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Abstracts

Use of larch in forestry in North Iceland

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Abstract
Continuous, relatively large-scale planting of larch in Iceland started around 1970 along with the first afforestation on farms with assistance from the Iceland Forest Service. The North Iceland Regional Afforestation Project was established in the year 2000 with the aim of supporting afforestation on farms. Since then, the Project has supported planting of about 13 million seedlings on 150 farms in North Iceland, covering roughly 4600 ha in area. Of that, 50% is larch (mostly *Larix sukaczewii* from Finnish seed orchards). Most of the land afforested with larch is rather dry, on fairly steep slopes and with low or sparse vegetation (former grazing land). It is therefore appropriate to use small, relatively inexpensive container-grown (multipot) seedlings. Afforestation plans are made for each area, including for example provisions to avoid planting too close to archaeological sites and other areas with high conservation value.

Climatically, interior North- and East Iceland has relatively dry summers and colder winters than coastal regions, especially in the South and West. The principal advantage that Russian larch has over other tree species in afforestation of treeless land is its rapid early growth on dry, nutrient-poor sites. Amelioration of site conditions occurs fairly rapidly, through formation of shelter and binding of snow, thereby increasing soil moisture. On eroded sites, frost-heaving rapidly decreases, soil starts to build up and understory vegetation becomes established. Mortality of seedlings is usually acceptably low, or around 20%, despite the prevalence of poor sites in planting. The larch plantations are bright and with appropriate thinning, conditions suitable for livestock grazing develop with time. The preferred planting density is 2800 seedlings/ha. At age about 20, the forest is thinned to 1200-1500 trees/ha. Mean annual volume increment is commonly on the order of 4-5 m^3/ha/yr. Only a small proportion of trees have good straightness, resulting in the necessity for high initial density followed by removal of crooked trees in thinnings. Removal of crooked trees by early spacing is becoming more common. Possible utilisation of wood from early thinnings includes fenceposts, fuelwood, cladding, chips for various uses and pellets. The aim is to ultimately produce a high proportion of valuable saw timber.

Yield of larch hybrids in northern Scandinavia

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Abstract
Hybrid larch is usually referred to as the hybrid between European larch (*L. decidua* Mill.) and Japanese larch (*L. kaempferi* Carr.) well known under the name of *Larix eurolepis* . Several combinations of these two species have been commercially developed and are widely used in practice in Europe, and North America. In northern Scandinavia hybrid larch (*L. eurolepis*) is not adapted to the hard climate and therefore excluded from practical use in forestry. Relatively little information is available on larch hybrids where Siberian larch species are involved as one of the parents. In the 1950s were established field trials in central Sweden including controlled crossings of *Larix decidua* x *L. sukaczewii* and *Larix kaempferi* x *Larix sukaczewii.* 50 years after plantation these hybrids indicate a stem volume which is 24-71 % superior to the stem volume of the best growing pure Russian larch provenance.

Use and Improvement of Larch in the Netherlands

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Abstract
Around 320.000 ha of the Netherlands is covered with forest (= app. 12% area NL).
Of this area 19.000 ha is covered with Larch (= app. 6% of the forest area) with European, Japanese & Hybrid Larch.

The Netherlands is not part of the distribution range of Larch. Most of the Larch forest in the Netherlands is planted; recently some natural regeneration started to take place however.
The majority of the planted material originates from Japan, Germany and Slovakia.
The history of the genetic improvement work started in early 1949 with the phenotypic selection of stands; the first Hybrid Larch seed orchard was established in 1969 and has been in production since 1975.
The future prospectives for the genetic improvement of Larch are discussed.

Specific purity of hybrid larch Forest Reproductive Materials: how much does it matter?

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Abstract
Since its discovery in Dunkeld (Scotland) at the beginning of the 20th century, hybrid larch (HL) (*Larix x eurolepis*) raised a strong interest among foresters and, later on, breeders. Dozens of hybridization orchards have been established in several European countries. All of them include selected genotypes of European Larch (EL) (*Larix decidua* Mill.) and Japanese larch (JL) (*Larix kaempferi* (Lamb.) Carr.) but they differ in the mother species (EL, JL, both), the number of clones used on both maternal and paternal sides (from one to several dozens) and in the planting design. However, the products of these seed orchards are composed of a mixture of hybrid and pure species seeds, the latter resulting from intraspecific crossings and/or self-pollination. Molecular markers show highly variable hybrid percentages among orchards but also, for a given orchard, among years. In addition to the number of mother clones, the proportion of hybrid seeds depends on several factors, *e.g*. clonal contributions to pollen and seed-cone production and flowering overlapping that are related to genetic factors, climatic conditions and seed orchard management (flower stimulation, supplemental mass pollination). Considering the extent of hybrid rate fluctuations (between 10% and 90%) it is important to study the effect of species purity on stand productivity and quality. The consequences are also discussed in the context of seed orchard testing.

Our data have been mainly collected in two "twin" trials managed by Irstea that aimed at comparing seed lots from six European hybridization orchards (64 seedlings per plot x 4 blocks for each variety). They were planted in 1995 in two sites, at mid-elevation (800 and 1000 m). The first one is subjected to an oceanic climate favourable to JL whereas the second one, more continental, is more suitable to EL. Bedrock is granite in site 1 and limestone in site 2. Taxa were first identified (100-120 trees per variety) by INRA using markers based on cytoplasmic DNA. It allowed us to compare the performances of hybrids and pure species and to study the evolution of HL percentage over time and thinnings. Hybrid varieties were: FH 201, Halle, Esbeek, Maglehem (in both sites) as well as FP 237 and Vaals in site 2. Seed lots were produced in seed orchards with various designs (one or several maternal clones, seeds collected from EL or JL).

Hybrid proportion varied tremendously in the tested populations. It was low in FP 237 and Halle (12-26%), intermediate in Maglehem (43%) and high in FH 201, Vaals and Esbeek (84-96%).

Taxa did not vary for survival and adaptation because no sanitary problem occurred in the trials after age 10-14 when taxa were identified. However, there was some evidence that pure species were more affected by early mortality than hybrids in some varieties.
For each variety and in both sites, hybrids had a better growth in height and diameter. Still, huge differences were found among varieties. At age 6, superiority of hybrids over pure species varied from 30% (Halle) to 500% (FP 237) for stem volume. Those differences can be partly explained by orchard composition, *e.g*. the species used as mother and the number of maternal clones. In addition, the last measurements showed that hybrids continue to grow faster than pure species after thinning.

Regarding stem form, hybrids were generally less slender than EL or JL. On average, they were also somewhat less straight but the differences were rarely significant.

Simulations of thinning show that the plots will become richer in hybrids if the trees are selected for vigour. Still, the final percentage of hybrids will remain far below 100% for the varieties characterised by a slight difference of growth between hybrids and pure species and/or low hybrid rate at planting. On the other hand, hybrid percentage is expected to remain more or less stable if stem form is the character taken into account. As form and growth are not correlated, thinning based on both traits will result in an intermediate enrichment in hybrids, at a level depending on the weight assigned to each character.

From a silvicultural point of view, the impact of hybrid rate depends on both forest owner strategy and the variety. For "stem form" objective, Forest Reproductive Material (FRM) richness in hybrids does not matter much (whatever the variety among those studied) but it would be nonsense to use expensive hybrid larch seedlings for that sole purpose. On the contrary, hybrid percentage is of major importance for timber production and its impact varies according to the variety. When hybrids do not differ much from pure species, the loss of productivity should be moderate even with medium hybrid rates. In varieties where hybrids grow much faster than pure species, the risk of poor timber production is high. Yet, the consequences are probably negligible if the hybrid rate is higher than 60-70% because most of the pure species would be eliminated after the first thinning that has no commercial value in standard silviculture. However, such FRM are probably not suitable for biomass production.

When testing seed orchard progenies, tree status (hybrid or not) is generally unknown, which may cause misinterpretation of the results. Firstly, there can be a large difference between observed performances and the variety “intrinsic” value, *i.e.* hybrid performances. This occurs in populations composed of few vigorous hybrids mixed with a lot of self-pollinated individuals, which is the case of FP 237 in our trials. However, it is hard to decide what the “actual" value of a variety is because the year-to-year variations of FRM hybrid rate are generally unknown. Secondly, even when tree status is known, comparing the performances of hybrids produced in different orchards may be inaccurate when the hybrid trials grow older. Indeed, competition among trees occurs earlier and is more intense in homogeneous varieties that might be at a disadvantage by comparison with varieties with a bimodal distribution.

Considering the importance of hybrid purity, the huge variations across seed and seedling lots and the existence of reliable markers for taxa identification, it seems of prime necessity that the FRMs are delivered to the land owner with this information.

European larch – a potential exotic species for northern Sweden?

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Abstract
A provenance trial of European larch was established in Sweden in the 1960´s by Milan Simak. European larch (*Larix decidua* Mill.) was planted on eight sites from Skåne in the south to Västerbotten in northern Sweden. A total of 76 provenances from the entire range of European larch (the Alps, Böhmen, Sudeten, Tatra mountains, Poland and Rumania) was included. Furthermore, some non-autochtonus provenances from Germany, Denmark, Great Britain and Sweden also were included. The results indicate a strong height growth during the first 40-50 years of growth. A dominant height of 28 m at 46 years of total age is possible in central Sweden. In northern Sweden on a fairly poor site, the dominant height was about 26 m at an age of 52 years for the best growing provenance. The best producing provenances are those from the Tatra mountains and Sudeten mountains. These provenances have also shown better resistance to larch cancer than provenances from the Alps. The results indicate, however, that their stem straightness is worse than in provenances from central or the eastern Alps. A comparison at the northern sites between European larch and Russian larch (*Larix sukaczewii*) demonstrates a better height growth in European larch, but a better stem form in the Russian larch. Earlier studies on the northern sites have recorded quite frequent frost damage in the seedling stage in European larch. Considering the limited experiences of growing European larch in northern Sweden it is too soon to recommend extensive planting of this species here. The material in this investigation indicates, however, that the growth potential is high. A concern is the stem shape and frost damage in the seedling stage.

Fungi in *Larix* plantations in Iceland

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Abstract
Funga of five stands of different age (13 to 53 years of age) in *Larix sibirica* plantations in Fljótsdalshérað, Eastern Iceland, was examined as part of the research project ICEWOODS once each summer in 2003, 2004 and 2005. At least 50 species of fungi were collected in those stands. The herbarium of the Icelandic Institute of Natural History, Akureyri Division (AMNH), stores 500 specimens which were collected in larch woodlands or near a larch in mixed woods. Thereof, 175 specimens of at least 45 species are registered with larch as their substrate. In the two oldest (40 and 53 years of age) ICEWOODS stands fungi fruiting on wood occurred on decaying stems and stumps of felled trees while absent from the younger stands. Fungi are important in nutrient cycling in the forest ecosystem. While edible fruiting bodies of mycorrhizal fungi can be harvested and the trees benefit from the symbiosis, parasitic fungi causing premature death of leaves or small branches can reduce the growth of the trees. Some insects or their larvae use fungi for food or shelter while certain fungi are parasitic to insects. Examples of different fungi and their function in the forest ecosystem are presented.

Mycorrhizal symbiosis of European larch (*Larix decidua* Mill.) – from seedlings to mature trees

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Abstract
European larch (*Larix decidua* Mill.) is in nature obligatorily dependent on ectomycorrhizal (ECM) fungi which facilitate both nutrient and water uptake, increase resistance to certain root diseases, and enhance stress tolerance of the plant. However, in spite of great economic and ecological importance of this tree, our knowledge about ectomycorrhizal fungal partners of European larch is rather scarce and still based on methods developed years ago. With the advent of DNA sequencing and the rapidly expanding sequence databases, new, highly efficient tools for species identification and classification has been developed that represent notable departures from earlier approach. Hence, this project was set up with use of combination techniques of morphotyping and molecular methods (sequencing of fungal ITS r DNA region) to reveal the ECM fungi associated with roots of European larch. The objectives of this study were (i) to compare the composition of the ECM fungi community on seedlings from forest nurseries and natural regeneration (ii) to determine the characteristics of ECM fungi along the chronosequence of forest development (10-150 years) inside and outside of natural range of European larch in Poland (iii) to estimate an effect of altitude above sea level on ECM community of *L. decidua* and (iiii) to test whether or not root colonization by different ECM fungi was related to European larch genotype (provenance).

At all study sites almost 100% of all fine roots were mycorrhizal. Under forest nursery condition ECM diversity of larch seedlings was low, consisting of a total of 7 ECM fungal taxa (data from 32 nurseries), with prevalence of *Wilcoxina mikolae* on one-year old seedlings and *Suillus grevillei* on 2- and 3-year old seedlings. In contrast, on naturally regenerated seedlings from two various sites, 22 ECM fungal symbionts were detected. At the site with higher mature tree density, seedlings were colonized mainly by fungi characteristic for old growth trees (*Hydnotrya tulasnei* and fungi from *Russulaceae* family), whereas at the site with lower mature tree density seedlings were clearly dominated by *W. mikolae*, fungus considered as a pioneer, poor competitor species. Studies along a chronosequence of larch forest development conducted on three geographically separated study sites revealed in total 40 ECM fungal species, with only 8 shared between all sites. There were no significant differences in ECM fungal species richness between forest age classes, however marginally significant effect of age was observed in species composition, and relative abundance of mycorrhizas made by fungi from *Russulaceae* family. Investigations conducted in Izerskie Mountains indicated that ECM fungal communities from larch stands located at 610, 860 and 1100 m a.s.l. did not differ significantly in terms of species richness, composition and abundance. Impact of larch tree genotype on ECM fungus community structure was verified on 2 provenances of *Larix decidua* subsp. *polonica* and 2 provenances of *L. decidua* subsp. *decidua* var. *sudetica* grown in provenances trial in the Beskid Sądecki Mountains. Obtained results revealed no significant effect of larch genotype on ECM fungal community in tested area.

The results obtained in our work significantly increase the knowledge about diversity of the ECM fungi hosted by *L. decidua*. Throughout the all study sites we discovered up to 80 ECM taxa, and large number of detected fungi was the first observation of these fungi as mycorrhizal partners of European larch.

Succession of ectomycorrhizae in different age Siberian larch (*Larix Sibirica*) forests in East Iceland

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Abstract
Diversity and abundance of ectomycorrhizal fungi in chronosequence of Siberian larch (*Larix Siberica*) forest sites in East Iceland, as well nearby treeless heathland and 20 year old birch forest. The following questions were asked: a) Are there some ectomycorrhizal fungi for larch in soils of treeless heathlands? b) Do young larch plants find ectomycorrhizal partners if they are planted in birch soils? c) Are microcosms good research tools in studies of ectomicorrhizal fungi on plant roots? d) Are there different between ectomicorrhizal communities in young and old larch forest in Iceland? If there is a different, could it be related to other biological and physical factors in the forest?

Both field studies and laboratory research were used to answer these questions. Larch seedlings were grown in microcosms with soil from four larch forests (13, 21, 40 and 53 years old), one birch forests (21 years old) and treeless heath land. Mycorrhizal colonization of roots was monitored every two weeks over six month period. Root samples from four different age larch forests (13, 21, 40 and 53 years old) were also collected *in situ* and studied. The main results of this study were that: a) ectomycorrhizal abundance was significantly reduced when grown in soil from treeless heath land compared to forest soils. b) Equal ectomycorrhizal abundance was found on larch planted in soils from larch forest and the same age-class of birch forests. c) The microcosm was shown to give a good relative estimate of mycorrhizal abundance at different study sites. d) Ectomycorrhizal diversity and abundance changed greatly with forest age. First it increased, but after canopy closure and the stands had reached their maximum current annual increment (ca. 20 years) it started to decrease again. The abundance of mycorrhiza was strongly related to amount of nitrogen and phosphorus in the topsoil, as well as soil acidity (pH).

The effects of afforestation with larch and birch on soil biota at East Iceland.

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Abstract
The effects of afforestation with either the native downy birch (*Betula pubescens*) or the introduced Siberian larch (*Larix sibirica*) on soil biota density and species composition were studied in East Iceland. Five stands of larch of different age were selected for a - chronosequence study. The larch stands were compared to two stands of birch at different age and one treeless heathland site, that was similar to the land as it was before afforestation.

Soil samples were taken from all stands in June, July and September 2004. Collembola (soil arthropods) were extracted from the soil, counted and identified to species level. During the same year, a study on soil microbial activity was conducted by using a " Cotton Strip Method". Cotton strips were inserted vertically into the soil in all stands in June 2004 and kept there for 5 or 10 weeks. The strips were then carefully extracted from the soil and their tensile strength determined at three different depths. The tensile strength indicated the decomposition of the cotton (i.e. more strength, less decomposition) and can be used as a relative measure of the soil microbial activity.

The density of collembola in soil was low and few species were found, regardless of vegetation type or the age of the forests. No significant difference was in either collembola species richness or density between the different vegetation types.

A significant difference was in the tensile strength of the cotton between birch and larch forests (TEST; P-value), indicating that the soil microbes in the exotic Siberian larch forests were more active than in the native birch forests. No significant difference was in the tensile strength between the heathland site and the forest sites or between the different age of either birch or larch forests

Carbon stocks and fluxes in a young Siberian larch (*Larix sibirica*) plantation in Iceland

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Abstract
The main aim of the present study was to evaluate the effect of afforestation on ecosystem C dynamics. For this, eddy covariance measurements of net ecosystem exchange (NEE) were made during three years over a Siberian larch (*Larix sibirica*) plantation with typical site conditions for afforestation in Iceland; previously grazed heathland that was site-prepared and planted in 1991-1992 and was therefore a 'Kyoto-forest'. The young Siberian larch plantation acted as a relatively strong sink for CO_2, with NEE of -375, -566 and -245 g CO_2 m^{-2} for years 2004, 2005 and 2006, respectively. The observed annual variation in NEE was more related to variation in the carbon efflux (R_e) than in the carbon uptake (GPP). Air temperature and soil water potential showed the strongest correlation to annual changes in R_e. The GPP was lower in 2005, when the plantation experienced severe spring frost damage, but that was also the year with the highest NEE. Stock-change measurements supported the results of the eddy covariance flux measurements, indicating a mean annual sequestration of -673 g CO_2 m^{-2}, $year^{-1}$. They indicated largest change in belowground C-stocks, in the fine root biomass and soil organic matter, not in aboveground C-stocks that generally is the main focus of carbon inventories.

Models for simulating the temporal development of Siberian larch (*Larix sibirica* Ledeb.) plantations in Hallormsstaður Iceland

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Abstract
Siberian larch (*Larix sibirica* Ledeb.) is one of the main tree species used in afforestation in the northern and north-eastern parts of Iceland. It grows well on infertile and dry sites and has therefore been the most planted tree species in Iceland during 1945–2000 (Pétursson 1999). Hallormsstaður and the surrounding area are the main production sites of larch, which will be a species of increasing commercial value in the coming years.

Predicting the future growth and yield of managed and unmanaged stands is necessary in modern forest management planning. Without yield models there are no means to evaluate which rotation length or thinning schedule would give the most favourable yield of different products (Pukkala and Pohjonen 1993). In recent years, forestry in Iceland has developed rapidly and the need to introduce and adapt growth models for commercial species has become more evident.

The aim of this study was to develop a model set for predicting stand development. The developed set of models consisted of a dominant height model, and individual-tree models for diameter increment, tree height and tree survival. Recently, Icelandic Forest Service introduced a new forest management planning system. The new models are an important component of that system because the stand structure and amount of timber in the forests can be evaluated and the forest resources can now be used more effectively.

Characterising *Larix kaempferi* among conifers in heartwood properties

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Abstract
Larix kaempferi (Japanese larch) is now the second leading species in Japanese plantation forestry. It shows good growth characteristics in the northern parts and high altitude areas in Japan. Introduced *L. kaempferi* is also good in European countries and used as a male (pollen) parent of hybrid larch with *L. decidua* (European larch). Timber of *L. kaempferi* is medium durable and shows good performance in mechanical properties.

The use of the timber of the species in Japan has been traditionally for posts, poles, boxes and pallets as well as construction members. However, the recent usage has become rather for construction as members of glulam and a raw material for veneer. In addition, usage for decorative purposes for interior has become popular mainly because of its beautiful colour of heartwood.

In this paper I review the heartwood properties of *L. kaempferi* in comparison to other coniferous species used in plantation forestry. Because of the current usage of its timber, the heartwood properties should become one of key features in the silviculural planning and breeding strategy of *L. kaempferi* in terms of wood quality.

The heartwood characteristics are discussed in the following context: relatively narrow width of sapwood; narrow width of intermediate wood; heartwood substance -- arabinogalactan and taxifolin; potential of heart-rot in aged plantations. Moreover, the advantage of *L. kaempferi* as a material plant in studies of heartwood formation is also discussed.

Effect of the flavonoids in heartwood on decay resistance of hybrid larches (*L. kaempferi* x *L. gmelinii*, and *L. gmelinii* x *L. kaempferi*)

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Abstract
The durability of the heartwoods of the two hybrid larches (*L. kaempferi* x *L. gmelinii*, and *L. gmelinii* x *L. kaempferi*) was examined. According to the European Standard EN 113, the adjusted blocks of the heartwoods from the 24 individual trees were exposed to the three fungi (Coniophora puteana, Gloeophyllum trabeum and Poria placenta) for two months. The durability of the heartwoods were evaluated with the mass loss of the blocks. The values of the mass loss showed 17.2-32.2 % in C. puteana, 4.5-15.9 % in G. trabeum and 1.1-11.6 % in P. puteana. Additionally, the polyphenolics in the heartwoods of the larch were analyzed with HPLC after the methanol extraction of the heartwood meals individually. The contents of the taxifolin known as the major polyphenolic compound in the heartwood of the larch were between 0.06-1.89%. In the presentation, we will discuss on the relation between the dispersion of the chemical contents and the difference of the durability of the heartwoods.

The metabolites in xylem cells of developing annual layer in *Larix sibirica* stem.

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Abstract
Metabolites in xylem cells of developing annual ring in *Larix sibirica* Ldb. stems have been studied to examine the distinctions leading to development of early and late tracheids differed by morphological parameters. Carbohydrates, as basic products of photosynthesis, taking part in the metabolism and in creation of cell wall polymer structure, and free and bound phenolic acids, which are precursors of lignin and can combine cell wall polymers, were examined in ethanol soluble substances, extracted from the cells on their consecutive developmental stages. The data were calculated per dry weight and per cell. The results are considered in line to the ratio ascorbic (AsA) and dehydroascorbic (DHA) acids, pointing oxidation/reduction potential which influence processes of polymerization in tissues.

During the season the content of carbohydrates within the cells of cambium zone decreased (per dry weight) as well as the content of AsA, taking part in division of cambial initials. As a result the number of cells, produced by cambium, are gradually reduced. Conducted phloem cells contained twice less of carbohydrates in period of early xylem formation than of latewood formation. This coincides with completely formed assimilative tissue in larch tree to this period. Carbohydrates in cambial zone were two times more during early xylem formation than that in the course of latewood development. The content of bound and free phenolic acids decreased during the season. The amount of bound acids was always more than that of free ones as the latter are “poisons” for cells and are undesirable for active processes. At the beginning of cell growth the content of carbohydrates (per cell) increased twice in the first phase of growth in comparison with cambium zone and then decreased in the course of cell growth simultaneously with dropping of cell growth rate. This was the result of wall strengthening due to binding of primary wall polysaccharides by diferulic bridges that corresponded to the increase of bound phenolic acids (per cell) and the decrease of such antioxidant as AsA. The ratio of AsA/DHA was considerably lower in early tracheids than late ones. In accordance with that the radial sizes of latewood tracheids are less than early cells.

The amount of carbohydrates increased at the beginning of secondary wall substances deposition and then is depleted during tracheid maturation, in agreement with the reduction of cellulose synthesis rate in the course of wall thickening of two types of tracheids. Higher content of carbohydrates within early tracheids in comparison with late ones shows that secondary wall development of earlywood cells isn’t limited by substratum. The reason for thin walls of earlywood cells is a shortening of development duration because of the presence of some free phenolic acids, which destroy protoplasts.

Before lignin biosynthesis the amount of free hydroxycinnamic acids, precursors of monolignols, in early xylem cells was twice more than in latewood cells. During lignification bound acids diminished simultaneously with the increase of lignin synthesis. The content of free cinnamic acids in earlywood cells increased in the course of lignin deposition while that in latewood cells declined, in agreement with opposite dynamics of lignin deposition in early and late xylem. The reason of different trends of lignin synthesis is the distinction in the ratio AsA/DHA in maturating cells of early and late xylem. The oxidation of AsA to DHA by peroxydase in the presence of hydrogen peroxide interferes in polymerization of monolignols, derivatives of hydroxycinnamic acids.

Karyological studies on *larix* species in connection with their adaptation to dfferent environments

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Abstract
The genus *Larix* comprises about 20 species [Sukachev 1924; Kolesnikov 1946; Dylis 1947; Bobrov 1972]. The paper deals with the results of karyological studies of eight larch species – *Larix sibirica* Ledeb., *L. sukaczewii* Dylis, *L. gmelinii* (Rupr.) Rupr., *L. cajanderi* Mayr, *L. ochotensis* Kolesn., *L. x czekanovskii* Sz., *L. x amurensis* Kolesn., *L. decidua* Mill. These species have been investigated in different parts of area, in normal and extreme conditions: near the borders of the species' ranges, in pessimal environmental conditions, in the anthropogenic influence zone. *Larix* karyotype consists of 24 chromosomes (2n=24). Diploid complement includes 6 pairs of metacentric (11,3-15,1 μm) and 6 pairs of submeta- and intercentric chromosomes (7,3-12,0 μm). Centromeric index for the chromosomes of the first group was 46,5-47,6%; centromeric index for chromosomes of the second group was 26,6-32,9%. Except A-chromosomes (normal chromosomes of the complement), in some populations of *L. gmelinii* (South Zabaikalje) and *L. sibirica* (Taimyr, Khakasia) B-chromosome was found. The length of B-chromosomes is 4,5-5,3 μm. They are metacentric or slightly submetacentric.

Karyologically larch species differ in number of constant secondary constrictions. Using usual methods of karyotype analysis in the metaphase of mitosis secondary constrictions are revealed as sites stained lighter than other chromosome parts. These regions are of great importance in the cell protein metabolism and have adaptive significance because the loci of rDNA are localized here [Kiknadze 1972; Prokof'eva-Belgovskaya 1986]. They represent sites of nucleolus organizing activity and form nucleoli in the interphase nucleus. The main feature of the conifer karyotypes from extreme conditions is increasing of the secondary constriction numbers and frequency in chromosomes. Chromosomes with two secondary constrictions have been revealed in *L. sibirica* from swamps of Western Siberia and other extreme regions.

Karyotypes of *L. sibirica*, *L. gmelinii* and *L. cajanderi* were analyzed using fluorescence in situ hybridization (FISH) with the 45S and 5S ribosomal RNA gene probes and DAPI staining. Two major 45S rDNA loci have been observed in two metacentric chromosomes, III and IV, of *L. sibirica*. Minor NORs were mapped in the pericentromeric regions of chromosomes I, II, VI, and XII. Two closely related species, *L. gmelinii* and *L. cajanderi,* showed similar hybridization patterns. Both species possessed an additional major locus for 45S rDNA in the distal region of the long arm of submetacentric chromosome VII that is absent in *L. sibirica*. Only one locus for 5S rDNA was found in these larch species. The 5S rDNA locus was observed in the distal region of the chromosome III short arm. This chromosome also carries the major NOR in the opposite arm. This chromosome contains the major loci of the two ribosomal RNA gene families and can serve as a marker for the *Larix* genus.

The number of genome and chromosome mutations including polyploid and aneuploid cells and ring and dicentric chromosomes, fragments with different morphology was found in larch species in extreme conditions. There are chromosome mutations in *L. sukaczewii* from Arhangelsk, Ivanov, Ekaterinburg, Perm regions, Bashkiria, *L. sibirica* from Kazakhstan's Altai, Khakasia, Tuva, Buryatia, Mongolia, Taymir, the swamps of Western Siberia, in *L.*

gmelinii from Chita region, Mongolia, Evenkia, in *L. cajanderi* from Central and Southern Yakutia, in *L. ochotensis* Magadan region. Pericentric inversion was revealed in *L. gmelinii* from Eastern Siberia. Irregularities of mitosis (bridges, fragments, lagging chromosomes, K-mitosis, pesistant nucleoli, and so on) occur in Sibeian larch in exteme environmental conditions.

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How climate influences the phenotypic variability of larch along an altitudinal gradient ?

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Keywords: Altitudinal gradient, *Larix decidua*, ring width, ring density, temperature, phenotypic variability.

Abstract
Temperature fluctuates with space and time. The rate of variation of mean annual temperature is 0.49 °C per 100 km in France with latitude (Moisselin 2002) and 5.5 °C per 1 km with altitude (Körner 2007). Related phenotypic variation has often been observed in forest trees. For example dendrochronological studies have shown that ring width varies along altitudinal gradients in many species (Splechtna *et al.* 2000; Affolter *et al.* 2010). However, ring width variation along an altitudinal gradient is not controlled only by temperature: other environmental factors may affect radial growth. Furthermore trees at different elevations may be genetically distinct, with conceivably different growth potential.

Our objective is to study phenotypic variation of larch (*Larix decidua*) for ring parameters along an altitudinal gradient, and to relate this phenotypic variation with the strong temperature gradient. We took into account as much as possible other factors that may partly explain altitudinal variation of tree radial growth and may bias temperature-phenotype relationship. As a first approach, we hypothesised that there is no genetic differentiation along the gradient.

Our study is based on 800 trees sampled in four plots distributed along an altitudinal gradient (from 1350 to 2300 meters) in the French Alps (Briançon, Hautes-Alpes). This altitudinal variation corresponds to a temperature shift of 6°C. Increment cores were collected and ring-width and ring density traits were obtained using indirect X-ray microdensitometry. Fourty-one successive rings (1967-2007) were available and studied in all trees.

In contrast with many studies, we attempted to statistically quantify effects of other biotic and abiotic factors (cambial age, tree competition, bud moth attack, soil and solar radiation). Then, raw phenotypic variables (ring width and ring density) were adjusted of significant effects.

Based on this adjusted dataset, “Response functions” were constructed at the population mean level representing the mean ring width and density relationship with mean annual temperatures of the last fourty-one years at each of the altitudinal levels. We interpreted the different responses observed along the gradient as an adaptive response, accepting the hypothesis that these phenotypic differences observed along the gradient were driven by adaptive mechanisms. This study is the first part of a larger study on adaptation. A next step will be to validate or not the hypothesis of absence of genetic differentiation along the gradient.

Drought impact on growth and wood properties of larch

By Luc E.Pâques

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Abstract
Larch is an opportunistic pioneer species. Its growth potential is highly dependant on soil fertility but also on climatic variation. Severe heat-drought wave of 2003 alerted foresters on potential risk to use larch on more marginal lands where water supply might be limiting during certain periods of the year. On the shallowest soils, crown dieback was even observed, more rarely death of trees. Rapid recovery of apical dominance might hide this type of accident and thereby has led to underestimate or even neglect larch sensitivity to drought. More frequent periods of water shortages during the growing season impose to breeders to consider more closely larch-water relationship.

An experiment was conducted with several European larch and one hybrid larch progenies to study the impact of soil water depletion on growth and on wood properties and during one season on the phenology of radial growth. Irrigated and non-irrigated plots were established on a coarse sandy-gravel soil with high drainage. Non-irrigated trees were submitted to repeated seasonal water shortages over years while for irrigated trees, we supposed that water was never limiting factor.

Irrigated and non irrigated trees performances will be followed over years to measure the impact of water shortages on annual ring properties and the behaviour of hybrid larch will be compared to that of European larch.

Influence of drought on ring width and wood density of hybrid larch (*Larix decidua x kaempferi*) in Eastern Austria

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Abstract
Increasing temperatures, shifting precipitation patterns and more frequent climatic extreme events will likely affect the vigor of forest ecosystems in the future. In order to understand the sensitivity of tree species, provenances and breeding material to these changes, we analyzed full-sib families of hybrid larch planted on a field trial in Eastern Austria by X-ray densitometric measures.

The trial, established in 1991, consists of six full-sib families of hybrid larch with female parents of *Larix decidua* and male parents of *Larix kaempferi* as well as one Austrian provenance of *L. decidua*.
The site is located in Mannersdorf am Leithagebirge in Eastern Austria (16.624 °E, 47.950 °N, 360 m a. s. l.) – a rather dry region with a mean annual precipitation of about 700 mm with a maximum of more than 80 mm in June and a mean annual air temperature of 9.3 °C (-0.4 °C in January, 19.4 °C in July). In single years with very little precipitation as for example 2000, 2001 and 2003, when annual precipitation was less than 80% compared to the average, the trees on the site can be severely stressed by drought.

To assess the influence of drought on the trees and the differences between hybrids, in 2011, cores from more than 140 trees (at least 20 per hybrid/provenance) were extracted and subjected to X-ray densitometry in order to measure/calculate ring width, earlywood width, latewood width, latewood percentage, mean density, earlywood density, latewood density, minimum density, maximum density and the occurrence of false rings on annual resolution.

First results show significant differences between the hybrid families for ring width and wood density parameters. Ring width, wood density and false rings are correlated with rainfall during the growing season – especially May and June precipitation seem to be highly important.

Crookedness in *Larix* plantations in Iceland

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Abstract
An important criteria for the success of cultivation of introduced species is its economic feasibility. One of the main aims of planting larch in Iceland is timber production. That makes the straightness of the trees an important factor to look after.

It has been noted that in Iceland crookedness in larch can be found in a large scale. The main reason is consideret to be poor climatic adaptation; in oceanic climatic conditions, such as in Iceland, with cool summers and mild winters with typical thaws and subsequent freezing, the apical growth of larch can be damaged. The result may appear as crookedness or as other various deviations of the stem from straight axis.

The aim of this study is to determine the mass character of crookedness in stems of larch in the plantations in Hallormsstadur forest station; to try to express it statistically; and to see if there is any dependence from provenance or other factors.

The age of the plantations was 25...55 years. The method of observations was as follows: the trees were measured, and for each meter of the stem's length from the ground up to 5 m height, the precence of crookedness or signs of earlier apical top dieback was indicated.

On the subsequent data processing the trees were grouped into classes conditional on the quality of the stem (i.e. straightness). The best sections were provenances originated from North-west Russia. The performance of European larch, and larch provenances from Ural and Altai was significally worse.

Spring and autumn frost damage to Russian larch provenances connected to weather events

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Abstract
No larch species or provenance is very well adapted to the Icelandic climate. They are all more or less often damaged by frosts in spring or autumn or both. However, larches are well adapted to Icelandic soil conditions and grow better on land most available for afforestation (former grazing land and eroded land) than other genera.

Damage caused by spring and autumn frosts during the first decade of the 21st century was recorded and the consequences measured in a provenance trial of *Larix sukaczewii* and *L. sibirica* in east Iceland. Provenances included planted stands of various origins in Iceland, Icelandic, Swedish and Finnish seed orchards, western Russia, the Altai region and Buryatia.

During the decade 2001-2011, three spring frost events (2003, 2005 and 2011) and two autumn events (2005 and 2007) caused widespread damage to larch in North and East Iceland. The spring events caused needle damage, as well as June but-set in a large proportion of trees in 2003 and 2011. The autumn events caused terminal leader die-back, mostly to sylleptic shoots in 2005. The consequence of spring damage was growth-loss but not form defects. The consequence of autumn damage was form defects due to multiple leader formation, but not much growth-loss since the die-back was usually minor.

Both spring and autumn damage varied significantly among provenances. Spring damage was greatest in Siberian provenances. Even though events that cause needle damage are the most severe, it is likely that late winter/spring conditions common in Iceland retard growth in Siberian provenances more often. This is the main reason why Siberian provenances are no longer used in afforestation. Autumn damage was greatest in the southerly Russian provenance Kostroma and the fastest growing seed orchard provenances (Östteg, Imatra, Vaglir). The seed orchard provenances were however quick to recover, possibly due to selection for straightness and fast growth rate, and are still the best sources of material available.

Since 1995, mean temperatures in March and April have increased by about 2°C in east Iceland, but May has not grown warmer. If this continues, it will cause increasing problems, not only for Siberian provenances but eventually all Russian larch. The autumn months are also warming but more slowly, with October and November having warmed by about 1°C since 1995. As long as there are heavy frosts in October, *Larix decidua* will not be a viable alternative to *Larix sukaczewii*.

Larches still have an essential part to play in afforestation in Iceland. Therefore, we must continue to monitor the effects of climate change on larch species and provenances and adjust selection of genetic material accordingly.

The circumpolar progeny test of Siberian larch species of 2003 - suggestions for international cooperation

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Abstract
Larch is probably the most common conifer in the northern hemisphere and the widest area of distribution in Siberia. Not until the beginning of the 1990s was it possible to organize and accomplish a collection of seed of Siberian larch available for international research. The Russian-Scandinavian larch project was accomplished in the years 1996-2001 in cooperation with Scandinavian and Russian research organizations. Seed was collected from 1005 individual trees distributed over 29 sites of collection from Kamchatka in the east to Archangelsk in the west. Progeny field trials were established in Sweden, Norway, Finland, Iceland and Russia in 2003. Seed of this material was also distributed to Japan, China, Canada, and USA to establish progeny field trials. Never before has such a big research material of Siberian larch species been available for international research. The material has been analyzed at an early age in national reports in some of the participation countries. But a coordinated international research project including all participating countries, now as the material has reached the age of 10-15 years, would bring a lot of useful information on the growth and adaptation of Siberian larch species. My suggestion is to discuss this topic at the IUFRO meeting Larix 2012 in Iceland.