected pattern, thus allowing movement of animals around an otherwise intensively farmed landscape (credit Simon Bell)

It was noted that structures where valuable broadleaves dominate, such as hedges, tree rows and belts, clumps and single trees, offer diverse habitats and corridors in an open landscape. Many of these species (with the exception of birch) are not often found in large forest expanses; they tend to be on woodland edges, as small components within woodlands or occupy special niches, such as wet areas (alder), rich soils (ash) or in mixture. In agricultural landscapes the networks of hedges found in Britain, Ireland or France form valuable corridors connecting smaller woods and larger forests together. Ash and elm have played important roles in this (along with many other trees such as oak). In other countries the trees are not so connected by hedges but form rows or lines, patches or other clumps within a matrix of, for example, olive groves (Greece), fruit orchards (Italy) or less intensively managed land (Poland). Trees may be found along streams and farm borders (Germany) or along roadsides (France). The trees themselves may host insects, birds and other fauna but it is their role in the wider landscape which is most important.

It was found that within European natural forest ecosystems valuable broadleaves rarely dominate, so it is assumed that they can fulfil a genetic diversity function even though they may be widely distributed.

7 Concluding remarks

Valuable broadleaved tree species may be considered to be valuable because of their high timber prices, the aesthetics of their timber, or just because of the rareness and beauty of their appearance. Ecological and economic considerations have recently increased the interest in growing valuable broadleaved tree species. They can be grown as part of an existing forest management regime, and in mixture with both broadleaved and coniferous trees. Furthermore, they can be grown along roads or in hedgerows.

Most valuable broadleaved tree species are light-demanding, especially as they mature. In natural conditions, valuable broadleaves often grow as scattered single trees or in groups. On certain sites or under certain conditions, valuable broadleaved trees are exposed to various kinds of pests, diseases and other disorders. To avoid major risks plantations should not be over large, and adoption of mixtures with other species in groups or small stands may be desirable. Both management and genetic characteristics have an impact on growth, on resilience and on wood quality. The site conditions also affect growth dynamics, including height growth and crown architecture, whilst diameter growth in forests is mainly affected by the growing space.

When aiming for high wood quality in a relatively short time, productive sites are required. High nutrient levels and good water supply are essential. Genetic material needs to be selected according to the management aims and the site conditions. Possible future changes in climate also have to be taken into account.

There may be a wide range of management aims to be accomplished. Aims may vary considerably in different regions and also change over time. Diversification and flexible management has to be able to cope with these challenges.

General silvicultural strategies are therefore difficult to develop for valuable broadleaves, especially because they are a heterogeneous group and species reactions differ between management regimes and site conditions. One common feature is that they generally require regular release from competitors on most sites for optimal growth and even for survival. Many valuable broadleaves have a limited capacity to compete in forests, and so they require more interventions especially when mixed with fast growing and shade tolerant tree species.

High-quality timber of large dimension consistently command high prices. The wood of lower quality is of far less value. What determines quality is defined by the user of the timber. Timber quality is modified by the genetic characteristics of the individual tree, by the site conditions, as well as by management. With an appropriate treatment they can yield high quality timber within a relatively short production time. The dimension, stem form and wood properties of the clear bole determine the value of the crop. These parameters can be controlled by forest management such as selection of species and selection of genetic characteristics, quality of the plant material, initial spacing, thinning, pruning and the time of harvest.

When planting, only a small number of genetically well selected and site adapted trees are needed. The spacing design is influenced by the need of selecting best performing trees out of a larger number of trees, the landscape and technical aspects.

Most valuable broadleaves grow fast in height during the first 10-20 years. This is the phase were pruning takes place. In dense stands natural pruning may be applied to those species losing fast their dead branches. As competition-induced natural pruning can be replaced by artificial pruning of open grown trees, alternative management options offer innovative ways for the production of valuable wood. These management options may at the same time also increase the supply of non-wood products and services. Valuable wood production must concentrate on the individuals that are expected to produce the high quality wood in the desired dimension. In order to improve management efficiency, interventions have to be limited to actions that support the valuable individual trees.

The number of future crop trees per hectare depends on the target diameter and the production time: the larger the diameter and the shorter the production time the fewer trees per ha should be selected as future crop trees. Artificial pruning has to be repeated in order to avoid pruning of large branches, to reduce the impact of pruning on the tree and to reduce the size of the knotty core inside the trunk.

Moreover, thinning is applied for controlling the quality of the wood production; in particular, it is used for favouring future crop trees, controlling their diameter growth. A two-phase management system is employed to improve quality: first phase emphasizing pruning, and second phase encouraging crown expansion and stimulating diameter growth. In the phase of crown expansion, the crown base should be kept at a fixed height. This requires regular interventions as valuable broadleaved tree species often are getting less competitive with increasing age.

Valuable Broadleaved species offer an option to produce high value timber in a relatively short time. They may as well fulfil the needs of stakeholders such as small forest owners, farmers and the wood industry. The new options for management include trees on small as well as on large holdings, in private and public forests. They allow effective production of high-quality hardwood from valuable broadleaved trees with methods adjusted to ownership, tree species, site conditions and type of land and region.

The proposed management options at the same time also increase the supply of non-wood products and services, as well as the diversity of habitats through the varying forest structure and light regimes. Valuable broadleaves produce flowers in springtime, their fruits enrich habitats, and they contribute with additional colour and texture to the beauty of the landscape. They can contribute to the uniqueness and beauty of an area, taking into consideration the aesthetic, ecological and economic values of the surroundings. As urban forests are becoming increasingly important for people living in cities, cultural values will increase in value.

Valuable broadleaved tree species offer options for increasing ecological, economic and social values and may contribute to sustainability of forestry. They may increase the production of high quality timber while maintaining and improving environmental values such as biodiversity, stability and naturalness.

New tools for inventories able to objectively control the development of wood quality are needed. Indicators for the value relevant wood properties are needed as well. Future management regimes have to take into account the aims and capacity of the forest owners; small forest owners and farmers as well as large forest enterprises. The management regimes should be able to adapt to changing ecological as well as to new socio-economic conditions, as to climate change, to urbanisation, to the demands of the people using urban forests and forest areas close to settlement. Valuable broadleaves may help balancing wood and non-wood production, while maintaining economic attractiveness of forests. The results have to be brought to the target audience in an adequate form.

- There exists much knowledge about suitable site conditions for the different valuable broadleaved species; they generally require high nutrient levels and good water supply.
- There is a lack of knowledge about provenances and genetics of valuable broadleaves, especially concerning their reaction to climate change. The knowledge base of existing seed orchards and clonal reproductive material should be communicated more widely.
- To produce high-value the trees have to be tended intensively for 3 to 4 decades. A high input of labour over a long time is needed.
- The price of the timber depends of the quality, dimension and on the market value.
- Valuable broadleaves often are important characteristics in the landscape and valuable elements of biological diversity. When well-tended they may provide additional benefit.

8 List of publications and presentations

8.1 Publications arising directly from Action E42

BASTIEN, J.-C., DE CUYPER, B., and CLARK, J.R. (submitted). Inventory of improved valuable broadleaved forest reproductive materials in Europe. *Forestry.*

CLAESSENS, H., OOSTERBAAN, A., SAVILL, P. (submitted) A review of the characteristics of black alder (*Alnus glutinosa* (L) Gaertn.) and their implications for silviculture guidelines. *Forestry*.

DOBROWOLSKA, D., HEIN, S., OOSTERBAAN, A., SKOVSGAARD, J.P., and WAGNER, S. (2008) Growth and silviculture of European ash (*Fraxinus excelsior* L.). http://www.valbro.uni-freiburg.de/

GIULIETTI, V. (2007) *Single tree oriented management in order to improve timber quality and value of broadleaved forests.* In: Short-Term Scientific Mission report for Working Group 2, COST Action E42. pp. 6.

HEIN, S.; COLLET, C.; AMMER, C.; LE GOFF, N.; SKOVSGAARD, J.P.; and SAVILL, P. (accepted): A review of growth and stand dynamics of *Acer pseudoplatanus* L. in Europe: implications for silviculture. *Forestry*.

HEMERY, G. (2007) *Forest management and silvicultural responses to predicted climate change impacts on valuable broadleaved species*. In: Short-Term Scientific Mission report for Working Group 1, COST Action E42. 191 refs. pp. 81. http://www.ForestryHorizons.eu/

HEMERY, G. (accepted). Forest management and silvicultural responses to projected climate change impacts on European broadleaved trees and forests. *International Forestry Review*.

HEMERY, G., CLARK, J., ALDINGER, E., CLAESSENS, H, MALVOLTI, M., O'CONNOR, E., RAFTOYNNIS, Y., SAVILL, P. and BRUS, R. (submitted). Growing scattered broadleaved tree species in a changing climate – risks and opportunities. *Forestry*.

HYNYNEN, J., NIEMISTÖ, P., VIHERÄ-AARNIO, A., BRUNNER, A., HEIN, S., and VELLING, P. (submitted). Silviculture of birch (*Betula pendula* Roth. & *Betula pubescens* Ehrh.) in Europe. *Forestry.*

MOHNI, C., PELLERI, F., and HEMERY, G.E. (2008) The modern silviculture of *Juglans regia* L: a literature review. http://www.valbro.uni-freiburg.de/

NICOLESCU, V.N., HOCHBICHLER, E., COELLO, J., RAVAGNI, S., and GIULIETTI, V. (submitted). Ecology and silviculture of wild service tree (*Sorbus torminalis* (L.) Crantz*)*: a literature review. *Forestry.*

OOSTERBAAN, A.; HOCHBICHLER, E.; NICOLESCU, N.; SPIECKER, H. (in press). Silvicultural principles, phases and measures in growing valuable broadleaved tree species. Die Bodenkultur 59 (1-4).

POLLEGIONI, P. (2007) STSM report: Application of NBS-profiling technique in Juglans spp. 16 refs, pp. 9. http://www.valbro.uni-freiburg.de/

RADOGLOU K, DOBROWOLSKA D, SPYROGLOU G, NICOLESCU VN (2008) A review on the ecology and silviculture of limes (*Tilia cordata* Mill., *Tilia platyphyllos* Scop. and *Tilia tomentosa* Moench.)

SINCA, I. (2008) *STSM report: State-of-the-art of valuable broadleaves silviculture in Austria*. 26 refs, pp. 12. http://www.valbro.uni-freiburg.de/

SKOVSGAARD, J.P.; O'CONNOR, E.; GRAVERSGAARD, H.C.; HOCHBICHLER, E.; MOHNI, C.; NICOLESCU, N.; NIEMISTÖ, P.; PELLERI, F.; SPIECKER, H.; STEFANCIK, I.; ÖVERGAARD, R. (2006) *Procedures for forest experiments and demonstration plots.* http://www.valbro.uni-freiburg.de/

STORCH, J.; BRIX, M.; SPIECKER, H. (2007) COST: Edellaubbäume im europäischen Fokus/ Valuable broadleaves in the European focus of interest. *AFZ-Der Wald* (2007) 19: 1046.

8.2 Presentations at COST E42 meetings

Authors	Subject
Ahtikoski, A.	Economy of high quality birch management
Broadmeadow, M.; Wohlleber, T.; Wilson, S.: Ray, D.; Grieves, Y.	Climate change and the future of valuable broadleaves in the UK
Bulfin, M.; Short I.; Radford, T.	Management of New Plantation Broadleaves: Formative Shaping
Brugnoli, E.; Pellegrini, M.; Manieri, M.; Lauteri, M.	The application of stable isotopes to study Biosphere-Atmosphere interactions in Mediterranean Forests Ecosystems
Collin, E.	Conservation and utilisation of genetic resources of European elms
de Cuyper, B.	Conservation and Utilisation of Forest Genetic Resources
de Cuyper, B.	Selection and Breeding of Valuable Broadleaved Tree Species
de Cuyper, B.	European inventory of improved varieties of valuable broadleaves
de Cuyper, B.	Pan-European Provenance Trial - Questionnaire
Douglas, G.	Genetic improvement of ash (Fraxinus excelsior)
Ducci, F.; Malvolti, M.	Recent developments in the selection and breeding programme on Juglans spp. in Italy
Eşen, D.	Turkish Forest Resources
Eşen, D.	The role of weed management in growing valuable broadleave tree species
Fineschi, S. ; Bagnoli, F.; Vendramin, G.G.	The role of historical and evolutionary factors on the dynamics of forest tree populations
Frascaria- LaCoste, N.; Raquin, C.; Dufour, J.; Morand- Prieur, M.; Fernandez, J.; Gerard, P.; Bertolino, P.; Nowak, L.	Population Genetics of Fraxinus spp. in France: Achievements and Perspectives
Hagqvist, R.	Curly beech (*Betula pendula var. carelica*) and its management in Finland
Heräjärvi, H.	Birch - properties and utilisation
Hemery, G. E.	Presentation of STSM undertaken on the impact and opportunities arising from climate change.
Kupka, I.	Pruning of young Wild Cherry trees
Malvolti, M.E.; Pollegioni, P.; Ducci F.	Characterization of walnut genotypes for production of hybrids: a case study in Italy
Mindas, J	Climate Change Consequences for Forest Tree Species
Musch, B.; Oddou, S.; Valadon, A.; Le Guerroué, B.; Lévèque, L.	Wild service tree - Result of research and management implications
Németh, R.; Molnár S.	Utilisation of walnut (Juglans), robinia (Robinia pseudoacacia) and ash (Fraxinus) on the basis of Hungarian experiences
Nicolescu, N.-V.	Early silivicultural interventions in *naturally regenerated mixed stands* including valuable broadleaved species
Niemistö, P.	Management of birch – methods to produce high quality birch
Nocetti, M.; Brunetti, M.; Ducci, F.; Romagnoli M.	Wood characterization of clones selected for valuable timber production: the case study of Italian wild cherry
Nylinder, M.; Woxblom, L.	Industrial utilization of hardwood in Sweden

Pakenham, R.	Growing Valuable Broadleaved Tree Species: Silvicultural Perspective
Pelleri, F.; Crivellaro, A.; Giulietti, V.; Pividori, M.	Ash-sycamore secondary forests: a new chance for the Italian Alpine region?
Pilotti, M.; Brunetti, A.; Tizzani, L.; Gallelli, A.; Lumia, V.; Gervasi, F.; Loreti, S.	Gene candidates for perception and signal transduction in the disease resistance response of woody species
Stener, L.	Results from genetic tests of Betula pendula and its impact on breeding in southern Sweden
Viherä-Aarnio, A.	Ecology of birch species

8.3 Recommended reading list

Belgium

CLAESSENS H., THIBAUT A., RONDEUX J. (1993) - Facteurs écologiques de production du frêne en Condroz et productivité des stations potentielles [Ecological factors of Ash productivity and potential sites in Condroz Ecoregion]. *Les Cahiers Forestiers de Gembloux*, 11, 25 p.

CLAESSENS H., PAUWELS D., THIBAUT A., RONDEUX J. (1999) - Site Index Curves and autoecology of Ash (*Fraxinus excelsior* L.), Sycamore (*Acer pseudoplatanus* L.) and Cherry (*Prunus avium* L.) in Wallonia (Southern Belgium). *Forestry* 72(3), 171-182.

CLAESSENS H. (2004) – Réflexion sur le détourage des feuillus à croissance rapide [Some reflexion about local thinning araound leading trees]. *Forêt Wallonne* 71, 3-11.

CLAESSENS H. (2005) – *L'aulne glutineux, ses stations et sa sylviculture [sites and sylviculture of Black alder]*. Forêt wallonne, Louvain-la-Neuve, 198p.

DE CUYPER, B., SONNEVELD, T., TOBUTT, K.R. 2005. Determining self-incompatibility genotypes in Belgian wild cherries. Molecular Ecology, 14, 945-955

JANSE, J.D. 1981. The bacterial disease of ash (*Fraxinus excelsior*), caused by Pseudomonas syringae subsp. savastanoi pv. Fraxini. I. History, occurrence and symptoms. European Journal of Forest pathology, 11, 306-315

MURANTY, H., SCHERMANN, N., SANTI, F., DUFOUR, J. 1998. Genetic parameters from a wild cherry diallel: consequences for breeding. Silvae Genetica, 47, 249-257

THIBAUT A. (2004) – Autécologie du merisier et de l'érable sycomore en Région wallonne [Autecology of Cherry and Sycamore in Wallonia (Southern Belgium)]. *Forêt Wallonne*, 73, 40-47

THIBAUT A., CLAESSENS H., RONDEUX J. (2004) - Site index curves for *Alnus glutinosa* (L.) Gaertn. in Southern Belgium : the site impact on the curve shape. *Forestry* 77 (2), 157-171.

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Czech Republic

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9 Appendices

9.1 Participants

Table 8 The 25 countries participating in COST E42

Austria	Ireland	Slovakia
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Croatia	Lithuania	Spain
Czech Republic	Netherlands	Sweden
Denmark	Norway	Switzerland
Finland	Poland	Turkey
France	Portugal	United Kingdom
Germany	Romania	
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9.2 COST E42 Meetings

Table 10 COST E42 Meetings and Topics

Place		Dates	Topic
Bussels	Belgium	03. -05.11. 2004	Inaugural meeting
Thessaloniki	Greece	18. -21.05. 2005	Workshop on Wood Quality
Leuven	Belgium	18. -22.04. 2006	Workshop on genetics
Oxford	UK	02. -04.10.2006	Site change issues and site requirements of the selected valuable broadleaved tree species
Toulouse	France	23 - 25.11.2006	Working Group 3 meeting
Jylland region	Denmark	28.- 30.11.2006	Field experiments and demonstration plots
Lahti and Savonlinna	Finland	10. -14.06. 2007	Pre-commercial and commercial thinning & pruning of Betula species.
Brasov	Romania	18. -22.09. 2007	Early silvicultural interventions in mixed stands including valuable broadleaved species
Laglow	Poland	04.- 07.02.2008	WG 3 meeting - Cultural values of valuable broadleaved trees
Orvieto	Italy	07.- 11.05.2008	Noble hardwood species for development: improvement of agro-environment and timber production.
Freiburg	Germany	06.- 09.10.2008	International Conference

9.3 Short-Term Scientific Missions

Table 11 Short term scientific missions undertaken within COST E42

Year	Name	Country	Host Institution and Country	Topic
2007	Dr Gabriel Hemery	UK	University of Bordeaux, Bordeaux (FR),	Forest management and silvicultural responses to predicted global climate change on valuable broadleaved trees
	Paola Pollegioni	Italy	Plant Research International Wageningen University Research Centre,Wageningen (NL)	Application of NBS-profiling technique in *Juglans* spp
	Valentina Giulietti	Italy	Institute of Silviculture,Vienna (AT),	Single tree oriented management in order to improve timber quality and value of broadleaved forests
2008	Ionut Cristian Sinca	Romania	Universität für Bodenkultur Wien, Wien (AT)	State-of-the-art of valuable broadleaves silviculture in Austria

9.4 About COST

COST- the acronym for European **CO**operation in the field of **S**cientific and **T**echnical Research- is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 35 European countries to cooperate in common research projects supported by national funds. The funds provided by COST - less than 1% of the total value of the projects - support the COST cooperation networks (COST Actions) through which, with EUR 30 million per year, more than 30.000 European scientists are involved in research having a total value which exceeds EUR 2 billion per year. This is the financial worth of the European added value which COST achieves.

A “bottom up approach” (the initiative of launching a COST Action comes from the European scientists themselves), “à la carte participation” (only countries interested in the Action participate), “equality of access” (participation is open also to the scientific communities of countries not belonging to the European Union) and “flexible structure” (easy implementation and light management of the research initiatives) are the main characteristics of COST.

As precursor of advanced multidisciplinary research COST has a very important role for the realisation of the European Research Area (ERA) anticipating and complementing the activities of the Framework Programmes, constituting a “bridge” towards the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of “Networks of Excellence” in many key scientific domains such as: Biomedicine and Molecular Biosciences; Food and Agriculture; Forests, their Products and Services; Materials, Physical and Nanosciences; Chemistry and Molecular Sciences and Technologies; Earth System Science and Environmental Management; Information and Communication Technologies; Transport and Urban Development; Individuals, Societies, Cultures and Health. It covers basic and more applied research and also addresses issues of pre-normative nature or of societal importance.

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