PROCEEDINGS

The 9th IUFRO
International Beech Symposium
organized by IUFRO working party 1.01.07
"Ecology and Silviculture of Beech"

12-17 September, 2011

Edited by
Sven Wagner
Nils Fahlvik
Holger Fischer

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The 9th IUFRO International Beech Symposium

12-17 September, 2011, Dresden/Göttingen, Germany

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Proceedings - The 9th IUFRO International Beech Symposium organized by IUFRO Working party 1.01.07 "Ecology and Silviculture of Beech", 12-17 September, 2011, Dresden/Göttingen, Germany

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Preface

The 9th IUFRO (International Union of Forest Research Organizations) Beech Symposium was held during September 12 - 17th, 2011, at hotel Pullmann in Dresden, Saxony in the eastern part of Germany. The conference included a half-day field trip to the campus of the Department of Forest Sciences of the Technische Universität Dresden in Tharandt as well as to Tharandt forest. At this opportunity, the 200 years anniversary of Forest Science in Tharandt was also commemorated.
Furthermore, a two-day field excursion to destinations in Thuringia and Lower Saxony (central Germany) focused on regeneration of beech (*Fagus sylvatica*), beech in mixtures and multi structural forests of beech.

The aims of the conference were to exchange and share state-of-the-art knowledge on the ecology and silviculture of beech (*Fagus*) forests among researchers and forest managers worldwide. Additionally, to reflect the current scientific achievements on the future directions for sustainable management of beech forests in the changing social needs and global climate.

77 participants from 21 countries attended the conference, ranging from senior researchers to PhD students. In the 3-day technical sessions, 5 keynotes, 25 volunteer orals, and 29 posters where presented. The succeeding sessions covered the following themes:

(1) Paleoecology and distribution of beech
(2) Drought and the response of beech
(3) Beech genetics
(4) Structure and dynamics of natural beech forests
(5) Regeneration of beech forests
(6) Management of beech forests

A special emphasis was given to findings at borders of the distribution range of the several beech species, e.g. northward expansion, genetic differentiation, and growth rings variation and to experiments highlighting the ecophysiological traits relevant to climate change phenomenon, e.g. in the regeneration phases.

These proceedings are published as a collection of the extended abstracts of papers being approved by the Scientific Committee and of abstracts of the posters presented at the conference.

We thank all of the people who participated in the conference, with special gratitude to the members of the Scientific Committee, keynote speakers and moderators of the technical sessions. Furthermore, the local colleagues did a very good job in hosting the field excursions. We also express our sincere thanks to all of the people and organizations who sponsored the conference.

Editors
Sven Wagner
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EXTENDED ABSTRACTS

*: corresponding author

_: presenting author (underlined)

THE FOSSIL HISTORY OF *FAGUS*

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Introduction

At the end of the 19th century, Gaston de Saporta (1873, 1884) suggested that beeches of the European Tertiary were derived from Cretaceous ancestors of North America. For Europe, Saporta (1884) considered the Early Miocene *Fagus pristina* Sap. as the prototype of the Miocene beeches and emphasised the striking similarity of *F. pristina* with the modern North American species *F. grandifolia* Ehrh. While the North American beeches underwent little evolutionary change in the course of the Tertiary, the Eurasian populations radiated and diversified into the modern *F. sylvatica* L. and *F. crenata* Blume (Saporta, 1884). Later scholars suggested various other evolutionary pathways leading to the modern diversity of beeches (e.g., Laurent & Marty 1904-1905; Kolakovsky 1960; Tanai 1974) but were largely hampered by the unclear taxonomy of modern beeches.

A landmark study for the systematics of modern beeches was provided by Shen (1992), who proposed two major groups within beeches, one comprising the eastern and north-eastern Asian species *F. engleriana* Seemen ex Diels, *F. japonica* Maxim., and *F. okamotoi* Shen, the informal subgenus *Engleriana*, and the other comprising the North American *F. grandifolia* and the Eurasian *F. sylvatica*, *F. crenata*, *F. longipetiolata* Seemen, *F. hayatae* Palib. ex Hayata, *F. lucida* Rehder & E.H. Wilson, and *F. chienii* W.C.Cheng, the informal subgenus *Fagus*. Shen's subdivision was later corroborated by morphological and molecular phylogenetic studies (Denk et al. 2002, 2005; Denk 2003; Grimm et al. 2007; Göker & Grimm 2009). These studies also demonstrated that the members of the subgenus *Fagus* show a complex pattern of molecular differentiation and generally low overall ITS divergence and high degrees of polymorphism. To fully understand the evolution of the modern members of the subgenus *Fagus* and the split between the two major groups in modern beeches, the fossil record plays a key role.

This contribution will provide an overview of the current knowledge surrounding the fossil history of beech trees and show how this knowledge enhances our understanding of modern patterns of morphological and molecular diversity in the genus *Fagus*.

Material and Methods

The presentation is based on a number of previous palaeobotanical studies (e.g. Denk 2004; Manchester & Dillhoff 2004; Denk & Grimm 2009) and on current research (recently collected fossil material from Anatolia). Previous molecular and morphological studies provided a systematic framework for placing fossils into a phylogenetic context (Denk et al. 2002, 2005; Denk 2003; Grimm et al. 2007; Göker & Grimm 2009).

Results and Discussion

No reliable records of beech trees are known from the Cretaceous and the Paleocene (the earliest epoch in the Tertiary, ca 66-56 million years ago). The success story of beech trees started 50 million years ago (late Early Eocene) in the northern Pacific area ("Beringia"). Oldest fossils unequivocally belonging to *Fagus* are from western North America, Kamchatka, and north-eastern China (Manchester & Dillhoff 2004; Fotjanova 1982; Denk & Grimm 2009; **Fig. 1**). These fossils are morphologically variable and cannot be attributed to either the subgenus *Fagus* or *Engleriana*. Based on the composition of the fossil plant assemblages, *Fagus* was part of mixed broadleaved deciduous and conifer forests. From the northern Pacific region, the genus colonized vast areas across the Northern Hemisphere. The earliest record of *Fagus* in Europe is from the Early Oligocene (ca 32 million years) of Germany (Denk et al., unpublished data). The arrival of beech trees in western Eurasia coincides with the closure of the Turgai Strait that had prevented floral and faunal exchange between Asia and Europe prior to the Oligocene (**Fig. 1**; Rögl 1999). During the Oligocene, a first differentiation within *Fagus* into a Pacific lineage (China, Japan, and western North America) and a continental Eurasian lineage is seen. The latter comprised a single widespread species, *F. castaneifolia* Unger, distributing from Central Asia to Western Europe, with a stratigraphic range from 32 million years ago to at least 15 million years ago (Middle Miocene). While chiefly part of mixed broadleaved deciduous and conifer forests, *Fagus* appears to have been among the dominant tree species in some of the lowland middle Oligocene forest communities of Central Germany (Mai & Walther 1991). Beech trees reached their maximum distribution about 20-15 million years ago (Early to Middle Miocene), when they thrived all over Eurasia and North America. At that time, beech forests and in general broadleaved deciduous forests not only were present in Iceland and Kamchatka, but probably also covered the northern margin of Arctic North America as evidenced by rich fossil assemblages, containing both pollen and leaves of *Fagus*.

A second differentiation appears to have occurred at the end of the Oligocene (about 23 million years ago), when the modern subgenus *Engleriana* emerged in north-eastern Asia. Importantly, fossil and modern members of this subgenus have largely remained restricted to this area. In the course of the Miocene, the North American beech trees became increasingly isolated from the Eurasian populations, leading to the disruption of the continuous area of beech in Eurasia and North Americam after 15 million years ago (**Fig. 1**). After this time, the Bering Land Bridge may not have played a major role for transcontinental migration of beech trees. In Central Asia, the uplift of the Himalayas caused colder and more continental conditions leading to the extinction of beech trees in the central part of Eurasia and eventually led to the isolation of western Eurasian (ancestor[s] of *Fagus sylvatica* s. l.) and East Asian beeches. This process of isolation, however, is not very well understood. Miocene and Pliocene beeches of western Eurasia display a mosaic of morphological features found today in East Asian and western Eurasian species of the subgenus *Fagus*. This, and shared molecular patterns among the modern species of the subgenus *Fagus* would suggest on-going gene flow during the Miocene. In particular, the close morphological and genetic similarity of *F. sylvatica* and *F. crenata* points to a connection between the western and eastern populations extending into the Late Miocene. Such a hypothetical connection could have been achieved by the so-called Himalayan Corridor, a connection that has been effective for other related plant groups such as the Ilex oaks within the genus *Quercus*. The modern western Eurasian *F. sylvatica* with its complex genetic structure, appears to be derived from two western Eurasian fossil species, *F. gussonii* Massal. And *F. haidingeri* Kov. At high latitudes, the global climatic deterioration led to a shift of climatic zones and vegetation belts. As snow and ice climates (mainly ET and Dfc climates according to Köppen; see Kottek et al. 2006) spread, the temperate climates favoured by beech trees (mostly Cfb climates) became restricted to the mid-latitudes. In North America, a single species, *Fagus grandifolia* survived, and the modern distribution in Mexico and eastern North America was established. During several phases of the Tertiary, the North Atlantic Land Bridge, the Himalayan Corridor, and the Bering Land Bridge might have facilitated transcontinental gene exchange among populations and species of beech trees (**Fig. 1**). The genetic differentiation between the modern taxa is relatively low as compared to other Northern Hemispheric tree genera (e.g. maples). Nevertheless, as also in oaks, beech trees show high levels of intraindividual variability, which is of some diagnostic value. Furthermore, modern species are clearly distinct by their morphologies and these can be used to trace lineages in time and space. If all evidence is combined, two main lineagescan be identified, which appear to have been isolated for about 20 million years.These lineages correspond to Shen's (1992) subgenera *Engleriana* and *Fagus*.

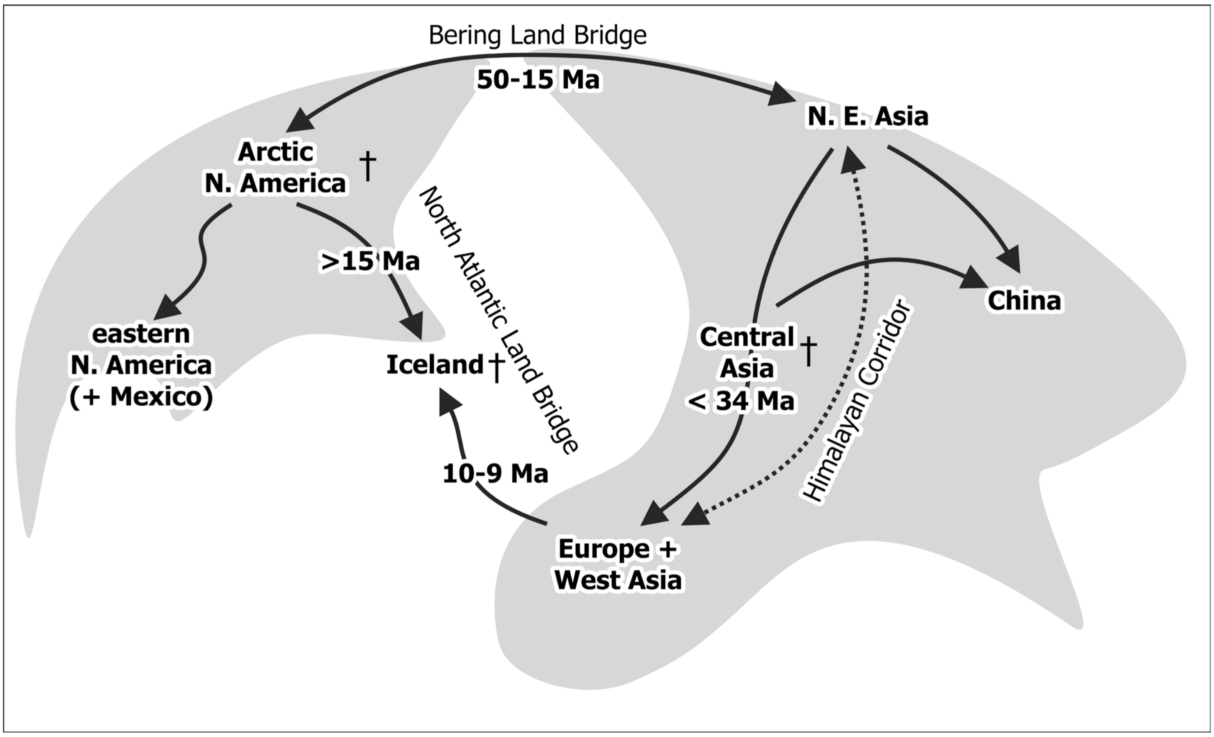

Figure 1: Migration routes of *Fagus* during the last 50 million years (Ma). Note that although *Fagus* colonized Iceland from the west and from the east, it never migrated from Europe to North America or vice versa. †indicates areas that no longer include *Fagus*. Broken line indicates that this corridor is hypothetical but may have been effective after 15 Ma.

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A VIEW OF THE FUNCTIONAL RESPONSE OF BEECH TO DROUGHT. WHAT DO WE KNOW? AND, WHAT DO WE NEED TO KNOW IN THE FRAME OF THE CLIMATIC CHANGE?

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Introduction

Fagus sylvatica L. may be one of the forest tree species with the widest range of distribution in Europe, which has driven this species to be one of the keystones of forest research from many years. Its high shade tolerance makes *F. sylvatica* to be highly competitive with other co-existing tree species of temperate forest ecosystems. However, its ability to regenerate under light-limiting shady conditions of many forest canopies does not seem to be in pace with the capacity to endure against other stresses such as drought (Aranda et al. 2001, Robson et al. 2008). This issue has gained relevance recently, particularly when perturbations of high intensity may be expected to increase in the future, such as the extreme dry period that affected important areas of Central Europe during 2003 summer (Ciais et al. 2005, Leuzinger *et al.* 2005; Granier *et al.* 2007). In fact, the intensification of water stress at the southward area of distribution of this species in the last decades seems to be the cause of the first symptoms of dieback and retreat of the species at the training edge (Jump *et al.* 2006). On the other hand, a lengthening of the growing season, and more mild winters at the North might be the basis for more favourable growing conditions for beech, increasing its current area at the North with latitudinal shifts at the rear edge (Meier et al. 2011).

Despite the huge knowledge accumulated on the physiology of beech during last decades, there are several keystones aspects that should be addressed in the future. Questions related with basic physiological issues, such as the hydraulic design of beech and its tolerance to withstand higher tensions in the xylem as a consequence of dry periods, or the inter-play between hydraulic sufficiency and carbohydrates balance, are of paramount importance from a functional point of view to understand the process of acclimation to new scenarios. Both issues are important to gain new insights for the understanding of current and future declining process in beech stands. Other aspects of high importance for the sustainability of beech forests are those related with the inter- and intra-population variability to water stress. So both the differential response of local populations, and the phenotypic plasticity, will influence the fate of future beech forests. Therefore, the selection of adequate reproduction materials will be important in order to improve the management of new stands better adapted to the expected harsher climatic conditions in the South. In addition, it should be considered that most of the studies performed to date have assessed the physiological response of beech under current atmospheric CO_2 concentration, but it has rarely been considered that beech forests will have to cope with a CO_2-enriched atmosphere in the future. All these questions will be treated briefly through the talk. In this summary, only some comments are noted on the vulnerability of the species to drought.

Materials and Methods

This extended summary comprises some few results from different experimental approaches of the physiological response of beech. Most of the data come from experiments carried out during the last 15 years in a population at the southern limit of distribution of this species. “Montejo de la Sierra” beech-oak forest is sited at the centre of the Iberian Peninsula. The stand must cope with recurrent dry periods that impact the optimal performance of the species. This has been observed at different scales, from seedlings during natural recruitment or artificial plantations (Aranda et al. 2002; Aranda et al. 2004), to mature stages (Aranda et al. 2000, Aranda et al. 2005). Overall, results show the high sensitivity of beech, with respect to other co-ocurring temperate species, to a decrease in soil moisture during Summer period.

Different issues are briefly treated in relation to the functional response of beech. This could be framed into the current knowledge of the physiological response of the species to drought. In addition, some additional remarks will be pointed out through the oral presentation on some possible scopes to prospect in depth in the near future regarding the response of beech to drought.

Results and Discussion

Beech is well-known for being a high shade tolerant species, but also by its low drought tolerance. This is clear when comparing with other co-ocurring species at its southern area of distribution. For instance some traits directly related to drought tolerance, such as those regarding water economy, set a clear differentiation between *F. sylvatica* and the more drought tolerant oak *Q. petraea* (Figure 1a).

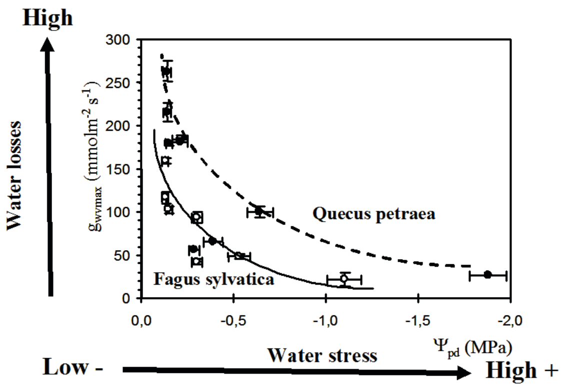

Figure 1a The decrease in the stomatal conductance to water vapour in response to water stress is different according to the tolerance of the species. *F. sylvatica* (continuos line) shows stomatal closure earlier than the most drought tolerant *Q. petraea* (dotted line).

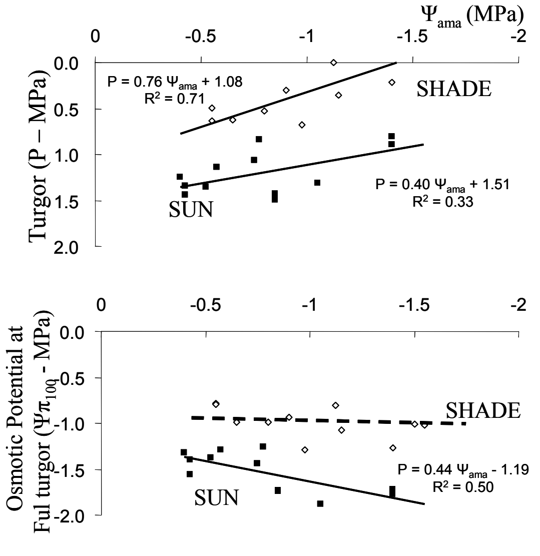

Figure 1b The decrease in osmotic potential at full turgor ($\Psi\pi_{100}$ – MPa) in response to water stress (osmotic adjustment) is impaired under shade conditions (lower graph). This has a direct effect in the capacity to maintain turgor under increasing water stress (upper graph). White points – shade; black points – sun.

On the other hand, dry periods are expected to increase in importance, especially for populations at the South of Europe. In this area, recruitment takes place under conditions where seedlings should cope with low soil moisture content in the shallow rooting zone in the understory of mature stands. This water stress situation is acute at the end of the summer months, compromising the overall carbon balance of the new offspring (Rodriguez-Calcerrada et al. 2010), even its survival (Robson et al. 2008). At last, it implies the balance of some trade-offs, such as the capacity to develop drought tolerance mechanisms under shade conditions (Figure 1b), and to maintain a positive carbon balance at the end of the Summer.

Carbon uptake is also limited at the mature phase from mid-summer to early autumn. The decrease in net photosynthesis is coupled to an increase in the limitation to water losses by trees. This has been observed so much from leaf gas exchange measurements into the canopy (Figure 3), as well as when the overall water used by the tree is considered (Figure 4).

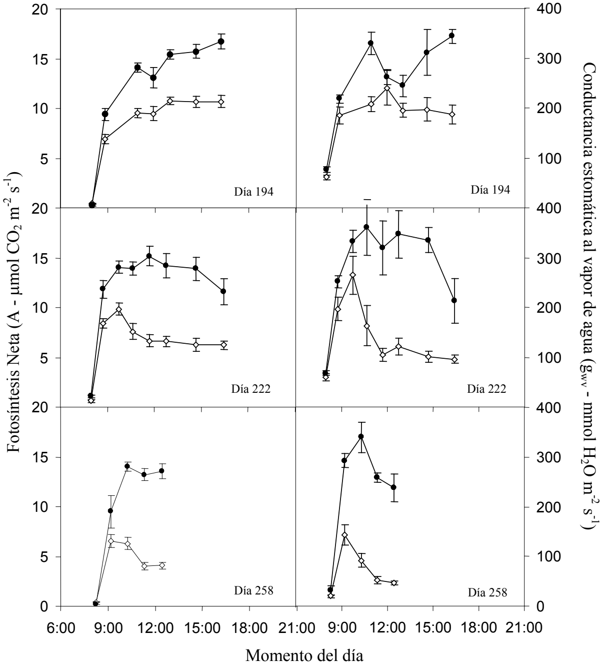

Figure 3 *F. sylvatica* shows a progressive decrease in net photosynthesis (left) thorough the growing season (top – June, middle –July, down – beginning of September). This decrease goes in parallel with the drop in stomatal conductance to water vapour (right). F. sylvatica white points, Q. petraea black points.

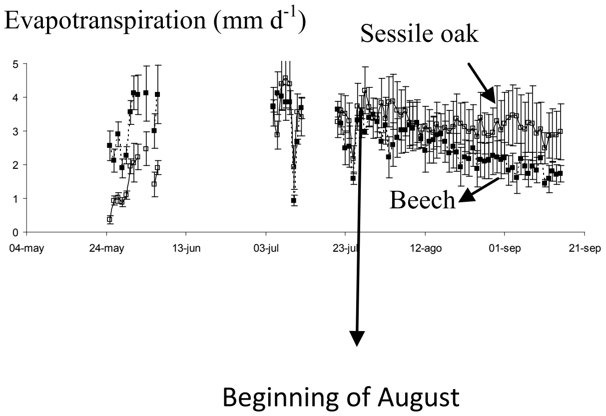

Figure 4 It merits especial attention the performance of both species at the end of summer. Beech shows a higher decrease in terms of daily values of evapo-transpiration calculated from sap flux data recorded in different mature trees of *Q. petraea* and *F. sylvatica*.

Other important aspect to consider would be the comparative drought response by populations at its southern area of distribution, such as “Montejo”, regarding northwardly populations. Some data seems to point out to a better performance (some information is showed through the talk). This issue deserves new studies, along with the potential to face new and more intense peaks of dry periods according to the intra-population genetic variability within populations. The adaptative potential enclosed within beech populations, and the phenotypic plasticity, will be the two main mechanisms to assure the adaptability of beech forests in the sort-term under new climatic scenarios. In the oral presentation, a more detailed review is done on some of the aforementioned aspects regarding the physiological response of beech to abiotic stresses.

Knowledgement:

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MANAGEMENT OF EUROPEAN MIXED BROADLEAVED STANDS WITH BEECH

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European beech tolerates a wide range of site conditions and accommodates well to interspecific competition and, therefore, may be found in different types of mixture with many other tree species. In mixture, beech is highly competitive and often tends to dominate the other species. The dynamics of changes in species dominance is determined by species composition, initial stand structure, site conditions, and browsing pressure.

On the southern and the western margins of its distribution area, beech is threatened by the expected future climatic conditions. Silviculture of beech dominated mixed stands must take into account this threat. In stands where beech is vulnerable, silviculture should aim at controlling beech down to a level where it does not impair the development of the other species, which should constitute the future stand. In stands where the future of beech is secured, silviculture should aim at a balanced mixture fulfilling the management objectives, which often also requires a control of beech dominance.

The presentation focuses on the control of beech dominance in mixed broadleaved stands at different developmental stages, from the regeneration to the adult stand, and is mainly based on examples from silvicultural experiments conducted in France.

MANAGEMENT OF CENTRAL EUROPEAN BEECH STANDS

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1. Introduction

Beech forest area today in Germany makes up 14.8 % of the total forest area which is only 16 % of the potential beech forest area. Since the postglacial arrival of beech about 3,000 years ago humans converted most of the beech forests to agriculture, settlements, and later on to conifer forests. There are no untouched old-growth forests left in Central Europe, with the exception of some reserves at the eastern margin in Slovakia and Ukraine. Therefore, it is not surprising that nature conservationists strongly demand large reserves of unmanaged beech forests in Germany, and a close to nature forestry in the remaining managed forests.

Beech possesses some characteristics that fit well to partial cutting systems, and also to heavy thinning interventions in older stages: shade tolerance, storm stability, and strong ability to crown expansion after release even in older stages. Beech is able to outcompete most other species and forms pure stands. It is a late successional species which is adapted to a light, single-tree disturbance regime (Wagner et al., 2010). In case this regime would shift to more frequent and heavier disturbances, e.g. due to climate change it might be desirable to have more mixed beech stands which contradicts the actual demands of nature conservationists.

Compared with Norway spruce, beech timber production stands out due to a longer rotation period (120-160 years), lower volume, but equivalent or higher dry weight production, less production risks, and on average somewhat lower prices per cubic meter wood. The requirements for high-quality saw-timber are demanding: at least 40 cm diameter, straight, no knots, no spiral grain, no red-coloured heartwood, and no other flaws like e. g. black spots from beech bark disease. This high quality can be achieved by self-pruning in dense stands. Long production periods entail the development of red heartwood which still is the most important cause for downgrading beech saw timber. Thus, it is desirable to shorten the production period to about 100-120 years.

Within a multi-purpose forestry in Germany, the following goals are aimed for in an integrative way within one stand: income for the landowner by production of high-quality timber, protection of biodiversity by leaving a certain amount of deadwood and very old trees in managed stands, and recreation.

2. Thinning, a common practice in beech management

Thinning, including cleaning or pre-commercial thinning is generally applied in German beech forest management in order to increase the amount of high-quality saw-timber and to accelerate the production process. The aim is to shift as much as possible of the total increment to the best trees without reducing the total growth too much.

Cleaning is a special sort of thinning in the thicket stage with the following main objectives:

- Removal of “wolf-trees” (predominant trees of clearly worse quality than neighbouring dominant trees).
- Maintenance of high stand density to enhance natural pruning.
- Preservation of desired admixed-species by removing competitive neighbouring beeches.

Thinning should start when dominant beeches of good quality have reached a branch-free bole length of 7-9 m. During the following decades, thinning is repeated 1-2 times per decade until the age of about 90-100 years. Future crop trees (dominant trees of good quality) are released from competing dominant and co dominant neighbours by crown thinning. As a rule of thumb, 150-200 future crop trees ha^{-1} are selected at the first thinning. Those selected trees will be reduced step by step in the following thinnings to a number of 80-100 in the final stage. Overtopped trees are kept to build the intended understory layer, but they are not systematically supported by any specific intervention (Röhrig et al. 2006). Today, some managers select only 40-60 trees ha^{-1} and release them heavily in order to reach the target diameter in shorter time, and by this prevent red heartwood. This method increases the risk to choose the wrong tree as future crop tree, and it contradicts principles of close-to-nature silviculture, e.g. long regeneration periods.

3. Natural regeneration: Methods and Evaluation

While about 50 years ago, natural beech regeneration was regarded as difficult and risky, and only achievable by means of soil preparation and regular shelterwood (Burschel et al. 1964), today nobody applies soil preparation anymore. Two reasons can explain this: masting years occur more frequently (Schmidt 2006), and the change to small-scale cuttings and long regeneration periods is appropriate to beech ecology. Today, target diameter cutting which resembles single-tree selection or group selection with regeneration periods of 40-70 years is the prevailing regeneration method. A comparison with (i) a true single-tree selection beech forest and (ii) old growth forests in Albania and Slovakia leads to following results:

- The smaller proportion of the aggradation stage and the lacking terminal and degradation stages in managed forests are the decisive differences to old-growth forests (Tabaku 2000, Drößler and Meyer 2006).
- In old-growth forests small, single-tree gaps predominate. The structure of target diameter stands is characterized by much more and larger gaps adding up to a total gap area of 23 % which is 3-5 times more than in old-growth forests. In contrast, the single-tree selection forest has a gap structure well comparable to old-growth forests.
- Light availability on the forest floor in old-growth forests is very low and reaches on average 4.9 % of above canopy light. Only 15 % of all data are above 10 % light. In the single-tree selection forest and even more in the target diameter forest mean and maximum values are much higher, and 24 resp. 64 % of all measurements are above 10 % light.
- In spite of the darkness on the ground of old-growth forests, 90 % of all sample plots contained beech regeneration with a mean density of 2.4 individuals m^{-2} (Tabaku 2000). Less shade-tolerant species are totally missing. According to our studies (Drößler and Lüpke 2007, Petritan and Lüpke 2009) a light availability of 15 % above canopy light seems to be a threshold above which mixed species like *Acer pseudoplatanus*, *A. platanoides* and *Fraxinus excelsior* can compete successfully with beech.
- Recent studies show that beech is not only well adapted to shade but also to belowground competition (Wagner 1999, Lüpke and Hauskeller-Bullerjahn 2004, Rewald and Leuschner 2009, Petritan et al. 2011).

The results clearly show that regeneration methods which mimic the conditions in old-growth forests are optimal for beech regeneration, but suboptimal for mixed species.

4. Aiming for mixtures: seeding and planting European beech in Norway spruce stands

In Central Europe – varying by site and owner intention – the most important species to be mixed with beech are Norway spruce, Silver fir, European larch, Pedunculate oak, European ash, Norway and Sycamore maple. From these species, Norway spruce is by far the most relevant in forest conversion now, as large proportions of pure spruce stands have been enriched with beech since the 1980ies. In those stands, regeneration techniques were improved a lot in recent years being more diversified, i.e. seeding and planting and more situations adapted, i.e. more or less intensive canopy manipulation, now. It has been proven that the qualitative development of the beech regeneration is influenced from both the spacing within the regeneration cohort and the canopy density (Leonhardt and Wagner, 2006) simultaneously. Thus, the manager has to find an appropriate setting of determining environmental conditions. The situation gets even more complicated when an admixture of Norway spruce and Silver fir is aimed for in the regeneration. Today, forest practice prefers to steer competition and quality development outcome by a combined spatial aggregation and temporal segregation strategy when regenerating different species within a single stand. The ecology of beech and a temporal segregation of mixed species establishment demand for long regeneration periods. However, with succeeding harvest cuts the Norway spruce stands get more sensitive to storm felling and thus most often regeneration periods are shorter than 20 years.

5. Outlook: future research

Today, much concern is given to the issue of climate change and the advantages of beech-mixtures over pure stands in this regard (Ammer et al., 2008). Possibilities to establish those mixed stands may include regenerating beech in mixtures with more drought-tolerant species, and using direct seeding or planting to introduce drought-resistant beech provenances (Wagner et al., 2010) as well. Less emphasis is directed so far to admixture of pioneer tree species and their ability to secure for catastrophic events by their good dispersal ability. Besides the choice of the species and their optimized proportions, researchers are asking for advantageous spatial layouts of mixtures to safeguard beneficial effects of admixed species, decrease competition effects between species, enable for high-quality development of beech by intra-cohort competition, and facilitate the self-establishment of pioneers in case of catastrophic events simultaneously.

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AMERICAN BEECH: THE NEMESIS OF FORESTRY IN NORTHEASTERN NORTH AMERICA

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American beech (*Fagus grandifolia* Ehrh.) occurs as a native tree throughout much of eastern North America, and among the overstory in 20 forest cover types. It is a major component of Sugar Maple–Beech–Yellow Birch; Red Spruce–Sugar Maple–Beech; and Beech–Sugar Maple. These forests occur primarily toward the northern part of the species' range. Regeneration derives both from seedlings and root suckers, but stumps of small trees also sprout following cutting. Seed crops commonly occur every two years in Northeastern North America, with heavy masting less frequently.

Beech Bark Disease (BBD) has drastically reduced American beech as an overstory tree across an important part of its range. It started with the introduction of felted beech coccus (*Cryptococcus fagi* Baerensprung) into Nova Scotia during 1890. This scale insect creates an entry court for infection by a native *Nectria* fungi (primarily *Nectria coccinea* var. *faginata* Lohman, Watson, and Ayers, and sometimes *N. galligena* Bres.). BBD weakens and eventually kills most large and medium-size trees, and degrades their potential for sawtimber uses. At present it has spread across eastern Canada and northeastern United States as far west as Michigan, and southward to western North Carolina.

American beech produces root suckers that develop from adventitious buds forming in callus on shallow roots after some kind of injury. And while disturbance from logging and similar activities may increase their development, many unmanaged stands also have abundant root suckers. These also derive from shallow roots, possibly after wounds from natural causes (e.g., by animals, or movement of stones due to freezing and thawing of the soil). Some reports suggest that progression of BBD triggers increased suckering, resulting in the dense beech understory that has formed beneath many northern hardwood stands. Due to their high shade tolerance these suckers and any interspersed beech seedlings may persist for years, and ultimately develop into canopy positions beneath openings caused by a stand disturbance.

In the aftermath of BBD, forests throughout Northeastern North America have developed understory and mid-story layers dominated by these root suckers, making that species an invasive native plant. When dense, this beech understory interferes with other tree regeneration, and dramatically reduces herb species diversity and abundance. As a consequence, ecosystem complexity decreases, particularly as cutting or natural causes remove other species from the overstory canopy, promoting subsequent development of the small beech. Eventually, these trees also become infected by BBD and generally succumb before reaching 25-30 cm in diameter, halting stand development at the pole stage, with later replacement largely by beech root suckers from the understory.

These effects make management of American beech impractical within the aftermath forest and along the advancing front of BBD. Landowners can maintain the species in stands free of BBD or with apparently resistant or tolerant trees, using light partial cutting to promote small beech into overstory positions. Yet research has not provided effective means for identifying truly resistant clones. Most beech trees eventually become infected and die. That complicates management in yet unaffected or recently infected areas.

To successfully regenerate other species among infected stands, understory beech must be controlled using herbicides or by cutting. Chemical control commonly involves mistblowing with glyphosate to reduce understory density, plus stem injection of trees larger than about 8 cm dbh. Those treatments effectively reduce beech understory and mid-story interference and promote regeneration of other species following a reproduction method cutting, including shelterwood method and selection system treatments. Sites prepared this way also developed a diverse array of woody and herbaceous species common to the site, and forest community structure has not shifted toward domination by beech after the overstory disturbance.

Though limited, pilot trials at the SUNY-ESF Huntington Wildlife Forest using brushsaw cutting of understory beech beneath closed canopy stands during the growing season resulted in few stump sprouts, or suckers. Afterward, regeneration of sugar maple (*Acer saccharum* Marsh.) become abundant, and the density and diversity of understory herbs increased. By contrast, plots having a sizable canopy opening or a low-density overstory cover developed root suckers and some stump sprouts, particularly in proximity residual beech trees. And while labor intensive treatments using brush saws would prove costly for large areas, removing small beech using mechanized harvesting equipment might prove feasible, given a market for even sapling-size trees as biofuel. One trial using that method to remove all beech from a stand, including the small ones in understory positions, effectively controlled beech suckering, even beneath an open overstory of widely-spaced trees.

Loss of American beech has important ecologic implications, particularly for wildlife species that use the nuts as food. Beechnuts have a high protein and fat content that promotes higher survival and fecundity of mast-eating species, particularly during harsh winters. And while seed production among trees > 25-30 cm dbh has decreased by two-thirds to three-fourths following BBD infection, masting recently increased due to modest seed production on large numbers of smaller trees that eventually reached pole stage. Studies of small mammals and black bear (*Ursus americana*) indicate that populations of these animals, as well as species that prey on the small ones, cycle in synchrony with available mast. To that end, strategies that might maintain mast-producing beech in northern hardwood forests seem vital as a wildlife management tool.

Some northern hardwood stands have few beech seedlings, and mostly saplings of root sucker origin. Other stands have many seedlings, but few develop to taller than 0.6 m at most sites due to interference by taller root suckers. This suggests that some American beech clones may produce good mast crops, while little develops on others. So management to maintain beech for mast production, and other purposes, should focus on clones showing resistance to BBD and also at least a moderate potential for seedling production. This might include release treatments to promote root suckers off resistant or tolerant trees, and particularly at the margins of their root systems. That could facilitate a spreading of those clones around the original tree. Also, harvesting seedlings from around resistant trees for replanting in other stands might introduce less susceptible clones to infected sites.

Long-term decline of American beech and the resulting structural and compositional shifts in northern hardwood forests seem destined to maintain the species as a small and understory tree. It will not grow to large sizes, except for widely scattered resistant or tolerant trees. In the absence of active measures to control beech interference, other species will decline in abundance due to failure of advance seedlings to survive and develop. Widespread lack of treatments to reduce beech interference currently makes this long-term scenario likely. That will have serious ecologic and economic impacts across hardwood forests of northeastern North America.

For details, including citations, see Nyland et al. (2006a, 2006b), and Wagner et al. (2010).

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WHY HAD *FAGUS* EXPANDED DURING THE HOLOCENE DRY SPELL IN CHINA?

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Introduction

China is abundant in beech species. Five of ten species from the genus *Fagus* are distributed in southern China. Only small patches of *Fagus* forests, however, are confined to the subtropical zone and mixed with evergreen trees, deciduous broad-leaved trees and conifers in China, which is quite different from the vastly distributed *Fagus* forest in North America, Europe and Japan (Liu et al., 2003). Continental climate in the temperate northern China was suggested to be the limiting factor for *Fagus* distribution (Cao et al., 1995. However, how *Fagus* development has responded to the Holocene wetness changes remains unclear.

Methods

We built a database of pollen diagrams from 68 sites in temperate, subtropical and tropical China to show the Holocene expansion of *Fagus* in China. *Fagus* distribution and expansion were linked to dynamics of the East Asian monsoon system, including both the summer monsoon (Pacific monsoon) and winter monsoon.

Results and Discussion

There has been no *Fagus* distribution in the current temperate and tropical zone of China even since the onset of the Holocene. Sites with *Fagus* distribution were mostly along the Yangtze River.

We found no *Fagus* expansion even during the peak of summer monsoon which brought water from the Pacific northwestward to continental China. In contrary, an evident expansion of *Fagus* from ~4000 to ~2500 a BP when the summer monsoon (Pacific monsoon) had already weakened and the winter monsoon had strengthened (Fig. 1). This period was also the driest spell in China during the Holocene, as indicated by climate proxies from stalagmites and lake sediments (Dykoski et al., 2005; Zhao et al., 2009). *Fagus* expansion was limited in subtropical southern China, as indicated by pollen diagrams from different regions.

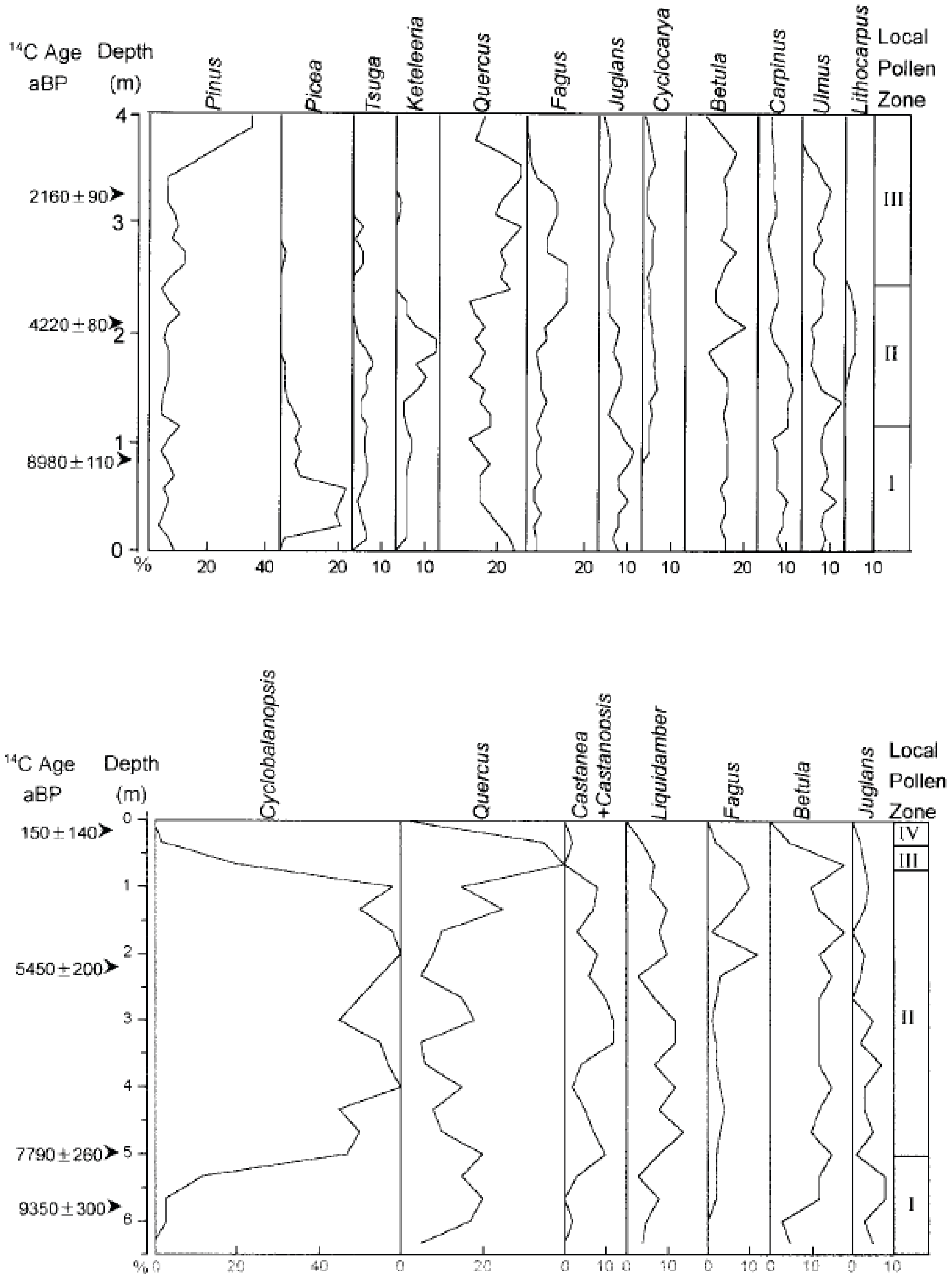

Fig. 1 Abbreviated pollen diagrams from Shenongjia (110.65ºE; 31.76ºN; upper panel) and Fanjingshan (108.85ºE, 27.90ºN; lower panel). *Fagus* expansion was found ~4000 to ~2500 ^{14}C a BP. Cited from Liu et al. (2003)

Although low annual precipitation was unfavorable for *Fagus*, decreased seasonality might lead to *Fagus* expansion during the Holocene in China. Winter precipitation might have increased in southern China owing to increase frontal rain, when humid air mass from the ocean and dry air mass from interior continent met in southern China. And therefore, precipitation became more evenly distributed across the whole year in spite of reduction in annual total precipitation.

We calculated factors influencing modern distribution of *Fagus* in China and found that winter precipitation was the primary driver. Similar distribution pattern was also found for *Fagus crenata* in Japan (Matsui et al., 2004). Decreased seasonality was also an alternative driving force for *Fagus* expansion in Europe and North America (Bradshaw et al., 2010). In addition, the low temperature in southern China during this period favored downward movement of *Fagus* by reducing competition from evergreen broadleaved tree species.

Even if decreased seasonality favored *Fagus* expansion, reduction in total amount of precipitation limited northward movement of *Fagus,* which was also confirmed by pollen diagrams from different climate zones in China. And therefore, *Fagus* expansion was restrained in some mountains.

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FUTURE POTENTIAL OF EUROPEAN BEECH IN ITS MARGINAL AND CORE DISTRIBUTION RANGES IN SLOVENIA

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Introduction

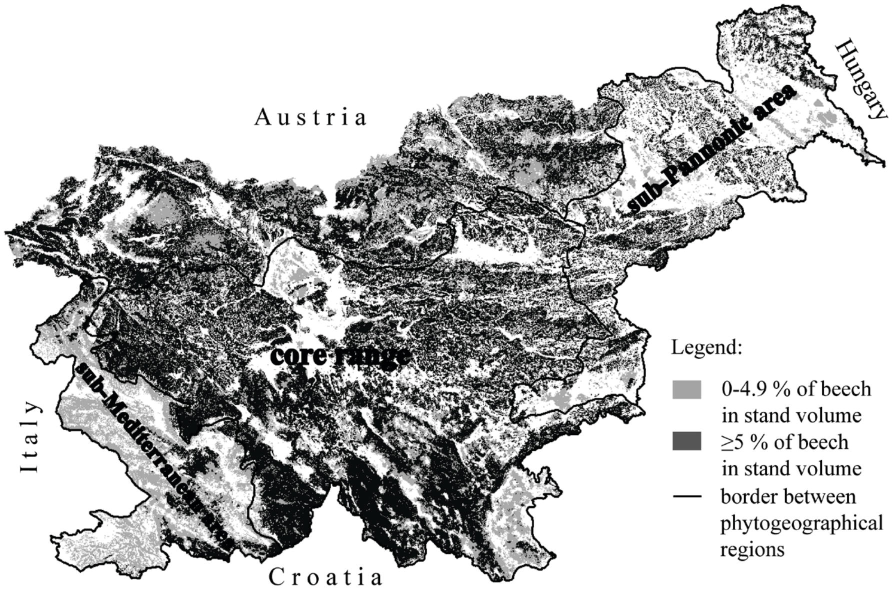
European beech (*Fagus sylvatica* L.) is widely distributed in Europe, from 60.7° north to 37.7° south. After the last glacial period, beech greatly expanded its distribution range in a relatively short period of time; however, the pattern of its migration northwards was not uniform (Magri, 2008). Even larger shifts, including expansion at the northern edge of the distribution range and contraction at the southern edge, can be expected in the future due to climate change (Kramer et al., 2010). In recent decades the dynamics of beech distribution has even been noticeable at the landscape and regional spatial scales (e.g. Poljanec et al., 2010). The main potential risks for beech in the future are thought to be associated with an altered precipitation regime and higher frequencies of summer droughts (Geßler et al., 2007). An increase in water limitation from the Temperate Oceanic to the Temperate Continental and Mediterranean zones in combination with higher temperatures could lead to more droughts in the Temperate Continental and Mediterranean zones (Lindner et al., 2010).

Our main goal was to evaluate the future potential of beech in its marginal distribution range in Slovenia based on data derived from the National Forest Inventory. For the purposes of comparison, we also assessed the future potential of beech in its core distribution range.

Materials and Methods

In our study, two separate areas, the sub-Mediterranean and sub-Pannonic phytogeographic regions, comprise the marginal distribution range of beech in Slovenia, while the Dinaric, pre-Dinaric, and pre-Alpine regions were considered as the core range of beech distribution (Figure 1).

Figure 1: Marginal sub-Mediterranean and sub-Pannonic and core beech distribution ranges in Slovenia with the presence of European beech in forest stands (data source: Slovenia Forest Service, 2010)



The future potential was assessed by comparing three indicators: the present abundance of beech (dbh≥10 cm) in basal area and number of trees of mature stands, its recruitment rate (i.e. trees outgrown the dbh=10 cm in the last ten years), and its abundance in natural regeneration. In order to do this and to test for differences between the study regions, data from permanent sampling plots (PSP; N=42,557 and N=39,323 for present abundance and recruitment rate evaluation, respectively; 500 m^2 each) and forest regeneration inventories (N=1,678; 25 m^2 each) of the Slovenian Forest Service were used. The database was created to include PSPs with the potential proportion of beech more than zero. The number of plots in each study region is shown in Table 1.

In addition, to examine differences in predictors between the study regions and between the forest stand types, the recruitment rate of beech (N_{rec} ha^{-1}) within the study regions was modelled separately for uneven-aged and young (seedling and sapling stage stands, pole stage stands) even-aged forest stands. To do this, selected environmental, forest stand, and forest management variables were used. A generalized linear modelling procedure using mainly negative binomial distribution of the dependent variable with log link function, as well as the Poission distribution with a loglinear link function, were used.

Results and Discussion

The future potential of beech in the examined distribution ranges differed significantly. When comparing beech proportions in basal area (Table 1), the highest future potential of beech was found in the sub-Pannonic distribution area. The ratio between the proportions of beech in the basal area of the recruitment and mature stands amounted to 0.84. The same ratio was 0.75 in the core range, but only 0.30 in the sub-Mediterranean area.

Table 1: The proportion of European beech in different stand developmental stages in the marginal sub-Mediterranean and sub-Pannonic and core beech distribution ranges

Developmental stage	European beech distribution ranges			ANOVA
Parameter	sub-Mediterranean	sub-Pannonic	core range	p
Mature stands				
N_{PSP}	2346	6462	33749	
BA_{FG}	4.9296	9.8814	10.5571	0.000
BA	23.8731	29.0556	30.2653	0.000
BA_{FG} / BA * 100	20.65	34.01	34.88	
Recruitment				
N_{PSP}	1914	6077	31332	
BA_{FG}	0.0920	0.3092	0.3522	0.000
BA	1.4994	1.0876	1.3506	0.000
BA_{FG} / BA * 100	6.14	28.43	26.08	
Regeneration				
N_{PSP}	189	240	1249	
N_{FG}	8.25	45.42	37.49	0.000
N	157.84	142.27	143.80	0.774
N_{FG} / N * 100	5.23	31.93	26.07	

Even more noticeable differences were found when the number of trees was used as an indicator of the recruitment rate. The ratio between the proportions of beech in the number of trees between the recruitment and mature stands amounted to 1.02, 0.82, and 0.31 for sub-Pannonic, core, and sub-Mediterranean areas, respectively. Moreover, when the same ratio was calculated between the regeneration and mature stands, similar results were found. The ratios were 1.04, 0.71, and 0.33 for the sub-Pannonic, core, and sub-Mediterranean areas, respectively, indicating very poor future prospects of beech in the sub-Mediterranean area.

The models for recruitment rate of beech showed significant differences in predictors between the beech distribution areas as well as between the stand types. In uneven-aged stands, the number of recruited beech trees was most significantly influenced by the average annual temperature, but the influences were not equal. In the sub-Mediterranean and core areas, the higher the temperature the higher the recruitment rate, but in the sub-Pannonic area, it was the opposite. In young even-aged stands, temperature was found to be a significant predictor only in the model for recruitment rate in the core distribution range, where its influence was the same as in uneven-aged stands. According to Geßler et al. (2007), summer droughts, which are closely correlated to high summer temperatures and low precipitation, could severely limit growth and competitive ability of beech. Droughts are expected to be more important in the sub-Pannonic area than in the other two distribution areas, where the potential for their occurrence, measured with water balance at increased potential evapotranspiration, is higher (Lorz et al., 2010). However, in our model average annual precipitation was found to have only a minor impact on the recruitment rate of beech. The next very important predictor in all distribution areas was the mortality due to harvesting and natural causes, which significantly increased the recruitment rate of beech. Tree mortality creates canopy gaps, reduces the stand density, and increases the light influx into the stand and was therefore expected to be important for the analysed recruitment rate. Among forest stand variables, the most important predictor was found to be the distance to the nearest forest stand where beech was registered. In both forest stand types and in all distribution areas, the distance to the nearest "beech stand" negatively influenced the recruitment rate of beech. This finding is in accordance with several other studies (e.g. Kunstler et al., 2007; Poljanec et al., 2010) indicating that beech expansion, regeneration, and recruitment is highly limited due to its heavy seed and dependence on animal transport (Nilsson, 1985). Important predictors were also current abundance of beech in all distribution areas and current abundance of Norway spruce in the core and sub-Pannonic areas, where Norway spruce is abundantly present. Unexpectedly, the potential proportion of beech had only minor influence on its recruitment rate and was significant only in both forest types of the core range and young even-aged stands of the sub-Pannonic distribution area. According to our results, we can conclude that the future potential of beech is the best in the sub-Pannonic marginal distribution area and relatively good in the core range, but very poor in the sub-Mediterranean marginal distribution area. Notwithstanding our findings in the sub-Pannonic region, the sensitivity of beech to climate change (Kajfež-Bogataj, 2007) is expected to be higher there than in the core distribution range, mainly due to the higher probability of drought occurrence (Geßler et al. 2007; Lorz et al., 2010). Obviously, the decline of beech is already apparent in the sub-Mediterranean area. Although this is not the case in the sub-Pannonic distribution area, beech decline can be expected in this area in the future.

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CLIMATE-CHANGE INDUCED BIOCLIMATIC SHIFTS IN *FAGUS SYLVATICA* FORESTS ASSESSED THROUGH A TREE-RING NETWORK CROSSING THE MEDITERRANEAN-TEMPERATE BIOMES

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Introduction

Climate signals in tree-rings have been widely used to understand the climatic factors controlling the growth of tree species in different environments, as well as a valuable proxy to reconstruct past climate variability. Given that such factors vary according to geographic (latitudinal/altitudinal) gradients, in the last years new approaches were proposed for the bioclimatic classification of forests based on tree-ring networks, i.e. the dendroclimatic classification (Piovesan et al. 2005). Tree populations can in fact be divided into bioclimatic zones and belts, according to variations of the main growth-limiting climatic factors with latitude (zones) and elevation (belts). In this context, beech (*Fagus sylvatica* L.) have been widely used in Italy, thanks to its sensitivity to climatic variations and to its widespread presence throughout all the national territory. Previous studies distinguished Italian beech populations into two zones, Mediterranean and Alpine (Temperate), each divided into three elevation belts (low-elevation, mountain and high-mountain). In the Alps, variability of beech radial growth with elevation is influenced more by air temperature than precipitation (Di Filippo *et al.*, 2007), while in the Apennines summer drought plays a dominant role (Piovesan *et al.*, 2005). Considering that climate-growth relationships can change through time (e.g. Di Filippo et al. 2007), it's possible that a dendroclimatic classification varies in time according to changing responses to the main growth-limiting factors, leading to bioclimatic shifts (Peñuelas et al. 2007). In this work we'll analyze the temporal stability of our dendroclimatic classification, relate the observed changes to the climate changes described for Italy in the last decades (Brunetti et al. 2006), and assess the impacts of such bioclimatic shifts on the organization of the tree-ring network.

Materials and Methods

We considered a tree-ring network of 36 beech forests with few signs of human disturbance. Sites covered a good part of the species latitudinal/elevation distribution range, with a special focus on Central Italy and the Eastern Alps. Within each site at least 20 dominant trees were cored. Crossdated tree-ring series were standardized to amplify their climate signal and averaged to obtain site chronologies. Hierarchical and fuzzy clustering applied to site chronologies in the common period (1942-2000) served to describe the spatial organization of the climate signals in tree-rings, i.e to build the dendroclimatic classification. The same clustering was performed on 30-yr moving windows shifted by 1 yr to check the stability of the long-term classification. Trees from sites stably pertaining to the same belt were used to build a belt composite chronology, whose growth limiting climatic factors were identified by correlation functions. Sites with unstable behaviour were instead analysed separately to identify the causes of their bioclimatic shift. The mean barycentre of each belt was computed as a weighted mean considering the relative contribution of each site to that belt according to fuzzy memberships. The changes of that barycentre was then tracked through time and plotted against the annual temperature.

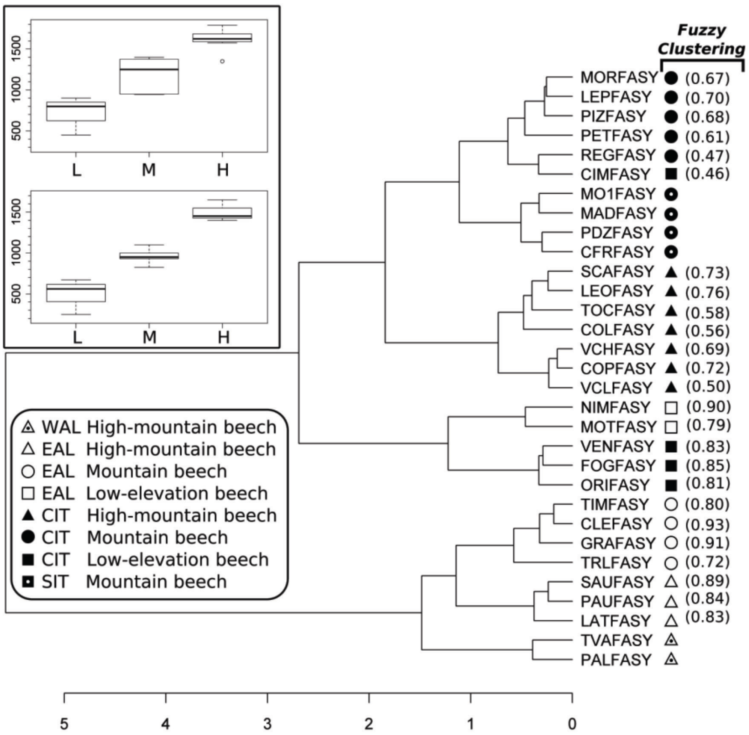

Figure 1. Classification of the beech chronologies: the dendrogram refers to the hierarchical cluster analysis (HCA), the symbols refer to the fuzzy clustering (FC). In parentheses: percentage of membership to the relative fuzzy cluster. WAL: Western Alps; EAL: Eastern Alps; CIT: Central Italy; SIT: Southern Italy.

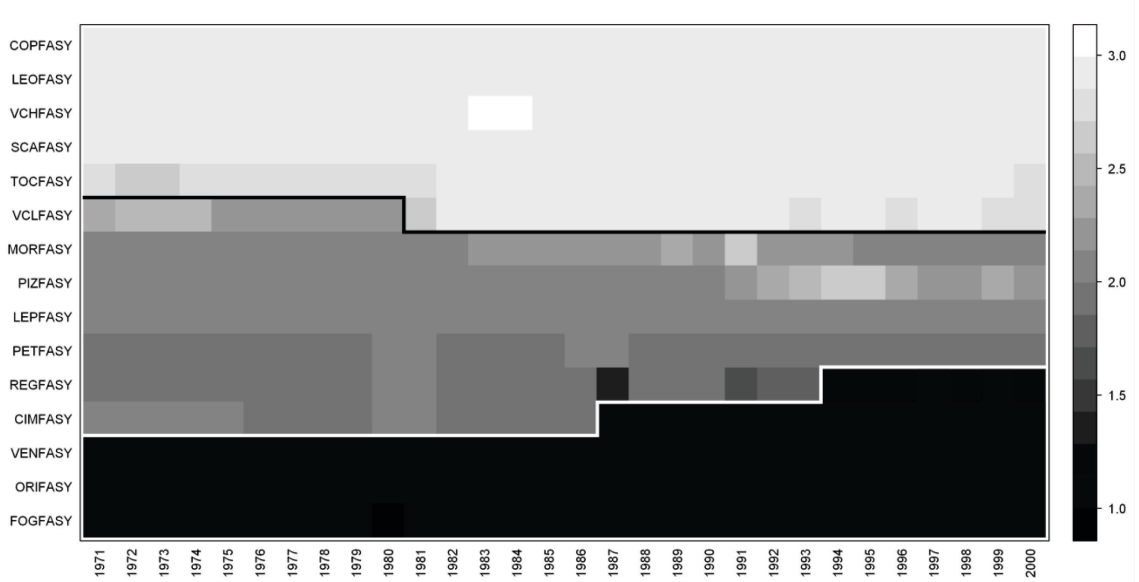

Figure 2. Moving Fuzzy Clustering of Central Italy site chronologies ordered according to their elevation. The intensity of grey describes the degree of membership of each site to a specific altitudinal belt (1 = low-elevation; 2 = mountain; 3 = high-elevation) in each 30-yr moving window (each date refers to the last year of each window). White line: low-elevation/mountain belt boundary; black line: mountain/high-mountain belt boundary.

Results and Discussion

In the long-term dendroclimatic classification populations were grouped according to their latitudinal/altitudinal position (Fig. 1). In central Italy, moving clustering analysis revealed that during the study period the site VCL passed to the upper belt, while CIM and REG passed to the lower one (in 1981, 1987 and 1994, respectively; Fig. 2). Besides VCL, whose shift was probably due to logging after WWII, CIM and REG downward shift occurred after that their correlation with the typical lower belt signals became stronger than those of the upper one. This lead to a raise of the low-elevation and mountain barycentre, in accordance to rising annual temperature (low-elevation belt: ~200 m/°C; mountain belt: ~320 m/°C; Fig. 3).

The Alpine populations were instead more stable through time. However, we observed a northward shift of mediterraneity, with Summer drought effects expanding to eastern Alps low-elevation beech forests in the last decade, following the increased importance of July drought effect on tree-growth variability.

Since the observed bioclimatic shifts were related to the recent climate warming, the described methods can offer a framework into which potential climate-change impacts on Italian forests functioning and services can be assessed. The methods presented here offer a new approach to track in time and space climate-change impacts on forests.

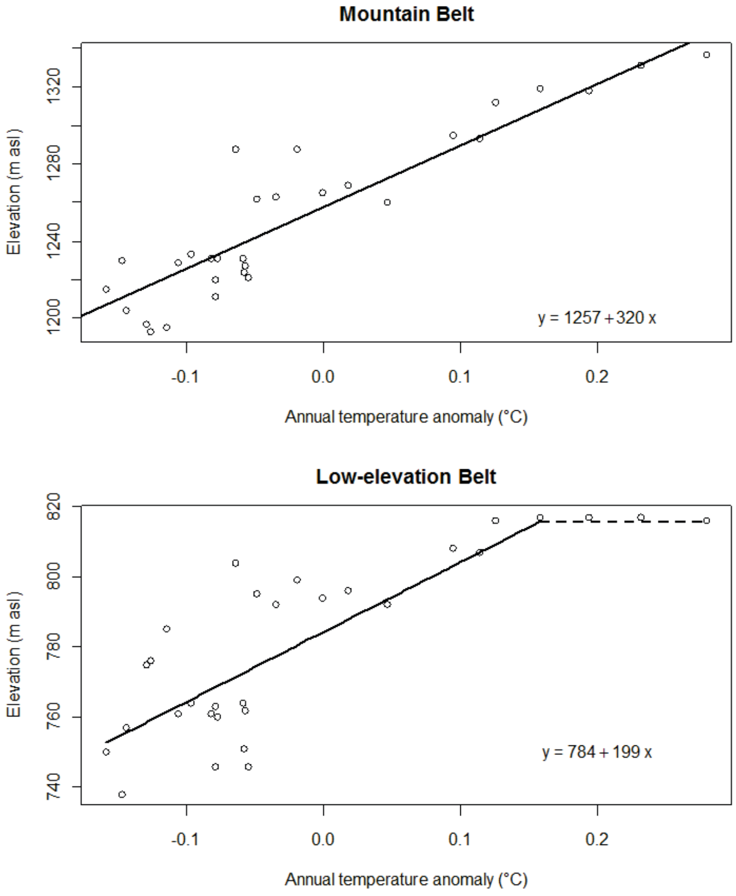

Figure 3. Central Italy. Fuzzy belt barycentre (*fB*) detected by the Moving Fuzzy Clustering for mountain (above) and low-elevation (below) belts as a function of the central Italy average annual temperature anomaly.

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IS THE HEMI-BOREAL DISTRIBUTION MARGIN OF EUROPEAN BEECH (*FAGUS SYLVATICA*) MOVING NORTHWARDS?

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Introduction

The recent natural vegetation in the hemi-boreal zone in Southern Sweden constitutes of mixed Norway spruce (*Picea abies* [L.] Karst.) and European beech (*Fagus sylvatica* L.) forests. There the distribution range margins of both species are overlapping (Björkman 1999). In this region, mean annual air temperature has risen about 1°C over the past 100 years and is projected to increase by a further 2 - 6 ºC by the end of this century due to climate change. It is likely that the extended growing season and a precipitation decrease of up to 40% (Christensen and Christensen. 2007) will increase the competitive ability of European beech compared to the currently dominant Norway spruce. Moreover, an intensified disturbance regime of abiotic impacts like storms and biotic impacts like bark-beetle attacks are expected (Schlyter et al. 2006). Using collaborative studies on stand structure development and forest growth we were looking for indications of an increase in competitive vigour of beech towards spruce which points to a northwards shift of the hemi-boreal beech distribution margin.

Materials and Methods

We focussed our studies on stand structure development in the Siggaboda forest reserve (Southern Småland, Southern Sweden) where we recorded dbh (tree diameter at 1.3m above the ground) for each tree of 7cm and larger in December 2004 (before Gudrun hurricane), May 2005 (after Gudrun hurricane) and June 2007. This was done in a quadratic 1ha core plot (100m x 100m) in the centre of the semi-natural old-growth forest, subdivided by using a 20m-grid (Bolte et al. 2010). For each tree, we recorded species, cardinal location coordinates of the stem and dbh. In addition, tree crown base height, crown mid height, and tree top height was measured in a central subsample of nine grid cells (0.36ha). In the last recording campaign in June 2007 we identified dead and dying trees affected by insect attacks. We performed dendroecological analyses at three south-swedish reserves in Siggaboda, Tolseboda (Blekinge) and Rågetaåsen (Eastern Halland). For tree coring, 81 beech and 80 spruce trees were selected in total. The study trees were cored at the end of August 2006 twice from opposing directions at a height of 1.3 m. The increment cores were mounted on wooden boards, sanded, polished and visually cross-dated. Then, the width of every tree ring was measured at a precision of 1/100 mm using a LINTAB positioning table (Grundmann et al. 2011).

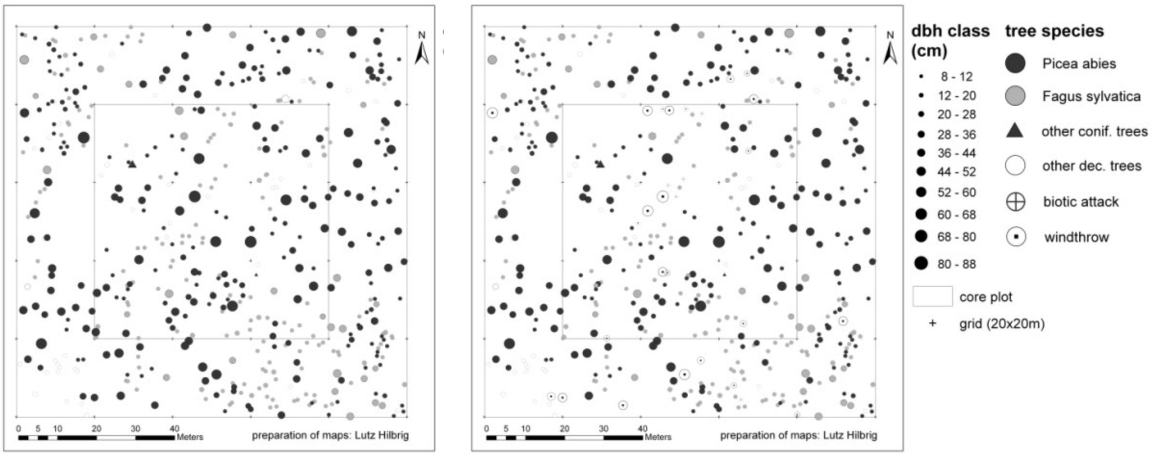
Result and Discussion

The comparison of stand characteristics gives insight into both abiotic and biotic effects on the forest development (Figure 1). In 2004, the spruce trees were, in comparison to the beech trees, higher and mean larger (Bolte et al. 2010) and contributed more to the growing stock (spruce: 87%, beech: 12%, Figure 1d). The ‘Gudrun’ storm in January 2005 had no significant impact on the mixed structure of the living elements of the stand. All together, 33 living trees per hectare were uprooted or damaged. 19 of them were spruces, and 11 were beeches. This accounts for only 7% of living trees (Figure 1b). The widespread tree damage recorded in June 2007 (Figure 1c) revealed a considerable increase of tree failure following the mid summer drought 2006 and the bark beetle infestation (*Ips typographus*) in spring 2007. However, only spruce was affected. In total approximately 19% of spruce trees and 41% of the standing volume was lost of the remaining living stand after the ‘Gudrun’ hurricane (Figure 1d). The trees lost were mainly the dominant spruce trees from the top tree layers, changing the mixed stand structure. Large canopy gaps were opened over mainly beech understorey in a belt from South-East to mid-West of the core plot (Figure 1c).

The increment analysis revealed a growth decline since the 1950s for both species. The only exception is the beech in Siggaboda, which increased their growth coming to a very low increment level before the 1930s (Table 1, Figure 2). In general, the increment ratio, spruce to beech, shows the high growth advantage of spruce. However, since the 1950s, this advantage has been decreasing and beech has gained on spruce (Table 1, Figure 2).

a) 2004 (before ‘Gudrun’ storm)

b) 2005 (after ’Gudrun’ storm)



c) 2007 (after 2006 drought)

d) Growing stock 2004 – 2007

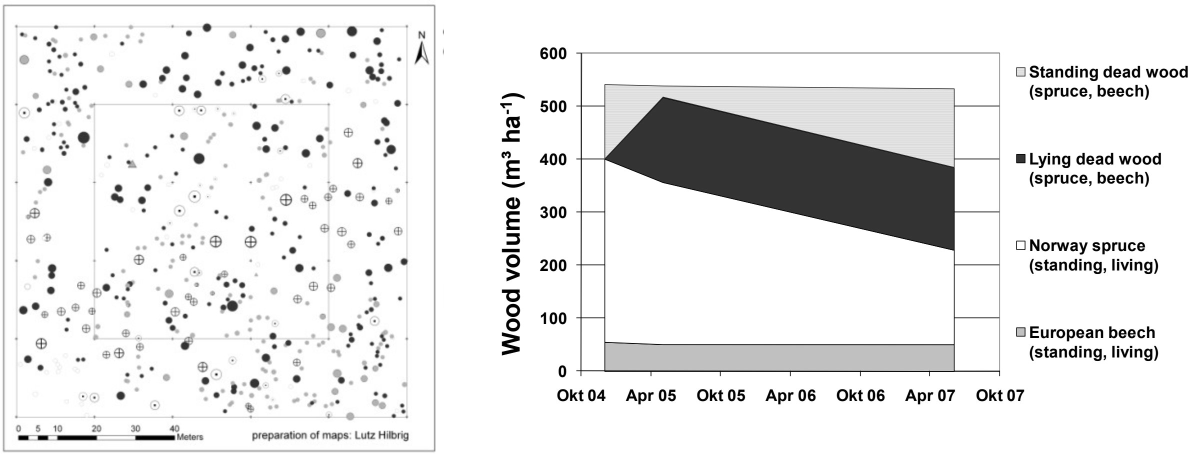


Figure 1: Mixed stand structure dynamics: (a) December 2004, (b) May 2005, (c) June 2007, and (d) Wood volume dynamics (2004 – 2007). (a to c): Map of tree (dbh≥7cm) position (incl. living tree removals); shown are tree removals due to 2005 Gudrun storm (b) or Gudrun storm, drought and biotic attack impacts (c). (d): Wood volume increment in 2005 and 2006 is not considered, partly adopted from Bolte et al. (2010).

Table 1: Increment analysis in percentage of the long-term mean (1894-2005) and the increment ratio spruce to beech in % in two periods (1894-1949; 1950-2005, respectively), taken from Grundmann et al. (2011))

		Diameter increment % of long-term mean		increment ratio spruce/beech [%]	
		1894-1949	1950-2005	1894-1949	1950-2005
Siggaboda	Beech	88.1	111.7		
	Spruce	100.7	99.3	282.4	219.6
Tolseboda	Beech	106.2	93.9		
	Spruce	109.0	91.1	206.4	195.1

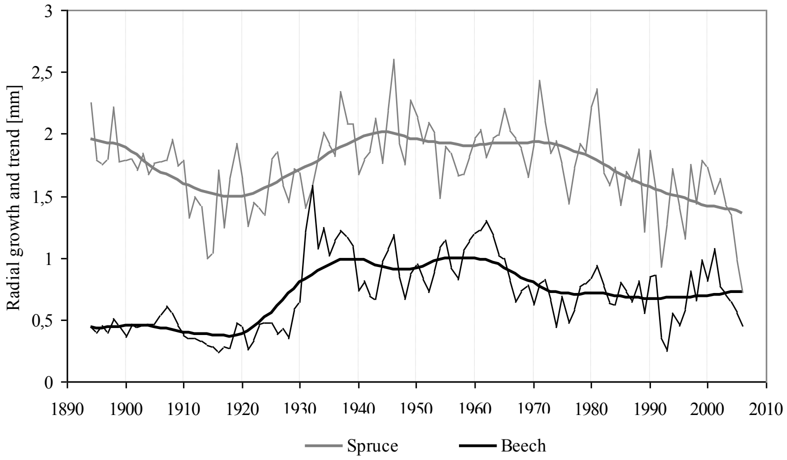


Figure 2: Radial growth and trend of European beech and Norway spruce in Siggaboda for the period from 1894-2006 (Bolte et al. 2010)

Results show that only the mid-summer drought in combination with the bark-beetle attack had considerable impact on stand structure at Siggaboda. Since swarming activity of spruce bark beetle (*Ips typographus*) in southern Sweden is temperature controlled (Jönsson et al. 2007), the warm growing seasons of 2006 and 2007 provided good conditions for the spread of bark beetles. Schlyter et al. (2006) illustrated for spruce in northern Europe the interacting effects of biotic agents and climate change: abiotic impacts of climate change (like drought) lowers the vitality of spruce and increases its susceptibility to biotic attacks, e.g. by spruce bark beetle. Possible root breakage due to the ‘Gudrun’ storm may have additionally raised spruce sensitiveness to drought in the following years. Thus, a combination of probable vitality decrease of the most dominant spruces and optimal infestation conditions for spruce bark beetle populations led to the remarkably high loss of spruce individuals. This supports prevalent ideas of an increasing abiotic and biotic risk for spruce in southern Sweden due to climate change (e.g. Jönsson et al. 2009) which is indirectly favouring beech which has a lower sensitivity to above mentioned impacts. Despite distinct disturbance events, climate change and species competitive performance are linked by the fact that spruce is already confronted by the higher growth vigour of beech. Thus, both more frequent short-term disturbances and long-term warming favourism may be indicative for beech’s competitive success and it’s northwards spreading in the future.

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EFFECT OF METEOROLOGY ON GROWTH OF EUROPEAN BEECH (*FAGUS SYLVATICA* L.) OUTSIDE NORTH-EASTERN NATURAL DISTRIBUTION RANGE. LITHUANIAN CASE STUDY.

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Introduction

European beech (*Fagus sylvatica* L.) is one of the most widespread and important tree species in Europe forest due to its height physiological tolerance and competitiveness (Ellenberg, 1996; Mayer 1984). Its proportion is currently increasing in Central Europe, particularly where forests with a high percentage of conifers are being converted into more natural mixed forests (Tarp et al. 2000; Cufar et al., 2008). It is also one of the most thoroughly investigated European tree species, due to its wide distribution range and domination as well as high ecological and economical importance (Dittmar et al., 2003; Jarcuska, 2009).

It has recently been reported that the competitiveness of beech might be considerably reduced due to climate change (Geßler et al. 2007) especially at the southern range of its distribution (Jump and Penuelas, 2006). However, the results obtained in Sweden support the idea of a northward migration of European beech, due to a higher tolerance to the abiotic and biotic threats accompanying climate change and an increased competitive ability compared to boreal tree species (Bolte et al., 2010). Despite this, a limited number of studies have examined mature beech tree growth outside their natural distribution range in relation to meteorological parameters. Therefore, new issues concerning its sensitivity to current environmental changes, in areas outside their natural distribution range arise.

The variation of tree ring width of Common beech was found to be a very sensitive indicator, reflecting clearly the signals of environmental influences (Dittmar et al., 2003). The present study aimed to detect sensitivity of beech tree growth to unfavourable meteorological conditions in Lithuania by using dendrochronological method. The objectives of the study were:

- to detect the effect of meteorological parameters on beech tree stem growth;
- to detect key meteorological parameters limiting growth of beech trees
- to prognosticate the growth of beech trees in Lithuania.

The obtained results allowed us to check the hypothesis, that Beech trees growing outside their natural distribution range should be more sensitive to heat, frost and drought than those growing in their natural habitats.

Materials and Methods

About 100 tree ring width series from 6 European Beech stands located in south-western part of Lithuania were used to meet the objectives of the study. The stands were located in about 150 km north from the edge of their natural distribution range in Poland (Fig. 1).

Meteorological data were obtained from the nearest to Beech stands Silute MS, i.e. about 15 km away from the monitored stands.

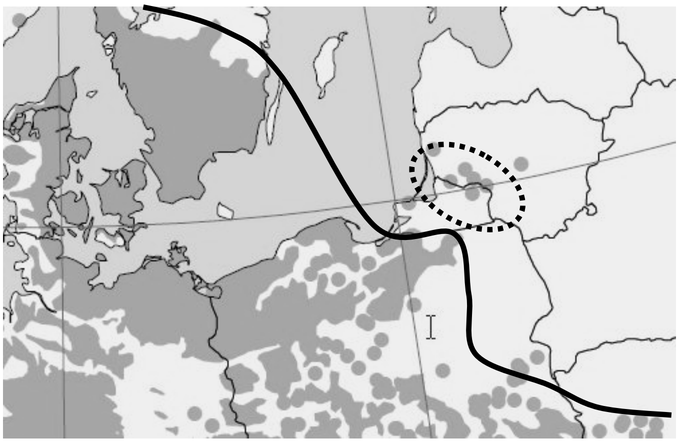

Fig 1. The edge of Beech trees distribution range in north-eastern part of Europe (continuous line) and location of experimental sites (dotted line) EUFORGEN (2009).

Simple correlation analysis was employed to detect significance of meteorological variables effect on the indices of beech tree radial increment. Tree ring width indices were computed using formula:

$$Zr_{index} = Zr - (a + b \times Year), \qquad (1)$$

here: Zr index – ring index in the year (i); Zr – tree ring width (mm);
Y - year from 1960 to 2010; a, b – independent variables.

Multivariable analysis was applied to detect the integrated effect of meteorological parameters on Beech tree growth and key factors limiting beech growth in Lithuania.

Results and Discussion

Analysis of tree ring indices showed that beech tree growth was reduced over the period from 1975 to 1980, as well as at the beginning of 2000 (Fig. 2). In addition, at the beginning of 1990's the reduced increment was detected at B2 and B3. The most favorable period for beech growth was the beginning of 1980's and the last 5 years, i.e. since 2005 up to now. These periods were taken into account analyzing variation in air temperature and precipitation amount.

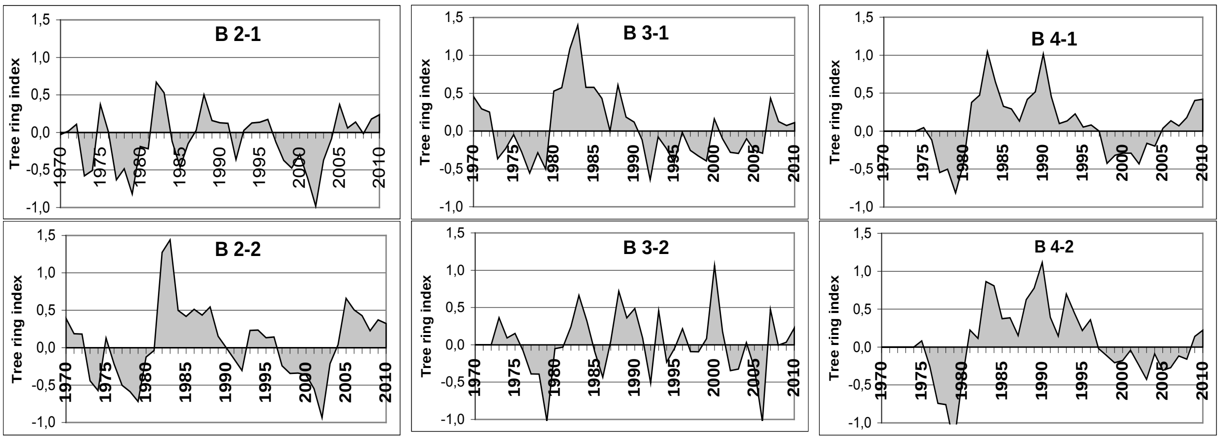

Fig. 2. Mean tree-ring indices of Beech in monitored stands

Changes in mean air temperature of the warmest, coldest months and annual mean value indicated that the warmest years were 1992 and 2002, whereas the coldest – 1979, 1987, 1996, 2003. Long term variation in mean temperature revealed that over the warmest months air temperature increases by 0.02 per year, coldest by 0.03 and annual value by 0.03 per year. Lack of the humidity was registered in 1976-77, 1997, 2006. Years with excessive humidity were: 1978, 1981, 1991, 1998, 2005, 2007. Precipitation amount over vegetation period increases by 0.7 mm, and over dormant period by 0.8 mm, what means that annual amount increases by 1.5 mm per year.

Positive effect of the air temperature was detected over the dormant period, especially over December-January, whereas negative effect - over June - August of the last and current years. The state of knowledge confirms that hot summers are not favorable for beech growth. No regular effect was detected over the period from February to May.

More abundant precipitation amount over the dormant period followed by higher air temperature resulted in wider beech stem ring. Positive effect over December-January and March – May was detected. Integrated effect of meteorological parameters on Beech tree growth was expressed by the following equation:

$$Zr_{\text{index}} = 1.19 - 0.12 \times Tm_{(VI)} + 0.067 \times Tm_{(IX\text{-}V)} + 0.003 \times Pr_{(XII)} + 0.002 \times Pr_{(III\text{-}V)}; \quad (2)$$

$$R^2 = 0.452; p<0.002$$

Meteorological parameters explained about 45% variation in tree-ring width indices. Hot summer, dry and cold dormant period and first half of vegetation period resulted in beech tree growth reduction.

Generalising presented data we could conclude that warmer dormant periods and rather stable temperature of summers should increase the tolerance of beech trees to unfavorable lack of humidity in the first half of vegetation. If changes in the considered parameters continue following the last 10 year period scenarios, the intensity of Beech tree growth in Lithuania should increase.

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THE EFFECT OF DROUGHT ON *FAGUS SYLVATICA*: ARE RANGE CORE POPULATIONS THREATENED TOO?

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Introduction

Climate change has been characterised by higher temperatures and altered precipitation patterns, as well as an increase in the severity and frequency of extreme climate events. In Europe, these trends have resulted in generally drier conditions, due to increasing temperatures with no increase in precipitation (Briffa et al., 2009). Additionally, an increase in extreme drought frequency has been both observed and predicted for the future (Della-Marta et al.,(2007); Schär et al., 2004).

These climatic trends have affected the living world, with a global reduction in the net primary production of all terrestrial vegetation observed as a result (Zhao & Running, (2010)). In forests, elevated levels of stress due to reduced moisture availability, combined with direct mortality due to extreme droughts, has resulted in an increase in reports of climate change induced tree mortality (Allen et al., 2010). Focusing directly on European beech, *Fagus sylvatica*, there is accumulating evidence from the southern edge of the species' range that growth is declining due to climate change (Jump et al., 2006; Piovesan et al., 2008). This is expected to result in a reduction in the available habitat space at the mountainous southern range edge, and is affecting populations which are of particular conservation significance (Hampe & Petit, 2005). Therefore, we urgently need to understand the response of *F. sylvatica* to extreme drought events.

One study linked an extreme drought in 1976 to localised elevated mortality of *F. sylvatica*, at a site within the core of the species' range (Peterken & Mountford, 1996). The drought resulted in 30% of mature *F. sylvatica* dead, 25% suffering severe damage (i.e. extensive crown dieback, limb loss and trunk scarring), and 45% showing no visible signs of damage. Due to this work, and the existence of a long term monitoring programme for the site, it is possible to identify individual trees belonging to each of the two survivor classifications. To increase our understanding of drought impacts on tree growth and productivity, we investigated the response of these different damage classes of *F. sylvatica* to severe drought and their capacity for subsequent post-drought recovery.

Materials and Methods

The site, Lady Park Wood, is a Natura 2000 nature reserve and mixed deciduous woodland in Gloucestershire, UK. In May 2010, 33 severely drought damaged trees and 33 less affected trees were identified using existing records. Core samples were taken from the trees and prepared using standard dendroecological methods, and tree girth at 1.3m was measured. Tree ring widths were measured using CooRecorder, visual crossdating performed using CDendro and statistical crossdating performed using ARSTAN. Statistical analysis of the resulting chronologies was performed in R. The tree ring chronologies were de-trended using a cubic smoothing spline, to remove the age related trend and then normalised, to allow the visual identification of drought years. Basal area increment (BAI) was also calculated, as a measure which allows the comparison of the long-term growth trends of trees without the age related trend associated with simple ring width. BAI is not expected to show a persistent decline in healthy trees once they have reached the mature phase of growth, therefore a linear regression analysis was performed on the mature phase of growth (post 1929) to identify growth trends of the two groups before and after the 1976 drought. Mean sensitivity is common measure of sensitivity to climate. Thus, a paired t-test, Wilcoxon signed rank test, and Wilcoxon rank sum test were used to compare the sensitivities of the trees, within and between groups.

Results and Discussion

The tree ring chronologies created for the two sets of cores are statistically robust, as demonstrated by the summary statistics presented in table 1 below. With chronologies of over a century for both sets, analysis of the mature phase of growth allowed for the comparison of 48 years of growth pre-drought, and 30 years of growth post-drought, allowing for a 3 year buffer period to exclude the extreme effect of the drought years. Mean BAI decreased as a result of the drought for both sets of trees, whilst the effective correlation between the cores and the signal strength remained high.

Table 1. Descriptive statistics for the tree-ring series.

	No. of trees	No. of cores	Mean age (years)	Length of series	Mean BAI (mm^2)	Mean Sensitivity[a]	$\bar{r}_{eff}$[b]	EPS[c]
Severely Drought Damaged	30	58	105.5	1857 - 2009	2567 ± 98	0.318	0.400	0.975
- mature growth pre-drought subset				1929 - 1976	3021 ± 92	0.297	0.461	0.980
- post drought subset				1980 - 2009	2029 ± 127	0.406	0.469	0.981
Less Drought Damaged	32	68	111.8	1832 - 2009	2907 ± 99	0.299	0.515	0.986
- mature growth pre-drought subset				1929 - 1976	3208 ± 112	0.271	0.556	0.988
- post drought subset				1980 - 2009	2532 ± 154	0.380	0.678	0.993

a – the change in ring width from one year to the next, describing growth sensitivity to environment/climate.
b – a correlation coefficient incorporating both within and between tree growth signals.
c – the proportion of the hypothetical perfect chronology captured in this sample.

The detrended chronologies (figure not shown) highlight that in addition to 1976, there was an effect on growth of subsequent droughts in 1989-90 and 2003. Analysis of mean sensitivity within the groups of trees (i.e. between the pre and post-drought subsets) shows that drought increased the sensitivity to climate in both the severely damaged ($t = 12.27$, $df = 57$, $p < 0.0001$) and the less damaged trees ($V = 2284$, $p < 0.0001$). However, comparing mean sensitivities between groups shows no significant difference either before ($W = 1604$, $p = 0.0720$) or after the drought ($W = 1644.5$, $p = 0.1095$). Basal area increment records for the chronologies are presented in figure 3 below, further demonstrating that both groups of trees have failed to regain pre-drought levels of growth. Linear regression reveals no significant trend in the post-drought growth of either the severely damaged ($R^2 = 0.089$, $p = 0.06$) or for the less damaged trees ($R^2 = - 0.035$, $p = 0.905$), indicating no further recovery beyond a new lower rate of growth. No trend in growth in either group was observed before the drought (severely damaged, $R^2 = - 0.020$, $p = 0.752$; less damaged, $R^2 = 0.011$, $p = 0.223$.

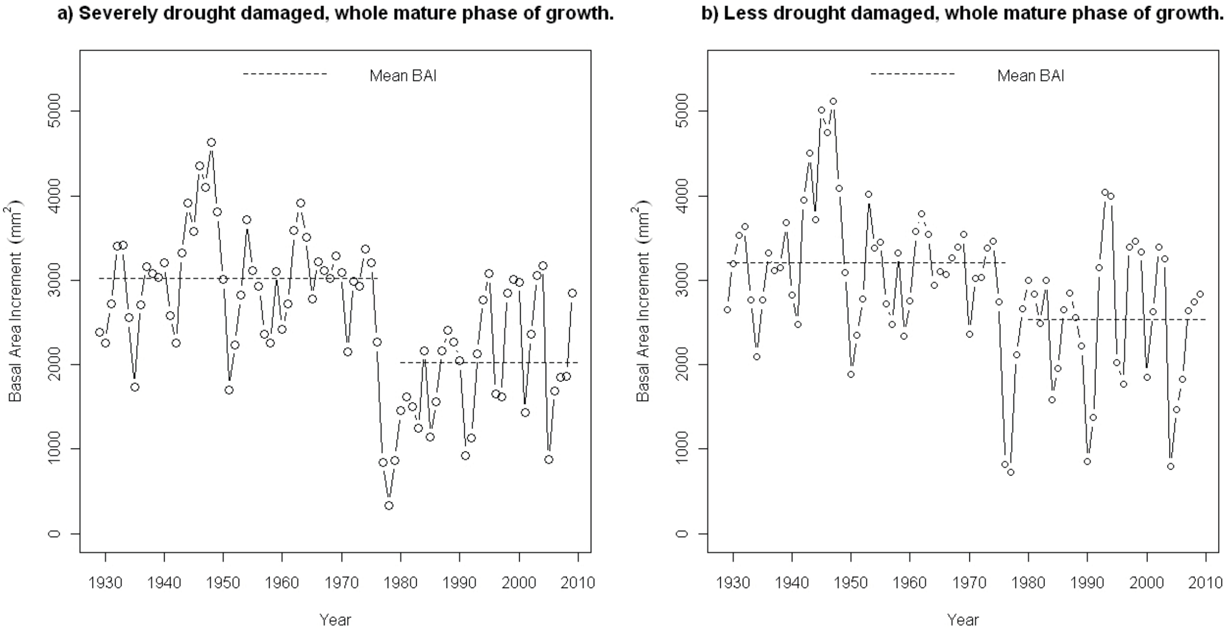

Figure 1. Basal area increment for a) severely damaged and b) less damaged trees.

The results of this study demonstrate that in addition to the large scale mortality previously recorded for this population of F. sylvatica, the effect of the drought on the surviving trees has been both pronounced and long lasting. The increase in mean sensitivities can be interpreted as being an increase in stress in both populations, resulting in more intense fluctuations in growth to subsequent environmental conditions. Both sets of surviving trees have responded to the drought with a step change in growth to a new lower mean, with no further recovery trend observed.

This has strong implications for the continued vitality of *F. sylvatica* in the 21st century. If forecasted increases in drought severity and frequency are correct, beech woodlands may be at risk of increased mortality and decline on sites at latitudes far higher than expected. Tree death on the same scale was not observed in the wider region following the 1976 drought, indicating that environmental factors specific to the site (such as well drained thin soils on steep slopes) play a role in the response to drought. The survival of individual trees will depend to some extent on the variation of conditions within the site, for example edaphic factors and drainage basins. In addition to this, survivors may be those individuals best adapted to drought conditions, and therefore represent a valuable genetic resource from which to re-stock the forest.

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RESPONSE OF EUROPEAN BEECH PROVENANCES TO DROUGHT

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Introduction

In Saxony, European beech (*Fagus sylvatica* L.) is the most important tree species of the natural forest societies which would have a percentage of 64 % on the present forest area in undisturbed conditions (Braun 1995). In opposite to this, the present proportion is 3.4 % (Anonymous 2004). Therefore, beech has a significant place in the process to convert pure and even aged conifer forests to nature oriented forest ecosystems. For two decades, about 35 % of the plantation area has been covered with beech in the state owned forests year by year (Anonymous 2010). Since the rotation time of beech is 140 years (Eisenhauer *et al.* 2005), the long term success increasing the beech area depends on the present and future climatic conditions among other factors. However, the increase of temperature and the decrease of precipitation in the vegetation period combined with an increase of extreme weather, especially of drought periods, due to climate change (Spekat *et al.* 2007) may call the future role of European beech into question.

For further plantation of beech, sound knowledge on the response to drought of the species generally and the intraspecific variation of the response especially is essential. Provenance trials can play an important role for the assessment of climate relevant parameters as the response to drought (Matyas 1996). Since 1990, the Staatsbetrieb Sachsenforst has been maintaining a network of four regional and international provenance experiments. The experiments comprise 13 trial plots with about 200 provenances of the natural distribution area. The trial plots established in different years with different provenances are connected to each other with standard material.

In this paper, results of anatomical, morphological and physiological investigations on progenies in beech provenance trials will be described with respect to effects of drought to selected provenances. Based on these results, preliminary conclusions will be drawn for the plantation of beech in future under changing conditions.

Materials and Methods

The response of beech provenances to drought was investigated on a selected number of provenances out of two provenance trials sown in 1993 and established at different sites in 1994 and 1995. The plant age varied from 10 to 15 years. Depending on the method, the sample size ranged from three to more than 40 individuals per provenance and replication.

At the end of a long lasting drought in August 2003, morphological drought symptoms were assessed on plants of 64 provenances at the trial site Graupa using a five staged scheme. Additionally, the impact of drought on the growth was evaluated by the retrospective measurement of the annual increment of the growth periods 2002 to 2004 in winter 2004/05. The mortality was observed in the course of the regular evaluation of the respective trial sites.

From 2005 to 2010, different physiological (predawn water potential, loss of conductivity, chlorophyll a-fluorescence), anatomical (vessels of one year old shoots) and morphological traits (stomata of fully developed leaves) were assessed on up to 17 provenances at the two trial sites Malter and Graupa.

The data were investigated with descriptive, variance and regression analytical statistics. The level of significance was set with $p \leq 0.05$.

Results and Discussion

In the year 2003, partly significant leave damages like naviculoid deformation and discolouration on the leaves of 64 beech provenances could be observed on the trial plot Graupa in August as a result of two long lasting warm-hot, radiation intensive and dry weather periods. On average, 35 % of all beech plants showed very or totally discolourated leaves, 42 % only little or no discolouration of the leaves. Among the provenances significant differences could be observed. The retrospective measurement of the annual height increment did not result in a significant difference between the increments of the year 2002 and the year 2003 over all provenances. Compared with this, the increment of the vegetation period 2004 was significantly smaller. However, the individual provenances reacted very different to the drought in the year 2003 and showed slight, but not significant differences in the increment compared to the year before. One year after the drought, individual provenances produced significantly smaller or bigger height increments than in the year of drought.

Again in the year 2006, naviculoid deformation of the leaves of 31 beech provenances could be observed on the trial plot Malter after a dry weather period lasting from April to June. The damages ranged from 15 % to 57 % of affected individuals per provenance. The predawn water potential assessed on 20 beech provenances at the end of a drought period in June 2006 resulted in different reactions to the drought: Some provenances showed only small differences to the values measured at sufficient water supply. Other provenances showed significant differences in the predawn water potential after the drought and at sufficient water supply.

In 2005, 2006 and 2010, the experimentally induced loss of conductivity resulted in significant differences among the 17 provenances investigated. Apart from these differences among the provenances on the same trial plot, differences were also observed on one and the same provenance growing at different sites or from year to year, respectively. However, the ranking of some provenances is the same independent of the trial plot or the year of assessment. Similar observations could be done with the assessment of the performance index (PI_{ABS}) based on chlorophyll a-fluorescence measurements of two provenances on the different trial plots Graupa and Malter.

The assessment of vessel and stomata parameters in one year old shoots or on fully developed leaves respectively showed a big variation of these parameters within each provenance. Only few significant differences could be found among individual provenances e.g. density of vessels or conductive cross section on the one hand and stomata density or size of stomata on the other hand at one and the same site. However, the observed results of the stomata assessment at different sites and in different years showed significant differences in stomata density as well as stomata size.

Between the level of morphological stress symptoms and the change of the predawn water potential observed in 2006, no significant correlation could be found. On the other hand, the loss of conductivity correlated significantly with the change of predawn water potential as well as the level of morphological stress symptoms. Among the described morphological and physiological parameters on the one hand and yield parameters or mortality rates on the other no significant correlations could be found. In no case, the mortality of provenances tested at the trial plots increased due to the drought periods 2003 and 2006.

The presented results showed significant differences in the appearance of drought damages, the height increment of the year after the drought as well as in the physiological response to drought. On the other hand, no correlations could be found until now between the response to drought and yield parameters in general. This observation confirms the results of Wagner (1990) and Tognetti *et al.* (1995), who also could not find relations between different parameters of photosynthesis and height growth or biomass production in plants.

The results presented possibly indicate different strategies of the provenances in the response to drought on the one hand. On the other hand, the results may indicate the existence of mechanisms allowing beech provenances to react to different weather conditions from year to year by modification of leave morphology and shoot anatomy. The questions to what extent the results presented are an indication for the validity of the "growth or defence"- thesis (Herms and Mattson 1998, Kaetzel 2001), what may be the reason for the differences in the response to drought and if the observations will be reproducible will be left to further investigations. One indication for the possible reasons could be the geographical variation patterns of leave parameters already described on beech and other species (Ni and Pallardy 1991, Aas *et al.* 1994, Larsen and Buch 1995, Tognetti *et al.* 1995).

However, a pilot experiment with two beech provenances was started in spring 2011 in order to assess the influence of the water supply on the development of beech leaves.

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INFLUENCE OF SOIL DROUGHT ON CROWN DIE-BACK AND BASAL AREA INCREMENT OF UNDERSTOREY *FAGUS SYLVATICA* AT THEIR DROUGHT LIMIT

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Introduction

Future climate projections forecast increased frequency and severity of soil drought due to reduced precipitation and temperature increase during the growing season in the Europe (IPCC 2007). Beech (*Fagus sylvatica* L.), one of the most important broad-leaved tree species with its large distribution in Central Europe, has low tolerance of drought (Ellenberg 1988, van Hees 1997) and is vulnerable to changing climate (Jump et al. 2006). The summer of 2003 with exceptional above-average radiation and below average precipitation cumulatively causing drought reduced net primary production of the beech forest in Europe (Ciais et al. 2005). Establishment and survival of young beeches are site dependent, especially from the soil drought (Topoliantz and Ponge 2000). Gärtner et al. 2008 discussed soil drought as an important limiting factor for beech distribution.

Some eco-physiological studies in controlled environment showed that with increasing frequency of drought, growth and competitiveness of young beech were reduced (Löf and Welander 2000; Fotelli et al. 2001; Lendzion and Leuschner 2008; Kohler et al. 2006) reported severe crown die-back of suppressed and intermediate beeches due to '2003 summer drought' in the beech-downy oak ecotone in southern Germany. Though, long-term decrease in the sense of competitiveness has yet not been observed in beech (Ammer et al. 2005). However, detailed local and stand level studies are needed to find out the influence of soil drought on young beech morphology and growth.

This study aims to (1) relate soil drought and crown die-back (CD) and (2) analyse the impact of soil drought on basal area increment (BAI) of understorey beech at their drought limit in a near-natural forest.

Materials and Methods

The area selected for the study was a sessile oak stand surrounded by beech stands, located at Schlossberg (400 m a.s.l.) of Black Forest mountain region in the southwestern Germany. The south-west facing stand is on the slope of a rocky gneiss outcrop and getting high exposure to sunlight. Naturally regenerated understorey beech and European hornbeam are found with seedlings of sessile oaks. Mean annual temperature and precipitation are 9-10 ° C and 800-1000 mm respectively. The stand grows on shallow sandy 'Hagerhumus' soils and remains commercially unmanaged for last decades.

24 circular plots (2 m radius) were established systematically in the 0.3 ha stand. Soil, morphological and growth parameters of understorey beeches (30 to 250 cm height, n = 47) were collected during the summer of 2010. Positions of all dead branches were recorded in three vertically divided (upper, middle, lower) tree crown compartments. Soil profiles were dug in the centre of each plot. Individual beeches for biomass and growth analysis were harvested from the plots.

Soil drought was quantified by the available soil water storage capacity (ASWSC). Plots were classified as “dry” when ASWSC lies between 19-60 mm or “less dry” when 61-136 mm (Standortskartierung 2003) respectively. CD of each beech was expressed as the percentage of dead above ground biomass (AGB) of that plant. AGB was calculated from the regression models (Table 1) prepared from the harvested sample trees. Tree rings on harvested discs were analysed and the regression models (Table 2) were prepared to calculate BAI.

Table 1 Regression model for biomass

Biomass model	Equation (power function)	R^2	*p*
Dry	$Y= 0.117 \times D^{2.22}$	0.98	<0.05
Less dry	$Y=0.108 \times D^{2.24}$	0.94	<0.05

*Y = biomass and D = diameter

Table 2 Regression model for BAI

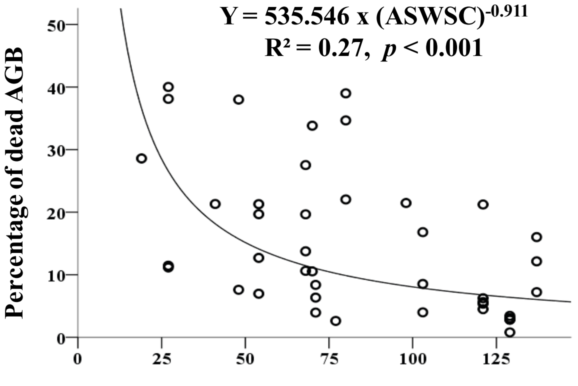
BAI model	Equation (power function)	R^2	*p*
Dry	$Y=0.156 \times RCD^{1.47}$	0.88	<0.05
Less dry	$Y=0.077 \times RCD^{1.80}$	0.87	<0.05

*Y = BAI and RCD = root collar diameter

Non-parametric Spearman correlation was performed between ASWSC and dead AGB. Non-parametric Mann-Whitney *U* test was performed to check the difference of CD between dry and less dry plots. Paired sample *t* test was performed between 2003-2004 and 2004-2005 BAI of dry and less dry plots to find out the effect of ‘2003 summer drought’.

Results and Discussion

A decreasing trend of CD with increasing ASWSC was found (Fig. 1). Significant strong negative correlation (r_s = -0.54, N= 42, p < 0.001) between ASWSC and dead AGB proved that beech vitality was negatively effected by the soil drought (Topoliantz and Ponge 2000). CD was significantly higher on dry plots than on less dry plots (U = 106.000, p = 0.002). Highest rate of dead AGB (42%) was noticed in the lower crown. By tuning the biomass partitioning (van Hees 1997) and through “survival through dieback” phenomenon (Schulze et al. 2005), beeches are trying to recover the drought stress. Steep slope, shallow soil and high solar radiation are reason for the drought limit of beech at southwestern Germany at 67 mm stand’s ASWSC (Gärtner et al. 2008).



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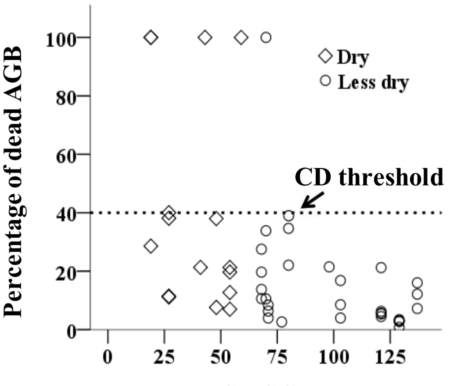

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Fig. 1: Regression between percentages of dead AGB and ASWSC of the living beeches.

Fig. 2: Mortality threshold of CD for the understorey beeches. 4 dead trees with 100% dead AGB were found in dry plots and 1 on a less dry plot.

In this study, the threshold mortality of CD to survive drought stress was found 40% for the beeches (Fig. 2). If frequent droughts occur in dry sites, survival probability of beeches having < 60% AGB is low, and indicates low tree vitality and no recovery for the trees (Pedersen 1998).

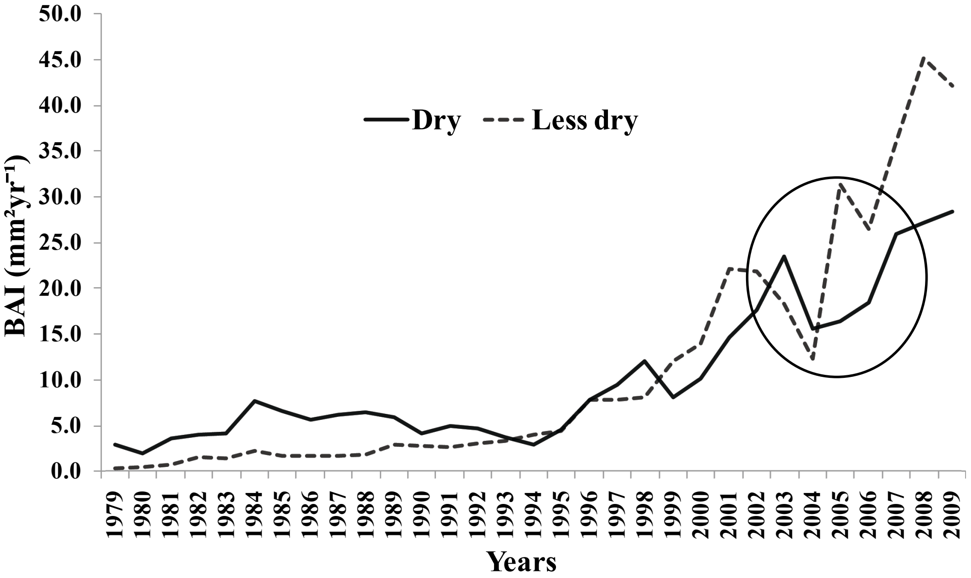

Fig. 3: Comparative growth trend of understorey beeches from dry and less dry plots. The circled area is showing the sharp fall of BAI on dry plots at 2004 and the recovery (sharp rise) of BAI on less dry plots after 2005.

The '2003 summer drought' had an adverse effect on BAI in both dry and less dry plots (Fig. 3). But on dry plots, 2003 and 2004 BAI differs significantly (dry plots: $t(20) = 2.739$, $p = 0.01$ and less dry plots: $t(19) = 1.543$, $p = 0.12$). Recovery of BAI on less dry plots was significantly higher than on dry plots after 2005 (dry plot: $t(20) = -0.177$, $p = 0.86$ and less dry plot: $t(20) = -2.130$, $p = 0.04$). A higher carry-over effect was observed on dry plots than on less dry plots (Löf and Welander (2000)).

Soil drought causes partial to complete CD of understorey beeches at their drought limit (stand ASWSC: 67 mm). Soil drought together with climatic drought resists growth and hinders the survival of understorey beeches.

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CHLOROPLAST DNA HAPLOTYPE VARIATIONS AMONG SIEBOLD'S BEECH, *FAGUS CRENATA*, OBSERVED AT ITS NORTHERNMOST ISLAND DISTRIBUTION

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Introduction

Siebold's beech, *Fagus crenata* Blume, is endemic to and widely distributed in the Japanese archipelago as well as several oceanic islands in the Sea of Japan. The northern limit of the geographical distribution of *F. crenata* is the mainland of Hokkaido, and the northern limit of the island distribution is Okushiri Island in the Sea of Japan. Okushiri Island is 144 km^2 in area and located 18 km to the west of the mainland of Hokkaido. The island's geological isolation history can be traced back. The strait of Okushiri, which lies between Okushiri Island and the mainland of Hokkaido, was present during the Riss glacier period, i.e., ca. 1.5 million years BP.

The *F. crenata* forests in this small island are rich in stand volume (Tatewaki 1958), but population in each forest is relatively small. Generally, the genetic diversity of a small and/or isolated island population is expected to be modest. However, our previous study involving the use of allozymes and microsatellites of the nuclear genome of *F. crenata* in Okushiri Island showed a high genetic diversity comparable to that of large populations in the mainland of Hokkaido (Kobayashi et al. 2009). We were interested in knowing how *F. crenata* populations maintain such high genetic diversity in this small island. In this study, we examined the cytoplasmic genome, particularly the chloroplast DNA (cpDNA) haplotype variations, among *F. crenata* populations of Okushiri Island to determine the species origin and patterns of migration history during northern distributional expansion.

Materials and Methods

We studied 22 populations of *F. crenata* that were distributed all over Okushiri Island, thus covering the entire area. We extracted total DNA from the leaf materials and examined the cpDNA haplotypes (Fujii et al. 2002) by using single nucleotide polymorphism (SNP) primers (Takahashi and Suyama, unpublished data), which discriminate 14 haplotypes with 6 site changes. We also sampled the increment cores from mature trees of 10 populations and examined the growth-ring variations.

Results and Discussion

Okaura and Harada (2002) and Fujii et al. (2002) investigated cpDNA haplotypes over the entire geographic range of *F. crenata*. They reported a single haplotype in the mainland of Hokkaido. Recently, Takahashi et al. (2008) conducted an extensive study of the cpDNA haplotype distribution and reported 2 haplotypes in the mainland of Hokkaido and Okushiri Island: one originated from *F. crenata* established in the region facing the Sea of Japan (haplotype A) and the other, from the region facing the Pacific Ocean (haplotype B). The major haplotype in the mainland of Hokkaido was haplotype A. Haplotype B was observed only in the eastern-most population of *F. crenata* in Hokkaido.

Our result mapped out the longitudinal variation of these 2 cpDNA haplotypes among 22 populations on Okushiri Island (Figure 1). The minor haplotype B of *F. crenata* from the mainland of Hokkaido was found to be prevalent in Okushiri Island.

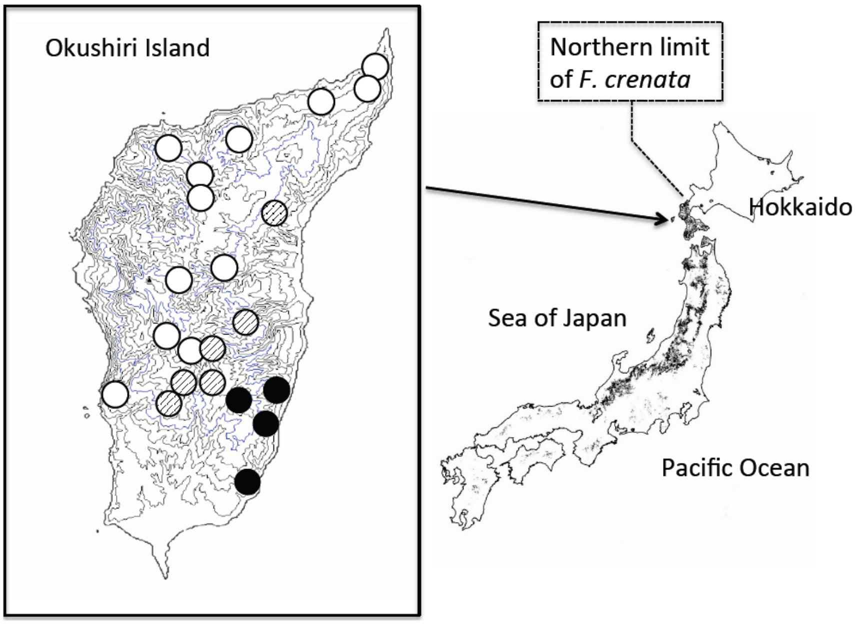

Figure 1. CpDNA haplotype variation among 22 populations in Okushiri Island. Black circle, haplotype A; white circle, haplotype B; hatched circle, haplotype A & B.

In addition, haplotype B ranged from the northwestern to the inland populations. Haplotype A forms a majority of the *F. crenata* populations in the mainland of Hokkaido, but it comprises only 4 populations in the mainland-facing southeastern area of Okushiri Island. The inland populations established on the eastern slope of the island were composed of both haplotypes A and B. An interesting coincidence was that populations comprising both haplotypes had higher genetic diversity in the nuclear genome than populations comprising either 1 haplotype.

The growth-ring examination showed that the maximum number of rings was found on a 374-year-old tree, as determined by the tree-ring count, and the tree belonged to the inland population with haplotype B. This is one of the longest-lived *F. crenata* ever reported in the Hokkaido region. The diameter of the trees of haplotype A population increased quickly during growth, but these trees showed short life spans (Figure 2).

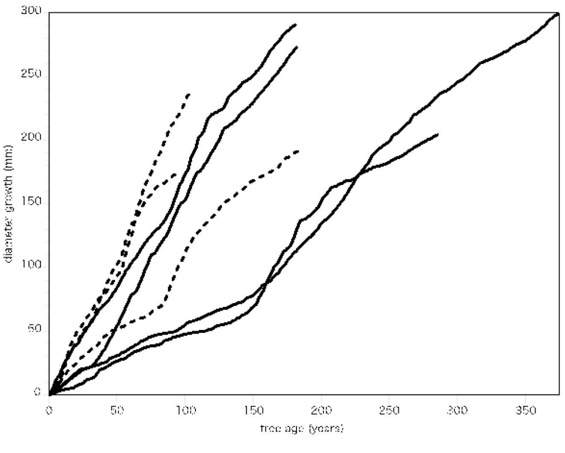

Figure 2. Diameter increment of *F. crenata* in Okushiri Island. Solid lines, trees from haplotype B populations; dotted lines, trees from haplotype A populations.

The results of this study indicate that *F. crenata* populations in Okushiri Island were derived from 2 different origins, represented by 2 different haplotypes. The immigration route and/or the immigration period must have differed between the 2 haplotypes, and they eventually crossed paths with the eastern slope populations of this island. The high genetic diversity of *F. crenata* population in Okushiri Island might be attributable to the secondary contact of different origins.

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MICROCLIMATIC INFLUENCE ON THE GENETIC STRUCTURES OF BEECH POPULATIONS GROWING ON SOUTHWEST AND NORTHEAST EXPOSED SLOPES

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Introduction

Increasing temperature extreme summer drought events as a consequence of the global climate change could lead to considerable changes in the ecological conditions in the forests of Central Europe and thus have long-term effects on growth and development of trees and forest ecosystems. Since forest tree populations are exposed to constantly changing environmental conditions, adaptive genetic variation and phenotypic or physiological plasticity play a central role (Krutovsky and Neale, 2005). It is therefore of great importance to characterize the genetic potential of natural populations and their adaptability to changing environmental conditions.

Large-scale beech (*Fagus sylvatica* L.) forests in Germany are mainly favoured in lowland cool and humid habitats and are scarcely found under warm and dry climatic conditions, like in slopes with south-west exposition. Considering the global climate change, the adaptability of such beech forests in changing environmental conditions is very crucial for their growth and development.

Materials and Methods

Beech populations including adult trees and natural regeneration from two opposite-exposed slopes (NE: north-east, and SW: south-west) located in a low mountain range in south-western Germany were genetically analysed. The analyses of meteorological data and the water status and growth of adult beech trees showed a continuously lower water availability and higher air temperature at the SW site compared to the NE site for several years (Gessler et al. 2001, 2005). Samples from 80 adult trees (A) and 100 seedlings of the natural regeneration (NR) were collected from each slope. Leaves were used for the microsatellite analysis and winter buds for the isoenzyme analysis.

Ten enzyme systems were investigated: AAT (EC 2.6.1.1), ACO (EC 4.2.1.3), IDH (EC 1.1.1.42), MNR (EC 1.6.99.2), MDH (EC 1.1.1.37), PGI (EC 5.3.1.9), PGM (EC 2.7.5.1), PEX, 6-PGDH (EC 1.1.1.44), SKDH (EC 1.1.1) according to Müller-Starck and Starke (1993). Additionally, five microsatellite markers were analysed: FS1-25, FS1-03, FS3-04, FS4-46 and FCM-5 (Pastorelli et al., 2003).

Genetic diversity within populations was estimated based on the actual number of alleles per locus (Na), effective number of alleles (Ne), observed heterozygosity (H_o) and expected heterozygosity (H_e) using the software GenAlEx 6.1 (Peakall & Smouse 2006). The same software was used to calculate genetic distances according to Nei (1972). Inbreeding coefficients (F_{IS}-value) were computed and tested for each locus and population for significance by performing 10,000 randomisations of alleles among individuals within samples using the software FSTAT (Goudet 1995). Differentiation patterns among the populations were also detected by calculating populations pairwise F_{ST}s (Weir & Cockerham 1984).

Results and Discussion

The isozyme analysis showed:

- Higher number of alleles and number of genotypes per locus in the adult population of the northeast slope (NE-A) but higher heterozygosity in the adult population of the southwest slope (SW-A).

In this case, natural selection favored the establishment of many different genetic variants which probably enable the survival of the population in extreme climatic conditions.

The microsatellite analysis showed:

- The total number of alleles ranged form 9 to 19, with FCM-5 as the most polymorphic microsatellite locus,
- The adult population from the southeast slope showed different allele frequency distribution from the other populations and for at least two microsatellites (FS3-04, FS1-04)
- Only in the adult trees from the south-west slope a relatively frequent private allele was present with a frequency of 12%

We assessed with both sets of markers:

- Significant genetic differentiation between the adult populations (A) growing at the NE and SW slopes,
- The adult population on the south-west slope (SW-A) is mostly differentiated from all populations,
- A higher genetic similarity between the subpopulation SW-NR to both NE-A and NE-NR populations than to the SW-A.

These results could be explained either by different origin of the seed material used for the establishment of the populations or by different adaptation processes occurring under different microclimatic conditions on the two slopes. According to historical data, both sites were established in the same way and developed by natural regeneration following a complete clear-cutting at the beginning of the 19th century (Paul 1998). Thus, natural selection is most probably the reason for the high genetic differentiation between the adult trees on the south-west slope and all the others subpopulations. Our explanation for the different genetic structures between the SW-A and SW-NR subpopulations is that the trees which survived the inconvenient microenvironmental conditions on the SW slope and reached the mature stage were considerably different genetically from the seedlings before the natural selection process.

Moreover, gene flow between the two slopes is evident, since the natural regeneration of the two slopes is genetically similar. Both the short distances between the slopes and the local relief seem to favour the exchange of genetic information through seed and pollen dispersal.

Generally, we found similar patterns by isozyme and microsatellite analyses but the genetic differentiation among the subpopulations was more pronounced by the microsatellite markers.

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TESTING THE ADAPTABILITY OF MEDITERRANEAN BEECH IN SWISS FORESTS

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Climate change is swiftly gathering pace, as recently proved by new climatic analysis for the period 1981 to 2010 (Meteoschweiz 2011). This change is having significant long-term effects on Swiss forests (Brang et al. 2008). Forecast models of tree evolution under climate change at Swiss level estimate beech forests as partly endangered in lower elevations (Zimmermann and Bugmann 2008). Forest managers are worried about the choice of tree species when practising forest regeneration: can they take any action to mitigate climate change effects in the future, without taking too many risks of unwanted effects? Two questions are being investigated in this ongoing project: (1) is Mediterranean beech (*Fagus sylvatica*) able to establish in Switzerland under current climatic conditions – including relatively cold winters and possible late frosts, and (2) is Mediterranean beech more drought-resistant than Swiss beech?

During autumn 2009, seeds of 14 provenances from Italy, Slovenia and Switzerland were collected. Two provenances are always located close to each other, one representing a mesic and the other a xeric site. Each provenance consists of six mother trees. The exact location of all 84 mother trees is known and site conditions were recorded.
On initially five experimental sites in forests, near the present drought limit of beech, all mother trees are tested under near natural conditions. The experimental sites represent a N-S gradient within Switzerland. Microclimatic data are recorded on each site. The germination and growth success of the seeds is monitored for each mother tree.
In addition, in a tree nursery, the issue of whether the southern provenances are as robust or react as sensitively to summer drought as Swiss provenances is being tested on seedlings under more controlled conditions during August 2011.

Germination in 2010 showed clear differences among the tested provenances. The pairs from the same location (xeric and mesic site) reacted in more or less the same way, but within the provenances we observed major variation from mother tree to mother tree. By coincidence, spring and early summer 2011 were extremely dry in Swiss forests. This unexpected fact led to more detailed experience regarding natural regeneration of beech and climatic conditions: during April, humidity of the upper soil and air humidity seemed to be crucial for germination. Growth parameters after a full vegetation period vary more between the experimental sites than between the provenances. However, some trends according to the provenances are visible. First results of the drought experiment are expected by September.

In addition to the above-mentioned field trials, the findings of the COST Action E52 “Evaluation of Beech Genetic Resources for Sustainable Forestry” may help to assess potential reactions when assisted migration is proposed as a strategy to enhance the fitness of beech forests (Alia 2011). Our results of beech seedling observations and experiments will be set in this larger context, i.e. the general adaptability of beech in terms of climate change (Mühlethaler et al. 2011). This may yield more general evidence to answer the above-mentioned questions.
Although the experiments and recordings are not yet finished, some conclusions may already be proposed:

a) Empirical lessons to take home:
    - Seed collection of beech in Mediterranean areas may be difficult, especially if seed from lower altitude is required. After a dry summer, seeds are often empty.
    - In natural conditions, the loss of seeds to mice and birds has a major impact. If seed quantity is limited, it is advisable to grow seedlings in a nursery first instead of direct seeding in the forest. However, the second method would allow a much more natural approach to enhance the genetic diversity by enrichment of the present regeneration.

b) Lessons from the experiments:
    - In each country or region, you will find both very good and very poor provenances. Mediterranean beech provenances are slightly superior compared to most Swiss provenances.
    - Within a stand, the quality of seeds differs very much from mother tree to mother tree.
    - When the period March – May is dry, very little success in germination will occur. Spring drought due to climate change may be a more important problem for Central Europe's beech forests in the future than summer drought.

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IMPACT OF FOREST MANAGEMENT ON STAND STRUCTURE AND GENETIC DIVERSITY OF BEECH (*FAGUS SYLVATICA*) FOREST STANDS

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Introduction

Genetic diversity, including the presence of rare alleles, has repeatedly been shown to be important for the survival of a range of biological populations due to the development of resistance following exposure to a variety of selective forces. Although essential to the long-term health and survival of all biological populations, genetic diversity may be particularly critical to the health of forest trees, because they have limited mobility, are slow to reach reproductive maturity, and are likely to encounter significant environmental change during their long lifespans. Indeed, relative to the many organisms evaluated, trees are among the most genetically variable organisms on earth (Bush and Smouse, 1992). Forest management is one of the human activities which can alter the gene pools of woodlands ecosystem reducing the genetic diversity within forest stands. For example, artificial regeneration with reproductive material of unknown origin can change genetic structures in unpredictable ways (Finkeldey and Ziehe, 2004). Furthermore, intensive or selective felling can reduce population densities or population sizes, thereby reducing gene flow, increasing inbreeding, and potentially elevating the possibility of genetic drift (Finkeldey and Ziehe, 2004). Silvicultural selection represents an anthropogenic selective force in which sometimes large numbers of trees (and the genes they contain) are removed from a natural system within a relatively short period of time while simultaneously safeguarding environmental quality. Certainly, tree harvests are critical to supply human resource needs. Still, the long-term impact of tree removals to the genetic base and ecological resilience of forests remains largely unknown.

In this study the impact of forest management on stand structure and genetic diversity has been examined in beech (*Fagus sylvatica* L.) forest stands in the Apennine Mountains, central Italy. The study aims at comparing both spatial stand structure and genetic diversity between an old-growth forest and a post-harvest naturally regenerated forest.

Material and methods

Two experimental plots were installed on the Gran Sasso Massif in Central Italy, at an altitude ranging from 1150 and 1250 m a.s.l. The plots were located in an unmanaged old-growth beech forest (plot A, 0.64 ha large) and in a pure beech forest managed according to the shelterwood system (plot B, 0.27 ha large). Plot A is 2 km far from plot B. Plot A has not been subject to any type of harvesting during the last 400 years. In Plot B a seed cutting had been carried out six years before the start of the study. In each plot the census of all living trees with a diameter at breast height (dbh) > 2.5 cm was performed. For all trees the following data have been collected: position of each tree according to polar coordinates, species, dbh, total tree height, height-to-base of the live crown and crown projection.

To characterize the structure of the stands several classic forest parameters have been computed (e.g. number of stems, basal area, volume etc.). Stand density has been measured on the basis of the percentage canopy cover. The vertical distribution of crowns in the stands has been assessed using the TSTRAT function (Latham et al., 1998). Horizontal stand structure has been assessed using the univariate L(d) function (Besag, 1977) which is the transformation of the Ripley's K function. The Monte Carlo simulations has been used to assess the significance of deviation from random distribution (95% confidence envelop).

Total DNA was extracted from the samples to perform microsatellite and RAPD analyses as reported by Pastorelli et al. (2003) and Emiliani et al. (2004), respectively. We inferred population structure using a Bayesian Monte Carlo Markov Chains method implemented in the Geneland package, described in Guillot et al. (2005) under the R Language and Environment for Statistical Computing software. Ten independent Monte Carlo Markov Chains runs were performed by Geneland with the following settings: 1000000 iterations with 100 thinning interval and a burning of 250000, using the correlated allele frequencies model.

Results and discussion

Data shows that the old growth beech forest (Plot A) has a more complex structure and a higher genetic diversity than the managed one (Plot B).

Classic forest parameters for the selected plots are shown in Table. 1. The stem number-diameter distribution is shown in Figure 1. Horizontal spatial pattern was clustered in Plot A and random in Plot B. The vertical distribution of crowns computed by TSTRAT consisted of 3 strata in Plot A and of 2 strata in Plot B.

In general, RAPD markers and microsatellite alleles detected in Plot A have a low frequency or are rare in Plot B, and those which are rare in Plot A are lost in Plot B. The results of Geneland clearly showed that seven distinct clusters can be identified in Plot A (Figure 2) and a high level of gene flow is present. In fact, the F_{st} value among clusters is low indicating a high gene flow among clusters. The same analysis indicates two clusters in Plot B (Figure 3) with a high gene flow among them but each cluster presents a high value of F_{is} respect to the clusters of Plot A.

In conclusion, under the examined conditions the shelterwood system reduces stand structure diversity in respect to old-growth beech forest. Furthermore, a reduction of rare alleles has been observed in Plot B due to the effect of human activity. The genetic diversity among the plots are similar, in contrast the spatial structures of genetic diversity are very different.

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Plot		Age		Num. of stems	Basal area	Volume	Canopy cover
	Min	Mean	Max				
	years	years	years	n ha^{-1}	m^{2}ha^{-1}	m^{3}ha^{-1}	%
A	85	207	448	184	58	1079	78
B	49	85	146	496	30	403	77

Table 1. Forest parameters for Plot A and B.

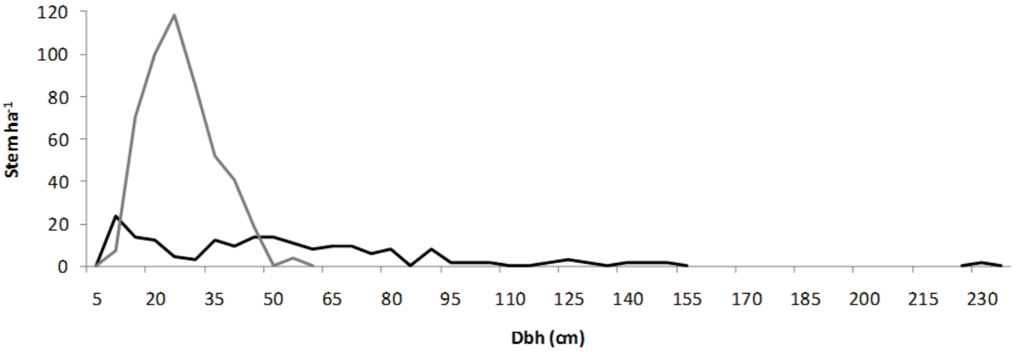

Figure 1. Stem number-diameter distribution for Plot A (in black) and B (in grey).

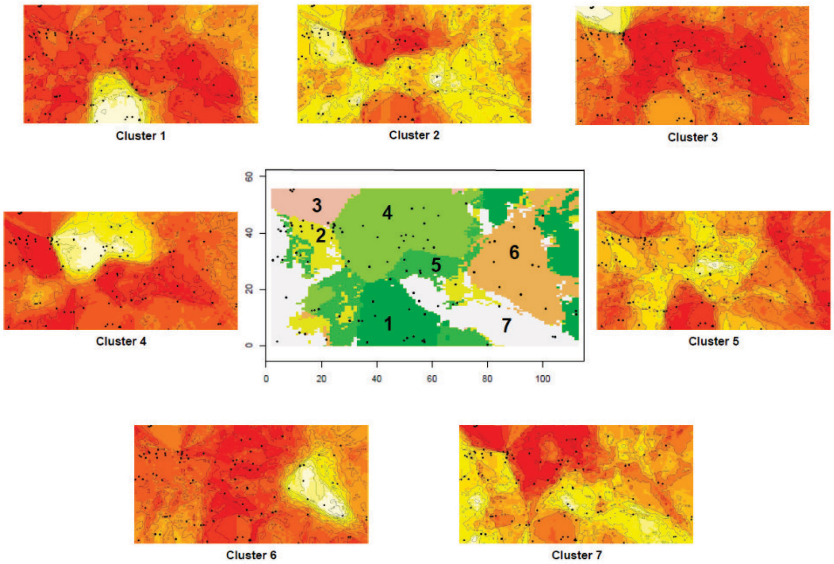

Figure 2. Plot A: results of Geneland analyses showing the spatial organisation into seven clusters and maps of posterior probabilities for each cluster.

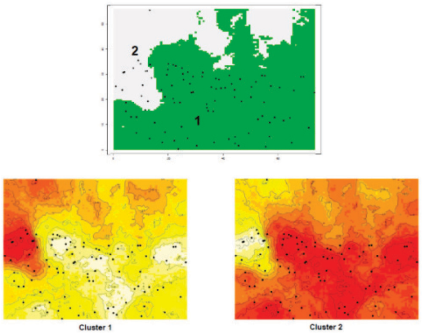

Figure 3. Pot B: results of Geneland analyses showing the spatial organisation into two clusters and maps of posterior probabilities for each cluster.

FOREST MANAGEMENT DOES NOT REDUCE GENETIC DIVERSITY OF ADULT BEECH (*FAGUS SYLVATICA*) STANDS BUT CHANGES THE SPATIAL STRUCTURE

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Forest trees are long-living, sessile organisms growing under temporally varying and spatially heterogeneous environmental conditions. Most temperate forest trees including beech are predominantly outcrossing with efficient means of gene dispersal through pollen and, to a lesser extent, seeds. These life-history characteristics result in usually high diversity within populations (Hamrick et al. 1992), but rather low differentiation among populations at biparentally inherited, nuclear genes (Austerlitz et al. 2000).

Forest management has a potential impact on genetic variation patterns of trees (Finkeldey and Ziehe 2004). Most studies aimed at the assessment of silvicultural treatments on genetic variation of beech were based on moderately variable isozyme gene loci (Lauber et al. 1997, Hussendörfer and Konnert 2000, Janssen and Nowack 2001, Finkeldey and Ziehe 2004). Buiteveld et al. (2007) used four microsatellite markers and investigated ten plots to analyse the influence of management on the genetic diversity of beech. With this limited number of genetic markers they found no significant differences in genetic variation between stands under different management regimes. Detailed information about patterns of the small-scale spatial genetic structure (SGS) within stands is very important to design and implement conservation practices (Vornam et al. 2004). Not only information about the amount of genetic diversity, but also its spatial distribution (Dunham et al. 1999) is crucial for the exact diagnosis of status, threat and viability of a population (Frankham 1995). The knowledge about SGS provides important information regarding local evolutionary processes such as gene flow, inbreeding and the action of natural selection (Epperson 1992, Ishida and Kimura 2003). Takahashi et al. (2000) studied the effect of forest management on the genetic diversity and the structure of two Japanese beech (*Fagus crenata* Blume) stands using nine isozyme markers. They found no significant effect of forest management on the genetic diversity of the beech stand, but the SGS was significantly affected.

The aim of our study is the investigation of the influence of management on the genetic diversity and spatial genetic structure of 30 beech stands in three study sites in Germany with the help of nine microsatellite and three AFLP (Amplified Fragment Lengths Polymorphism) primers.

Material and Methods

Three study regions, Schwäbische Alb, Hainich-Dün and Schorfheide-Chorin, were investigated in Germany (Fig. 1) within the framework of the German Biodiversity Exploratories (www.biodiversity-exploratories.de). Within each of these regions, ten plots were selected ranging from intensively managed to currently unmanaged. In total, 3600 adult trees were sampled from 30 different plots. The exact locations of the sampled trees were recorded by using a TruPulse 360 range finder (Laser Technology Inc, Colorado, USA).

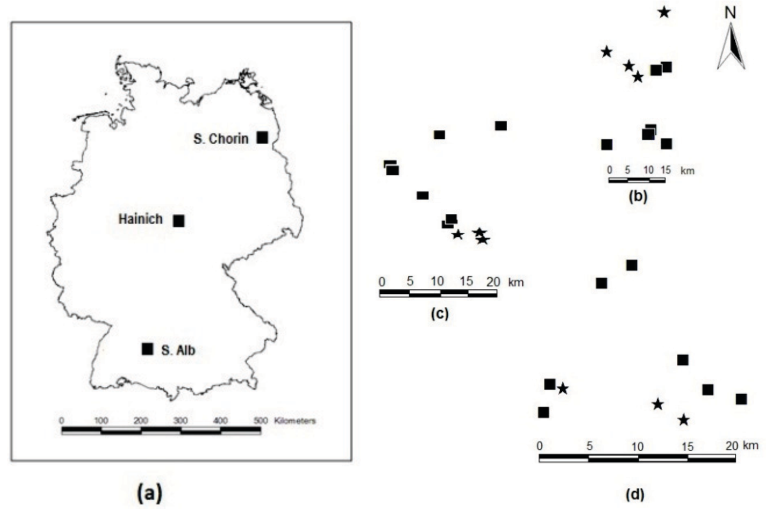

Fig. 1: Location of the studied areas (a) and of the plots (b) Schorfheide-Chorin (c) Hainich-Dün and (d) Schwäbische Alb: solid boxes indicate managed stands, stars indicate unmanaged stands.

Nine polymorphic microsatellite marker loci were used following published protocols with slight modifications (Asuka et al. 2004, Durand et al. 2010, Pastorelli et al. 2003, Vornam et al. 2004). For the investigation, two to four loci were analysed together (set 1: sfc0018, sfc0161, sfc1063, sfc1143, set 2: FS 3-04, mfs 11, set 3: GOT006, FIR065, FIR004). AFLP reactions were done for a subset of 600 samples from six populations following the protocol of Vos et al. (1995) with slight modifications. Altogether, 126 AFLP loci were used for the analyses. Genetic diversity parameters were calculated using GenAlEx 6.3 (Peakall and Smouse 2006) and FSTAT 2.9.3 (Goudet 2001). SPAGeDi 1.3 (Hardy and Vekemans 2002) was applied to compute multilocus kinship coefficients and the Sp statistics to estimate and quantify the strength of spatial genetic structure.

Results and Discussion

Genetic Diversity

The genetic diversity was not significantly different between managed and unmanaged beech stands (Table 1). At the regional level, the observed heterozygosity (H_O) and genetic diversity (H_S) were slightly, but significantly lower for managed than for unmanaged stands only in the Schwäbische Alb; tendencies in the other regions were mostly opposite, though non significant. Only for the unmanaged beech stands in Hainich-Dün, the inbreeding coefficient was slightly, but significantly higher (Table 1).

Table 1: Comparison between managed (M) and unmanaged (UM) stands (microsatellite data; *p values for* A_T *and* A_{rare}*: one tailed t-test, for others two-sided p-values obtained after 5000 permutations, * p<0.05, **p<0.01, ***p<0.001;* A_R*: allelic richness,* H_S*: mean genetic diversity within population;* F_{IS}*: inbreeding coefficient)*

	All Exploratories			S. Alb			Hainich-Dün			Schorfheide-Chorin		
	M	UM	P	M	UM	p	M	UM	p	M	UM	p
Pop N	20	10		7	3		7	3		6	4	
A_R	8.091	7.948	0.434	7.754	7.733	0.961	8.182	7.871	0.257	8.433	8.205	0.414
H_O	0.616	0.621	0.532	0.605	0.638	0.026*	0.619	0.607	0.257	0.625	0.620	0.689
H_S	0.619	0.626	0.260	0.606	0.630	0.008**	0.620	0.625	0.453	0.635	0.626	0.363
F_{IS}	0.005	0.008	0.725	0.001	-0.012	0.393	0.001	0.028	0.042*	0.015	0.009	0.694
F_{ST}	0.015	0.022	0.136	0.006	0.027	0.0002***	0.006	0.009	0.112	0.013	0.018	0.463

There were no significant differences between the genetic differentiation coefficients (F_{ST}) between managed and unmanaged beech stands. At regional level, F_{ST} was significantly smaller among managed beech stands than among unmanaged beech stands only in the

Schwäbische Alb (Table 1). Hierarchical AMOVA analysis indicated no significant differences due to management activities on the genetic structuring of beech stands (data not shown).

Spatial Genetic Structure

Forest management activities have a significant impact on reducing the genetic structure of beech stands (Table 2). In total, the strongest genetic structure was found in unmanaged beech stands (mean *Sp*=0.0148). At regional level, the estimation of *Sp* were significantly higher in unmanaged beech stands in the Schwäbische Alb (*Sp*=0.0252) compared to managed beech stands (*Sp*=0.0089). Similarly, higher levels of mean spatial genetic structure was found for unmanaged than for managed beech stands for Hainich-Dün and Schorfheide-Chorin (Table 2). However, these values were not statistically significant ($p>0.05$).

Table 2: Amount of SGS in managed (M) and unmanaged (UM) beech stands (microsatellite data), significance test: student's 't' test, df: degree of freedom; F_1: mean kinship coefficients at first distance class, bf: regression slope of kinship coefficients over logarithm of distances; *Sp* statistic quantifies the SGS, p: level of significance

Exploratory	df	Mean kinship (F_1)			Regression slope (b_f)			*Sp*		
		M	UM	p	M	UM	p	M	UM	p
All	27	0.0162	0.0351	0.002	-0.0068	-0.0141	0.012	0.0069	0.01477	0.011
S. Alb	8	0.0163	0.0570	<0.001	-0.0088	-0.0237	0.011	0.00893	0.02523	0.009
Hainich	8	0.0175	0.0209	0.680^{ns}	-0.0057	-0.0071	0.582^{ns}	0.00584	0.00725	0.579^{ns}
S. Chorin	8	0.0144	0.0290	0.153^{ns}	-0.0055	-0.0121	0.221^{ns}	0.00561	0.01257	0.221^{ns}

Conclusions

High levels of genetic variation, low inbreeding coefficients and low but significant differentiation among the regions and among stands were observed. In general, the intensity of forest management had neither a significant impact on genetic diversity within stands nor on differentiation patterns among stands. We conclude that intraspecific diversity in beech is an aspect of biodiversity remarkably 'resistant' to management impacts. In contrast, managed and unmanaged stands differ significantly concerning spatial structures. We assume that most thinning and logging operations reduce family structures by the removal of trees in pairs or groups of related, neighbouring trees.

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IMPLEMENTATION OF A GENETIC MONITORING SYSTEM IN EUROPEAN BEECH (*FAGUS SYLVATICA*) POPULATIONS - FIRST RESULTS OF A PILOT STUDY

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Introduction

In the framework of forest monitoring activities, the species level creates the basic level for the observation of the composition, state and development of forest ecosystems under the influence of environmental factors and their changes. Genetic aspects have not been integrated in this context so far, although the genetic systems of populations determine the essentials of adaptation, reactivity and adaptability of ecosystems. Knowledge on the present genetic status and the dynamics of forest tree populations is also fundamental for any measures for the conservation of forest genetic resources (Paul *et al.* 2000). For the long-term observation of the response of tree populations on the impact of environmental effects, a concept for a genetic monitoring scheme in forest tree species was elaborated (BLAG-Expertengruppe "Genetisches Monitoring" 2004, 2008; Kätzel *et al.* 2005). This concept makes the effort to conceive the genetic system in its entirety. The status of the genetic systems of forest tree populations is assessed on the basis of criteria, indicators and verifiers. For this purpose the genetic as well as the phenological and physiological levels are taken into consideration in order to follow temporal developments and to estimate influencing factors.
The realization of the concept has been tested in two pilot studies for European beech (*Fagus sylvatica* L.) and Wild cherry (*Prunus avium* L.), reported by Maurer *et al.* (2008) and Degen *et al.* (2008). First results and practical experiences of the monitoring study with European beech are presented in this contribution.

The Pilot Study – Material and Methods

Four monitoring plots were established in mature uneven-aged beech stands in different German regions, with ecosystem data available from various long-term studies. On a total of 4 hectares, each plot consists of three parts with different investigation intensity (Fig. 1). In the intensive section of 1 ha all adult trees and 4 clusters of regeneration with 50 individuals each were marked permanently and investigated. The individuals for phenological observations and for harvesting of single tree seed were also chosen from this part. In the extensive section, some more adult individuals were sampled. Over the entire plot, 200 representative distributed regeneration plants and a seed mixture completed the sampling.
The genetic studies were based on isozymes and molecular genetic markers including SSRs and AFLPs. The calculated genetic parameters reflect genetic variation, spatial genetic structures, mating system, pollen distribution functions and parental analysis. The following programs were applied: GSED (Gillet 2008), GDA_NT (Degen 2008), SGS-SPATIAL GENETIC SOFTWARE (Degen 2001), MLTR-MULTILOCUS MATING SYSTEM PROGRAM (Ritland 2002), POLDISP (Robledo-Armuncio *et al.* 2007) and CERVUS (Kalinowski *et al.* 2007). The seed quality of the mixed samples was tested according to the ISTA regulations (Anonymus 2003). The expression of flushing as phenological phase was estimated once per week in spring.

Results and Discussion

Similar as in genetic inventories, the results of this initial study reflect a “snapshot” of the current condition of the investigated beech populations. Each of them represents a different local gene pool showing a high level of genetic variation. To consider local peculiarities, plots distributed in different regions must be included.

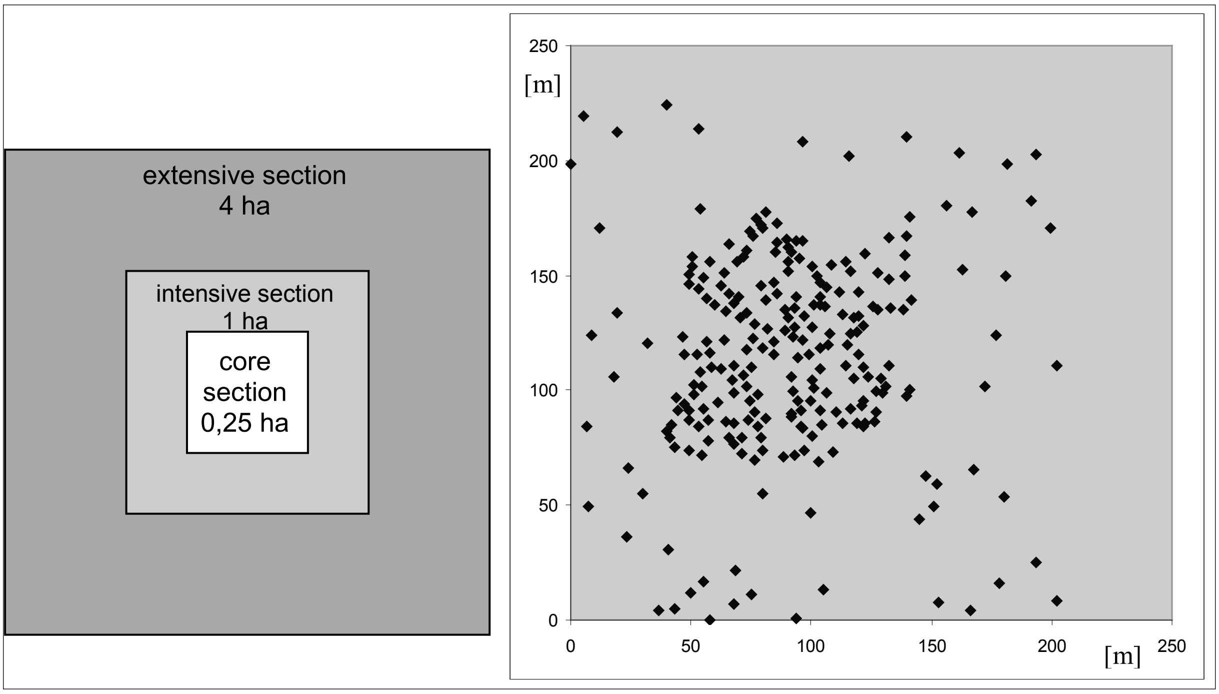

Fig. 1: Schematic design of the monitoring plots and distribution of investigated adult trees in the East-German plot

With one exception, the differences in genetic diversity between the developmental stages adult trees, natural regeneration and seed are low. However, spatial genetic analyses reveal family structures with different expression. That means that a representative image can be achieved only by sampling homogenously in the entire population or stand. Moreover, simulation studies show that the genetic distances decrease with increasing number of included trees for seed harvesting and of reproducing trees, with wider distribution of pollen and more homogenous distribution of male fertilities.

Tab. 1: Variation between the studied plots in parameters characterizing the mating system

Parameter	Variation of results
Deficit of heterozygotes (isozymes, %)	-0,8 - 6,3
Outcrossing rate (%)	95 - 97
Number of effective pollen donors per tree	12 - 63
Max. pollen dispersal (m)	112 - 133
Viability (TTC) of seed in 2006 (%)	59 - 80

Concerning the results of the parameters characterizing the mating system (Tab. 1), in all four populations high outcrossing rates and high numbers of effective pollen donors have been found, as well as relative wide maximum pollen dispersal distances. Apparently, the values indicate intact mating systems in the four populations, so that a high potential of transmitting genetic information to further generations can be assumed. Mating system and gene flow determine essentially the genetic variation and its spatial structure of a species. Repeated observations and analysis will show, if this intactness will be maintained under the influence of possible changes of environment.

Differences in flushing progress and flowering intensity were evident between the years as well as in all of the four plots. To allow an interpretation of the results, evaluations in association with plot-related climate data are required. The results of seed quality testing give also just information on the current state, but no information on seed quality development over the time.

In a holistic approach, these results were used as verifiers to indicate the state of the genetic system of the monitoring stands according to the Concept of Genetic Monitoring:

- The level of genetic diversity in the mature stand was verified by the effective numbers of alleles of the analyzed gene markers, the level of heterozygosity of isozymes and flushing.
- The changes in gene and genotype frequencies were verified by differences between the developmental stages as well as between the clusters of regeneration within the stands.
- The mating system was verified by the comparison of the heterozygosity rate (isozymes) of the adult trees with Hardy-Weinberg-Equilibrium, open pollination rate, number of effective pollen donors, family structures and viability of seed in 2006.
- Migration was verified by genetic differentiation between the adult stands and its pollen dissemination in 2006.

Each verifier was given a value for the expected effect (positive: +1, negative: -1, unknown or incomplete data: 0) on the genetic system of the population. The current status of the genetic system was judged using the average of these values. For two populations the genetic system was estimated to be undisturbed, for one no clear statement could be made and one was found to be in a critical situation.

Repeated observations and the management of collected information in a database create the basis for describing population genetic processes being influenced by environmental effects. The first experiences allow recommendations for the further strategy and realization of genetic monitoring, that may serve as an efficient early warning and controlling system for environmental changes.

Acknowledgements

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INVESTIGATING THE SPATIAL STRUCTURAL COMPLEXITY OF NATURAL ORIENTAL BEECH (*FAGUS ORIENTALIS*) IN DIFFERENT FOREST DEVELOPMENT STAGES AND SPATIAL SCALES USING NEIGHBORHOOD BASED VARIABLES

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Introduction

The natural dynamics, and resulting development phases and macro-structures, of European (*Fagus sylvatica* L.) and Oriental beech (*Fagus orientalis* Lipsky) forests are characterized by a mosaic of small-scale patches of different developmental phases with variable duration and spatial extent (Leibundgut 1993, Korpel’ 1995, Sagheb-Talebi and Schütz 2002), which are thought to be distinguishalbe using measures of stand size structure and volume accumulation (Korpel’ 1995; Heiri et al. 2009). Three developmental stages characterize the dynamics of natural beech forests (Korpel’ 1995): (1) the decay stage, in which canopy tree senescence increases the number and size of gaps, permitting the regeneration and recruitment of shade-tolerant tree species beneath persistent canopy gaps; (2) the initial stage, in which regenerating trees grow slowly due to competition with one another and the few remaining older trees in the overstory; and (3) the optimal stage, in which the closure of canopy gaps increases crown cover but reduces regeneration and thins suppressed trees.

An important feature of the development cycle is the contrast in the vertical structure, between typically multi-layered (decay and initial stages) and single-layered (optimal stage) canopies (Rademacher et al. 2004): (1) in the decay stage, the presence of dead trees and regeneration in the openings accentuates vertical irregularity; (2) in the early initial stage, the increasing proportion of young trees and decreasing proportion of old trees gradually shifts stand structure from multi-layered to two-layered; and (3) in the optimal stage, the death of the remaining overstory trees in the late initial stage shifts stand structure toward an almost single-layered structure. Lately, however, the absence of distinct differences in basal area and stand volume among development stages in the western Carpathians has led to a rejection of the view that beech forest development stages may be characterized by their biomass/basal area/stand volume accumulation and homogeneity of vertical structure (Paluch 2007). In this study, we hypothesized that (1) abundance-based structural attributes [tree density (TPHA), stand basal area (BA), mean stand diameter (DBH) and diameter variation (STD)] and spatially-explicit structural metrics [the aggregation index *R* (Clark and Evans 1954), which characterizes the horizontal spatial tree distribution pattern; the diameter differentiation index *T* (Füldner 1995), which characterizes the vertical size differentiation within small neighborhoods of four trees; and the structural complexity index *SCI* (Zenner and Hibbs 2000), which reflects both spatial positioning and tree size differentiation] would differ among development phases, (2) the variation in abundance-based structural attributes and in spatially-explicit structural metrics would decrease along the development phase sequence of decay, initial, and optimal, and (3) these differences would be scale-independent, at least at the neighborhood scale.

Materials and Methods

Our approach was to quantify the structure of nine (three development stages replicated in three sites: Kelardasht, Neka, and Shastkola) stem-mapped natural beech stands in the Caspian region of northern Iran using both structural attributes and spatially explicit metrics across scales up to 1 ha, with the objective of contrasting means and standard deviations among the development phases. Stands were dominated by shade-tolerant oriental beech (77.6 – 97.2% of all stems), with minor components of less shade-tolerant hornbeam (*Carpinus betulus* L.; 0.8 – 10.9%), maple (*Acer velutinum* Boiss.) and elm (*Ulmus glabra* Huds.). The stands had very limited human interventions and disturbances in the past and experienced no silvicultural activities for 50 years.

Three one hectare (100 m × 100 m) permanent plots were established in each of the three study areas in close proximity to one another. In each plot, species and diameter at breast height (1.3 m above the ground, dbh) of every live or standing dead tree (snag) with a dbh greater than 7.5 cm were recorded and mapped using slope-corrected distance and azimuth from a reference point that were later transformed to Cartesian coordinates. Abundance-based structural attributes and spatially-explicit structural metrics were computed for the 1 ha plot and, after adding sufficient buffer areas, for different scales (0.01, 0.025, 0.05, 0.1, 0.25, 0.5, and 0.75 ha) based on 30 random plots whose centers were located within the 1 ha plot.

Results and Discussion

Very few structural attributes were consistently different among the development stages at the 1-ha scale (Table 1). As expected, values for STD were low in the optimal stage and high in the Initial stage. Both *T* and *SCI* reached highest values in the Initial stage, reflecting large size differences among neighboring trees; values observed in the optimal stage were not consistently the lowest, however.

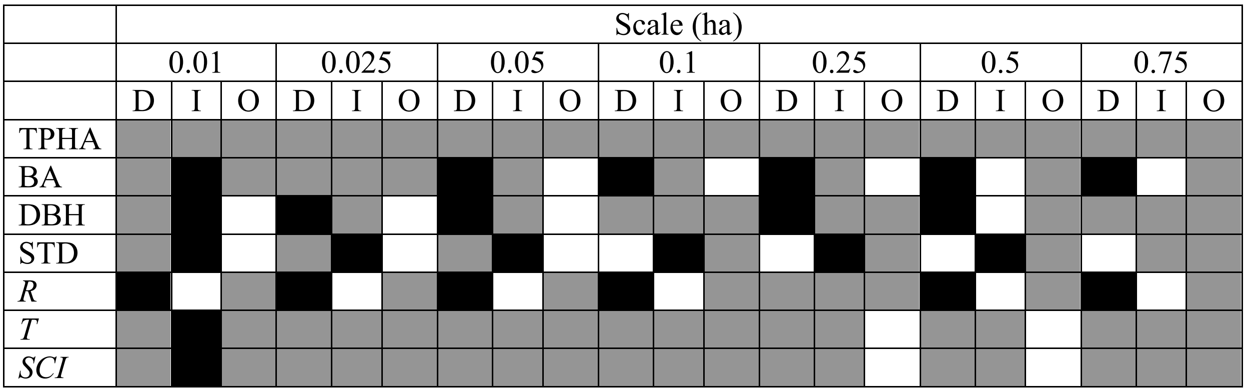
Table 1. Values of abundance-based structural attributes and spatially-explicit structural metrics in the decay, initial and optimal stages of stand development in the 3 study areas.

	Region								
	Kelardasht			Neka			Shastkola		
Structural Attribute	Decay	Initial	Optimal	Decay	Initial	Optimal	Decay	Initial	Optimal
TPHA	325	446	300	225	315	389	174	194	191
BA	44.5	47.6	45.7	42.1	38.4	39.9	33.7	35.3	37.1
DBH	35.8	28.2	39.0	40.4	28.2	29.4	41.5	39.8	43.1
Std DBH	21.5	23.7	20.6	27.4	27.6	21.0	27.3	27.2	24.8
R	0.92*	0.93*	0.94*	1.01	1.02	0.91*	0.92*	1.04	0.92*
T	0.38	0.38	0.36	0.39	0.43	0.40	0.48	0.50	0.44
SCI	6.099	7.311	5.891	6.4389	7.735	6.776	6.338	7.780	6.134

* spatial clustering of trees.

Similarly, our results do not lend support to the hypothesis that the variation of structural attributes and metrics would decrease along the development phase sequence of decay, initial, and optimal nor that differences in attributes and metrics among development phases would be scale-independent (Figure 1). Although the variability was often least in the optimal stage, this was not the case for all variables or consistent across scales for a given variable. The initial phase had generally the highest variability in STD, regardless of scale; for most other variables, this was only found at the smallest scale (0.01 ha). These findings indicate that homogeneous patches consisting mainly of saplings exist only at very small scales in the initial phase and that the regeneration is highly interspersed with larger trees in all development stages, supporting findings by Paluch (2007) that called into question the postulated homogeneity of patches even as small as a single canopy tree crown in the optimal stage.

Figure 1. Variability (standard deviation) of structural attributes and metrics in 3 developmental phases across scale: black indicates highest variability of at least 2 of 3 replications in a development phase; white indicates lowest variability of at least 2 of 3 replications; gray indicates medium variability or inconsistent results among replications.



	Scale (ha)																				
	0.01			0.025			0.05			0.1			0.25			0.5			0.75		
	D	I	O	D	I	O	D	I	O	D	I	O	D	I	O	D	I	O	D	I	O
TPHA	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
BA	▒	■	▒	▒	▒	▒	■	▒	□	■	▒	□	■	▒	□	■	□	▒	■	□	▒
DBH	▒	■	□	■	▒	□	■	▒	□	▒	▒	▒	■	▒	▒	■	□	▒	▒	▒	▒
STD	▒	■	□	▒	■	□	▒	■	□	□	■	▒	□	■	▒	□	■	▒	□	▒	▒
R	■	□	▒	■	□	▒	■	□	▒	■	□	▒	▒	▒	▒	■	□	▒	■	□	▒
T	▒	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	□	▒	▒	□	▒	▒	▒
SCI	▒	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	□	▒	▒	□	▒	▒	▒

Diameter distributions more readily revealed differences among the development phases (data not shown) and fit very closely the idealized diameter distributions along the development cycle presented by Heiri et al. (2009). Diameter distributions in the initial stage were characterized by a more or less pronounced reverse-J shape with highest stem frequencies in the first, second, and third diameter size class. Stem frequencies were more even in the decay and optimal stages, with highest stem frequencies observed in the first diameter class in the decay stage and higher diameter classes in the optimal stage, largely reflecting the dynamics of the regeneration in the development cycle (e.g., Korpel’ 1995). Findings from this study indicate that while macro-structures in the development phases may be well understood und predictable, small-scale micro-structures may be much more similar among the development phases and need to be investigated in more detail in a spatially explicit manner.

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SOME STRUCTURAL CHARACTERISTICS IN THE FAR EAST BORDER OF THE DISTRIBUTION RANGE OF ORIENTAL BEECH (*FAGUS ORIENTALIS* LIPSKY) STANDS

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Introduction

One of the most abundant and economic hardwood genera in the northern hemisphere temperate forests is the *Fagus* genus. The oriental beech (*Fagus orientalis* Lipsky) is distributed on the southern coasts of the Caspian sea in the Hyrcanian forests of northern Iran. The Iranian beech belt is connected from west to the European forests; regarding to plant composition it has many similarities with Balkan's beech forest (Sagheb-Talebi et al., 2003). Towards east, oriental beech is distributed to Ziyarat Valley in Gorgan, where an abrupt border for presence of beech occurs. This far east border of beech is the driest distribution area of this species in the Hyrcanian region with a mean annual precipitation of 530 mm and mean annual temperature of 17.8 °C (Annon. 2000). Genetical studies in this region have recognized 3 rare and 2 specific alleles in the higher elevations as well as 7 rare and 4 specific alleles in the middle and lower elevations of Gorgan beech forests (Salehi Shanjani and Sagheb-Talebi 2004). On the other hand deterioration of forests situation in the last decades has lead the foresters to manage the forests close to nature. Nature-based silviculture is a promising approach to meet the criteria for sustainable forestry. This brings the natural forest into focus as a basic reference for forest management (Emborg et al. 2000). The ecological oriented silviculture shows interests on study of forest stands which have kept their virgin characters, and many researchers are motivated to study the reserved or protected stands recently (Korpel 1995). The virgin forests are free of charge natural laboratories that could improve our information on the structure, regeneration process and dynamics of natural forests and can provide us lessons and knowledge for how to manage our natural stands close to nature (Leibundgut 1993). So far, the study area in Gorgan could gain an importance role for silvicultural and genetical investigations in the most adapted beech stands to dry climate regarding to global climate change aspects. This paper aims to study the structure of virgin like unmanaged beech stands in the eastern border of distribution range of beech and compare it with other stands in other locations.

Materials and Methods

The study area is located in the reserved district No.2 from the experimental forest (Shastkola), 12 km south-east of Gorgan city and the Ziyarat Valley, the far east border of the distribution range of oriental beech in 54°13' E and 36 ° 42' N. This district was kept as a natural reserve area and no silvicultural intervention has occurred in it. In frame of a National Research Project, with 4 locations in the whole Hyrcanian region, three permanent experimental plots, each 1 ha (100x100m), were laid out in three different development stages within unmanaged beech stands of Shastkola forest at an altitude of 1100 m.a.s.l. Generally, the forest type is irregular oriental beech and it has a forest brown soil after F.A.O classification and Cambisol after US classification (Habibi Kasseb 1992; Zarrinkafsh 2002). All trees with a dbh over 7.5cm were assessed in the plots. Tree species, dbh and coordinates of all trees including dead wood were assessed or measured. Moreover, tree height, crown length and crown width of all trees were measured within a transect (10x100m) in the middle of the sample plots. Furthermore, 5 micro sample plots (2x2m) were established within the transect and some quantitative and qualitative characteristics of seedlings and saplings were assessed. Also all gaps within the development stages were recorded and the present regeneration was studied.

Results and Discussion

Results showed that the stem number of trees varied between 206 and 188 per ha, total volume varies between 580 and 658 m^3ha^{-1} and the dead wood volume between 11.1 and 106 m^3ha^{-1} (table 1). The stem number and volume of the studied stands in Gorgan are less than other beech stands reported by Sagheb-Talebi et al. (2010) in other parts of the Hyrcanian region. Height of beech trees varied between 7.4 and 43.6m in the initial and decay stages, respectively. The initial and decay stages illustrated a stratificated multi storey stand while the optimal stand showed two layers with a poor under storey. The least slenderness coefficient with least standard deviation (72.8 ± 22.8) was observed in the optimal stage, while the h/d coefficient was higher in the initial stage, because of higher proportion of younger trees and height growth potential, and decay stage because of higher proportion of taller trees in these two stages.

Table 1. Some characteristics of the studied plots in Gorgan.

Parameter	Initial stage	Optimal stage	Decay stage
Total stem (N ha^{-1})	207	206	188
Dead wood (N ha^{-1})	12	15	14
Total volume (m^3 ha^{-1})	580	636	658
Dead wood volume (m^3 ha^{-1})	11	40	106
Mean height (m)	21.3	27.2	28.8
Slenderness coefficient (h/d)	79.9 ± 40.4	72.8 ± 22.8	79.8 ± 28.7

The stem number distribution showed an uneven-aged structure with high frequency of small timber size (dbh<35cm) in the initial (figure 1) and decay stages, while it illustrated an even-aged like structure in the optimal stage.

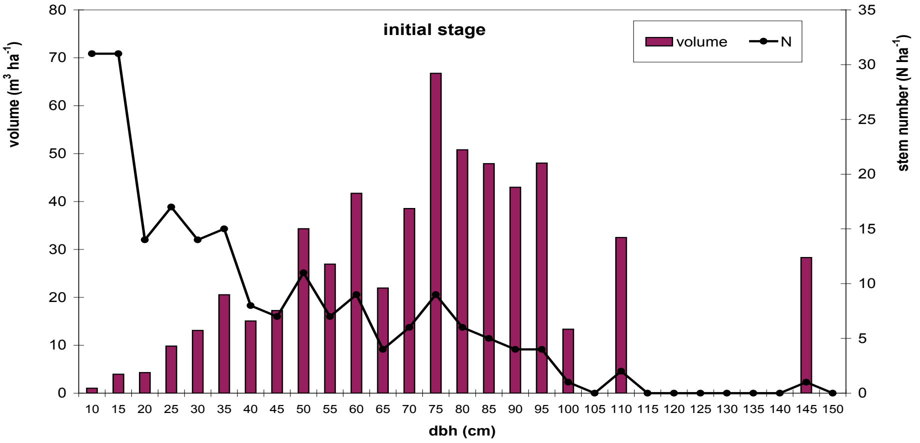

Figure 1. Stem number distribution and volume structure of the stand in the initial stage.

The proportion of small timber was much higher in the initial stage than that in other two stages, while the proportion of volume in the large (55cm<dbh<70cm) and extra large (dbh>75cm) timbers in the decay stage was much higher than those in the initial and optimal stages. Figure 3 illustrates the proportion of total and dead wood volume by timber sizes in the decay stage. The maximum total and dead wood volume was observed in the extra large timber size, while the dead wood in the initial stage was only observed in the small timber, because of competition among younger trees for light, and in the extra large timber because of mortality of older trees.

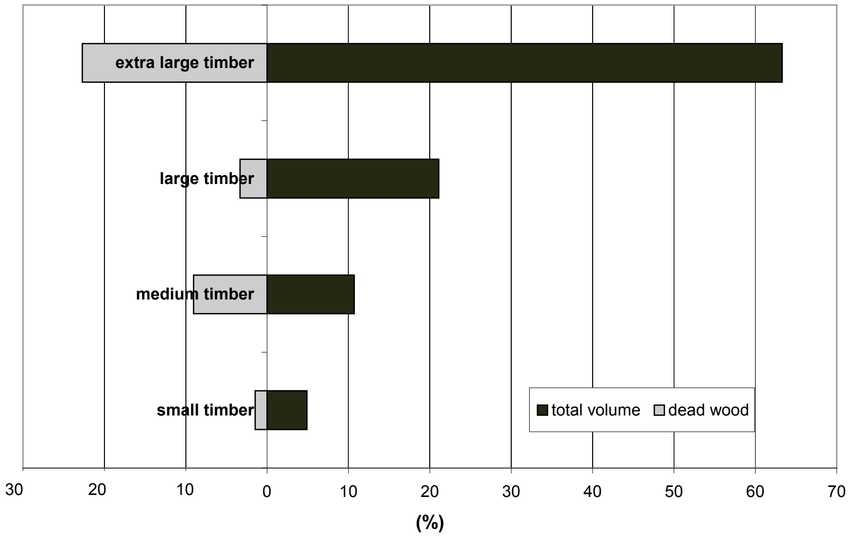

Figure 3. Proportion of total and dead wood volume by timber size in the decay stage.

In general, the initial and decay stages showed a diverse multi layer structure with open canopies because of presence of some gaps and regeneration within the stand which could be more expected to keep the sustainable condition in long term. Whereas, the optimal stage presented a less diverse, more or less one storied stand with closed canopy and no gaps as well as with more homogeneity in diameter and height of trees. Regeneration was very poor in this stage which could have negative impact on the sustainability of the stand.

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DEADWOOD DYNAMICS IN MANAGED AND UNMANAGED FORESTS OF BEECH (*FAGUS ORIENTALIS*) IN THE NORTH OF IRAN

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Introduction

Deadwood is an important component in natural forests. Its quality and spatial distribution are indicators of forest naturalness (Laarman et al., 2009) and reflecting forest management history. The amount of deadwood occurring in natural forests depends on many factors such as forest management (Stevenson et al., 2006; Yan et al., 2007; Woodall and Liknes, 2008). Presence of deadwood can be related to the intensity of silvicultural interventions and the way these are carried out (Guby and Dobbertin, 1996; Green and Peterken, 1997). Despite deadwood has received increasing attention during the last decades due to its importance, it is now at a critically low level, mainly due to inappropriate management practices in natural forests. So, managers attempt to emulate in their interventions by adopting principles of "ecological forestry" (Franklin et al., 2007).

Deadwood quantities are normally much lower in managed forest than in unmanaged old-growth forest, as most of the large sized harvestable timber is extracted (Green and Peterken, 1997; Kirby et al., 1998; Odor and Standovar, 2001). Therefore, the aim of the present study is to describe and compare the amount of deadwood and its spatial distribution in managed and unmanaged forests of beech.

Materials and Methods

The study site was located in Kheiroud forest, a natural beech (*Fagus orientalis* Lipsky) forest in west of Mazandaran province, north of Iran at 51^{o} 35′ N and 36^{o} 35′ E. The extended between 800 and 1450 m.a.sl. with a mean annual precipitation of 1360mm. The soil type is forest brown and soil texture varies between clay-loam and clay. The most important forest community of the region is Fagetum typicum and in the study areas all stands were dominated by beech.

In this research, all living trees and all standing (snags) and fallen deadwood (logs) of diameter of over 7.5 cm were measured in full callipering method. Measuring parameters include diameter, height, basal area, volume and stem coordinates (exact to 0.1m, using a compass and an ultrasonic distance-meter) in order to determine spatial distribution of all trees in the natural beech stands. The above mentioned parameters were measured in two areas: managed and unmanaged area. Each area was about 10 hectares. For volume estimation, the height and dbh of all standing dead tree and the dbh of logs was measured. The volume of standing and fallen entire deadwoods was estimated by using Huber's formula and the volume of living trees measured by using regional tariffs based on DBH and height measurements. Differences between areas have been analyzed by the T test.

The decay condition of deadwood was determined using a key for a five-class for decay of deadwood where each stem was assigned to a decay class by test of hardness combined with a visual estimation of outline and bark.

Mathematical method

Stand spatial pattern is complicate concept, including both horizontal and vertical use of space by trees. To simplify this approach, we focus on the horizontal location of trees in the stand and each tree is represented by a point, defined by its co-ordinates (x, y). In order to determine the spatial pattern of the distribution of trees in beech stand and with regards to an initial hypothesis for this research would be that in uneven-aged stands, a clustered or random distribution would be expected.

Therefore, specific tools are necessary to characterize the structure. Many methods have been developed to study structure (Ripley, 1981). Point pattern analysis, a branch of spatial statistics, can be used to analyze horizontal stem scattering and quantify the spatial pattern of plant community (Cressie, 1993). Spatial statistics based on point processes such as Ripley's function have often been used to describe the spatial distribution of trees and seems all the more interesting as it gives a description of spatial structure at different scales at the same time (Cressie, 1993), and it could be applied on each species separately. In this study, we used the Ripley's M function determine the spatial pattern of trees.

Results and Discussion

Based on Ripley's M function (Fig 1) the spatial pattern of deadwood in both area (managed and unmanaged) is aggregated. M value in the same distance, in managed area is less than unmanaged area. This result illustrated that the structure pattern in beech stands is heterogeneous and in order to determine silvicultural method, this knowledge can be useful.

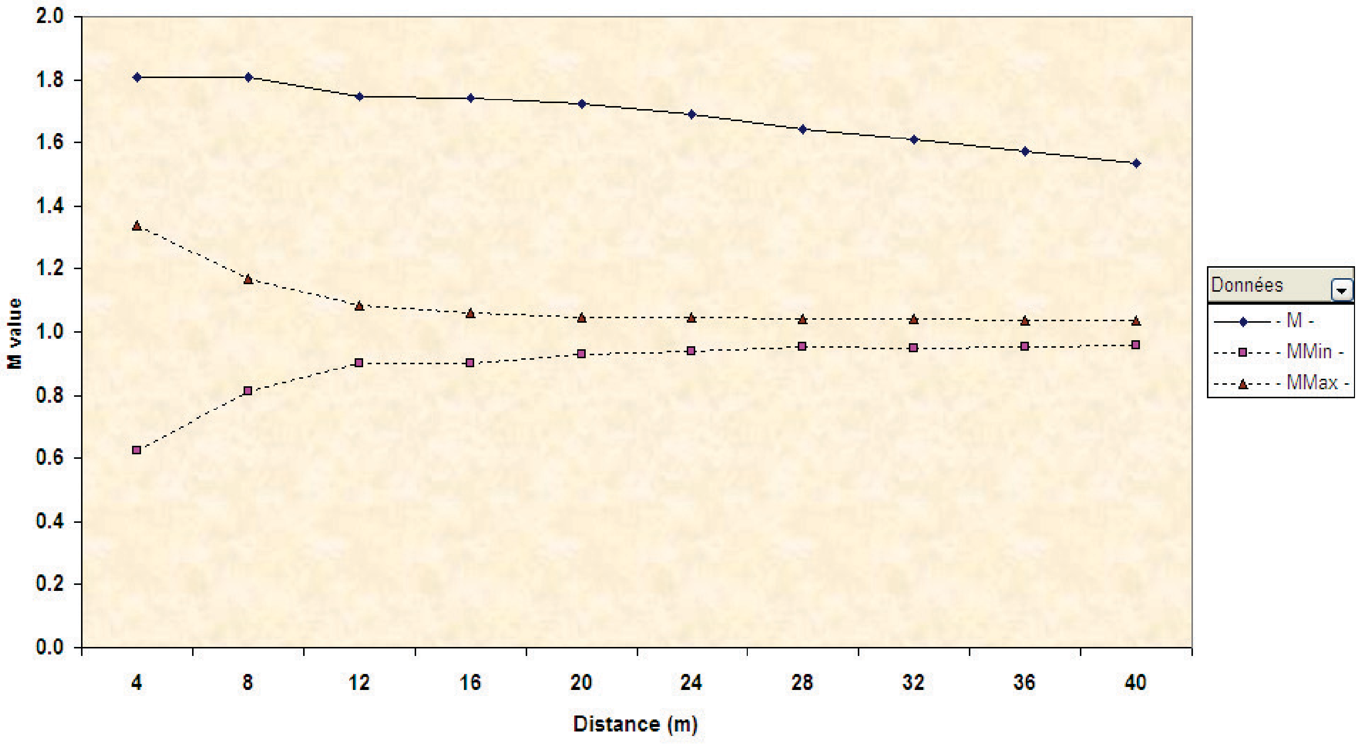

Fig1. Ripley's M function value in unmanaged area

The mean volume of deadwood (snags and logs) in unmanaged forest was 32.3 m^3/ha from which 31% were snags and 69% logs. The amount of deadwood between both areas is difference significantly. In unmanaged forests it is 3 times higher than that of managed forests. There is only a few amount of deadwood is present in most managed forest that mainly is snags. The main reasons for such large differences are forest management measures (e.g. wood extraction, short rotation time, reduction of natural tree mortality), which decrease quantity, distribution and size of deadwood. This research illustrated that in managed forests, deadwood decrease in compare to it from last decade and increase in deadwood volumes must be carried out in accordance with the forest type and natural disturbance regime.

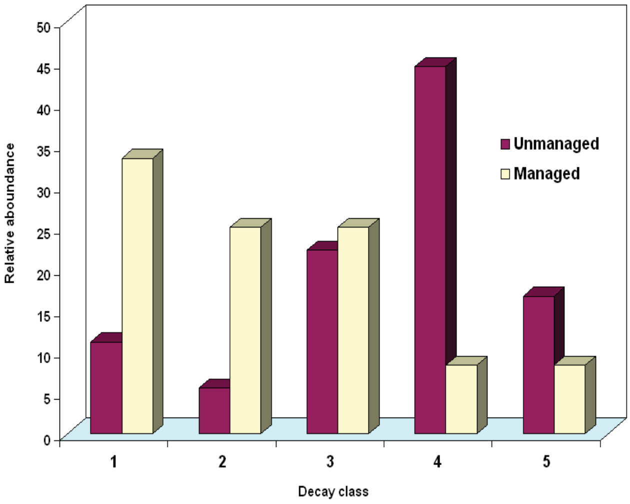

Fig2. Relative abundance of deadwood in different decay classes

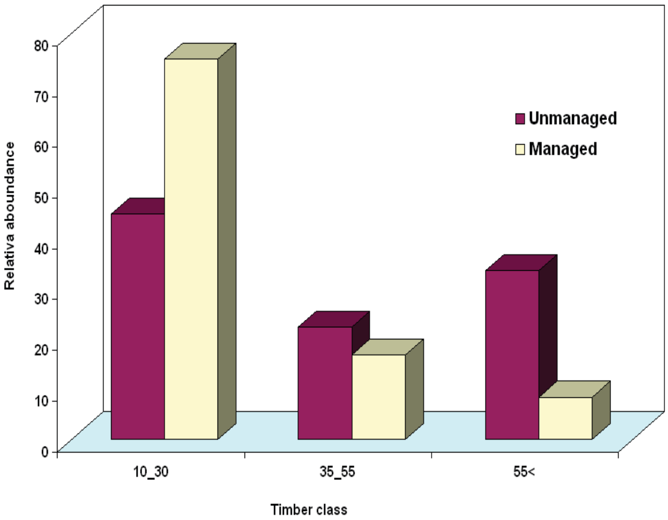

Fig3. Relative abundance of deadwood in different timber classes

Figure 2 shows the distribution of deadwood to the 5 decay classes. In managed stands, the higher percentage of deadwood occurs during first and second stages of decomposition, but in unmanaged it can be found in forth stage of decomposition (Fig2). Also, in managed area, relative abundance of small timber (10-30cm) of deadwood is more than other one, but in unmanaged stands large timber (55< cm) is more than others (Fig3). This study showed that the main reasons for such a large difference are forest management measures. Typical managed forests of beech contain only small amount of deadwood and forest management causes reduction and homogenization of deadwood (Debeljak, 2006). Without sufficient amount of deadwood the stability of forests will continue to decline due to less attention to stand structure in managed forests.

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EUROPEAN BEECH SEEDLINGS ARE MUCH MORE RESPONSIVE TO LIMITED RESOURCES THAN NORWAY SPRUCE

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Introduction

As long as large scale mortality does not occur, European beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* [Karst.] L.) will form future mixed forest stands in Central Europe on many sites. In pure Norway spruce stands which have been underplanted with European beech on a considerable area throughout Europe because of ecological and economic reasons, tree regeneration is exposed to limited resource availability due to the impact of the overstorey trees. However, with decreasing summer rainfall, water availability during the vegetation period is likely to be further reduced. Given the different abilities of the species to cope with further limitations in resource availability, changes in competitiveness among regenerating trees are assumed (Grundmann et al. 2011). Thus it may be that species such as Norway spruce, which is not as shade tolerant as European beech, will benefit relatively from dry summers if it is less affected by water deficits than European beech.

From many studies it is known that the response to a limited resource, e. g. light, is dependent on the availability of other resources, e.g. soil water or nutrients. This means that interactions between resources need to be taken into account. In fact Madsen (1994) and Löf et al. (2005) showed, for European beech, that the growth response of the seedlings to increased light availability and biomass partitioning were strongly dependent on soil moisture status. However, in absolute terms plants that have been exposed to low light conditions for a long time and which, therefore, have favoured aboveground biomass at the expense of roots, may respond more strongly to drought than plants with full access to light (Valladares and Pearcy 2002). Nevertheless, there is an ongoing debate on whether or not shifts in biomass allocation are primarily caused by ontogeny, and thus tree size, or driven by environmental conditions (Curt et al. 2005, Sack and Grubb 2002, Sack 2004, Shipley and Meziane 2002).

To investigate the response of European beech and Norway spruce seedlings in growth and biomass partitioning to reduced light and water availability, we conducted a three-year greenhouse experiment with three levels of irradiance and two levels of soil water supply. The aim of this study was to test the following null hypotheses: (i) the response of seedlings to reduced light availability does not vary between tree species; (ii) the response of seedlings to reduced light availability is independent of soil moisture; and (iii) shifts in biomass partitioning are caused by tree size, not by environmental conditions.

Materials and methods

To investigate the effect of light availability and soil moisture on growth and biomass partitioning of Norway spruce and European beech, we established a 3 x 2 factorial greenhouse experiment with 32 replicates per treatment and species using potted plants. In total 384 seedlings were examined (2 species x 3 light levels x 2 soil moisture levels x 32 seedlings) between April 2006 (experiment begin) and November 2008 (experiment end). The pots of a given treatment were randomly rearranged once per year. Before the experiment began, the 30 l pots were filled with mineral soil which had been removed from two adjacent, very productive forest stands growing on haplic luvisols from loess near Freising, southern Germany. The experiment was established using one-year-old European beech and two-year-old Norway spruce seedlings obtained from a nursery, where they had grown in open field conditions. In 2006 all seedlings were well watered and received a photosynthetic radiation representing 65 % of open field conditions. In 2007 and 2008 the seedlings were exposed to different treatments. The factor levels for light availability were 28.7 %, 58.9 % and 80.8 % of ambient light. The R/FR-ratio, measured by Fieldscout Red/Far Red Meter (Spectrum Technologies, Inc, USA) remained at 93 to 96 % of the open field conditions. The two soil moisture levels were designed to represent a moist and a dry year. Thus, as under natural conditions, fluctuations in soil moisture were achieved. However, the soil water potential was significantly different between the moisture treatments between May 01 and September 30 of each year. During winter all plants were well watered.

The effects of factor levels and treatments on length, diameter and biomass growth were analyzed using ANOVA. Differences between factor levels and treatments were determined by Tukey's HSD post-hoc test ($P < 0.05$). As plant allocation patterns are size-dependent (Weiner, 2004), tree size effects on morphometric ratios were analyzed by extending the factorial ANOVA to an ANCOVA, introducing tree size as a covariate.

Results and discussion

European beech and Norway spruce showed substantial differences in their response to limited resources. While Norway spruce responded to increasing light availability with an increase in length and diameter growth, only a slight shift in shoot/root ratio (SRR) and no significant response in the leaf/fine root ratio (LFR) was evident. For European beech the opposite pattern was found: growth or total biomass production did not increase with increasing light under moist conditions, but a distinct shift in biomass partitioning resulting in strongly increased Shoot/root ratio (SRR) and LFR with decreasing light availability. The differences were also apparent in the leaf weight/sapwood area ratio (LSAR). In our experiment the two different growth strategies were found to be independent of soil moisture. Thus a response of SRR and LFR to reduced light availability could be observed even under dry conditions. This finding raises the question of whether our drought treatment caused insufficient stress to the plants compared to light, even though a significant response to drought was found for stem length and diameter, all aboveground components and fine root biomass of European beech, and stem diameter, stem and branch biomass of Norway spruce as in other studies (Coll et al. 2003, Löf et al. 2005, Alavi 2002, Jyske et al.2010). Although soil water potential was well below that of drought treatments in other experiments (Wallin et al.2002), it may have had little effect on the plants. Although Löf et al. (2005) observed no effects of soil water treatment on leaf, stem and root dry weight, they did find differences in SRR between watered and dry seedlings at high light conditions, indicating an interaction between light, the primary limiting resource, and water. Madsen (1994) reported that both light and soil moisture levels affected shoot and root growth and SRR. In his study, an interaction between light and water was found, resulting in a slight response of European beech seedlings to increased light if the soil water content was low. In our study, the phenotypic plasticity of shoot-root ratios to both shading and drought differentiated the two species. In theory the growth of plants is a result of a balance between plant components capturing resources (Shipley and Meziane 2002). Leaves and fine roots increase in mass or area and/or should become more efficient in resource uptake if resources are limited. The balanced-growth hypothesis suggests that biomass is allocated preferentially to leaves if light is limited, and to roots if belowground resources are limited (Shipley and Meziane 2002). In our case European beech showed much higher phenotypic plasticity, at least to reduced light, than Norway spruce. SRR increased slightly with decreasing light and LFR changed significantly only for European beech. As in other studies, European beech reduced fine root biomass with increasing drought (Meier and Leuschner 2008). However, SRR decreased slightly under dry conditions, indicating reallocation in favor of belowground biomass (Čater and Simončič (2010)). Importantly, the differences in SRR between moist and dry conditions result from a disproportionately high reduction in aboveground biomass compared to the belowground components. Thus, as shown for oak (Arend et al. 2011), European beech adapts to drought by restricting water loss rather than tapping new water reservoirs. Nevertheless, this species proved to acclimatise efficiently to reduced resource availability through biomass partitioning. Whether or not morphological (e. g. expressed by the specific root length/specific leaf area-ratio) and physiological adjustments (van Hees and Clerkx 2003, Köcher et al. 2009, Ditmarova et al. 2010) are also used by the two species could not be investigated in this study. Decreased light availability changed SRR of Norway spruce, but not to the same degree as European beech. SRR of Norway spruce did not respond at all to drought. The response to shading is clear. As expected, European beech not only exhibited greater plasticity, but was also less stressed under reduced light availability. While Norway spruce reduced its total biomass to 37.5 % of the maximum in the low light treatment, European beech still reached 59.2 %. The higher plasticity of European beech in response to decreased light availability corresponds with its shade tolerance and competitiveness in low light environments. Analogously it may be that its higher plasticity to drought reflects another competitive advantage in dry conditions over Norway spruce (Čater and Simončič 2010). This hypothesis contrasts with the inverse relationship between tolerance to shade and drought suggested by Niinemets and Valladares (2006). Our results indicated that biomass partitioning is not only driven by ontogeny, and thus tree size, but to a substantial degree also by environmental factors. A possible explanation for diverging results may be that the ability of seedlings to respond to limited resources by plasticity decreases with increasing tree age and/or time of exposure to limited resources.

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REGENERATION DEVELOPMENT IN DINARIC BEECH PRIMEVAL FOREST IN SLOVENIA: INFLUENCE OF LIGHT CLIMATE, GROUND VEGETATION AND BROWSING

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Introduction

Natural regeneration of beech (*Fagus sylvatica* L.) is a result of complex interactions of many biotic and abiotic factors (Wagner et al. 2010). Its shade tolerance and overall resource use efficiency often obscures direct connections with crucial factors, such as light (Madsen and Hahn 2008). However, in the understory of old-growth forests beech reaches its ecophysiological limits, especially on sites where it replaces itself in the canopy (Emborg 1998). Disturbance dynamics research of European old-growth beech forests revealed relatively small average gaps sizes (Tabaku and Meyer 1999; Zeibig et al, 2005; Drössler and von Lüpke 2005); since these forests are predominantly driven by the endogenous events. Due to fast lateral crown growth of beech canopy trees it seems likely that the dominant pathway to canopy recruitment combines beech advance regeneration and several gap releases. However, the regeneration strategy of beech may be well adapted to different site conditions, especially in beech optimum, where it covers a variety of substrates in an altitudinal span from lowlands to the upper timberline. To obtain more insight into gap recruitment processes we studied beech regeneration over a period of ten years on a specific site with heavy competition from ground vegetation.

Materials and Methods

The old-growth forest reserve Krokar (74.5 ha) in Slovenia is dominated by beech and silver fir (*Abies alba* Mill.) stands. The parent material is limestone and dolomite, the soil type is Calco- Cambisol, and the altitude ranges from 840-1170 m. Mean yearly precipitation is more than 2000 mm and the mean temperature is about 6 °C. The growing stock in 2004 was 636 m^3/ha and was composed of 93% of beech, 6% of silver fir and 1% of other broadleaves. The average volume of coarse woody debris was 154 m^3/ha, 43% of which was snags and 57% logs. Several site types are within the reserve (Accetto 2002). This study focused on a pure beech site on a dolomite Karst plateau (*Isopyro-Fagetum*). This area had a relatively closed canopy. In 2000 a total of 49 canopy gaps were inventoried, which covered 5.6% of the sampled area, and gap size varied from 6 to 833 m^2 (Zeibig et al. 2005). In 1999 we selected the five largest, but relatively young gaps (about 10 years old). Within each gap we systematically placed 13 permanent regeneration plots (1 x 2 m): one in the gap centre, and three in each direction of the compass – the first in the gap, the second at the gap edge and the third below the closed canopy (sensu Diaci 2002). We sampled regeneration (density, coverage, growth of dominant regeneration, browsing, definitive gapfillers sensu Lertzman (1995), ground vegetation (composition, coverage) and light climate (fish-eye) in 1999, 2004, 2010. Regeneration was assessed in three height classes: small seedlings (older than one-year-old and h < 20 cm), seedlings (21-130 cm) and saplings (131-500 cm). We also evaluated the position and decomposition rate of gapmakers. Plots within gaps were classified in four different gap positions: (A) plots with high levels of diffuse and low levels of direct light, (B) plots with high levels of both components, (C) plots with low levels of both components and

(D) plots with low levels of diffuse and high levels of direct radiation (Diaci 2002). The Spearman correlation coefficient and Kruskal-Wallis test were used to analyse the data.

Results and Discussion

In 2010 the gap area of five gaps ranged from 25 m^2 to 270 m^2 (average 122 m^2) and extended gap area from 411 m^2 to 821 m^2 (average 471 m^2). Gap history was estimated from the decomposition class of gap makers. In 1999 the average gap age ranged from 5-10 (20) years. One gap was a result of a single disturbance event (gapmaker), three gaps were a result of at least two events, and one gap was a result of several events. The features of gaps were comparable with those reported by Zeibig et al. (2005) from the total gap inventory of the same site (e.g. average gap = 137 m^2), while average gaps were slightly larger than those reported by Tabaku and Meyer (1999; average gap size = 60-74 m^2). Thus, the gaps in this study might well represent the recruitment in gaps with several gap makers. The average diffuse light levels decreased during the decade of measurements and amounted to 10.97% (SE 0.46), 7.09% (SE 0.31) and 5.67% (SE 0.21) in 1999, 2003 and 2010, respectively. Beech and sycamore maple (*Acer pseudoplatanus* L.; hereafter maple) regeneration density was relatively low (Table 1) and it increased slowly, but steadily. However, in contrast to beech, maple did not recruit to higher regeneration stages. Maple share in density remained stable with about 30%, 12% and 0% within small seedlings, seedlings and saplings, respectively.

Table 1: Development of regeneration density (n/m^2)

	1999		2003		2009	
	beech	maple	beech	maple	beech	maple
small seedlings	1.22	0.63	2.25	0.63	0.77	0.35
seedlings	0.84	0.10	1.08	0.16	1.38	0.18
saplings	0.05	/	0.05	/	0.11	/
total	2.10	0.73	3.39	0.79	2.25	0.53

During the course of this study the coverage of regeneration and ground vegetation increased to 9%, 11% and 20% for regeneration and to 47%, 65% and 70% for ground vegetation in 1999, 2003 and 2009, respectively. In 2009 the highest overall ground vegetation coverage was recorded by *Allium ursinum* – hereafter *Allium* (43%), beech (19%), *Senecio fuschii* (8%), *Galium odoratum* (6%) and *Mercurialis perennis* (4%). Maple coverage reached 1.4%. In all three years of measurements the regeneration and ground vegetation coverage responded similarly to within gap positions. Beech and *Senecio fuchsii* coverage were highest in gaps (positions A and B) and lowest under closed canopy, while the coverage of shade-tolerant *Allium ursinum* reached highest values under closed canopy (positions C, D; Figure 1A). The highest increase of beech coverage was recorded in position B: from 3%, 16% and 30% in 1999, 2003 and 2009, respectively. Beech regeneration density followed the same pattern. There was a significant negative correlation between beech regeneration characteristics (coverage, height, height increment) and *Allium* coverage. Maple did not respond significantly to gap versus non-gap partitioning. In 2003 the average height and height increment of dominant beech regeneration reached 435 mm and 73 mm, respectively, and for maple 188 mm and 36 mm, respectively. The relation between height and height increment of dominant regeneration suggests that maple rarely overgrows the height of 50 cm in recorded light conditions (Figure 2B). Four gaps had several gapfillers higher than 500 cm; the definitive gapfiller in two gaps was silver fir and in three gaps beech. Ungulate browsing was a serious obstacle for recruitment, since 60% of dominant beech and 74% of dominant maples experienced browsing of terminal shoot or severe browsing of more than 50% of lateral shoots. Based on regeneration growth data presented here and in comparative beech regeneration studies (Nagel et al. 2006, Nagel et al. 2007) it could be estimated that beech recruitment would often need 100 years and more to reach 20 m to fill the gap, if it would start growing after the creation of gaps. The gaps in this study would close in the next 20 years by crown lateral growth if further gap extension will not occur.

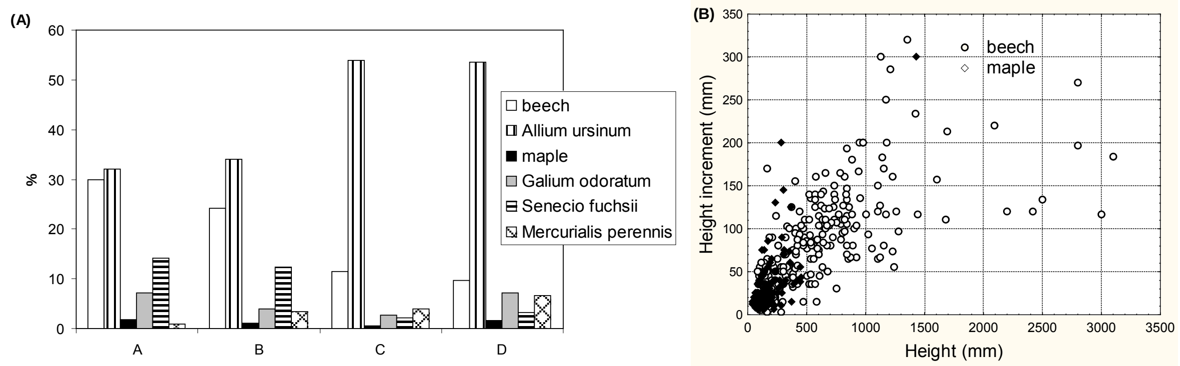

Figure 2: (A) Coverage of beech, maple and dominant species of ground vegetation, according to four positions within gap in 2009; (B) Relation between height increment and height for dominant beech and sycamore maple regeneration

The pattern of beech regeneration on this site differed from the regeneration strategy in mixed silver fir-beech old-growth forests were less gap vs. non-gap partitioning was observed (Rozenbergar et al. 2007). This would suggest lesser importance of beech advanced regeneration on this site. However, the repeated inventories of regeneration linked with gap history revealed some beech, maple and silver fir advanced regeneration. Therefore, it seems likely that also on this site different gap recruitment patterns exist: single and several gapmaker gaps created in one or several events with and without advanced regeneration. The frequency of different recruitment patterns appears to be a function of forest site. On this site single tree gaps with sparse advance regeneration and several releases might be common. Future research of regeneration dynamics in old-growth forests should combine research on site ecology and disturbance regime.

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REGENERATION OF BEECH BY POST-LOGGING SEEDLINGS: GROWTH AND SURVIVAL DURING 40 YEARS

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Introduction

Siebold beech (*Fagus crenata* Blume) is a dominant species in temperate forests of Japan, and is important for timber (hereafter, denoted simply as beech). For successful regeneration of beeches in Japanese temperate forests, two processes are important. One is establishment of abundant seedlings, and the other is subsequent growth and survival of seedlings. The former process has been studied so often, and several techniques to prompt seedling establishment (e.g., leaving seed producing adult trees, scarifying soil surface, etc.) have been proposed (Maeda 1988; Terazawa and Koyama 2008). In contrast, the latter process still remains to be studied. This lack of study is mostly because it takes long term to observe full fate of established seedlings.

In Japan, there are many forest stands which lack beech saplings, even though they were clear-cut with careful application of the methods stated above to promote seedling establishment. In such forests, dense undergrowth vegetation (such as dwarf bamboo), which is a characteristics of Japan, has developed more rapidly than the growth of beech seedlings, suppressed them, and made them to die. Therefore, we need to develop a system also to facilitate growth and survival of established beech seedlings.

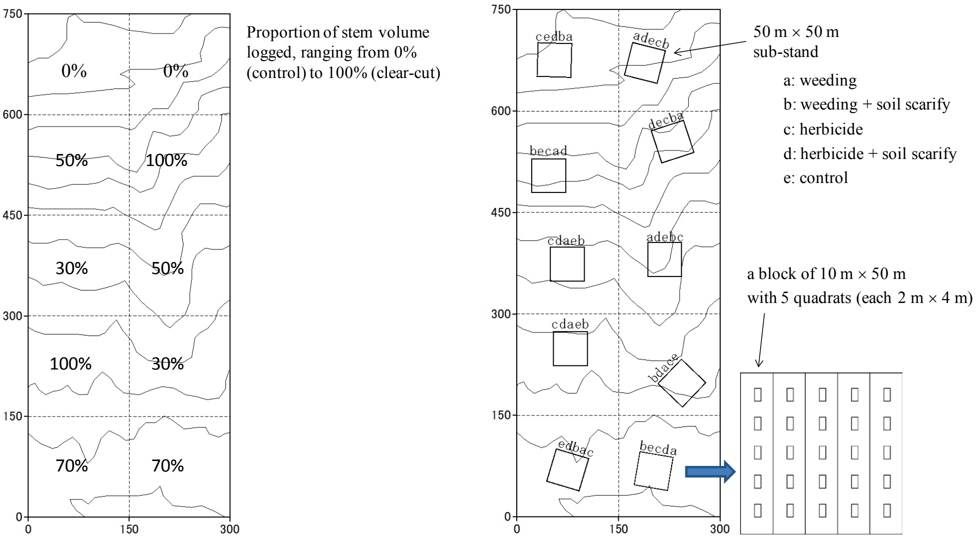
For this purpose, we analyzed 40-years growth and survival of beech seedlings under various treatments (i.e., variation in logging intensity, with or without weeding, with or without scarifying soil, with or without herbicide).

Materials and Methods

The study site, Mt. Naeba Experimental Beech Forest, is a forest of 22.5 ha (300 m × 750 m) dominated by beech, ranging from 1169 m to 1462 m in altitude. Mean annual temperature is 5.4 – 6.3 ^{o}C and mean annual precipitation is 2321 – 2391 mm. Maximum snow depth reaches more than 4 m in winter.

In 1968, this site was divided into 10 stands (each 150 m × 150 m) (Fig. 1). These stands were logged in 1969 with different magnitude: 100% (i.e., cleat-cut), 70%, 50%, 30% and 0% (i.e., control) in terms of stem volume (4 canopy treatments + control, 2 replications; Fig. 1, left). Within each stand, a sub-stand of 50 m × 50 m was set to test effects of several treatments for forest floor (Fig. 1, right). Each sub-stand was divided into five blocks (each 10 m × 50 m) and following treatments were randomly assigned: weeding, weeding + soil scarification, herbicide, herbicide + soil scarification, and no treatment (i.e., control) (4 forest floor treatments + control) (Fig. 1, right). Within each block, 5 quadrats (each 2 m × 4 m) were installed to monitor fate of seedlings (Fig. 1, right).

In 1978, height and number of regenerating beech saplings were tagged, and in 2008 their growth and survival were checked again. Based on these data, it is tested which treatment is most effective to maximize survival and growth of regenerating beeches during the period of 40 years.



Proportion of stem volume logged, ranging from 0% (control) to 100% (clear-cut)

50 m × 50 m sub-stand

a: weeding
b: weeding + soil scarify
c: herbicide
d: herbicide + soil scarify
e: control

a block of 10 m × 50 m with 5 quadrats (each 2 m × 4 m)

Fig. 1. Study system of Mt. Naeba Experimental Beech Forest. Left figure shows treatments of canopy, and right figure shows treatments of forest floor.

Results and Discussion

In 2008, the dominance of beech substantially varied among quadrats (Fig. 2, left). Only ca. 20% of the quadrats were dominated by regenerating beeches (>50% in coverage), and more than half of the quadrats (55%) did include almost no beech regenerates (<1% in coverage). Maximum height of regenerating beeches reached no more than 13 m (Fig. 2, right). For the quadrats with beech coverage >50%, maximum height of beeches exceeded >4 m.

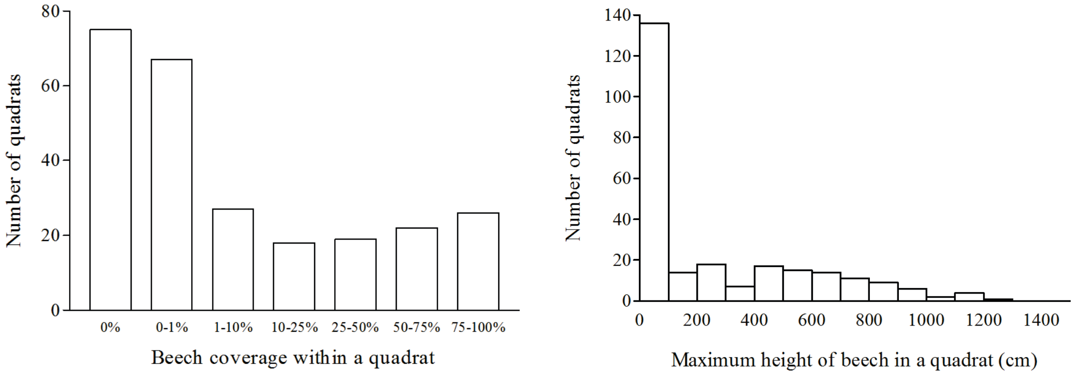


Fig. 2. Coverage (left) and maximum height (right) of regenerating beeches within each quadrats in 2008.

Those quadrats which were dominated by beeches in 2008 had abundant saplings than others in 1978; >40 saplings of mean height of 50 cm were found within each of those quadrats (corresponding to density of >50,000 saplings per hectare) in 1978. Those quadrats were found under combined treatments of logged proportion 30% - 100% and of weeding (+ soil scarify). In contrast, the quadrats with no logging and with herbicide or no treatment for forest floor had fewer saplings in 1978. However, some random effects were also found; for example, quadrats with logged proportion 50% and with weeding treatment had very few regenerating saplings in 1978. Microtopography or any unmeasured site conditions should affect fate of established seedlings.

Furthermore, about one-third of quadrats with >40 seedlings in 1978 were not dominated by beeches in 2008. Those failed quadrats were characterized by wet conditions, where competing plants such as *Acer*, *Prunus*, etc. and woody vines became dominant in 2008, even though beeches were dominant in 1978.

Conclusion

Thus, although some treatments on canopy and forest floor potentially promote survival and growth of regenerating beeches, this study shows that site conditions (including any unmeasured or unknown variables) also influence their fate substantially during the period of 40 years. This means that we need to take into consideration uncertainty of regeneration of beech trees under variable natural conditions.

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EFFECTS OF PLANTING TIME AND CONTAINER VOLUME ON THE ESTABLISHMENT SUCCESS OF CONTAINERIZED BEECH (*FAGUS SYLVATICA*) SEEDLINGS FOR FOREST REGENERATION IN DENMARK

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Beech (*Fagus sylvatica*) is a popular forest tree species and is as such commonly used in forest regeneration, forest restoration and afforestation. Planting beech usually involves a stock density of 4-6.000 bareroot seedlings per ha, which is expensive (3-4.500 Euro per ha). The present study is part of an overall effort to develop more cost-effective artificial regeneration methods to be applied mainly where natural regeneration is not an option. The objective of the study is to identify suitable planting times for small (3-14 month old) containerized stock types and generate new knowledge on the effects and interactions with planting time of container volume on planted beech and their survival and growth. We established two planting time experiments each year in three years (2006, 07 and 08) and establishment success was recorded in 2008 and 2010. Results and conclusions are presented at the conference.

INFLUENCE OF A SHADING TREATMENT ON THE SURVIVORSHIP AND SOME LEAF CHARACTERISTICS OF NATURALLY REGENERATED BEECH SEEDLINGS (*FAGUS SYLVATICA* L.)

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Introduction

Due to many ecological and economic advantages, the natural renewal of the temperate deciduous forests is more and more promoted in the silvicultural strategies. In these systems, the light dynamic is complex but its control by the forester is the key for successful management. However, in the mixed-species stands, the management of the recruitment is tricky, particularly because of the differentiated behaviors from the species and particularly by their degree of shade tolerance (von Lüpke, 1998).

In the Walloon region (Belgium), the mixed 'oak-beech' stands illustrate the questions of recruitment in dynamic light conditions. Resulting of human activity, the oak stands were favored in place of the naturally dominated beech forests. The advantages of the beech, in mixture with the oak, are primarily of silvicultural purposes (von Lüpke, 1998). On the other hand, because of the superior competitive strength of beech, the perenniality of the oak is currently threatened. The area of oak stands has been reduced from 40 to 50% since the early 20th century. The differences in shade tolerance of these two species can partly explain this evolution.

The objective of this study consists in the investigation of the reactivity to canopy closure of two contrasting shade tolerance species: the European beech and the sessile oak. Using shade clothes, the short-term survival (from 1 to 3 years) and the foliar properties of seedlings were studied by taking into account the effect of initial tree size. In this paper, we will briefly present the results concerning the two studied species and will place the emphasis on the reactivity of beech.

Materials and Methods

Shade clothes were installed in forest above thickets of naturally regenerated beech (*Fagus sylvatica* L.) and sessile oak (*Quercus petraea* (Mattus.) Liebl.) seedlings - 1 to 4 meters tall - to simulate the canopy closure. Two study sites were chosen in the Ardenne region, in the Southern part of Belgium, on acidic and loamy soils, characterized by rainfall close to 1000 mm and an average air temperature of 8.5°C. Highly dense thickets (close to the theoretical maximum density) were selected.

The percentage of above canopy light (PACL) was monitored by using photosynthetically active radiation sensors (Solems SA, Palaiseau, France) according to the method of Parent and Messier (1996). All the seedlings were initially described by the total height, the diameter at 10 cm from the collar and the annual height increments during the last three years. A sample was then selected to characterize the seedling morphology and the foliar characteristics. The social status of the tree was quantified by an index called the 'relative height', which corresponds to the ratio between the individual total height and the mean height of the plot.

The response variables were *(i)* the survivorship at the end of the growing season for 1 to 3 years of shading as well as *(ii)* the specific leaf area (SLA) and the nitrogen and carbon content ($g.g^{-1}$) as rough indicator of tree physiology. Mixed logistic regression was used to model the survivorship.

Results and Discussion

The shade clothes reduced the light availability to low levels, 1 to 15 % of above canopy light (7 to 54 % before the shade treatment).

Survivorship

After one year of treatment, we observed a substantial mortality for the oak only with average mortality rates of 44 % (range : 15-70%) and a significant difference with the control plots (p-valeur < 0.0001) (Baudry et al., *in preparation*).

For the beech seedlings, in the shaded plots, the cumulated mortality rates progressively increased from the first to the third year (3, 27 and 46 %, respectively) whereas they remained weak (0, 2, 6 %, respectively) in the control areas.

As a powerful individual cumulated mortality predictor, the relative height of the tree was positively correlated with the survivorship (Figure 1). This predictor has discriminated the survivorship after the second and third year of treatment with ROC value of 0.71 and 0.74. Model including *(i)* the mean height of the thicket, *(ii)* the diminution of illumination and *(iii)* the social status have shown very high value of discrimination (ROC: 0.83) and all these factors were significant (*p*-value < 0.0001). The survivorship was positively correlated with the mean height of the thicket and negatively with the decrease of illumination.

These results indicated an inter-specific difference between the two studied species, with sudden mortality for the oak. Under very low light levels, the mortality of beech seedlings was largely dependent on the initial individual vertical position of the tree.

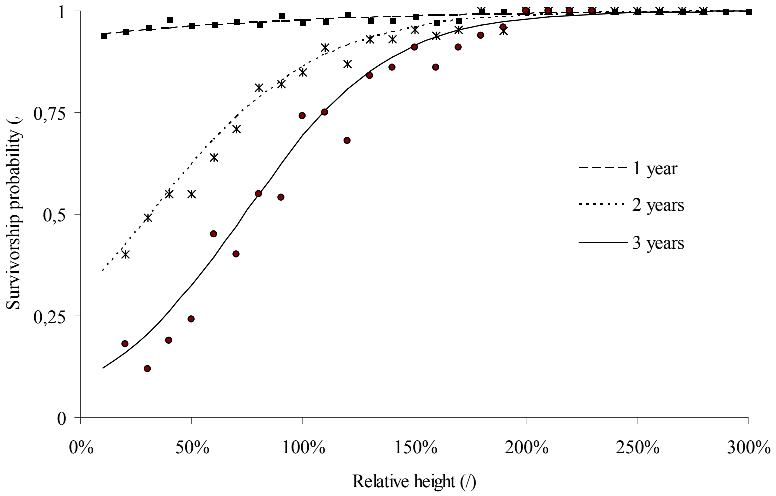

Figure 1 : survivorship probability predicted from the relative height for the three years of treatment (cumulated mortality). The curves represent the developed models and the points correspond to the proportions observed.

Beech leaf properties

After three years of shading, the shaded beech seedlings displayed plasticity at leaf level with significantly (*p*-value < 0,0001) higher specific leaf area (465 vs 404 $cm^2.g^{-1}$ for the control plots), which is in agreement with results from van Hees (1997), Valladares and Niinemets (2008) and Poorter (2009). No relationship was shown between specific leaf surface and the height of seedlings. On the other hand, the shading treatment did not significantly affect the carbon (*p*-value: 0.38) content and, but less, the nitrogen (*p*-value: 0.09) content.

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COMPARATIVE QUALITY ASSESSMENT OF NATURALLY REGENERATED AMERICAN BEECH, SUGAR MAPLE, AND YELLOW BIRCH SAPLINGS

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Introduction

Northern hardwoods cover more than 40 million hectares in southern Canada and the eastern United States (Tubbs 1977), and are often typical examples of uneven-aged forests (Majcen et al. 2003). They may be managed for a number of objectives such as timber, wildlife, water and recreation (Tubbs 1977). Hardwood management oriented towards timber production not only focuses on maximizing the quantity but also the quality of the harvested trees. When tree quality becomes a silvicultural objective, appropriate quality assessment systems are required to evaluate stand development.

Natural regeneration is considered the most important component of managed uneven-aged hardwood forests because of ensuring continuous stand regeneration and structural diversity (Strong et al. 1995). However, it is often overlooked that tree quality may be determined already at a very young tree age, and quality assessment systems are rarely applied to hardwood saplings. The present study therefore focuses on selected quality aspects of natural regeneration in northern hardwoods as influenced by forest management and evaluates two different quality assessment systems.

Materials and Methods

Two northern hardwood stands in southern Québec, Canada were chosen for study: a managed stand subject to selection cutting and a protected old-growth forest. All gaps with a minimum radius of $r \geq 2.52$ m were located within the studied stands (Brokaw 1982, Runkle 1992). Vital, dominant or co-dominant, 2.5–13.0 m tall saplings of American beech (*Fagus grandifolia Ehrh.*), sugar maple (*Acer saccharum Marsh*), and yellow birch (*Betula alleghaniensis Britt.*) growing in these gaps were sampled for sweep, forks, the number of live and dead branches, branch diameters and angles, and other defects like rot, crack, or canker (Figure 1). Quality assessment was based on parameters developed and suggested by Börner et al. (2003) and Sonderman (1979).

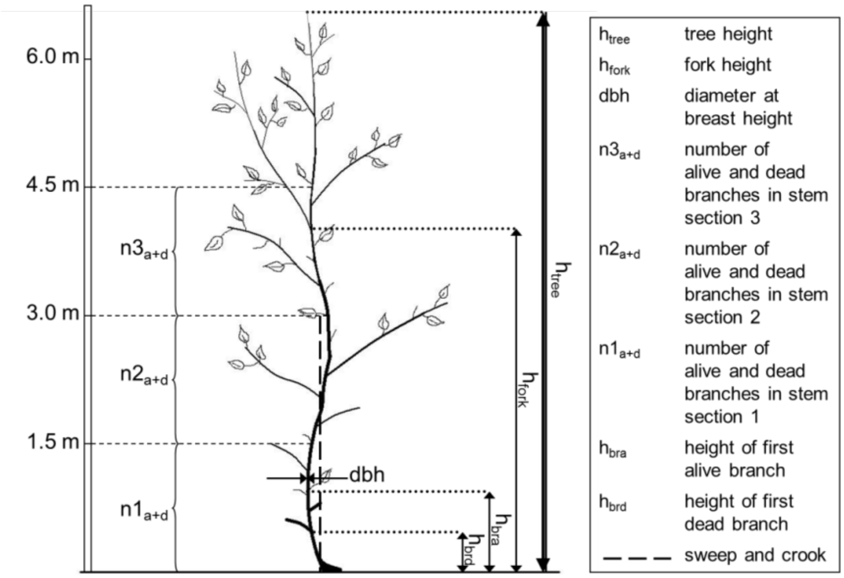

Figure 1. Illustration of measured parameters.

Results and Discussion

A total of 881 and 853 saplings were measured in 44 and 31 gaps the old-growth and selection-cut stand, respectively. Sugar maple clearly dominated the regeneration in both stands, resulting in higher sampling numbers compared to American beech and Yellow birch. The majority of sampled saplings in the old-growth stand was in height class 3 (>6.0 m, 44%). In contrast, most saplings in the selection-cut stand where in height class 1 (2.5–4.0 m, 58%), indicating the presence of a homogenous layer of regeneration established as a result of the canopy opening in the course of the last silvicultural treatment.

All species featured a higher percentage of forked trees in the selection-cut stand compared to the old-growth stand ($P \leq 0.05$). American beech and yellow birch generally had fewer forks than sugar maple, which is considered especially prone to forking due to opposite branching and little apical dominance (Beaudet and Messier 1997).

Compared to the old-growth stand, the first live branch of beech and maple was generally lower in the selection-cut stand ($P \leq 0.05$). Also, more live branches per stem section was found in the selection-cut stand across all species ($P \leq 0.05$), likely caused by higher light levels after harvesting due to the close proximity of adjacent gaps. The highly shade-tolerant American beech had significantly shorter live limb-free boles than sugar maple and featured the highest live crown ratios ($P \leq 0.001$). Beech is characterized by delayed and often incomplete natural pruning (Balleux 2002), with substantially lower clear-bole percentages than maple.

The consistently lower relative live branch diameters (ASIX index; Struck and Dohrenbusch 2000) of maple, birch and beech in the old-growth stand indicate more progressive self-pruning than in the selection-cut stand ($P \leq 0.05$). For beech, differences in ASIX values between stands were less pronounced, because the crown architecture of beech is less affected by environmental changes than that of maple or birch (Canham 1989).

Due to the occurrence of fewer forks and fewer live branches of smaller absolute and relative branch diameters, saplings of all species were of better overall quality in the old-growth stand compared to the selection-cut stand (Figure 2). Differences between stands were most pronounced for sugar maple. Although beech saplings mostly featured less stem deviation, beech saplings were of significantly lower quality than sugar maple saplings measured in the same stands due to their branchiness. None of the beech trees in the selection-cut stand was classified as good quality. For almost all individual parameters, yellow birch was either found intermediate or grouped with one of its associates.

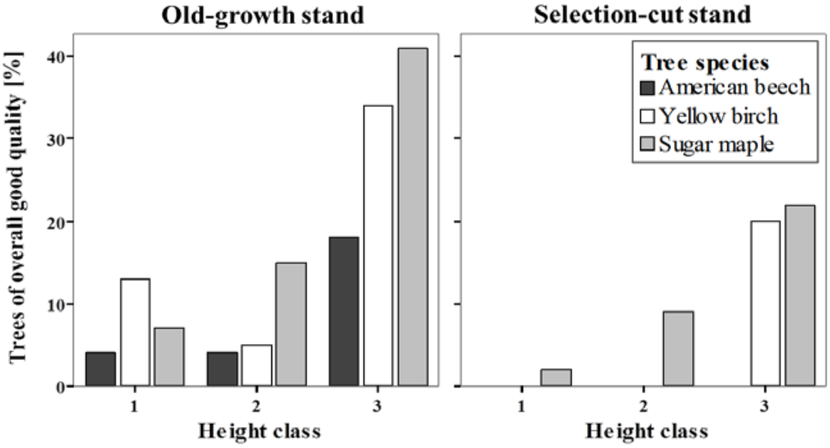

Figure 2. Proportion of good quality trees.

The observed differences in gap regeneration quality between the selection-cut and the old-growth stand are indicative of the influence of forest management on the quality of regeneration, which needs to be investigated in detail in larger-scale studies.

The applied quality assessment systems have been found insufficient for characterizing the overall sapling quality. Although the modular quality survey system by Börner et al. (2003) was found to be applicable to northern hardwoods for assessing parameters of tree quality, it does not provide a measure of overall quality as an aggregation of individual tree characteristics. The quality index by Sonderman (1979) includes important quality parameters such as crown class, sweep and the number of branches, but it disregards information about branch diameters and angles. Further evolution of quality survey systems is hence required to allow for a comprehensive quality assessment.

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SUSTAINABLE MANAGEMENT OF BEECH FORESTS IN THE APENNINES (ITALY): LESSONS FROM LOCAL TRADITIONAL KNOWLEDGE

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Introduction

Management plans for beech high forests in Italy have usually prescribed the uniform shelterwood system. Selection felling has instead been considered inadequate for beech forests because of the supposed "natural tendency" of this species towards even-aged structures and the belief that only even-aged beech stands produce high quality timber. Nevertheless, in some private properties in the Apennine Mountains, beech forests have long been managed with a selection cut applied without precise written rules but carried out according to criteria derived from local traditional knowledge. This type of management maintains stands characterized by continuous cover, natural regeneration and high quality timber production.

Here we analyse structural characters of beech forests managed following this type of selection cut. We examine two case studies, one in the Northern Apennines (Pian degli Ontani, Pistoia, Tuscany) and one in the Calabrian Apennines (Monte Crocco, Serre Vibonesi Mountains, Cosenza) which show differences in site conditions and in some aspects of the cultivation approach. We discuss whether this type of management, which is the result of knowledge accumulated locally, can contribute to sustainable beech management in the Apennines.

Materials and Methods

The property in Pian degli Ontani is approximately 10 ha and, at least to our knowledge, it is a unique example of a peculiar management system which was once more common in the area. The aim was the production of high quality boles used for manufacturing snow shovels entirely carved from one piece of beech wood. Selection felling is carried out on the same area at very frequent intervals (3-6 years), only few trees reaching dbh 40-45 cm are felled at each coupe, choosing the ones that are hindering younger trees. Usually no thinning is carried out in the smaller dbh classes. The family of the owner has continued this type of management for over a century, while most of the surrounding beech forests were converted to coppices in the second half of the 19th century. In Monte Crocco (Calabria) the property is approx. 100 ha and beech is managed according to a type of selection felling which is common in the area. Felling is carried out on the same area every 8-10 years. Trees reaching dbh > 40-45 cm are felled, usually in groups of 2-3 individuals, selecting them so as to open up space for regeneration. Only very few trees are felled in the smaller dbh classes.

Both sites are in areas where beech is the dominant forest species. Mean annual temperature is 6,7°C in Pian degli Ontani and 12,0°C in M.Crocco; total annual rainfall is 2449 and 1700 mm. In Monte Crocco there is a very high relative humidity all year round (>70%).

We delimited 1 square plot 2500 m^2 in Pian degli Ontani and 1 square plot 4800 m^2 in Monte Crocco. For all trees we measured (dbh>2,5 cm): position, dbh, total height, height to living crown and crown projection (4 perpendicular radii on the cardinal directions). Cut tree stumps and trees marked for felling by the owner within the plots were measured.

We analysed the following parameters: N/ha, G/ha, Vol/ha, tree distribution in 5 cm dbh classes, mean dbh, mean height of 3 tallest trees per hectare, crown cover. Vertical crown distribution has been assessed using the TSTRAT function (Latham et al., 1998), horizontal stand with the univariate L(d) function (Besag, 1977) a transformation of Ripley's K function.

Results

Main stand parameters for the two sites are in Table 1. In Pian degli Ontani estimated average dbh for cut trees, randomly distributed within the stand, is between 40 and 55 cm. Crown cover in 95% and crown overlap is 2,4. Stands have a multi-stratified vertical structure (TSTRAT indentified 4 strata); horizontal structure does not show clustering and single trees of different sizes are intermingled.

Table 1. Average stand parameters for Pian degli Ontani and Monte Crocco

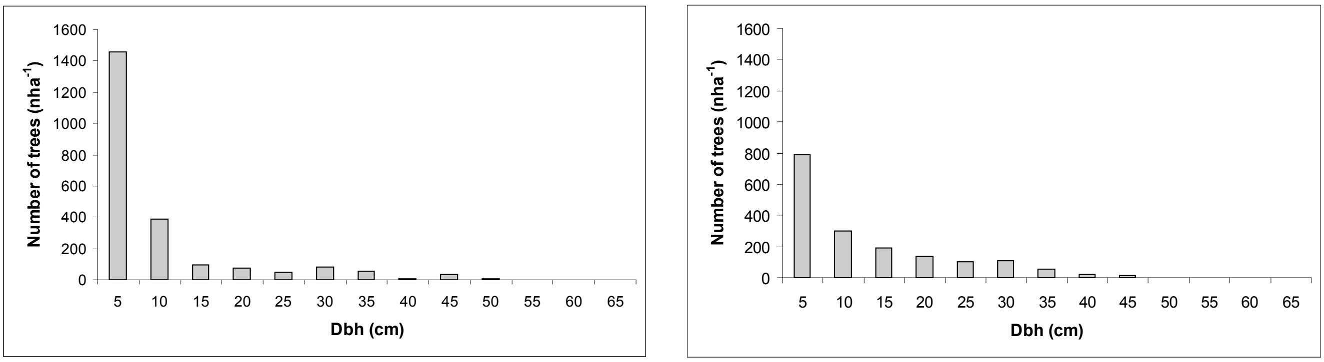
Site	N/ha dbh>2,5 (cm)	N/ha dbh>17,5 (cm)	G/ha dbh>2,5 (cm)	G/ha dbh>17,5 (cm)	Vol/ha dbh>2,5 (cm)	Vol/ha dbh>17,5 (cm)	Av. dbh dbh>2,5 (cm)	Av dbh dbh>17,5 (cm)	Height* (m)
Pian degli Ontani	2240	304	30,32	23,02	358,4	295,2	13,1	31,1	29,0
Monte Crocco	1718	442	33,86	26,77	391,6	330,4	15,8	27,8	32,1

* mean height of 3 tallest trees per hectare

Tree distribution in 5 cm dbh classes (Figure 1) for both sites roughly follows the inverse J shape, although with some differences due to different structure of the stands.

In Monte Crocco crown cover averages 92% and crown overlap 1,6; trees marked for felling have 30 to 50 cm dbh, are usually in groups of 2-3 individuals. Trees of different sizes and ages form very small groups. Stands are multistratified. Trees in the smaller dbh classes form dense groups in the gaps (approx. 40-100 m^2) opened up by previous fellings.

Figure 1 – Tree distribution in dbh for Pian degli Ontani (a) and Monte Crocco (b).



(a) (b)

Discussion

While in Pian degli Ontani frequent felling maintains a typical single tree uneven aged structure, in Monte Crocco stands are characterized by a very small group structure which is the consequence of the type of felling. Even though only few big trees are harvested at regular intervals, the trees are chosen with particular attention to favouring regeneration and growth of young trees.

A comparison of structural characters of these two case studies with a model worked out by Schütz (2006) for the Langula *plenter* forest is particularly interesting. In Pian degli Ontani and, especially, in Monte Crocco, G/ha and Vol/ha are higher than the values of 22 m^2/ha and 250 m^3/ha considered by Schütz as being the upper limit for preserving an "irregular" stand structure. On the other hand, N of trees in the 10 cm dbh class is well above the limit for satisfactory recruitment indicated by the same model. The relatively high density of the stands in both sites produce good shaped boles.

Conclusion

Pure beech selection forests, especially with a single tree uneven aged structure, have been usually considered as an exception in beech management, which has been typically oriented towards even aged models and shelterwood silvicultural systems. This latter type of management has also been supported in Italy, following ideas coming from "scientific forestry" developed by the German school and which was the basis for the development of the Italian forestry school. Thus, beech management based on selection felling has been strongly opposed by forest administrations and the scientific world.

Our work shows that this negative reputation for uneven aged beech management in not well founded. Both in the Tuscan and Calabrian examples selection felling has maintain a balance between harvest and stand regeneration for a very long period. Although product destination has changed, production is still considered profitable by the owners and they can place on the market very good quality beech wood.

The lessons we can learn from these stands which have been managed for a very long time on a sustainable basis, is that the balance between all the factors involved in uneven aged management must be found locally, by adapting felling to stand reaction both in terms of regeneration and growth. In other words, there can be no general structural model for managing beech forests on an uneven-aged and continuous cover basis, because selection felling is in fact a flexible system, which gives the best results when it is applied following this adaptive approach.

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EFFECTS OF TREE AGES, ASPECTS AND ALTITUDES ON SOME SEED CHARACTERISTICS OF ORIENTAL BEECH (*FAGUS ORIENTALIS* LIPSKY.)

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Key words: *Fagus orientalis*, tree age, altitude, seed characteristics

Introduction

Oriental beech (*Fagus orientalis* Lipsky.), is one of the major hardwood tree species, comes in the first place of naturally spreading kinds in Turkish forests which are quite rich in terms of kind diversity with the effect of different growing site conditions (Saatçioğlu 1969; Atalay 1992; Özel, Ertekin 2011). Natural or artificial regeneration, rehabilitation and convert from coppice to high forest practices is very important for beech forest in Turkey (Özel 2007). In addition, investigations on the seeds of this species have been increased because of rare mast years and germination problems due to physiological dormancy (Yılmaz 2005). So, this study was conducted to determine the effects of tree ages, stand exposures and altitudes on some seed characteristics (seed germination, moisture content and 100 seed weight) of Oriental beech.

Materials and Methods

Seeds of Oriental beech were collected from natural forest in Kumluca-Bartın, (41º 30′ 25″ - 41º 20′ 27″ N, 32º 23′ 46″ - 32º 33′ 44″ E) located in the Western Black Sea region of Turkey. For this aim, six trial sites were chosen to represent from 600 and 800 m altitudes and from young trees (40-59), middle age (60-79) and mature trees (80-99). The effect of exposure factor was determined by collecting the seeds from even aged trees (60-79) grown upon different exposures (West North, South and East). These trees, by 150 m distance between each other, were selected and seeds were collected.

Results and Discussion

The result indicated that seed germination and moisture content were affected by all three studied factors. However, the 100 seed weight were only showed differences by exposures. The highest germination percentage was seen on the north aspect, altitude of 800 m and the middle age trees.

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MANAGING FOR STRUCTURAL HETEROGENEITY AND/OR SUPERIOR NATURAL REGENERATION OF BEECH STANDS - ARE THESE TWO CONCEPTS COMPATIBLE?

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Introduction

In the last two centuries the European beech (*Fagus sylvatica* L.) was considered to be a commercially less interesting species than widely introduced conifers and its representation in the Czech forests decreased dramatically. During the last decades the beech is considered as a suitable tree species to be used to solve some very topical contemporary problems of European forestry. The aim of the study was to formulate suitable management techniques for beech in the conditions of Central Bohemia.

Materials and Methods

The natural regeneration and structure of beech forest stands under different management strategies and intensities were studied between 2003 and 2007 within 8 one hectare permanent research plots. The seedling emergence and development in relation to different stand densities and under gaps of different sizes were followed. In even-aged managed stands sample plots in the regular matrix 20 m x 10 m spacing over the area of the whole 1 ha permanent research plots were established. Sample plots were in the form of a square (1 m^2). In unmanaged stands with certain degree of differentiation a 5 x 5 m grid inside gaps was installed; at the grid intersections always one 1.5 x 1.5 m^2 square sample plot was placed. On each sample plot we recorded the number of seedlings and additional micro-site characteristics. For more details see Bilek et al. (2009). For stand structural characteristics followed in the study see Bilek et al. (2011).

Results and discussion

Uniform regeneration felling reducing the stand density on the whole plot area at the level of 60% was an appropriate measure for high survival and successful development of beech regeneration four years after heavy mast year. Gap creation that reduced stand density by 30% equally ensured successful development of natural beech regeneration and contributed to further stand differentiation. Regular, even-aged structure as observed in present-day managed stands is not natural for this ecosystem and is responsible for loss of biodiversity. One approach to increase the habitat diversity and promote natural regeneration of beech could be to develop management systems that mimic the natural patterns and processes related to the mosaic cycle.

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THE CONCENTRATION OF HEAVY METALS IN LEAVES OF BEECH IN THE AREA OF JUŽNI KUČAJ (SERBIA)

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Introduction

Monitoring of heavy metals is especially important due to the fact that their toxicity and accumulation is huge. The harmful effects calculated on an annual basis of all those metals exceed the overall harmful effect of radioactive and organic waste produced each year as claimed in the works of Nriagu (1979), Pacyna et al. (1989). Potentially, each plant species may be used as bioindicator of environmental condition. The necessary precondition is knowledge of biology as well as ecology (ideoecology) of each individual species which is to be used as bioindicator (Stankovic at al. 2011).

Matherials and Methods

The goal of this researc is aimed at determining the degree of concentration of heavy metals (Ni, Pb, Cr and Cd) in leaves of Beech in the three localities in the mountain Južni Kučaj, located in the largest complex of beech forests in Serbia. The choice of sites was made according to the position in the forest complex, from the center toward the edge of the forest complex. Only leaves were sampled and for each species there was taken 1-2 kg of material from all locations. The samples were dried to airy dry mass without previous washing. Airy dry leaves were further dried in dry-kiln at 105ºC, ground and used for laboratory analyses. The concentrations of heavy metals in plants are determined by atomic absorption spectrophotometry method (AAS).

Results and Discussion

The results show that Beech accumulate approximately equal amounts of heavy metals regardless of the location. Determined concentrations of the investigated sites are consistent with those of other researches for beech in similar environmental conditions and have the following values: lead 13.48-14.68 ppm, nickel 2.63-5.92 ppm, cadmium 3.55-4.40 ppm, chromium 0.05-0.12 ppm. Heavy metal concentrations don't exceed the maximum allowable concentration in any of the tested sites, so heavy metals aren't currently threatening factor for the development of Beech forests in this area. The current contents of heavy metals in plants in the mountain Južni Kučaj for the time being do not represent danger which would cause notable damage to forests but show the tendency of the increase of concentrations. Therefore this issue should be constantly monitored.

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SPONTANEOUS REGENERATION OF PURE BEECH FORESTS IN THE AREA OF JUŽNI KUČAJ (SERBIA)

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Introduction

Renewal of beech forests in Serbia is performed only as a process of natural regeneration (Banković et al. 2009). Small-scale gap disturbances are the decisive factors influencing the spatial and temporal regeneration dynamics. Monitoring of forest reserves and its including in management forest plans will increase the credibility of close-to-nature forest management and nature protection in forest ecosystems (Diaci et al. 2005).

Matherials and Methods

The object of this study is pure beech forests on the mountain Južni Kučaj in northeastern Serbia. The research was conducted in the beech forests, which has emerged and developed in conditions of minimal anthropogenic influences, where the regeneration occurs spontaneously. As a comparison, the research was also conducted in the managed forests. It was determined the site conditions and stand structure elements that define the degree of canopy cover. Light conditions was determined by taking and processing of hemispherical photographs and linked with the regeneration characteristics (abundance, growth, morphology) and ground vegetation (Diaci et al. 2005), also, on the dominant beech individuals was assessed height, length, crown width and height increment and described branching patterns of the terminal shoot and the whole plant. The stands were determined as montane beech forest (*Asperulo odoratae-Fagetum moesiacae* subass. *typicum*) on acid brown soil on schists, at the altitude 900-1000m, slope 15-35° and east to north exposure.

Results and Discussion

The appearance of young trees, sufficient number and quality, its survival and further development, are caused by the appropriate stands state and light regime. In old-growth forest remnant the results showed differences in analysed structural characteristics, light intensity, seedlings density, ground vegetation coverage, height, length and height increment of beech dominant seedlings compared with the managed forest. The results of investigation of spontaneous regeneration of beech forests are useful in order to define an appropriate system of close-to-nature forest management.

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RESTORATION OF BEECH FORESTS AFTER FOREST FIRE IN NORTHEASTERN SERBIA

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Introduction

Beech forests in Serbia are restocked only by natural regeneration why that is dominant process in the regeneration system. The problem in the natural regeneration system of beech forests occurs in cases of large-scale disturbance. Forest fires are the most extreme kind of forest devastation in Serbia (Aleksić et al. 2009). Effects of fire on forest ecosystems are numerous (DeBano et al. 1998), thus creating need for finding recovery method, regeneration techniques, solutions for problem of herbaceous ground vegetation (Ledgard, Murray, 2004).

Matherials and Methods

This study was conducted in northeast Serbia in the area under the beech forests damaged by forest fire and followed by herbaceous ground vegetation (*Rubus* sp.). Process of recovery was done by direct seeding beech. Fired area is located on the site of montane beech forest at the altitude 450m, slope 20-25° and south exposure. Sample plots are established in different site conditions: on poorest, shallow and skeletal, soil; on more productive, deep and moist, soil. It was determined the abundance and following characteristics of seedlings: damage, branching of the terminal shoot and branching of the whole plant, height, length, diameter at root collar and 10 cm above the ground, length of summer shoots zone.

Results and Discussion

The success of regeneration and growth characteristics of beech in the first growing season was studied at sample plots of seeding beech in conditions without overshadow. Determined the average number of seedlings indicates the difference in survival after the first growing season in different site conditions of about 50%. Height is approximately 10 cm higher in the more productive site. In line with the difference in height determined the difference for all measured characteristics. Due to favorable environmental conditions there was multiphase growing, and that for all individuals in at least two phase, usually three phase. In the more productive site 5% of seedlings formed the five or six phase, with a maximum length of 67 cm. Plagiotropic growth is not expressed, the relationship between lenght and height is 0.83-0.90. However, a certain number of seedlings has a deformed growth and develops several terminal shoots due to weed infestation which is an obstacle to normal development. The obtained results have applicative value in beech forest restoration after large-scale disturbances as well as in conditions where dominated weedy surface.

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TREE FORM QUOTIENTS AS VARIABLES IN VOLUME ESTIMATION FOR ORIENTAL BEECH (*FAGUS ORIENTALIS* LIPSKY) IN TURKEY

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Introduction

Volume equations, which depend just on height and diameter, account for tree form differences only to the extent that form is predictable from height and diameter. Volume depends on a combination of diameter, height, and form yet only rarely is form included as an additional variable in standard volume equations (Carus, 1998; Çatal, 2009). The study briefly reviews Hohenadl's procedure for defining form quotients and tree volume from diameters measured at fixed proportions of total tree height. Modifications of Hohenadl's procedure were applied to one set of data for Oriental beech (*Fagus orientalis* Lipsky.) from Turkey. Hohenadl's procedure was used to define volume differences on unthinned stands, and selected form quotients were used as variables to improve accuracy and precision of standard tree volume equations (Kalıpsız, 1984).

Materials and Methods

The form quotients ($d_{0.5}/d_{0.1}$), ($d_{0.1}$/dbh), ($d_{0.3}/d_{0.1}$), and others were calculated for 157 Oriental beech sample trees by interpolating for unknown upper stem diameters when measurements at $d_{0.5}$, $d_{0.3}$, and $d_{0.1}$ were missing. In addition, the logarithm, the square, and the square root of each form quotient were computed and each multiplied by tree height and included as variables in regression analysis. The variables and transformations selected by step-wise multiple regression appear.

Results and Discussion

Volume computed from tests of equation 12 shows that the influence of form has practical significance. The equation was solved using smoothed values for the average high and average low of the two form quotients while holding height and diameter constant. As expected, using one or more form quotients increased the precision of volume computation beyond that given by standard volume equations that exclude a form variable. With height and diameter held constant, differences in stem form can lead to tree volume differences in trees. This is important, especially in cases where stand treatment can cause extreme differences in tree form. Estimating form quotients on standing trees requires less time than complete stem dendrometry. The technique described could be used with other tree species for which stem measurement data are available and for which the specific form quotient measurements may not have been recorded.

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ROCK-FALL AND DEBRIS FLOW HAZARD ASSESSMENT IN PROTECTION FORESTS: A CASE STUDY IN SLOVENIA

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Introduction - Protection forests have an important role of mitigating the influence of various natural hazards. In Slovenia the main natural hazards are floods, rock-fall, debris flow, avalanches and land slides. Only 10% of all forests in Slovenia have an indirect protection function, out of which 30% perform a direct protection role. They protect state roads, railways and buildings. More than 40% of them are European beech (*Fagus sylvatica* L.) dominated forests. Since beech dominated protection forests have not received enough attention in the Alpine region, our goal was to make a contribution to the overall understanding of their protection functioning.

Materials and methods - We studied protection efficiency of beech dominated forests in the Soteska valley in NW Slovenia, where a main state road and railway are endangered. We assessed the influential area of the debris-flow natural hazard based on a small-scale geological survey of the terrain characteristics. For determination of the run-out zones we used the TopRunDF model. For rock-fall hazard assessment, source zones were delineated and roughness of terrain was estimated. We used the RockyFor3D model for precise delineation of the rock-fall run-out zones. Forest structure data was obtained from 47 sample plots (500 m² each) where all trees with DBH≥ 10 cm were measured. Social status, health status, number of injuries from rock-fall and number of intercepted fallen rocks were sampled on the plots. Furthermore, a detailed description of forest stands was performed. We assessed the performance of the protection function of the forest stands (Frehner et al. 2005).

Results and discussion - Our results identified the forests stands that play a crucial role in protection of infrastructural objects. We found that 1,9 km of the railway is endangered by rock-fall and 4,5 km of the road is in danger of debris flow and rock-fall. For long-term protection efficiency, spatially-explicit regeneration patches were planned in uniform forest stands. For long-term protection efficiency, regeneration patches must be established in even-aged stands of the research area. In areas where silvicultural measures could not provide sufficient protection, technical measures are needed. Since these forests have not been managed for several decades, natural disturbances (e.g. wind throw) are frequent thus causing a high amount of coarse woody debris. In places where torrent channels are present, coarse woody debris removal is essential. Our research findings suggest that assessment and management of these beech dominated protection forests is necessary, contrary to the current practice of non-management in these forests in Slovenia.

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DENDROECOLOGY OF *FAGUS SYLVATICA* IN NORTHERN GREECE

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Introduction

We present early results from a dendrological study on the radial growth of beech (*Fagus sylvatica* L.) in Greece. Tree ring datasets have been developed for much of the range of beech but to the authors' knowledge no published studies have been conducted in Greece, at the south-eastern distribution limit of the species.

The aim of the study was to investigate the climate sensitivity of ring width with elevation, using an altitudinal transect (~900 to ~1900m a.s.l.) on Mt Vermio.

Materials and Methods

Standard dendrological techniques were employed in data collection and processing. Tree cores were taken from approximately 250 trees located at 8 sites along the transect. Ring width was measured using the CooRecorder system (Larsson, 2003). Cross-dating, chronology construction and detrending were completed using the dplR package in R. Correlation analysis and response functions were performed using DENDROCLIM2002 (Biondi and Waikul, 2004). Climate data was provided by the Hellenic National Meteorological Service.

Results

Mid-altitude results show that ring width is negatively correlated with higher temperatures in the previous summer. Additionally warmer temperatures in February are also negatively correlated with ring width. Mean temperatures of growing season months have low correlation with ring width at this site.

Winter precipitation is negatively correlated with ring width of the following year. This is in contrast to previous studies that have shown positive correlation between winter "re-charge" precipitation and ring width (e.g. Dittmar et al, 2003). Possible explanations of this result will be discussed. However, there is evidence that the negative effect of winter precipitation has decreased in recent decades.

Precipitation during the growing season, like temperature, shows low correlation with ring width at this site.

Further results from high elevation and low elevation stands will be included in the poster.

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IMPACT OF DEAD TREE ON PLANT SPECIES DIVERSITY OF FOREST FLOOR (REGENERATION & HERB LAYERS) IN THE CASPIAN BEECH FORESTS OF IRAN

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Introduction

When trees start to dry alone or collectively , gaps create in forest canopy. Such gaps increase the forest biodiversity by settling new species.

Since the 1980s, these canopy gaps have therefore been a major focus of forest ecologists.

They studied not only environmental conditions (Ritter et al. (2005)) and effects on tree regeneration (Busing and White (1997)), but also herb layer response (Anderson and Leopold (2002)).

This study is helpful to understand mechanism of the development of vegetation influenced by different decomposition classess and different gap size, and to derive some rules for nature-based management of beech forests with gap dynamics.

Materials and Methods

In order to study the role of dead tree on plant species diversity, 13 canopy gaps created by oriental beech (*Fagus orientalis Lipsky*) deadwoods with an area between <200 m^2 and 1000 m^2 were selected in a reserve oriental beech stand. Moreover, three beech snags without creating any gap was considered as control sample. Ground vegetation and regeneration were assessed within five 2x2m sample plots from center to the gap edges.

Results and Discussion

Results indicated that the maximum amount of regeneration was observed around the control deadwood and those in the 4th decomposition class, namely collapsing logs, friable wood and completely decomposed crowns. Menhinick and Margalef richness indices for regeneration layer increased with increasing of gap area. Number of herb species and Margalef richness index increased, whereas Sheldon evenness index decreased significantly with gap creating for herb layer.

Studies on the herb layer species composition generally report that plant species number, herb layer cover and the abundance of many species are higher in gaps than under closed canopy (Goldblum 1997).These differences increase with increasing gap size (Galhidy et al. (2006), Naaf and Wulf (2007)), which were in harmony with the results of present study.

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AGE AND DISTURBANCE DYNAMICS OF THE VIRGIN BEECH FOREST UHOLKA IN THE UKRAINIAN CARPATHIANS

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The virgin beech forest of Uholka is with an area of more than 14,000 ha of primeval forest one of the largest stands of virgin European beech (*Fagus sylvatica* L.). Understanding the growth dynamics of beech under natural conditions without human intervention is crucial for a close to nature management of beech forests. The main objectives of this study were to analyse the present structure of a virgin forest on small areas, describe the diameter and age structure and give an insight into the natural disturbance dynamics.

DBH and height of all living and dead trees $\geq$6 cm DBH were measured on four subjectively chosen plots of 0.1 ha. For age estimation and growth pattern analysis increment cores of all the 172 trees were taken. To identify significant growth releases a dendroecological approach, referred to as the boundary line method by Black and Abrams (2003), was employed.

The density of the living trees on the four plots ranged from 270 to 590 stems per ha, the basal area from 30.9 to 62.7 m^2 ha^{-1} and the volume from 524 to 1237 m^3 ha^{-1}. The longest tree-ring series is 451 years long (core missed the pith), however age estimation methods show that beech can reach an age of 550 years. All the plots cover an age span of at least 300 years and can be characterised as uneven aged with continuous tree establishment. Growth releases could be observed regularly distributed over the analysed period from 1750 to 2000. This indicates that the forest is shaped by small scale dynamics and no stand-replacing disturbance occurred on the studied plots.

The results suggest that stand dynamics in these forest are driven by periodic, small disturbances events and larger events only occur rarely. Mimicking a small-scale natural disturbance regime in a managed forest would provide suitable conditions for a continuous beech establishment.

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TRANSFER OF GERMAN BEECH PROVENANCES TO BULGARIA AND VICE VERSA

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Climate change is increasingly recognized as one of the most important challenges in this century. According to the Intergovernmental Panel on Climate Change (IPCC), in Europe the temperatures could increase in average by 2 – 4 ^{o}C over the next 50 years. This causes probably changes in seasonal and regional patterns of precipitation, the frequency of extreme events and the occurrence of drought periods. Due to climate change the question arises whether forest tree species and provenances may be able to cope with future environmental changes. Such considerations derive from the discrepancy between the rate of evolution and the rate of present climate change (Davis et al. 2005). Therefore the introduction of forest reproductive material from warmer or drier regions is deemed as one way to prepare forests by artificial regeneration to the challenge of climate change.

In collaboration with the University of Forestry in *Sofia* (Bulgaria) a transfer project (Provenance test) was initiated from the Bavarian Institute for Forest Seeding and Planting. Seed from eight beech provenances (Fagus sylvatica) was collected under controlled conditions in Bulgaria (3 provenances) and Bavaria (5 provenances) and sowed in the two nurseries *Berkovitza* (Bulgaria) and *Laufen* (Bavaria). The two-year old seedlings were planted on three experimental plots in Bulgaria (*Vidin*, *Stanjantsi*, *Kipilovo*) and two sites in Bavaria (*Krainholz*, *Gickelhausen*) in autumn 2009 and spring 2010. Of special interest is the growth of provenances from South-Germany (Bavaria) under warmer and dryer conditions in Bulgaria and vice versa of Bulgarian provenances under the influence of late frost events and low winter-temperatures.

In the nursery *Laufen* all beech provenances show a better height-growth than in the nursery *Berkovitza*. Height growth of the seedlings in *Berkovitza* shows that beech provenances from Bavaria grow better under warmer conditions than provenances of Bulgaria.

First measurements on the five experimental plots suggest that height development of beech provenances (3 years old) is influenced strongly by the seasonal rainfall distribution, drought periods and late frost events. In May 2011 late frost in northern *Bavaria* led to a strong damaging of leaves and twigs on the two Bavarian trial sites, especially from Bulgarian provenances. Observations at the experimental plot in *Vidin* indicate that beech is severely affected in his height growth at its ecological border to dryer site conditions (intersection to oak forests). Loss rate shows also a very high level, without strong differentiation between beech provenances.

The question whether domestic provenances or provenances from southern regions in Europe will grow in *Central Europe* in the future can be answered only by scientific transfer or provenance tests which base on long-term observations with a minimum of 15 years (e.g. beech). At the moment provenance recommendations can not be derived from the experiment due to the short observation time. First advices for cultivation, sowing and planting of beech seedling and their sensibility are already available.

CARBON STOCKS IN ABOVE-GROUND WOODY COMPARTMENTS OF A PURE AND MIXED BEECH (*FAGUS ORIENTALIS* L.) STAND IN CASPIAN FORESTS IN NORTH OF IRAN

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The effect of forest stand composition on carbon stocks in the above-ground woody compartment of a pure and mixed uneven-aged beech stand in Caspian forests in north of Iran was investigated. In each stand 30 circular sample plots of 0.1 ha were selected in each stand and inventoried. Allometry equations for biomass estimation were made. The two stands were compared using Mann-Whitney non-parametric test. Results show that there is a significant difference ($P<0.05$) between carbon in standing stem volume in pure (158.9 t/ha) and mixed (129.6 t/ha) stand as well as total above-ground carbon in pure (193.2 t/ha) and mixed (161.7 t/ha) beech stand. In this case we can conlude that pure beech stand has a higher biomass in stem and crown and totally in above-ground woody compartment as a typical climax community in Caspian forests comparing to the mixed beech with hornbeam stand as a pre-climax in the successional sequence.

DIVERSITY STUDY VEGETATION IN TWO REGIONS IN INTERFERENCE AND INTERFERENCE ARE NOT INTERFERENCE COMMUNITY *FAGUS-CARPINETUM*
(THE CASE STUDY: LAROOCHAL SERIES - NOSHAHR)

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Introduction

The biodiversity of forest ecosystems will increase the reproductive capacity and their capacity for adapting to changing environmental conditions (Macneely, 2002). So to protect biodiversity for future forest management is an important task (Amborg, 1996). Considering the importance of biodiversity, management and protection and conservation of forests and special place and importance of Iran's northern region vegetative biodiversity, this study intends to review part of the vegetation in forests, the relationship between biodiversity and diversity Through the comparison of vegetation management areas and un management.

Materials and Methods

Then dismantle the network inventory 150 × 100 m 400 square meter 60 plots for woody species diversity in the form of a square (20 × 20 m) were selected and in each of the plots were measured by the number of tree species. To study the diversity plant species within each plot, 5 part small samples with dimensions 1 × 1 m plots in four corners and the center was selected and measured all plant species. Then compare the two plant biodiversity of the area was used diversity indices Shannon-Wiener, Simpson, species richness and uniformity were used for the uniformity index, Shannon-Wiener.

Results and Discussion

Results show that there is no significant difference in the two regions about Simpson diversity. There are not also significant differences between the mean consistency index, Shannon, Shannon diversity, Simpson and the species richness in two area management and not management. Shows that some indicators had increased significantly in the zone not manage. Because of mass destruction that the forest and cut trees and livestock grazing in forest areas, which severely reduced the number and diversity of species is regenerated. This result is consistent with the results of research Qomi et al (2008) and Pour Babaei (2000) concerning decreased species diversity in the destroyed region. Bertoncini & Rodrigues in (2007) said that forest protection against grazing is added on the number of species.

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THE EFFECT OF MANAGEMENT INTERVENTION ON QUALITY AND QUANTITY CHARACTERIC IN MANAGED FOREST AND COMPARISON TO UNMANAGED PARCEL

(CASE STUDY: GOLBAND FOREST MANAGEMENT PLAN – MAZANDARAN PROVINCE)

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The aim of this research is reviewing the effect of management intervention on quality and quantity characterics of forest by comparison a managed parcel with an unmanaged parcel. Also for help to the next planing, predict the future condition if the current management continue in next period. This study carried out in north of Iran, at watershed no 45, seri of jamand. For above propose two parcels, 317 and 318 with more similarity on type and other ecologic condition, by the area respectively: 64 and 47 hectares, selected as managed Parcel and unmanaged parcel. The primary inventory completed with more samples, because of non homogeneous of forest and inaccessibility to accepted accuracy, finally 47 sample plot for managed parcel and 50 sample plot for unmanaged parcel were taken. In each sample all quantity characteristics of trees with dbh > 7.5 cm and quality factors for dbh > 37.5 cm were measured. The results shows although the number of trees per hectare in managed parcel is more than the unmanaged parcel, but the volume and basal area is significantly less, in other word shows the existent of thick and old trees in unmanaged parcel and younger trees in managed parcel, also specified that the reason for increase of hornbeam species is because of centralized the management operation on beech logging which affected forest characteristics. also the result of quantity reviewing shows that management operation had negative effect on stand quality, such as health of trunk and crown, crown homologous, and by centralized the logging on high quality beech trees is the cause of quality decrease in managed parcel.

DISTRIBUTION AND STAND STRUCTURE OF EUROPEAN BEECH (*FAGUS SYLVATICA* L.) IN LITHUANIA

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Introduction

European beech (*Fagus sylvatica* L.) is widespread in Central and Western Europe (Bohn et al., 2004; Bolte et al., 2007). Lithuania is situated outside their north-eastern natural distribution range. It is considered that Southern Baltic is a northern range limit of the European beech, but we can find beech in Polish near Vištytis and in many parts of Kaliningrad region. In some of these forest situated closer to the river Nemunas beech grow in stands as single trees or in groups, taking up to 10 hectares of forest land (Jankauskas, 1980). Due to climate change growth conditions for beech in this region are likely to become more favourable (EEA, 2004; IPCC, 2007). Therefore, to increase knowledge about diversity, sensitivity and adaptability of beech the presented study was performed in the western part of Lithuania.

Materials and methods

The distribution of the beech forests was identified from State forest inventory, other written sources, like dendrological literature and journals. The dendrometic characteristics of the stand structure were recorded in the field survey.

Results and Discussion

The age of oldest beech trees growing in forest parks reaches 130 years. There are also more than 20 ha of mixed stands, where beech trees grow in the first storey. Scots pine stands, where beech trees (60-80 years old) grow in the second storey cover more than 40 ha. Pure 70 years old beech stands reach 26 m of height, 25.3 $m^2 ha^{-1}$ of basal area and 350 m^3 volume per ha. Beech growing in the second storey of Scots pine stands prevailing in Lithuania increases the total stand volume up to 30-60 %.

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GENETIC STRUCTURES OF ADULT EUROPEAN BEECH STANDS AND NATURAL REGENERATION (*FAGUS SYLVATICA*)

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A high genetic diversity is essential for long-term adaptability and survivability of forest tree populations. Previously, the genetic structure of European beech (*Fagus sylvatica L.*) was examined mainly in pure stands. For an ecological forest conversion, the effect of the mixture with other tree species on genetic variability needs to be clarified.

In the present studies, adult beech stands with various mixture ratios of Norway spruce (*Picea abies L.*) were selected to research possible filter-effects on the transport of pollen and seeds. The genetic structures of adult population, beechnuts (Morgenstern 2005) and natural regeneration (Ißleib 2006) were characterised by the microsatellite markers mfc5 and mfc11. Further, the gene flow within and between the stands were evaluated by a pedigree analysis.

At both microsatellite loci a high allelic diversity can be determined. Certainly genetic diversity and heterozygosity showed no differences between the various structures of beech stands respectively the different offsprings. The pedigree analysis showed an intense gene flow by seeds and pollen. The average transport distance for pollen ranged from 90 meters to 284 meters. On average, the distance between seedling and possible seed parent was 14 meters to 90 meters (Ißleib 2006). In the analysis was also shown that only few offsprings originated from self-fertilization. A filter-effect by the Norway spruce (*Picea abies L.*) could not be proved.

In summary our results demonstrate that genetic variability of offspring is not restricted by the stand structure or by a decreasing number of potential parents. Thus natural regeneration of actual beech stands can be used for an ecological forest conversion.

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SPATIAL PATTERNS AND COMPETITION IN A NATURAL MIXED BEECH - SESSILE OAK FOREST IN RUNCU NATURE RESERVE (WESTERN ROMANIA)

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The concept of close to nature, which assumes the extension of mixed-species stands and continuous cover management (Lüpke 2004), has become very important in the last decades in the European forestry sector. Nevertheless, in order to know how to manage an uneven-aged mixed forest, one firstly needs to understand the tree-on-tree interactions of natural forests, which are influenced by different species-specific shade tolerance (Kobe et al. 1995). Therefore, by using point pattern analysis, the present study focuses on the potential interactions between two different shade tolerant species (beech - *Fagus sylvatica*, L. and sessile oak - *Quercus petraea*, Matt. (Liebl.)), and the possible interactions between trees of different size strata. We have two guiding hypotheses: (1) Due to the difference in shade-tolerance between the two species, a strong interspecific competition is expected to separate them in space. (2) The trees in the overstorey stratum should be unaffected by competition from smaller neighbours belonging to under- or midstorey layer, the tree mortality of the overstorey being thus a random process.

Two 1-ha plots were located in a natural mixed beech-sessile oak forest of "Runcu Grosi" Natural Reserve (western Romania), differing in beech participation rate (as % total volume): one dominated by beech (P1-58%) and other by sessile oak (P2-78%). All individuals of each plot were classified on basis of trees distribution on height classes into three development strata: understorey (height < 18 m), midstorey (18-28 m), and overstorey (> 28 m). Spatial structure and competition were investigated by uni- and bivariate point pattern analysis (pair-correlation and mark (e.g. dbh - diameter at breast height)-correlation functions. All univariate and bivariate point pattern analysis were performed using the grid-based estimators Programita software package (Wiegand and Moloney 2004). Significant departure from the null models was evaluated based on 95 % simulation envelopes, which were calculated from the 5th-lowest and 5th-highest value of 199 Monte Carlo simulations.

While beech individuals are represented in all height strata, sessile oak belongs only to the overstorey layer. The competition between the two species was more pronounced in P2 as shown by bivariate pattern analysis. The mortality process occurred mainly among sessile oak trees and was randomly distributed. Competition between overstorey and understorey in P1 has been showed by the distance correlations at the scale 5-6 m and 7-8 m. The positively correlated dbh at the scale of 6-7 m between over- and understorey trees found in P1 is probably the radius outside the immediate canopy of the overstorey trees (Getzin et al. 2011). The significant competition in P2 between all three size classes has been detected neither by the distance correlations, nor by the mark-correlations in dbh, the second hypothesis being thus confirmed. The results showed a different shade tolerance ranking of species, and the tendency for sessile oak to be displaced by beech. This information can be very useful in the management of mixed beech-sessile oak stands.

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A STUDY OF HYDROGEN PEROXIDE EFFECTS ON ORIENTAL BEECH *(FAGUS ORIENTALIS)* NUTS GERMINATION STIMULATION

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Introduction

Oriental beechnuts are deeply dormant seeds that can germinate after 8-19 week cold stratification (Rezaii, A.*et al.*, 2010). Hydrogen peroxide (H2O2) have been found to stimulate seed germination in *Pseudotsuga menziesi* (Ching 1959), *Picea smithiana* (Chandra & Chauhan, 1976), *Northofagus obliqua* and *N. procera* (Shafiq, 1980), *Pinus wallichiana* (Thapliyal *et al.*, 1985 V, *Pinus roxburghii* (Ghildiyal, 2003). H2O2 pretreatment also increased seed germination capacity (Ching, 1959; Ogawa and Iwabuchi, 2001; Sarath *et al.*, 2007). This study was explored the efficiency of different (H2O2) concentrations with different duration prior to cold stratification for breaking dormancy and increasing germination capacity.

Materials and methods

Nuts which collected from 700 masl on northern slopes of Derazno region analysed at seed laboratory according to ISTA rules. Nuts, by two methods, with pericarp and without pericarp, treated with H2O2 solution concentrated to 1, 2 and 3 percent for 12 and 24 hours and 30 percent for 15 and 30 minutes prior to cold stratification. Control sample only exposed to cold stratification. Germination characteristics such as GC, GR, GS, GE and MGT were calculated. One-way ANOVA and GLM analysis were performed to determine differences in germination characteristics.

Results and Discussion

This study showed that soaking the seeds in H2O2 solution not only increase germination capacity (Ching, 1959; Ogawa and Iwabuchi, 2001; Sarath et al., 2007), But also accelerated the germination of seeds and allowed especially a faster start of germination than control. MGT Reduction was most evident in seeds soaked in all concentrations and both methods prior to stratification. Results of this study can provide a cheap means for large scale germination treatment to achieve maximum germination of oriental beech nuts in the short treatment time before seeding.

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A STUDY OF GIBBERLLIC ACID EFFECT ON ORIENTAL BEECH (*FAGUS ORIENTALIS*) NUTS DORMANCY REMOVAL

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Introduction

Oriental beechnuts have deep dormancy that can be released by 8-19 week cold stratification (Rezaii, A. et al. 2010). Dormancy breaking and germination are complex phenomena which are affected by growth regulator (Holdsworth, MJ. *et al*., 2008). The most important of which are Gibberellic acid. Exogenous growth regulator treatments-gibberellins have been shown to break dormancy in many seed species (Karam, NS. *et al* 2001). In present study the effect of different GA concentrations (250,500,1000ppm) prior to cold stratification was investigated on oriental beech nuts to shorten their long dormancy duration.

Materials and methods

Beech nuts were collected from 1100 masl on northern slopes of Derazno region and then analysed at seed laboratory according to ISTA rules. Nuts, by two methods, with and without pericarp, were soaked in 250, 500 and 1000 ppm concentration of GA solution for 24 h before cold stratification. Control sample only exposed to cold stratification. Germination characteristics such as GC, GR, GS, GE and MGT were calculated. One-way ANOVA and (GLM) analysis were performed to determine differences in germination characteristics.

Results and discussion

Seed germination can be induced by Gibberellic acid in *fagus sylvatica* (Nicolás,c. et al., 1996); and *morus nigra* (Koyuncu F. 2004). Results of this study showed that, effect of GA treatments on dormancy release significantly improved when beech nuts were soaked in GA of all concentrations in both methods. In addition MGT was reduced in seeds soaked in GA prior to stratification so that their cold requirement time was reduced (Baskin C.C., Baskin J.M. 2001) by 54 and 33 days respectively in both methods compared to control. Results also showed that exogenous GA does not increase the germination capacity of beechnuts in compared to control which presented the highest germination capacity (Kolářová.P, L. *et al*., 2010). Although In earlier experiments the application of GA was effective only for beechnuts without pericarp (Suszka, 1990s), this study showed GA applying before stratification is effective in both methods. Finally as exogenous GA supplied at the beginning of stratification can accelerate dormancy breaking, it can be suggested that the methods could be effective for species with the same dormancy behaviour.

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INTERSPECIFIC DIFFERENCES IN SHADE TOLERANCE OF *FAGUS SYLVATICA* AND *ABIES ALBA* DURING THE SMALL TREE PHASE

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Introduction

Interspecific variation in shade tolerance is widely accepted as an important driver of succession in forest communities. Recent work on this topic suggests that the light requirements of many tree species increase with tree size, which may lead to a shift in the shade tolerance rankings among coexisting tree species. In this study, we examined shade tolerance differences between fir (*Abies alba* Mill.) and beech (*Fagus sylvatica* L.) during the late sapling-pole sized life stage. Both species have similar regeneration niches during early regeneration stages, so a potential coexistence mechanism could be related to differences in shade tolerance as trees reach larger regeneration stages. Both species are regarded as shade tolerant, but beech is typically described as less shade tolerant than fir. We hypothesized that beech will have higher growth rates in optimal light conditions compared to fir, and that fir can survive more and longer periods of suppressed growth in low light conditions.

Materials and methods

The study was performed in mixed Dinaric fir-beech stands that were managed with a low intensity selection system for more than 100 years. Trees below 12 m in height with no side competitors were randomly selected over an area of approximately 50 ha in different light conditions. For all the trees, basic dendrometric data was measured. All trees were cut at the base and discs were analyzed for radial growth. Potential growth responses to disturbances and suppression periods were identified by calculating percent growth change (%GC) using a 10-y moving median (release > 100 % growth increase; suppression > 50 % growth decrease). Light was measured 6 m above the ground.

Results and Discussion

Fir minimal growth was half that of beech, while maximum values were greater. Fir had more suppressions than beech, but the difference was not significant. Only 19 % of beech and 11 % of fir trees were never suppressed. The median duration of suppressions was 9.5 years for beech and 15 years for fir. Maximum suppression periods were 37 years for fir (50 % of the total age) and 39 years for beech. The growth patterns of beech and fir in general differ. Most fir trees showed slow initial growth and a gradual growth increase with age. Sudden increases in growth can be observed in both species but was much more pronounced for beech, especially during younger stages of growth. The average radial and height growth of the last 5 years was positively correlated to relative diffuse radiation for both species. A much larger increase in height growth was observed for beech above 4.5 % of DIF, while fir outperformed beech below that value. This result confirms the hypothesis of faster beech growth compared to silver fir at higher light levels. At the same time, the performance of fir was better in lower light levels. Our study shows that fir has some characteristics that suggest it is more shade tolerant, but beech also has shade tolerant characteristics. If both species have similar regeneration niches and life spans, and apparently similar tolerances to shade, then coexistence may more likely be related to neutrality rather than niche differences. It seems unlikely that the small difference we found in this preliminary study contributes to the coexistence of these two species, but more research is warranted.

GAP DISTURBANCE REGIME IN BEECH-DOMINATED OLD-GROWTH FORESTS OF THE BALKAN PENINSULA

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Introduction

Understanding natural disturbance processes plays an important role in close-to-nature silviculture. This is particularly true in European beech (*Fagus sylvatica* L.) dominated forests because they encompass a large portion of forests in South East Europe, yet we still lack information on the natural disturbance regime in beech forests. Since beech has rapid lateral crown growth, it is often considered that small gaps do not play a significant role in gap dynamics of these forests. Due to the uniform appearance (cathedral like) of old-growth beech stands (Korpel 1995, Ellenberg 1996), large disturbances have been hypothesized to be the main driving force of forest development. On such occasions, the improved overall light conditions could enable large-scale regeneration establishment, thus forming even-structured forest stands.

Materials and methods

We studied canopy gap disturbances in six old-growth forest reserves in Slovenia, Croatia and Romania. The sizes of the old-growth forests ranged from 13 to 5000 hectares and were mostly situated in the mountain belt of South-east Europe. Altogether we sampled 211 canopy gaps using line-intercept sampling. We surveyed gap size, extended gap size, gap-maker characteristics (mode of mortality, size, tree species, and decay class) and regeneration of each tree species in three size classes.

Results and discussion

The gap fraction ranged from 10% to 35%. Most gaps were small (< 250 m^2) and were formed by up to three gap-makers. Larger gaps were rare and occurred on extreme site conditions where multiple (> 10) trees died simultaneously. Gap-makers were predominately uprooted and wind-snapped (> 50%), while standing dead trees were infrequent (< 5%). We conclude that small to intermediate (< 500 m^2) gaps are the dominant driving force of dynamics in beech dominated old-growth forests. Large gaps (> 1000 m^2) are rare and were found only on the extreme (slope angle > 40°) forest sites, such as subalpine beech forest in northern Slovenia. Here most of the gaps were formed by one disturbance event (2008 wind throw). There was no relationship between regeneration density and expanded gap size for beech, but Sycamore maple (*Acer pseudoplatanus* L.) regeneration density was positively related to expanded gap size. We speculate that beech regeneration is more related to the overall light climate, particularly the amount of diffuse light in the forest understory, which is related to the spatial pattern and density of gaps rather than gap size alone.

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TRADITIONAL ANIMAL HUSBANDRIES AND THEIR EFFECTS ON PLANT COMPOSITION IN ORIENTAL BEECH COMMUNITIES IN THE CASPIAN FORESTS OF IRAN.

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The Caspian mountain forests have a unique richness of biological diversity and contain relicts of the Arcto-Tertiary and Indo-Malesian flora. In Iran, since 1962 grazing by domestic animals is forbidden in forests. However, due to high dependence of forest inhabitants on natural resources, still about 1500,000 cows graze in the Caspian forests. The traditional animal husbandry (T.A.H.) consists of a seasonal transhumance movement through these forests from the Caspian Sea shores to the high mountainous grasslands of Elburz. The objective of this study was to evaluate the effects of the animal husbandries on plant composition and establishment of invasive species in different oriental beech communities.

This study carried out in “Kheiroud investigation forest” in the middle of Caspian region. 25 relevés in active and abandoned T.A.H. and 60 relevés in surrounding beech forests measured. To analyze the effect of these animal husbandries and cattle grazing on plant diversity, plant richness and Shannon index calculated and their differences analyzed by GLM. TWINSPAN analyses carried out to recognize different plant groups and subsequently indicator species analysis was performed to specify the indicator species in each group.

Altogether 158 plant species were found representing 17 trees, 8 shrubs, 18 ferns and 115 herbaceous species. Low grazing generally lead to increase in species richness, but in animal husbandries due to high soil disturbance and grazing pressure, both plant richness and composition are changed. TWINSPAN analysis resulted in five groups which consisted undisturbed, un-grazed gaps, grazed forests, active T.A.H. and abandoned T.A.H. (Table 2). Indicator species analysis for these groups revealed the effect of these animal husbandries on plant composition and establishment of ruderal species in grazed forests and mainly invasive and apophyte species in animal husbandries.

Traditional animal husbandries lead to the introduction of new species to the investigated *F. orientalis* communities. These species could be mainly classified as: ruderal, apophyte and invasive plant species.

Animal husbandries are like islands (with different plant composition) surrounded by beech forests, therefore they can be an important center for propagule dispersal (especially in the case of invasive and apophyte species). On the contrary cattle grazing is important both for maintaining forest dwellers livelihood and biodiversity.

Keywords: Community composition, Invasive Plants, The Caspian Forests, TWINSPAN.

CONTROLLED - DECOMPOSING FERTILIZER INFLUENCE ON BEECH SEEDLINGS MORPHOLOGICAL QUALITY PARAMETERS

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Introduction

Quality of seedlings could be significantly improved by fertilizer application as an alternative source of nutrients and powerful mean for multifunctional high quality seedling material production. The main aim of this paper is to examine and experimentally confirm positive influence of adequately selected fertilizer on beech seedlings development and quality improvement.

Materials and Methods

Controlled-decomposing fertilizer „Osmocote® Exact®" influence on morphological parameters of beech seedlings quality has been analyzed within experiments, using "Gocko" container type (cell dimensions 5 x 5 x 15 cm) and mixture of peat, sand and humus (2:1:1) as medium in autumn planting. The analyze of beech seedlings morphological quality parameters (seedling height (cm), root neck diameter (mm), aboveground and underground part biomass in fresh condition (g) and main root length (cm)) was conducted at the end of the first and the second vegetation period. Numeric data have been analyzed applying computer package «Statistika 6.0». Statistical importance of differences between treatment and control, for analyzed morphological parameters, has been calculated by Student t-test.

Results and Discussion

Results presented in this paper show that relation between main nutritive elements in controlled-decomposing fertilizer „Osmocote® Exact®" has positive influence on development and improvement of beech one-year-old and two-year-old seedlings in containers (Sijacic-Nikolic et al. 2006, 2006*a*, 2006*b*). Wide range of macro- and microelements, simple using, controlled decomposing according to plant needs and relatively long influencing period, are significant traits which approve applying of this fertilizer in massive production of high-quality seedling material of beech, and potentially all other deciduous forest tree species.

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SPRING PHENOLOGY OF EUROPEAN BEECH (*FAGUS SYLVATICA* L.) PROVENANCES WITHIN INTERNATIONAL PROVENANCE TRIAL IN SERBIA

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Introduction

The paper presents research results of spring phenology of European beech in international provenance trail established in 2007 at the site „Debeli Lug" in Eastern Serbia. The site is characterized with altitude of 742 m, East aspect, ridge of uniform slope and humus-siliceous soil. The trial consists of 25 European provenances, where each provenance is represented by 50 plants, planted in rows with 2x1 m spacing in two repetitions (von Wühlisch et al. 2010, Stojnic et al. 2010).

Materials and Methods

Spring phenology monitoring of different beech provenances was conducted during April and May of two consecutive years, 2009 and 2010, according to the guidelines established within the COST Action E52 "Evaluation of the Genetic Resources of Beech for Sustainable Forestry" and uniform within the European network of beech provenance trials.

Results and Discussion

Spring phenology monitoring during two years shows earliest foliation for Serbian provenances Fruska gora (68 and 36) and Avala (66), while Hungarian (42), German (47) and Serbian provenance Kopaonik (38) are the latest in spring foliation process. These observations can be explained with geographical origin of provenances, because Fruska gora and Avala are located at lower altitudes where vegetation period is longer and starts earlier than for Kopaonik, German or Hungarian provenances originating from north areas and high altitudes with shorter vegetation period which starts later than at the international trial established in Serbia.

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ESTIMATES OF BIOMASS AND CARBON STOCK IN UNEVEN-AGED BEECH STANDS IN EASTERN SERBIA

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Introduction - Scientists worldwide have recognised the importance of studying biomass or carbon stock and cycling in forest ecosystems. A great number of studies have dealt with Europen beech (*Fagus sylvatica L.*). Researches of this kind have been recently initiated in Serbia (Koprivica et al. 2010). The aim of the research is to provide an accurate estimate of biomass and carbon stock in both living and dead wood in uneven-aged beech stands.

Materials and methods - A set of five beech stands that used to be virgin forests at the beginning of the twentieth century was selected. Site class is II-IV, altitude 450-1050 m. Altogether 111 circular sample plots of 500 m^2 in size were established. Both living and dead wood were measured. The age of the trees was determined. Equations (Wutzler et al. 2008) were used to determine the tree biomass, while the dead wood biomass was determined on the basis of wood volume and density (Mund 2004). Tree carbon was calculated by using the equation (Joosten et al. 2004), while the carbon in roots and dead wood was calcuated by multiplying biomass by a 0.5 coefficient.

Results and discussion - The stands are characteristically uneven-aged, with a decreasing distribution of tree diameters. Ellenberg (1996) noted that the old-growth broadleaved forests in Europe are usually not even-aged, which is consistent with our results. The average dead wood biomass above the ground is 25.2 $m^3 ha^{-1}$ (15.6-28.0 $m^3 ha^{-1}$), with the error +/-19.7%. Analysis of variance showed insignificant differences between the stands ($p = 0.71$). The average dead wood biomass is 2.5 times higher than the dead wood biomass in the managed beech stands in Europe (Christensen et al. 2005). The average living wood biomass above and under the ground is 288.3 t ha^{-1} (228.6-393.2 t ha^{-1}). The average dead wood biomass above and under the ground is 22.1 t ha^{-1} (12.6-33.6 t ha^{-1}). The average biomass of living and dead wood above and under the ground is 310,4 t ha^{-1} (253,1-405,8 t ha^{-1}). Analysis of variance showed significant differences between the stands ($p < 0,0001$). The error of the living wood biomass is +/-7,1%, while the error of the dead wood biomass amounts to +/-20,4%. The average carbon stock in dead wood above and under the ground is 11,1 tC ha^{-1} (6,3-16,8 tC ha^{-1}). The average carbon stock in living wood above and under the ground is 153,6 tC ha^{-1} (124,7-201,1 tC ha^{-1}). In comparison to the researches carried out in Germany (Mund 2004), carbon stock in the beech stands in the Eastern Serbia is lower by 13.8%.

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A TRIANGULATING APPROACH TO ASSESSING MULTIPLE STRESS IN SWEDISH BEECH FORESTS TROUGH FOLIAR NURIENT ANALYSIS

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Introduction: At currently projected climate change, assessments show that Scandinavian beech forests (*Fagus sylvatica*) are likely to extended their distribution significantly (Koca 2006). These assessments, however, take little account of the fact that climate change impacts needs to be combined with the effects of nutrient poor and acid soils (haplic podsols to dystric cambisols) and the soil nutrient imbalance caused by long-term nitrogen accumulation. Compared to the European situation, the Swedish beech forests have lower deficiency thresholds and recommended target values for nutrient ratios to N (Stjernquist and Sonesson 2006). A systems view on multiple stress factors affecting forest vitality is clearly needed (Serengil et al. 2010). Further, climate models indicate higher temperatures and longer dry spells during the vegetation period in Sweden (Persson et al. 2007). The aim of the study was to analyse the effects of excess of nitrogen in combination with drought and acid soil conditions using foliar nutrient concentrations as indicators of tree vitality.

Material and Methods: The study was designed as controlled field experiments using both seedlings and mature trees. The seedling experiment was randomised using acid and moderately acid soils (haplic podsol and eutric cambisol) and different levels of drought and nitrogen fertilization. After two years, growth and foliar nutrients were analysed. The mature trees was growing on the same two kinds of soils as the seedlings. For each soil, the experiment included control and nitrogen treatment in triplicate. After five years the foliar nutrient condition was analysed through samples taken each month from May to September.

Results and Discussion: Under climate change conditions, beech may be important for Swedish forestry as other decidous species are threatened by new pests and pathogens. Beech regeneration is dependent on seedling survival and growth capacity under existing stress conditions. This study indicate that drought increases the negative effects on both growth and nutrient uptake caused by multiple stress factors. For mature trees as well as for seedlings nitrogen excess, both on acid and moderately acid soils, reduces the uptake of essential nutrients, expressed as the leaf content of Ca, K, Mg, and P to N ($p > 0{,}0001$). For mature beech trees, this is significant from June to September, and the effect is larger on acidified soil ($P > 0{,}0001$). The seedling experiment show a similar pattern; on the acid soils, drought over the vegetation period drastically reduceed the P, K and Mg uptake. The relative growth rate of leaf to plant is reduced by both drought and excess nitrogen. In Sweden, the soils in the area between the current and potential future distribution limits are mainly acidified and have as well accumulated nitrogen over decades. With increased summer drought risks, the beech forest vitality and regeneration is likely to be threatened in many areas.

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SPATIAL DIVERSITY OF NATURALLY REGENERATED 80-YEARS OLD BEECH STANDS (*FAGUS SYLVATICA* L.) IN SOUTHERN POLAND

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Common beech reaches in Poland the north-eastern limit of its natural range and it is very important and valuable forest tree species in Polish forestry.

Data presented here were derrived from 3 naturally regenerated forest stands at the age of 80 years. Dominant tree species is common beech. Silver fir and common oak form an admixture. All stands were thinned and future crop trees (FCT) were selected according to selective thinning.

The main purpose of this paper is the description of the spatial divesrity of trees and their sizes (heights and DBHs) using standard indices proper for such analysis. The following indices were applied: Clark-Evans index in Donnelly's modification (CE), size differentiation index TD (DBH) and TH (height). Analysis was carried out for all living trees (LT), separately for beech (BE) and other species (OS), and for future crope trees (FCT) separately. Measurements were carried out on rectangular plots of size of 0,35 ha each. Calculations were made using SIAFOR software (Kint 2004).

In two stands LT as well as for BE and FCT showed regular distribution (α=0,05). In the 3rd stand they were randomly distributed. Values of CE index for OS were below 1, but only in one of them the observed deviations were statistically significant (α=0,05) indicating groups of trees. More or less regular distribution of living trees or future crop trees was reported by Szwagrzyk (1990), Pretzsch (1996), Boncina et al. (2007). Mean TD index showed small DBH differentation between neighbouring trees (LT, BE and FCT) and the highest value was observed in case of OS. Future crop trees showed the smallest mean TD index. Distribution of TD index showed that neighbors didn't differ mostly more that 40%. FCT showed very small or small differentiation in DBH between neighbors. Small DBH differentiation between neighbors in old stands reported Drössler and Lüpke (2004) in 140 years old beech stands. Height differentiation between nieghbors was very small or small. FCT showed very small (differences<20%) differentiation in height in 3 stands. He highest values of TH showed OS. Barbeito et al. (2009) reported similar values of height differentiation for managed pine stands. The main reasons for the emergence of regularity in spatial distribution of trees and small size differentiation of them could be attributed to the density-dependent mortality (e.g. self-thinning) and human activities (thinning operations). Especially the latter in managed stands influences the forest diversity but more studies on that should be undertaken.

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A DETAILED OBSERVATION OF FLOWERING PHENOLOGY AT CURRENT-YEAR SHOOT LEVEL IN *FAGUS CRENATA*

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Introduction

Flowering phenology is a species-specific reproductive trait in flowering plants, and it could be quite sensitive to potential changes in local and global climate (e.g., Dunne et al. 2003). Phenology of flower development is also an important aspect of biotic interactions between plants and animals which could act as predators or pollinators (e.g., Elzinga et al. 2007). There have been little studies on flowering phenology of temperate tall tree species, based on the shoot-level observation in particular. In this study, flowering phenology of *Fagus crenata* Blume was observed at the current-year shoot level to analyze the effects of temperature and shoot characteristics on the flower development.

Materials and Methods

Flowering phenology was observed in three individual trees of *F. crenata* in Hokkaido, northern Japan. For each tree, five to seven branches at the height of 5 – 8 m above ground were randomly selected. All of the 1-year-old shoots within a length of 50 cm at the top end of each selected branch were tagged, and flowering stages of each current-year shoot were recorded at 2 – 6 days intervals. Flowering stages were classified into five categories for both female and male inflorescences. Total numbers of observed shoots were 330 – 400 shoots per tree. Effects of the cumulative temperature above $0^{o}C$ (CT_0) and shoot characteristics, i.e., monosexual/bisexual and relative shoot position in a branch, on the flower development were analyzed by the GLMM.

Results and Discussion

Medians of the CT_0 at the appearances of female flowers with receptive stigma and pollen-dispersing male flowers (stage IV for both female and male), were 258 ^{o}C-days and 277 ^{o}C-days, respectively. Appearances of stage IV flowers were earlier in the bisexual shoots than the monosexual ones by about 10 ^{o}C-days of CT_0. Relative shoot position in a branch has small effects on the timing of the appearance of stage IV flowers; outer shoots reached the stage IV earlier. Mean durations of the stage IV were 7.1 and 3.5 days for female and male flowers, respectively. The durations of the stage IV were shorter for the flowers of later anthesis.

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VARIABILITY OF GROWTH PARAMETERS OF DIFFERENT EUROPEAN BEECH (*FAGUS SYLVATICA* L.) PROVENANCES IN INTERNATIONAL PROVENANCE TRIAL IN SERBIA

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Introduction

Provenance trials provide a rich source of information that can be utilized to evaluate adaptive potential of forest trees. For this reason, a large network of beech provenance trials was established using a total of 202 seed sources representing most of the species' distribution range. At each field trial a subset of 30-100 provenances are being tested. Within the last series of European provenance tests in 2007 two provenance tests were established in Serbia.

Materials and Methods

Growth parameters of European beech in international provenance trial established on the site "Debeli Lug" in Eastern Serbia were researched. Provenance trial was established in spring 2007, from two- and three-year old seedlings, in the framework of COST Action E52: "Evolution of Beech Genetic Resources for Sustainable Forestry". Site is characterized with altitude of 742 m, East aspect, ridge of uniform slope and humus-siliceous soil. The test consists of 25 European provenances, where each provenance is represented by 50 plants, planted in rows with 2x1 m spacing in two repetitions.

Results and Discusion

Based on the analysed parameters: plant height, height increment, plant diameter and diameter increment at root collar over the three-year period, it can be concluded that the highest values of the study parameters were achieved by: Bosnian provenances (32, 33 and 30) and Serbian provenance Fruška Gora (36). The lowest values were attained by Romanian provenances (63 and 64), Serbian provenance Avala (66) and one Bosnian provenance (59). The obtained study results refer to the juvenile phase of development, so a continued monitoring is required (von Wühlisch et al. 2010, Stojnic et al. 2010).

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Stojnic, S. 2010. International Scientific Conference: Forest ecosystems and Climate Change. March 9-10th, Belgrade. Book of abstracts: 40.

CONFERENCE PROGRAM

Conference program

Monday 12.09.2011	
16:00-20:00	Registration and icebreaker at Hotel Pullman
Tuesday 13.09.2011	
09:00-12:15	Session 1
12:30-13:00	Travel to Tharandt
13:00-14:00	Lunch
14:00-15:30	Presentation of the Department of Forest Sciences in Tharandt with reference to the 200 years anniversary
15:30-19:00	Field trip to Tharandter Wald
19:00-19:30	Travel back to Dresden
Wednesday 14.09.2011	
08:30-12:20	Session 2 and 3
12:20-13:20	Lunch
13:20-18:10	Session 4,5 and 6a
19:00-20:30	Guided tour in Dresden
Thursday 15.09.2011	
08:30-10:00	Session 6b
10:00-11:30	Poster session
12:00-15:30	Travel to Thuringia. Lunch will be served during the travel
15:30-19:00	Excursion in Thuringia
19:00-20:30	Travel to accommodation in Göttingen
Friday 16.09.2011	
09:00-17:15	Field trip to Lower Saxony. Lunch will be served during the excursion
18:30-20:00	Guided tour in Göttingen
20:00-22:00	Conference dinner
Saturday 17.09.2011	
End of the conference	

Session program

Tuesday 13.09.2011

9:00	9:20	Introduction to conference (Khosro Sagheb-Talebi, Sven Wagner)

Session 1 - Paleoecology and distribution of beech
Chair: Khosro Sagheb-Talebi

9:20	9:50	Thomas Denk	**-Keynote-** The fossil history of *Fagus*
9:50	10:10	Hongyuan Liu	Why had *Fagus* expanded during the holocene dry spell in China?
10:10	10:30	Mette V. Overballe-Petersen	Early holocene occurrence of *Fagus sylvatica* in Northern Europe
10:30	10:50	*Coffee break*	
10:50	11:10	Andrej Boncina	Future potential of European beech in its marginal and core distribution ranges in Slovenia
11:10	11:30	Alfredo Di Filippo	Climate-change induced bioclimatic shifts in *Fagus sylvatica* forests assessed through a tree-ring network crossing the Mediterranean-temperate biomes
11:30	11:55	Andreas Bolte	Is the hemi-boreal distribution margin of European beech (*Fagus sylvatica*) moving northwards?
11:55	12:15	Vitas Marozas	Effect of meteorology on growth of european beech (*Fagus sylvatica* L.) outside north-eastern natural distribution range. Lithuanian case study

Wednesday 14.09.2011

Session 2 - Drought and the response of beech
Chair: Alfredo Di Filippo

8:30	9:00	Ismael Aranda	**-Keynote-** A view of the functional response of beech to drought. What do we know? and, what do we need to know in the frame of the climatic change?
9:00	9:20	Liam Cavin	The effect of drought on *Fagus sylvatica*: are range core populations threatened too?
9:20	9:40	Heino Wolf	Response of European beech (*Fagus sylvatica* L.)-provenances to drought
9:40	10:00	Tamalika Chakraborty	Influence of soil drought on crown die-back and basal area increment of understorey *Fagus sylvatica* at their drought limit
10:00	10:20	*Coffee break*	

Session 3 - Beech genetics

Chair: Kazuhiko Terazawa

10:20	10:40	Keiko Kitamura	Chloroplast DNA haplotype variations among Siebold's beech, *Fagus crenata*, observed at its northernmost island distribution
10:40	11:00	Aikaterini Dounavi	Microclimatic influence on the genetic structures of beech populations growing on southwest and northeast exposed slopes
11:00	11:20	Urs Mühlethaler	Testing the adaptability of mediterranean beech in Swiss forests
11:20	11:40	Davide Travaglini	Impact of forest management on stand structure and genetic diversity of beech (*Fagus sylvatica*) forest stands
11:40	12:00	Sarah Seifert	Forest management does not reduce genetic diversity of adult beech (*Fagus sylvatica*) stands but changes the spatial structure
12:00	12:20	Ute Tröber	Implementation of a genetic monitoring system in European beech (*Fagus sylvatica*) populations - first results of a pilot study
12:20	13:20	*Lunch*	

Session 4 - Structure and dynamics of natural beech forests

Chair: Jurij Diaci

13:20	13:40	Eric K. Zenner	Investigating the spatial structural complexity of natural oriental beech (*Fagus orientalis*) in different forest development stages and spatial scales using neighborhood based variables
13:40	14:00	Khosro Sagheb-Talebi	Some structural characteristics in the Far East border of the distribution range of oriental beech (*Fagus orientalis* Lipsky) stands
14:00	14:20	Asadollah Mataji	Deadwood dynamics in managed and unmanaged forests of beech (*Fagus orientalis* Lipsky) in the north of Iran
14:20	14:50	*Coffee break*	

Session 5 - Regeneration of beech forests

Chair: Sven Wagner

14:50	15:20	Catherine Collet	**-Keynote-** Management of European mixed broadleaved stands with beech
15:20	15:40	Christian Ammer	European beech seedlings are much more responsive to limited resources than Norway spruce
15:40	16:00	Jurij Diaci	Regeneration development in Dinaric beech primeval forest in Slovenia: influence of light climate, ground vegetation and Browsing

16:00	16:20	Takashi Masaki	Regeneration of beech by post-logging seedlings: growth and survival during 40 years
16:20	16:40	Palle Madsen	Effects of planting time and container volume on the establishment success of containerized beech (*Fagus sylvatica*) seedlings for forest regeneration in Denmark
16:40	17:00	Olivier N. Baudry	Influence of a shading treatment on the survivorship and the leaf characteristics of naturally regenerated beech seedlings (*Fagus sylvatica* L.)
17:00	17:20	*Coffee break*	

Session 6a - Management of beech forests

Chair: Palle Madsen

17:20	17:50	Ralph D. Nyland	**-Keynote-** American beech: the nemesis of forestry in Northeastern North America
17:50	18:10	Ulrike Hagemann	Comparative quality assessment of naturally regenerated American beech, sugar maple, and yellow birch saplings

Thursday 15.09.2011

Session 6b - Management of beech forests

Chair: Palle Madsen

8:30	9:00	Burghard v. Lüpke Sven Wagner	**-Keynote-** Management of Central European beech stands
9:00	9:20	Susanna Nocentini	Sustainable management of beech forests in the apennines (Italy): lessons from local traditional knowledge
9:20	10:00	Organizational matters IUFRO	

10:00	11:30	**Poster session**

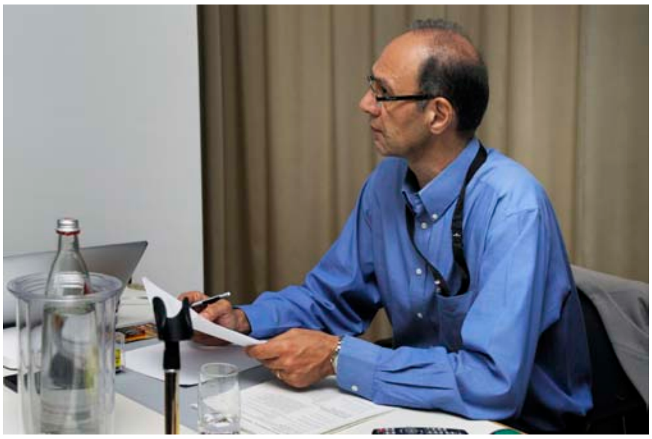
PHOTO GALLERY

Photo gallery

Group photo in the Institute of Silviculture and Forest Protection (Sept. 13, 2010)

Registration and Ice-Breaker on Monday, Sept. 12

Technical Session on Tuesday, Sept. 13

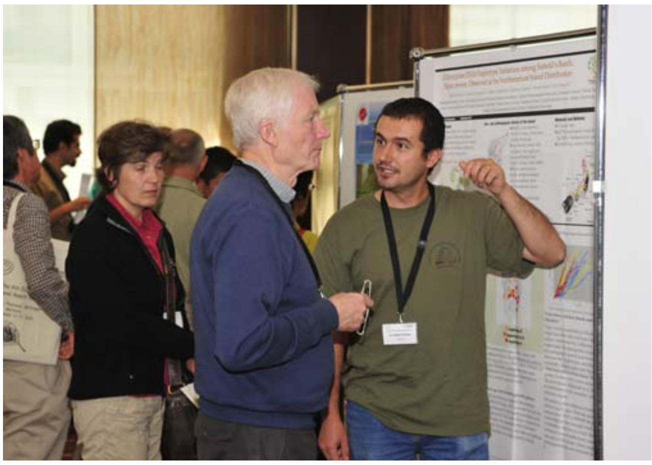


Walk on Campus of Department of Forest Sciences in Tharandt (Tuesday, Sept. 13)

Excursion in the Forest District 'Tharandter Wald' – Artificial Regeneration of European Beech by advanced planting and sowing (Tuesday, Sept. 13)

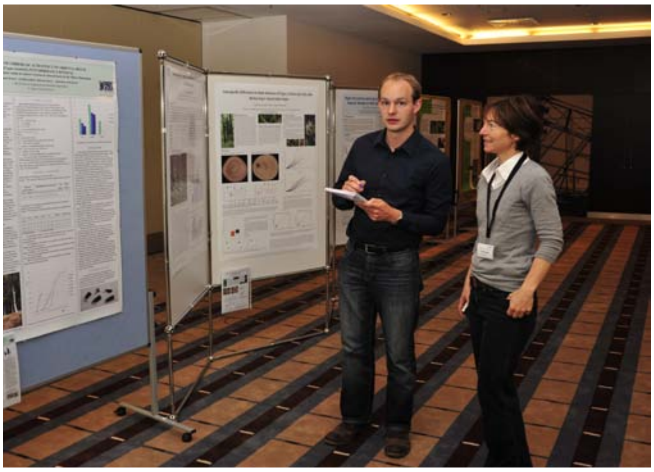
Guided Walk through Historic Centre of Dresden and Dinner in the Restaurant "Alte Meister" (Wednesday, Sept. 14)

Poster Session (Wednesday, Sept. 14)

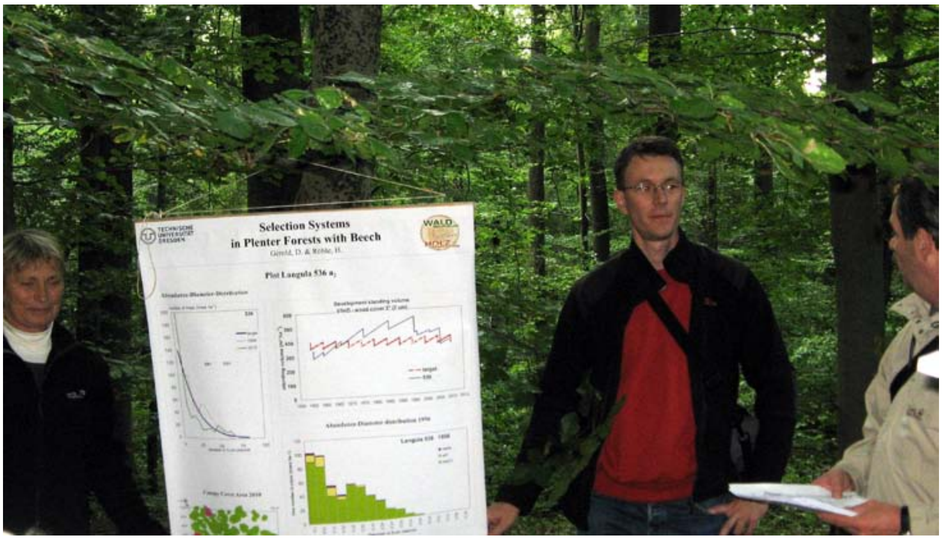









Excursion in Forest Districts of Thuringia – Single Selection Forestry with European Beech (Thursday, Sept. 15)



"Dresdner Eierschecke" !

Excursion in Forest Districts of Goettingen – Regeneration Trials in Mixed Stands of European Beech, Sycamore and Ash on Soils with Lime Stone
(Friday, Sept. 16)

Excursion in the Solling Mountains (Lower Saxony): IBP Research Stands in European Beech and Thinning experiments (Friday, Sept. 16)








Guided Walk in the City of Goettingen and Farewell-Party, Friday, Sept. 16

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