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Proceedings of the 8th International Christmas Tree Research & Extension Conference

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By Iben M. Thomsen, Hanne N. Rasmussen & Johanne M. Sørensen (Eds.)

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IUFRO Working Unit 2.02.09 - Christmas Trees
Hotel Bogense Kyst, Denmark, August 12th - 18th, 2007
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During August 2007, the University of Copenhagen's Forest & Landscape Denmark in collaboration with the Danish Christmas Tree Growers' Association hosted the 8th International Christmas Tree Research & Extension Conference. Nearly 50 professionals who support the Christmas tree industry attended representing eleven countries: Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, Germany, Greece, Latvia, Norway, and the USA. A total of 28 talks and 21 posters embodying a wide array of research and extension topics related to Christmas trees and greenery were presented. Three field excursions were also integrated into the program including a day-long visit to Langesø Fair, an impressive Christmas tree trade show.

Although this group has met periodically since 1987, this conference was our first since organizing as the IUFRO Christmas Tree Working Unit 2.02.09. Operating under the auspices of IUFRO has provided more visibility to our efforts. Additionally, we are taking advantage of the opportunity to develop a unit web site and are initiating a unit newsletter to better communicate among ourselves during the time lapse between our biennial conferences.

Congratulations are due to our conference hosts for planning and implementing such a successful and flawless event. The idyllic coastal location of Bogense, the informative technical and poster sessions, the wonderful food and drink, the stimulating field excursions, and especially the collegiality among the attendees combined to make for both an educational and memorable conference.

We are all looking forward to the 9th International Christmas Tree Research & Extension Conference which will be hosted by our Oregon State University colleagues in Fall 2009.

John Frampton, Coordinator
Chal Landgren, Deputy
Ulrik Bräuner Nielsen, Deputy

IUFRO Christmas Tree Working Unit 2.02.09

Participants at conference in Bogense

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Lars Hvidtfeldt (Owner), Ulrich Gejl (Manager), Gl. Kirstineberg Plant Nursery

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Abstracts of Oral Presentations and Poster Presentations

(in order of presentation)

Oral Presentations: Breeding

Initial steps in the improvement of *Abies balsamea var. phanerolepis* (Canaan fir)

Ricky M. Bates
Pennsylvania State University

Surveys indicate that needle loss or "messiness" is a major reason why consumers choose artificial over real Christmas trees. Renewed marketing efforts might help the industry sell more trees, but certain problems still exist with the product itself. We need to continue and strengthen our efforts to improve several Christmas tree traits, including needle retention, pest resistance, growth rate and tree form. The Christmas tree industry must provide consumers with a product that will perform well while on display in their homes. Maintaining hydration is critical for acceptable needle retention in the postharvest environment, however genetics also play a crucial role. Needle retention performance varies widely between species, between seed sources within a species and even within a single seed source of the same species. The objective of this long-term research project is to locate and develop sources of Abies balsamea var. phanerolepis (Canaan fir) with improved postharvest quality, superior growth characteristics, and adaptability to heavy soil types.

Canaan fir with excellent Christmas tree characteristics can be found on farms throughout Pennsylvania and the eastern U.S. Much of this important genetic resource is harvested annually and lost, however many of these individual trees have been periodically set aside and planted into seed orchards. Needle retention testing of fifty-five trees in one such Adams County Canaan fir seed orchard began in 2003 and continued through 2005.

During October 2003, 2004 and 2005, branches with the current and previous season's needles were removed from the trees and transported to the P.S.U. post harvest display room at the Russell E. Larsen Research Center, Rock Springs, PA. Testing was also performed at Washington State University Puyallup Research and Extension Center, Puyallup, WA. Branches were displayed dry for the duration of the display period and maintained under continuous standard fluorescent lighting, at 48% ± 5% relative humidity, and 68°F ± 4. Needle loss data was obtained at day 0, 7, and 10 by gently rubbing two fingers over the needles. The extent of needle loss was evaluated on a 0 to 7 scale where 0 = none and 7 = 91-100 % loss. Needle loss data was compared and correlated each year of the 3-yr. test period to verify individual tree performance.

Results

Of the fifty-five trees tested, eight received an excellent needle retention rating of less than 1% needle loss for first and second year needles over the test period, during the 3 test years. These eight trees were selected for grafting and terminal leaders were harvested during spring of 2005 and 2006. Cleft grafts were made using containerized 5-year old Canaan fir as rootstocks in April of each year (Figure 1). Approximately 75 clones were derived from the original eight mother trees. After the grafts successfully healed, the trees were transplanted into larger containers and moved into the P.S.U. Pot-in-Pot nursery (Figure 2). This production system optimizes the root growth environment resulting in a large plant in a relatively short period of time. After the 2006 season in the Pot-in-Pot nursery the first group of grafted trees were large enough to move to the seed orchard.

In 2005 a six acre site was secured at the P.S.U. Horticulture Farm at Rock Springs, PA for the establishment of the Canaan fir seed orchard. The site was cleared and prepared for planting during 2005-2006. The first grafted Canaan fir trees were planted in October, 2006 (Figure3). Spring 2007 projects included the construction of a deer fence and expansion of the Canaan fir needle retention testing. The Canaan fir seed orchard established near State College, PA by Dr. Henry Gerhold entered the needle retention trials in 2005, with 50 of the 165 trees being tested. Plans are also underway to test the progeny of Canaan fir selected from the Adams County seed orchard.

A secondary objective of this project includes the establishment of a system and protocol to investigate the adaptability of Canaan fir selections to poorly drained (hypoxic) soil conditions. Individual trees have been identified and moved to the P.S.U. Horticulture Farm at Rock Springs, PA for screening and propagation. Development of the testing site began during summer, 2007.

Figure 1. Terminal leaders from Canaan fir with superior needle retention are cleft grafted to container-grown 5-year old Canaan fir rootstock. This procedure is usually performed late March to early April.

Figure 2. After the cleft graft has healed, the tree is transferred to a larger container and moved to the P.S.U. Pot-in-Pot nursery for a season of accelerated growth.

Figure 3. Seed orchard of improved Canaan fir established at the P.S.U. Horticulture Farm, October 2006. The orchard will eventually contain clones of at least 20 parents with excellent Christmas tree characteristics and proven needle retention performance.

Acknowledgements The author wishes to thank the Pennsylvania Christmas Tree Growers Association for their generous support of this, and other research projects.

Provenance and progeny growth and postharvest needle retention test results from Nordmann (*Abies nordmanniana*) and Turkish fir (*A. bornmuelleriana*) trials in Oregon and Washington

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During the past 15 years there has been increasing interest in growing Nordmann and Turkish fir as Christmas trees in Oregon and Washington. These species can be grown in sites where Phytophthora root rot limits the production of noble fir and have been shown to be resistant to a number of the common insect problems that occur on other *Abies* spp. In an effort to identify sources of Nordmann and Turkish fir that perform well as Christmas trees, a series of five replicated regional test plantings were established in 1999.

These plantings ranged from Springfield, OR north to Satsop, WA. Each planting contained 25 trees from each of eight sources. The sources of Turkish fir included progeny from 1) a tree in the Peavy Arboretum at OSU (TP), 2) a tree in the Kintigh seed orchard near Eugene (TK), and trees from the Bolu-Kokez provenance in Turkey (TB). In addition there were trees from the following five provenances of Nordmann fir: Ambrolauri (NA), Borshomi (NB), Savsat Yayla (NSY), Savsat-Meydancik (NSM), and Savsat-Velikoy (NSV). In 2003 and 2006, evaluations were made during mid-May to determine variation in bud break between the different sources of trees at three of the sites. During fall 2006, all of the trees in the plantings were evaluated for growth characteristics and grade (Fig. 1-2). A single branch was also harvested from the north and south side of each tree during early October and early December to assess differences in postharvest needle retention (Fig. 3-5).

Figure 1-2. Evaluation of growth characteristics. **Figure 3.** Cut branches placed in holder. **Figure 4.** Needle retention testing. **Figure 5.** Discoloration of needles during drying.

Field evaluations indicated that the Turkish fir tended to have a lighter green color, faster growth and earlier bud break than the Nordmann fir. Based on bud break, the relative ranking of the sources was the same in both years. The rank (from earliest to latest) of these sources was: TP, TK, TB, NSM, NSV, NSY, NA and NB. Broadly, the Turkish fir sources tended to have early bud break, and NA and NB were significantly later. Generally, frost damage across all sites appeared to be minor.

There were large differences in the percentage of harvestable trees at the different sites. Overall the sources with the highest value, based on grade and height, were the TP ($18.9), TB ($16.2), and TK ($16.1) sources of Turkish fir. The common Georgia sources of Nordmann fir (NA and NB) were intermediate in value, while the NSY, NSM, and NSV performed poorly and had an estimated value of less than half that of the top performing Turkish fir sources.

Needle loss was highly variable, ranging from branches that did not lose any needles to ones that completely defoliated. Based on the percentage of trees that had $\leq$ 5% needle loss, the following had a significant effect on needle loss severity: site, source, harvest date (Oct. > Dec.), and needle age (2005 > 2006). Branch location (north vs. south) had no effect on needle loss. The percentage of trees that did not shed any needles ranged from a high of 16 to 20% for the TB and TP sources of Turkish fir to a low of 5% for the NSM source of Nordmann fir. When harvested early, the TB source of Turkish fir had a significantly higher percentage of trees with superior needle retention at all sites. Additional growth and needle retention information will be obtained in the future from a series of larger Nordmann and Turkish fir trials that were established in 2004.

Acknowledgements: This project was supported by the Pacific Northwest Christmas Tree Association and the Oregon Department of Agriculture Christmas Tree Research Program. The authors gratefully acknowledge the assistance of other members of the team that made this project possible. This includes Rick Fletcher, Mike Bondi and Brad Withrow-Robinson, all with Oregon State University Extension Service and WSU's Gil Dermott, Jan Sittnick, and Annie DeBauw. A special thanks is given to the growers who installed and maintained the plots.

Genetic Variation in the Economic Value of Fraser Fir (*Abies fraseri*) Christmas Trees in North Carolina, USA

John Frampton[1)], Fikret Isik[1)], AnneMargaret Braham[1)]

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In 2000, an eight site, provenance-progeny test series of Fraser fir (*Abies fraseri* [Pursh] Poir.) was established in western North Carolina, USA. The objectives of this test series were: 1) to refine our knowledge of geographic variation in Fraser fir, and 2) to provide a genetically diverse population from which to select trees valuable for Christmas tree production.

The provenance-progeny test series included open-families grown from seeds from trees originating in all six natural populations of Fraser: Great Smoky Mountains National Park, the Balsam Mountains, the Black Mountains, Roan Mountain, Grandfather Mountain, and Mount Rogers. The test series evaluated 188 families plus three control seedlots originating from bulked wild seeds and included over 28,000 trees.

After the seventh growing season (2006) in the field, height was assessed for all trees in the test series. Additionally, a Christmas tree grade (premium, 1, 2, or cull) was assigned to each test tree according to standards specified by the U.S. Department of Agriculture. During the data analysis, trees were assigned to height classes and accounting for their USDA Grade, assigned a wholesale value ($US). Genetic variation among the six seed sources and genetic parameters for Christmas tree wholesale value were determined.

Variation among geographic seed sources for economic value was significant but modest while the variation among families was large. Individual tree heritabilities were moderate and family mean heritabilities were high.

Elite trees from this test series were selected and grafted in 2005 and again in 2007. The 2005 grafts have been established in a clone bank at two sites to be used for advanced generation breeding. The 2007 grafts are currently in a nursery bed but will be used to expand the clone bank at both sites. Plans are also underway to graft the best selections from this test series during 2008 to establish a commercial seed orchard that will be managed by Christmas tree growers. Large economic gains are expected from future planting stock derived from this orchard.

Breeding and Seed Source Management of *Abies S*pecies with DNA markers

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Abies nordmanniana and *Abies procera* are the two main species for greenery production in Denmark and a breeding programme was initiated in the early 1990's. Plus-tree selection, progeny testing and clonal seed orchard establishment are the major traditional components of this programme.

In the latest 5 years, efforts have been made to integrate DNA markers into the breeding activities and its supportive research, as well as to facilitate seed source management.

Examples of the utility of DNA markers for this purpose are:

- Studies of cryptic dysfunctions in clonal seed orchards:
    - Non-equal contribution of pollen
    - High selfing
    - Outside pollen contamination
    - Grafting/labelling errors
- Barriers to hybridization
- Seed source certification of imported provenances
- Male-female complementarity in relation to seed orchards with low number of clones
- More advanced breeding with conversion of half-sib trials to full-sib trials
- Conversion of production stands to genetic field trials

At Forest & Landscape Denmark, microsatellite markers (SSRs) have been the marker of choice, and the talk will present a range of studies using them.

Results from 15 years of breeding for improved quality of Christmas trees and greenery in Denmark

Ulrik Bräuner Nielsen
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Introduction

Nordmann fir (*Abies nordmanniana* (Stev.) Spach.) is a valuable species that is being used for cut Christmas trees and greenery products, especially in Europe. Denmark is the leading producer of Nordmann fir Christmas trees and greenery products in Europe, producing about 9-11 million trees and an estimated 6,000 tons of bough material per year. Noble fir *(Abies procera)* is mainly used for bough production, and the estimated Danish production is around 20.000 t per year, or approximately 70% of the total European consumption.

In 1992 new breeding activities were initiated by Forest & Landscape Denmark standing on the shoulders of all the earlier work done in Christmas tree and greenery breeding of the two Danish main species Nordmann fir and noble fir.

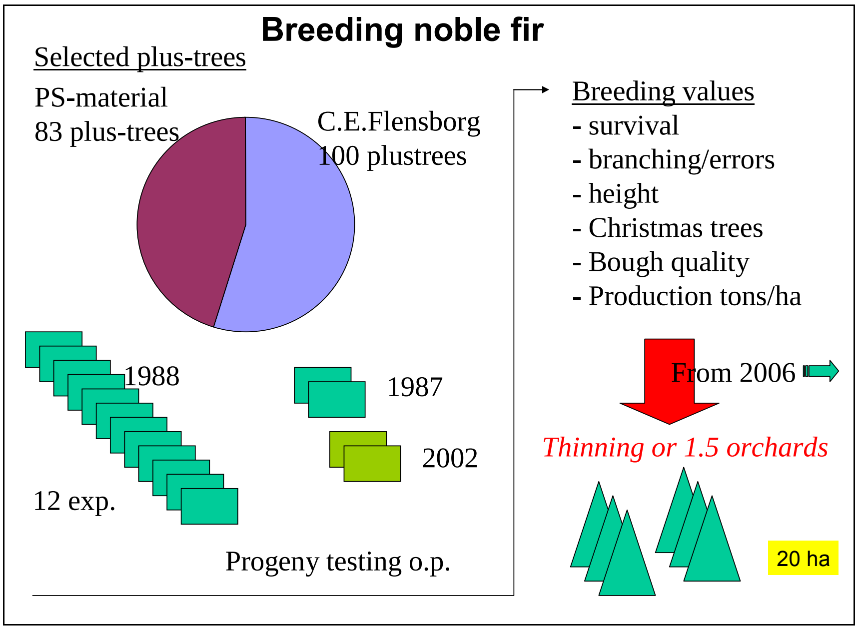


Figure 1. Overview of the noble fir breeding program in Denmark.

Provenance testing of both species was first initiated in the early 1960s, and at the same time the first clonal seed orchards were grafted. In the mid 1980s a second selection of plus-trees in noble fir was carried out, and a set of field trials were established, figure 1. In the early 1990s a set of first generation plus-trees were selected in Nordmann fir, and progeny testing was initiated, figure 2. All selections were based on Danish stands (seed sources).

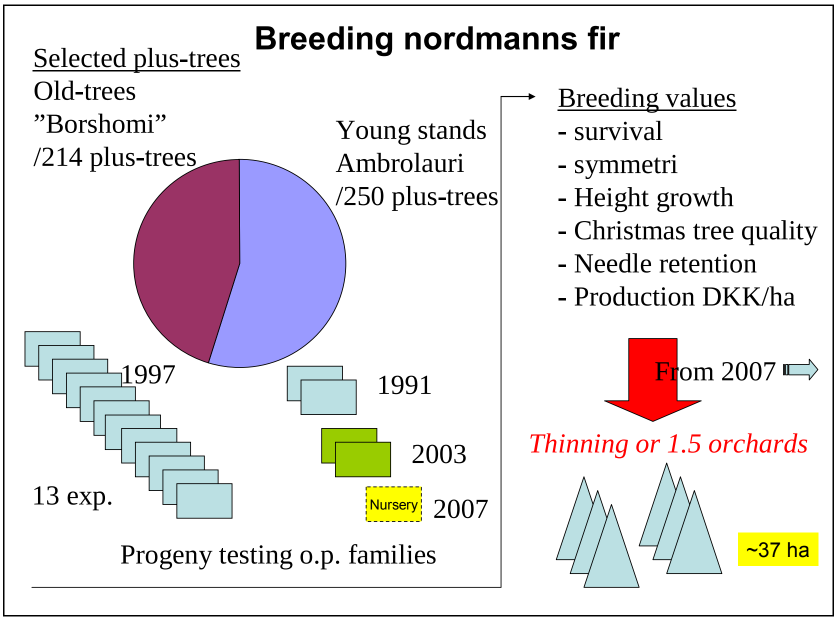


Figure 2. Overview of the Nordmann fir breeding program in Denmark.

Parallel to the plus-tree selection a set of seed orchards were established, using the selected material. This was mainly done by the Danish Tree Improvement Station in Humlebæk, but also HedeDanmark, and a private nursery. The majority of orchards were grafted during the 1990s. Some rough estimates on possible seed supply from these orchards are shown in fig. 3. In the case of Nordmann fir the present export of around 10 mill. trees underline the need for stand seed for a long time horizon – only part of the seed needed can be supplied from the present clonal orchards. In the case of noble fir the seed demand is for the time being rather low. It is thus expected that most if not all seed needed in the near future can be supplied from clonal orchards based on tested material, fig. 3.

Testing

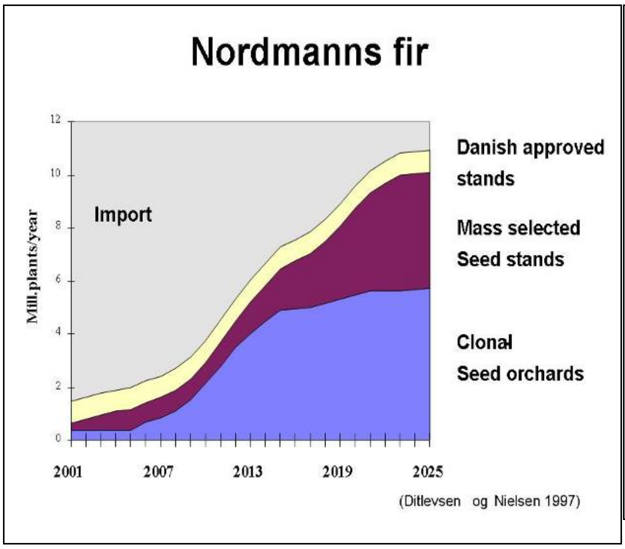
Noble fir:

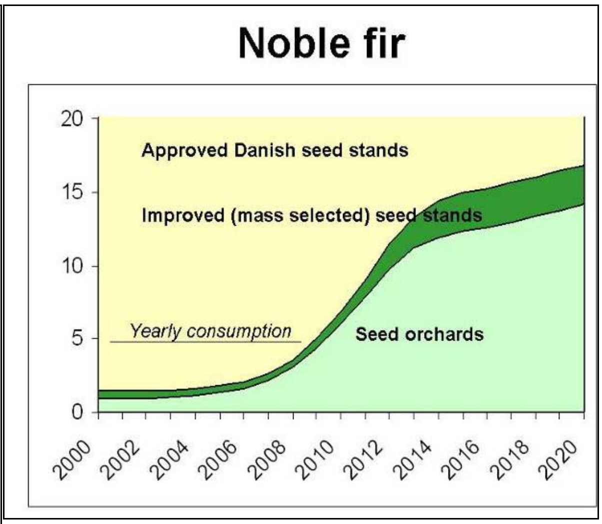
Noble fir was tested in randomised block experiments based on open pollinated progenies of the selected plus-trees using 3 x 3 or 6 x 4 tree plots. A set of characters were measured: height growth, branch length, Christmas tree quality, as well as branch quality including: colour, branch density (coverage), and needle orientation (from flat to upright). The latter three major components of quality were transformed into a simple index describing the value of the greenery:
Net value of harvested branches per kg
= a×color + b×coverage + c×needle_orientation,
were a,b and c is estimated (BLUP) breeding values.

In addition, production in kg saleable branches per plot per harvest was measured. Optimal characteristics for bough material are short branches with superior blue colour, good coverage and an upright needle structure.

Nordmann fir:

Nordmann fir from the 1997 plantings (figure 2) were tested in randomised block design with single tree plots and 4 reps per block and a total of 10 blocks per site – ideally 40 trees per family per site, and a total of 128 families.
Characters important for Christmas tree production are date of flushing, growth rates, branching, foliage quality, symmetry, and Christmas tree quality. Further, post harvest quality was measured as needle retention, when cut branches were allowed to dry. Nordmann fir is generally considered to have very good postharvest moisture and needle retention characteristics, but needle loss problems are known to occur in certain years, especially for boughs that are harvested in early October and for Christmas trees in warm weather conditions. The commercial value of each tree were assigned using height and Christmas tree quality (measured on a scale from 1 to 9 – 9 being the best) and height at harvest, see table 1.





Nielsen & Thomsen 1998

Figure 3. Estimated number of plants produced in seed orchards, stands were mass selection have been carried out aiming at seed production from the first thinning, and approved stands.

score	100-125	125-150	Height classes 150-175	175-200	200-250	>250	Commercial - grade
9	40	50	65	95	120	130	ON
8	38	48	63	89	115	125	ON
7	35	45	60	83	110	120	ON
6	33	43	58	76	105	115	ON
5	30	40	55	70	100	110	B
4	0	35	40	45	50	50	B
3	0	23	28	34	38	38	B
2	0	0	0	0	0	0	B/cull
1	0	0	0	0	0	0	B/cull

Table 1. Values (DKK) assigned to trees for different height classes (cm) and quality scores (score 1 to 9). The commercial grade ON is the trade mark Original Nordmann (equivalent to European grade A) and grade B is a standard tree of lower quality than ON/A. Cull is normally unsaleable trees.

Results Nordmann fir
The testing of Nordmann fir plus-trees were done using single-tree plots. However, a demonstration row-plot were established at Langesø Estate, photo 1. After 5 seasons substantial differences were seen for a range of characters.

Photo 1. Rows of open pollinated families after 5 seasons in the field. Substantial variation in growth and form were seen.

Summing up the major findings of the testing three different characteristics is presented: Post harvest quality, Christmas tree quality and economic value. Estimated gains from grafting the best plus-trees into a clonal seed orchard are shown in figures 3 and 4 – lines are showing the gains dependent on the selection intensity, i.e. the number of clones grafted out of the total number tested.

An essential trait for a high quality Christmas trees is the post harvest quality – here measured as needle retention after drying cut branches from the trees, fig. 3, Selecting solely for needle retention can improve keep ability to an interesting low level of needle loss.

Assuming a grafted seed orchard of the 20 best out of 90 tested plus-trees – the predicted number of first quality trees can be increased from 59 % to 73 %, fig. 4, or by a corresponding net-value of 51.000 DKK per ha per rotation. In this experiment, across sites, the average rotation age was close to 10 years from planting to end of harvest. Dividing the improved net-income per ha by rotation time means an extra net-income per ha of 5100 DKK per year (1 Euro = 7.45 DKK).

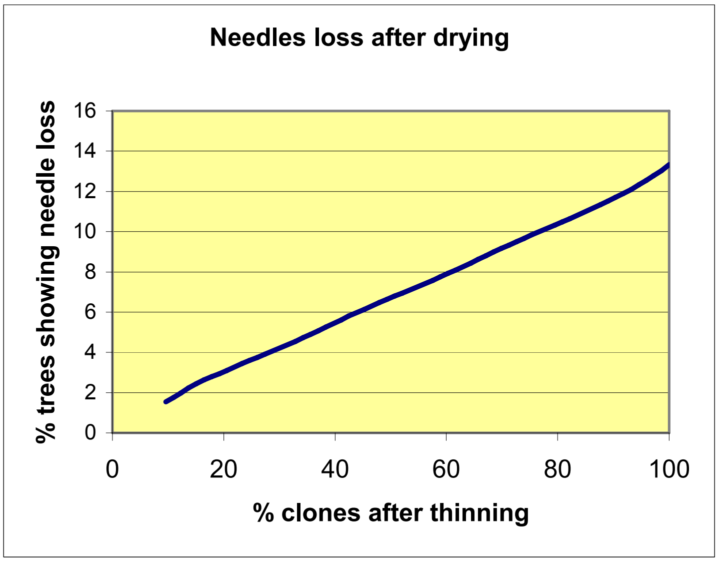


Figure 3. Estimated gains from a clonal seed orchard – selected solely for needle retention (post harvest quality).

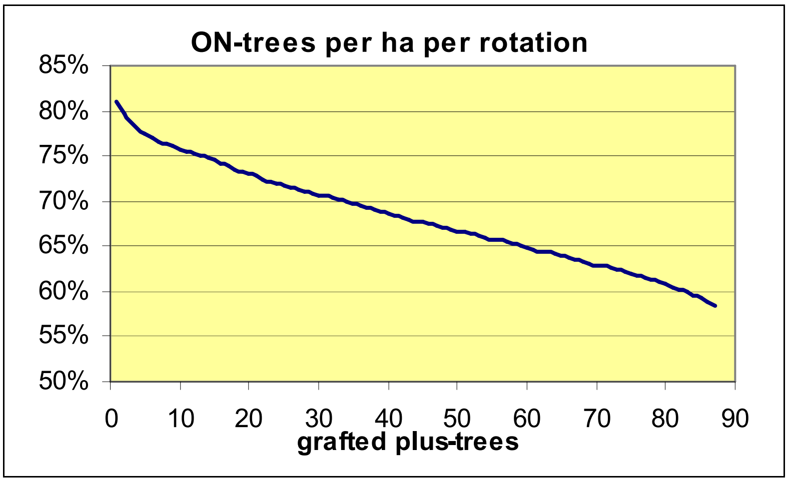


Figure 4. Estimated gains from a clonal seed orchard selected for increased Christmas tree quality – saleable trees grading ON(A). ON is a Danish trade mark which quality is the same as European grade A.

Results Noble fir

Results are shown from the PS-material comprising 78 tested plus-trees tested on 11 sites.

Substantial variation is present among selected plus-trees, and in general bough production of saleable branches correlate positively to quality traits, fig. 5. Blue colour and up-right needle orientation are positively correlated, but correlate negatively to coverage – meaning branches with good coverage tend to be green with a flat needle structure.

Two selection strategies were evaluated – when selecting the best 20 plus-trees out of 78 tested, table 2:

1) Maximum quality per harvested kg – meaning optimal net-value per kg cut branch material.
2) Maximum economic gain per harvest per ha.

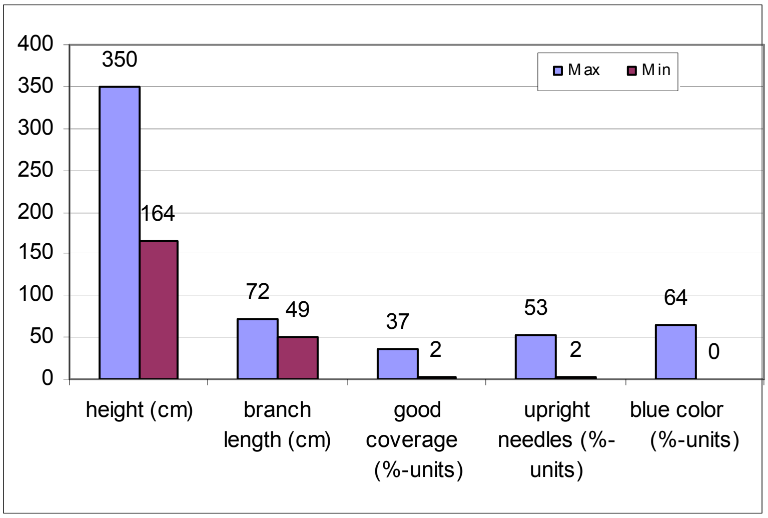


Figure 5. Estimated breeding values (BLUP) for the 78 selected plus-trees showing the range across plus-trees.

Strategi	Height (cm)	Branch length (cm)	Price DKK	Coverage (%-units)	Upright needlles (%-units)	Blur colour (%-units)	kg/harvest, ha	DKK total per harvest
Quality	11	0	0.46	0	8	14	541	4600
Total gain	32	2	0.31	1	4	10	1400	6700

Table 2. Estimated gains by selection using two strategies.

Despite the two different strategies, 12 of the 20 selected plus-trees were included in both selections.

Photo 2. Bough harvest stand and a bundle of saleable branches

Acknowledgements: Our field trail hosts are gratefully thanked for participating in the testing and in the case of noble fir for careful weighing of bough material. Groups of student workers have done a good job measuring heights etc. and Hans Kristian Kromann, Gerner

Frederiksen, Viggo Jensen have carried out the Christmas tree evaluations. Ole Kim Hansen and Hans Kristian Kromann have been involved in several aspects from nursery management to bough quality measurements. The State Tree Improvement Station and HedeDanmark produced the Nordmann fir seedlings. Progeny trials in noble were initiated by the Christmas Tree Growers Association. Essential parts of the work have been financed by the Production Fee Foundation for Christmas Trees and Greenery.

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Possibility of the Hybrid Fir Research Use in Christmas Tree Production

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Department of Dendrology and Forest Tree Breeding, Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, is interested for a long period in fir breeding on basis of hybridization. This research continues former research activities, which have been realized from sixties of last century. This older research stage has been aimed mainly on increase European silver fir vitality in connection with its large decline by interspecific hybridization. From the beginning of nineties aim has been partially modified on breeding on tolerance to ecological changes influenced by global climatic change with use of Mediterranean fir species (*A. nordmanniana, A. cilicica, A. cephalonica*....).

Figure 1. Isolation of female flowers in hybrization seed orchard (hybrid clones of *A. cilicica* x *A. cephalonica*) for control pollination by *A. fraseri* near Kostelec n.C.l. (Central Bohemia) in 2007.

Figure 2. Fructification in hybridization seed orchard (hybrid clones of *A. cilicica* x *A. cephalonica*) after control pollination by *A. fraseri* near Prostejov (Central Moravia) in 2007.

Hybrids, respectively hybrid progenies and clones are tested for example on tolerance to dry conditions. Various experimental plots have been established, concretely hybridization seed orchards for production of F_2 generation hybrids, hybrid progeny tests and hybrid clonal tests in the middle Bohemia and middle Moravia. Vegetative propagation of hybrid material has also been solved for purposes of cloning.

Recently new international project has been started on level of Czech - American cooperation, concretely among our department and prof. John Frampton from the North Carolina State University Raleigh, which is also directed on use of interspecific hybridization and vegetative propagation for breeding of Christmas trees. This research is aimed also on breeding on resistance of Fraser fir to *Phytophtora cinnamomii*.

Figure 3. Roentgenogram of seeds of *Abies koreana* x (*A. cilicica* x *A. cephalonica*).

Figure 4. Hybrid fir progenies (parent trees…A. cephalonica, A. nordmanniana, A. cilicica, A. numidica).

Poster Presentations: Breeding, Propagation, Nutrients

High Throughput DNA Sequencing of Fraser Fir (*Abies fraseri*)

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Background

Recent advances in technology for DNA sequence determination have increased the sample throughput and decreased the cost per unit of DNA sequence obtained. These advances will make the analysis of DNA sequences a cost-effective approach for many more research questions in biology than ever before. Analysis of biological and genetic diversity and the development of genetic markers are potential applications of DNA sequence determination that are relevant to many research problems.

We have used the multiplex pyrosequencing method developed by 454 Life Sciences (Margulies et al, Nature 437:376-380, 2005) to begin DNA sequence analysis of Fraser fir (*Abies fraseri* [Pursh] Poir.).

Objectives

The objectives of this work are 1) to identify genes expressed during normal growth and development of both the above-ground and below-ground portions of the plant, and 2) screen identified genes for DNA sequence variation (single-nucleotide polymorphisms, or SNPs), which would be useful as genetic markers

Methods

RNA samples were prepared from two Fraser fir seedlings – newly-expanded shoot tips and foliage were collected as a sample of above-ground organs, and roots (including both root tips and more mature fully-elongated primary and secondary roots) were collected as a sample of below-ground organs. One seedling was infected with a suspension of *Phytophthora cinnamomi* four days prior to sample collection, while the other seedling was maintained as a non-infected control. Complementary DNA was prepared from RNA isolated from infected roots (Sample 1), non-infected roots (Sample 2), and the shoot tip from the non-infected plant (Sample 3). The cDNA preparations were normalized using the duplex-specific nuclease method (Zhulidov et al, Nucl Acids Res 32:37, 2004), and submitted to the University of Florida Interdisciplinary Center for Biotechnology Research (UF-ICBR) service facility for DNA sequence determination.

Results

Preliminary results presented in the accompanying table demonstrate that the combination of 1) PCR-based cDNA synthesis, 2) an efficient normalization method, and 3) massively-parallel DNA sequencing technology has produced a very efficient gene discovery process for Fraser fir. Over 15,000 candidate SNP loci that can be assessed as possible genetic markers and occurring over 3,000 different genetic regions have been identified and are currently being validated. The availability of DNA sequences for Fraser fir genes will allow the design of oligonucleotide probes for microarray analysis of gene expression and the design of SNP genotyping assays to allow efficient high-throughput genetic analysis of both breeding populations and the threatened natural Fraser fir populations.

	Sample 1 Roots[1]	Sample 2 Roots[1]	Sample 3 Shoot
Total bp	95 Mb	78 Mb	41 Mb
bp in Contigs	16.8 Mb	14.4 Mb	8.55 Mb
Total # Contigs	38,823	33,318	18,869
# Contigs with HC-SNPs	3,087	3,955	Not Tested
Mean Contig Length	433 nt	434 nt	439 nt
Range in Contig Lengths	215-1000 nt	214-1000 nt	231-945 mt
Contigs with BlastX hits to Plant Proteins ($E < 10^{-8}$)	12, 892 (33%)	11,739 (35%)	9,216 (47%)

[1] 25,542 (66%) of the Sample 1 root contigs are similar to Sample 2 contigs by BastN.

A Collection of Turkish (*Abies bornmülleriana*) and Trojan (*Abies equi-trojani*) Fir Seeds

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[1)] Department of Forestry and Environmental Resources, North Carolina State University

Turkish (*Abies bornmülleriana* Mattf.) and closely related Trojan (*A. equi-trojani* Coode et Cullen) fir are of interest to Christmas tree producers in North Carolina, USA, since they: 1) possess some resistance to root rot caused by *Phytophthora cinnamomi* Rands, and 2) can survive the warmer climates of the lower elevation piedmont and coastal plain of the state.

Results from a previous trial in which seedlings of 32 *Abies* species were inoculated with *P. cinnamomi* showed that North American species are completely susceptible while many Mediterranean and Asia species have some trees with resistance. Turkish and Trojan firs were ranked third and tenth for the frequency of resistant seedlings.

Route taken through northwestern Turkey and location of Turkish and Trojan fir provenances sampled during the 2005 seed collection.

Experience with field trials of Turkish fir in the piedmont and coastal plain regions of North Carolina over a six year period has indicated that this species can survive the warm climate of the region. However, growth has been slow and form poor. Unknown seed sources likely of limited genetic diversity were necessarily used in these initial trials.

In order to gain a better understanding of variation in Turkish and Trojan fir, we organized an extensive seed collection expedition in Turkey during Fall 2005. Cones from at least 20 trees in each of two provenances of Trojan fir and four provenances of Turkish fir were collected. Within each provenance, the entire range of elevations was sampled. During collection, cones of each tree were put into a separate bag and labeled. At the end of each collection day, bags were shipped to the Forest Trees Breeding Institute in Ankara for seed extraction. Turkish researchers shipped the extracted seeds to the U.S. Inspection Agency in Miami. We received the seeds in Raleigh during early February 2006.

Seeds were further cleaned, counted, and germination tests conducted. Germination averaged near 40% with open-pollinated families ranging from 0 to 87%.

This extensive collection probably represents *the most genetically diverse seed collection of Turkish and Trojan fir in the world.* We are currently growing seedlings in the greenhouse for three studies to evaluate: 1) resistance to *P. cinnamomi* via a shadehouse inoculation trial, 2) adaptation and growth in the mountains of North Carolina, and 3) adaptation and growth in the piedmont of North Carolina. Additional seeds of most seedlots are still available for other future investigations.

Acknowledgements Special gratitude is extended to the North Carolina Christmas Tree Association and the Eastern North Carolina Christmas Tree Growers Association who contributed funds for the seed collection expedition and green-house culture of this material.

The Selection of Coniferous Species for Christmas Tree Plantations in Latvia.

Mudrite Daugaviete[1)], Monika Martinova[2)]
[1)] Latvian Forestry Research Institute „Silava", [2)] Ltd Olaine's Nursery

Summary. The results of long-term investigations for selection the perspective Christmas tree coniferous species is presented. The following species was tested: Norway spruce *(Picea abies*), White spruce (*P. pungens*), Serbian spruce (*P. omorica*), Silver fir *(Abies alba*), Balsam fir (*A. balsamea*), provenance of Balsam fir (*A. balsamea* var. *phanerolepis*), Colorado fir (*A. concolor*), Korean fir (*A. koreana*), Veitch fir (*A. veitchii*), and Nordmann fir (*A. nordmanniana*).

The frost resistance, growth, technologies of establishment plantations, crown quality, pest-resistance were evaluated. Recommendations of useful tree species and provenances for Christmas Tree plantations in Latvia were possible from experiment results.

Objective: to select the perspective coniferous species for Christmas tree plantations in Latvia.

Materials and methods
The experimental plantations of following tree species: Norway spruce (*Picea abies* (L.) Karst.; *P. abies* 'Ohlendorfii'), White spruce (*P. pungens* Engelm.), Serbian spruce (*P. omorica* (Panč.) Purk.), Silver fir (*Abies alba* Mill.), Balsam fir (*A. balsamea* (L.) Mill.), provenance of Balsam fir (*A. balsamea* var. *phanerolepis* Fern.), Colorado fir (*A. concolor* Gord. et. Glend.) Lindl. ex Hildebr.), Korean fir (*A. koreana* Wils.), Veitch fir (*A. Veitchii* Lindl.), and Nordmann fir (*A. nordmanniana* (Stev.) Spach.) were established in the different climatic regions of Latvia.

During the 7 years of experiments the time of bud-blowing, frost resistance, technologies of establishment plantation, stability of crown form, different shaping methods, pest resistance, time of lignifications of shoots etc. were evaluated.

Discussion

The plantations were established by different methods of soil preparation: ploughing, furrows, using of herbicides etc. The different rate of fertilization, tending technologies, crown shaping methods was tested for each species.

The indigenous coniferous tree species Norway spruce (*Picea abies* (L.) Karst), Ohlendorfii spruce (*P. abies* 'Ohlendorfii') and their provenances can reach medium height 70 cm per 5 years, 120 cm for 7 years and 190-200 cm for 9 years.

The medium height of White spruce (*P. pungens*), Serbian spruce (*P. omorica*) and their proveniences is lower about 30 cm, but for *Abies* species (*A. balsamea, A. balsamea* var. *phanerolepis*, *A. concolor, A. koreana, A. veitchii*) about 50-60 cm in comparison with Norway spruce (Figure 1).

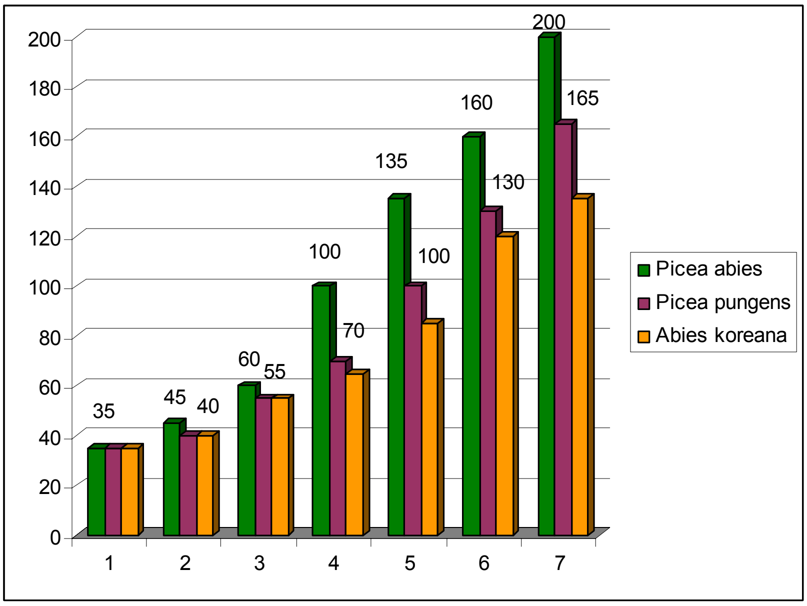

Figure 1. Growing stock of different coniferous species in experimental Christmas tree plantations in Latvia climatic conditions.

The fertilization of plantations increased the growth and number of buds. The number of buds increased from 15-20 to 30-40 on the first year shoots, and it is the precondition for good quality of crown. The growth in height after fertilization was increased about 30-50% and was different for soil and climate region and species.

Conclusions

1. Only the frost resistant coniferous species and provenances are useful for Christmas tree plantations in Latvia.
2. The following indigenous and introduced tree species and provenances can be recommended for Christmas tree plantations in Latvia: Norway spruce (*Picea abies*); *P. abies* 'Ohlendorfii', White spruce (*P. pungens*), Serbian spruce (*P. omorica*), Silver fir (*Abies alba*), Balsam fir (*A. balsamea*), provenance of Balsam fir (*A. balsamea* var. *phanerolepis*), Korean fir (*A. koreana*).
3. The selection of useful frost resistant provenances of Nordmann fir (*A. nordmanniana*) is not finished in Latvia.

Initiation of somatic embryogenesis from young and adult material of *Abies nordmanniana*

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1) CRA W Department Biotechnology, Belgium

Introduction

Nordmann fir (*Abies nordmanniana*) is a much-appreciated Christmas tree in Europe for persistent needles and smooth foliage. In the Walloon region of Belgium, fir-tree is of great economical importance. Its cultivation covers an area estimated to 5000 ha that produces annually about 4 millions trees intended uppermost for export.

Seeds remain till now the only reproduction means. Beyond the seed origin, different culture techniques can be carried out to blend the achievement of quality tree parcels like pruning, fertilization, growth regulators, but high disparity affect marketable trees. Advantage could also be taken from a genetic improvement after the selection of «Plus» trees in the forest and the set up of new seed orchards.

Clonal multiplication can be achieved through somatic embryogenesis. Its principal interest would however be the propagation of 4 to 5 years old seedlings, the threshold of tree growth for field evaluation. Obviously, it should be of higher interest to induce somatic embryos from selected adult individuals.

This paper describes improved culture medium to initiate embryogenic masses in *Abies nordmanniana* from mature zygotic embryos, its application to somatic embryos and further preliminary success obtained with 5 and 15 years old trees.

Material and methods

Initiation of somatic embryos using zygotic embryos

Mature seeds of *Abies nordmanniana* coming from Ambrolauri and Borshomi regions (delivered by Levinsen company, Denmark) were disinfected. Once excised, zygotic embryos were placed onto media (Table 1) based on Bornman & Jansson (BJ: described by Hristoforoglu *et al.*, 1995) macroelements and vitamins, microelements of Verhagen & Wann (1989) respectively.

We compared 3 variants of NH_4^+/NO_3^- ratio (0, 0.2 and 0.4: obtained by the addition of $(NH4)_2SO_4$) at two nitrogen levels (15 and 24 meq). Besides, the six culture media contain 500 mg l^{-1} L-glutamine (ICN) added by filtration, 1000 mg l^{-1} casein hydrolysate (Merck) and 1 mg l^{-1} benzylaminopurine (Sigma). After three weeks, subculture took place on corresponding media. Cultures were kept in the dark, at 22°C.

For each combination (culture medium x origin of plant material), 40 embryos (2 per Petri dish) were tested. Statistical analysis of initiation percentages was performed on the determination of confidence intervals calculated using arc sinus transformation.

Table 1. Macro-elements composition (mg l^{-1}) of induction media based on Bornman & Jansson in relation with NH_4^+/NO_3^- ratio and the total concentration of nitrate utilized for somatic embryo initiation from zygotic embryos of *Abies nordmaniana*.

Macroéléments (mg/l)	**A0**	**A2**	**A4**	**B0**	**B2**	**B4**
$CO(NH_2)_2$ *	-	100	100	-	62,5	62,5
KNO3	2000	2000	2000	1515	1515	1515
$CaNO_3.4H_2O$	500	500	500	-	-	-
$(NH_4)_2SO_4$	-	99	400	-	61	259
KH_2PO_4	135	135	135	135	135	135
KCl	75	75	75	358	358	358
$Mg\ SO_4.7H_2O$	125	125	125	125	125	125
$CaCl_2.2H_2O$	-	-	-	309	309	309
K_2SO_4	-	-	-	87,2	87,2	87,2
NH_4^+ / NO_3^- ratio	*0*	*0,2*	*0,4*	*0*	*0,2*	*0,4*
Total NO3 $^{(meq)}$	24			15		

*added by filtration after autoclaving (in mg l^{-1}).

Initiation from germinated somatic embryos
We compared the embryo induction for three lines (280306, 010900, 060502) of zygotic origin that had been pre-cultivated as follows:

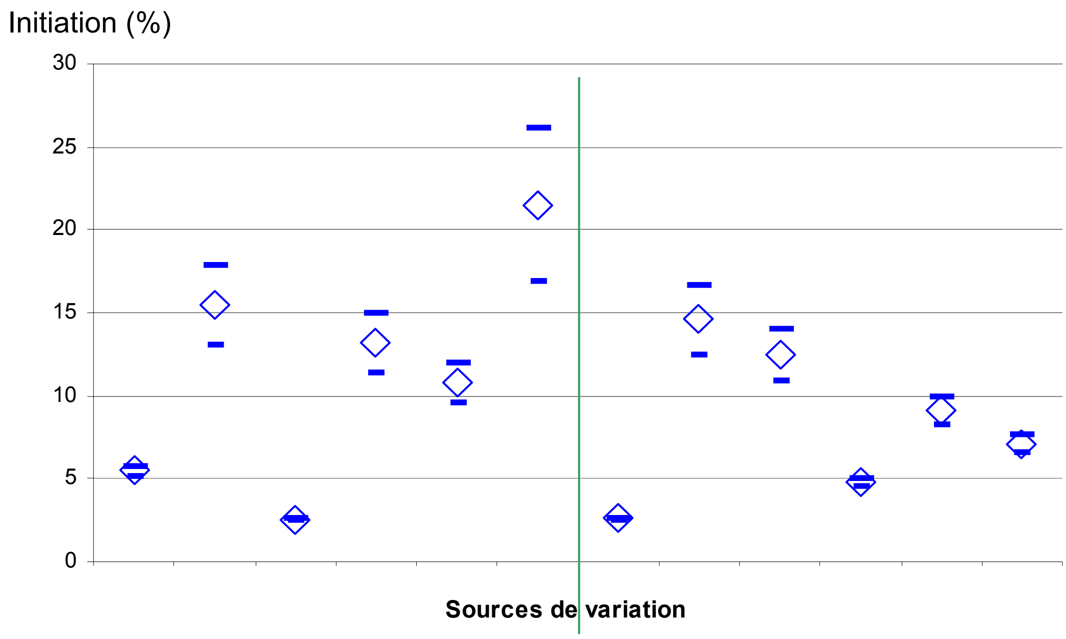
- 6 subcultures of 15 days on BJ medium modified by reducing ammonium sulfate (to 130 mg l^{-1}) and using P9 microelements (Misson *et al.*, 2006)
- 3 subcultures of 15 days on SH culture medium (Schenk & Hildebrandt, 1972)
- maturation following Norgaard (1997) method and cold treatment at 4°C during 4 months
- germination on Gupta *et al.* (1995) medium, modified by adding 35 g l^{-1} glucose and 150 mg l^{-1} L-glutamine (ICN), BLG microelements and vitamins of Verhagen & Wann (1989) and by removing activated charcoal. For this last step, embryos were lay out onto the surface of the culture medium.

Germs of 20 days old came from 16 h daylight (40 µE/m².s) photoperiod or darkness respectively. They were sliced into three fragments (base + top of hypocotyl axis and cotyledonnar zone respectively) and were placed on A4 medium (Table 1). For each trial, 36 somatic embryos /line were tested.

Initiation from meristems removed from 5 and 15 years old trees
Vegetative buds were collected from December to February on 5 and 15 years old trees respectively. After bud disinfections in calcium hypochlorite (9% - 20 minutes), meristematic domes were removed (200 micrometers), sometimes with leaf primordia, and were cultivated on A4 medium. After a culture period of 1 to 4 months, appeared calluses were monthly subcultivated on BJ medium modified by reducing ammonium sulfate (to 130 mg l^{-1}) and using P9 microelements (Misson *et al.*, 2006).

Results
Initiation from zygotic embryos. All tested media led to the induction of somatic embryogenesis (Figure 1) whatever the seeds origin. However initiation rate do not rises above 25 % of the tested seeds.

The highest rates are obtained respectively on A4 and B2 media for Ambrolauri origin and on A4 and B0 media for Borshomi origin. At low nitrate concentration (15 meq), Ambrolauri seeds need a minimum ammoniacal nitrogen for the somatic embryo induction while this seems unfavorable to seeds of Borshomi origin. Medium A4 gives the most favorable initiation rates for both seeds origins.



Seed origin	A	B	A	B	A	B	A	B	A	B	A	B
NH_4^+/NO_3^- ratio	0		0.2		0.4		0		0.2		0.4	
NO_3 meq			24						15			

Figure 1. Initiation of embryogenic masses (% ± confidence interval) from mature zygotic embryos of *Abies nordmanniana* as a function of the seed origin (**A**: Ambrolauri, **B**: Borshomi), the NH_4^+/NO_3^- ratio and the nitrate concentration (meq).

Table 2. Induction of embryogenic masses (%) on 3 lines of somatic embryos of *Abies nordmanniana* as a function of their previous germination occurring in 16h photoperiod or in darkness.

	Germination origin	
Lines	16 h Daylight	Darkness
280306	29.0	70.3
010900	36.6	85.7
060502	2.7	10.8

Basal germination medium of Gupta *et al* (1995)

<u>Initiation from somatic embryos</u>. Somatic embryos appear after 4 weeks of culture on A4 medium and only in distal part of top of hypocotyl axis fragments. Sometimes we observe the presence of friable and opaque calluses paired or not with foliar structures. Excepted for ‘060502’ line, initiation rate are higher than those with zygotic embryos (Table 2), all the more when somatic embryos are coming from a germination realized in the dark.

Initiation from meristems of trees. Observations made during 1 to 4 months after the introduction of meristems on A4 culture medium permit to distinguish two types of callus. The "yellowish-white" ones are only constituted by small vacuolated cells. Others are compacted and look necrotic with mostly elongated and largely vacuolated cells. In some cases, in this type of callus, a lot of polarized structures become visible. Structures were constituted by a group of meristematic cells prolonged by long vacuolated cells (= somatic embryos). These structures develop even better when callus are transferred onto BJ culture medium.

Up to know, 4 embryogenic lines were obtained on the 40 genotypes tested using 5 years old plant material and one more embryogenic line was obtained from the 10 tested genotypes of 15 years old plant material.

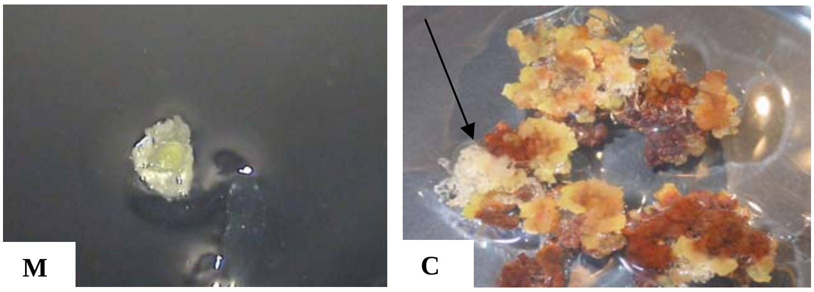


Figure 2. Initiation (**C**)* from meristems (**M**) of 5 years old trees.
→: embryogenic masses appearing after 10 months subcultures on A4 medium.

Discussion and conclusion

In conifers, successful initiation is firstly conditioned by the genotype and next by the development stage of the initial zygotic embryos. The ratio of somatic embryognesis decreases with zygotic embryo aging. With *Abies nordmanniana*, it may vary from 0 to 30% (Norgaard & Krogstrup, 1991) or from 11 to 44% (Rahmat & Zoglauer, 2001).

Our results show that initiation percentage of somatic embryos from zygotic embryos can be influenced by seed origin and improved with the adaptation of the nitrogen nutrition. Moreover, such improved culture medium (A4) allowed further re-initiation from germinating somatic embryos and the first initiations from meristems collected on 5 or 15 years old trees. We have now to determine the culture conditions required prior to meristem culture and to investigate on the cell initializing the somatic embryos *in vitro*.

Acknowledgement: The authors are grateful to the Research Department of the Walloon Ministry of Agriculture for funding and to S. Tarin for her effective technical assistance and to P. Geerts for paper review.

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Nordmann fir (*Abies nordmanniana*) grown in chelator-buffered nutrient solution with different combinations of Ca and Mg.

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Summary
The effects of low and adequate supply of Ca and Mg on plant mineral status were investigated on nordmann fir (*Abies nordmanniana*) grown in chelator-buffered nutrient solution in a greenhouse trial. The results suggest that a balanced supply of Ca and Mg is of importance for the nutrition of nordmann fir (*Abies nordmanniana*) to avoid nutritional disorders based on the antagonistic relationship between Ca and Mg. The methodology of chelator-buffered nutrient solutions may be appropriate for detailed studies of mineral nutrition to nordmann fir.

Introduction
Magnesium deficiency represents the major nutritional constraint for nordmann fir (*Abies nordmanniana*) plantations in Norway (Talgø et al. 2005). Mg deficiency may result in necrotic tips of older needles (Fig. 1). Another needle damaging factor is current season needle necrosis (CSNN), and the latter has been associated with lack of Ca (Chastagner et. al 1997). Both factors are considered to be of importance in controlling the quality of nordmann fir in Christmas tree production systems. Thus, we decided to run a greenhouse experiment to investigate uptake of essential minerals under various supply of Ca and Mg.

Fig. 1. Typical symptoms of Mg deficiency in nordmann fir (*Abies nordmanniana*). When there is lack of Mg, current year shoots get their supply from old needles. This result in chlorophyll-collapse in old needles, and the tip of the needles turn yellow and finally necrotic. Photos: V. Talgø

Material and methods
The treatments were arranged in a factorial design including all factor combinations of normal and low supply of either Ca or Mg, but here only the main effects are presented. Small plants of nordmann fir were grown in chelator-buffered nutrient solution for 31 days (Fig. 2). Fixed free metal activities calculated with Geochem-PC 2.0 (Parker et al. 1995), were obtained in the nutrient solution by addition of HEDTA [N-(2-hydroxyethyl)-ethylenediamine-triacetic acid]. Adequate solution concentrations of Ca and Mg were set to

2.0 and 0.5 mM, respectively, and the deficient conditions were set to 0.04 and 0.01 mM, respectively. The nutrient solution was changed weekly, and pH was adjusted every day in all pots to pH 6.0. At the end of the experiment, mineral analyses of macro- and micro-elements were obtained from current year shoots, old needles, stems and roots.

Fig. 2. Nordmann fir (*Abies nordmanniana*) grown in chelator-buffered nutrient solution with different combinations of calcium and magnesium. A small pump continuously supplied air to the nutrient solution. Photos: V. Talgø

Results and discussion

Both Ca and Mg supply affected macro- and micro mineral status in all plant parts. Low Ca-supply induced chlorosis of new shoots, and suppressed significantly both Ca and Mg shoot concentration (Table 1). Low Mg supply only affected Ca and Mg mineral status of the roots, where an antagonistic relationship between Ca and Mg was obvious (Table 2). The effect of low Ca and Mg supply on mineral status was most pronounced in roots and current year shoots. This suggests the roots to be more active in redistributing Ca and Mg compared to old needles and the stem (data not shown for old needles and stem).

Adequate Ca supply also had a positive impact on the Mn concentration in young shoots (Table 1). Adequate Ca supply induced elevated levels of P and K in the roots compared to the deficient treatments, while opposite relationship was valid for the new shoots. This suggests that Ca uptake in roots affected the translocation of P and K from roots to new shoots.

Table 1. Current year shoot nutrient concentration of selected elements at low (0) and sufficient (1) supply of calcium and magnesium.

Treatment		Macronutrients, % of dry weight (dw)					Micronutrients, mg kg^{-1} dw	
		N	P	K	Ca	Mg	Mn	Zn
Ca	0	1.80 a	0.29 a	1.30 a	0.051 b	0.067 b	77.6 b	26.3 a
	1	1.77 a	0.24 b	1.11 b	0.082 a	0.077 a	126.3 a	26.1 a
Mg	0	1.84 a	0.27 a	1.24 a	0.067 a	0.071 a	100.6 a	27.7 a
	1	1.72 b	0.26 a	1.17 a	0.066 a	0.073 a	103.2 a	24.6 a

Values of means of 12 replicates. For each of the two elements, means in the same columns with different letters are significantly different at P = 0.05.

Table 2. Root nutrient concentration of selected elements at low (0) and sufficient (1) supply of calcium and magnesium.

Treatment		Macronutrients, % of dry weight (dw)					Micronutrients, mg kg^{-1} dw	
		N	P	K	Ca	Mg	Mn	Zn
Ca	0	1.54 a	0.16 b	0.23 b	0.13 b	0.13 a	49.8 a	29.6 a
	1	1.50 a	0.22 a	0.36 a	0.40 a	0.09 b	44.0 a	37.2 a
Mg	0	1.53 a	0.19 a	0.30 a	0.31 a	0.08 b	53.0 a	40.0 a
	1	1.51 a	0.19 a	0.28 a	0.23 b	0.14 a	40.8 b	26.8 b

Values of means of 12 replicates. For each of the two elements, means in the same columns with different letters are significantly different at P = 0.05.

Acknowledgements. We want to thank Marit Larssen Sekse for technical assistance.

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Talgø, V., Lombnæs, P., Pundsnes, T., Sæbø, A., and Stensvand, A. 2007. Nutrient deficiencies on *Abies nordmanniana* in Norwegian Christmas tree plantations. Proceedings of the 7th International Christmas Tree Research & Extension Conference in Michigan, USA, October, 2005.

Evaluation of needle nutritional status in a Christmas tree fertilization and water manipulation experiment.

Lars Bo Pedersen[1)], Morten Ingerslev[1)], Claus Jerram Christensen[2)]

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In Denmark, soil analyses as well as needle analyses are used to compile or adjust fertilizer plans for Christmas tree stands. Being the more “coarse” method, soil analyses are often carried out in the beginning of a new rotation. Contrary, needle analyses are regarded as a more precise method that takes the current nutritional status into account, and are recommended to be carried out several times during the rotation or when nutritional problem may arises or be observed by e.g. needle discoloration.

In this study needle analyses have been utilised to evaluate the effects of fertilization and water manipulation in 13 treatments on a nutrient poor sandy soil. The stand is characterized by continuous growing management where a tree is planted in the spot where a newly harvested tree stood. Needle samples were taken each year from three tree categories: 1 One year old trees, 2) Trees between 80 – 120 cm and 3) Trees between 160 – 200 cm. Each year in the dormant season, needle samples of 10-20 handpicked needles were taken from every tree in each treatment and pooled to one sample for each of the three tree categories. The samples were analyzed for the concentration of N, P, K, Ca, Mg, Na, Mn, Fe, B, Zn, and needle weight.

The fertilizer was applied as NPK 14-3-18 in the spring or as split application with amounts ranging from 0 to 750 kg/ha NPK fertilizer. The irrigated treatments received an additional amount of 462 mm water in June to September as a mean whereas 67 mm of precipitation water was removed in the drought treatment in June.

All treatments resulted in N concentrations in the needles below 13.5 mg/g well below the optimum range. Also Ca, Mg, Fe, and Zn were below recommended optimum range whereas the concentration of K in most treatments was above the optimum range. Concentrations of P, Mn, S were in general within the optimum range.

The results indicates that the effect on the nitrogen concentrations in the needles of increasing the amount of N-fertilizer from 75 to 90 kg/ha did not have the same positive effect as split fertilizing with the 75 kg/ha/year.

In general, needle weight as well as needle concentrations of K and Mn increased with tree size. All other concentrations were not influenced by tree age. Irrigation resulted in a larger uptake of most nutrient probably because this treatment forced the concentrations as well as the contents of the nutrients to increase. On the other hand, the drought treatment did not change the nutrient concentrations and contents in the needles significantly.

Evaluation of needle nutritional status in a Nordmann fir Christmas tree fertilization and water manipulation experiment

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SKOV & LANDSKAB

BACKGROUND

In Denmark, soil analyses as well as needle analyses are used to compile or adjust fertilizer plans for Christmas tree stands. Being the more "coarse" method, soil analyses are often carried out at the beginning of a new rotation. Contrary, needle analyses are regarded as a more precise method that takes the current nutritional status into account. They are recommended to be carried out several times during the rotation or when nutritional problem may occur or be observed by e.g. needle discoloration.

AIM

Evaluation of fertilization effects and water manipulation on the tree nutritional status determined by interpretation of needle analyses results.

MATERIALS

Fertilization experiment on a coarse sandy soil in a Nordmann spruce stand managed by continuous harvesting and planting each year.

- Needles were sampled from three tree sizes:

- **Small**: one year old trees,
- **Medium**: tree height 80 – 120 cm,
- **Large**: tree height 160 – 200 cm.

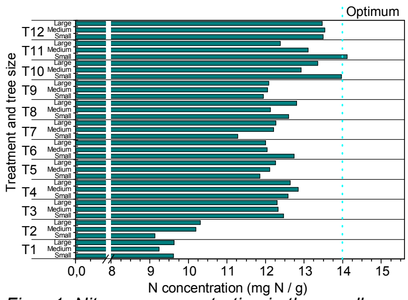
- NPK 14-3-18 was used as fertilizer.
- 462 mm water was added from June 1st until Sept. 1st in the irrigation treatment, whereas 62 mm was removed in June in the drought treatment.
- Treatments:

-**T1**: Untreated (no fertilization or irrigation)
-**T2**: Only irrigation
-**T3**: Apr. 75 Kg N/ha/year
-**T4**: Apr. 75 Kg N/ha/year + irrigation
-**T5**: Apr. 90 Kg N/ha/year
-**T6**: Apr. 45 Jun. 30 Kg N/ha/year
-**T7**: Apr. 45 Jun. 30 Kg N/ha/year + irrigation
-**T8**: Apr. 45 Jun. 30 Kg N/ha/year + drought
-**T9**: Apr. 45 Jun. 30 Kg N/ha/year + extra irrigation
-**T10**: Apr. 45 Jun. 45 Kg N/ha/year
-**T11**: Apr. 45 Jun. 15 Aug. 15 Kg N/ha/year
-**T12**: Apr. 45 Jun. 30 Aug. 15 Kg N/ha/year

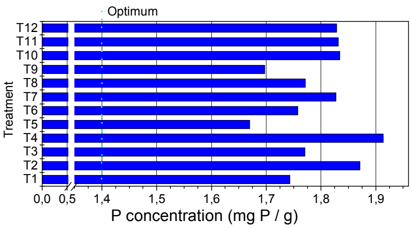
METHODS

Fertilizers were broadcasted by hand every year from spring 2003. Needles were sampled in December 2003 -2006. Only needles emerged from the upper whorl on the south-pointing branch were sampled. Approx. 25 needles were sampled from each tree and pooled together with needles from other trees subjected to the same treatment. Needles were analyzed for concentrations of N, P, K, Ca, Mg, Na, Mn, Fe, B, Zn, and 100-needle weight.

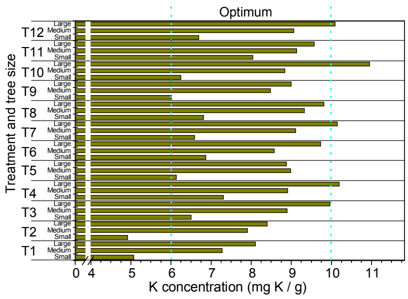
RESULTS



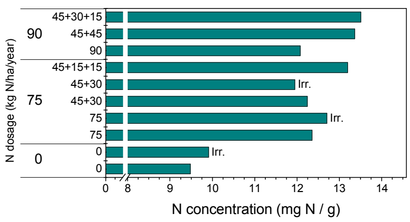
Figur 1. Nitrogen concentration in the needles presented as an average for all the years (2003-2006). Optimum range is indicated.



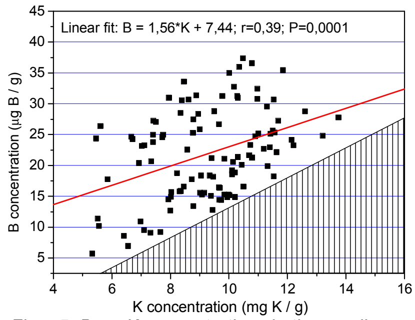
Figur 2. Phosphor concentration in the needles presented as an average for all the years (2003-2006). Optimum range is indicated.



Figur 3. Potasium concentration in the needles presented as an average for all the years (2003-2006). Optimum range is indicated.



Figur 4. Nitrogen concentration in the needles presented as an average for all the years (2003-2006). N dosage, fertilizer split and irrigation regime (Irr.) is indicated.



Figur 5. B vs. K concentrations in the needles presented as an average for all the years (2003-2006). Linear fit is indicated. No observations were found in the masked area.

CONCLUSIONS

➢ N fertilization increased the needle N concentrations, however, in this experiment, not sufficiently compared to optimum. Highest needle N-concentrations were observed for small trees, in non-irrigated plots applied with high dosage of N spread twice or a normal to high dosage spread on three occasions. Fertilization affects the needle N concentration more than irrigation alone. Generally, the irrigation effect on the N concentration appears to be relatively small.

➢ Concentrations of P, Mn, and S were most often within the optimum range. Irrigation combined with fertilization appears to increase the needle P concentration more than fertilization alone. Also relatively high concentrations of P were observed in non-irrigated plots applied with a high dosage spread twice or a normal to high dosage spread on three occasions.

➢ K fertilization increased the needle K concentrations. K in most treatments was within the optimum range. Needle weight as well as needle concentrations of K and Mn increased with tree size.

➢Ca, Mg, Fe, and Zn were all below the recommended optimum ranges.

➢ Irrigation resulted in a larger uptake of some of the nutrients (P, Ca and Mg) most likely because this treatment forced the concentrations as well as the contents of the nutrients to increase. On the other hand, the drought treatment did not change the nutrient concentrations and contents in the needles significantly.

➢ There appears to be a weak linear correlation between the needle concentration of K and B. Hence, B deficiency (< 15 µg B/g) is not likely to occure, when the K concentration is above 11 mg K/g, and visa versa.

Seasonal change in Noble Fir, Douglas Fir, Grand Fir, Turkish Fir, and Nordmann Fir needle nutrient concentration.

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Nutrient application decisions for established Christmas Tree plantations and other woody perennial crops are made with the assistance of tissue samples. Before tissue samples can be used for this purpose, three conditions must be met; 1) plant part to sample must be designated, 2) stage of development or date for sampling chosen, and 3) nutrient standards or sufficiency levels for comparison available. Ideally, a stage of development or sampling date is chosen when concentration of all nutrients is stable. Nutrient concentration will be stable when changes from nutrient uptake or growth are minimal. Since growth dilutes nutrient concentration, a sampling time after annual growth is chosen for woody perennial crops.

The OSU Christmas Tree Nutrient Management Guide for western Oregon and Washington specifies that samples should be collected in the late summer or early autumn, before the rainy season begins. This guideline is logically during September or October since the rainy season or steady rain begins in November. Danish guidelines advise needle collection near the end of the dormant season or from January to March.

The needle sample time used in western Oregon and Washington is adapted from forest practices. Standard forest practice for conifer needle collection is at the end of summer. The definition of “end” summer will vary, beginning as early as August (Steve Webster, Personal Communication 2007), or from September through December (Weetman and Wells).

Discussion occurred about appropriate sampling date at the 2005 International Christmas Tree Research and Extension Worker Conference. Danish scientists presented annual needle concentration of N, K, Ca, and Mg from Nordmann fir. Needle Nitrogen concentration wasn’t stable until late December or January. The discussion revealed that no data exists to support the September-October sampling time recommended in the OSU guide.

The objective was to measure seasonal change in *Noble Fir, Douglas Fir, Grand Fir, Turkish Fir, and Nordman Fir* needle nutrient concentration so we can affirm or modify recommended needle sampling time of mid-September to mid-October for routine needle nutrient monitoring.

Method/approach

Three replications for each species were sampled monthly for a year. Samples were taken the same time each month, approximately the middle of the month from new or current season growth. The same trees were sampled each time. Needles were air dried and prepared for nutrient analyses by dry ash process, then analyzed using Leco CNS analyzer and ICP for N, P, K, Ca, Mg, S, B, Zn, Mn, Cu, and C.

Results and Discussion

Average monthly needle nutrient concentration for N, P, K, S, Ca, Mg, and B from Noble Fir, Douglas Fir, Grand Fir, Turkish Fir, and Nordmann Fir are presented in Tables 1 through 6. Nutrient concentration varied for species and nutrient. Noble fir needle nutrient concentration changed little change compared to other species. Douglas Fir needle nutrient concentration was the most variable of the five species sampled.

For noble fir, concentration of N, P, K, and S was highest in June after the flush of new growth. Conversely, Ca and B concentration was lowest in June and increased as needles aged. Magnesium needle concentration was low in June, increased until October and remained unchanged through February. Nitrogen concentration changed most June through

August in four of the five species. The period when nitrogen concentration changes least is winter/early spring. The same is true for most elements. The period when needle concentration does not change is species dependent beginning as early as September or late as February.

Danish Nordmann fir nitrogen, potassium, calcium and magnesium needle concentration temporal change was quite similar to data collected for this project (Pedersen and Christensen 2005). We wished to affirm or modify recommended needle sampling time of late summer until the fall rain begins, or approximately mid-September to mid-October for routine needle nutrient monitoring.

Evaluating or choosing a sampling time from data collected is difficult task. Needles were sampled carefully in three replicates that made statistical differences between dates quite small and significance level high. Using standard statistics (ANOVA) to separate nutrient concentration into changing or stable periods did not provide an easily understood or clear group of months. Our careful sampling technique allowed us to find many small differences, the opposite of our goal.

The small statistical differences measured between nutrient concentrations for dates are less than the variation found in a field. If we repeatedly sample the same field, the result will vary between 5 and 10%, even when sampling is performed carefully.

At least a two month period is desired for needle sampling. Sampling based on a development or physiological stage is the best approach for describing sampling time. Since no physiological stage can be given for Christmas Tree needle sampling, a range of calendar dates is needed to accommodate weather patterns.

Before spending effort to find single appropriate sampling time for all nutrients, we can easily eliminate dates that are not appropriate as determined by nutrient concentration changing rapidly. For most species and nutrients, the time not to take needle samples is May through August. The time most nutrients change little for the five species samples is winter, January through March as indicated by the shaded portions of the tables. We will change the recommended sampling time from fall to winter.

Changing needle sampling time should be considered carefully. One reason to change sampling time is the current time is inappropriate as shown by rapid and large tissue concentration changes. The current time of late summer to early fall before rain begins is not the most stable for some nutrients, but does not have as much nutrient concentration change as the late spring and summer months of May through August. We think a winter sample date provide less change than current time, especially for potassium.

Management choices are another consideration in choosing or changing a needle sampling time. The current sampling time is 6 months from fertilizer application and a year from harvest. Moving the sampling time closer to fertilizer application and harvest allows growers to use current tree appearance and tissue analyses to formulate fertilizer program for the current season.

Changing the recommended time for taking a tissue sample is logical if the new time for sampling enhances the utility of nutrient monitoring and recommendation with needle sampling and is not physiologically incorrect or illogical.

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Table 1. Annual needle nitrogen concentration from five species of Christmas Trees. Current season needles taken from upper one-third of tree.

	Noble	Douglas	Grand	Nordmann	Turkish
	------------------------------ % ------------------------------				
June	1.6	1.7	1.6	1.6	1.3
July	1.3	1.9	1.6	1.8	1.6
August	1.1	1.7	1.4	1.5	1.7
September	1.1	1.5	1.5	1.5	1.5
October	1.4	1.6	2.0	1.2	1.4
November	1.3	1.5	2.1	1.2	1.5
December	1.2	1.6	2.0	1.3	1.5
January	1.2	1.6	2.0	1.3	1.4
February	1.2	1.5	1.9	1.1	1.3
March	1.1	1.6	2.0	1.1	1.3
April	1.1	1.6	2.0	1.1	1.3
May	1.2	1.7	2.0	1.2	1.4

Table 2. Annual needle phosphorus concentration from five species of Christmas Trees. Current season needles taken from upper one-third of tree.

	Noble	Douglas	Grand	Nordmann	Turkish
	------------------------------ % --------------------------------				
June	0.20	0.12	0.17	0.13	0.12
July	0.18	0.14	0.16	0.13	0.12
August	0.19	0.15	0.19	0.14	0.16
September	0.17	0.13	0.20	0.14	0.15
October	0.17	0.12	0.20	0.13	0.15
November	0.17	0.14	0.20	0.13	0.15
December	0.16	0.14	0.18	0.13	0.15
January	0.15	0.16	0.16	0.13	0.16
February	0.14	0.13	0.17	0.11	0.14
March	0.16	0.15	0.18	0.11	0.14
April	0.15	0.15	0.18	0.11	0.14
May	0.14	0.13	0.14	0.09	0.10

Table 3. Annual needle potassium concentration from five species of Christmas Trees. Current season needles taken from upper one-third of tree.

	Noble	Douglas	Grand	Nordmann	Turkish
	------------------------------ % ------------------------------				
June	1.1	0.5	0.8	0.7	0.7
July	1.0	0.9	0.7	1.0	1.0
August	0.9	0.9	0.8	0.9	1.0
September	0.7	0.9	0.8	1.0	1.0
October	0.8	0.8	0.9	1.0	1.0
November	0.7	0.7	0.8	0.8	0.8
December	0.7	0.6	0.6	0.8	0.8
January	0.6	0.7	0.5	0.7	0.8
February	0.5	0.4	0.5	0.7	0.6
March	0.6	0.5	0.6	0.5	0.6
April	0.6	0.5	0.7	0.6	0.6
May	0.6	0.6	0.6	0.7	0.6

Table 4. Annual needle calcium concentration from five species of Christmas Trees. Current season needles taken from upper one-third of tree.

	Noble	Douglas	Grand	Nordmann	Turkish
	-----------------------------	-----------	%	-----------	-----------------------------
June	0.25	0.22	0.24	0.18	0.28
July	0.31	0.41	0.63	0.39	0.51
August	0.33	0.42	0.79	0.31	0.47
September	0.34	0.31	0.90	0.27	0.40
October	0.41	0.39	0.78	0.48	0.60
November	0.42	0.42	0.77	0.45	0.59
December	0.45	0.47	0.73	0.50	0.62
January	0.48	0.47	0.74	0.53	0.69
February	0.49	0.47	0.80	0.51	0.56
March	0.49	0.47	0.82	0.40	0.55
April	0.56	0.49	0.89	0.44	0.59
May	0.89	0.60	1.20	0.56	0.70

Table 5. Annual needle magnesium concentration from five species of Christmas Trees. Current season needles taken from upper one-third of tree.

	Noble	Douglas	Grand	Nordmann	Turkish
	-----------------------------	-----------	%	-----------	-----------------------------
June	0.09	0.09	0.09	0.17	0.09
July	0.09	0.12	0.13	0.10	0.14
August	0.10	0.12	0.15	0.10	0.12
September	0.11	0.12	0.18	0.10	0.13
October	0.12	0.13	0.14	0.11	0.16
November	0.12	0.12	0.13	0.10	0.16
December	0.12	0.14	0.11	0.11	0.15
January	0.12	0.13	0.12	0.11	0.17
February	0.12	0.15	0.13	0.11	0.14
March	0.11	0.14	0.12	0.08	0.14
April	0.09	0.11	0.10	0.08	0.12
May	0.10	0.10	0.10	0.07	0.12

Table 6. Annual needle boron concentration from five species of Christmas Trees. Current season needles taken from upper one-third of tree.

	Noble	Douglas	Grand	Nordmann	Turkish
	-----------------------------	-----------	%	-----------	-----------------------------
June	27	11	23	14	9
July	32	12	31	22	14
August	41	20	55	21	16
September	44	14	72	23	15
October	48	12	66	17	13
November	45	11	60	16	12
December	40	15	53	17	12
January	42	13	51	20	15
February	43	17	54	19	12
March	46	18	58	15	13
April	44	16	56	16	13
May	55	12	71	14	13

Oral Presentations: Propagation

Current accomplishments in propagating *A. nordmanniana* at the CRA W

Jean Pierre Misson 1), JP and Philippe Druart 1)
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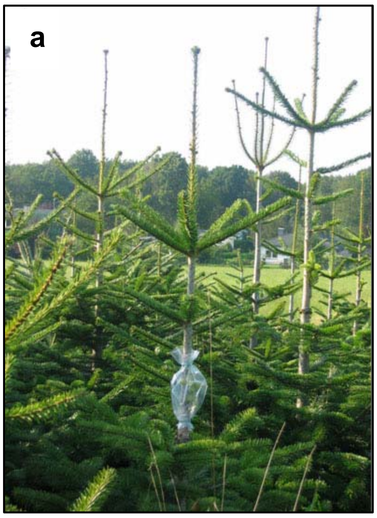
The investigations on the propagation of *A. nordmanniana* started at the CRA W in 1996 with the priorities to establish selected clones in seed orchards of this Christmas tree and to set up a technology for a large scale propagation based on somatic embryogenesis. Cutting more classical method was also considered a few years later.

Selected clones have been fixed following an original grafting method on adult plant material (J. P Misson Rev. For. Fr. LVII-4 2005) :

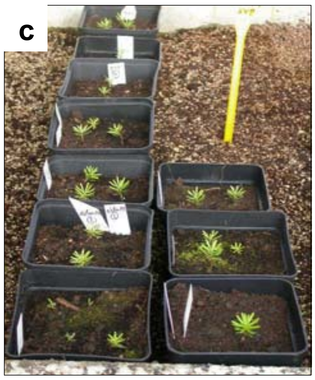
- Elites scions: first shoots from secondary axes (± 20 cm long), collected at early spring and cold preserved for 1 month (+4°C)
- Rootstocks: 8-10 years old trees from common seedlings.
- Cleft and side grafting or plate grafting: scion being cut closely under a bud and inserted until a close contact with the cambium occurs.
- Unions are held together tightly, protected against desiccation by a plastic bag and shaded (a).

First cones observed after ten years growth in the field proved that this manipulation hastened blooming.

a


A few lines from zygotic origin gave plantlets (c) after regeneration (b), maturation and germination of somatic embryos. Most of the lines are preserved in liquid nitrogen (Misson, J.P., Druart, Ph., Panis, B. and Watillon, B. 2006. *Propagation of ornamental plants* 6 (1):17-23.

b


c


d


The first results obtained from cuttings pointed out that some genotypes of *A. nordmanniana* are not recalcitrant to that easiest vegetative propagation method (d).

Integration of biotechnology, robot technology and visualisation technology for development of methods for automated mass production of elite trees

Jens Find
Tissue Culture Laboratory, Natural History Museum of Denmark

Biotechnology has become an integrated part of plant breeding, and in recent years new methods have been developed for breeding and propagation of important plants in the agricultural-, ornamental- and forestry sector.

One of the promising methods is somatic embryogenesis (SE), where plants are produced from single cells without sexual reproduction. SE has some particular advantages for the development of cost effective methods for clonal mass propagation of elite plants:

- It is a very effective and fast method for clonal propagation.
- The method is suitable for automatisation and robot technology.
- The method is, for several plant species, the preferred basis for development of additional biotechnological breeding technologies as e.g. genetic transformation.
- Elite clones can be stored over extended periods in liquid nitrogen at -196°C

However, commercial application of the technology has until now been hampered by two essential problems:

- The production costs per plant must be reduced. Labour costs are low in the early steps of the process whereas they increase dramatically during the later stages (Fig. 1).
- Improved methods must be developed for transfer and acclimatisation of plants from sterile *in vitro* conditions to non sterile (*ex vitro*/*in vivo*) conditions at the nursery.

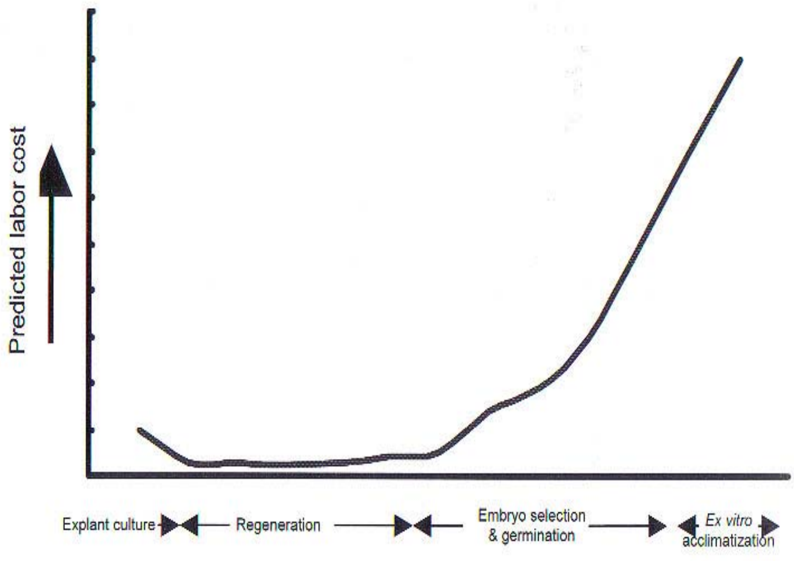


Fig. 1. Predicted labour cost by clonal propagation through somatic embryogenesis. The labour costs are very low in the early steps of the production, whereas they increase dramatically during the later stages: 'embryo selection & germination' and 'ex-vitro acclimatization'). The aim of the present project is to reduce labour costs associated with the late stages of the production of cloned plants through development of robot and visualisation technologies. (From Afreen & Zobayed, p. 96, 2005)

The presentation will report on a present project that takes advantage of effective methods for SE in Nordmanns fir (*Abies nordmanniana*) and Sitka spruce (*Picea sitchensis*) developed at the University of Copenhagen. These methods are used as model systems for development of automated plant production of plants for the forestry industry based on robot- and visualisation technology.

The commercial aspect of the project aims at: 1) the market for cloned elite plants in the forestry sector and 2) the market for robot technology in the production of plants for the forestry sector.

Oral Presentations: Growth Conditions

Effects of split fertilization on a coarse sandy soil as affected by climate manipulation and water accessibility

Lars Bo Pedersen[1)], Claus Jerram Christensen[2)], Morten Ingerslev[1)]
[1)] *Forest & Landscape Denmark, University of Copenhagen*
[2)] *Danish Christmas Tree Growers Association*

In Denmark, sandy soil has a large production potential for high quality Christmas trees, mainly because the tree growth is more easy to control without the risk of achieving too long leaders. On the other hand, it has only been allowed to fertilize the Christmas tree on sandy soils with 75 kg N/ha/year (mean value during the rotation) in Denmark. Furthermore, climate change scenarios for Denmark predict increased yearly precipitation, but also more warm and dry summers.

The objective of this study was to investigate the sufficiency of the current fertilizer standard for high quality Christmas tree production and to elucidate different fertilizer regimes effects on leaching of especially nitrogen.

The study was carried out on a out washed moraine soil in Southern Jutland from 2002 to 2006. Different fertilization regimes (fertilizer amounts, time of application) combined with water supply and drought during the growth period was compared in 13 fertilization treatments. Christmas tree quality (leader length, colour etc.) was measured every year whereas measurements of nutrient and water cycling were performed on a continuously basis.

Christmas tree quality responded positively on split fertilization and drought and negatively on increased supply of water. Leaching of nitrogen was only slightly reduced by split fertilization (10,5 kg N/ha/year) and drought (8.9 kg N/ha/year) manipulation compared with spring fertilization (11.5 kg N/ha/year). However, increased watering (462 mm/year) as well as increased supply of N-fertilizer (from 75-105 kg/N/ha/year) increased the N-leaching (16 kg/ha/year). However, leaching of nitrogen varied considerably between the different years. We believe that different success with weed control may have had a pronounced effect on the leaching.

In order to improve the tree quality it is recommended to split the fertilization. An altered precipitation in the growth period as a result of climate changes may result in appreciable effects on the tree quality on comparable soils. Increased precipitation resulted in a poor green needle colour and promoted more open trees with longer leaders. The effect of drought was opposite. Drought also reduced the nitrogen leaching slightly whereas the water application caused a significant increase in nitrogen leaching.

None of the fertilizer treatments raised concerns regarding an increase in nitrogen leaching. The results suggest that increased N-fertilization probably could work without serious effects on the ground water. However, such recommendation can only be given on the basis of new experiments with increased fertilizer amount as well as experiments which take into account the effect of weed control on the leaching.

Canopy Temperature as Crop Water Stress Indicator in Irrigated Fraser fir (*Abies fraseri*)

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Background

Fraser fir is currently the most valuable Christmas tree species in Michigan and is now one of the major planted tree species in the State. However, the native range of Fraser fir in the southern Appalachian Mountains receives more total precipitation and has lower average temperatures than Michigan. Consequently growing Fraser fir in Michigan presents some management challenges, including the need to provide supplemental irrigation to meet the physiological needs of the tree.

Several Michigan growers now routinely provide supplemental irrigation to maintain the quality of their trees. Recent water use regulation requires irrigators to develop and document a clear rationale for irrigation scheduling. We have been investigating several approaches for scheduling and timing irrigation in Christmas tree farms in Michigan.

One very attractive approach currently under study is the use of canopy temperatures as indicator of the plant water stress. This approach is based on the basic assumption that transpiration cools the leaves and as available soil moisture decreases, transpiration is reduced and therefore the temperature of the leaves increases. The energy balance equation (1) can therefore be used to define the condition of transpiring and non-transpiring foliage.

$$R_n = G + \lambda E + H \qquad (1)$$

Where: R_n is the net radiation in (W m^{-2})
H the sensible heat flux from the canopy to the air in (W m^{-2})
G the soil heat flux below the canopy (W m^{-2})
λE the latent heat flux to the air in (W m^{-2}) with λ being the heat of vaporization.

Using the approach developed by Monteith (1973), H and E can be expressed as:

$$H = \rho C_p (T_c - T_a)/r_a \qquad (2)$$

$$\lambda E = \rho C_p (e_c^* - e_A)/[\gamma(r_a + r_c)] \qquad (3)$$

Where:
- ρ — The density of air (kg m^{-3})
- Cp — The heat capacity of air (J Kg^{-1} °C^{-1})
- e_c* — The saturated vapor pressure of the air in (Pa)
- e_A — The actual vapor pressure of the air (Pa)
- γ — The psychrometric constant (Pa °C^{-1})
- r_a — Aerodynamic resistance (s m^{-1}) and
- r_c — the canopy resistance (s m^{-1}) to vapor transport

By combining equations (1), (2) and (3), assuming G is negligible and defining Δ as the slope of the saturated vapor pressure temperature relation (e_c* -e_A*)/(T_c-T_A) in Pa °C^{-1}, we obtain the following equation:

$$T_c - T_a = \frac{r_a R_n}{\rho C_p} * \frac{\gamma(1+{r_c}/{r_a})}{\Delta + \gamma(1+{r_c}/{r_a})} - \frac{e_a * - e_a}{\Delta + \gamma(1+{r_c}/{r_a})} \quad (4)$$

This equation relates the difference between the canopy and air temperatures (Tc-Ta) and the vapor pressure deficit of the air. The upper limit (ul) can then be calculated by allowing r_c to increase without bound (r_c ----> ∞), and the lower limit (ll) is found r_c = 0.

The crop water stress index is then calculated as follows:

$$CWSI = \frac{(Tc - Ta) - (Tc - Ta)_{ll}}{(Tc - Ta)_{ul} - (Tc - Ta)_{ll}} \quad (5)$$

The goal of the project is to evaluate changes in canopy temperature measurements and crop water stress index as related to changes in soil moisture for the purpose of scheduling and timing irrigation.

The study

Canopy temperatures were continuously recorded by infrared thermometry (IRT). The IRT readings were stored in a CR1000 datalogger (Campbell Scientific Cie, Logan, Utah). Weather parameters including air temperature, relative humidity sensor, wind speed and direction, solar radiation, and rain fall were also continuously recorded and datalogged.

Pertinent variables recorded between 11:00 and 14:00 each day were fed into models derived from the Penman-Monteith equations to determined the crop water stress index (CWSI), use as tool for irrigation scheduling in Fraser fir. The usefulness, practicality and limitations of such model in Christmas tree production will be discussed.

Graphical summary of results

We calculated the upper limit, and lower limit of the relation between the VPD and the Tc-Ta (Example presented in figure 1), and throughout the season, Tc-Ta measured between 11:00 and 14:00 (when plant stresses are supposed to be at the maximum) were calculated. The weather data including rainfall and temperature for that location are presented in figure 2. The data shows that from early June to late July, the area received very low levels of rainfall, increasing the possibility of water stress in non irrigated plots. We then used the equation (4) presented above to calculate the CWSI for that day (Figure 3 (a)).

The CWSI chart (Figure 3 (a)) shows the calculated crop water stress index for non-irrigated Fraser fir trees at one of our experimental sites. The x axis shows the day of the year, with the experiment starting on day 138 (May 16, 2007). The recommended threshold for most agricultural crop is between 0.3 and 0.7. The data clearly shows that as the season progressed the CWSI increased.

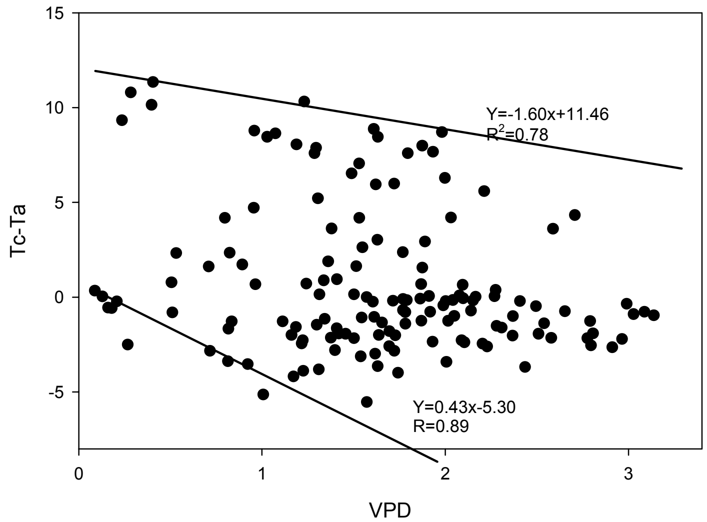


Figure 1: Tc-Ta and VPD relationship for non irrigated trees at the research location.

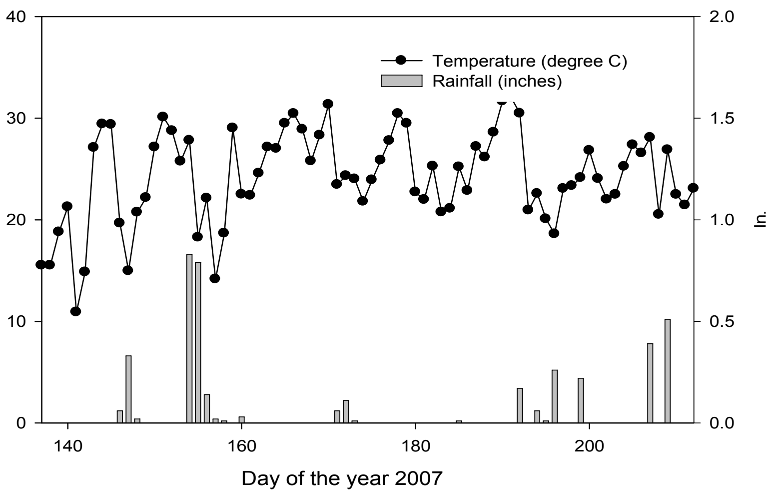
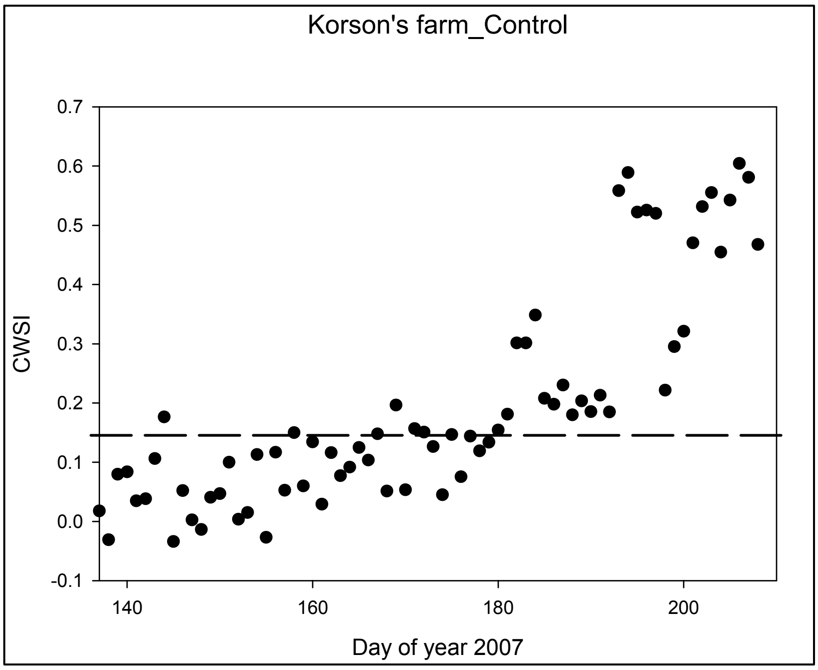


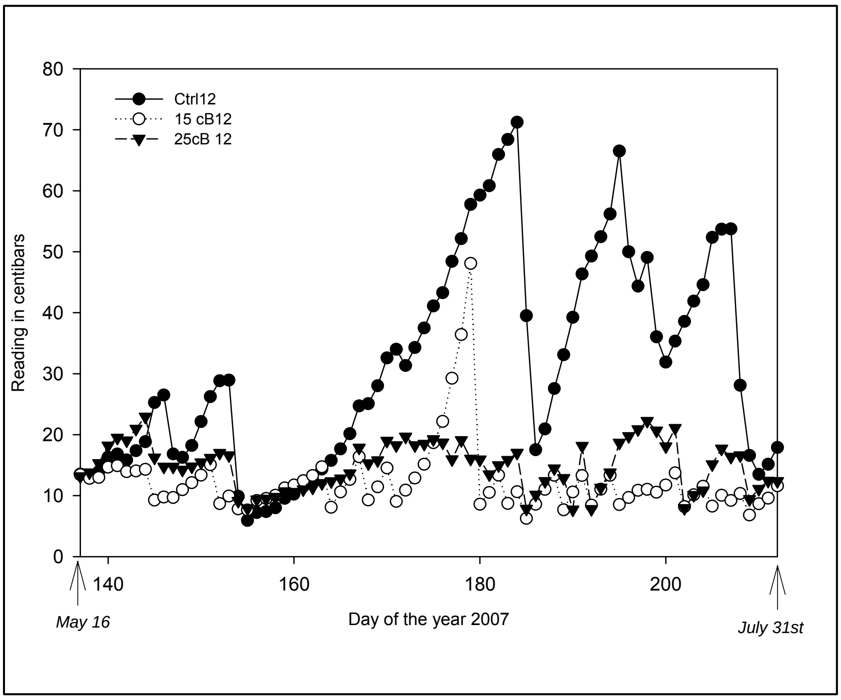
Figure 2: Rainfall and average temperature at the research site.

We are also looking at the possibility of using canopy temperature alone may be combined with readily available climatic factors to determine or predict plant stress for the purpose of scheduling and timing irrigation.

Increased in CWSI were correlated with increases in soil water potential data measured with tensiometer (Figure 3 (b)). We are working on approaches to determine the exact threshold to recommend for irrigation of Fraser fir at various stages of the rotation.



(a)



(b)

Figure 3: (a) Calculated crop water stress index for a non irrigated Fraser fir plot. Horizontal line at CWSI=0.3 indicate the published stress threshold for most agricultural crops. (b) Changes in soil water potential measured by tensiometers at the same location. The data show increased soil water tension well correlated to increase CWSI.

Cold Hardiness and Morphological Characterization of Containerized Conifers Used as Live Christmas Trees

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Containerized conifers are increasingly marketed and used as live Christmas tree in the United States and around the World. The idea is to use the tree for the holidays and plant it into the landscape after the season. However, prolonged duration under warm winter indoor conditions can reduce the cold hardiness, resulting in shortening of the dormancy and resumption of growth. The goal of the study was to investigate the morphological and physiological changes on trees exposed to indoor conditions with the aim to determine the optimal duration for indoor use of live containerized trees.

The study

Three species, Black Hills spruce, Balsam fir and Douglas fir were included in this study. Fifteen trees of each species measuring 3-4 ft in height were dug in the fall of 2006 and potted in a potting medium made of pine bark (85%) and peat moss (15%), with a sulfur amendment to achieve a target pH of 5.5. In addition nine 5 ft tall pot-in-pot container-grown Black Hills spruce donated by Candy Cane Christmas tree farm were included in the study.

All trees were transported into a heated room at MSU for conditioning and testing. Trees were assigned at random to three indoor display durations: 0 (control), 10 or 20 days. All trees were placed in a heated and lighted room simulating conditions similar to those a containerized tree would be exposed to in any standard household. Trees were watered as needed and thermocouples connected to dataloggers were used to measure soil and air temperatures in each treatment. Cuttings were taken from each tree on days 0, 3, 7, 14, and 20 for cold hardiness testing. The cuttings were divided into one control and 10 temperature treatments from -3 to -30°C for the artificial freeze testing.

Visual evaluations were made on both the buds and the needles of each clipping, and the temperature necessary to cause more than 50% damage (LT50) on buds and needles was recorded as the cold hardiness temperature. At the end of the indoor exposure, trees were moved into an unheated barn until planting in the spring on March 30, 2007. The post transplant quality and survival was assessed on a monthly basis and the final evaluation and survival recorded three months after transplanting.

Bud Morphology

Our study showed that it took average temperatures of -27°C to -30°C to cause more than 50% damage (LT50) on buds of trees that were not brought indoors. After 3 days indoors, the LT50 was between -24°C and -27°C depending on the species. After 7 days indoors, the LT50 decreased by another 3 degrees to -21°C for balsam fir and Douglas fir, and -24°C for Black hills spruce. After 14 and 20 days indoors it took temperatures of -18°C and -15°C to caused more than 50% damage on buds respectively (an example for black hill spruce is presented in figure 1).

This indicates that after 20 days indoor display, trees are hardy to approximately -15°C, and when placed outdoors, tress are likely to develop serious winter damages if the outdoor temperature reaches this point. For example, average January temperatures for East Lansing are -11°C, and the record minimum temperature is -29°C. The maximum air, minimum air, and average soil temperatures (inside the pot) recorded during our experiment are presented in figure 2 below. The difference between average winter temperatures and the bud and needle LT50 following various indoor exposure treatments, gave us an indication of what can be acceptable. The study showed that the LT50 after 14 days (-18°C) and 20 days (-15°C) are very close to winter averages and shall normally result in serious bud damage. After 3 and 7 days indoor buds had LT50's 10°C or more below normal winter averages suggesting good bud survival, unless we have an exceptional cold year with temperatures nearing this bud LT50 temperature.

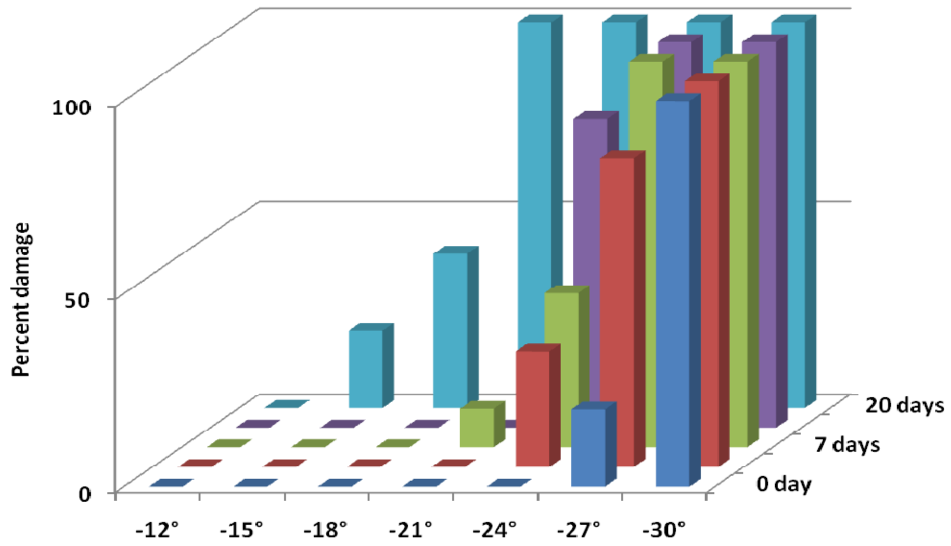

Figure 1: Bud damage rating for Black hills spruce after indoor storage and laboratory artificial freezing test.

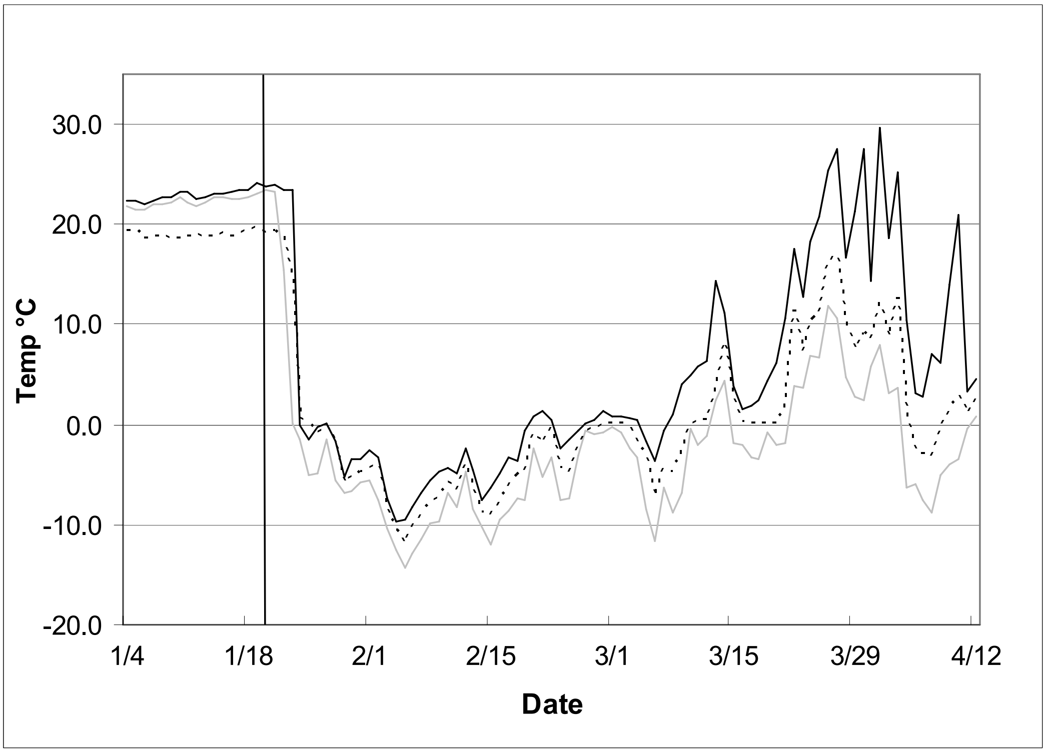

Figure 2: Maximum air (black line), minimum air (grey line), and average soil temperatures (dashed line) observed during treatment. The vertical line represents the time at which the last trees were moved into cold storage.

Needle damage was apparent for *Picea glauca* at -21°C and *Pseudotsuga menziesii* showing damage at temperatures as high as -3°C. Chlorophyll fluorescence measurements were good indicator of needle damage at low temperatures. Visual ratings of trees after transplanting were consistent with morphological changes observed in terms of damage to the buds and needles. Our results indicate that the appropriate duration for keeping containerized trees indoors is somewhere between 7 and 14 days. Further research including larger sample sizes and more variables is in progress to improve the understanding of physiological processes and determine the appropriate threshold.

Warm temperature spells affect dormancy and cold hardening in *Abies procera* and *A. nordmanniana*

Christian Nørgaard Nielsen[1], Hanne N. Rasmussen[1]
[1] *Forest & Landscape Denmark, University of Copenhagen*

Bud damages due to climate are frequent in cultivation of *Abies procera* Rehder in Denmark, less so in *A. nordmanniana* Spach. More extreme weather, such as spells of unseasonal warmth during winter, are expected with the pending climate change.

Cold hardiness and bud dormancy were tested during winter under varying acclimation regime (closed-top chambers) and experimental warm spells. *A. procera* revealed a deeper dormancy than *A. nordmanniana*. Acclimation regime did not strongly alter *average* dormancy, but seriously affected within-sample variation in dormancy release.

High acclimation temperatures resulted in less hardiness in *A. procera*. *A. procera* did not deharden in response to a warm spell in autumn, while *A. nordmanniana* dehardened considerably. Both species dehardened with warm spells in early spring, i.e. the natural dehardening was accellerated, but only *A. procera* could subsequently recover to approach the seasonal control. Responses differed with duration and timing of the warm spell. Warm spells raised the frequency of “secondary dormancy” in in buds of *A. procera*, i.e., buds that remain apparently intact but with a delay in bud break.

For *A. procera*, fluctuating temperatures appeared particularly problematic, not only because of frost damages *per se*, but also because of reduced vitality, presumably because the adjustments (dehardening and recovery) are energy consuming. This explains the coastal climate preference of this species. Subcontinental cultivation requires sheltering, e.g by hedging, snow cover or topography.

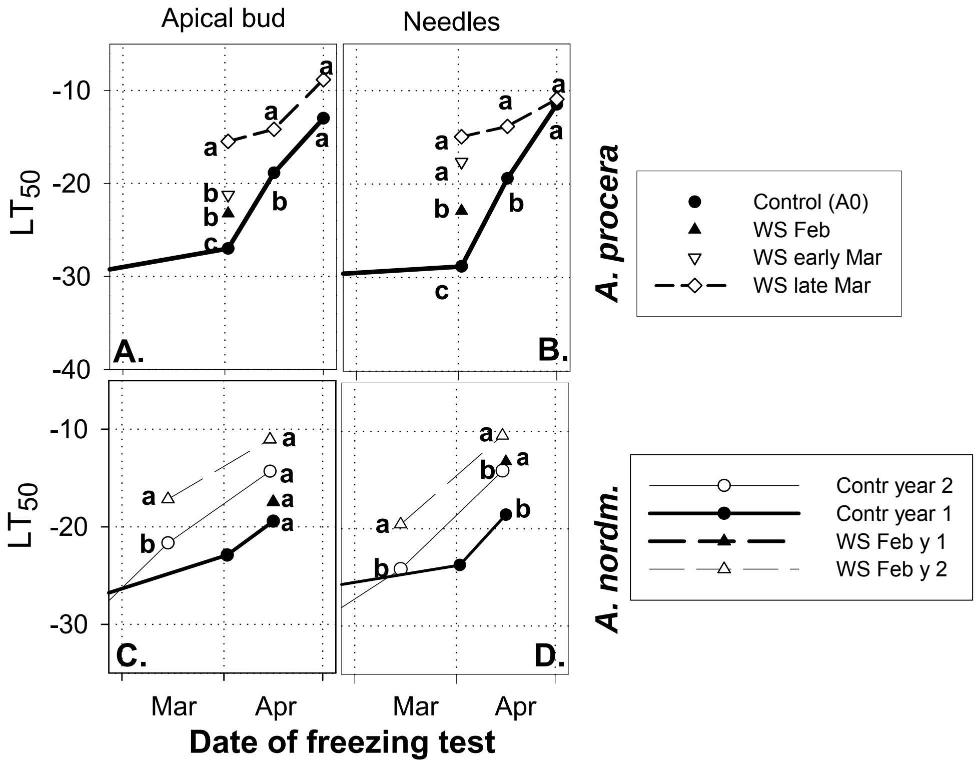

Figure 1. Dehardening in *A. procera* and *A. nordmanniana* in response to warm spells in later winter, parallel reactions in apical buds (left) and needles (right). Dehardening is expressed as an increase in the temperature that causes 50% of damage (LT_{50}). The more recent the warm spell at testing time, the stronger effect on LT_{50} (A, B). The late March treatment is seen to recover in subsequent tests (curve convergent to the control curve). In *A. nordmanniana*, however, dehardening after warm spell appears to be a permanent shift compared to the normal (control) spring dehardening process.

Hanne N. Rasmussen, Ph.D and D.Sc., is a plant biologist and senior scientist at Forest & Landscape Denmark, University of Copenhagen and has worked on species of *Abies*, mainly *A. nordmanniana*, for seven year. Main interest are growth regulation, hormonal relations in the tree crown, and whole plant physiology generally.

Christian Nørgaard Nielsen, D.Agr., is associate professor in forestry, also at Forest & Landscape Denmark. His research interests are within ecology and management of trees, particularly relating to structure and organization of the woody root system, biomass research, tree architecture, anchorage and physiological stability, tree longevity, and stress hardiness.

Oral Presentations: Tree Health

Challenges to managing *Phytophthora* root rot in California's Sierra Nevada foothills

Lynn Wunderlich[1] Gary Chastagner[2]
[1] *University of California-Cooperative Extension,* [2] *Washington State University, Puyallup, WA.*

Introduction

Phytophthora root rot has been found to be a major problem in the choose- and-cut Christmas tree production region of the California Sierra foothills. In this region, white fir *(Abies concolor*), California red fir (*A. magnifica*), and Douglas-fir *(Pseudotsuga menziesii)* are the dominant Christmas tree species grown. Heavy clay soils, spring temperatures that fluctuate rapidly prefacing typically hot summer climates, and the lack of summer rainfall, which makes it necessary to irrigate during the growing season, may all predispose trees to *Phytophthora* infection.

Managing *Phytophthora* in soils where it has become established is extremely difficult and is causing economic losses for foothill Christmas tree growers. In 2002, growers with dying trees began making inquiries to the U.C. Cooperative Extension office as to what was killing their trees and what might be done about it. *Phytophthora*, specifically *P. cinnamomi*, and in some cases the "oak root fungus" *Armillaria*, were indicated during several farm calls. In 2003, a pilot study evaluating two fungicides, mefenoxam (Subdue), applied at planting as a root dip and after planting as a soil drench, and fenamidone applied as a soil drench, as well as a cultural technique, planting on a raised bed, resulted in no difference in mortality to white fir and noble fir (*A. procera*) as compared to an untreated control. However, none of the Nordmann *(A. nordmanniana)* and few of the Douglas-fir in the trial died.

This pilot study indicated that while chemical control of *Phytophthora* in field situations is difficult, planting species with possible *Phytophthora* resistance, such as Nordmann fir, may be a means of managing this disease. Furthermore, some growers in the area were beginning to experiment with growing Nordmann fir, but little is known about how this species will respond to local growing conditions. Thus, with the assistance of the Chastagner lab in Washington State, the opportunity to evaluate selections of Nordmann and Turkish *(A. born-muelleriana)* fir planted in naturally infested *Phytophthora* sites was undertaken in 2004.

Our objectives for this study were:

1.) to evaluate the susceptibility of twelve sources of Nordmann and Turkish fir to *Phytophthora* under naturally infested <u>field</u> conditions and

2.) to evaluate the growth and potential of Nordmann and Turkish fir for Christmas tree production in the California Sierra Nevada foothills.

Methods

In early March 2004, bareroot seedlings (P1-2) of nine sources of Nordmann fir and three sources of Turkish fir were shipped to Placerville, California from Washington State (Table 1).

Eight single tree replicates of each of the twelve sources of Nordmann and Turkish fir, and a local 'Grizzly Flat' source of white fir (P1-1) included for comparison, were planted in a randomized complete block design in early March, 2004 at three farm sites located at three elevations (approx. 2600-4100 ft., or 792-1250 m) in El Dorado county, California (Table 2).

The three sites chosen had various histories of native *Phytophthora* infestations. Once planted, the management of the blocks was left to the individual growers.

Table 1: Sources of Nordmann (*Abies nordmanniana)* and Turkish (*Abies bornmuelleriana)* fir Provenances and Progeny planted in 2004 California study.

Nursery Code	Seedlot & Source
	Turkish fir sources
1	291 , Turkey, District: BURSA, Locality: Komursu
3	297 , Turkey, District: Adapazan, Locality: Hendek
4	298 , Turkey, District: Adapazan, Locality: Akyazi
	Nordmann fir sources
5	302 , Turkey, District: Artvin, Locality: Yayla
12	Randbol 053/00, Denmark Statsskovenes Planteavlsstation
22	Koberhavn 076/00, Denmark Statsskovenes Planteavlsstation
13	Vallo #1 H 254-00, Denmark Klon Hedeselskabet Forest Seed Center
14	Vallo #7 H 212-00, Denmark Klon Hedeselskabet Forest Seed Center
15	Vallo #12 H 213-00, Denmark Klon Hedeselskabet Forest Seed Center
16	Vallo #13 H 256-00, Denmark Klon Hedeselskabet Forest Seed Center
17	Vallo #15 H 267-00, Denmark Klon Hedeselskabet Forest Seed Center
18	Vallo #18 H 214-00, Denmark Klon Hedeselskabet Forest Seed Center

Table 2: Planting dates and site descriptions for 2004 California Nordmann/Turkish *Phytophthora* studies.

Site	Date planted, 2004	Elevation ft. (m)	*Phytophthora* history/ field notes
Rapetti Farms	March 6	2600 (792)	New site with no known history of disease. *P. cinnamomi* positively identified on block across road.
McGee/Carson Ridge	March 8	2850 (869)	Known *Phytophthora* site. Interplanting among stump cultured trees made block design difficult. Reps. 1-4 at McGee, Reps. 5-8 at adjacent Carson.
Harris Ranch	March 12	4100 (1250)	History of aerial *P. citricola* shoot blight (1986). Potential infested ditch irrigation water.

Periodic visits to the sites to visually check for dead and dying trees occurred in 2004, 2005 and 2006. In 2004 and 2005, the dying trees were dug up, the roots were inspected and any j-rooting or girdling noted, and then the roots were shipped to Puyallup for *Phytophthora* isolation and culturing. In 2004, five pieces of suspect roots from each root system were randomly chosen and plated onto CARP medium. The resulting *Phytophthora* cultures were transferred to V8 agar and the cultures were then examined to identify the species of *Phytophthora* isolated. In 2005, ELISA tests were performed on root pieces to confirm the presence of *Phytophthora* spp. Tree height and central leader measurements were taken in September of 2005 and 2006.

Results and Discussion

The percent survival of trees varied by site and source (Table 3). Overall, the Nordmann fir Vallo #13 H 256-00, and Vallo #12 H 213-00 (nursery codes 15 and 16) progeny had the greatest survival at all three sites. The McGee-Carson site lost the most trees, 25-100% of specific sources planted at this site died. *Phytophthora* was recovered from most of the root systems that were sampled (46 of 59 positive) at this site. One isolate was positively confirmed to be *P. cinnamomi*, although other isolates also appeared to be this species based on hyphal characteristics. *Pythium* and various contaminants, or no growth developed from the 13 root systems that did not yield *Phytophthora*.

None of the trees lost at the Rapetti and Harris Ranch sites died due to confirmed *Phytophthora* infections. Some of the trees from these sites failed to break bud the first year. *Pythium*, a potential pathogen whose importance is not well understood, was isolated from about half of the samples from the Rapetti and Harris sites. The other samples were either contaminated or yielded no growth.

We were only able to recover *Phytophthora* from dead and dying trees at the McGee-Carson test site in this study. Overall, this test site had the highest mortality rates and most of the mortality appeared to be caused by *P. cinnamomi*. This site differed from the other sites in that the seedlings were interplanted among larger stump-cultured trees. It is unclear if this increased disease pressure due to increased inoculum availability or if the seedlings at this site were under more stress because of increased competition for nutrients and water.

Although only a small number of seedlings from each source were planted at this site, this study raises questions about the potential effectiveness of planting Nordmann or Turkish fir as an acceptable management tool to minimize losses associated with *Phytophthora* root rot that is caused by *P. cinnamomi.* It would be beneficial to confirm the results of these tests with larger numbers of seedlings under more controlled conditions. Additional tests are also needed to determine the susceptibility of Nordmann and Turkish fir to other species of *Phytophthora* that are commonly found in Christmas trees. If additional studies confirm the results from our experiment, other strategies for controlling this severe disease will need to be developed.

Table 3: Percent survival of trees by nursery code (n=8 trees) from each field site.

Nursery Code	Seedlot & Source	Rapetti	McGee-Carson	Harris
Turkish				
1	291 BURSA, Komursu	100	38	88
3	297 Adapazan, Hendek	100	38	63
4	298 Adapazan, Akyazi	100	38	88
Nordmann				
5	302 Artvin, Yayla	75	38	88
12	Randbol 053/00	88	0	100
22	Koberhavn 076/00	75	38	75
13	Vallo #1 H 254-00	100	25	100
14	Vallo #7 H 212-00	88	38	88
15	Vallo #12 H 213-00	100	50	100
16	Vallo #13 H 256-00	75	75	100
17	Vallo #15 H 267-00	100	38	100
18	Vallo #18 H 214-00	88	25	100
White fir	Grizzly Flat, CA.	88	25	88

Although the trees in these trials are still fairly young, some growth differences are already evident. In comparison to the average height measurements of the twelve sources of

Nordmann and Turkish fir at the Rapetti and Harris Ranch sites in 2006, the white fir has grown the fastest thus far, with an average height of 91 to 117 cm (Figure 1). Among the Nordmann and Turkish fir sources, the Turkish fir sources tend to be taller than the Nordmann fir sources. Since these trees were only in their third growing season when measured, it will be beneficial to continue annual measurements to monitor changes in the height of the Nordmann and Turkish fir to see if they "catch up" to the native white fir. In addition, grower feedback on tree quality will be gathered and observations of other pest damage, particularly adelgids, will be noted in the coming years prior to harvest.

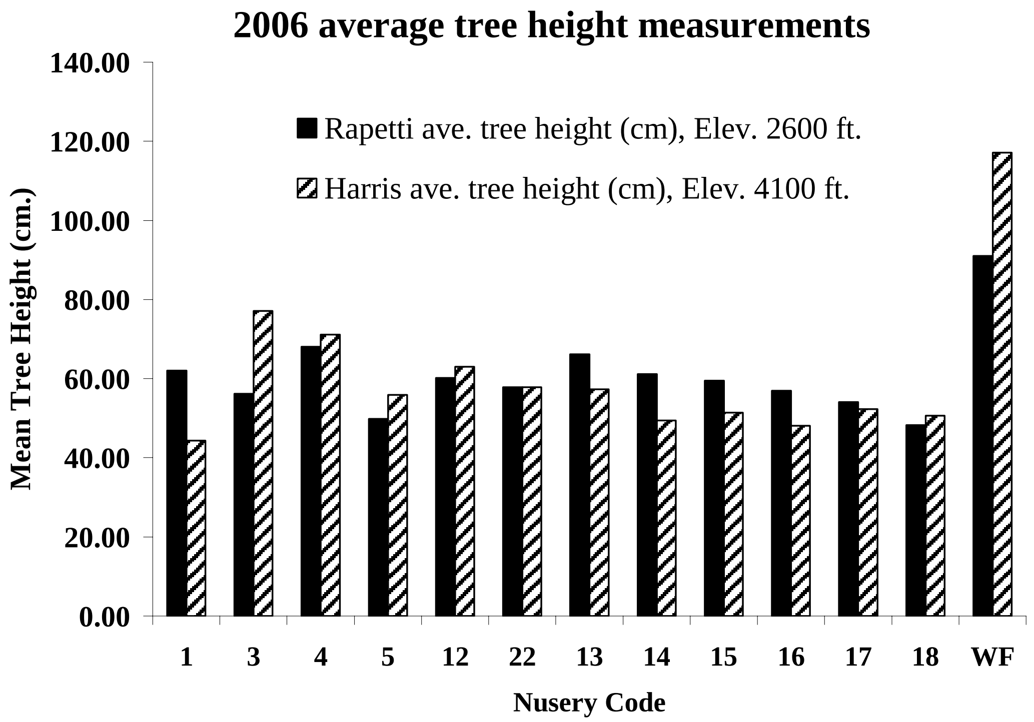

Figure 1. Average height measurements (cm) of Nordmann and Turkish fir sources by nursery code as compared to a native 'Grizzly Flat' white fir at two sites: Rapetti and Harris Ranch, 2006.

*Acknowledgements***.** A special thanks to the grower cooperators: Mike Mcgee, Randy Rapetti and Bill and Blair Harris and to the El Dorado Christmas Tree Growers Association for support. The assistance of Kathy Riley, Annie DeBauw, and Jenny Glass at Washington State University for their work on isolations, and to Oregon State University's Paul Reeser for assistance in the *Phytophthora* species identification. The production of seedlings by the B.C. Ministry of Forests Tree Improvement Branch and Silver Mountain Conifer Nursery and the assistance of Chal Landgren is gratefully acknowledged.

Biography for Lynn Wunderlich
Lynn has worked since 2000 as a Farm Advisor for the University of California Cooperative Extension in El Dorado and Amador Counties. Her responsibilities include vineyards, tree fruits and specialty crops in addition to Christmas trees. Her program emphasis is on sustaining agriculture with an emphasis on environmentally sound pest management.

Risk of spread of *Phytophthora ramorum* in Christmas trees

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The identification of several conifers as hosts of *Phytophthora ramorum* has increased concerns about the potential spread of this regulated exotic pathogen via shipment of Christmas trees, conifer nursery stock, and various forest products. This exotic, federally-quarantined plant pathogen causes sudden oak death and Ramorum blight. Sudden oak death was first reported from the central California coast in the mid-1990s and a previously unknown *Phytophthora* species, *P. ramorum*, was shown to be the cause of this new disease in 2000. In the California counties of Marin, Santa Cruz, and Monterey, portions of the wildland-urban interface changed dramatically as tree crowns turned brown and died. Since then, over a million tanoaks (*Lithocarpus densiflorus*), California black oaks (*Quercus kelloggii*), and coast live oaks (*Q. agrifolia*) have been killed in the central California coastal area by *P. ramorum*. In addition to tanoak, coast live oak and black oak, this organism has naturally infected more than 100 other plant species from 21 different plant families including several species of conifers.
(http://www.aphis.usda.gov/plant_health/plant_pest_info/pram/downloads/pdf_files/usdaprlist.pdf)

Most of the non-oak hosts develop leaf spots and/or twig dieback when infected by *P. ramorum* and are not usually killed. These diseases are commonly referred to as Ramorum blight or dieback. Currently, the United States Department of Agriculture Animal Plant Health Inspection Service (USDA-APHIS) recognizes Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), white fir (*A. concolor*), California red fir (*A. magnifica*), coast redwood (*Sequoia sempervirens*), Pacific yew (*Taxus brevifolia*), and California nutmeg (*Torreya californica*) as proven or associated hosts of *P. ramorum*, making these native conifers subject to federal and state quarantines in regulated areas. In addition, some 20 species of conifers have been shown to be susceptible to this pathogen under experimental conditions.

The risk of conifers being infected by *P. ramorum* under natural conditions is poorly understood. In California, infected conifers commonly occur as understory plants beneath or adjacent to heavily infected plants like California bay laurel (*Umbellularia californica*). During wet periods, *P. ramorum* is known to produce a copious amount of spores from spots on infected leaves of this epidemiologically-important host. In Oregon, however, infection on California bay laurel is uncommon and infection of Douglas-fir trees has been limited to two seedlings directly beneath infected tanoak trees in the regulated area in Curry County.

A number of studies are currently underway that are examining the influence of various environmental conditions, inoculum levels and host phenology on the infection of a number of hosts by *P. ramorum*. Most of these studies are being conducted on hosts growing within various types of mixed forest communities. Currently, it is unclear what the level of risk is for infection of conifers in Christmas tree plantations, conifer nurseries, and coniferous forests. Laboratory studies indicate that infection of Douglas-fir seedlings is limited to a brief period of time right after bud break and is dependent on the inoculum concentration they are exposed to. It is unclear if conifer-to-conifer spread of this disease is possible.

To assess the potential risk associated with the movement of *P. ramorum* via infected Christmas trees, a better understanding of the factors that influence infection under field conditions is needed. The spread and development of *P. ramorum* has been monitored since 2005 in a 23-acre U-cut Christmas tree farm near Los Gatos, California. Located within a regulated county, this site provides a unique opportunity to study the spread of *P. ramorum* from the interface of a mixed forest containing highly susceptible hosts into a Christmas tree plantation.

Conifers being grown at this site include Douglas-fir, grand fir, giant sequoia (*Sequoia-dendron giganteum*), Scots pine (*Pinus sylvestris*), white fir, and California red fir. Some known *P. ramorum* hosts in the infected forest adjacent to the edge of the Christmas tree farm include: California bay laurel, madrone (*Arbutus menz*iesii), big leaf maple (*Acer macro-phyllum*), toyon (*Heteromeles arbutifolia*), coast redwood, and tanoak. After mapping the perimeter of the farm to identify areas where Ramorum blight was evident, 500 trees in the largest area with a past history of infection were mapped, tagged and measured for height.

A series of 6 transects were established in 2005 from the edge of the forest into the Christmas trees in this area to monitor the spread of *P. ramorum*. The length of these transects ranged from 17 to 27 meters. In addition to the established Christmas trees, in 2006 and 2007 container-grown Douglas-fir and grand fir seedlings that had just broken bud, as well as small rhododendron plants (*Rhododendron* x 'Nova Zenebla'), were also placed along three of these transects at approximately 0, 3.5, 8, and 13 meters from the forest edge. The level of infection and extent of shoot dieback was assessed on the tagged trees and containerized seedlings periodically during the spring and summer.

In 2005, 2006, and 2007 new shoot infections on the Christmas trees developed only in the spring, and initial dieback symptoms were limited to newly expanded shoot tips (Fig. 1). Environmental conditions during spring 2005 were much more favorable to initial shoot tip infections than in 2006 and virtually no infections occurred during spring 2007. In particular, along the 6 transects where grand fir were underneath the canopy of infected California bay laurel, virtually all of the new shoots were infected shortly after bud break in 2005. The progression of dieback on infected shoots of Douglas-fir and grand fir in 2005 continued for about 4 weeks after the initial appearance of symptoms, typically spreading about 5 cm into the previous year's growth (Fig. 2). The extent of dieback did not increase between early summer and mid-November. In addition, preliminary data indicates that *P. ramorum* does not produce sporangia on infected Douglas-fir and grand fir shoots.

Figure 1 Symptoms on Grand fir: wilting of new shoots and shoot dieback.

Figure 2. Shoot dieback on Grand fir.

Infection rates and disease severity were very high among container-grown seedlings that were placed along the interface of the forest and Christmas tree farm in 2005. On May 19, 2005, 81.7 and 94.3% of the Douglas-fir and grand fir seedlings, respectively, that had been exposed since April 21 had become infected. The percentage of each seedling that was killed as the result of shoot dieback averaged 52.8% for the Douglas-fir and 81.2% for the grand fir. In 2006 and 2007, infection of conifer seedlings and rhododendrons placed along the transects only occurred during exposure periods when precipitation occurred and when the plants were in close proximity to infected California bay laurel.

Data collected during the past three years at this site indicates that distance from infected plants (predominantly California bay laurel) within the forest is an important factor relating to the infection of the Douglas-fir and grand fir Christmas trees. Most of the infected Christmas trees and seedlings occurred within 2 to 4.4 meters of the edge of the forest. Virtually no infection was evident on Christmas trees or seedlings that were 5 to 8 meters away from the forest edge. These data and the apparent inability of the pathogen to spread from conifer to conifer, suggest that there is a very low risk of *P. ramorum* developing in Christmas tree plantations that are not associated with infected high inoculum producing plants, such as California bay laurel, and thus there is very little risk of spreading the pathogen via the movement of Christmas trees from these types of sites.

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Delphinella abietis and *Herpotrichia parasitica* cause needle damage in Norwegian Christmas tree plantations

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Summary
Extensive damage by the needle parasites *Delphinella abietis* and *Herpotrichia parasitica* was recently observed on fir (*Abies* spp.) in Christmas tree fields at the west coast of Norway. *D. abietis* was by far the most widespread, but once established in the field, the damage potential seemed to be equally high for both pathogens. None of the diseases are new to the flora of Norway, but they have previously not been problematic in Christmas tree fields. Fungicide application on Christmas trees infected by *D. abietis* gave good results.

Introduction
Delphinella abietis (Rostrup) E. Müller (syn. *Delphinadella abietis* and *Rehmiellopsis abietis*) is according to Ellis and Ellis (1997) parasitic on living needles of fir (*Abies* spp.). In Norway it attacks current year needles during shoot elongation in May/June. The disease is mainly a problem in north-western Europe, but limited attacks have been seen in regions further south. In Austria, only minor damages were observed (Thomas Cech, Federal Research and Training Centre for Forests, personal communication). We had access to herbarium material collected by T. Cech from silver fir (*Abies alba*) in Austria during 1990 and 1991. Compared to Norwegian samples, the symptoms were identical, but much less severe. Jørstad (1936) reported that *D. abietis* was found along the coast in southern Norway (Kristiansand to Trondheim) on silver fir, *A. cephalonica,* and other fir species, except balsam fir (*A. balsamea*). Solheim (1999) reported that the disease so far had been found on silver fir, *A. cephalonica*, subalpine fir (*A. lasiocarpa*), cork fir (*A. lasiocarpa* var. *arizonica*), nordmann fir (*A. nordmanniana*), *A. pinsapo*, Noble fir (*A. procera*), and Siberian fir (*A. sibirica*) in Norway, but not on fir for Christmas trees. In later publications (Solheim & Skage 2002, Solheim 2003), symptoms on Christmas trees were mentioned, but the main focus was on *D. abietis* in Noble fir for bough production and a clonal trial with subalpine fir. *D. abietis* is also reported from North America on subalpine fir (Funk 1985), but there the closely related species *Delphinella balsameae* is more common on fir species.

Herpotrichia parasitica (Hartig) E. Rostrup (syn. *Trichosphaeria parasitica, Acanthostigma parasiticum*) infect both young an old fir needles, and cause socalled Herpotrichia needle browning. Butin (1995) reported that symptoms mainly occur on silver fir, but also nordmann fir, Noble fir, Veitch fir (*A. veitchii*), and even spruce (*Picea* spp.) may be attacked when the disease pressure is high. Stone (1997) reported that *H. parasitica* causes blight on silver fir in Europe, but that most reports about occurrence in North America are unconfirmed. In Norway, *H. parasitica* was found on silver fir in Hordaland county in 1974 (Roll-Hansen and Roll-Hansen 1995). In 2004, we found severe attacks by Herpotrichia needle browning on silver fir in a forest stand in Rogaland county (Fig. 1). In the same area, we found symptoms of the disease in three Christmas tree fields during the first half of 2007.

Figure 1. Silver fir (*Abies alba*) with severe symptoms caused by *Herpotrichia parasitica*. Rogaland 2004. Photo: V. Talgø.

Material and methods
Delphinella abietis
During the last few years, damage by *D. abietis* in Christmas tree fields was reported to us by the extension service from different locations along the west coast in southern Norway, and we received samples from Christmas trees that were severely damaged; subalpine fir, Turkish fir (*A. bornmuelleriana*), Siberian fir, and nordmann fir (Fig. 2). On a field trip in Hordaland and Rogaland county in April 2007, we also collected samples from Noble fir bough trees adjacent to Christmas trees. Normal procedure was to incubate samples in a moist chamber (100% RH) at room temperature for approximately one week before they were examined by microscope.

Figure 2. Needles and shoots of different fir species killed by *Delphinella abietis*. From left to right the species are Siberian fir (*Abies sibirica*), nordmann fir (*A. nordmanniana*), subalpine fir (*A. lasiocarpa*), and Turkish fir (*A. bornmulleriana*). The samples were collected in a Christmas tree field in Møre og Romsdal county in January 2006. Photo: V. Talgø.

In 2006, a fungicide field trial was carried out in a Christmas tree field with subalpine fir heavily infected by *D. abietis* on the northwestern coast of southern Norway (Møre og Romsdal county). Each of the fungicides dithianon (product: Delan WG) and tolylfluanid (product: Euparen M) were applied two or three times during the shoot elongation period. There were three trees per treatment and it was sprayed to runoff. Assessments of disease severity were done in mid September 2006. A new fungicide trial was run in 2007.

Herpotrichia parasitica
H. parasitica has so far been found on Christmas trees in three different locations in Rogaland county. Minor damages were found on nordmann fir in a plantation on an island in January 2007, but a more thorough investigation in May, revealed more damage. In May 2007, extensive damage by *H. parasitica* was found on nine year old Turkish fir in a Christmas tree plantation on the main land (Fig. 3). In June 2007, a third plantation with damaged nordmann fir was located. Samples were incubated for approximately one week and examined in microscope. Christmas tree growers in Austria (Perny et al 2002) and Denmark (Lyhr 1994) were advised to let more light and air into plantations where *H. parasitica* was a problem. Thus, we gave the growers in Rogaland the same advice. In early spring 2007, the grower with the severely damaged Turkish fir pruned out damaged shoots and in some cases whole trees. He also cut off branches at the base of the trees to allow better air circulation. In addition he applied a copper compound when the new shoots appeared.

Figure 3. Severe attack by *Herpotrichia parasitica* on Turkish fir (*A. bornmuelleriana*) in a Christmas tree plantation in Rogaland county. April 2007. Photo: V. Talgø

Results and discussion
Delphinella abietis
Symptoms on samples included a few to 100% dead needles on current year shoots and numerous black pseudothecia (easily visible to the naked eye), especially on the upper surface of the needles (Fig. 4). The needles curled downwards along the edges. Ascospores (hyaline, one septate) were only found on samples incubated at the end of April 2007. On samples collected during autumn or winter times the pseudothecia were not mature. Results from the fungicide trial are summarized in Fig. 5. Applications of fungicides clearly reduced the disease severity, but there were no significant differences between fungicides or whether they were applied two or three times. The first application was carried out when the shoots were approximately half expanded. Better results of fungicide application might have been obtained if the first application had been carried out a bit earlier in the season, that is as soon as the shoots emerged.

Figure 4. Brown needles on a current year shoot of subalpine fir (*Abies lasiocarpa*) caused by *Delphinella abietis*. The dead needles were covered with pseudothecia (black spots), especially on the upper surface of the needles. January 2006. Photo: V. Talgø.

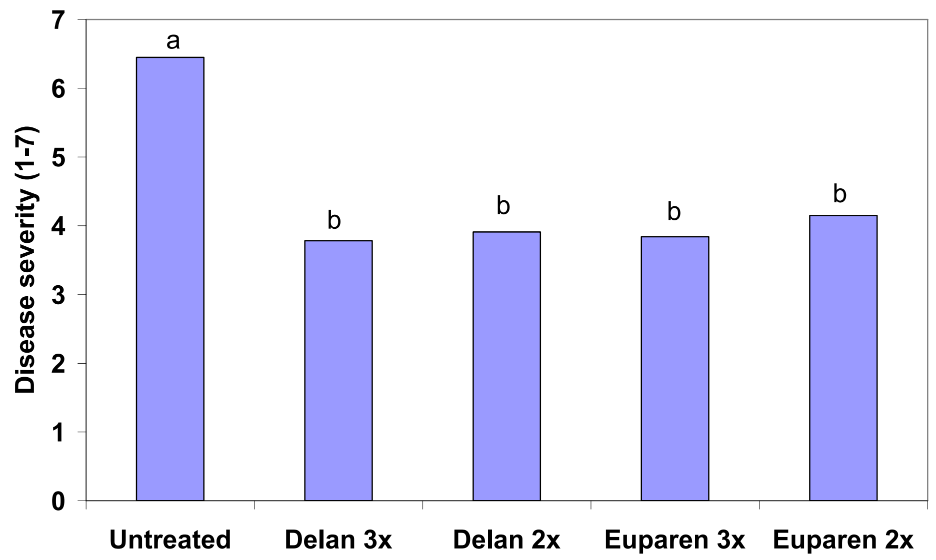

Figure 5. Delan WG (dithianon) and Euparen M (tolylfluanid) against *Delphinella abietis* on subalpine fir (*Abies lasiocarpa*) in a Christmas tree field on the north west coast of Norway in 2006. Small letters (a and b) indicate significant differences between treatments. Fungicides were applied two (2x) or three (3x) times during shoot elongation. Assessments of disease severity followed a scale from 1-7 where 0 = no brown needles, 1 = <1 %, 2 = 1-5 %, 3 = 6-15 %, 4 = 16-33 %, 5 = 34-66 %, 6 = 67-90 %, and 7 = 91-100 %.

Fig. 6 shows an unsprayed tree in front of a tree treated with dithianon three times after bud break. Although it looked very dramatic on the unsprayed tree, most of the new buds that had formed by September 2006, looked healthy when cut through. Thus, in most cases only the current year needles were killed, but not the shoots. No results are yet available from the 2007 experiment.

Figure 6. An unsprayed subalpine fir (*Abies lasiocarpa*) severely damaged by *Delphinella abietis*. The tree in the background was sprayed three times with Delan WG (dithianon) during shoot elongation in 2006. The picture was taken 15 September 2006. Photo: V. Talgø.

Herpotrichia parasitica

Typical symptoms included greyish needles hanging straight down from the twigs and they were only attached by a light brown coloured mycelium (Fig. 7). Both old and young needles were killed. Approximately 70% of the Turkish fir trees showed varying degrees of symptoms. A few shoots on four year old nordmann fir adjacent to the Turkish fir also showed symptoms.

Figure 7. Turkish fir (*A. bornmuelleriana*) damaged by *Herpotrichia parasitica*. The dead needles stay attached to the twigs by superficial mycelium, and they typically tend to hang straight down. April 2007. Photo: V. Talgø

The stomata lines under the needles were partly covered with a brownish, hyphal network (Fig. 8). We did not find any perithecia in the material we incubated in the laboratory. This corresponds well with Butin (1995), who wrote that perithecia are rarely produced, and if so only in small numbers. Results from the management strategies undertaken by the growers are not yet available. A wet and mild autumn in 2006, followed by a relatively mild winter might have triggered the massive attack. The trees had also reached a size where air movements between them were restricted.

Figure 8. Needles of Nordmann fir (*Abies nordmanniana*) (left) and a Turkish fir (*Abies bornmulleriana*) (right) with a brownish, hyphal network of *Herpotrichia parasitica* partly cowering the stomata. Photos: V. Talgø

Acknowledgements: We want to thank Steinar Haugse, Terje Pundsnes, and Nils Eldar Linge in The Norwegian Agricultural Extension Service (LFR) for valuable help with the field work.

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Risk evaluation of *Pucciniastrum epilobii* rust attacks on Nordmann Fir, *Abies nordmanniana*

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Introduction

The normal hosts of the rust fungus *Pucciniastrum epilobii* are European Silver fir (*Abies alba*) and fire weed (*Chamaenerion angustifolium*). On *A. alba* the damage caused by the rust fungus is negligible, except for the rare epidemics in nurseries. However, since Nordmann fir (*A. nordmanniana*) became widely used as Christmas tree species in Denmark, *P. epilobii* has occasionally been reported as the cause of severe needle deformation, discolouration and needle shedding. Nordmann fir is not resistant to *P. epilobii*, but due to a later flushing than *A. alba*, the Christmas trees avoid attacks in most years (disease escape).

This study aimed to

1. test the theory that infection risk depends on precipitation in May,
2. determine which stage of flushing is most susceptible to infection,
3. analyze the possibility of variation in genetic resistance to infection.

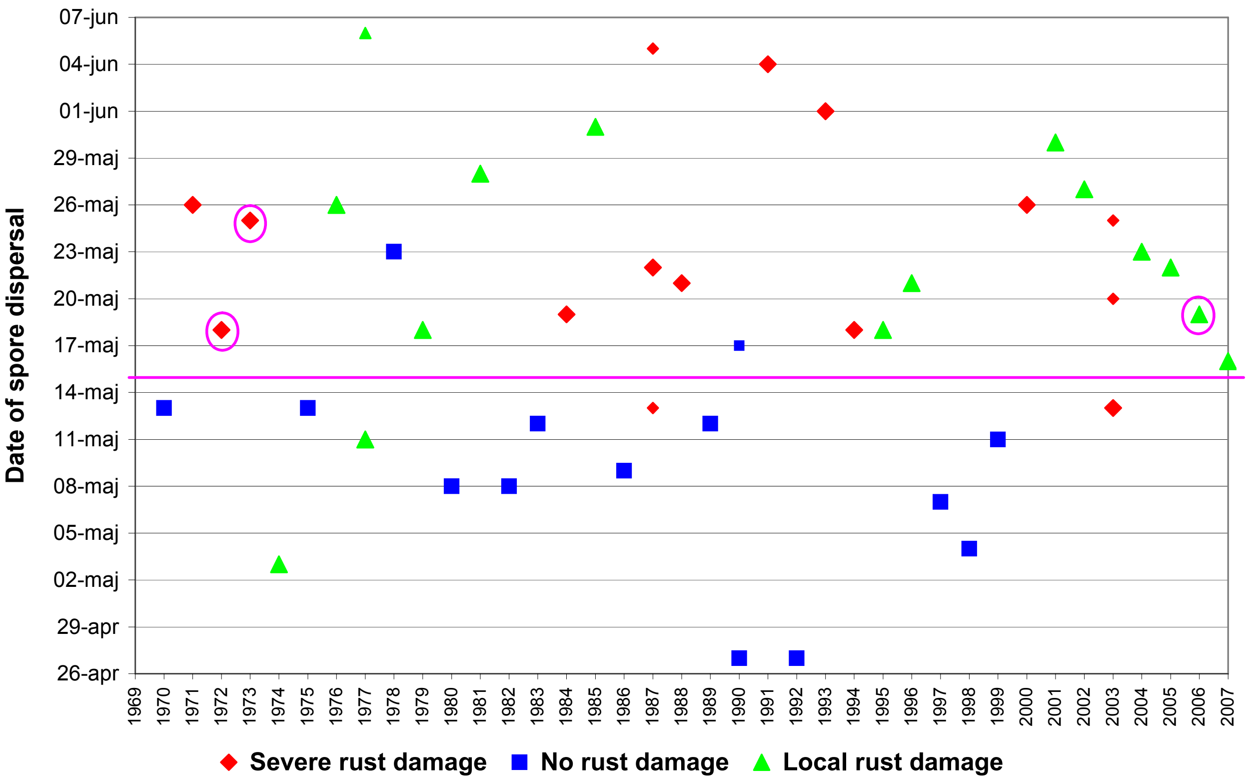

Figure 1. Predicted date of spore dispersal of *Pucciniastrum epilobii* based on the first major precipitation (>10 mm) event in May. Circles indicate that the date was confirmed experimentally (1972-73 by J. Koch). More than one dot pr year indicates multiple possible dispersal dates. May 15th is considered to be the cut off date. Economically significant damages were experienced in the early 1970's, in 1987-88, and in 1993-94.

Results

Data were collected via observation of natural infection and via artificial inoculation of needles with the fungus during flushing of *A. nordmanniana*. Previously, records of attacks in

Nordmann fir had been used to determine that rain in the latter half of May was the crucial factor (fig. 1), and experiments proved this to be true (fig. 2).

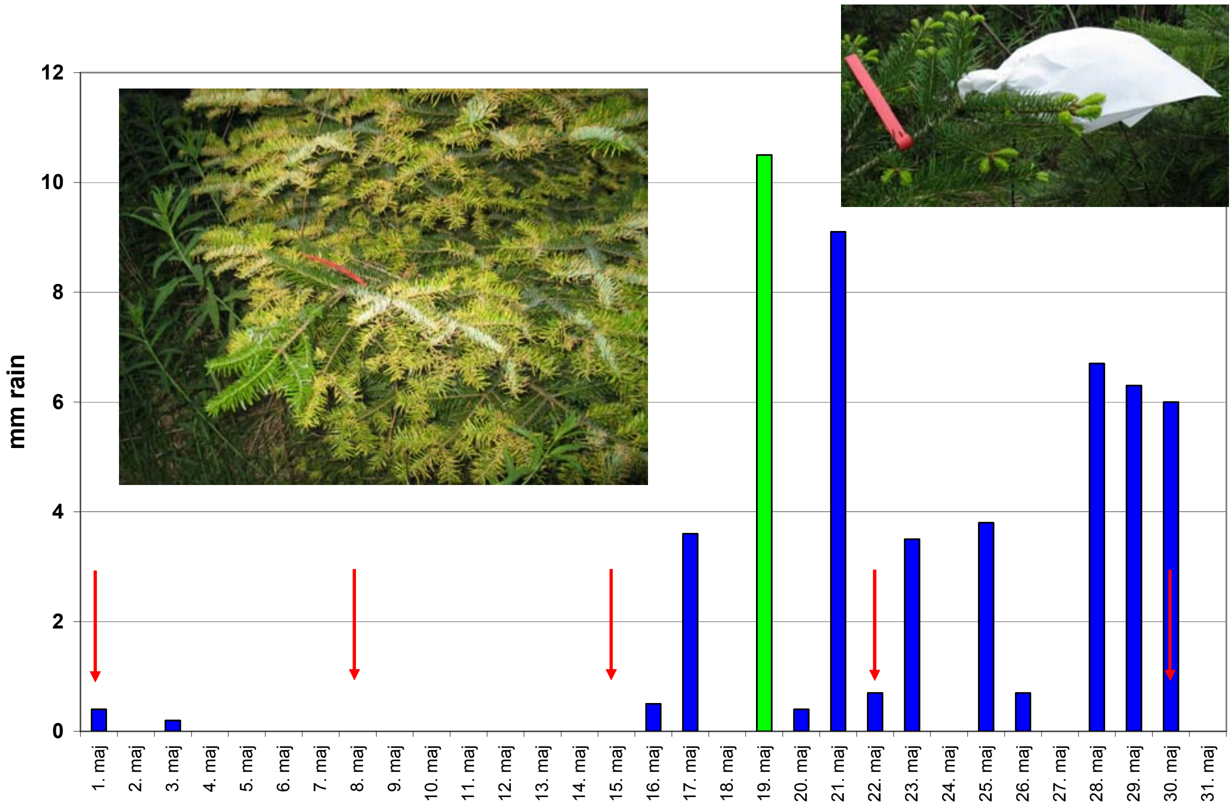

Figure 2. Date of spore dispersal (green column) for *Pucciniastrum epilobii* in 2006 proved by tying bags (photo right) around shoots at regular intervals (arrows). Flushed shoots which were covered in bags on May 15th were not infected, and the same was true for shoots which had not flushed before this date. Flushed, unprotected shoots were heavily infected, as seen on photo left, where only the shoot from the bag is green and all other needles are yellow due to rust sporulation. Note young fireweed plants in left side of photo, their leaves are now infected by the rust fungus.

Previously, it had been assumed that infection could take place right after bud burst, i.e. as soon as needles were exposed even a little. This was confirmed, but the inoculation experiment showed that the later stages of flushing are much more vulnerable (fig. 3). Thus, severe attacks are only seen when the bud scales have dropped, elongation has started, and needles are beginning to spread out. This stage is often described as ‘paint brush’ shaped shoots (photo in fig. 3).

Genetically based resistance to rust fungi is commonly utilized in agricultural crops. If variation in resistance to *P. epilobii* rust could be shown in Nordmann fir, breeding for this trait would be possible. As the artificial inoculation experiment took place in a stand with known genetic origin of the trees, it was possible to test for variation in infection severity according to this parameter. The trees had been chosen to represent early, medium and late flushers. Infection rates showed significant differences amongst offspring groups (fig. 4), however when flushing stage was included in the equation, no statistically significant differences could be seen.

Thus it was concluded that there is no direct, genetically based resistance of *A. nordmanniana* towards *P. epilobii* rust. However, late flushing trees had fewer infections, and as flushing is strongly dependent on genetic constitution, there is an indirect correlation.

Selecting for late flushing in Nordmann fir Christmas trees to avoid spring frost damage will thus have the added benefit of reducing the risk of *P. epilobii* rust infections.

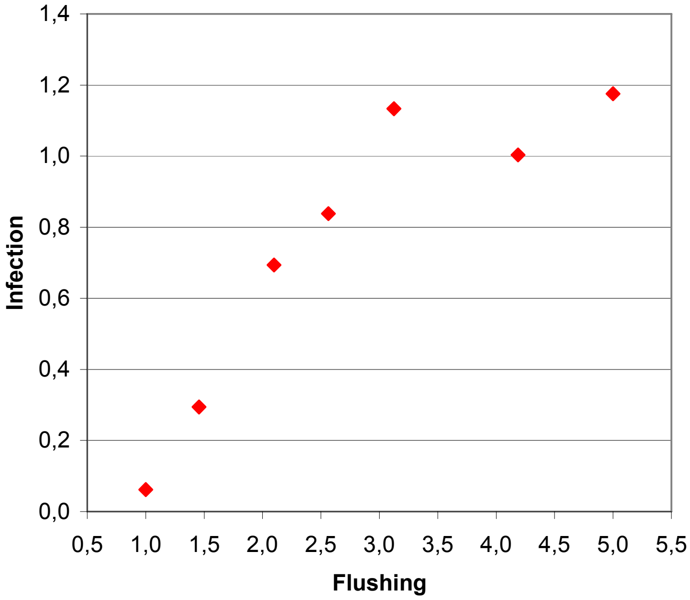

Figure 3. Rate of infection by *P. epilobii* in relation to stage of *A. nordmanniana* flushing. Flushing stage 3 is depicted on photo, and this stage ('paint brush') heads the most vulnerable period.

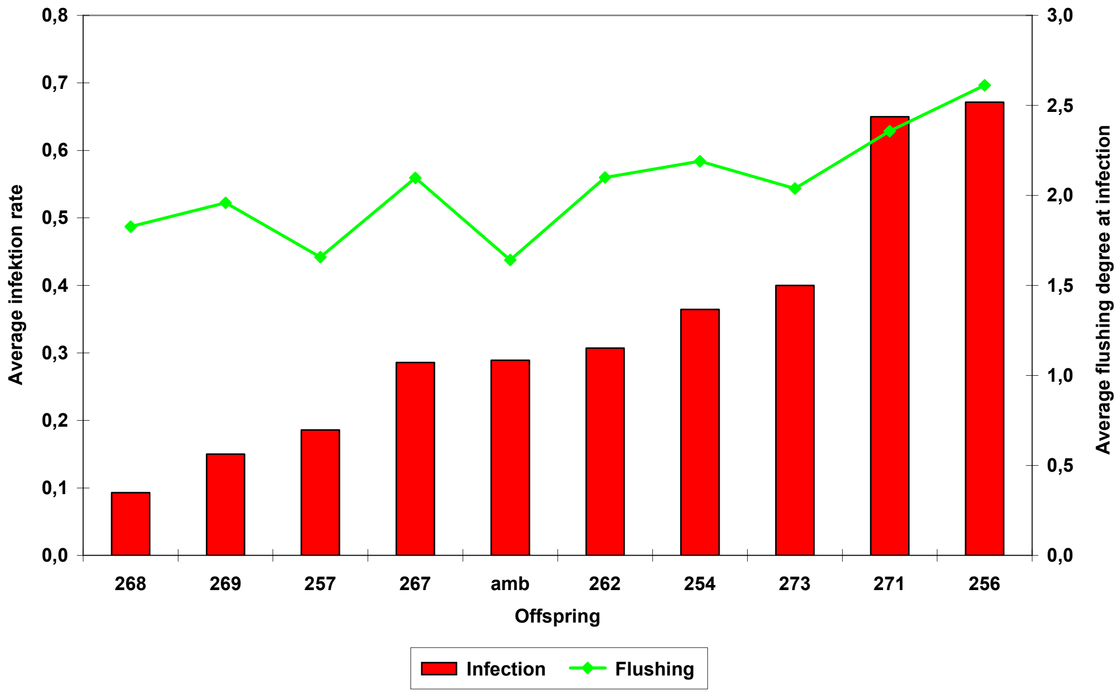

Figure 4. State of flushing (curve) and rate of infection by *P. epilobii* (columns) in open pollinated offspring of *A. nordmanniana* from 9 trees and a provenance. Numbers refer to sib-related offspring of single clones in the Valloe clonal seed orchard, and amb is Ambrolauri, a commercial standard provenance imported from Georgia, Caucaus. The difference in infection severity is not due to difference in resistance but to the variation in flushing.

Acknowledgements: This project was supported by the Production Fee Foundation for Christmas Trees and Greenery (PAF). Ulrik Bräuner Nielsen made the statistical analysis of data from the artificial inoculation trial in the Nordmann fir seed source trial (1415 Arboretum).

Oral Presentations: Weeds

Monitoring Fraser fir (*Abies fraseri*) growth to determine safe timing of glyphosate applications

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North Carolina Fraser fir Christmas tree growers have learned to broadcast 4 to 8 oz. per acre rates of glyphosate (Roundup Original) to suppress weeds without injuring their trees. However, calendar-based timing of July applications has resulted in tree injury when foliage maturity is delayed. Fraser fir growers need to know when it is safe to again use the 8 oz suppression rate to optimize treatment effectiveness. A study was conducted in 2006 and repeated in 2007 to link glyphosate injury to observable stages of Fraser fir growth. Glyphosate treatments were applied weekly from the last week of June to the third week of July. Growth characteristics were monitored from mid-June to the beginning of August. Monitored growth characteristics included branch and leader foliage color, bud color, bud scale color, bud shape, branch and leader bark color, bark cilia color, branch angle, and branch and leader length. Glyphosate damage was evaluated three weeks after each treatment. Several characteristics correlate with the occurrence of damage. Addition of 2007 data will provide greater confidence in selecting the best field parameters to monitor.

Ground cover suppression in North Carolina Fraser Fir production

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Approximately one half of the Fraser fir growers in Western North Carolina are now using this practice called “chemical mowing” for ground cover management. The practice has resulted in widespread groundcover development dominated by native white clover, nimblewill, and a variety of addition low-growing forbs that effectively suppress undesirable weed species. In most cases two applications of glyphosate per year are adequate once the native groundcover has developed. Economic benefit has been substantial. At less than $4 per acre per application for glyphosate and an average labor cost of $10 -$12 per acre, the over all cost of weed management has been reduced greatly from previous weed control strategies. The groundcover establishment has provided many advantages including soil stabilization and beneficial insect habitat in Fraser fir production.

One of the challenges growers face in the implementation of this system is the need for glyphosate applications during the season of active growth, when Fraser fir trees are most sensitive to glyphosate injury. Therefore, beginning in the spring of 2001 and continuing through the fall of 2003, an on-farm research project was undertaken to determine the tolerance of Fraser fir to low rates of glyphosate applied during the growing season, and to identify the minimum glyphosate doses required for effective ground cover suppression.

On-farm tests were conducted on 10 grower sites over three years. During the first year rates of glyphosate (Roundup Original) tested were from 4oz. to 12 oz. product per acre. Weekly applications were initiated on or about April 15th and continued to August 1st. Herbicide applications were made with a backpack sprayer equipped with a Teejet 8004 nozzle calibrated to deliver 17 GPA, applied as a directed spray contacting the lower 12-24 inches of the tree foliage. After the 2001 season, research focused on lower application rates of 4 to 8 oz. per acre, and application dates were focused on the May 1st to July 15th time period. The number of tree growers and acreage included in the study increased substantially. The project was continued in the 2003 with the addition of new tools to increase the accuracy of the backpack application, reduce spray volume, and fine tune other features of the applications. Tree damage was rated on a subjective scale using tree grower participation. Weed suppression ratings were also documented using a subjective scale involving tree grower participation.

Rates of Roundup Original at 4-8oz. per acre were found to provide effective vegetation suppression without significant damage, with new growth present throughout the period. Eight oz/acre provided the best control and could be used without damage except during a 6 week period of time that begins two weeks after budbreak begins, about May 15th and continuing until July 1st. During this period a 4oz/acre rate is required to avoid damage.

Final equipment choice has resulted in Roundup Original or generic equivalent applied with a TQ15004 or a TK-2 with the addition of a 14 psi flow regulator (yellow). At various worker comfort levels the calibrated application will range from usually from 8 – 12 GPA, applied as a broadcast spray contacting the lower 6-12 inches of the tree foliage and make full groundcover coverage.

Comparison of integrated weed management strategies in Christmas tree plantations

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Since Christmas tree value is based mainly on their appearance, pests that reduce the visual quality of trees are intensively managed. Michigan Christmas tree growers rely heavily upon pesticides, including atrazine and simazine, to control these pests. However, atrazine and simazine have ground and surface water concerns. Therefore, field studies were conducted in 2005 and 2006 to determine integrated weed management programs utilizing alternative herbicides and non-herbicidal techniques to replace and/or reduce triazine use.

Study 1. Treatments were flumioxazin plus glyphosate at 0.28 and 1.12 kg/ha applied broadcast, flumioxazin plus glyphosate at 0.28 and 1.12 kg/ha applied within the row, organic mulch, organic mulch plus glyphosate at 0.84 kg/ha, hard fescue (*Festuca brevipila* 'Aurora Gold') groundcover, white clover (*Trifolium repens* L.) groundcover, mechanical control system, mechanical control plus glyphosate at 0.84 kg/ha, and an untreated control. Organic mulch consisted of a coarsely ground pine bark and was applied as a 91 cm wide band in the tree rows. Hard fescue and white clover ground covers were broadcast seeded into plots in the fall of each year at rates of 250 and 7 lb/A, respectively. Mechanical control treatments were imposed using a hand-operated mower between and within the tree rows. Flumioxazin and glyphosate treatments were applied on April 19, 2005 and April 11, 2006. Glyphosate plus mechanical treatments were imposed in June, July, and August of each year. Experimental design was a randomized complete block design with 4 replications with individual plot sizes of

7.3 by 9.1 m. Conifer injury was evaluated 8, 12, and 16 weeks after treatment (WAT) on a 0 to 100% scale with 0 indicating no injury and 100 equal to crop death. In addition, plots were visually evaluated for percent groundcover of each weed.

Overall ground cover in the 2005 site was denser than in the 2006 site. In general, hard fescue established and provided a denser groundcover than the white clover did. In the hard rescue plots, other weed species did not thrive in the plots; however, quackgrass [*Elytrigia repens* (L.) Nevski.] was observed at a low percentage of the total groundcover (8%). This indicates that a living mulch, such as hard fescue inhibited light-dependent weed seed germination. The organic mulch provided excellent groundcover until weed seeds started germinating within the mulch layer. In the mulch plus glyphosate treatment, glyphosate eliminated most of the weeds emerging between the rows and within the mulch layer. Plots receiving flumioxazin plus glyphosate treatments, regardless of the broadcast or strip application, remained bare with the exception of a few weeds throughout the growing season.

Conifer injury was virtually non-existent in all treatments. Similar to 2005, hard fescue provided greater than 65% groundcover throughout the growing season. Common milkweed (*Asclepias syriaca* L.) was observed in some of the hard fescue plots (less than 10%). The use of a living groundcover, such as hard fescue, is a beneficial cultural control because it minimizes herbicide use while providing suppression of light germinating weed species. In addition, for suppression of perennials, such as quackgrass and common milkweed, hard fescue is also tolerant to over-the-top applications of glyphosate.

Study 2. Premergence treatments were applied on April 19, 2005 and April 11, 2006 which included atrazine (0.84 kg/ha) plus simazine (0.84 kg/ha), flumioxazin (0.28 kg/ha), mesotrione (0.28 kg/ha) plus simazine (0.84 kg/ha). Postemergence treatments were applied on June 23, 2005 and May 23, 2006 which included clopyralid (0.28 kg/ha), mestrione (0.28 kg/ha) plus crop oil concentrate (1% v/v), trifloxysulfuron (9.9 g/ha) plus non-ionic surfactant (NIS) [0.25% v/v], rimsulfuron (34.8 g/ha) plus NIS, and imazethapyr (34.8 g/ha) plus NIS. Herbicides were applied in water at a carrier volume of 187 L/ha with a pressure of 207 KPa. Experimental design was a randomized complete block design with 4 replications and individual plot sizes of 5.5 by 7.6 m. Weed control and Douglas fir injury ratings were evaluated 8 weeks after treatment (WAT), 12 WAT, and 16 WAT on a 0 to 100% scale with 0 indicating no control or injury and 100 equal to weed or crop death.

In 2005, atrazine plus simazine and mesotrione plus simazine provided greater than 96% horseweed (*Conzya canadensis*) and hoary alyssum (*Berteroa incana*) control 8 WAT and greater than 91% hoary alyssum control 16 WAT. In contrast, trifloxysulfuron, provided only 8% hoary alyssum control 8 WAT. In addition, hoary alyssum control with rimsulfuron was 81% 8 WAT. Douglar fir injury, regardless of treatment, was less than 5% 16 WAT. In 2006, atrazine plus simazine and mesotrione plus simazine provided excellent control (>95%) of hoary alyssum and common catsear (*Hypochoeris radicata*). Initial Douglas fir response to mesotrione, trifloxysulfuron, rimsulfuron, and imazethapyr was greater in 2006; however, tree grew out of the injury by 16 WAT. Mesotrione shows promise as a preemergence alternative to atrazine and simazine. In addition, imazethapyr, rimsulfuron, and mesotrione applied postemergence provided good to excellent control of common broadleaf weeds found in Christmas tree plantations.

Oral Presentations: Cultivation techniques

Growth and physiology of newly planted Fraser fir (*Abies fraseri*) and Colorado blue spruce (*Picea pungens*) in response to mulch

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Introduction. Weed control is one of the major concerns for Christmas tree growers in the Midwestern United States. Mowing and chemical weed control may comprise up to 18% of the direct production costs for growers in Michigan (Nzokou and Leefers 2007). In order to determine the potential of plasticulture and other mulches as alternative weed control methods, we established a Christmas tree plasticulture study at Michigan State University's Southwest Michigan Research and Extension Center (SWMREC) near Benton Harbor, Michigan. The overall goal of this project was to determine the effect of plasticulture technology and other weed control techniques on growth and physiology of Fraser fir (*Abies fraseri* (Pursh) Poir.) and Colorado blue spruce (*Picea pungens* Engelm.) Christmas tree plantations

Plastic mulch, usually black polyethylene film, has been shown to improve crop growth in a variety of horticultural production systems (Lamont 2005). Plastic mulch or synthetic mulch mats have also been used to aid in the establishment of trees for afforestation and reforestation (Samyn and DeVos 2002, Walker and McLaughlin 1992). In general, plastic mulch improves early tree plantation survival and growth, although Harper et al. (2005) found relatively little effect of mulch mats on 10-year height and diameter of Douglas-fir trees. Plastic mulch reduced growth of Scots pine Christmas trees compared to a bare-ground control (Lamont et al. 1993).

Plastic mulches affect plant growth by modifying the micro-environment around the crop plants. Mulches improve soil moisture availability by reducing surface evaporation, reduce water and nutrient loss to competing vegetation, reflect radiant energy to the crop, and increase the length of the effective growing season by warming the soil (Lamont 2005).

Specific objectives for the current study were to:
1) Evaluate growth and physiological responses of Christmas trees to plastic and other mulches
2) Monitor changes in soil environment associated with the mulch treatments.

Methods and results. In the spring of 2006 we initiated a Christmas tree plasticulture trial at Michigan State University Southwest Michigan Research and Extension Center (SWMREC) near Benton harbor, MI. We laid out 32 row plots to accommodate 4 replications of 8 ground-cover treatments (Table 1).

Table 1 Ground Cover Treatments for SWMREC Christmas Tree Mulch Study

Treatment	Mulch/Weed control	Irrigation	Bedded
Black poly + Irr	Black polyethylene	Yes	Yes
White poly + Irr	White polyethylene	Yes	Yes
Mulch mats + Irr	VisPore® Mulch mats	Yes	No
Wood chips + No Irr	Hardwood chips	No	No
Bedded + Irr	Post emerge + hand weeding	Yes	Yes
Flat plant + Irr	Post emerge + hand weeding	Yes	No
Weed control + No Irr	Post emerge + hand weeding	No	No
No weed control + No Irr	None	No	No

Polyethylene mulch, bedding, and irrigation were installed prior to planting seedlings. Mulch mats and wood chip mulch were installed after planting. The mulch mat and wood chip mulch treatments were selected as alternative mulch options for growers that may not have access to equipment needed to install polyethylene mulch. The SWMREC crew planted 320 Fraser fir and 320 Colorado blue spruce 2+2 transplants in 10-tree row plots on 2.1m x 2.1m spacing. Irrigation was supplied at 25 mm per week via a drip system. Weed control was maintained on the un-mulched plots by a combination of hand-weeding and post-emergent herbicide (glyphosate). Irrigated plots were fertilized via the drip system with a water soluble fertilizer (Peter's conifer grower 21-5-20) at a rate of 67 kg of N per ha in 2006 and 84 kg of N per ha in 2007. Non-irrigated plots were fertilized with a comparable amount of nitrogen with a granular fertilizer (Scotts field fertilizer 33-3-6) applied around the drip line of each tree in the spring of each year.

Seedling heights and stem caliper were measured at the beginning and end of the 2006 and 2007 growing seasons. In June and July, 2006 and July and August 2007 we measured photosynthetic gas exchange on three seedlings per plot using a portable photosynthetic system. In 2007 we evaluated plant moisture stress by measuring pre-dawn shoot water potential using a pressure chamber.

Analysis of data after the first growing season after planting (2006) indicated that seedling growth increased with mulch and there was a trend toward greater growth with white mulch compared to black mulch. We hypothesized that increased growth with white plastic was related to lower soil temperature and reduced root respiration. In order to test this hypothesis we installed an automatic data logger and temperature thermocouples to measure soil temperature under the various mulches. We installed temperature thermocouples to a depth of 5 cm on five treatments: white plastic, black plastic, mulch mats, wood chip mulch, and non-irrigated + weed control. The probes were replicated 4 times in each treatment.

TABLE 2. Caliper, height and survival of Fraser fir and Colorado blue spruce Christmas trees after two years under various combinations of weed control, irrigation and bedding at MSU Southwest Michigan Research and Extension Center, Benton Harbor, MI. 2007.

			Fraser fir			Colorado blue spruce		
Weed control	Irrigation	Bedding	Caliper (mm)	Height (cm)	Survival	Caliper (mm)	Height (cm)	Survival
White plastic	Irrigated	Bedded	27.6a	64.4a	100a	26.0a	52.6a	98a
Mulch mats	Irrigated	Flat	25.6ab	66.8a	100a	24.7ab	53.1a	100a
Chemical + Hand weed	Irrigated	Flat	23.0bc	63.5ab	100a	24.1ab	53.6a	100a
Wood chips	Not irrigated	Flat	23.0bc	62.1ab	100a	22.3bc	52.7a	95a
Black plastic	Irrigated	Bedded	21.7c	58.8b	95a	24.9ab	51.6a	98a
Chemical + Hand weed	Irrigated	Bedded	22.3c	63.1ab	100a	21.8bc	53.2a	95a
Chemical + Hand weed	Not irrigated	Flat	18.2d	52.4c	95a	19.2c	49.0a	88a
None	Not irrigated	Flat	12.1e	52.6c	67b	11.0d	41.3b	71b

Chemical + hand weed: Weeds controlled with combination of direct sprays of glyphosate and hand weeding. NOTE: Means within a column followed by the same letter are not different at 0.05 significance level.

In fall 2007 (two years after planting) seedling survival was high (88% or higher) for all treatments except non-irrigated + no weed control (Table 2). The high overall survival rate is likely due to relatively frequent rainfall immediately after planting in 2006. The weather in 2007 was much warmer and drier until late summer than 2006 resulting in increased water stress and mortality in the non-irrigated + no weed control treatment. Seedling caliper growth varied widely among treatments. Irrigation increased caliper growth compared to the non-irrigated plots, except for seedlings in the wood chip mulch treatment which grew as much as most of the irrigated treatments. Over the two years of the study height growth varied less than caliper growth, with differences most apparent between the non-irrigated + no mulch treatments and the irrigated or wood chip mulch plots (Table 2).

Plant moisture stress During the summer of 2007 plant moisture stress, as indicated by predawn water potential, increased significantly for the seedlings in the no irrigation + no weed control treatment. Moisture stress also increased for the blue spruce in the non irrigation + weed control plots. Water potential of seedlings in the wood chip mulch treatment did not differ from the irrigated plots.

Soil temperature All of the mulches moderated soil temperature compared to the bare ground plots (Fig. 1). In late July when daily maximum air temperatures were around 31°C (88°F), mean temperatures reached 38°C (100.4°F) on the bare ground plots. The wood chip mulch had the largest effect on moderating soil temperature, followed by the white plastic mulch. The reduction in soil temperature along with conservation of soil moisture resulted in comparable growth between seedlings on the wood chip plots without irrigation and the irrigated plots (Table 2). The two black ground covers; black plastic and mulch mats, had similar effects on soil temperature.

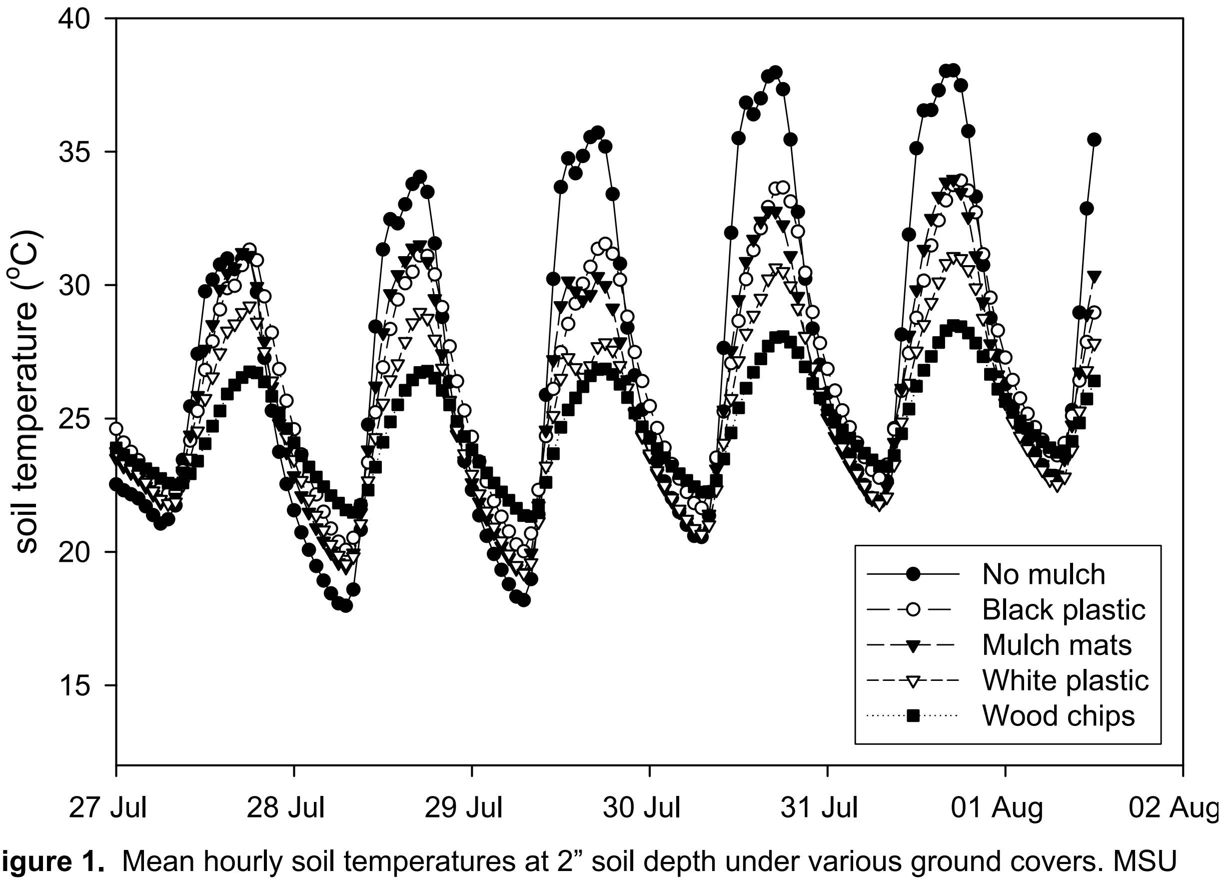

Figure 1. Mean hourly soil temperatures at 2" soil depth under various ground covers. MSU Plasticulture Study at SWMREC, July 27-Aug. 2, 2007.

Biography for Dr. Bert Cregg
Dr. Cregg is an Associate Professor and Extension Specialist in the Department of Horticulture and Department of Forestry at Michigan State University, East Lansing, Michigan USA. Dr. Cregg conducts research and extension programs on the production and physiology of trees in Christmas tree, nursery and landscape systems.

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Using phenology to improve establishment in A. nordmanniana Christmas tree production in Denmark – a practical approach

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Optimum planting time in Abies nordmanniana is when the new leader shoots have reached about 90% of their final length. The young elongating shoots require water, nutrients, and energy resources that dictate a mainly upward distribution stream. When the shoots approach their final length, however, resources can be directed towards new root development. In Denmark this occurs about 1st of July.

The reserves available for root development depends on the photosynthetic capacity of the plants, i.e., other factors being equal, a 4 years old seedling will establish better than one that is 3 years old. The optimum type of root system is created in the nursery by undercutting and wrenching, which stimulate root branching. A reduction in the crown (removal of branches or needles) leads to a proportional reduction in root regeneration capacity. A notion that reduction of the crown might reduce transpiration and thus help establishment of new plantings does not apply in *A. nordmanniana.* However, bud removal may be used to shape the crown without adverse effects on the establishment.

Root growth is strong until about 1st of September, while the ground is warm. Thus, planting should be carried out as soon after 1st of July as weather conditions permit, so that the trees can make the best use of this optimum growth period on their new growing site. The amount of root regeneration is proportional to the length and quality of the summer time at the new site, and the amount of root system established strongly influences shoot growth the following year. When planting is carried out in summer, new long root tips appear within the first week after planting. While root development during the first months mainly consists of long roots, strong branching occurs during winter in the most vigorous root systems. This results in short roots that become mycorrhized. Thus, lifting during autumn may damage the long root development, while lifting during winter may inhibit mycorrhization.

Steen Sørensen is educated as forest ranger and is an accomplished Christmas tree grower and consultant. He was a pioneer in using and developing growth regulation methods, primarily the use of Pomoxon (an auxin-derivative) for leader growth control, a methods that has become widespread in recent years.

Leader Control on noble (*Abies procera*) and Nordmann fir (*Abies nordmanniana*) using NAA

Chal Landgren, Rick Fletcher, Mike Bondi, Joe Cacka, Manuela Huso
Respectively Oregon State University Extension Agents, Washington, Benton and Clackamas Counties, Agronomist, Western Farm Service and OSU Forest Science statistical analyst.

Summary
Our 2006 research efforts had three objectives. Those were:

1. Evaluate a range of rates for leader control using Sucker-Stopper RTU
2. Compare Pomoxone with Sucker-Stopper RTU
3. Evaluate various surfactants for efficacy.

Study Details
Tree size at treatment: .9-1.5 m (3-5 feet) tall. Trees needed to have grown > 35 cm (14 inches) in the prior year.

Experimental Design (Randomized Individual tree plots): Each set of treatments was repeated 50 times for each plot, using a randomly assigned order (350 trees per plot). Four plots/species. Application used the EasyRoller with one roll/wipe at the rates listed:

- Control
- 40 ml Sucker-Stopper RTU (SS)/L. Water+5ml/L WA100 (surfactant)
- 80 ml SS/L. Water+5ml/L WA100
- 120 ml SS/L. Water+5ml/L WA100
- 160 ml SS/L. Water+5ml/L WA100
- 250 ml SS/L. Water+5ml/L WA100
- 500 ml SS/L. Water+5ml/L WA100

Pomoxone Trial (Row plots- 50 trees/treatment): This treatment investigated the NAA product, Pomoxone (1.5 a.i.) from Denmark on selected plots at the following rates.

- 40 ml/L Pomoxone+5ml/LWA 100
- 80 ml/L Pomoxone+5ml/LWA 100

Timing of Treatments: Easy roller treatment will begin when new leader growth is 7-20 cm (3-8 inches) long.

Nordmann fir Results
Figure 1 revels that on control treatments, around 85% of the trees had leaders exceeding 35 cm (14 inches). With increasing Sucker-Stopper RTU concentrations, the percentage of long leaders decreased. Also, as the rate of Sucker-Stopper RTU increases, the number of “damaged” leaders rises. An effective rate then is one that maximizes the percentage of trees in the 20-35 cm (8-14 inch) size with few trees in the < 20 cm (8 inch) category. With Nordmann fir, the most effective Sucker-Stopper RTU rate is likely in the 40-80 ml/L range.

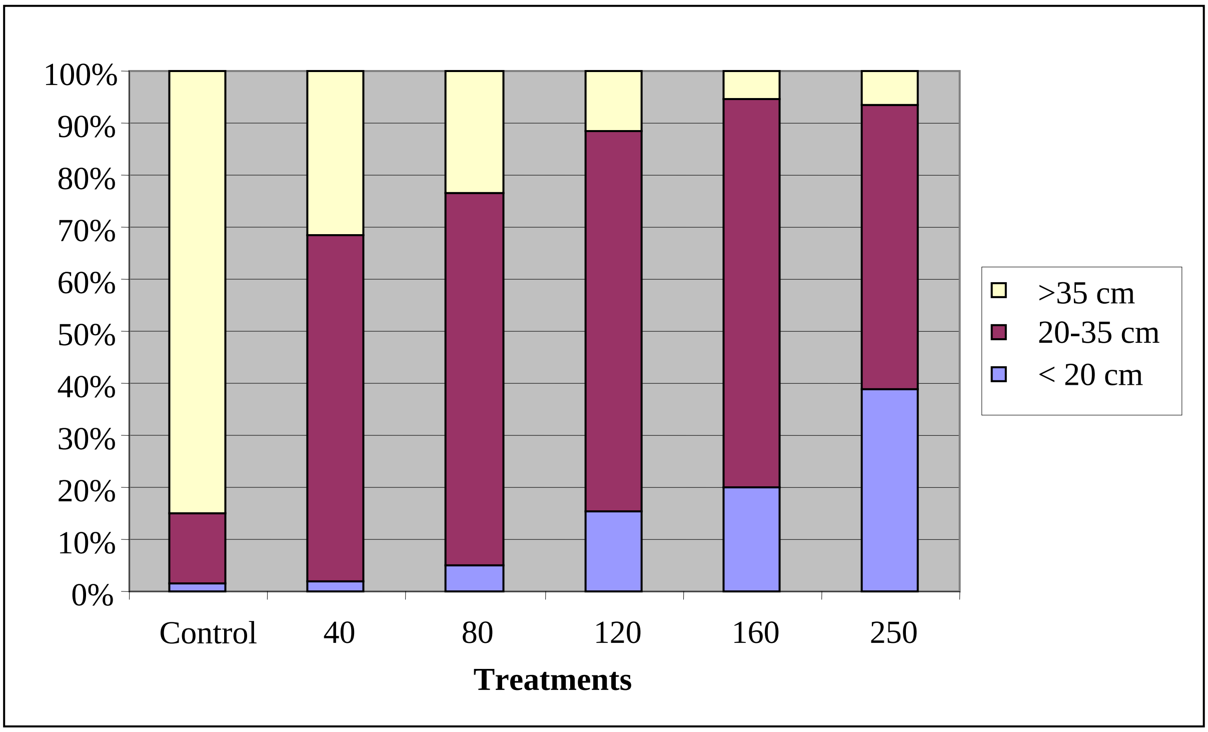

Figure 1 Nordmann Fir Leader Controls (% of leaders within target length).

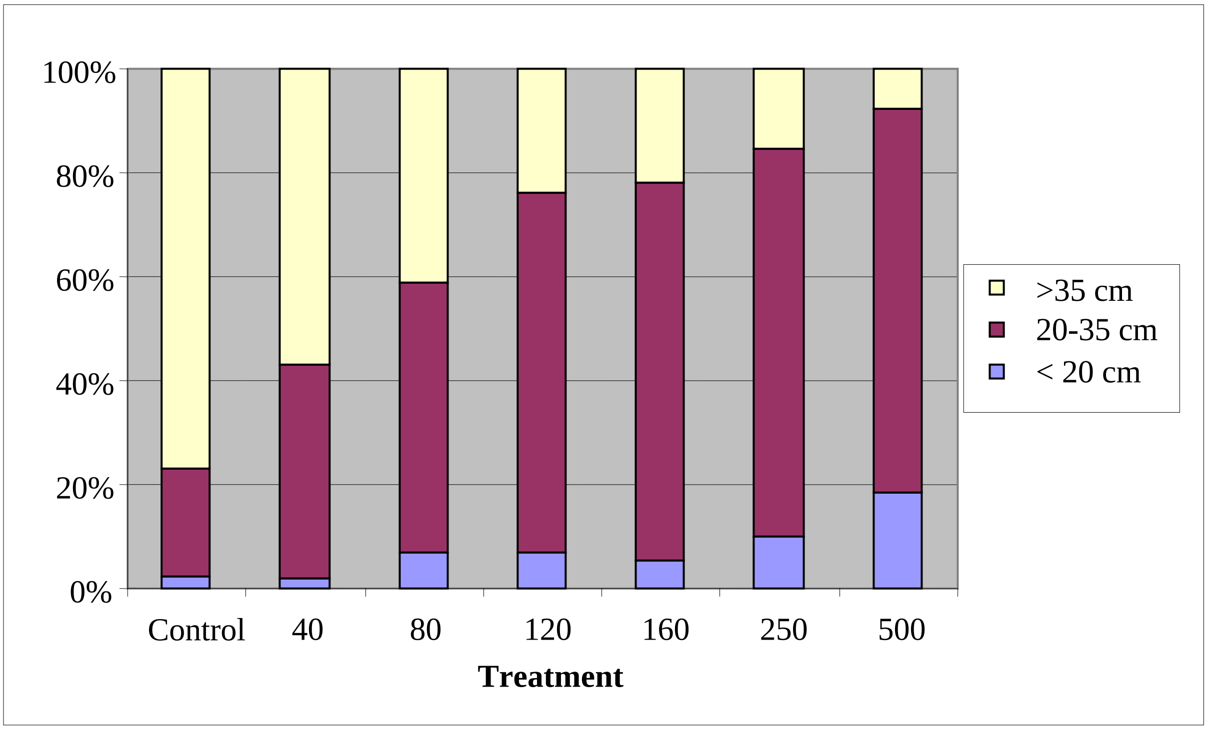

Figure 2 Noble Fir Leader Controls (% of leaders within target length).

Noble fir Results

On control treatments around 78% of the trees had leaders exceeding 35 cm (14 in.) (figure 2). As with Nordmann fir, increasing Sucker-Stopper RTU concentrations decreases the percentage of long leaders. With noble fir however, a higher concentration of Sucker-Stopper RTU is needed to increase the percentage of leaders in the target length. Similarly, as the rate of Sucker-Stopper RTU increases, the number of "damaged" leaders increases. An effective rate then is one that maximizes the percentage of trees in the 20-35 cm (8-14 inch) size with few trees in the < 20 cm (8 inch) category. With nobles, it appears the species has a wider range of treatment "tolerance" to the Sucker-Stopper RTU up to the point of around 250 ml/L. as illustrated by the low percentage of trees with leaders shorter than 20 cm (8 inches). The range of treatment rates for noble is likely in the 80-160 ml/L range. This is roughly double that of Nordmann.

Damage

Sucker-Stopper RTU will induce a number of transitory damage patterns that are easily noticed, but of little consequence. For example, there may be reddish needles along the roller "lines" or individual needles that turn yellow or red. These patterns are difficult to find one year following treatment.

More significant are dead leader buds, wavy leaders or dead leaders. The wavy pattern is likely not a significant problem until it becomes pronounced. In sever cases; the leader takes the shape of a pronounced and compacted S curve, or even a droopy "L." We also, included Sucker-Stopper concentrations that we knew would produce damage in order to test the "margin of safety" between rates. With both species, damage levels were significant above 120 ml/L.

Pomoxone Trials

Pomoxone is the NAA material used in Denmark for leader control. The material is more concentrated (1.5 % a.i.) than Sucker-Stopper RTU. Pomoxone was compared to Sucker-Stopper RTU on 3 plots (1, 2 and 8) in hopes of evaluating relative performance. On noble fir, Pomoxone produced a 10% and 16% reduction in leader length with 40 and 80 ml/L of Pomoxone respectively. This was approximately the same as the average reduction achieved on noble at equal NAA concentrations of SuckerStopper RTU (+- 40 and 100 ml/L). See table 1 for comparable rates.

On Nordmann fir, Pomoxone produced a 42% and 43% reduction in average leader length at 40 and 80 ml/L. This percentage leader reduction is greater than that achieved with Sucker-Stopper RTU (around 28-36%) for reasons unknown.

Table 1. Summary of various NAA products with NAA/L listings

Product	NAA % a.i.	ml Product/ L water	NAA/L	NAA Formulation
Pomoxone	1.5	15	0.2	
Pomoxone	1.5	30	0.5	
Pomoxone	1.5	40	0.6	
Pomoxone	1.5	80	1.2	
Sucker-Stopper RTU	1.15	20	0.2	Ethyl 1-naphthaleneacetate
Sucker-Stopper RTU	1.15	40	0.5	Ethyl 1-naphthaleneacetate
Sucker-Stopper RTU	1.15	80	0.9	Ethyl 1-naphthaleneacetate
Sucker-Stopper RTU	1.15	120	1.4	Ethyl 1-naphthaleneacetate
Sucker-Stopper RTU	1.15	160	1.8	Ethyl 1-naphthaleneacetate
Sucker-Stopper RTU	1.15	250	2.9	Ethyl 1-naphthaleneacetate
Sucker-Stopper RTU	1.15	500	5.8	Ethyl 1-naphthaleneacetate

Table 2. - Surfactant Treatments and Phytotoxicity

Surfactant/Treatment	Noble fir Phytotoxicity Rating*	Nordmann fir Phytotoxicity Rating*
UTC	0.09	0.00
Oranj-All 0.25%	0.73	0.04
Oranj-All 0.5%	0.72	0.09
Oranj-All 1.0%	0.73	0.00
COC 0.25%	0.26	0.08
COC 0.5%	0.29	0.14
COC 1.0%	0.15	0.11
MSO 0.25%	0.75	0.12
MSO 0.5%	0.78	0.11
MSO 1.0%	1.05	0.04
A Plus Spreader 0.25%	0.4	0.05
A Plus Spreader 0.5%	0.4	0.23
A Plus Spreader 1.0%	0.59	0.08
Solar 0.25%	0.79	0.03
Solar 0.5%	0.85	0.04
Solar 1.0%	1.01	0.04
BreakThru 0.05%	0.21	0.09
BreakThru 0.1%	0.23	0.13
BreakThru 0.2%	0.5	0.08
Ag300 0.25%	0.4	0.05
Ag300 0.5%	0.39	0.25
Ag300 1.0%	0.7	0.28

*** Key to Phytotoxicity Rating**
0 = no needle burn
1 = <20% needle burn
2 = 20-40%
3 = 40-60%
4 = 60-80%
5 = 80-100%

Surfactant Trials

A surfactant is typically added to the Sucker-Stopper RTU to spread and stick the material to the leader. Joe Cacka, Agronomist with Western Farm Services, conducted experiments using a variety of surfactant types on both noble and Nordmann fir. One trial evaluated surfactants without the addition of Sucker-Stopper RTU to determine if surfactant and distilled water had a phototoxic effect on leaders. Needle damage was rated on a 1-5 scale as shown in Table 2 above. The yellow/shaded highlights note those surfactants with more damage relative to others. Only Solar and MSO at 1% showed needle damage on more than 20% of the needles. Though the needles may look poorly, the damage is transitory. Generally, adding surfactants at the 0.5% range provided adequate protection and efficacy.

A second set of trials examined the effects of these surfactants when applied in combination with Sucker-Stopper RTU at a standard rate of 80 ml/L. The surfactant rate was set at the medium rate, generally 0.5% v/v for most surfactants, and 0.05% for BreakThru.

Noble fir and Nordmann fir responded differently to the surfactants applied with the Sucker-Stopper. Noble fir showed phytotoxicity as needle burn or necrosis, while Nordmann fir exhibited phytotoxicity as needle yellowing or chlorosis.

The acceptable surfactants to use on Noble fir are First Choice MSO, First Choice Oranj-All, First Choice A Plus Spreader, and First Choice Solar. The acceptable surfactants to be used on Nordmann fir are First Choice Crop Oil Concentrate, First Choice Oranj-All, and First Choice MSO.

Chemical and Mechanical Methods to Reduce Leader Growth in Fraser fir (*Abies fraseri*)

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The purpose of this research was to provide American Christmas tree growers with alternative methods of reducing leader growth compared to the traditional cultural practice of shearing. Separate experiments involving the use of a mechanical tool, the Top-Stop Nipper (TSN), and the application of naphthaleneacetic acid (NAA) were conducted in Avery County, North Carolina, on Fraser fir during spring and summer of 2005 and 2006.

The Top-Stop Nipper, a four-bladed hand-held tool, placed incisions (nips) on the previous year's leader to reduce the amount of photosynthate being transported to the developing leader. The treatments for the 2005 experiment consisted of a control (0 nips), one, two, three, or four nips at each of three stages of leader elongation [pre-budbreak, 2-3 cm, and 6-9 cm]. For the 2006 experiment, a regression model, based on an apical bud volume index from the 2005 experiment, was used to predict the number of nips to apply to each leader to yield a target length of 25 to 36 cm. The treatments included control trees (0 nips, nonsheared) and one to seven nips per leader. Treatments were applied in early May as buds began to swell and elongate.

Top-Stop Nipper

Results for the 2005 TSN experiment included a significant reduction in leader elongation; the percentage of leaders that were within the target range of 20 to 36 cm increased from 18% for the control (no nips) to 46% with four nips. In 2006, when treatments were based on a bud volume index, leader growth was about the same among all TSN treatments. Bud density on the 2006 leader also increased with the number of nips applied to the 2005 leader.

Easy Roller

German Sprühsystem

Comparison of Fraser fir leader elongation of a non-treated control tree (left) versus one receiving four nips with the TSN (right).

In 2006, two methods of application, the Danish Easy Roller and the German Sprühsystem, were tested to evaluate the effectiveness of ethyl 1-naphthaleneacetic acid (NAA) at reducing leader growth of Fraser fir Christmas trees. A commercial product, Sucker-Stopper RTU (SS-RTU), which contains 1.15% ethyl 1-naphthaleneacetic acid was applied to leaders at concentrations of 0 to 500 ml/L commencing when leaders were 8 to 15 cm long.

As the concentration increased, leader elongation decreased. The Easy Roller more effectively reduced leader growth, but leader mortality was unacceptable at concentrations ≥120 ml/L. Although less effective than the Easy Roller in reducing leader growth, the Sprühsystem caused virtually no mortality among leaders. Applying 40 ml/L with the Easy Roller yielded about 50% of leaders with target lengths of 20 to 36 cm, with little mortality. The Sprühsystem gave similar results at 250 ml/L.

The TSN or the application of NAA might be useful alternatives to standard shearing for growers who intend to produce dense trees with minimal shearing or for growers who leave longer leaders to produce a more open "European-style" tree during a shorter rotation time.

Test of various NAA-products for leader control on Nordmann fir

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Introduction
In Denmark as well as most other European and North American countries there is increased concern for controlling the leader growth on various species of Christmas trees. Many growth retardants have been tested for that purpose during the last 20 years though it seems to be a fact that today most growers prefer to use naphthyl acetic acid (NAA).

In the various countries there are a number of different trade products on the market containing naphthyl acetic acid, and experiences from some European growers are that the different products do not act the same way on Christmas trees of Nordmann fir (*Abies nordmanniana*).

Experiment
In an experiment in Denmark in 2006 all the different available trade products for Christmas trees in Europe and USA were tested. In the experiment were included, TopStar from Denmark, Obst Hormon 24 A from Italy, Tipoff Solution from UK, Sucker-Stopper and Tre-Hold from USA.

The three first mentioned were acid formulations while the last two from USA were salt formulations in form of naphthalene acetate.

The experiment was designed as a randomized block experiment with four blocks. All trade formulations were applied in the recommended concentrations by spraying the liquid on the leaders in mid summer.

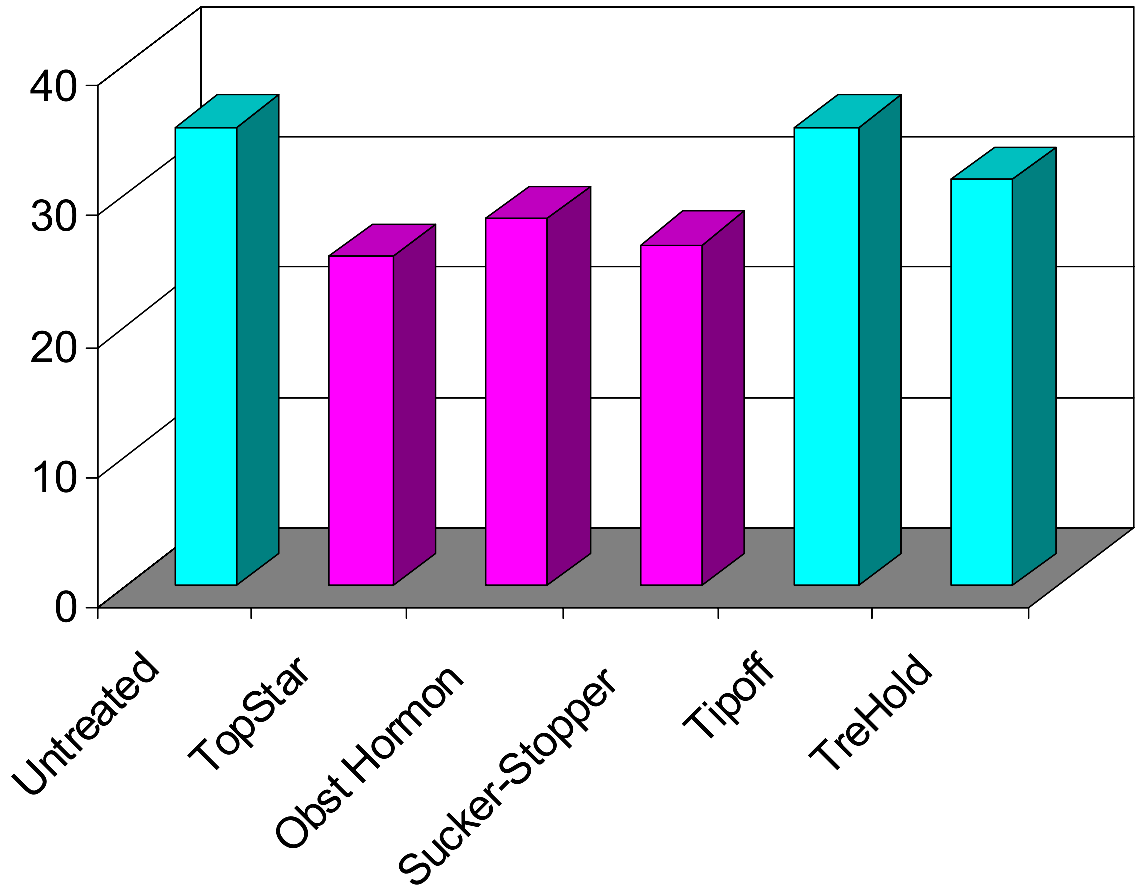

Figure 1. Leader length depending on product used.

Results

TopStar, Obst Hormon and Sucker-Stopper all worked as expected and gave significant shorter leaders compared to the untreated control (Fig. 1). Tipoff and Tre-Hold did not give any retarding effect on the firs.

A few treatments gave a slight discoloration of the needles, especially TopStar and Obst Hormon which gave a light yellowing.

When added to water, the two salt formulations, Sucker-Stopper and Tre-Hold, immediately gave a white sediment that blocked all filters in the spraying equipment. The filters had to be removed before these two retardants could be used for spraying the leaders.

Oral Presentations: Market and economy

Christmas trees in Denmark

Kaj Østergaard and Claus Jerram Christensen
Danish Christmas Tree Growers Association

Internationally, Denmark is one of the leading countries regarding production of Christmas trees and greenery. With an annual production of 10 million trees, mainly Nordmann fir (*Abies nordmanniana*) Denmark is the second largest producer in Europe next to Germany. In addition, the annual production of 35.000 ton of greenery, mainly noble fir (*A. procera*), makes Denmark the largest producer of bough material. In Denmark some 1,7 million trees are used in private households and professionally in relation to e.g. shops and city malls. The rest of the trees are exported to primarily Germany. This makes Denmark the largest exporter of Christmas trees in Europe.

Value and size of export

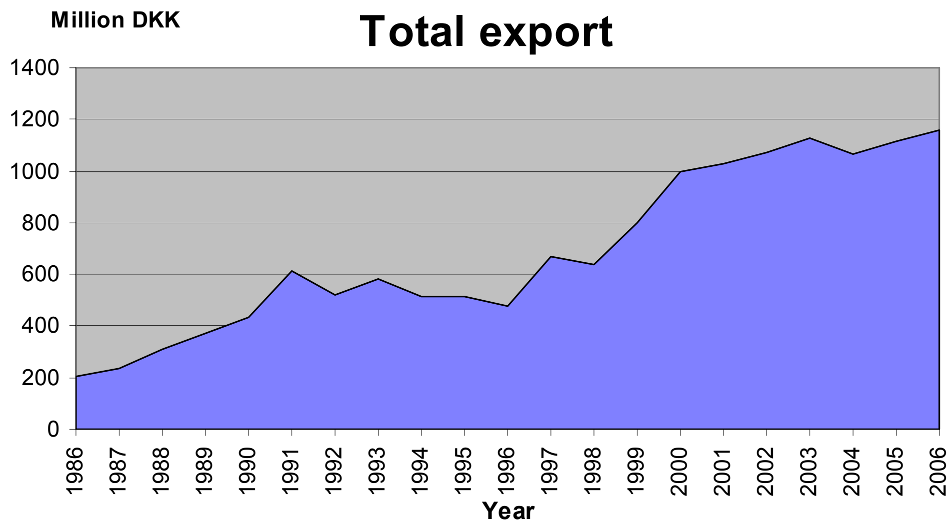

Figure 1. Since year 2000 the total value of the Danish export (Christmas trees and greenery) has made up to over one billon DKK – in 2006 the export value was close to 1,2 billon DKK.

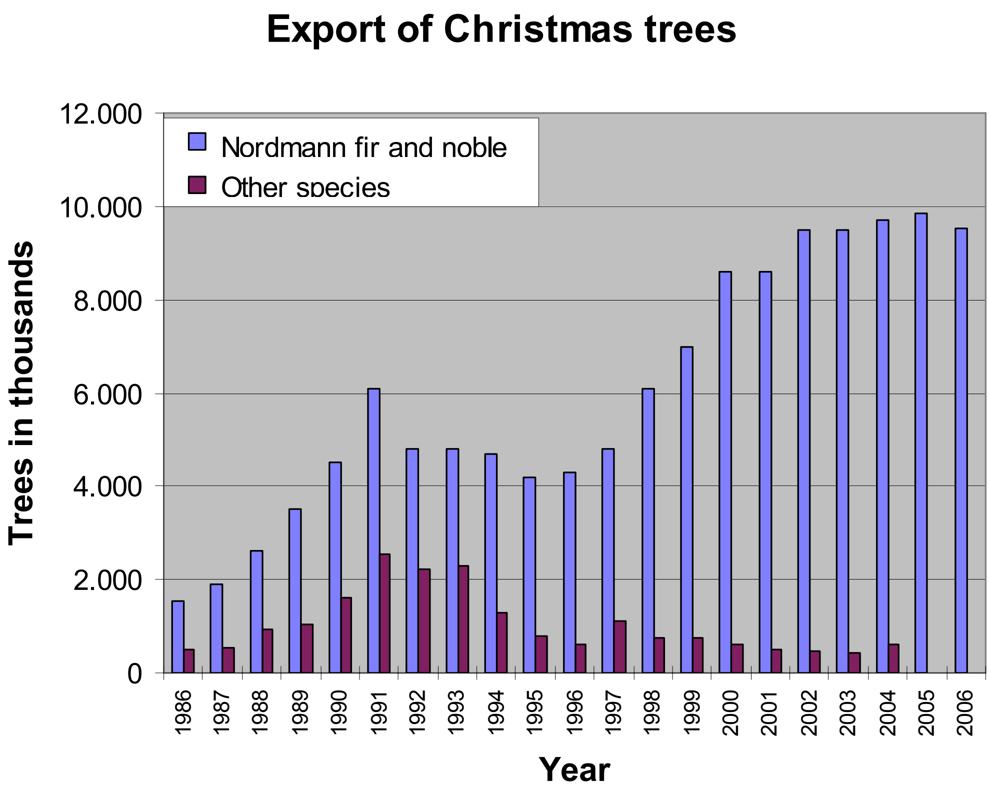

Figure 2. In 2002 to 2006 the number of exported Christmas trees added up to some 10 million trees, mostly Nordmann Fir. The category "other species" is manly Norway spruce, but in 2005 this minor export was grouped with Nordmann fir and noble fir.

Exporting countries – Christmas trees

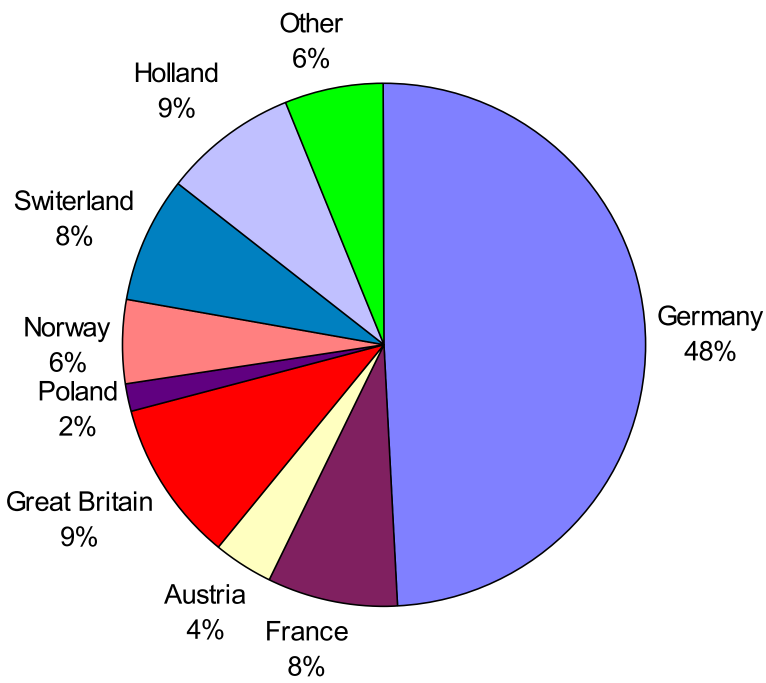

Figure 3. Most of the Danish export goes to Germany followed by Great Britain and France. The Dutch export is re-exported and is accounting for the real end-user export.

Amount of exported greenery

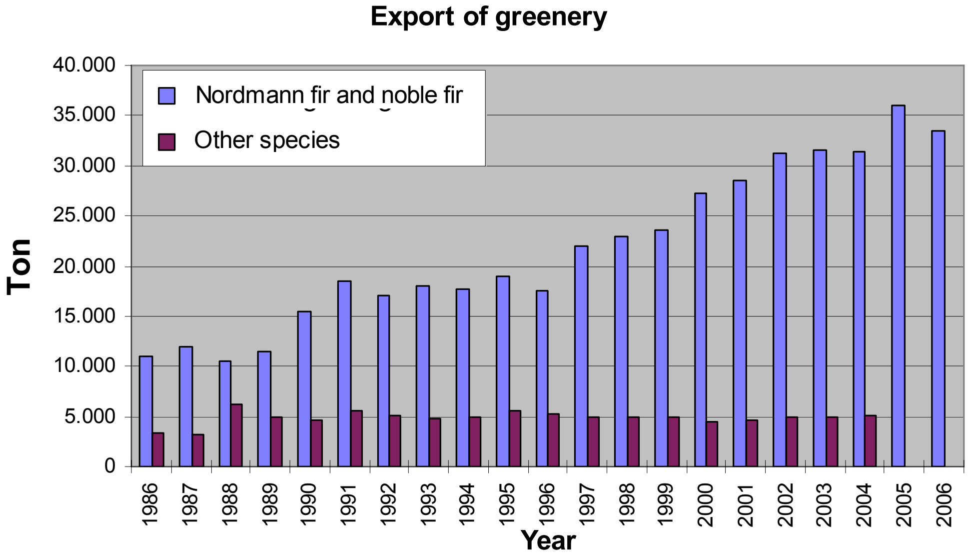

Figure 4. The amount of exported greenery are rather stable around 35.000 ton annually. As for the Christmas trees, the category "other species" was gruped with Nordmann fir and noble fir from year 2005. Other species accounts for species like Norway spruce, white spruce and some pine species.

The Production of Christmas Trees in Belgium

Claude Guiot, Dominique Raymackers
Direction Générale de l'Agriculture Division de la Recherche, du Développement et de la Qualité,Direction du Développement et de la Vulgarisation

The Christmas Trees' production in Belgium is located primarily in Wallonia, , more especially in the South of the furrow Sambre and Meuse, in the provinces of Luxembourg, Namur and Liege. The total covered surface in Christmas trees borders 5.000 Ha, including approximately 65% with *Abies nordmanniana*, 20% of *Picea abies*, 10% of *Abies fraseri* and 5% composed of the other varieties such as *Abies nobilis*, *Picea pungens*, *Picea omorika*, etc. The total superficies concerned by the Christmas Trees' production in Belgium is around 5.000 Ha composed with about 65 % of *Abies nordmanniana*, 20 % of *Picea abies*, 10 % of *Abies fraseri* and 5 % with the other varieties as well as *Abies nobilis*, *Picea pungens*, *Picea omorika*, etc.

The producers are to 95% mainly Walloon. They have been members for the majority of the "Of the Ardennes Union of Nursery gardeners" (U.A.P. a.s.b.l.), of the professionals gathered in an existing non-profit-making association for more than 40 years. Their joined together production reached four (4) million Christmas trees annually on average, of which 80% are intended for export (France, Netherlands, Great-Britain, etc).

Since 2006, the Walloon Area subsidizes a Center Controls "Christmas trees" (C.P.S.N.) intended to support/reinforce this economic sector. The axes of priority of the CPSN are:

- to coordinate the activities of the UAP
- to develop experiments
- to promote the economic development of the sector

The CPSN is managed by a Forestry expert full-time, incorporated in the Horticultural Die not Comestible (F.H.NC) of the Horticultural Walloon Federation (F.W.H.), concerned with the Directorate-General of the Agriculture of the Walloon Area (DGA-MRW), Division of the Research, the Development and Quality (FD-RDQ), Direction of the Development and Popularization (DDV).

Christmas Tree Extension Service Delivery in New Brunswick and Canada's Maritime Provinces

Chris A. Dickie
BSc. Forestry Extension Program Manager, INFOR Inc.

New Brunswick is one of Canada's Maritime Provinces and is located between Quebec and Nova Scotia on Canada's east coast. New Brunswick is Canada's only officially bilingual (French/English) province, having a population of 749,168 people (2006) and a landmass of 72,908 square kilometres. The province is 85% forested and land tenure is split between crown land (50%), private land (30%) and industrial freehold (20%). Currently there are approximately 350 Christmas tree growers in New Brunswick producing 500,000 trees annually, with 85% of the production being exported to the United States, Caribbean, Central and South America. New Brunswick is Canada's largest exporter of wreaths and greenery products. In excess of 1,000,000 alone are produced and exported annually. Other products include garland, kissing balls, swags, grave blankets and bundled brush. Balsam fir is the primary species grown and used in the production of wreaths and greenery as it occurs naturally in extreme abundance and possesses many qualities sought after by consumers.

Founded in 2001, INFOR Inc. was set up to serve as the provincial private forestry extension service provider. INFOR's mandate includes delivering education, training and information and technological transfer services to the province's 40,000 private woodlot owners, Christmas tree growers, maple syrup producers and the general public. Currently in New Brunswick the Christmas tree and greenery industry is facing several major issues which threaten the future viability of the industry. The effects of a warming climate threaten the industry through a reduction in product quality, the emergence of new invasive pests and an intensification of current pest outbreaks and abiotic stressors including water and soil nutrient management. Competition from artificial trees and increasing export regulations have also lead to reductions in total real tree sales. General market conditions including a strong Canadian dollar and increasing production costs are further reducing producer's profit margins.

In response to all of these pressures, INFOR Inc., in conjunction with the New Brunswick Christmas Tree Industry Association and a strong network of partners from neighbouring provinces are working on several initiatives. In order to effectively deal with new and emerging threats, and to ensure that producers are receiving the information and training they require to remain viable, a strong regional extension service must be developed. To that end INFOR and its partners are continually seeking support and funding to increase its service capacity. Supporting regional rural development is key to New Brunswick's future prosperity.

Marketing Christmas Trees to Christmas Tourists

Mark Richman
Faculty of Forest Sciences, University of Joensuu, Joensuu, FINLAND

In Finnish Lapland, Christmas tourism or tourism that is concentrated during the Christmas Season and involves the Christmas celebration, has grown considerably and continues to grow. Large groups of foreign tourists visit the region during this period, there were more than 100,000 visitors to Lapland during the three month Christmas season of 2006 (Finavia 2006), some came for only a day. A central part of the experience for almost all of these guests is a visit with or from Santa Claus or Father Christmas. At this time trees surround the visitor. The trees stand decorated in the forest with snow and with lights and ornaments in community parks, court-yards, as well as in and outside buildings. These Christmas trees, like Father Christmas are a necessary part of the celebration.

After meeting Father Christmas, those visitors who return to their homes for Christmas Day celebrations often have Christmas trees in their homes. These trees are usually purchased from local distributors in their home regions. Since these persons had travelled to Lapland to be surrounded by the spirit of Christmas and experience meeting the “real Santa Claus,” they may wish to take back with them, for their celebration at home, a “**real**” Christmas tree. Some benefits and the potential of marketing real Christmas trees to Christmas tourists was examined by means of a market survey of visitors to determine preferences and pricing.

Figure 1. Display of the dropbox, Christmas tree, survey with questionnaires in eight languages, located at the main outside entrance to Santa's Main Post Office, in Santa Claus Village on the Arctic Circle near the city of Rovaniemi in Finnish Lapland.

The survey work was conducted in Rovaniemi, the centre of Christmas tourism in Finnish Lapland. Initially contacts and discussions were made with local representatives from a wide range of organisations involved. The next phase of the work was a survey of visitors during the peak Christmas tourism season from December 2001 to the first week of January 20002. More than 250 interviews with visitors were conducted at the Rovaniemi Airport and at Santa Claus Village. These interviews included more in-depth open-ended questions that allowed for a broader input from the respondents, including suggestions. In addition self-selected drop-box questionnaires were available in eight languages at seven locations in Rovaniemi, with more than 650 returned. The markets for supplementary products like ornaments, and decorations made from tree greenery, were also examined.

Examples of souvenir purchase theory and tourism based on cultural symbols were examined to better understand the behaviour and preferences of Christmas tourists. These tourists are seeking a preconceived experience based on their own culture and media experiences as well as the Christmas tourism industry's marketing. Consideration was also made as to whether this experience could be successfully modified, and even enhanced by the acquisition of a souvenir that is also a material symbol of Christmas. A Christmas tree from Lapland would not only satisfy the need for this centrepiece of the Christmas celebration, but would also be the proof and centrepiece for conveying feelings about the Christmas tourism experiences to others. In some cases any gap between what a Christmas tourist expects from their experience and reality may be filled to some extent by acquiring such a symbol. In this way it may be that Christmas tourists who return home with their experiences and a real Christmas tree are more satisfied with their trip than if they had only their experiences and less symbolic souvenirs.

The marketing of locally produced Christmas trees to Christmas tourists will provide a new market for this product. The product supply source would provide income and employment opportunities to rural areas as well as sectors of society that do not normally benefit from tourism. When combined with experience tourism and related Christmas products, rural entrepreneurs can develop beyond acting only as wholesale suppliers of trees.

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Christmas Tree Production in Austria

"The long way to a seed orchard for Nordmann Fir, *A. nordmanniana*"

Karl Schuster

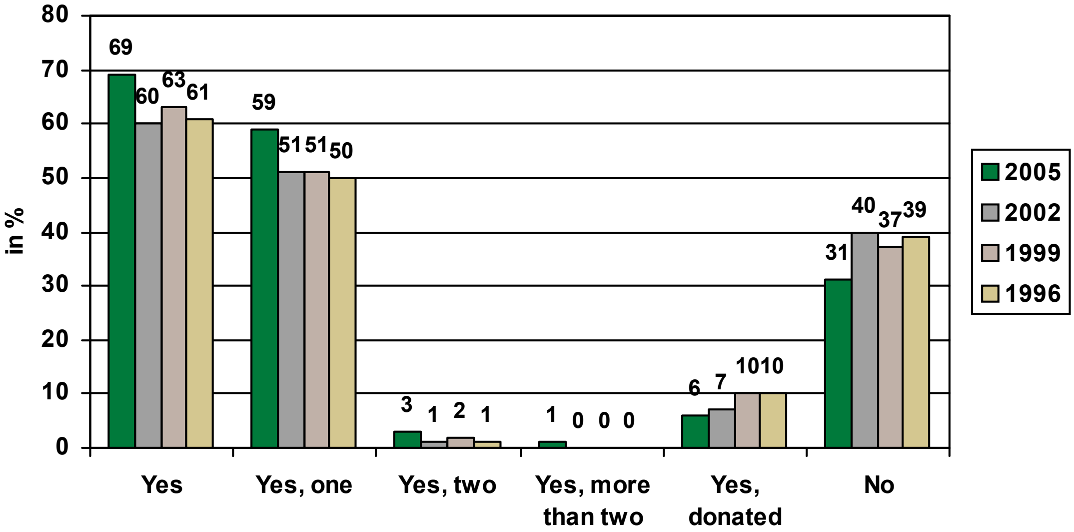
Department of Forest in the Chamber of Agriculture of Lower Austria/Association of Christmas Tree Growers of Lower Austria

Every year about 2.6 millions of Christmas trees are set up in Austrian households, which make a value of 50 Mio Euro. Furthermore, thousands of tons of greenery are taken into process by market-gardens every year. The material comes partly from agricultural areas and partly, especially the greenery, from forests.

Market

The numbers and facts (GfK 2005):

- 69% of households had a Christmas tree
- 4% had more than one tree
- 4,7% had a tree from their own forest
- 5,3% had an artificial tree
- costumers kept their tree indoors for 15 days, on average
- 75% bought their tree directly from the grower
- every costumer spent nearly 20 Euro, on average, on a tree
- 75% preferably bought a tree from Austria



From previous analyses we know that
- two thirds of the trees were 1 – 2 metres
- 21% of the persons interviewed stated that they did not buy their own Christmas tree for the following reasons:
  - 1/3 spent Christmas with relatives
  - 1/3 never buys a Christmas tree
  - 1/3 had other reasons (too much dirt, alone at home, away ...)

Customers state that their most important criteria of buying a Christmas tree are the appearance, price and also factors such as freshness, the recognisability of the homey origin and personal relations to the producer. Special tree-cut-periods (accommodated to the phases of the moon) and nearness of the shopping area also matter.

Many consumers in Austria do not like to just buy a Christmas tree; they also want to take home the mood of Christmas when buying their tree.

Many growers adapt to this trend and arrange coach-tours, build wonderlands for children or offer their clients homemade pastries and mulled wine to make the purchase of the Christmas tree an experience.

Growers

About 85% of the Christmas trees come from Austria (70% from cultivations, 30% from forests), 15% from foreign countries, mostly Denmark and Northern Germany and almost exclusively *Abies nordmanniana*. The high percentage of local trees is due to our country's abundance of wood, since more than 47% of Austria's whole area is covered with forests, more than ¾ being coniferous. The local tree trade is decreasing rapidly, however, because more and more people want a good quality tree like Nordman fir.

Due to climatically conditions there are traditional areas with a high number of Christmas tree plantations (e.g. South Waldviertel in Lower Austria), above all areas with a structure of small holdings. In Austria the average plantation has a dimension of 0.7 – 1 hectare, so you cannot speak of plantations in the original meaning. Many holdings have several fields of production and run the growing of Christmas trees to make additional profit besides the normal agricultural income.

In 2005 the inland production was about 2.25 Mio trees.
In Austria there are about 1,000 growers, 600 are organized in one of the 7 federal Associations, but there exists no National Association in Austria. The average of each grower is 3 hectare, so there are about 3,000 hectares Christmas tree plantations in Austria.
The official statistics are somewhat under-estimated, because some growers do not declare their full plantation area for taxation:

Year	Number of plantations	Increase of plantations in %	Area in hectares	Increase of area in %
1993	1714	-	1110	-
1994	2117	23,5%	1435	29,3%
1995	2294	8,4%	1624	13,2%
1996	2644	15,3%	1798	10,7%
1997	2791	5,6%	1901	5,7%
1998	2959	6,0%	1963	3,3%
1999	3032	2,5%	2050	4,4%
2000	3084	1,7%	2084	1,7%
2001	3157	2,4%	2189	5,0%
2002	3199	1,3%	2246	2,6%

(Half of production is in Lower Austria).

The Association in Austria, especially in Lower Austria
Christmas tree grower associations were founded in 7 federal states during the years1994-1997, the primary reasons being:

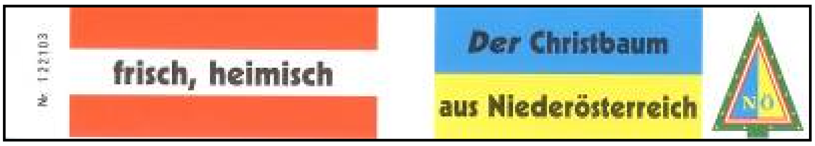
- the opening of the eastern European countries
- the entrance of Austria into the EU and the increasing number of growers
- the import pressure from Denmark

A market study in 1996 was the first joint action of the associations. Other polls followed in 1999, 2001, 2003 and 2005.

Opening of the borders to the eastern European countries seems to be a particularly impending competition to many Austrian growers. Some large-scale producers laid out extensive plantings (mostly with *Picea pungens*), for example in Hungary, that could overflow the Austrian market. On the other hand, eastern Europe is a new market with an enormous sales prospect, since many people in these countries are catholics and therefore celebrate Christmas with a tree. Most Austrian grower who went to sell trees for example in Hungary obtained higher prices than in Austria. In the last two years Austrian growers have also sold Nordman firs to the eastern countries.

The associations set themselves the goal of advising and training their members more effectively by means of seminars and exhibitions. Especially in questions of cultivation of alternative sorts and correct origins of the *Abies nordmanniana* there are possible rationalisations resp. alternatives that also can influence the future success.

TV, radio station and newspapers are the most important partners for our advertising. Therefore our slogan is: buy a natural tree – buy an Austrian tree – buy a tree from our members! A very important thing therefore is the homepage www.weihnachtsbaum.at for the customers and journalists.



The consumer is persuaded of the good quality and freshness of the home product, the associations try to make easier the search for Austrian goods by own labels of origin on the Christmas-trees and labelling of the market stalls. One of our main problems is to protect this label, because some growers try to sell imported trees under the local label. Therefore we have a project with the Seibersdorf Research Centre to find a method to analyse the growing place of a tree with the different isotopes of some elements like H, O or S. For examples there are different isotopes of H in trees of Denmark and Austria because the rain is “heavier” in Austria than in Denmark because of less Tritium.

All in all, it is not only the price that counts. Also as the origin and high quality are decisive for the success of the Christmas tree production.

The future customers!

An important thing for our future is working with children, our costumer of the future. In cooperation with the Forest-Youth-Games in Lower-Austria we have the chance to give information to more than 15.000 children of the 6th school class to tell them the importance of using a natural tree. On the other hand we have many social activities during Christmas time to get a good “press”, for example we give trees to SOS children homes and to soldiers on the Golan. We also bring a big tree to Brussels to EU parliament each year.

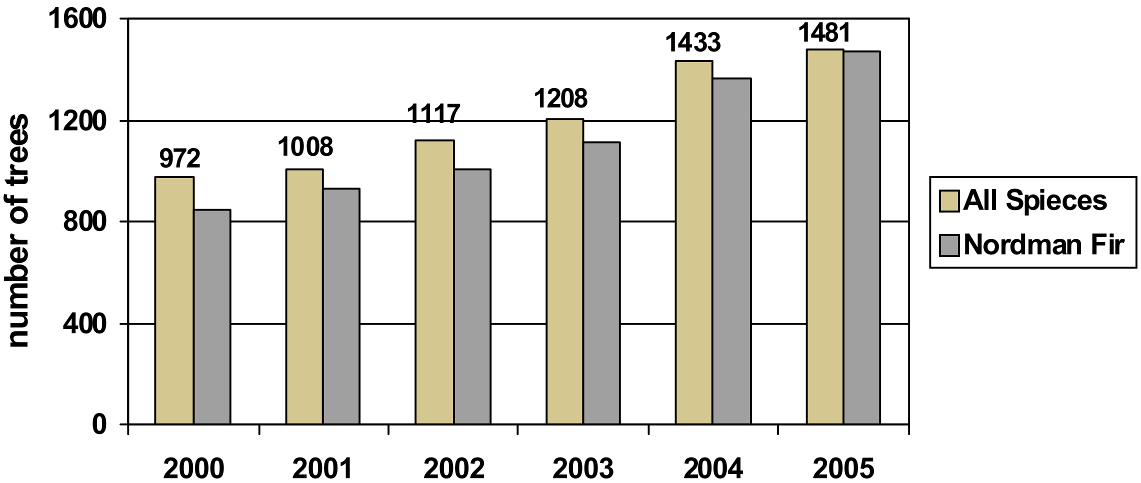
Numbers and facts of the Association of Lower Austria

Tree species in plantations in 2004 and prospect:

Nordman fir	61% ↑
Blue Spruce	11% ↓
Grand fir	6% ↓
Red Spruce	6% ↓
White fir	4% ↔
Noble fir	4% ↔
Silver fir	3% ↓
Others	5% ↔

Area of Nordman fir is increasing rapidly

During the past years the Christmas tree production shift more and more from forest to cultivations, which can be due to the changing preferences of the customers – from the native *Abies alba* or *Picea abies* to bigger-needled, denser *Abies*-sorts, mostly Nordman fir. Also the better durability of the needles is an important reason for this change.

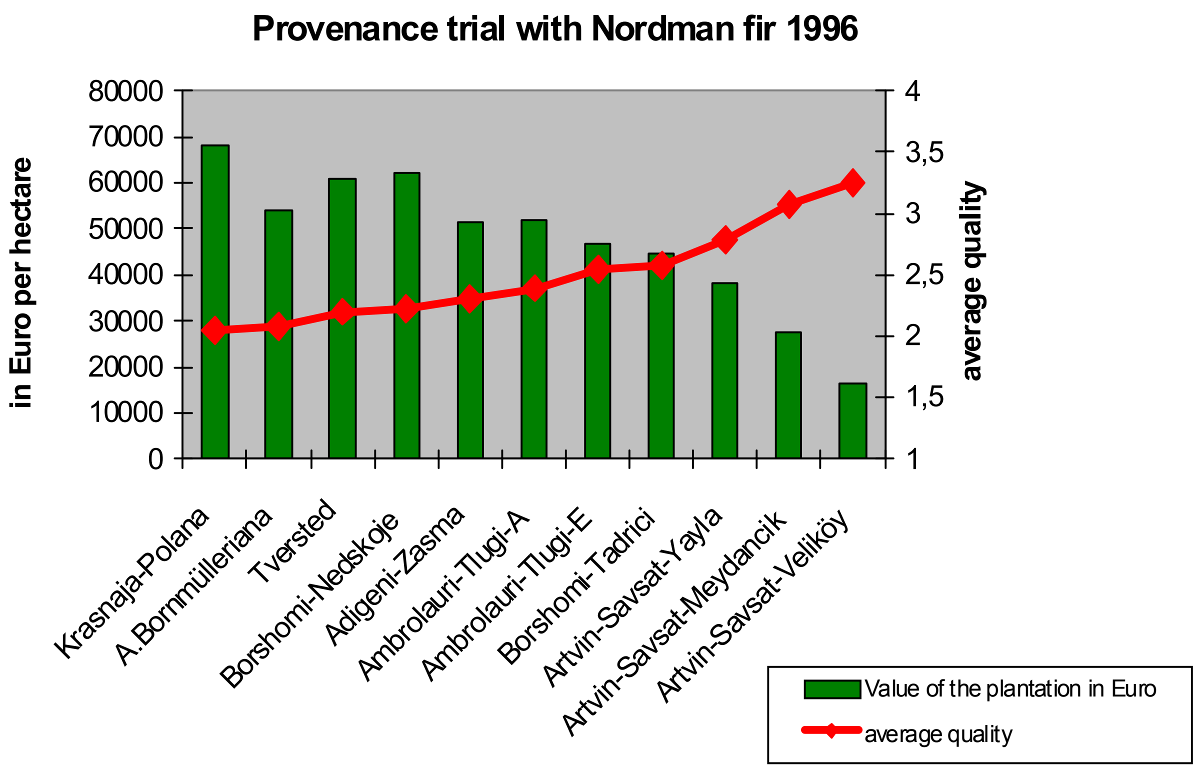


Average of sells per farm and year

The members of the Association in Lower Austria from 2000 to 2005 increased the number of sold trees by nearly 50%. The amount of Nordman fir increased. During the same time the average price fell from nearly 20 Euro under 17 Euro per tree. The reason was that the Association began to sell about 100.000 second class trees to two big stores and so the numbers of sells per member rose but the average price fell. The turnovers increased and the qualities of the plantations got better, because the second class trees were sold for a good price. This was very important because most of the Austrian growers sell their tree in own stand or from farm and therefore they need good qualities.

Branch regulator to higher quality

The Association in Lower Austria tries to persuade their members to produce more A-trees, also with cutting methods and Top-Stopp-Clipper. Different praxis trials were made, often in cooperation with our research institutes. For example provenance-trials, trials with fertilizer, herbicides and projects with cuttings of Blue spruce. Courses to raise quality were made and a new tree regulator for the branches of the trees was found. Most of these things were communicated with the homepage www.christbaumtag.at for the growers.



The provenance trial from 1996 showed us that the Turkish provenances are not the best for Austrian climate. A new trial beginning in 2006 compares 18 different Georgian and Southern Russian Nordman fir provenances.

Christmas tree fair in Lower Austria

One of the most important activities for the Association is the biennale Fair in Lower Austria. Between 500 and 1.000 growers come to see the new things in the business. The first fair started in 1996 and was directed to growers who could not go to Langesø, the greatest event in the scene. The fair offers a program for a whole day with talks, machine-shows, exhibitions, field-tours, showing field-trials and evening-talks. Also the “most beautiful Austrian tree” is chosen by the visitors of the exhibition.

This fair is one of the three biggest in Europe besides Langesø and Gudensberg.

Field tours are very popular for growers

Machine exhibitions in the plantations

Seed Orchard for Nordman fir

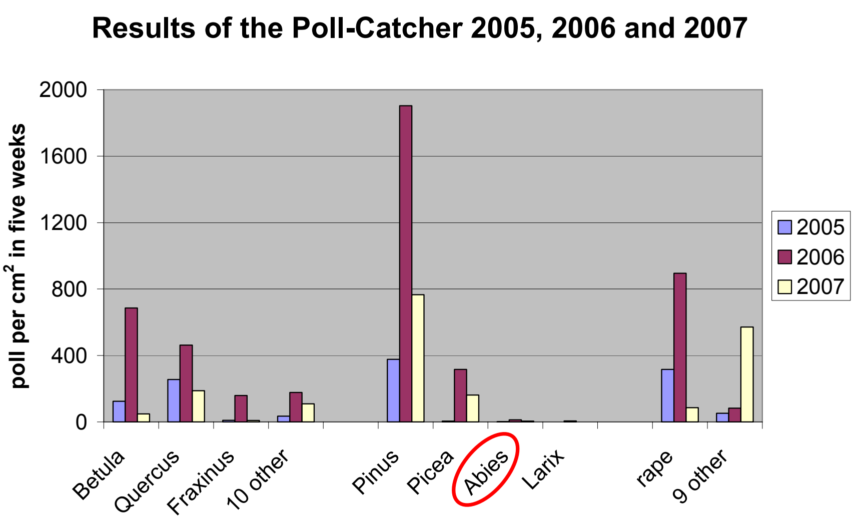
Only very good qualities were taken for the seed orchard

Since 1996 as the Association of Christmas Tree Growers of Lower Austria was founded, the members objected to bad seed qualities. Not one of the nurseries had the high quality of Nordman fir seed as the years before. So we decided to make a seed-orchard for Nordman Fir in Lower Austria.

Some of our members had older trees of Nordman Fir in their plantations. The quality of these 20 to 30 years old trees was the A-Quality of former times. The most important criteria being: needle quality (colour, length and density) and growth form. Frost hardiness, should also be good, because the trees clearly had no serious frost damage in the last 20 or 30 years, judging from the crown form. Branches from these trees were grafted on 4 y old Nordman firs by staff from the Federal Research Centre of Forest. We founded 22 different clones on 5 stands that had the quality we wanted. We took material only from trees that had cones in the last years.

Potted trees after inoculation

We looked for a field in an area with few Silver Firs to get no crossings in the seed. We placed a poll-catcher in the field in 2005, 2006 and 2007 to see the influence of Silver fir. The results are in the graphics below. The influence is very little also there are some silver firs in this area and 2006 was a very good seed year for Silver fir. We didn't want to establish the orchard in the north-western part of Lower-Austria which is free from silver fir, because the dryness of this area. We will leave the poll catcher the next years on the field and also when the first cones will grow to know the influence of silver fir. If there will be some influence later we can also make an artificial pollination. As we wanted to know where the old trees are originally from, we sent some branches from each tree to ISOGEN in Germany to make Iso-Enzym-Analysies. They compared the allele frequency of the three gene locus GOT-B, PGI-A and PGI-B with control samples. The genetic distance was very low to samples of Ambrolauri Lemaneori, and low to Ambrolauri Nikordcminda and to two samples from Bakuriani and Bordjomi. Now we know that the material is probably from the Ambrolauri-Area.



In autumn 2007 the plants will be planted in the field we chose in the northern part of Lower Austria. The field is at the border of the natural range of Silver Fir. The plant spacing will be 4 to 5 meters in a kind of a triangular planting, so that the plants have space enough for growing and the full sunlight for making cones. We have 2.5 hectares so we need about 1,250 plant for the whole plantation or 60 plants from each clone. In a similar orchard of the Federal Research Centre of Forest for silver fir, the first cones with seeding followed after about 7 years. The clone dispersal plan is made by specialists of the Federal Research Centre of Forest.

Now everybody hopes that in about 10 years we will have the first Austrian Nordman Fir seed and we hope from good quality.

This is one further step in the right direction and a sign for the importance of the work together.

The next step should be more teamwork in whole Europe in the European Association, the Christmas Tree Grower Council of Europe (CTGCE) – www.ctgce.com .

Poster Presentations: Tree Health, Cultivation Techniques, Market and Economy

Fungi found in Norway and Austria in association with *Abies*-needles developing current season needle necrosis (CSNN).

Venche Talgø[1)], Thomas Cech [2)], Arne Stensvand[1)]
[1)] Norwegian Institute for Agricultural and Environmental Research, Plant Health and Plant Protection Division, [2)] Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Department of Forest Protection, Unit of Phytopathology and Biochemistry, Vienna, Austria

CSNN is common on *Abies* spp. both in the USA and Europe. To our knowledge the main focus on seeking an explanation to the problem has been on noninfectious/abiotic factors like nutrition and effect of shading. Thus, we decided to look into possible fungal infections on symptomatic needles. We examined samples from Nordmann fir (*Abies nordmanniana*) both in Norway and Austria. This resulted in a number of fungi, see attached poster.

Fungi found in Norway and Austria in association with *Abies*-needles developing current season needle necrosis (CSNN)

Venche Talgø[1], Thomas Cech[2], and Arne Stensvand[1]

Bioforsk
Norwegian Institute for Agricultural and Environmental Research

Symptoms

Current season needle necrosis (CSNN) is a problem on fir (*Abies* spp.) both in the USA and Europe. Initial symptoms appear in May/June in Norway as chlorotic spots like on the nordmann fir (*Abies nordmanniana*) needles in Fig. 1. During the summer, damaged parts of the needles turn brown to reddish like on the nordmann fir from Norway in Fig. 2 (left) and grand fir (*Abies grandis*) from Austria (right). Often the tip of the needles show symptoms, and sometimes entire needles turn brown and shed.

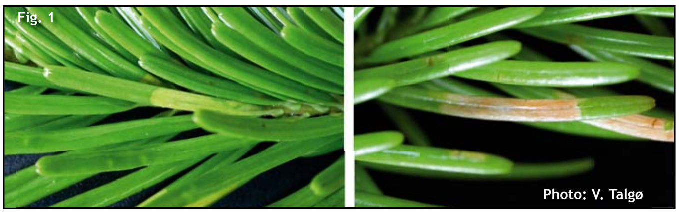


Fig. 1 Photo: V. Talgø


Fig. 2 Photo: V. Talgø Photo: T. Chech

Possible disease causing agent

To our knowledge the main focus on seeking an explanation to the problem has been on noninfectious/abiotic factors; heat tolerance, nutrition, and effect of shading. The fact that diseased needles occur between perfectly healthy looking needles, may indicate that a pathogen is causing the problem.

In Austria, the fungus *Kabatina abietis* Butin & Pehl sp. nov. was associated with CSNN symptoms on grand fir, nordmann fir for Christmas trees, and noble fir (*Abies procera*). *K. abietis* was first described in Germany on needles from grand fir with spotty discoloration (browning) (Butin and Pehl 1993). Fig. 3 shows a culture of *K. abietis* isolated from nordmann fir in Austria (left) and hyphae with conidial glomeration (right).


Fig. 3 Photo: T. Cheh

Norwegian investigations

In 2004, we decided to look into possible fungal infection on symptomatic needles on nordmann fir from south-western Norway. In early October, we collected six needle samples (Fig. 4) from five different farms in Rogaland county. Small needle sections were surface sterilized before they were placed on potato dextrose agar (PDA). Parallel samples were incubated (100 % RH and 20 °C).


Fig. 4 Photo: V. Talgø


Fig. 5 Photo: V. Talgø

Pestalotiopsis sp. dominated both on PDA and on incubated samples (Fig. 5). *Pestalotiopsis* spp. are considered weak pathogens or saprophytes. Interestingly though, a dark culture with morphological characters resembling *K. abietis* (Fig. 3, left), was present on six out of six samples.

Since the samples in Norway were collected late in the season in 2004, we could not eliminate that the fungi we found were secondary invaders, and therefore new samples were collected in July 2005, at the time when the first symptoms developed. Isolations on PDA and water agar (WA) resulted also at this time of the year in cultures resembling *K. abietis*. The same result was obtained from a CSNN sample of nordmann fir sent to us from Denmark in 2005, and from other occasional samples sent to us during 2004 to 2007. On the upper side of the needles from a majority of those samples, there were densely situated acervuli (Fig. 6). Occasionally greyish spore masses oozed out from the acervuli after incubation.


Fig. 6 Photo: V. Talgø

Isolation on PDA directly from the spore masses yielded a culture identical to the culture in Fig. 3. The acervuli had textura angularis as described for *K. abietis* by Butin and Pehl (1993), and the morphology of the spores corresponded well with their description. Butin and Pehl (1993) reported that *K. abietis* mainly form on the lower side of the needles (hypophyllous). As far as we observed, acervuli did not appear on the upper surface (epiphyllous) until the necrotic areas changed from brown to more greyish. Thus, acervuli seemed to form later on the upper side of the needles than on the lower side.

Fig. 7 shows erumpent conidiomata in the stomatal area of an incubated nordmann fir needle with CSNN symptoms collected in July 2007 (left), and hypha and conidial glomeration from a culture obtained in July 2006 (right). According to Butin and Pehl (1993), these morphological characters are typical for *K. abietis*.

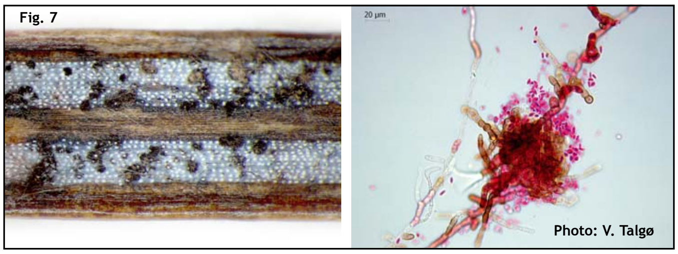


Fig. 7 Photo: V. Talgø

On CSNN samples collected in January and April 2007 from different locations in Rogaland county, we found a discomycete among the acervuli mentioned above (Fig. 8). Apothecia grew on both the upper and lower side of the needles. We were wondering if it could be the teleomorph state of *Kabatina abietis*, but sequencing revealed that it was a *Mollisia* sp. *M. fusca* had the closest match (99,64 %). *Mollisia* spp. are common on rotting wood (Ellis and Ellis 1997).


Fig. 8 Photo: V. Talgø

Conclusion

It may be concluded from our investigations in Norway and Austria that we have clear indications that CSNN is caused by *K. abietis*.

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Variation in the susceptibility of noble fir (*Abies procera*) to current season needle necrosis.

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Current season needle necrosis (CSNN) is a poorly understood physiological disorder that can limit where susceptible Christmas trees can be grown. In the Pacific Northwest (PNW) portion of the United States, this disorder is most commonly seen on noble and grand fir (*A. grandis*) Christmas trees that are grown at low elevation sites. It has also been observed on noble fir in Europe. Although foliar applications of calcium chloride and calcium nitrate and shading shoots during shoot elongation have been shown to reduce the development of CSNN in the PNW, management of this disorder is currently based on roguing both susceptible seedlings in nursery beds and severely damaged trees in plantations, as well as planting resistant seed sources of noble fir.

Currently, there is only a limited amount of information on the susceptibility of various sources of noble fir to CSNN in the PNW. This is partly due to the seasonal variation in development of this disorder and the fact that very few noble fir genetic trials have been planted in low elevation sites. During the past 5 years, two large noble fir regional genetic trials have been established in the PNW. In a 2002 trial, trees were planted at 6 test sites in Oregon and Washington, including WSU Puyallup.

Each test site consists of replicated plantings that contain 25 trees from each of 37 different sources. Sources include trees from Washington DNR Toutle River area, BLM Coastal Oregon, the PNW Christmas Tree Association Hostetler seed orchard space trees, grower selections, Danish provenances, and progeny from controlled crosses of some of the Riley/Fanno trees in the Hostetler seed orchard that appear to be resistant to CSNN. In 2004 a second set of replicated trials was established at 8 sites in Oregon and Washington, including WSU Puyallup. Each test site contains 25 trees from each of 46 sources of trees. Sources include trees from BawFaw Peak (WA), North Cascades (WA), Stott Mt. (OR), Oregon Coast, Riley Peak (OR), and Hostetler seed orchard space trees.

Figure 1. Severe current season needle necrosis (CSNN) on noble fir in genetic trial.

Although limited CSNN has developed on trees at most of the test sites, WSU Puyallup is a low elevation site (40 ft) that is very conducive to the development of CSNN (Fig. 1). Data on the severity of CSNN was collected on the trees in the 2002 planting in 2004, 2005, and 2006. The severity of damage caused by CSNN on the trees in the 2004 planting was collected in 2006. Damage was rated on a scale of 0 to 10, where 0 = no damage, 1 = 0 to 10%, 2 = 11 to 20%,

…. , and 10 = 91 to 100% of the foliage damaged. In 2006, the potential effect of the damage on tree grade was also rated on a scale of 1 to 3, where 1 = no affect, 2 = grade reduced to a #2, and 3 = grade reduced to a cull.

Figure 2. Differences in damage levels between sources were evident.

Data from the 2002 trial confirms that CSNN severity can vary significantly by year. The overall average damage ratings were 2.33 in 2004, 1.59 in 2005 and 3.42 in 2006. Damage also varied by source in both trials (Fig. 2). In general, no local patterns were apparent, but the Danish provenances and a few seemingly random Oregon /Washington families tended to have limited damage while sources from the North Washington Cascades tended to have high levels of damage. Progeny from some of the "resistant" Riley/Fano sources may not be as resistant as once thought.

Acknowledgements: This project was supported by the Pacific Northwest Christmas Tree Association Research Funds. The authors gratefully acknowledge the assistance of Gil Dermott, Jan Sittnick, Rick Fletcher, Mike Bondi and Annie DeBauw. A special thanks to Silver Mountain Conifer Nursery and Kintigh Mountain Home Ranch for growing the seedlings.

Current season needle necrosis (CSNN) in Denmark.

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Forest & Landscape Denmark, University of Copenhagen

In Denmark symptoms of CSNN on Nordmann fir (Abies nordmanniana) were first described in 1981 as "red needle" syndrome (Christensen 1981). But similar symptoms had been observed since 1969 (J. Koch, unpublished data), often on Grand fir (Abies grandis). Later, a similar damage was described on noble fir (A. procera), which is normally used for bough production (Nielsen and Christensen 1995). However, the probable connection with the disease called Current Season Needle Necrosis (CSNN) in the Pacific Northwest America came later, when observations confirmed that the symptoms occur in early July and are connected with wet springs. In Denmark, the damage is only severe in some years, so it is difficult to suggest control measures.

Figure 1. Typical symptoms of ”red needles”, also called “red tip syndrome” on Nordmann fir. This disorder is thought to be equivalent to CSNN.
Photo: Paul Christensen.

In Germany, similar symptoms are considered to be caused by the fungus *Kabatina abietis*. In Denmark, there have been efforts to isolates fungi from symptomatic needles of Nordmann fir and Grand fir. Although the dead tissue of needles is colonized by many different fungi, it has never been possible to get any fungal growth from surface sterilized needles in the early stages of the disorder. Therefore, CSNN has not been considered a fungal disease in Denmark, but a physiological disorder related to disturbed Calcium uptake in rainy springs, according to the North American definition (Chastagner 1997).

In 2003 a project was initiated to test the theory of Calcium deficiency as the cause of CSNN. However, no matter which combination of artificial precipitation and temperature we tried, we did not succeed in causing CSNN on the test plants (Thomsen 2007). Nor did treatment of Nordmann fir stands with needle fertilizer products with high Ca content show any results, but this was due to low frequency of red needles in all three experimental years (Olsen et al 2007).

However, analysis of climate data showed that wet springs were associated with higher risk of CSNN damages (Table 1, Fig 2). In addition, there seems to be a genetic component, as offspring of selected trees and provenances have shown a difference in symptom frequency (Fig. 3).

Table 1 Test of influence of precipitation in May and temperature in July for occurrence of red needles (CSNN). Three models were tried, and in all cases precipitation was significant, but temperature was not. The model shown below is illustrated in Fig. 1.

Precipitation	P value	Temperature	P value
Total precipitation in May - June combined with amount of rain from May 25th till June 3rd	< 0.0001	Average temperature in the second week of July combined with maximum temperature of the same week	0.8437

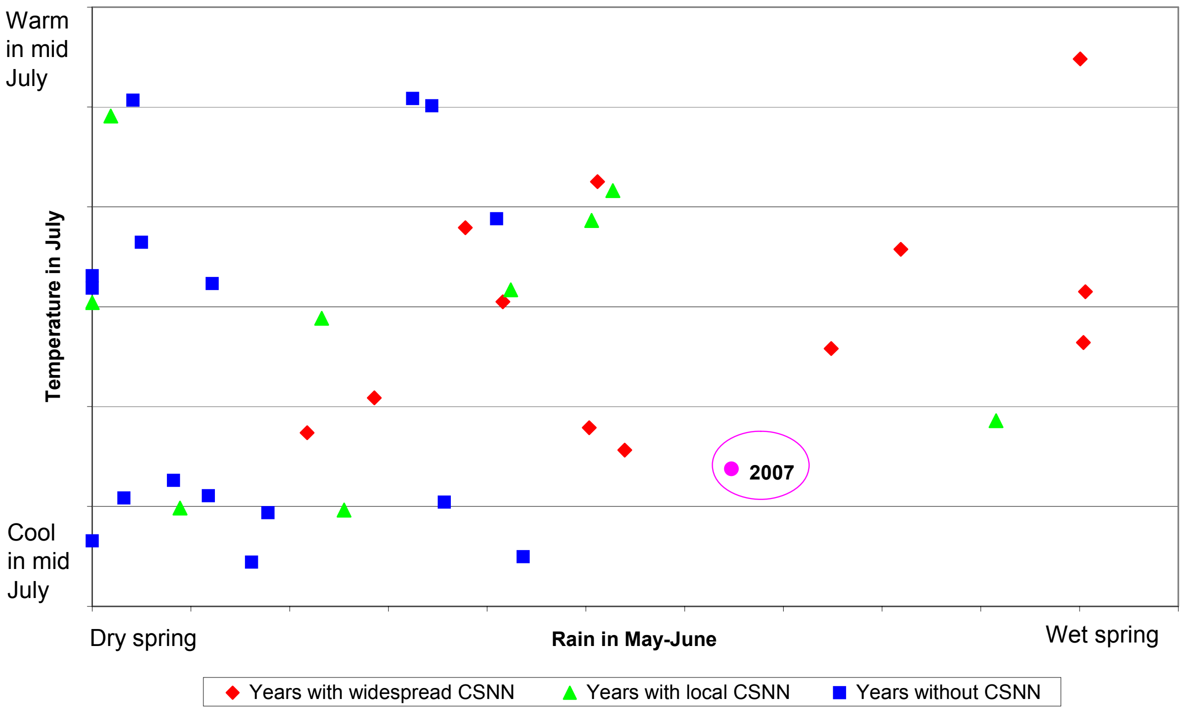

Figure 2. Occurrence of CSNN symptoms in relation to weather. Springs with high rainfall during shoot elongation had higher probabilities of symptoms on Nordmann fir. 2007 was a year with fairly widespread damages.

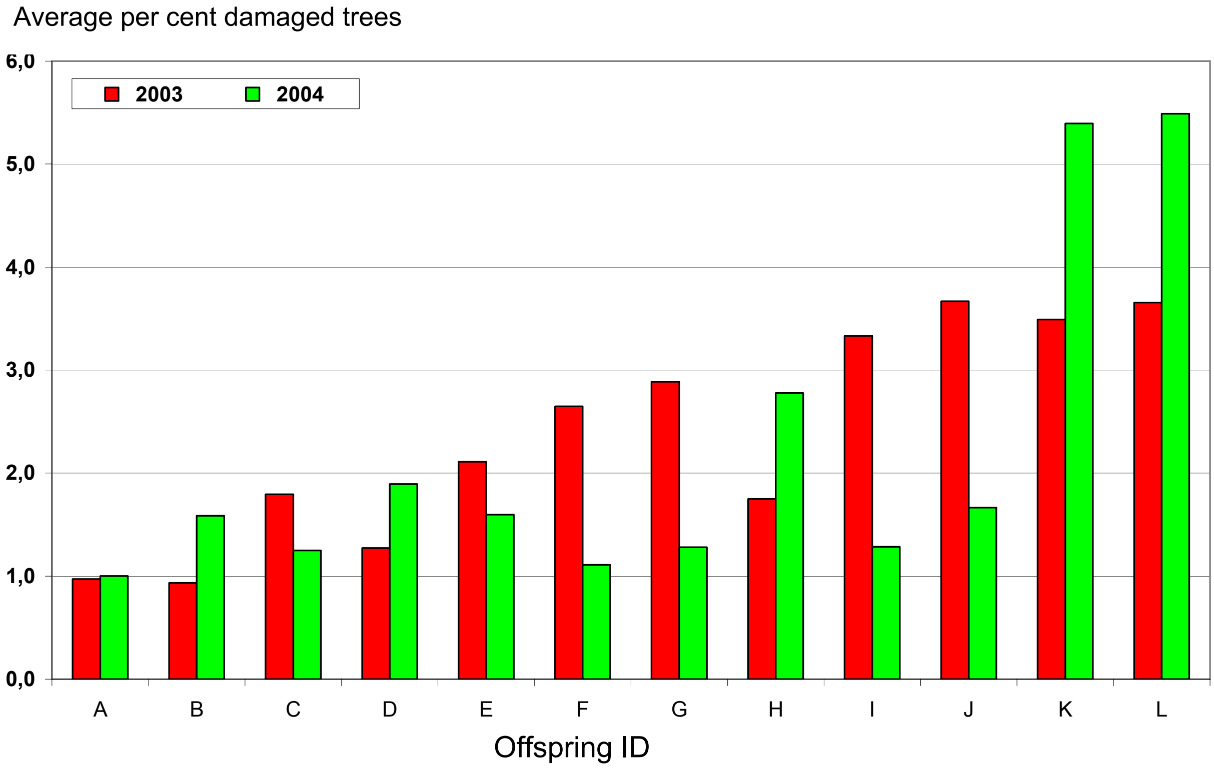

Figure 3. Frequency of red needles (CSNN) was studied in offspring of selected trees and provenances planted at various locations in Denmark. There was a low damage frequency both years, but even so offspring of some trees had no symptoms, whereas others had symptoms

both years. The damage frequencies of the offspring with most symptoms are shown, and offspring K and L stand out as having the highest damage frequency. These two also have symptomatic trees at most locations.

Acknowledgements: This project was supported by the Production Fee Foundation for Christmas Trees and Greenery (PAF). The author gratefully acknowledges the assistance of Ulrik Bräuner Nielsen concerning data on genetic association and statistical calculations.

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Efficacy of preharvest applications of permethrin in controlling infestations of yellowjackets (*Vespula* spp.) and other insects on harvested Christmas trees

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[1)] USDA-Agricultural Research Service, US Pacific Basin Agricultural Research Center [2)] Washington State University, Research and Extension Center, Puyallup

Insects are commonly found by quarantine inspectors on Christmas trees imported into Hawaii from the Pacific Northwest. To reduce the numbers of hitchhiking insects and especially the risk of importing queen yellowjackets, quarantine officials in Hawaii and the Pacific Northwest initiated an inspection and tree shaking certification program beginning in 1991. Under the program, exporters were required to either manually shake 10% of the trees in a consignment in the presence of an agricultural inspector, or mechanically shake 100% of trees with no inspection requirement.

For the period 1993-2006, the percentage of shipping containers rated as moderately or highly infested with insects following manual and mechanical shaking was 17.0% and 2.6%, respectively. During this same time period, 271 species of arthropods were intercepted on Christmas trees, including multiple interceptions of western yellowjacket (*Vespula pensylvanica*) queens in containers holding trees certified as 100% mechanically shaken.

Figure 1. Western Yellowjacket (*Vespa pensylvanica*).
Figure 2. Testing effect of permethrin by exposing the insects to sprayed foliage.

Because tree shaking is not 100% effective in removing pests, we investigated the potential use of preharvest sprays of permethrin (Astro), a pyrethroid insecticide for controlling infestations of yellowjackets and other insects. Western yellowjacket queens (Fig. 1) and honey bees (*Apis mellifera*, used as surrogates for wasp pests) were exposed to noble fir (*Abies procera*) foliage which had been removed from trees that had been sprayed in the field with permethrin at 0.18% active ingredient (the maximum label rate) up to six weeks before harvest (Fig. 2). Pesticide residues caused complete morbidity over a 24-hour test period in both species. In companion tests, we dipped freshly harvested noble fir boughs in various concentrations of permethrin and exposed insects to the treated, dried foliage. A dip concentration of 0.002% permethrin resulted in complete morbidity of western yellowjacket queens and bees over a 24-h test period. The dip concentration associated with 100% morbidity of European paper wasp (*Polistes dominulus*) queens was 0.02% permethrin.

We conclude that pre-harvest sprays of pyrethroid insecticides could be used in combination with mechanical shaking to significantly reduce the risk of accidental transport of yellowjacket queens and other insects in exported Christmas trees.

Acknowledgements: Work on this project was supported by a USDA T-Star grant and the Pacific Northwest Christmas Tree Association Advanced Research Fund. The assistance of John Ross, Mike McKenney, Jan Sittnick, Annie DeBauw, Art Antonelli, Pete Landolt, Dave Stokesberry, and SnowShoe Evergreen, Inc. is gratefully acknowledged.

The Grand Fir Twig borer (*Argyresthia* sp): A new pest of grand fir (*Abies grandis*) in the Pacific Northwest United States

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During the past 5-10 years, a tiny caterpillar has been increasingly found attacking grand fir Christmas trees grown in central western Washington, in particular near Rochester, WA. This moth pest has been found burrowing in small twigs usually emanating from the tree's leader, but can be found on twigs in other parts of the tree as well. After shoot elongation in spring, these infested twigs begin to appear slightly off color (a little lighter green than uninfested twigs).


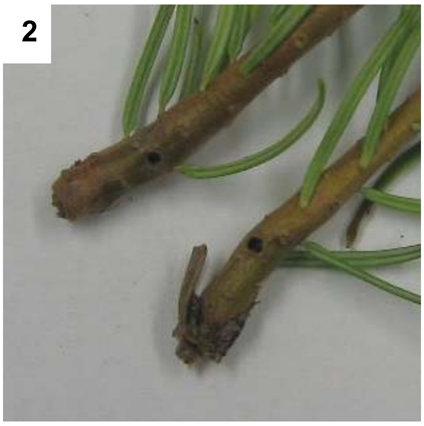

Figure 1. Yellow discoloration of foliage as symptom of Grand Fir Twig borer attack.

Figure 2. Exit holes in twigs.

As the larvae develop, the base of the twig may begin to appear swollen in many instances and the twig becomes yellow in color (fig. 1-2). Larvae chew an exit hole in the stem in March and April and then pupate inside the stem (fig. 3). Adults begin to emerge in April and May and lay eggs shortly thereafter (fig. 4). After insect emergence, the previously infested twigs die and fall off the tree leaving it unmarketable.


Figure 3. Pupae inside the shoot. **Figure 4.** Adult insect.

In some fields it affects up to 70% of the trees and some trees may have multiple infested twigs. In others, only a limited number of trees and twigs are infested. This insect has been tentatively identified to the genus level as *Argyresthia* sp. (Yponomeutoidea: Argyresthiidae) and we are calling it the Grand Fir Twig borer. It appears to be related to the Balsam Fir Twig borer, *Argyresthia abies*. The origin of this pest is unknown, and may be an invasive species introduced from another country. Additionally, we have found an encyrtid parasitoid, *Copidosoma* sp., attacking this species. We are conducting surveys of commercially-grown Christmas trees to determine the distribution and life history of the Grand Fir Twig borer in Washington and Oregon. Life history data is being developed by monitoring grand fir plots and sampling for various stages of the insect. Additionally, measures of population density and levels of parasitization are being determined.

Acknowledgements: Work on this project is being supported by the Pacific Northwest Christmas Tree Association Advanced Research Fund and the USDA CSREES Critical Issues: Plant and Animal Pests and Diseases Program. The assistance of Oriki Jack and KLM Tree Farm are gratefully acknowledged.

Fate of glyphosate in soil under a young stand of Christmas trees

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The aim of the project was to establish knowledge on the fate of glyphosat and the degradation product AMPA in a soil under newly established Nordmann fir Christmas trees. A main topic was to study the risk for leaching of glyphosate and AMPA to groundwater. Two managing procedures were compared and effect on tree quality was evaluated.

In the project, two experimental plots were established at a field site in Slæggerup, Sealand, Denmark. The field site is situated on a loamy soil previously used for conventional agricultural crops. Young trees of Nordmann fir (*Abies nordmanniana*) were planted on this farmland and two growth strategies were compared:

- Common pesticide treatment using glyphosate for weed control
- Reduced pesticide application and use of mechanical weed control ('mulching')

In addition, a control plot was established, where the trees were left to grow without treatment of any kind after planting. Tree quality and the leaching of the pesticide glyphosat and its transformation product AMPA was monitored for three growth seasons (May 2004 to October 2006).

Content of glyphosate and AMPA was measured in samples of soil and water. Soil samples were collected from the uppermost meter of the soil (0.15, 0.50 and 1.10m), while water was collected from drainage and horizontal filters situated 1.5 m below the soil surface. The quality of the trees was monitored to evaluate the effect of management practise on the trees, and to assure that the treatments use would produce trees usable for selling as Christmas trees.

Christmas tree quality and management - results
During the three season study period the herbicide based treatment resulted in increasingly better height, clearly improved needle colour, and significantly different uptake of nitrogen. Significant differences in growth of the trees were observed when comparing trees from the two treatments plots. There is a clear risk that the reduced pesticide treatment could lead to trees

with a reduced tree quality, necessitating at least one additional growth season in order to produce trees suitable for being put on the market.

Glyphosate and AMPA - results
Glyphosate and AMPA were not detected in any of the 29 water samples collected from the horizontal filters. Content of glyphosate and AMPA was observed in water samples from the drainage systems below both plots. During the project 11 and 15 samples were analysed from drainage under the conventional and reduced plot respectively. Drainage from the reduced plot had content of glyphosate and AMPA in one ample, whereas detections were made in three drainage samples from conventional plot. However, whenever content was detected the concentration was below the residue limit of (0.1 µg/l)

Content of both glyphosate and AMPA was observed in soil samples from both experimental treatments. A total of 114 soil samples were analysed as 19 samples were analysed from each plot in three depths. The data demonstrated a general tendency to higher content of AMPA than glyphosate in the soil matrix.

Overall, the project indicates that the fate of the pesticide under young stands of Nordmann fir Christmas trees is comparable to more conventional agricultural uses of glyphosate. Thus, the contents observed in some water samples from the drainage systems were few and at low concentration levels, and summing up, the mass transferred in these events were insignificant. Within the time span of the project, the leaching risk of glyphosate and AMPA was considered minor at the field site investigated. However, it must be emphasised that contents of glyphosate and AMPA was observed in the soil below the Christmas tree cultures, and these findings were consistent for a prolonged period of sampling.

Acknowledgement: This project was supported financially by a grant from the Danish Environmental Protection Agency, under the program “Bekæmpelsesmiddelforskning”.

Test of new herbicides, Katana and Accurate, for weed control in Christmas trees

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Introduction
In Denmark as well as most other EU-countries (European Union) there is increased concern for the environmental effect caused by chemical weed control. Most of the traditional soil herbicides, atrazine, cyanazine, hexazinone and simazine have been banned in all of EU during the last 10 years while terbuthylazine was banned only in Denmark in 2005. Furthermore diurone will be banned in EU from 2008.

During the last 10 years a lot of new herbicides have been tested in Denmark for use in Christmas trees. Most of the newly tested herbicides are sulfunylureas, and some of them have now been registered via an off-label registration for use in Nordmann fir (*Abies nordmanniana*).

Among the tested herbicides are the two sulfunylureas, Katana and Accurate, which at present are considered to be the most interesting herbicides for Christmas tree usage.

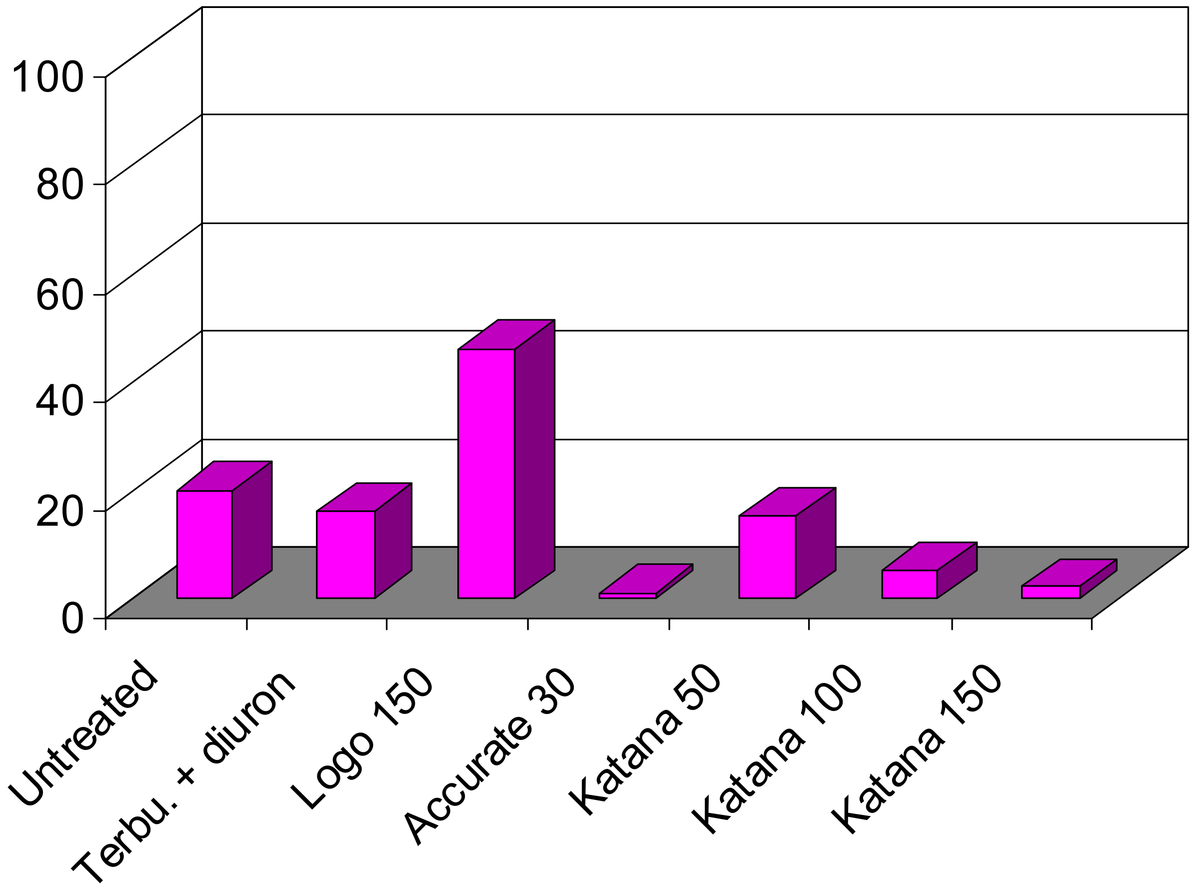

Figure 1. Vegetation control of *Epilobium* sp. 2006

Katana

The trade product Katana contains 250 g/kg flazasulfuron. It will not be registered in Denmark because it is suspected that some of the decomposed product can be leached down to the ground water. Nevertheless it is already registered in Germany for Christmas trees, and it is expected it will be marketed in lot of other European countries as well.

Katana does not harm or discolour Nordmann fir if applied before bud break. Katana controls a variety of grasses and broadleaved weed species.

Accurate

Accurate contains 20% metsulfuron methyl. It contains the same active ingredients as Ally, but Accurate is a different formulation that seems to be more gentle on the trees and gives less risk of discoloration of the needles compared to Ally. Accurate is not yet registered in any of the European countries but it is expected to happen later this year.

Accurate does not harm or discolour Nordmann fir if applied before bud break and if not applied in too high a dose. Accurate has no effect on grasses but has a very strong and long lasting effect to a variety of broadleaved weed species. The grass vegetation can pretty easily be controlled by use of glyphosate in the autumn.

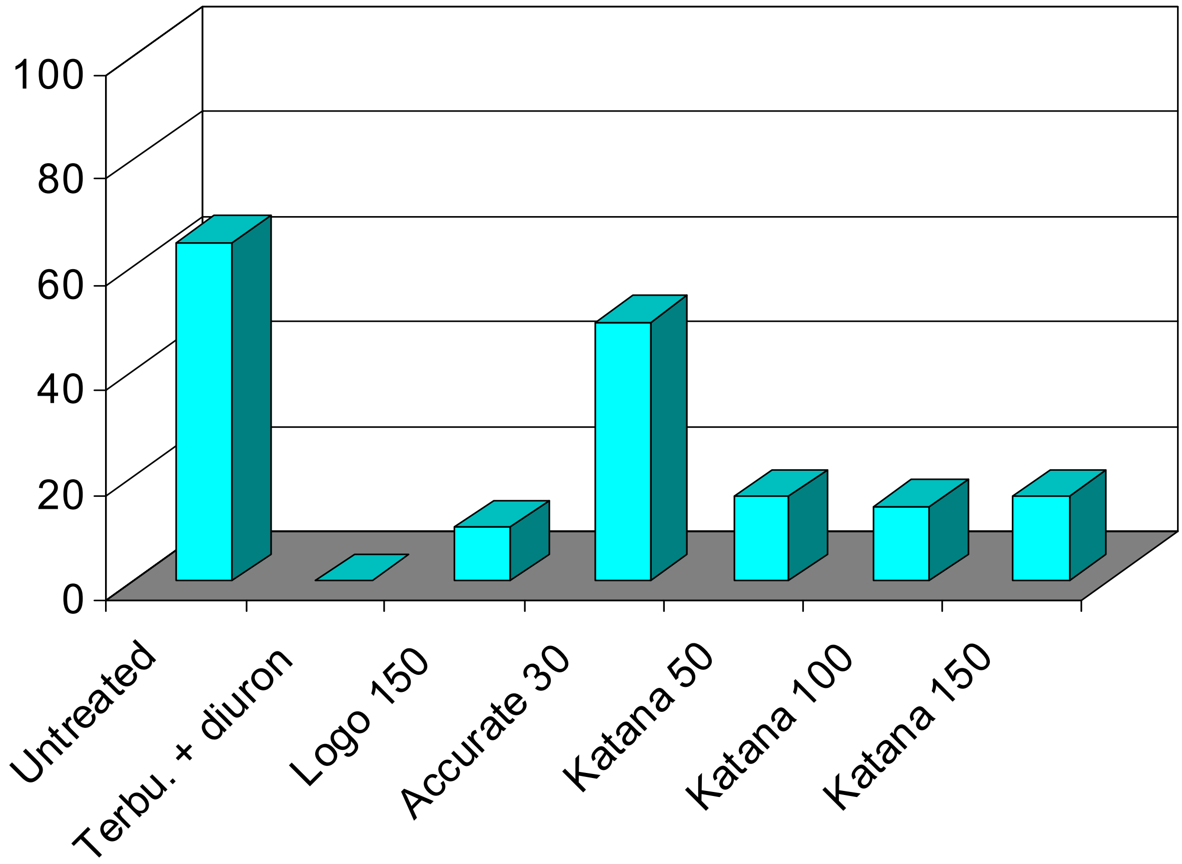

Figure 2. Vegetation control of *Galium aparine* 2006.

Establishment routines for *Abies nordmanniana* and *Abies lasiocarpa*

Inger Sundheim Fløistad, Hans Martin Hanslin
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Background
The use of Christmas trees is a more than one hundred year old tradition in Norway. Two to three decades ago most of the trees were collected at regeneration sites in the forest or imported. Today an increasing part of the trees produced in Norway are grown in Christmas tree plantations.

The production of Christmas trees is demanding as customers pay well only for high quality trees. Crucial factors are the plant material used and the establishment routines. On the average the fraction sold amounts to only 50 % of the of Christmas trees planted in a Norwegian plantation. Increasing the proportion of trees sold will substantially improve the economy of the production. Optimal planting dates and establishment routines will further contribute to the development of a vigorous, domestic Christmas tree industry.

The Christmas tree seedlings typically appear with initial slow growth during the first 2-3 years. In the next couple of years the trees grow well, and then during the final 2-3 years before harvest the growth frequently is too vigorous. This growth rhythm often requires laborious growth regulation by mechanical or chemical methods. A dense concentration of branches on the lower part of the tree tends to allocate a lot of resources to the tree base, which grows wide and heavy. Such trees are costly to cut and transport and difficult to sell. Therefore, the growers want transplants with rapid growth after planting.

To satisfy their demand there is a need for better plant materials than what are available today. More knowledge is needed about the relation between seedling quality, their physiological status and the plants response to different planting dates.

In the year 2007 a new project “Seedling qualities and establishment routines for a rapid growth start of Abies nordmanniana and Abies lasiocarpa for Christmas tree production” was established in Norway to improve our knowledge of establishment of Christmas trees. Financial support is given by the Norwegian Research Council, “Skogtiltaksfondet” and “Forskningsfondet for Norsk Pyntegrønt Forsøksring”.

Objectives

The main goal of the project is to achieve production systems for optimal plant qualities of transplants for a cost effective, high quality Christmas tree production. The goal of the sub-project presented here is to obtain knowledge on how planting time and site conditions affect establishment in *Abies* plantations.

Methods

Field experiments are established on three locations, representing both *A. lasiocarpa* and *A. nordmanniana* in the eastern inland and in the western coastal climates as shown in table 1.

Table 1. Locations of the field experiments and species represented

		A. lasiocarpa	*A. nordmanniana*
Ås (Akershus County)	59°N, 10°E	X	
Lier (Buskerud County)	59°N, 10°E		X
Klepp (Rogaland County)	58°N, 5°E	X	X

Planting will take place six times from late April to late August in 2007. The first three plantings were performed with winter stored seedlings in weeks 17, 21 and 25. Then summer-planting is planned with seedlings directly from the nurseries in the weeks 29, 32 and 35. The experiment will be replicated in 2008.

On each planting date, additional *A. lasiocarpa* seedlings are planted at Ås, both in the field and in controlled environment, in order to explore the root growth capacity on the different planting dates and to determine seedlings frost hardiness in autumn. Measurements of height and root collar diameter, as well as registration on lammas shoots, are performed following planting and will be repeated again following growth cessation in autumn.

Development of a Model to Project Height, USDA Grade, and Economic Value for Fraser Fir (*Abies fraseri*) in North Carolina, USA

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[1)] Department of Forestry and Environmental Resources, North Carolina State University, [2)] Department of Forestry and Environmental Resources, North Carolina State University,
[3)] Department of Forestry and Environmental Resources, North Carolina State University

Fraser fir (*Abies fraseri* [Pursh] Poir.)is a highly valued fresh cut Christmas tree species in the United States. It draws a high price from consumers and is an economically important species in the western portion of North Carolina. North Carolina ranks second in the nation in the number of Christmas trees produced, most of which are Fraser fir. Tree quality can be assessed by standards developed by the United States Department of Agriculture (USDA), which divides trees into four grades (premium, 1, 2, and cull) based on factors such as crown density and the number and distribution of defects. Although Fraser fir Christmas trees are economically important, management decisions are still not based on empirical growth predictions. Growth prediction models use mathematical equations to describe stand dynamics and to predict the future growth and final yield of forest stands. These models have been used extensively to aid in forest management decisions for traditional long-term forest management. Statistical distributions are typically fit to data collected in the field to project the proportion of trees in a specific product class.

This study fits the two-parameter Weibull probability density function (pdf) to empirical height distributions of Fraser fir Christmas trees over a range of ages and sites. The parameters from the statistical distributions are then predicted from the individual stand characteristics (e.g., soil series, elevation, slope, aspect, and stand age). The predicted parameters are then used to create a statistical distribution that can be used to estimate the proportion of trees in each height class and USDA grade combination. Stand value can then be ascertained by taking the proportion of trees in each height and grade class and multiplying it by the price per tree for the specific class. Example results from the model will be presented.

Crown shape management in *A. nordmanniana* by the 4+4 method

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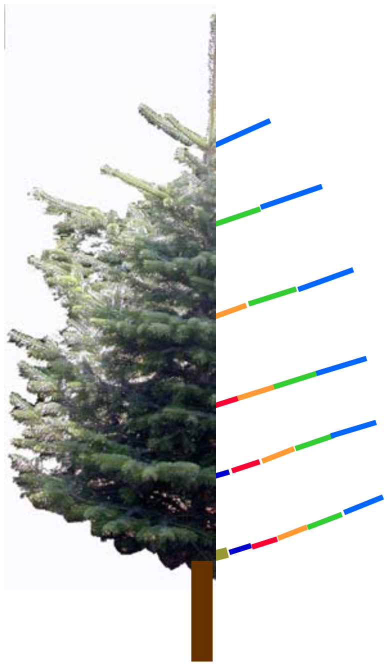
Extensive production of Christmas trees in Denmark involves little shape regulation, but the percentage of salable trees is expected to be low (≤60%, even with a good quality seed source), and so the average price. The most frequent shape problems are: uneven density of the crown, loss and incomplete replacement of leader, excessive width, and unbalanced symmetry. Because a near-natural crown shape is desired, the intensive production scheme includes time consuming shaping of individual crowns. However, this procedure may increase the salable percentage (80-95%) and raise the price. Choice of production method depends on the market demands, and the available man-power. In terms of sustainability, the extensive production is wasteful, but the intensive often involves a moderate use of growth regulating chemicals (primarily the auxin NAA). With skilled labor available, however, the potential added income by crown shaping is in the range of 30% or more.

To approach this goal, both leader control and side line regulation is usually needed. The first to avoid a top that will appear too “open”, the second because the expansion of whorl branches is proportional to that of the leader. Thus if the leader is artificially restricted without any treatment to the side line, the tree will appear too broad.

Leader length regulation is carried out while the leader is expanding, either with a pair of growth regulation nippers or by NAA application.



The target tree (Figure 1) has:
Equal distances between branch whorls.
Crown height/breadth ratio 1.3-1.6
Gradually sloping side line
Dense, uniform foliage
A tree of 1.8 m should have 6 distinctive branch whorls

Side line regulation consists of treating radiating whorl branches either before bud break (a) or between the time of bud break and the time when the new needles part on the adaxial side of the branch (b).

Side line regulation before bud break (a)
involves selective bud removal. The terminal cluster of buds includes the proper terminal and normally 2-3 subterminal laterals (Figure 2). Regulation consists of removing the terminal which is the most vigorous of these buds. If there are 3 sublaterals, the one on the underside of the branch will continue to expand radially. When there are only two subterminals, a horizontal dichotomy results, and the branch will loose its radial identity.

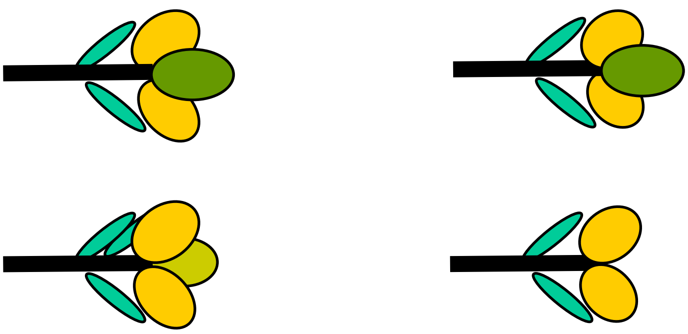


Figure 2. Branches seen from above. Left, three subterminals, before and after terminal bud removal. Right, two subterminals; when the terminal is removed, a dichotomy arises.

Side line regulation after bud break (b)
involves pinching of young shoots, that should remove about half their length.This will ensure that an adequately sized new “terminal” bud is generated (Fig. 3c). If more is removed, the broken tip will develop a subterminal cluster of undersized buds (b); if less is removed, the new “terminal” bud will become too vigorous and may later present a problem (d). Bud size reflects the length of the shoot emerging the following year, and thus the horizontal expansion of the branch whorl.

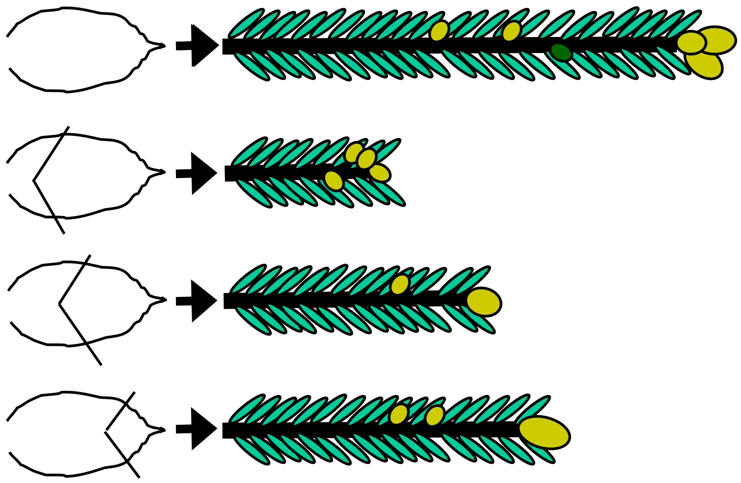


Figure 3. Branches seen from the side

The 4+4 method
proceeds over the 3 last seasons before sale.

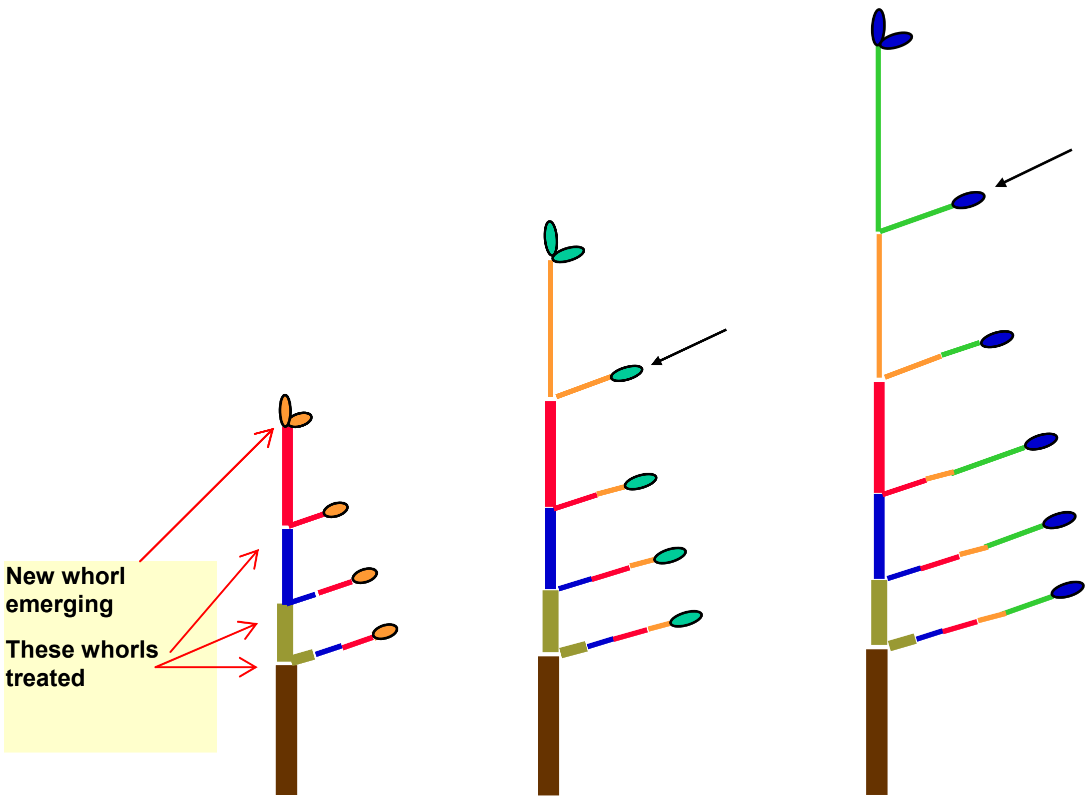
1st treatment year begins when the tree has

- 3 saleable branch whorls,
- Each containing at least 4 radiating branches,
- Spaced by at least 22 cm (Figure 4).
- Lowermost saleable whorl 25-30 cm above ground.

Figure 4.
Apical bud
1st branch whorl
2nd branch whorl
3rd branch whorl

Winter: Branches below the saleable crown are removed, to mark the candidate trees for crown shaping. This treatment will also restrict the subsequent leader expansion, if carried out after 15. March (in Denmark)

May-June: side-regulation is carried out on the three woody branch whorls (Figure 4) but not the new whorl! The same year the leader shoot is restricted to a final length of 33-38 cm.



2nd and 3rd year
Second-highest whorl is side-regulated, i.e. always the whorl that was left untreated the year before (Figure 5). The leader shoot is restricted to 28-35 cm in the 2nd, and to c. 35 cm in the 3rd.

3rd treatment year is the sale year. Side-regulation should be not so strong as before, and top regulation must be inconspicuous. A bit of adjustment in the crown lower down may be carried out at the same time.

Time investment, economy
When no special crown shaping is carried out, a typical example of Danish Christmas tree culture would yield about 60% of salable trees. With a planting density of 6000 tree/ha, that is 3600 tree/ha. A normal quality distribution would be 10% prime trees, 40% standard, and 50% unclassified trees, yielding an average sales price of 50.5 Dkr. *Thus 181.800 Dkr./ha*.

Depending on the labor experience, the capacity is 100-200 trees/hour for side-regulation the first year, and 250-500 the two subsequent years. Estimated cost (for Danish workforce) is 2.25 Dkr. for side-regulation and 1.60 for top restriction, i.e., 3.85 for crown shaping per tree (c. 0.5 Euro, or 0.7 US$).

Crown shaping increases number of salable trees, a typical situation might be 90% salable trees. Again with 6000 trees/ha, a yield of 5400 tree/ha. Assuming *the same* average sales price per tree as above, and the additional expense of crown shaping, this gives 5400*50.5= 272.700, minus 6000*3.85=23100. *Thus 248.900 Dkr/ha*. The added income by crown shaping is thus about 37%.

Most likely, the culture brings in more than 50.5 Dkr./tree, since quality is improved. By 60 Dkr./tree, the advantage of crown shaping is about 65% increased income. Furthermore, the better and more uniform quality would increase chances of selling more rapidly and maintaining faithful customers.

Simple Steps to Keep Christmas Trees Fresh: An Extension Program for Christmas Tree Retailers

Jeffrey Owen
Extension Forestry, NC State University, North Carolina, USA

NC State University has established an extension program to teach Christmas tree retailers ways to keep their Christmas trees fresh. Recommendations are based on post harvest quality research and on results from three years of retailer surveys. Information has been distributed to retailers through an annual newsletter distributed by individual growers that supply the trees, a new website at NC State University, and a pilot video developed for a specific retail chain. The diversity and dispersion of Christmas tree retailers in the United States has required several alternative strategies to reach them with tree care information. This Extension program has developed from a partnership among NC State University, the North Carolina Christmas Tree Association, the Marketing Division of the North Carolina Department of Agriculture, and the support of individual growers.

Changes in the moisture status of the 2006 United States Capitol Christmas tree during shipment from Washington State to Washington D.C.

Gary Chastagner[1)], Mark Savage[2)], Kathy Riley[1)]
[1)] Washington State University, Research and Extension Center, [2)]Special Forest Products Coordinator, Washington Department of Natural Resources, Products Sates and Leasing, WA

Every year, several carefully selected Christmas trees make their way across the United States to Washington D.C. Destinations include the White House, congressional offices, government buildings and the U.S. Capitol. Since 1970, the U.S. Forest Service has selected one National Forest to provide the Capitol Christmas tree. Washington State and the Olympic National Forest were selected in 2006 to find, harvest and transport a tree that would grace the front lawn west of the U.S. Capitol building.

Large Christmas tree harvest and transport can be a very difficult undertaking. Selecting the right tree in a harvestable location, having experienced people, using the right equipment, and minimizing moisture loss during transit are critical to success. The 2006 Capitol tree from Washington State was a 65-foot-tall Pacific silver fir (*Abies amabilis*) growing at 2,100 feet in the Wynoochee drainage of the Olympic Mountains. Large, open-grown Pacific silver firs have a traditional alpine shape and make a handsome Christmas tree. The boughs are thick and have needles that are dark green above and white below. The branches are supple and bend quite a ways without breaking. This is an important factor when placing a tree on a flatbed for transport.

The selected tree was harvested on November 1st, and a large crane was used to place the 5,000-pound tree on a trailer. Ropes were used to compress the branches around the trunk of the tree, which was fastened onto four support stands on the trailer. In an effort to protect the tree during its 5,000-mile, 27-day journey from the Olympic National Forest to the U.S. Capitol, a series of metal frames and wooden panels were used to make sidewalls that extended the length of the trailer (Fig. 1). The top and back of the trailer were then covered with a large tarp. A sensor was also attached to the tree to record the temperatures and relative humidity the tree was exposed to during its journey.

Figure 1. Left: Packing the tree for transport. Right: Watering during the journey.

During the tree's journey, it was part of tours and programs at over 20 community events during a 10-day tour around Washington State prior to heading to D.C. There were also a number of community events at various cities en route to D.C. To minimize moisture loss during the trip, the tree was periodically sprayed with water during the journey (Fig. 1).

At the time of harvest, the small shoots on the tree had a moisture content of about 112%. To monitor changes in the moisture status of the tree, small samples of current season shoots were periodically collected and sent back to Washington State University, Puyallup. During the trip, the moisture content of the tree varied slightly, but the moisture status of the tree when it arrived in D.C. was essentially the same as when it was harvested. Although not a replicated test, the data collected from this tree is similar to research results obtained with much smaller, traditional–sized retail Christmas trees.

The 20-meter-tall Pacific silver fir (*Abies amabilis*) as the 2006 Capitol Christmas tree in Washington D.C.

Acknowledgements: Photos courtsey of Green Diamond Resource Company, the USDA Forest Service, and Robert Hubner. The assistance of Sara Savage, USFS Olympic National Forest, in collecting samples during this test is gratefully acknowledged. This project was supported by the Pacific Northwest Christmas Tree Association Advanced Research Fund.

Rehydration of noble (*Abies procera*) and Fraser (*A. fraseri*) Christmas trees: Effect of interval between recutting the base of a tree and its placement in water.

Gary Chastagner[1)], Annie DeBauw[1)], Kathy Riley[1)]
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Displaying Christmas trees in water-holding stands is an effective way of maintaining tree freshness, reducing potential fire hazards and improving needle retention. One of the factors that potentially affect the ability of trees to rehydrate when placed in water is the length of time between when the base of the tree is recut and its placement in water. Commonly it is recommended that consumers make a fresh cut on the base of their trees just prior to setting it up in a water-holding stand (Fig. 1). However, studies with Douglas-fir indicated that delaying placement of trees in water for up to 24 hours has little effect on rehydration of this species.

During 2004 and 2005 a series of experiments were conducted to determine what effect delaying the placement of noble and Fraser fir Christmas trees in water would have on their ability to rehydrate. Commercially-grown trees were harvested during late November, baled and stored at a wholesale shipping facility. After Christmas, unsold trees were obtained, transported to Puyallup and stored outdoors under shade cloth. On February 10th, 30 trees of each species were trimmed to approximately 4 feet in height and mechanically shaken to remove old needles. The moisture status of each tree was determined using a pressure chamber to measure xylem water potential.

Figure 1. A) Trees at a retail lot in southern California. **B)** Re-cutting the base of each tree.

Five trees of each species were assigned to six blocks based on the initial moisture status of the trees. One of the five trees in each block was then randomly assigned to one of five treatments. Treatments included the following time intervals between when the base of the tree was recut and when it was placed in water: 0, 12, 24, and 48 hours. One treatment consisted of displaying the tree with a dry base. Once the trees were assigned to specific treatments and blocks, they were placed in an unheated display room for 72 hours (Fig. 1B). During this time, the bases of the trees were recut at appropriate intervals so that all of the trees were ready to be placed in water stands or displayed dry at the end of the 72-hour period (Fig. 2). The effects of delaying the placement of the recut bases in water on the ability of the trees to rehydrate were monitored by periodically measuring changes in the moisture status of the trees, which were displayed in a randomized split block design in a large room that was maintained at 20C with continuous light.


Figure 2. Setting up trees in buckets of water.

Prior to assigning the trees to specific treatments and blocks, the average water potential of the noble and Fraser fir trees were -20.2 and -13.4 bars, respectively. After 72 hours in the unheated display room, the noble and Fraser fir water potentials had decreased to -23.2 and -18.5, respectively. The noble and Fraser fir trees which were immediately placed in water after their bases were recut rehydrated to about -10 bars within 5 hours. Delaying placement of the trees in water for 12 to 48 hours slowed the rate of rehydration, but within about 48 hours all of the trees rehydrated to the same level as the trees which were immediately placed in water. As expected, the water potentials of the noble and Fraser fir trees which were not displayed in water dropped as these trees dried. After 7 days of display, they averaged -41.2 and -31.2 bars, respectively.

The data from our experiment indicates that noble and Fraser fir trees that have been cut and stored outdoors under cool, moist conditions for extended periods of time have the ability to rehydrate to moisture levels typical of freshly-harvested trees when their freshly-cut bases are placed in water. In addition, delaying the placement of trees in water for up to 48 hours only temporarily slowed the initial rate of rehydration. Although these data indicate that there is very little adverse affect of delaying the placement of freshly-cut bases of noble and Fraser fir in water on the extent of rehydration, consumers should still be encouraged to place their trees in water as soon as possible after the base is recut.

Acknowledgements: This project was supported by the Pacific Northwest Christmas Tree Association Advanced Research Fund. The assistance of Jan Sittnick and SnowShoe Evergreen, Inc. are gratefully acknowledged.

The status of Christmas tree market in Greece

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Abstract
The current trends of Christmas tree market in Greece are examined in this paper. Although Greece is famous worldwide more about its marine regions than its forest ecosystems, there is a large potential of Christmas tree production. Previous studies have demonstrated that Christmas tree production and trading have resulted in the mountainous development of Greece and in the use of land areas that remained for years uncultivated, degrading, thus, natural environment. For some years Christmas tree production was supported economically by European Union resulting in a large production. The combination of this factor and the low quality of the available artificial trees created a high economic result in Christmas tree market. Lately, though, a smaller production is observed. A lower demand is also observed due to reasons like the fact that there is a greater variety of available artificial trees and that they have a longer life cycle than the natural trees. Our analysis investigates the trends in the Greek Christmas tree market from the production point of view. An analysis also is made about the reasons which drove in the current status.

Key words: Christmas trees; production of Christmas trees; ARIMA models; Greece

1. INTRODUCTION
Christmas tree is the most beautiful symbol of Christmas celebration. Its story as a custom is lost into the far past (Mantel 1977) and it is proved that "it originates from the Christian East during the widespread Christian celebration" (Kalokyris 1973). In Greece, the great majority of the households are used to having a decorated Christmas tree, either natural or artificial, during the Christmas season. In the past, there were many objections from an important portion of the Greek population about the custom of buying a natural Christmas tree.

These objections had to do both with the fear of destroying natural environment and with the accusation that it is a "foreign-originated" custom. While these viewpoints seem to have been vanished with the help of some foresters articles (Christodoulou et al. 1992), nowadays' objection has to do with the post-Christmas use of the natural trees. There is also the viewpoint that buying a beautiful artificial tree is a more inexpensive move comparing to the every year purchase of a natural one. This last reason seems to have played a significant role to the descending trend of the natural Christmas tree production that is observed lately in Greece. The aim of the present research is to explore the current trends in the production of natural Christmas trees in Greece by using methods of descriptive statistics and by establishing more applied statistics like the autoregressive integrated moving average (ARIMA) models (Box and Jenkins 1976).

2. MATERIALS AND METHODS
In Greece there are five major production centers of natural Christmas trees: Arnea-Polygyros (Northern Greece), Sperceiada (Central Greece), Sparti (Peloponnesus), Karpenisi (Central Greece) and Astros Kynourias (Peloponnesus). Christmas trees are cultivated in artificial private plantations, chestnut coppice orchards and in various other places (Christodoulou et al. 1992). The Hellenic Ministry of Rural Development and Food collects every year data from these areas about the potentiality of Christmas tree production. Until August 31st the producers make an application for how many trees they want to cut from their plantation. The Ministry, then, decides

how many trees will be cut, according to the applications. In this way it ensures the sustainability of Christmas tree plantations. If a larger amount of trees are cut by an individual producer, this is an illegal action. Below, this type of data will be called "approved".

It is a producer's decision of how many trees, below, or equal to the approved number, will be cut each year. This is usually depended on the existing demand for natural Christmas trees. This type of data will be called "cut". Of course, the Christmas trees that are not finally cut are included in the next year's application. This means that the "approved" data are only the annual demand from the producers to cut Christmas trees and not the potentiality of the respective production, because last year's trees are added to the new ones. The "cut" data are the real annual production of Christmas trees, which take part in the trade of Christmas trees, but it is also an indication of the demand for Christmas trees, because it is a usual practice by many producers to examine the demand first and then to cut the trees. So, the proportion of the equation 1 is an indication of the annual production trend (APT) of Christmas trees in Greece

$$APT = \frac{cut}{approved} x100 \quad (1)$$

The data that was available by the Hellenic Ministry about the "approved" and "cut" Christmas trees concerned the period from 1981 to 2006. From equation (1) the annual production trend data was extracted. So, three major time series were derived with each one having 26 observations. Although they do not have many observations (according to the classical Box-Jenkins theory for a good analysis a time series should include at least 50 observations (Gaynor and Kirkpatrick 1994)) previous analyses (Christodoulou et al. 2001) have shown good results with fewer observations. These series were analyzed by establishing autoregressive integrating moving average (ARIMA) models (Box and Jenkins 1976, Gujarati 2003). These models are very useful for short-term forecasts. An ARIMA (p,d,q) model is described by the following equation

$$Y_t = a + \vartheta_1 Y_{t-1} + \vartheta_2 Y_{t-2} + ... + \vartheta_p Y_{t-p} + \varphi_0 u_t + \varphi_1 u_{t-1} + ... + \varphi_q u_{t-q} \quad (2)$$

where α the constant term, θ, φ, coefficients, Y_t the p autoregressive terms, u_t the q moving average terms and d the times that the series has to be differenced in order to become stationary, meaning that its mean and variance are constant during the observed period (Patterson 2000).

There was also data for the three sources of production, from 1981 to 2006 about the "cut" trees and from 1990 to 2006 about the "approved" trees. Finally, there was also data for the species that are produced for Christmas trees in the three sources of production from 1997 to 2006. All these were analyzed using methods of descriptive statistics. For the analysis the statistical software program SPSS 15.0 was used (SPSS 2005).

3. RESULTS AND DISCUSSION

3.1 Production of Christmas trees in Greece

In Table 1 there are some main descriptive statistics about the production of Christmas trees in Greece for the period 1981 to 2006.

Table 1. Annual production quantities and trend of Christmas trees from 1981 to 2006

	Sum	Mean	Standard deviation	Minimum	Maximum
APPROVED (trees)	-	217,298	62,264	116,400	312,293
CUT (trees)	2,266,033	87,155	24,648	32,957	133,447
ANNUAL PRODUCTION TREND (%)	-	41.51	11.23	23.42	59.55

It is proved that every year in Greece, approximately only a 40% of the available Christmas trees is finally cut. Stamou (1985) found out that a market annual potential equal to one million Christmas trees is an absolutely realistic estimation, taking into consideration that the required respective areas for their cultivation are available in the mountainous and semi-mountainous regions. It is concluded, thus, that almost only a 9% of this potentiality is realized annually in Greece, comparing it to the findings of the writer.

Table 2 shows some descriptive statistics of how Christmas trees are distributed to the places they are produced. The real production of Christmas trees ("cut" trees) comes mostly from artificial private plantations, which is almost triple comparing to that from chestnut coppice orchards.

Table 2. Distribution of Christmas trees in proportion to where they are produced

	Source of production	Mean	Sum	% Sum
CUT (trees)	Artificial private plantations	64,714	1,682,559	74.3
	Chestnut coppice orchards	19,387	504,070	22.2
	Other	3,176	79,404	3.5
	Total	-	2,266,033	100.0

As long as there was available data only for the last ten years concerning the species that are produced as Christmas trees, Table 3 presents the mean contribution to Christmas tree production from the main forest species that are used within this scope.

Table 3. Mean production quantities by forest species during 1997-2006

Forest species	APPROVED (trees)	CUT (trees)	% CUT (trees)
Abies borisii regis and *A. cephalonica*	82,647	27,674	83,7
Picea excelsa (P. abies)	3,156	206	0,6
Pseudotsuga menziesii	8,255	1,505	4,6
Pinus nigra and *P. silvestris*	14,634	1,464	4,4
Cupressus sempervirens	2,332	2,205	6,7
Cedrus atlantica	580	0	0

The above table shows that the great majority of Christmas tree production consists of *Abies* trees (*Abies borisii Regis and Abies cephalonica).* A very remarkable fact is that while every year a mean quantity of 580 *Cedrus* trees are approved for cutting, they have never been cut the last ten years in order to be used as Christmas trees.

3.2 Time series analysis

Figure 1 shows the trends of the three time series that characterize Christmas tree production during 1981-2006 by using their standardized values. This figure proves that although there is an upward trend of "approved" trees (which is due to the addition of last year's not cut trees to the new ones), "cut" trees show a declining trend after 1994, resulting in an also declining annual production trend that shows its minimum value (23.42%) in 2006. This turning point in 1994 for the "cut" trees is due to the fact that after that year some very attractive for the customers artificial Christmas trees entered in the Christmas market, with a long life cycle and low prices that influenced in a negative way the natural Christmas tree market. Also, there is a chance that the very last years the production was influenced by the cut-off in 1991 of the European Union's compensation to the producers.

Table 4 shows that the fitted models for the three time series were ARIMA (0,1,0), meaning that no one series that is related with the Christmas tree production in Greece is stationary. They follow a random walk model, that is, their mean and variance during 1981-2006 has never been stable. Only the model of the "approved" trees includes a constant. This model seems to fit better to the real data comparing to the other two. Its R-squared is very high and close to 1 and its Mean Absolute Percentage Error (MAPE) is the lowest. The other two models seem not to fit so good to the available data, especially the one for the “cut” trees. The Ljung-Box Q statistic proves that all the models were correctly specified.

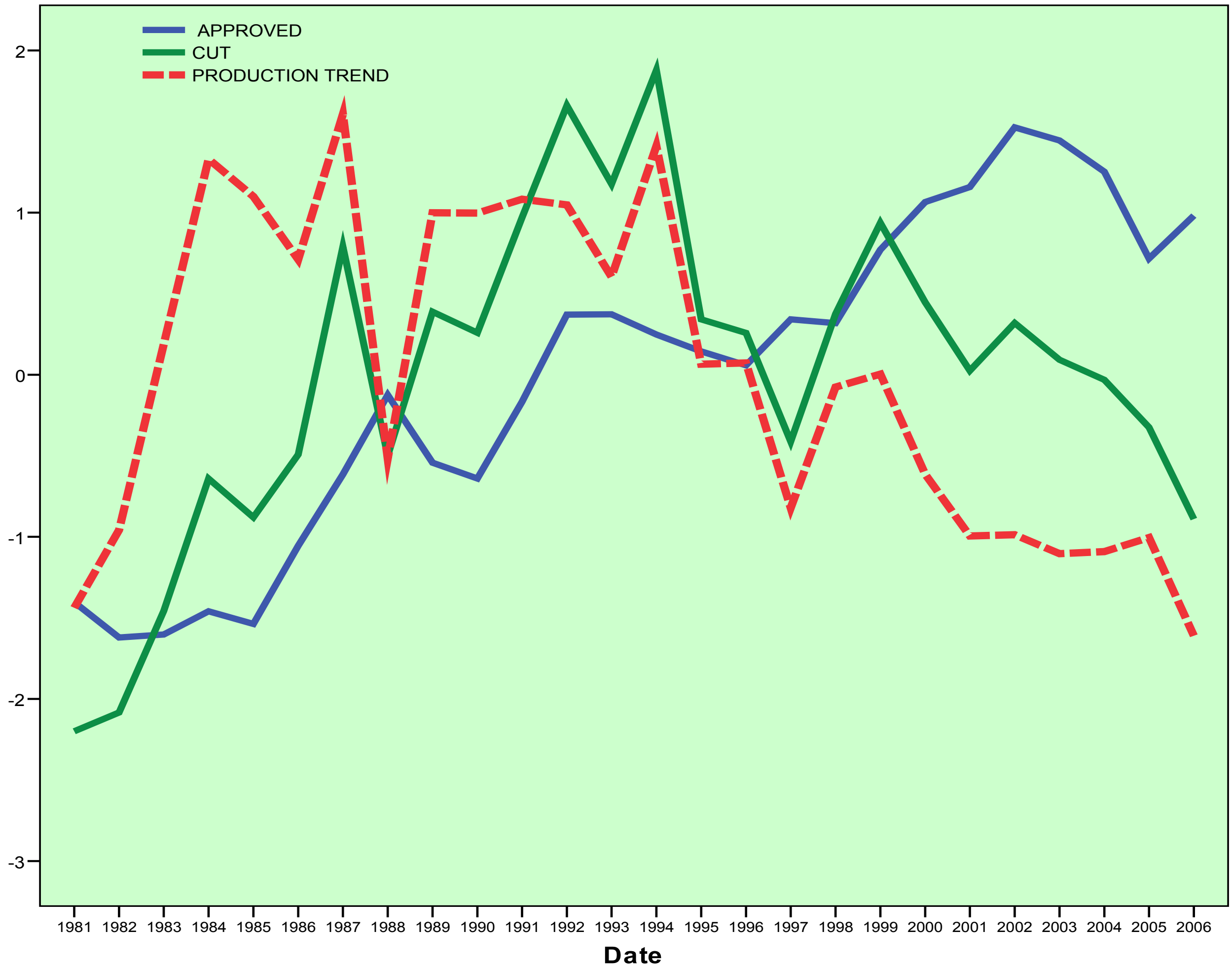

Figure 1. Sequence chart of the three time series (standardized values)

Table 4. Models and model fit statistics of the three time series

	Model	Constant	Model fit statistics		Ljung-Box Q(18)		
			R-squared	MAPE	Statistics	DF	Sig.
APPROVED	ARIMA(0,1,0)	5937.6	0.906	7.690	19.659	18	0.352
CUT	ARIMA(0,1,0)	-	0.573	13.384	12.641	18	0.812
PRODUCTION TREND	ARIMA(0,1,0)	-	0.607	12.264	10.325	18	0.921

Using these models, short-term forecasts can be made about future values. For 2007, the expected quantities of Christmas trees and their production trend are shown in Table 5.

Table 5. Forecasts and confidence intervals for 2007

APPROVED			CUT			PRODUCTION TREND		
Forecast	95% Confidence interval		Forecast	95% Confidence interval		Forecast	95% Confidence interval	
284343	245781	322904	65216	34897	95535	23.42	9.25	37.60

A small rise in the “approved” Christmas trees is expected, while the other two models can give only an indication that the expected values will be the same as 2006 (this is because they don’t include a constant).
It is a fact that these values remain far from the Greek potentiality for Christmas tree production. The real production becomes less and less and this is a sign that there are fewer producers now than the previous years. But most of the producers didn’t have these plantations as their main occupation; instead, they used them to earn a second income. Of course, in Greek market is observed a limited demand for this product, too, and this is maybe due to the marketing tools that the producers (don’t) use in order to promote their production. Larson (2004) serves some helpful ways in this direction. But Greeks seem to prefer an artificial Christmas tree because it is an inexpensive way to have a tree for ten or more years. They seem not to be aware of the environmental degradation that occurs from artificial trees production, or artificial trees waste. At least, the small production results in plantations that are converted into a sort of forest, something that also Kristensen (2003) has remarked. Maybe this fact is a disadvantage for Christmas tree producers, but it is an advantage for the natural environment.

4. CONCLUSIONS

From the above analysis it is concluded that although in Greece there is a production potentiality of a million Christmas tree per year, almost only 87,000 are finally cut. The great majority of Christmas trees come from artificial private plantations and almost eight out of ten belong to the *Abies* gender. After 1994, the real production of Christmas trees in Greece started a downward trend. The worst year for the real production was 2006. The three time series that characterize Christmas tree production in Greece are ARIMA (0,1,0), showing an unstable development during 1981-2006. These models can offer an indication for the production of 2007, which seems to remain at the same bad level as it was in 2006. The only positive fact is that large plantations in the mountainous and semi-mountainous areas of Greece are now converted into forests, upgrading, thus, natural environment.

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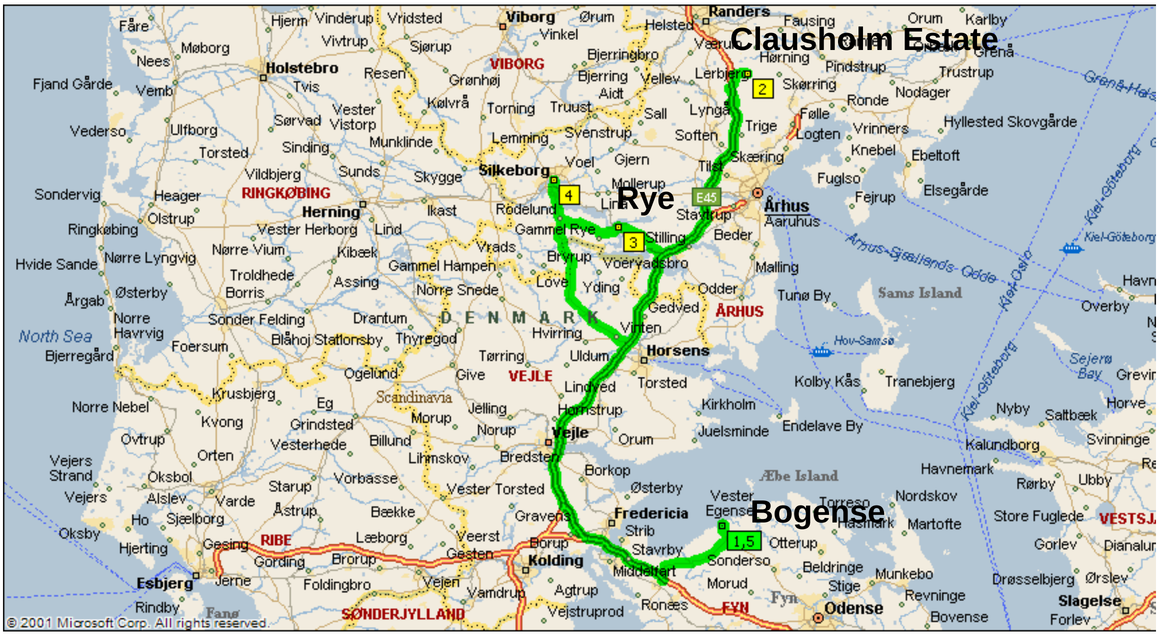
Abstracts of the excursions

Tuesday August 14



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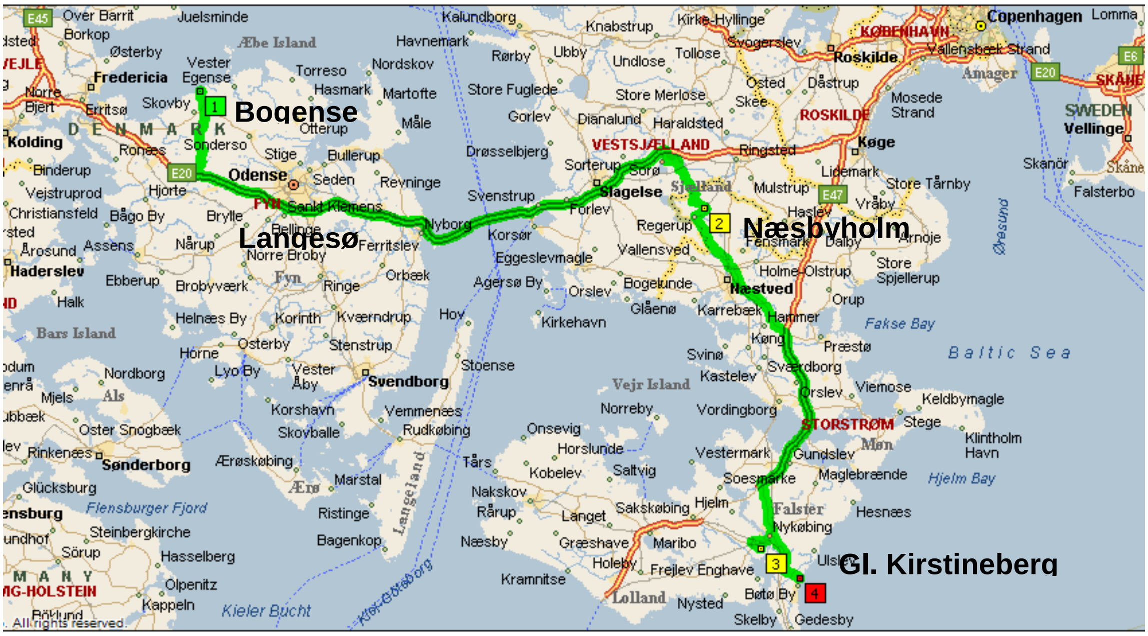


Clausholm Estate

Noble fir provenance and progeny test.

Ulrik Bräuner Nielsen
Forest & Landscape Denmark, University of Copenhagen

Introduction to Clausholm Estate

Ulrik with noble fir bough material.

Plant material

In 1983, a set of plus-trees was selected for bough quality in 15 Danish forest districts. Seed was harvested in the autumn of 1984.In 1988, field trials were established using three-year-old (2/1 or 2-1) bare root seedlings. A total of 68 open-pollinated families were included together with 9 provenances: one import from Oregon, 4 imports from Washington and 4 Danish seed sources presumably 2nd or later generation of Danish origin.

Sites and design

In the spring of 1988, 14 test sites were established, but due to severe frosts, game damage, and severe weed problems only 11 sites were included in this study.

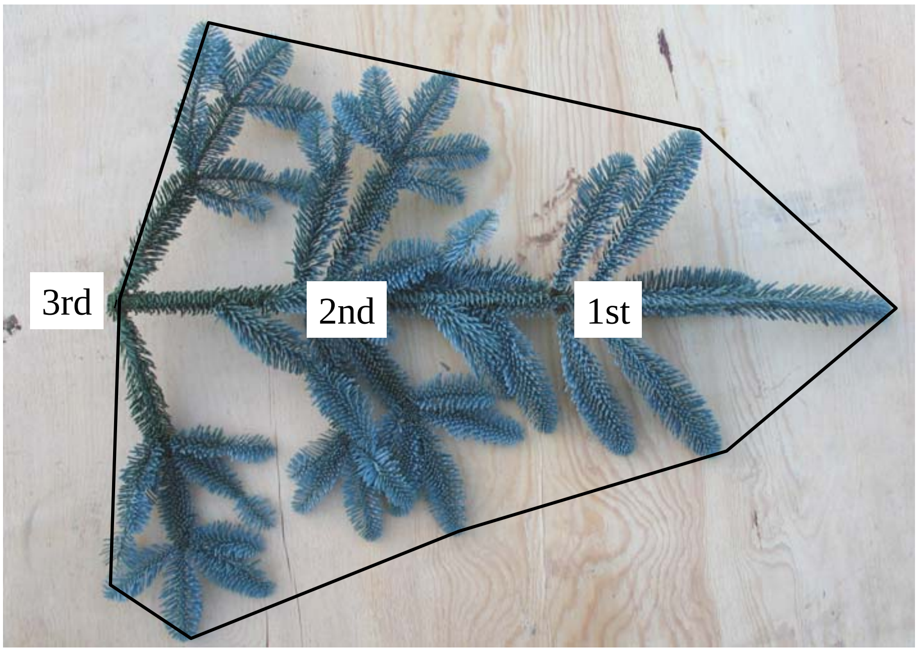
Each trial was designed as a randomized complete block design with four replications consisting of 6 x 4 plants plots of each family or provenance at a spacing of 1.5 m x 1.5 m between trees in the plots. Transportation tracks were placed every 12 m and were 3 m wide giving each plot a border row to the track.

Only 9 families were represented on all 11 test sites and 4 on 10 sites. Almost all other families were only represented in one to three test sites. Provenance standards were represented on all sites with just a few exceptions.

Characters measured

Branch quality traits were measured 10 years after planting. The commercial bough product is generally a branch with three years of growth – typically cut in the 4th whorl from the top. Thus leaving three years of growth on the cut commercial branch – also referred to as a "3-cross branch" (Figure 1). The branch oriented nearest to south in the 4th whorl from the top was evaluated. Only in cases where this branch was damaged was another branch chosen.

The following branch characteristics were measured (all traits measured on the same branch):



Length: Length of the 3-cross branch from shoot tip to the base of the 3rd crossing covering the last three years of growth (cm).

Branch coverage; measured in two different ways:

Branch coverage is defined as the ability of the branch to cover the area within a polygon drawn around the branch from shoot-tip to shoot-tip (Figure 2). It is an overall measure and usually flat needle structure, a rich branching and a short branch increase the branch coverage.

1. Coverage score: Before measuring coverage, 5 branches were selected representing the variation at each site: 1: very open, 2: below average, 3: average cover, 4: good cover above average and 5: very good cover. These branches were kept as references while making the measurement of the site for daily calibration of the scorings.

2. Number of shoots at the 3rd crossing: A trait important for the wreath maker is how many shoots he can cut from the branch. At the base of the 3-cross branch, at the 3rd crossing (Figure 2) the total number of side-branches developed was counted. A further measure was made, where only well-developed branches were counted. The criterion was that branches should be valuable for wreath making.

Shoot-type: This measure describes the orientation of the needles. Some are rather flat and some have a "tooth-brush-like" upwardly swept needle structure. The shoots were evaluated on the current year's growth (1st cross) by giving a score of 1 to 5; 1 for flat and 5 for a very upright needle structure (Figure 3).

Colour: Colour was measured at age 6. Reference branches were used applying a scale from 1 to 5; 1: green; 2: below average; 3: average; 4: more blue; and 5: very blue. The use of reference branches provides a great advantage compared to plant colour charts. The reference shoots take into account the effect of changing weather conditions (sun/rain) by not changing as a colours chart often do. Reference shoots were used while measuring shoots in both shade and in direct sunlight.

A set of possible types of damage were recorded on the same branches. These included:

Yellow tip syndrome: In some cases, especially in the Danish material, yellow needle tips were present. The yellow tip makes the branch non-saleable.

Needle loss: Branches showing more than 2-3 cm accumulated needle loss were recorded.

Height: Simple measure of total tree height in dm.

Number of branches: Count of total number of branches in the 4th whorl.

Bough harvest: The production of saleable boughs was recorded as soon as bough harvest was possible in each trial. Due to differences in development and differences in local practice the number of harvest years varies, but generally covers the years 1994 to 2005 (7 to 17 years from planting).

For each harvest, the amount of saleable boughs were recorded in kg per plot, mean kg boughs per harvest per plot, and cumulative harvest in kg per plot .
Plot data (kg/plot) can approximately be converted to kg/ha by multiplying a factor of 148.2 (plot size was185.2m² and field layout includes transportation tracks on 20% of the area).

RESULTS

Site-effects

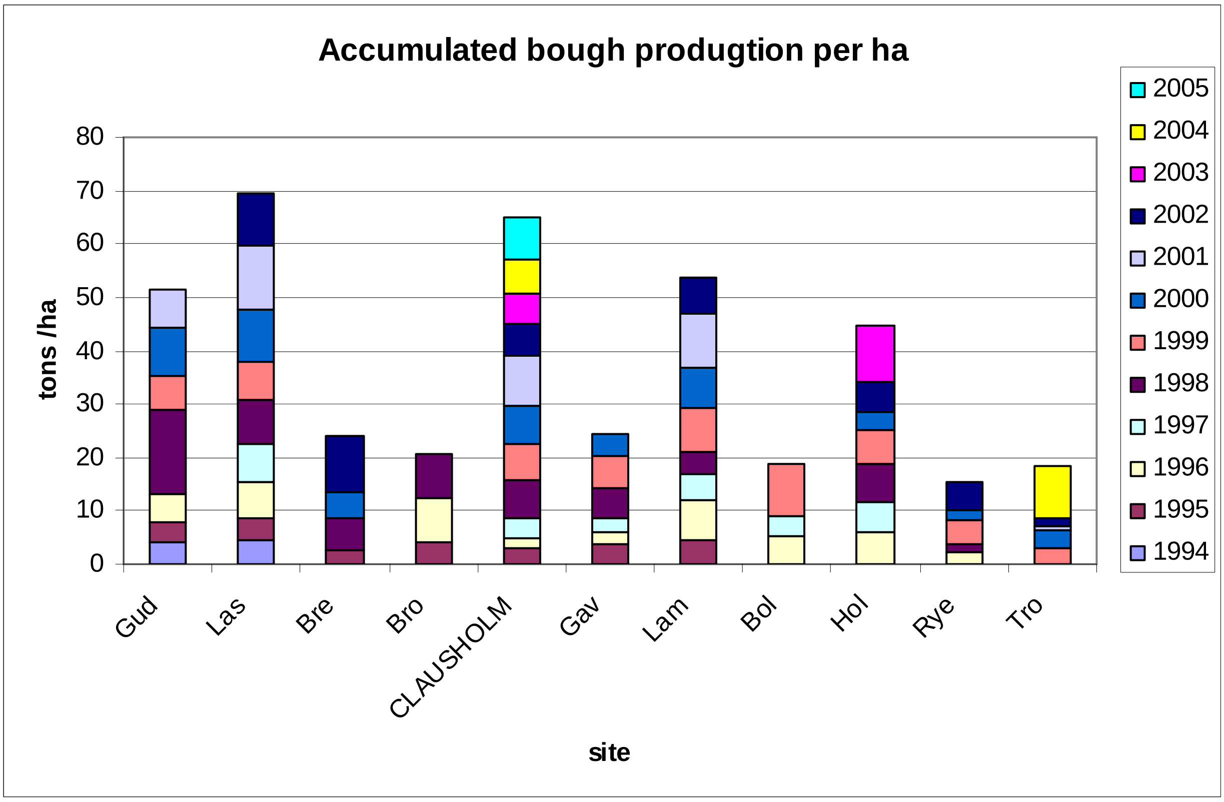


Table 1 Provenance results.

Provenance results: estimated values (best linear unbiased predictions) for provenance within country group, and LSmeans of country group comparing Danish versus imported material.

				Bough production					
Provenance	Height (cm)	Branches (no.)	Branch length (cm)	per plot (kg)	per ha (kg)	Shoot type % class 4+5	Coverage % class 4+5	Colour % class 4+5	Branches 3rd cross no.
Danish sources (DK)									
F.480, Frijsenborg	18	0.18	2.3	2.1	314	−0.5%	−1.7%	1.8%	0.0
Overgaard Estate	3	0.15	1.2	2.2	330	2.0%	0.2%	0.4%	0.1
F.587, Ulborg	10	−0.01	−0.2	1.6	231	1.0%	2.8%	−2.7%	0.1
F.479, Rye Nørskov	−32	−0.32	−3.4	−5.9	−875	−2.5%	−1.2%	0.5%	−0.2
US sources (US)									
Mt St Helens	−6	0.04	−3.0	4.5	665	1.1%	−0.3%	1.0%	0.0
West Centralia	5	0.00	1.4	2.9	432	−0.5%	−0.1%	0.3%	0.0
Old Baldy Mt	17	0.12	−0.5	−2.4	−361	−0.1%	0.0%	−0.3%	0.1
Cowlitz Randle	31	−0.02	5.8	−4.1	−612	−1.1%	−4.8%	−0.8%	0.0
Mary's Peak	−48	−0.14	−3.7	−0.8	−123	0.7%	5.2%	−0.2%	0.0
Country means									
UK	281	3.7	61.4	42.2	6249	27.3%	13.4%	23.5%	3.5
US	321	3.9	68.1	34.2	5061	12.3%	14.0%	3.7%	3.6
Probabilities									
Site	<0.001	<0.001	<0.001	<0.001	–	<0.001	<0.001	<0.001	<0.001
Block (Site)	<0.001	<0.001	<0.001	0.007	–	0.007	0.403	0.012	0.035
Country	0.083	0.090	0.030	0.046	–	<0.001	0.808	<0.001	0.268
Country*Site	0.021	0.040	0.256	0.002	–	<0.001	0.170	0.004	0.314
Prov. (Country)	<0.001	<0.001	<0.001	<0.001	–	0.147	0.004	0.294	0.004
Prov. (Country)*Site	1.000	1.000	1.000	0.584	–	0.752	1.000	0.317	0.527

Table 2 Progeny results, gain from breeding efforts for certain traits

Trait	**Heritability**		**Gain**
	h^2	h^2fam	i=20/68
Height (dm)	0,15	0,89	33
Branches (numbers)	0,04	0,81	0,3
Branch length (cm)	0,17	0,90	5
Bough production:			
Mean (kg/plot/harvest)	-	0,89	10
Cumulated (kg/plot)	-	0,92	65
Branches 3rd cross (total numbers)	0,10	0,90	0,34
Branches 3rd cross (commercial numbers)	0,04	0,82	0,20
Coverage (score)	0,05	0,80	0,18
Coverage (% in class 4+5)	0,06	0,88	10%
Shoot-type (score)	0,15	0,94	0,30
Shoot-type (% in class 4+5)	0,12	0,92	17%
Colour (score)	0,12	0,78	0,27
Colour (% in class 4+5)	0,12	0,93	15%
Yellow tip syndrom (%)	0,03	0,85	2%
Needle length disorders (%)	0,02	0,57	3%
Needle loss (%)	0,02	0,71	4%

Table 3 Estimated genetic correlation between traits

	Height	Branches (no.)	Branch length	Coverage	Shoot type	Colour	Trees per plot (no. at age 10)
Height	-						
Branches (no.)	0.17	-					
Branch length	0.51	-0.04	-				
Coverage	0.10	0.48	-0.41	-			
Shoot type	0.21	-0.23	-0.09	-0.47	-		
Colour	0.38	0.30	0.16	-0.20	0.36	-	
Bough production	0.91	0.34	0.47	0.39	0.12	0.40	-0.87
Branches 3^{rd} cross (total)		0.73		0.68			
Branches 3^{rd} cross (commercial)		-0.14		-0.18			

Estimated gains

Two selection strategies are suggested: 1) Selecting solely for high quality, and 2) Selecting for highest income per harvest. Both selection strategies are based on choosing the best 20 of the 68 tested plus-trees.

Strategy 1) The high quality strategy gives a gain in PI of 0.06 EUR per kg selecting solely for this trait. The average effect on the other traits is that coverage is constant; the number of trees having a shoot-type above average is increased by 8%-units, and number of trees with a blue colour above average increases by 14%-units. Further, that there is a slight increase in height growth (+11cm) and an increased production per harvest of 541 kg. No practical influence on other traits was found. Assuming an average harvest of 5.7 tons, an increase in net income of 352 EUR per harvest is expected simply due to the improvement in quality and, of course, including the extra weight giving a total of 614 EUR per harvest.

Strategy 2) Selecting for highest income per harvest is a combined strategy choosing the best individuals having a superior combination of price (PI) and production per ha. The estimated gain in selecting for highest economic value of a harvest is 904 EUR compared to unselected material. Besides a gain in price of 0,04 EUR and 1426 kg/ha/harvest, the selection for economic value per harvest influences the other traits in the selected group compared to unselected material as follows: Height increased by +32cm, branch length by +2cm and a minor increase was seen in the number of branches. Further quality traits: coverage, shoot-type and colour increased by 1 %-unit, 5 %-units and 10 %-units respectively.

Selecting solely for quality lowers the production compared to selection for total economic gain, however the same12 plus-trees were selected in both situations indicating a superior group of trees combining production and quality.

Reference:

Nielsen, UB 2007: Genetic variation in characters important for noble fir greenery production. Scandinavian Journal of forest Research 22:99-109.

Test site map: Clausholm 4 rows

						76	77	6	**90**
59	**84**	46	**16**	30	31	22	46	71	30
76	40	22	**88**	77	15	59	**89**	26	83
34	26	12	**44**	**89**	25	**16**	12	**85**	**44**
71	80	**90**	31	15	**86**	**88**	40	**86**	**84**
80	49	**85**	83	25	6	49	80	34	34
90	**85**	49	31	**16**	31	**85**	40	12	**84**
89	**76**	**86**	77	22	30	**89**	**88**	25	**16**
46	34	12	30	71	83	59	**90**	22	46
25	**44**	59	40	15	26	77	**76**	6	71
6	**88**	83	26	**84**	80	49	15	**44**	**86**

6 plants

road

List of tested provenances and progenies:

Origin group - selected plus-trees	Plus-trees no.	Stands no.	tree # Clausholm
Randbøl, State Forest Distr., Lystrup Forest, dept. 210g	10	1	6
Broholm Estate, dept. 95c	3	1	12
F.240a Frijsenborg	6	2	15,40
F.54 Holsteenshuus	11	5	22, 25, 26
F.443 Klosterheden Hornet, dept. 468d	3	1	30, 31
Langesø	4	2	34
F.516 Sorø Grydebjerg dept.	2	1	46
F.535 Staurby, dept. 37	3	1	49
F.681 Mølleskoven	7	5	59
F.588 Ulborg, dept. 409b	3	1	71
Ulborg dept. 128	2	1	
F.587, Ulborg dept. 514	7	1	
Palsgaard, dept. 65	7	1	77, 80, 83
Provenance standards	68	23	In total
Danish seed sources			
F.480, Frijsenborg, Hagsholm dept.314			16
Overgaard Estate, Overgaard dept. 2			44
F.587, Ulborg, Fejsø dept. 514			76
F.479, Rye Nørskov dept. 315			90
United States seed sources			
Mt. St. Helens, seed zone 440, elev. 3500 ft			84
Fraser fir, N.C.Jackson			85
West Centralia, seed zone 241, elev. 3500 ft			86
Old Baldy Mt., seed zone 421, elev. 3500 ft			87
Cowlitz Randle, seed zone 430, elev. 3000 ft.			88
Mary's Peak, seed zone 252, elev. 3500 ft.			89

Discussion of herbicide experiments with dosage and application time.

After lunch at Clausholm Castle

RYE

Rye experiment site: Two projects, both aiming at high quality Nordmann fir Christmas trees produced in an environmentally friendly manner.

Lars Bo Pedersen[1)], Morten Ingerslev[1)], Claus Jerram Christensen[2)] and Simon Skov[1)]

[1)] Forest and Landscape Denmark, Department of Applied Ecology, University of Copenhagen, [2)] Danish Christmas Tree Growers Association

Host: Lars Geil Claus and Lars Bo

PROJECT 1: NORDMANN FIR CHRISTMAS TREE FERTILIZATION GRADED BY AGE - A NEW PROJECT AIMING AT OPTIMAL CHRISTMAS TREE PRODUCTION CONSIDERING THE INCREASING FERTILIZATION DEMAND DETERMINED BY AGE.

New results indicate that the application of fertilizer among growers seldom reflects the actual nutritional demand of the Christmas trees. The main reason is a lack of knowledge on how to adjust the fertilizer amount and composition to the increasing demand of the growing trees. The aim of this project is to illustrate advantages of fertilization graded by age compared with the traditional fertilization method.

The project activities will provide fertilization recommendations that enhance the sustainability of the Danish Christmas tree production especially concerning preservation of the soil fertility by a better utilization of the applied fertilizer. The recommendations should also take into account the wish for a better Christmas tree quality and thus, diminish the risk of an inappropriate development of the needle color in the last year before cutting. The project is sponsored jointly by the Growers' Production Fee Foundation, 'Forest and Landscape, University of Copenhagen' and the Danish Christmas tree Growers Association.

In the project we compare:

1) Fertilization graded by age with traditional fertilization,
2) fertilization by broadcasting with needle fertilization,
3) organic fertilizers with mineral fertilizers,
4) spring fertilization with split fertilization,
5) two fertilizer application amounts, and
6) fertilizer distribution in spring vs. summer.

The fertilization graded by age is based on a growth model that includes the uptake of nutrients. This model was presented at the last International Christmas tree Research & Extension Conferences at Tustin, Michigan, USA, and shown for nitrogen in figure 1.

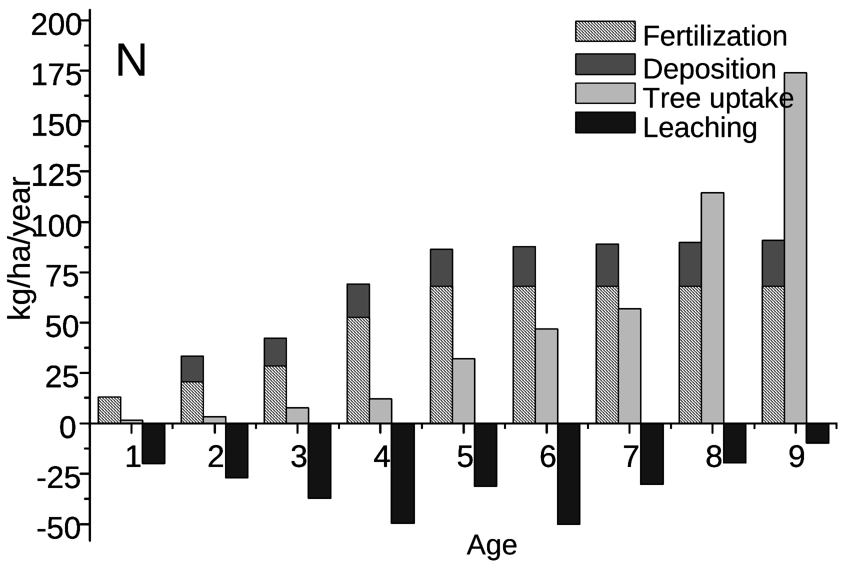


Figure 1 Nitrogen cycling model for a typically Danish Christmas tree stand.

The experiment is conducted on to different soil types:

- Nutrient poor – melt water sand from the Weichel glaciation (Rye Estate in Central Jutland)
- Intermediary – sandy clay loam from the Weichel glaciation (Clausholm Estate in Central Jutland)

The treatments that are included in this experiment are listed in table 1 and figure 1, 2, and 3 provides an overview of the experimental design. On the sandy site at Rye, NPK 21-3-10 is used as spring fertilizer and NPK 23-3-7 as late summer fertilizer. In the treatment with organic fertilizer, Binadan (produced from chicken manure) is used in the spring followed by NPK 23-3-7 in late summer. At the more clayey site at Clausholm NPK 21-3-10 is used as the spring fertilizer and NS 28-4 as late summer fertilizer. In the treatment with organic fertilizer Binadan is used as spring fertilizer followed by NS 28-4 in late summer.

Table 1 Treatments in the experiment with fertilization graded by age in Nordmann fir stands. All fertilizer application is broadcasted. Measurements related to nutrient cycling are carried out in the grayish treatments. All fertilizers are merchandise mineral fertilizer.

No	Treatment	Method	Fertilizer type	Age grading	N-dose Kg ha^{-1} $year^{-1}$	Quota in Spring (%)	Quota in Autumn (%)
1	Control	-	-	-	0	0	0
2	Spring	Broad	Mineral	No	100	100	0
3	Split	Broad	Mineral	No	100	70	30
4	Split	Broad	Mineral	Grading	75	70	30
5	Split	Broad	Mineral	Grading	75	40	60
6	Split	Broad	Organic+ mineral	Grading	75	70	30
7	Split	Broad + foliar	Mineral	Grading	75	70	30
8	Split	Broad	Mineral	Grading	100	70	30
9	Split	Broad	Organic + mineral	Grading	100	70	30
10	Split	Broad + foliar	Mineral	Grading	100	70	30

Discussion in the field, at the Rye experiment.

PROJECT 2: UTILIZATION OF WOOD CHIP ASHES FOR FERTILIZATION OF NORDMANN FIR CHRISTMAS TREES

Morten (seen from the back) explains about ash recycling.

Harvest of forest biomass for heat and energy production leads to export of nutrients from the forest ecosystem. The ash contains a notable amount of the nutrients that originate from the wood fuel. Currently, recirculation of wood ash from bio-energy production to the forest has come into focus as a mean for counteracting the nutrient export that occurs during harvesting. However, the ash may also prove to be a suitable fertilizer component in the fertilizer regimes of Christmas trees growing.

Hence, the aim of this project is to develop and compile a well-documented concept for utilization of wood chip ash as a component in the fertilizers that are used for growing of Christmas trees. At the same time, the project should take part in the breakdown of the current barriers for application of wood ash as a fertilizer in varies growing systems.

This project is a part of a larger research project that aim at developing and testing of methods for pre-treatment/hardening and spreading of wood ash and application in both forest and Christmas tree ecosystems. The pre-treatment should enable the wood ash to be spread without introducing unwanted effects in the surrounding environment.

The Danish legislation for bio-fuel ash limits the dosage of wood ash application in Christmas tree stands. Hence, only a part of the nutrient supply can be covered by ash spreading and the fertilizer will therefore consist of ash mixed with other fertilizer agents. The treatments that are included in this experiment are listed in table 2 and figure 1, 2, and 3 provides an overview of the experimental design.

Table 2 Treatments in the experiment with ash fertilization. All fertilizer application is broadcasted. The nutrient flows are measured in plots with the grayish treatments. Treatment 11 consists of pure wood chip ash with a dosage that is parallel to the ash component of treatment 12. Treatment 12, 13 and 14 are made of a mix of wood chip ash, the solid fiber fraction from pig manure separation and ammonium nitrate with lime. Treatment 12 can be regarded as a parallel to treatment 6 with respect of the N dosage and split. Treatment 13 and 14 can be regarded as a parallel to treatment 9 with respect of the N dosage and split, with the exception that treatment 14 is added extra nitrogen in the autumn. These fertilizers are not merchandise mineral fertilizer.

No	Treatment	Method	Fertilizer type	Age grading	N-dose Kg ha^{-1} $year^{-1}$	Quota in Spring (%)	Quota in Autumn (%)
11	Split	Broad	Ash	Grading	0	0	0
12	Split	Broad	Ash + organic + mineral	Grading	75	70	30
13	Split	Broad	Ash + organic + mineral	Grading	100	70	30
14	Split	Broad	Ash + organic + mineral	Grading	115	60	40

The experimental site at Rye, the set up is thoroughly photographed.

INSTRUMENTATION AT THE RYE EXPERIMENT LOCATION

At the fieldtrip on Tuesday 14 August there will be a stop at the Rye site where forester Lars Geil will be our host. In the experiment there is a lot of equipment to measure the nutrient and water flux in different ways. The equipment will be demonstrated.

The plantation was established in 2003 and 2004 with Nordmann fir and the experiment began in the spring of 2007.

Bulk precipitation, air temperature (2 m), global radiation, and air humidity are logged approx. every 30 minutes. Samples of bulk precipitation are sampled using three single collectors each comprising of a polypropylene funnel assembly (diameter 0.135 m) and a collection bottle enclosed in PVC tubing buried in the soil.

Soil water is sampled continuously below the root zone (depth 0.6 m) using porous Teflon suction samplers (® PRENART). The collected soil water is transported through Teflon tubes to separated glass bottles placed in ‘blue’ thermo-boxes. In order to store the water in a cool environment free from extreme heat, frost and light and to secure, that mice do not perforate the tubes, both tubes and boxes are diged into the soil. Nine samplers are used in each treatment, three in each plot. Samples of both bulk precipitation and soil water are collected monthly.

Volumetric soil water content is measured by means of time domain reflectometry (TDR). We use two systems; an automatic one logging measurements of 32 pairs of probes approx. every second hour; and a manual system established to make monthly measurements on 20 different probe pairs.

Water samples are generally analyzed on non-filtered pooled samples. Ammonium (NH_4-N) is analyzed on a FIA star analyzer. Chloride (Cl) and NO_3-N are determined by means of Ion chromatography (®Shimadzu LC 10 AD) and Mg and K by means of AAS (®Perkin-Elmer 2380) or ICP (®Perkin-Elmer Optima 3000 XL).

Input of N, K and Mg are estimated by combining the fertilizer nutrient declaration with the amount of supplied fertilizer as well as combining the collected bulk precipitation with analyzed nutrient concentrations. Soil percolation was estimated on a daily basis by hydrological modeling using a modification of the SIMPEL model (Hörmann 1998) against the measured TDR data. The model calculates the water balance by means of a simple linear reservoir with temperature, global radiation, precipitation, and potential evaporation as input variables on a daily basis. Potential evapotranspiration are calculated by Makkink´s equation (Makkink 1957) modified by Aslyng & Hansen (1982). The soil is treated as one layer with a matching plant available water capacity calculated by standard values estimated on the basis of measured soil texture and content of organic matter. The model was modified to calculate the soil water percolation from 0.6 meters depth corresponding to the root depth of Nordmann fir Christmas trees. Cl is used as a relative conservative anion to establish an overall confirmation of the soil percolation. Monthly soil solute fluxes are obtained by multiplying monthly water fluxes by appropriate solute concentrations (mean values from blocs in the individual treatments).

Christmas tree quality included responses on growth (height and leader length), vigor (number of buds, (internodial) branches and needle length), needle color and damages/health as well as needle chemistry. These quality parameters will be measured annually outside the growth period during the whole investigation period. Furthermore, growth of the leaders is recorded by webcams taking pictures every 2 hours during the day. Afterwards leader length is measured manually on the digital pictures. The pictures are finally compiled to one film per camera.

Each year in the dormant season, needle samples of 10-20 handpicked needles will be taken from every tree in each treatment and pooled to one sample for each treatment. The samples will be analyzed for the concentration of N, P, K, Ca, Mg, Na, Mn, Fe, B, Zn, and needle weight.

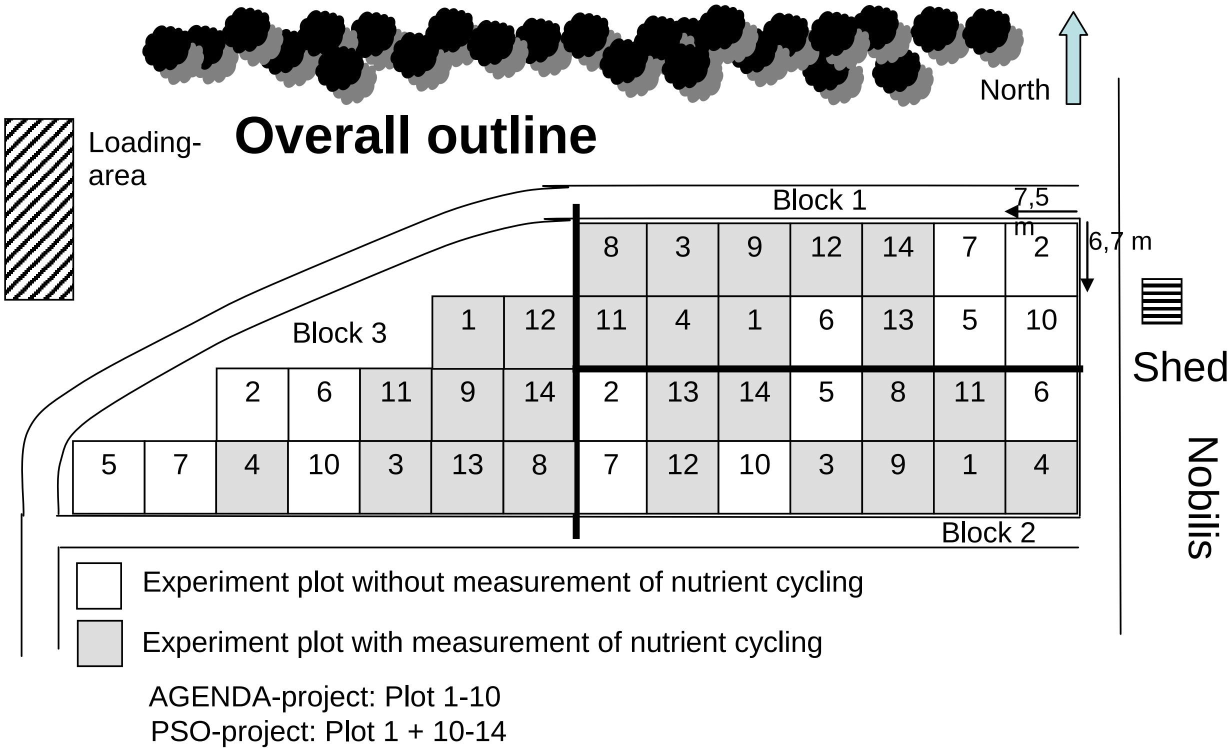


Figure 1 Overall outline map of the Rye experiment site.

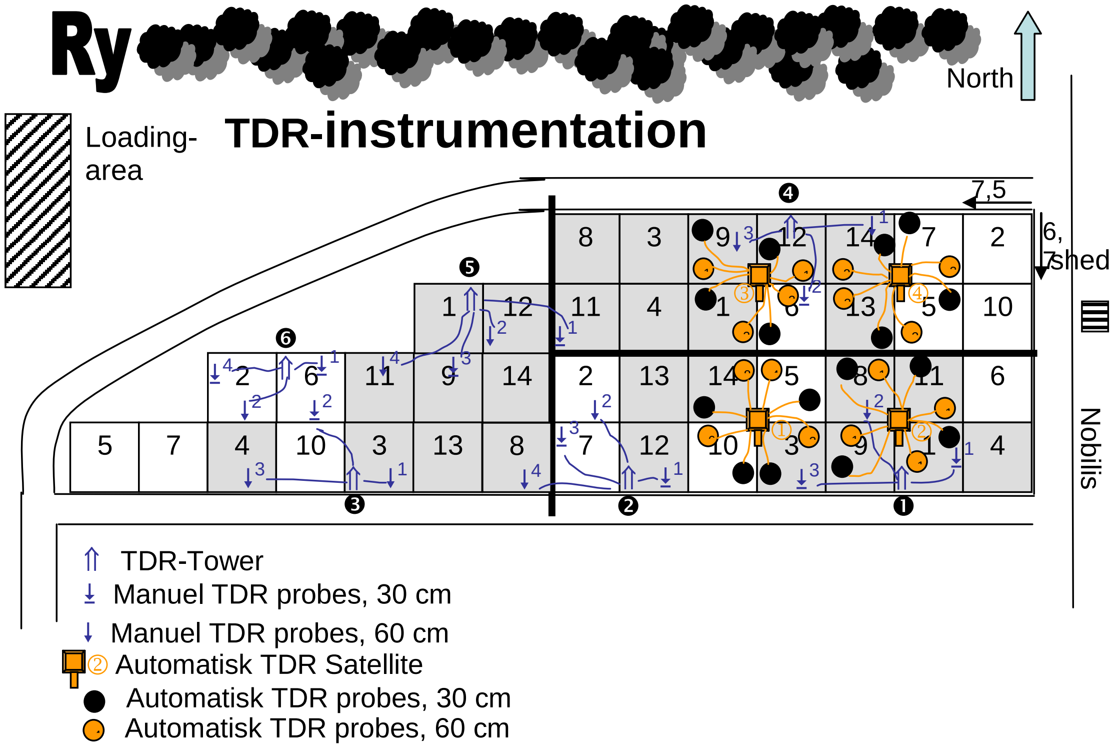


Figure 2 TDR instrumentation, Rye experiment site.

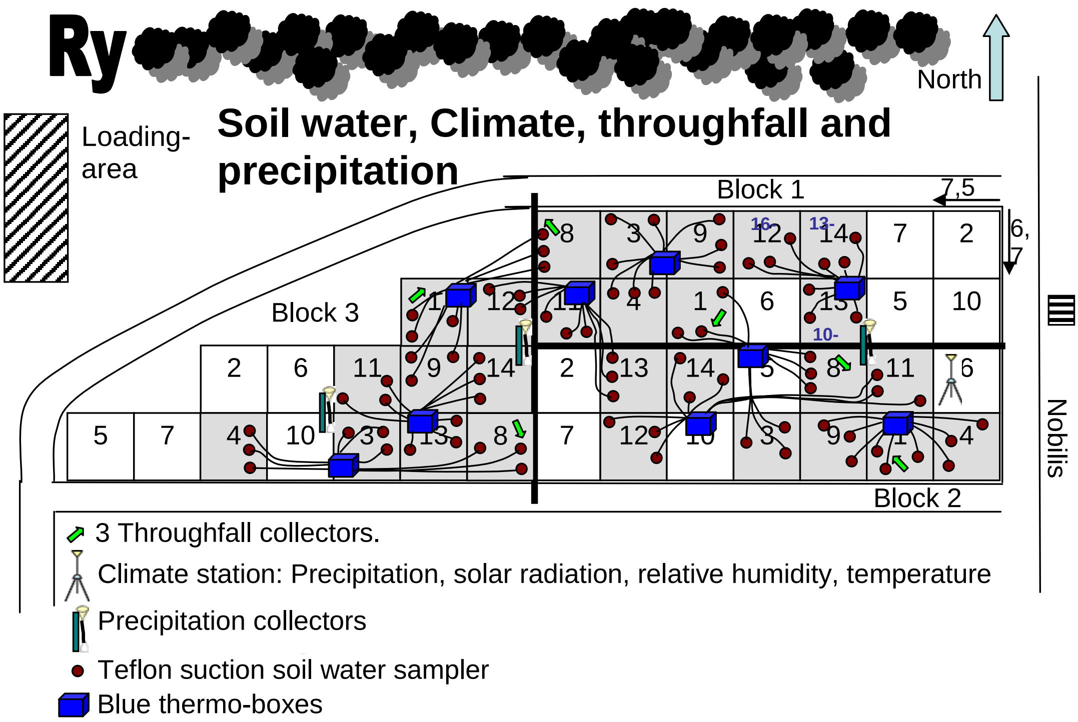


Figure 3 Soil water, climate, throughfall and precipitation, Rye experiment site.


Lars Geil shows four-wheeled motorbike used for herbicide treatment between rows.

SILKEBORG

Provenance trial with 26 provenances of *Abies lasiocarpa* and *A. lasiocarpa* var. *arizonica* - Christmas tree production.

Ole K. Hansen & Ulrik Bräuner Nielsen
Forest and Landscape Denmark, Department of Applied Ecology, University of Copenhagen

Ole K. Hansen describing the provenance trial, flanked by foresters from the State Forest District. Below: each provenance is planted as a row of trees to demonstrate differences visually.

Photos AnneMargaret Braham.

Introduction

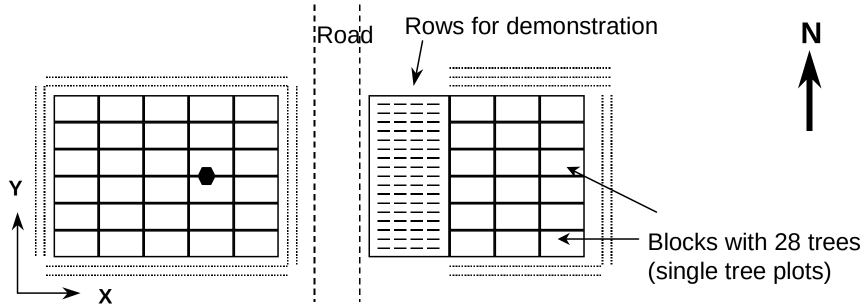
Besides the breeding programme for Nordmann and Noble Fir, Forest & Landscape also have activities in order to find alternative tree species for Christmas tree production.

The present provenance trial belongs to a series of 3 trials, all located in Jutland, and is part of an inter-Nordic research programme with the aim of obtaining knowledge on how to produce Christmas trees of *A. lasiocarpa*. The field trials were established in spring 1999 with 3/2 seedlings (5 years old from seed). The provenances included in the trial are listed in table 1.

Experimental design

The trial is a randomised complete block design with 48 blocks and 28 single tree plots in each block (24 provenances represented only once, 2 provenances represented twice), giving a total of 1344 trees. In addition a row with 10 trees of each provenance have been planted for demonstration purpose. Below is shown an outline of the trial.

Outline of trial no. 1469 - Abies lasiocarpa - Silkeborg



= Border rows af A. lasiocarpa (Provenance no. 217)

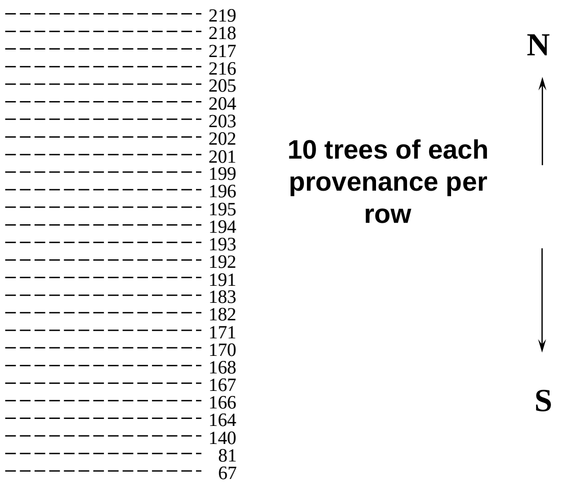
X-Y-system of co-ordinates used for reading of detailed map and identification of single tree plots

= Climatic station

4	5	12	13	20	21	28
3	6	11	14	19	22	27
2	7	10	15	18	23	26
1	8	9	16	17	24	25

Distribution of trees in blocks

Outline of the demonstration planting *A. lasiocarpa* - 1469 - Silkeborg



164 Apache N.F Arizona
Photo Gary Chastagner.

Table 1. Provenances in the field trial 1469, Silkeborg. Provenances where seeds have been harvested from less than 6 mother trees are marked with an *.

State	Geographic Location	Height a. sea	Locality/provenance	No.	Number of plants
Name	Latitude/ longitude	Meter	Name		
Arizona		-	Apache N.F., Hannigan Meadows	67	48
Montana	47°30/113°30	-	Flathead N.F., Hungry Horse	81	48
Arizona		2900-3200	Apache N.F., Hannigan Meadows + Big Lake	140	48
Arizona		2900-3200	Apache N.F.	164	48
Br. Col.	59°40/133°45	800	Atlin	166	48
Yukon	61°50/133°	900	Canol Road	167	40
Br. Col.	50°50/119°45	1400	Adams Plateau	168	24
Montana	48°00/115°30	-	Kootenai N.F.	170	96
Montana	48°00/114°15	-	Flathead N.F.	171	48
Wash.	46°10/122°15	1200-1400	Seed zone 440, South- west of Mt. St. Helens	182	96
Alaska		800	Seed zone A16, Skagway	183	72
Montana	48°10/113°30	1200	Flathead N.F., West of Marias Pass	191*	48
Wash.	47°55/117°07	1400	Mt. Spokane	192*	48
Wash.	47°55/117°07	1500	Mt. Spokane	193*	48
Wash.	48°29/119°58	1300	Okanogan N.F., For. Rd. 42, Looploop Campg Rd.	194*	48
Wash.	48°26/119°50	1500	Okanogan N.F., For. Rd.42, Rt.20	195*	48
Wash.	48°37/120°36	-	Okanogan N.F., Mile Marker 172, Rt. 20	196*	48
Wash.	46°47/121°40	-	Mt. Rainier N.F., Before Stevens Creek Cross.	199*	48
Utah	40°15/112°00	-	Wahsatch N.F., Rt. Cottonwood Canyon	201*	48
Wyoming	41°21/106°32	2400	Medicine Bow N.F., East of F.S. Work Camp	202* 203*	12 36
New Mexico	35°11/106°25	2900	Cibola N.F., Sandria Crest	204*	48
New Mexico	35°15/107°40	2900	Cibola N.F., Mt. Taylor	205*	48
Br.Col.	49°33/118°31	1970	Blue Joint	216	48
Br. Col.	55°48/129°10	320	White River	217	48
Br. Col.	50°43/115°27	1525	Albert River	218	56
Br. Col.	49°14/118°30	1300		219	48

In broad terms the provenances represent the natural distribution of the species - the geographic locations of the provenances are shown on figure 1.

Results

Results from three growing seasons after establishment (autumn 2001) has been published in Hansen *et al.* (2004): Nordic Provenance Trials with *Abies lasiocarpa* and *Abies lasiocarpa* var. *arizonica*: Three-year Results. Scand. J. For. Res. 19: 112-126. See also table 2 and figure 2.

<u>Abstract:</u>

In three Nordic field trials, 26 provenances of *Abies lasiocarpa* (Hook.) Nutt. and *Abies lasiocarpa* var. *arizonica* (Merriam) Lemmon were evaluated 3 yrs after establishment. The focus was on 16 traits important for adaptation, establishment and production of Christmas trees. For all three sites in Denmark, Norway and Iceland, survival ranged from 89 to 96%. Provenances showed statistically significant differences for all but two traits. For all traits there was significant interaction between provenance and site. Analysis of ecovalens showed that for most traits, only a limited number of provenances contributed substantially to the interaction. Therefore, a large proportion of the provenances showed a fairly consistent ranking across sites. The frequency of potential Christmas trees in the provenances ranged from 10 to 49%. Southern provenances from New Mexico and Arizona seemed to have the best potential for producing high-quality Christmas trees. The southern provenances added substantially to the interaction between provenance and site for budset, lammas growth and colour. When using multivariate statistical methods on all measured traits, the provenance clusters fitted neatly into six distinct geographical regions.

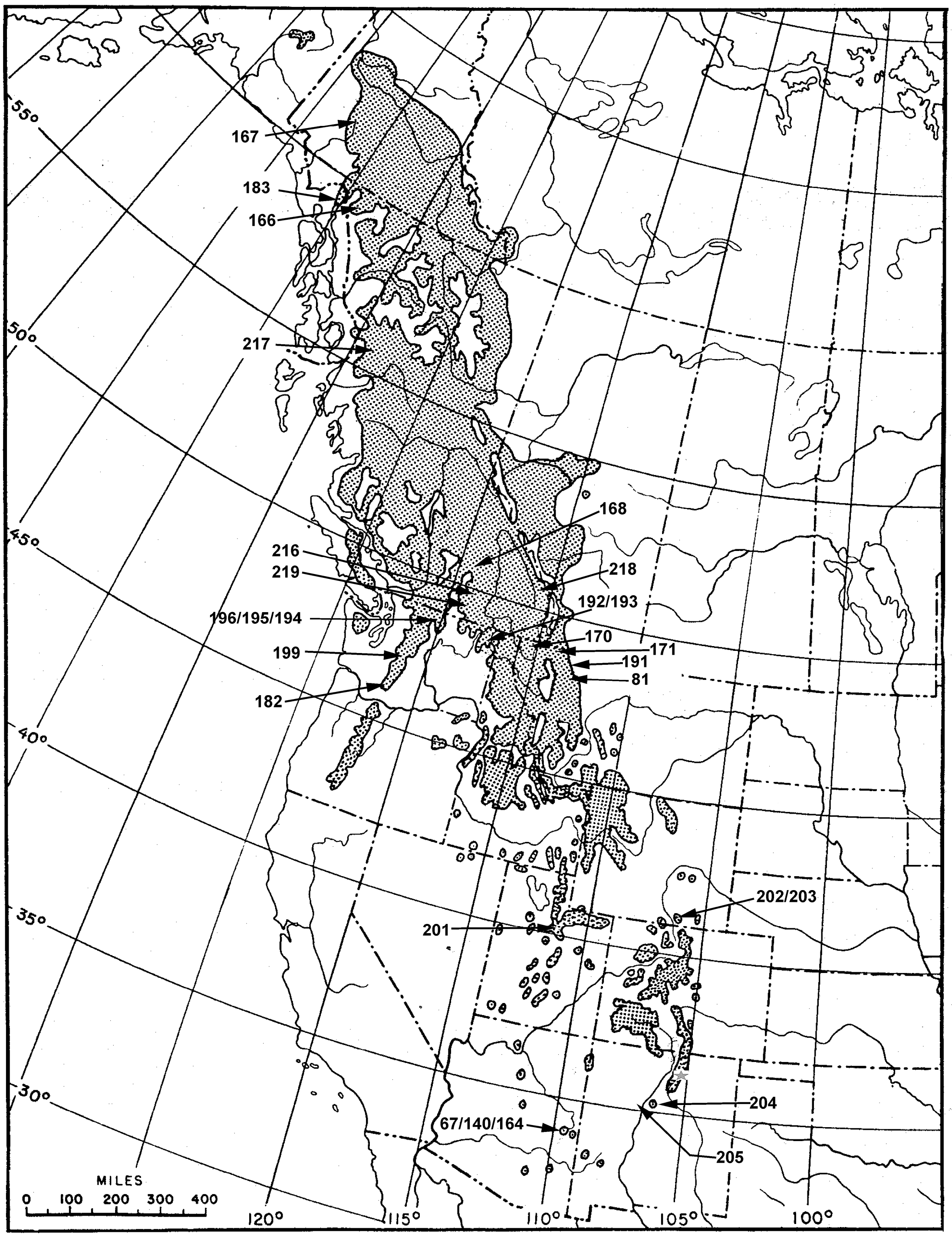


Figure 1. The geographic location of the 26 provenances illustrated together with the natural distribution area of *A. lasiocarpa* (modified from Fowells 1965).

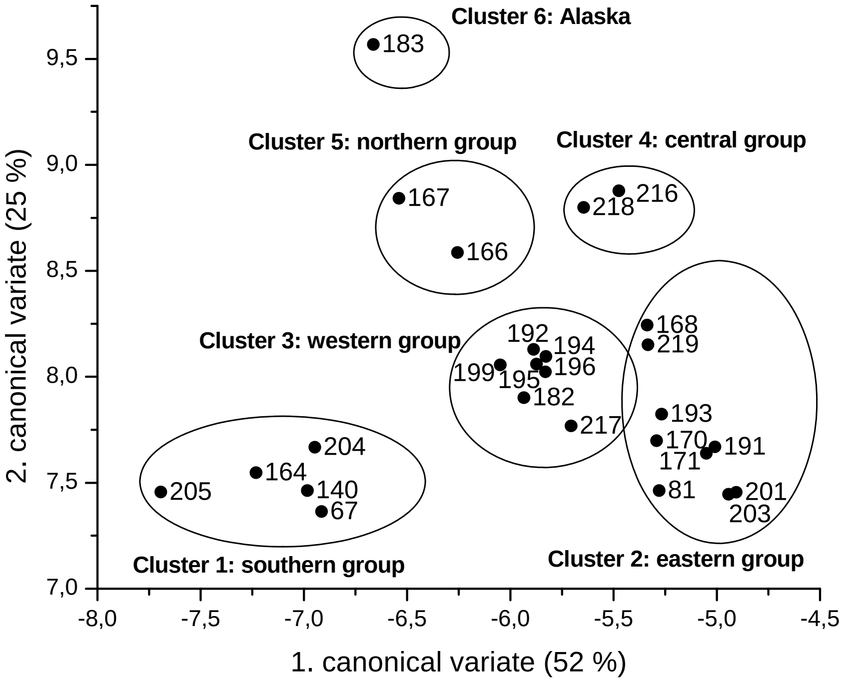


Figure 2. Average canonical values resulting from canonical variates analysis. The analysis is based on 15 characters. Resulting clusters from a cluster analysis on the canonical values are indicated in the figure.

Participants discussing the quality of trees.

Photo AnneMargaret Braham.

Swollen branch nodes (‘bird claws’), a characteristic damage due to aphids (*Dreyfusia* (*Adelges*) *picea*). Photo Gary Chastagner.

Table 2. Overall provenance means across all three sites. Provenances are listed in order of latitude, with the most northerly provenances at the top.

Prove-nance	State	BUD SET1	BUD SET2	FLUS H	COL OUR	BLU ISH	FOR KS	HW1	H TOT	WID TH	W_H	LAM MAS	NBRAN *	N BUDS	NI BRAN	SURV *	C TREE
167	Yukon	2.44	2.79	3.13	2.83	13	57	25.4	38.5	34.3	0.90	2	2.3	3.6	2.4	98	17
183	Alaska	2.42	2.75	2.95	2.95	14	57	20.1	30.4	28.3	0.94	2	2.2	3.3	1.2	94	10
166	Br. Col.	2.28	2.65	2.75	2.66	9	47	26.7	40.0	36.3	0.93	2	2.4	3.7	1.7	96	20
217	Br. Col.	1.90	2.55	1.91	2.62	3	33	28.8	42.1	35.0	0.84	4	2.6	4.4	1.4	86	29
168	Br. Col.	1.99	2.64	2.50	2.29	0	56	23.8	36.4	30.3	0.86	0	2.1	3.6	2.2	95	13
218	Br. Col.	2.02	2.66	2.81	2.38	3	53	21.5	32.3	27.1	0.86	2	2.1	3.6	1.9	96	14
216	Br. Col.	2.20	2.69	2.76	2.37	3	58	24.1	37.4	29.2	0.80	1	2.5	3.7	2.0	94	21
219	Br. Col.	1.98	2.64	2.57	2.27	4	59	26.0	39.8	32.3	0.83	1	2.3	3.9	2.3	92	14
196	Wash.	1.99	2.70	2.47	2.58	4	41	26.5	38.5	35.0	0.92	4	2.3	3.8	1.5	97	23
194	Wash.	1.94	2.66	2.72	2.53	6	41	27.4	40.6	35.0	0.88	6	2.5	4.4	2.2	98	24
195	Wash.	1.90	2.59	2.61	2.49	5	47	27.1	40.0	35.2	0.90	3	2.6	4.3	2.1	91	26
191	Montana	1.81	2.61	2.46	2.08	2	56	27.6	41.3	33.5	0.85	4	2.4	4.1	2.9	91	15
170	Montana	1.76	2.55	2.44	2.19	2	46	27.1	40.6	34.2	0.87	4	2.4	4.0	2.2	91	18
171	Montana	1.68	2.50	2.27	2.10	3	44	26.2	38.9	32.2	0.86	3	2.4	3.9	2.0	88	20
192	Wash.	1.83	2.54	2.79	2.41	5	58	26.6	39.0	34.9	0.98	7	2.5	3.8	2.3	93	18
193	Wash.	1.73	2.51	2.48	2.17	0	45	26.2	40.1	34.5	0.88	5	2.3	4.2	1.9	96	22
81	Montana	1.73	2.53	2.30	2.21	3	48	28.5	41.8	33.2	0.81	4	2.4	4.1	2.5	91	22
199	Wash.	2.08	2.71	2.02	2.70	12	48	27.4	38.0	32.8	0.87	2	2.2	3.7	1.4	92	16
182	Wash.	1.92	2.61	2.19	2.67	6	40	27.3	39.0	32.6	0.84	6	2.6	4.3	1.4	84	24
203	Wyoming	1.47	2.25	2.46	1.94	6	45	29.5	41.7	33.1	0.81	4	2.4	4.1	2.2	98	23
201	Utah	1.52	2.31	2.31	1.87	1	59	29.5	42.0	33.2	0.80	1	2.3	4.1	2.2	99	14
204	New Mexico	1.46	2.15	2.43	3.17	56	21	27.4	39.9	37.5	0.96	8	2.6	3.7	1.4	96	43
205	New Mexico	1.26	2.02	2.16	3.69	84	14	27.0	38.4	36.0	0.96	5	2.7	3.8	1.4	98	49
67	Arizona	1.00	1.69	2.16	3.49	73	16	28.3	43.1	36.4	0.89	17	2.5	3.8	1.8	95	39
140	Arizona	0.97	1.64	2.34	3.40	74	22	27.6	42.4	37.3	0.93	20	2.6	3.8	1.3	96	41
164	Arizona	0.99	1.59	2.25	3.35	71	25	27.6	41.8	38.6	0.94	19	2.4	3.8	1.2	96	37
Total mean		1.81	2.47	2.51	2.60	17	44	26.6	39.5	34.0	0.88	5	2.4	4.0	1.7	93	24
		score	score	score	score	%	%	cm	cm	cm	figure	%	no.	no.	no.	%	%
Correlation with latitude**		**0.87**	**0.81**	**0.65**	-0.19	-0.36	**0.53**	**-0.63**	**-0.50**	**-0.44**	-0.14	**-0.67**	**-0.41**	-0.24	0.26	-0.13	**-0.57**
Correlation with elevation		**-0.68**	**-0.65**	-0.33	0.19	0.33	-0.45	0.21	0.14	0.33	0.21	0.45	0.28	-0.07	-0.29	0.39	**0.54**

*= no significance of provenance effect in the ANOVA. **=Correlations in bold are significant on a 5 % level. Only 19 observations were used in calculation of correlation to elevation due to missing information about elevation for 7 provenances. BUDSET1= bud set assessed first time; BUDSET2= bud set assessed second time; COLOUR= tree colour on current year needles; BLUISH= frequency of the bluish type; FORKS= development of forks or ramicorns in the last two growing seasons; HW1=height to branch whorl no. 1 from above; HTOT= total height; WIDTH= maximum width of the tree; W_H= width-height relationship; LAMMAS= Occurrence of lammas shoots or proleptic shoots; NBRAN= number of branches in branch whorl no. 1 from above; NBUDS= number of buds surrounding the terminal bud of the leader; NIBRAN= number of internodal branches on the second last developed leader; SURV= Survival; CTREE= potential of developing into a first-class Christmas tree.

NÆSBYHOLM

Fertilization of greenery producing stands in noble fir - a new project aiming at ecological sustainability and high yield of branches in a good quality

Claus Jerram Christensen[1)] and Lars Bo Pedersen[2)]
1) Danish Christmas Tree Growers Association
2) Forest and Landscape Denmark, Department of Applied Ecology, University of Copenhagen

Host: Morten Nedergård Claus

Noble fir is the main specie in the Danish bough greenery production. Typically, the rotation can last for over 40 years and the last branches are taken down by lifts. Investigations carried out in the late 1960's and early 1970's indicate, that huge amounts of nutrients are removed with the branches. These old investigations states, that for each ton (1000 kg) of noble fir branches that are removed from the stand, it is necessary to compensate with an amount of nutrients equivalent to 33,6 kg NPK 23-3-7 (with micro nutrients). From the age of 10 the annual production varies between 2000 and 4000 kg branches ha^{-1} depending on soil fertility, cutting technique, stem reduction scheme and rotation length. Many growers apply 300 kg NPK 23-3-7*ha^{-1}*yr^{-1} (approx. 70 kg N*ha^{-1}*yr^{-1}) in order to compensate this loss of nutrients. However, these old investigations only accounts for the whorl branches, whereas the internodial branches are unaccounted for. Today, the softer internodial branches are the most important product for the customer because of a much broader range of use. Because these internodial branches are characterized by much less branch material and far more needles compared to the whorl branches, it is assumed, that the amount of fertilizer need to compensate this production has been set too low. Contrary, greenery production on fertile soils often leads too long branches (above 90 cm for a three cross branch) that make the branches unmarketable or at least less valuable. For these growers on these soils the challenge is to apply fertilizer enough at the right time to obtain good color and quality without the branches gets too long.

A new project sponsored jointly by the growers' production fee foundation and '*Forest and Landscape*, University of Copenhagen' aims at finding a sustainable fertilization regime for noble fir bough producing stands on different soil types. The main focuses are application amounts, application time(s), the type of fertilizer (Table 1) and nutrient cycling especially the balance between loss of nitrogen by leaching and branch removal compared with input from fertilization and deposition.

Table 1 Treatments in the experiment with greenery producing noble fir stands. All fertilizer application is broadcasted. In the grayish treatments investigations of measurements of nutrient cycling are carried out. All fertilizers are merchandise mineral fertilizer.

No.	Treatment (Type of fertilizer)	Dosage of nitrogen (N)	Time of application (Month)
1	Control	0 kg N*ha^{-1} every year	-
2	NPK 23-3-7	37,5 kg N*ha^{-1} every year	April
3	- - -	37,5 kg N*ha^{-1} every year	June
4	- - -	75 kg N*ha^{-1} every second year	April
5	- - -	75 kg N*ha^{-1} every year	April
6	- - -	75 kg N*ha^{-1} every year	June
7	- - -	75 kg N*ha^{-1} every year	Split in April and June
8	- - -	75 kg N*ha^{-1} every year	Split in April, June & August
9	- - -	105 kg N*ha^{-1} every year	April
10	NPK 14-3-15	37,5 kg N*ha^{-1} every year	April
11	- - -	37,5 kg N*ha^{-1} every year	June
12	- - -	75 kg N*ha^{-1} every second year	April
13	- - -	75 kg N*ha^{-1} every year	April
14	- - -	75 kg N*ha^{-1} every year	June
15	- - -	75 kg N*ha^{-1} every year	Split in April and June
16	- - -	75 kg N*ha^{-1} every year	Split in April, June & August
17	- - -	105 kg N*ha^{-1} every year	April

Besides comparing the two commonly used fertilizer types; NPK 23-3-7 and NPK 14-3-15, varies degrees of split fertilization is investigated. The fertilizer amounts varies between 0 kg N*ha^{-1}*yr^{-1} up to 105 kg N*ha^{-1}*yr^{-1}. In the low end of the application amounts different methods of avoiding long branches are investigated by 1) Application of half the common amount of fertilizer every year and 2) fertilizer application with the common amount only every second year.

The experiment is conducted on three different soil types:

- Nutrient poor – coarse sand from the Zahle glaciation (Ulborg State Forest in Western Jutland)
- Intermediary – sandy loam from the Weichel glaciation (Næsbyholm Estate on Sealand) and
- Nutrient rich – heavy clay till from the Weichell glaciation (Holckenhavn Estate on Funen).

At the fieldtrip on Friday 17 August there will be a stop at the Næsbyholm site, which was planted in 1987. The experiment began in the spring of 2006, and the trees have had nearly two seasons of treatments (Figure 1).

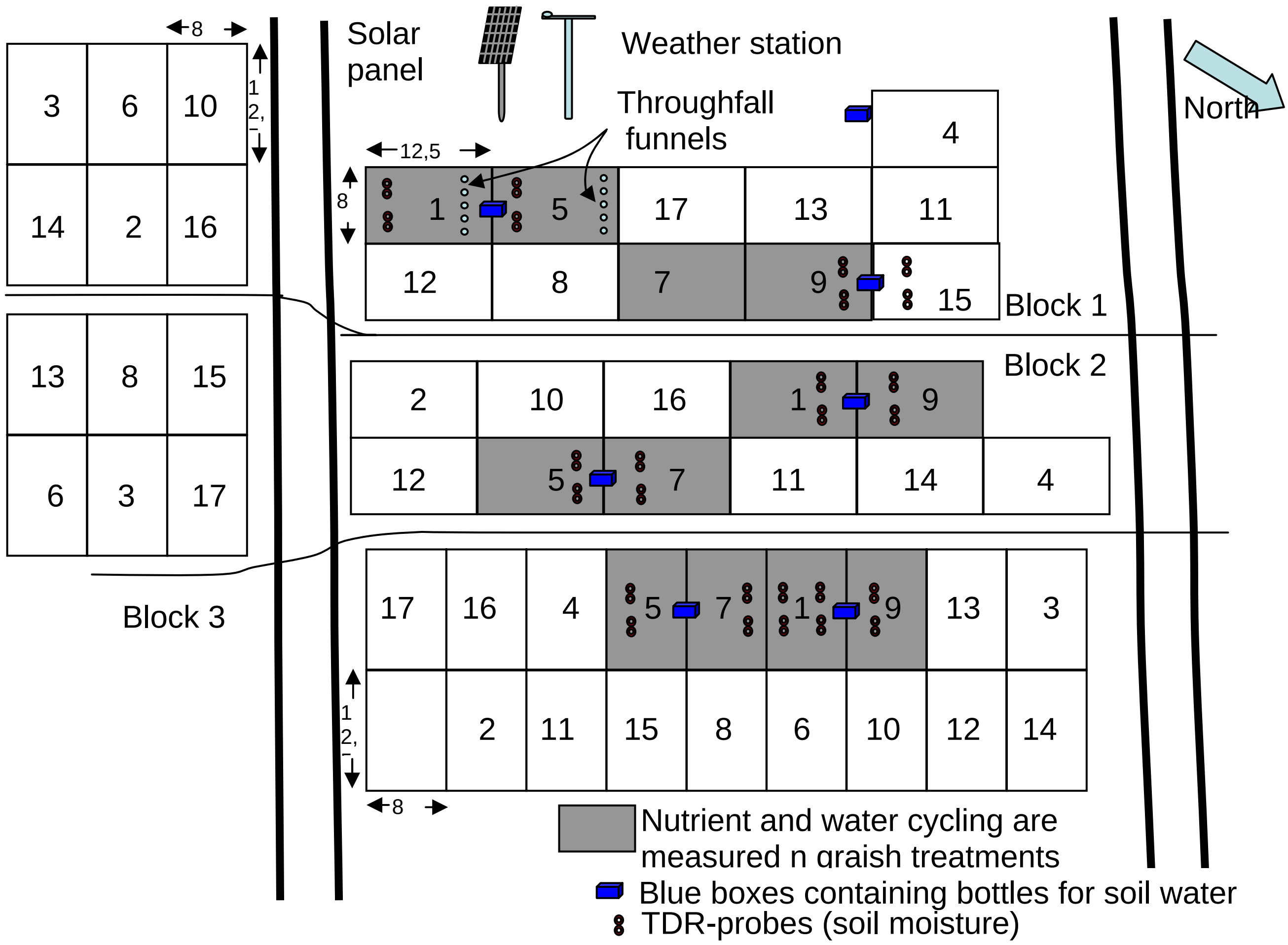


Figure 1 Map of the Næsbyholm experiment site.

The amounts of branches that left the stands in 2006 varied between 7,800 kg and up to 19,200 kg*ha^{-1} at Næsbyholm, where harvest is conducted every second year (Table 1). Given a cautious amount of nitrogen in the green biomass of 1.0 % and a water amount of 0.6 % the amount of nitrogen removed corresponds to 31 kg N*ha^{-1} (Ulborg), 52 kg N*ha^{-1} (Holckenhavn) and 77 kg N*ha^{-1} (Næsbyholm) respectively.

Table 2 Amounts of harvested branches, number of (internodial) branches and percent of too long branches. Tracks are not included in the figures – tracks can take up to 25 % of the production area.

Site	Harvested Kg*ha^{-1}	Total no of branches*ha^{-1}	No of internodial branches*ha^{-1}	Percent branches above 90 cm
Ulborg	7,800	220	-	0.5
Holckenhavn	12,900	270	-	4
Næsbyholm*	19,200	476	259	12

* At Næsbyholm the harvest is carried out every second year. At Ulborg and Holckenhavn the harvest was carried out every year.

Participants discussing noble fir fertilization in experimental plot at Næsbyholm.

Old Noble fir stand used for bough production at Næsbyholm. Morten Nedergård shows cut material with desirable blue colour.

Gl. Kirstineberg

Lars Hvidtfeldt[1)], Ulrich Gejl[2)]
1) Owner, 2) Manager, Gl. Kirstineberg Plant Nursery

Lars Hvidtfeldt shows the potted trees.

Ulrich Gejl demonstrates pot lifters.

Products

Gl. Kirstineberg Planteskole A/S (www.kirstineberg.dk) is specialized in the production of pot grown Nordmann fir (*Abies nordmanniana*) and is today Europe's leading producer and supplier. The pot grown Nordmann firs ensure these high-quality demands by the following guidelines:

- The tree is replanted manually at least 2 times according to its growth.
- The tree is produced with high-grade raw materials.
- Growth regulating additives are used with careful dosage and according to the trees' needs.
- During the manufacturing process the tree is constantly inspected for quality and tailored to the appropriate size.

The pot grown *Abies nordmanniana* are sold in sizes of 60/80 cm, 80/100 cm, 100/120 cm and 120/140cm. The size is measured from the edge of the pot to the top of the tree. The trees are ready for sale after 4-6 growth seasons.

Potting Nordmann fir before taking them to the field.

Pot grown trees
The consumer buys a beautiful and exclusive tree, which can be used as a Christmas tree at first and then be planted in the garden. Garden centres and similar selling places have got the advantage of being able to sell the tree 2 times a year, because it is a genuine tree nursery product. In case the tree is not sold as a Christmas tree, it can be offered for transplanting in spring or autumn.

<u>Pot grown trees versus Potted trees</u>
Christmas trees in pots are constantly gaining popularity. The product you'll find most of the time is a so-called "sale-potted" product: Just before its sale, the tree is dug up the ground, its roots are cut off and it is placed in a pot. These kinds of "sale-potted" trees are as good as dead due to the destroyed roots -like a cut down Christmas tree.

<u>Growth guarantee</u>
Our very specialized and careful 4- 6 years production methods assure, that the tree has got well-developed roots, where the roots stay in the pot. For this reason, we do guarantee the trees further growth, as long as the directions for maintenance and planting are followed.

Gift box
Our living Christmas trees can also be bought with an exclusive gift box. This makes the trees a new and exciting idea for a Christmas gift. When the upper part of the gift box is lifted, the most beautiful little Christmas tree unfolds its green branches. This little Christmas tree is a living Nordmann fir, which since its tender years has been nursed in a pot. The lower part of the gift box is designed in such a way, that it may function as a kind of water-tight bowl. The tree can therefore be watered without any problems.

The tree has grown in a pot to secure that it will develop a healthy and vital root system. The tree can therefore be planted in the garden, where it will grow big and beautiful, or it can be left in its pot and kept on the balcony.

Delivery and logistics
For delivery, the trees are wrapped in a net and provided with a maintenance label. The trees can be delivered either on cc-containers, on expendable pallets or using Claus Thomsen pallets. Depending of the size of the trees there are 110 – 150 pot grown trees on a pallet. It is the cheapest transport system and it works well. The pallets are 120 x 190 cm meaning that there is room for 14 pallets on a truck.

GK-Pallets are based on two separate boxes we put on top of each other. These make then one GK-pallet containing from 40–80 pot grown trees. It is a very flexible system and it is easy to handle for smaller florist etc. The size of the pallet are 120 x 135 cm, meaning that there can be 20 pallets on a 13,6 m. truck.

Height of the trees	Number per GK-pallet
60/80	80
80/100	80
100/120	40

In all transport systems it is possible to mix the various heights, depending on the demand from the customer.

Advice on tree care
- The customer should lay down the tree during transportation.
- When used indoors, the tree should get used to the indoors temperature slowly.
- If possible, the tree should be placed as far away as possible from direct heat.
- The tree should be watered daily with a quantity of 300-400 ml.
- After Christmas and in case of an outdoor use, the tree should get used to the temperature just as carefully.

When planted outside prepare the following:
- Carefully consider the tree's placement in the garden as the tree will grow big
- The hole to be dug out should be 3 times as big as the actual roots
- Mix the dug out earth with e.g. humus to improve the air circulation
- Remove the pot and stretch the roots gently in different directions
- Place the tree right in the middle of the hole and cover the roots with the soil. It is also possible to plant the tree in bigger pots.

Ulrich Gejl demonstrates machinery used for shaping of young trees in pots.

Innovations are often made to facilitate easier handling of pots in order to give better working conditions for the staff. This reduces sick leave due to back and shoulder problems.

Langesoe Christmas Tree Fair

15th of August 2007.

The first real Langesø Fair was held in 1992, and soon it appeared that the need for an annual “Christmas tree growers day” was so pronounced, that the Fair has been held yearly **every third Thursday of August,** from nine in the morning till five in the afternoon on the Langesø Estate (www.langesee.dk).

Every year, the Fair is visited by more than 2500 professionals (growers and dealers) of whom about 20% comes from foreign countries. The Fair is build up round the exhibition grounds, where suppliers and customers of the production have more than 100 stands.

The Danish Christmas Tree Growers Association (www.ps-xmastree.dk) awards a golden star to the grower of the nicest Christmast tree of the year. The “Original Nordmann” (http://www.ps-xmastree.dk/English/OriginalNordmann_UK.aspx) campaign is promoted at the fair.

Best Christmas tree of the Year Award.

Examples of stands at the Langesoe Fair.

Business Meeting and discussions

Hanne N. Rasmussen
Forest & Landscape Denmark, University of Copenhagen

15th of August, IUFRO group 2.09.02, Christmas trees and greenery.

Held in connection with the 8th International Christmas tree research and extension conference, CTRE Bogense, August 12-18, 2007.

Hanne N. Rasmussen took down the minutes, final editing 26 Sept. 07.

The groups' entry on *the **IUFRO homepage***: The group is new as a IUFRO activity. John Frampton is president, Chal Landgreen and Ulrik Bräuner Nielsen are contact persons. All three agreed to continue in this capacity at least until the next CTRE, see below. The conference was announced on the homepage but we do not know if anybody was stimulated specifically by that announcement to participate at the conference.

It was agreed that the homepage should provide links to other Christmas tree information, and that we would help contribute such links when we come across any. Material should be e-mailed to John Frampton who will pass this information on to the IUFRO web managers for posting.

Newsletter. Pascal Nzokou has offered to edit a biennial newsletter which was gratefully accepted. At six months' intervals he will mail us to ask for personal news regarding: new results, new publications, new research activities, events and so forth, to compile in the newsletter. The members of the group are responsible for the relevance of this newsletter.

Proceedings from 7th CTRE: The Michigan delegates agreed to assemble abstacts and papers from the 7th conference into a proceedings. This document will be available on the web and linked to the IUFRO Christmas tree working unit page.

Proceedings from 8th CTRE*:* The paper version is already available. The internet version (pdf) will be updated to fill obvious gaps and omissions. Iben Thomsen (imt@life.ku.dk) receives files from you until the end of October 2007. At your own discretion, you may turn in files with your posters, corrections to the paper version or additional extended abstracts (if you already sent in some material that did not make it to the paper version before the meeting, please drop us a reminder so that it can be added to the final net version). It is agreed that all authors are responsible for their own contribution, quality-wise. Please remember to be metric and add the Latin plant names.

The front page will be provided with the IUFRO logo. The publication will be connected with a link from the IUFRO page.

Next CTRE: The Oregon/Washington delegates offered to host the next meeting, probably early September 2009. This was accepted with applause. It was mentioned that quite a few of the delegates are specialists in their respective departments, and that it takes more than a few people's efforts to host a meeting. Arranging minor satellite meetings for part of the group either before or in succession to the main meeting, would be an option for bringing colleagues together in new places.

Collaborative E-mail tool for the group was introduced by Lynn Wunderlich. It was decided to set a Christmas tree and greenery list in action. Delegates agreed to also send words around to extension colleagues or other interested parties not present at the CTRE meeting, inviting them to join. The list would be for members only, and require password**.**

Conversion tables. Such a tool was wanted. It was also pointed out that different traditions in measurement standards may create misunderstandings in communicating data. The point was taken but it was not decided who might compile such tables.

Teaching collaboration*.* Ulrik Bräuner Nielsen mentioned the Christmas tree and greenery course offered to forestry students at the University of Copenhagen. It is probably the only course of its kind. However, it has attracted fewer students in recent years, and is approaching a critically low number.

Ulrik suggested that in the group we might think about internationalizing it, using internet tools, guest lecturers, and trying to involve international students.

Research collaboration*.* Hanne N. Rasmussen wanted to draw the group's attention to the possibilities in the 7FP for EU-funding of personal collaborative grants in the *Peoples Programme*. The grants might benefit young as well as more experienced scientists to participate in research in another country for 1-several months, either among EU countries or between EU and abroad. Philippe Dryart added the Conserted Actions' programme as a possibility for the group. Both agreed to place links to particulars in the IUFRO homepage.

This concluded the business meeting.

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No. 3 • 2004 Identifying forest-livelihood research priorities in Mozambique
No. 4 • 2004 Breeding for die-back resistant Dalbergia sissoo in Nepal
No. 5 • 2005 Farmers' planting practices in Burkina Faso
No. 6 • 2005 Cocoa agroforests in West Africa
No. 7 • 2005 Observations on timing and abundance of flowering and fruiting of woody plants
No. 8 • 2005 Tree seed in Malawi
No. 9 • 2005 Commercial distribution of tree seed in small bags
No. 10 • 2005 Using soft systems methodology to develop a mango forest management and planning decision support system in a buffer zone
No. 11 • 2005 Integration of Urban Woodland Policies
No. 12 • 2005 Substitutes or Complements?
No. 13 • 2005 Landscape values of rural inhabitants in the Sound region
No. 14 • 2006 not yet published
No. 15 • 2006 Timing and abundance of flowering and fruiting of woody plants in the Hørsholm Arboretum
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