Examensarbeten 2010:19
Institutionen för skogens ekologi och skötsel

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Sveriges Lantbruksuniversitet Utb program: ERASMUS
Examensarbete i skogshushållning, 15 hp, grund G2E ISSN 1654-1898
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Examinator: Göran Hallsby, SLU, Inst för skogens ekologi och skötsel Umeå 2010

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Nyckelord / *Keywords:*
exotic species, forest regeneration, growth, northern Sweden, survival

ISSN 1654-1898 Umeå 2010

Sveriges Lantbruksuniversitet / *Swedish University of Agricultural Sciences*
Fakulteten för skogsvetenskap / *Faculty of Forest Sciences*
Utb program: ERASMUS / *Exchange program ERASMUS*
Examensarbete i skogshushållning /*Bachelor thesis in Forest Management*, EX0645, 15 hp, grund G2E
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Abstract

As choice of species is important to reforest harvested areas and regenerate damaged areas, the present study compares growth of ten different species in Northern Sweden. Height growth, diameter, basal area and survival rates were compared, fifteen years after planting. By regression analysis, relationship between diameter and height was studied, suggesting that species which grew faster until that age were pioneer species as *Betula pendula, Larix sukaczewii* and *Pinus contorta*.
Abies and Picea species showed the lowest values for all the parameter except for the survival rate. This agrees with its slow growth under the shade of pioneer species.
Pinus species had the largest values for basal area; although this parameter doesn't highlight the reality in the site due to many trees of slow growth species didn't reach breast height and thus, these species had low basal areas.
Pinus contorta, *P. banksiana* and *Larix sukaczewii* seem to be the exotic species best adapted to site conditions in the studied area, but further research will determine how the rest of the species can fit to the northern part of the country. The different characteristics of the species together with the location and desired final product will determine the choice of species.

Introduction

All silvicultural systems began as a set of practices developed in response to local, site-specific needs and ecological conditions. Silviculture is practiced with the aim of utilizing the primary product (e.g., timber and pulpwood) for a certain purpose, and silvicultural progress has directly followed socioeconomic trends (Puettmann et al., 2009).
In Sweden, forestry has been of great importance for the economy of the country for a long time. During periods of fairly constant social and environmental conditions, such as during the 1950's through the 1970's, there was little change in the objectives for cultivating forests (Erefur, 2010), which were to prioritize timber production.
In Sweden, the primary choices for reforesting an area have been Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), downy birch (*Betula pubescens*) and silver birch (*Betula pendula*) (Anon., 2006), as these species amount to 91% of the standing volume (Anon., 2006).
But, in the mid 1960's it was thought that the uneven distribution of age classes in the forests, could lead to a serious drop in the annual allowable cuts. In order to fill this shortage, some forest companies looked for species with high volume production and short rotation which would be suitable for planting in Northern Sweden, and the choice became lodgepole pine (von Segebanden, 1992). Since that time, forestry companies are working on several other species to increase production or to meet other needs of demand. This increased yield is achieved with the introduction of certain exotic species as discussed in Tigertedt (1993), who stated that higher yields in exotics species must be due to genotype x environment interactions that ultimately cause larger risks. Changed root-shoot relationships, manipulation of site fertility may all be interacting components.
With the introduction of exotic species there is an associated risk which is the introduction of diseases, capable of damage both exotic and native species (Karlman, 1981). This is one of the mean reasons why a forest landowner shall give advance notification to the Swedish Forest Agency if he intends to use reproductive material of foreign species on an area exceeding 0,5 ha (SVL, 2009). In this way, future percentage of exotic species is restricted by the Swedish Forestry Act of 1979, which stipulates that for instance *Pinus contorta* should be used "in areas difficult to regenerate satisfactorily with indigenous tree species". In addition to the limitations described above for lodgepole pine it is also said in the Swedish Forest regulations that foreign tree species should be used only in a very restricted way (SVL, 2009).

Thus, knowledge of the growth potential of different tree species (as well as the regulations which are subject to) is important in forest management. Furthermore, as one of the major goals in Swedish forest policy is sustainable yield (Anon., 1998), it is important to choose the tree species best adapted to different site conditions.
Below, there is a brief description of the ten tree species included in this study.

Siberian fir (*Abies sibirica*)

Native from Siberia can be found from the east of the Volga river and south of 67°40'N through Turkestan, northeast Xinjiang, Mongolia and Heilongjiang. It lives in the cold boreal climate at elevations of 1900 – 2400m.
Abies sibirica is capable of re-sprouting and layering in addition to wind dispersal (Green et al., 1999) which makes it a special species of the Siberian dark taiga making possible a pronounced dominance of Abies after nonfire disturbances, in this region (Schulze et al., 2005).
It is very shade-tolerant, frost-resistant and can survive temperatures down to -50°C. Grows 30 – 35 m tall with a conical crown and with a trunk diameter of 0,5 – 1 m. Grow quickly after a slow establishment and is expected to have high production potential (Rosvall et al, 1996)

Alpine fir (*Abies lasiocarpa*)

It has a wide natural distribution range in western North America, ranging from south-eastern Alaska, through the Yukon Territory, British Columbia and Washington, down to southern Oregon, further south also present in Colorado, Arizona and New Mexico. The altitudinal range of the species is also wide, with localities about sea level at the northern limit of its range and up to 3600 m in the south (Hansen et al., 2004).
In Iceland and especially Norway there has been an increasing interest in using this species for the production of greenery and Christmas trees. In Denmark it has also a big interest, but the role is here most likely to be as a secondary species in Christmas tree production (Hansen et al., 1990).
It is a medium-sized tree growing to 20 m tall, exceptionally to 40 – 50 m tall, with a trunk up to 1 m diameter, and very narrow conic crown. It is deep rooted, initially slow growing and its life expectancy is short. Alpine fir is shade tolerant and because of its faster and deep root penetration, regenerates well even on organic material (Eis et al., 1983). It also appears to compete successfully with the shrubs to provide forest cover, wildlife habitat and eventually a harvestable crop. Grow quickly after the establishment and is expected to have high production potential.
According to Eis et al. (1983), in a study which compared several regeneration characteristics of alpine fir and white spruce (*Picea glauca*), at the end of the seventh growing season, the average height of the former species seedlings on unscarified soil was 52 cm (range 38 – 62), compared with 77 cm (range 56 – 87 cm) on scarified soil, whereas spruce seedlings averaged 51 cm on scarified soil with no survivals on unscarified soil. In the same study, survival rate was much bigger, and close to 90% in some cases, in alpine fir.

Norway spruce (*Picea abies*)

The Norway spruce is a native species to Europe, from Norway in the northwest and Poland eastward, and also the mountains of central Europe, southwest to the western end of the Alps, and southeast in the Carpathians and Balkans to the extreme north of Greece.
It is a large coniferous tree growing to 35 – 55 m tall and with a trunk diameter up to 1 – 1,5 m.

Jonsson (2001) states in his article about yield volume that this species reach at the age of 15 years an average height of 2 m in pure stands, although the same height in mixed Scots pine and Norway spruce stands.
It is known that in young stages Scots pine grows faster than Norway spruce, although growth potential of pine on mature stands is usually slower than spruce (Öyen and Tveite, 1998). The same was stated by Parviainen (1985) who demonstrate that between 16 – 23 years after planting, the growth of spruce was clearly slower than that of the other species compared (*Pinus sylvestris*, *Larix sibirica* and *Betula pendula*).
Norway spruce, regarded as sensitive to frost, has generally much better survival than the known frost tolerant Scots pine on harsh sites (Fries, 1991).
In parts of North America it is naturalised, although not so extensively as to be considered an invasive weed tree. It can grow fast when young, up to 1 m per year for the first 25 years under good conditions, but becomes slower once over around 20 m tall (Mitchell, 1974).

Black spruce (*Picea mariana*)

Picea mariana is a species native to northern North America, from Newfoundland west to Alaska, and south to northern New York, Minnesota and central British Columbia.
It is a species of small to medium-sized coniferous tree, slow-growing and forms relatively pure stands on both uplands and peatlands, remaining even-aged until 160 years approximately (Groot and Horton, 1994). It is a pioneer species that invades the sedge mat in filled-lake bogs.
Through much of its range it averages 5 – 15 m tall with a trunk 15 – 50 cm diameter at maturity, though occasional specimens can reach 30 m.
The species is highly valued for lumber, pulpwood and round timber. Over 100000 ha of black spruce plantations are established in Canada each year (CCFM, 1996).
As Weng et al. (2010) showed the height in black spruce trees from different provenances, 15 years after planting ranged between 536 to 640 cm, for site index (50 years) of 15 to 17 m, respectively. For the same sites index, the survival rate was 87% and 92%.

White spruce (*Picea glauca*)

It is a native species to the north of North America, from central Alaska east to Newfoundland, and south to northern Montana, Michigan, Maine and Wisconsin.
It is a medium-sized tree growing 15 – 30 m tall, rarely to 40 m tall. The crown is narrow conic in young trees, becoming cylindrical in older trees.
According to Eis et al. (1983) white spruce is usually shallow rooted, initially slow growing and fairly long lived. The same author stated that white spruce had a very low survival rate seven years after planting, between 10 to 15%, when there is a high shrub competition.
Some other studies affirmed after fifteen years, height of white spruce seedlings ranged from 420 cm, at site index (50 years) 16 m, to 612 cm at site index (50 years) 19 m (Weng et al., 2010).
In the other hand, the Alberta Forest Service (1985) stated that pure white stands on good sites are 324 cm at 20 years, compared to 309 cm stated by Lieffers (1996).

Jack pine (*Pinus banksiana*)

Pinus banksiana is a boreal conifer indigenous to North America. The species is widely distributed in Canada, from the Maritime provinces in the east to Alberta and the northwest Territories in the west. In the United States, jack pine is restricted to portions in some northern states (Kenkel et al., 1997). It is an important pulp and timber species in Canada and Lake States; the rapid juvenile growth on sites that require a minimum of preparation and tending

has given jack pine a preferred status in the reforestation programs of Ontario and Québec (Magnussen et al., 1985).
Jack pine commonly regenerates in pure, even-aged, well-stocked stands following wildfire, because of prolific seed dispersal from serotinous cones. Pure, even-aged jack pine stands are particularly common on frequently burned dry sites such as glaciofluvial sands and shallow to bedrock soils (Carmean et al., 1989).
In its natural distribution, *Pinus banksiana* is a relatively short-lived tree, 80 – 100 years, of medium size, growing to 15 – 25 m in height and 20 – 30 cm in diameter in typical sites. The species grows quite rapidly in youth, and under good growing conditions can reach a height of 1,5 m by ages 4 – 6 years and 6 m by 18 years (Kenkel et al., 1997).

Lodgepole pine (*Pinus contorta*)

Lodgepole pine (*Pinus contorta*), native to North America, has been the first species introduced systematically on a large scale to Sweden. The first plantations in Sweden were established at the end of the 1920's using seed mainly coming from Finland, but it is not until 1970's when it was introduced on a large scale (von Segebanden, 1992; Elfving et al., 2001). Lodgepole pine covers close to 600000 ha in Sweden today (Elfving et al., 2001).
Pinus contorta (including all subspecies) is widely spread throughout western North America, growing between the latitudes 30 and 64°N and spanning 0-3900 m in elevation (Wheeler et al., 1985).
This species has wide ecological amplitude. Its varieties are adapted to maritime, continental and subalpine conditions and can grow on any type of site, including both dry and wet soils (Elfving et al., 2001). It is a shade-intolerant, deep-rooted, hardy, initially fast-growing, but short-lived pioneer species. It regenerates best following removal of the original stand and, if seed is available, it will colonize any disturbed area. Fire and logging have been the primary factors in the present distribution of pine in its natural habitat (Eis et al., 1982).
Wood quality of lodgepole pine seems to be comparable to that of Scots pine grown under similar conditions. However, according to Persson (1993), lodgepole pine has a slightly lower wood density, higher proportion of heartwood and better stem form than Scots pine.
Elfving and Norgren estimated in 1993 that yield production of lodgepole pine was 36% larger than Scots pine on the same site, determined from the maximum mean annual increment before the first thinning. The optimum rotation is 10-15 years shorter for lodgepole pine and the natural mortality after the first thinning is about twice as high. However, survival is higher for *Pinus contorta* during the initial stand development (Ackzell, 1993; Ericsson, 1993).

Scots pine (*Pinus sylvestris*)

The Scots pine is a species native to Europe and Asia, ranging from Ireland, Great Britain and Portugal in the west, east to eastern Siberian, south to the Caucasus Mountains, and as far north as well inside the Arctic Circle in Scandinavia.
It is a coniferous tree growing up to 25 m in height and 1 m trunk diameter when mature.
Traditionally it has been, together with *Picea abies*, the most common planted tree species in Sweden, although during the past 10 years the share of broadleaved trees has increased (Ekö et al., 2008). However, Scots pine was commonly planted because of its rapid early growth, tolerance of transplant shock, good timber properties and adaptability to a range of site conditions (Mason, 2000).
Yield tables from Hamilton and Christie (1971) suggest an age of maximum mean annual volume increment of 65 to 90 years according to declining productivity. Yields vary from 450 to 200 m^3/ha according to declining site quality corresponding to top heights of 17 to 27 m and mean diameter of 20 to 45 cm.

Jonsson (2001) states a dominant height of 4,8 m in Scots pine trees of 15 years in pure stands, although no difference is shown in mixed Norway spruce stands.
Although Scots pine has faster early growth than spruce, Ekö et al. (2008) showed that the ratio of potential growth between pine and spruce was 60 % in southern Sweden (close to 1 in northern Sweden).

Russian larch (*Larix sukaczewii*)

It has a scattered distribution in western Russia from Lake Onega in the west to the River Ob in the east, between latitudes 52°N to 68°N (Karlman, 2010), occupying the most westerly area of distribution of the three most common larch species in Russia (Abaimov et al., 1998). It grows mostly in mixtures with Norway spruce, Scots pine and birch. Earlier the distribution area was larger but it has declined during the last century, mainly due to exploitation of the forests and bad management. Also the controlling of wild fires has lead to poor regeneration.
In Northern Sweden several small stands of Russian larch were established between 1900 and 1940 and are the oldest stands of larch existing in that region (Martinsson, 1994).
Larix sukaczewii grows normally up to 30 – 35 m tall trees, but in Finland trees up to 46 m have been recorded at Punkaharju research station; at Raivola there are trees reaching over 50 m (Karlman, 2010).
According to Martinsson (1994), who carried out an investigation and studied yield of twenty small stands of *L. sukaczewii*, on average, the yield of this species was 25 – 40 per cent superior to that of the indigenous conifers, depending on site index. Calculated under bark, the volume yield was 10 – 25 per cent superior to that of conifers as Norway spruce or Scots pine. Also compared to lodgepole pine, the volume yield of larch was superior at high elevations and on hilly sites with mobile soil water. In the same investigation, Martinsson figured out a dominant height of 25 – 27 m to be expected at 60 years, and still increasing at 90 years.
Fries (1991) stated that survival rate after four growing seasons, in a trial at Lat. 67°N, was 88 – 91% in two different facing slopes.

Silver birch (*Betula pendula*)

It has a wide natural distribution area on the Eurasian continent, ranging from the Atlantic to eastern Siberia and absent from Iceland and most of Greece and the Iberian Peninsula.
Birch is an essential ecological component in northern temperate and boreal forests; it is light demanding and early successional pioneer species (Tham, 1994), which rapidly occupy open areas after forest fires and clear-cuttings due to their prolific seed production on fast juvenile growth (Fischer et al., 2002).
The most important site characteristics for the vigorous growth are adequate moisture and air content, being the best forest sites sandy and silty till soils and fine sandy soils (Hyninen et al., 2010). On the other hand, root system of birch is not able to function properly in poorly aerated soils like clay soils and soils where the ground water table lies close to the soil (Raulo, 1978).
Oikarinen (1983) figured out after studying different plantations in fertile forest sites in the south of Finland, growths of 11 m in 15 years trees in plantations of 2000 trees/ha; also recorded basal areas of 10,2 m^2/ha. Parviainen (1985) also affirmed rapid height growth in birch; more than in Norway spruce or Scots pine.

The primary aim of the present study was to analyze the growth (height, diameter and basal are) and survival rate of these ten tree species in Northern Sweden. Also to compare the study results with previous studies performed by other authors.

Materials and methods

Site description

The study area is located at Manjaur, in Vindeln Kommun, Västerbottens, Sweden (64º 43' N, 19º 19' E), on level ground ca. 300 m a.s.l. The area is slightly sloped (5-15%) and NW faced.

The vegetation type on the site is dominated by blueberry (*Vaccinium myrtillus*) and is included on the boreal forest within spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) domain. It is located in a subarctic climate with short cool summers and long cold and snowy winters; the mean annual temperature is 0,7 °C and the annual precipitation ca. 572 mm (SMHI, 1991). The sum temperature, as the sum of all daily mean values exceeding 5 °C is 825 day-degrees.

The sort of soil is a podsol of medium texture with a total depth close to 70 cm, and with a humus layer of about 3-6 cm. Soil moisture regime is predominantly mesic.

The site index for the experiment is T21 m for *Pinus sylvestris*.

Figure 1. Location of the studied area

Experimental design

The experiment was laid out in three blocks, each containing 10 plots of 36 x 41 m with square shape. Thus, the experimental site comprised 4,43 ha in total. The species used came from different provenances (Table 1) and the seed material for each species was bulked. These

Table 1. Provenances of the species in the studied area

Species	Provenance	Latitude	Altitude
Siberian fir (*Abies sibirica*)			
Sort 1 – 2	Punkaharju (Finland)	61° 45'	-
Sort 3	Punkaharju (Finland)	61° 45'	-
Alpine fir (*Abies lasiocarpa*)			
Sort 4	Yukon, BC	49° - 62°	730 – 1250
Sort 5	Steamboat Mtn, BC	58° 42'	1050
Sort 6	Jackson Lake, Wyoming	60° 42'	1366
Sort 7	Meziadin Lake, BC	56° 08'	300
Norway spruce (*Picea abies*)			
Sort 8 - 9	Färilvägen (Sweden)	62° 15'	200
Black spruce (*Picea mariana*)			
Sort 10 - 12	Minto, Yukon	62° 38'	700
Sort 13		63° 20'	-
White spruce (*Picea glauca*)			
Sort 14 - 16	Minto, Yukon	62° 34'	700
Jack pine (*Pinus banksiana*)			
Sort 17 - 18	Birch Lake, Northwest Terr.	62° 38'	250
Lodgepole pine (*Pinus contorta*)			
Sort 19 - 20	Carmacks, Yukon	62° 05'	570
Scots pine (*Pinus sylvestris*)			
Sort 21, 23	Hortlax (Sweden)	66° 20'	310
Sort 22	Östteg (Sweden)	65° 10'	390
Sort 24	Robertsfors (Sweden)	64° 30'	220
Russian larch (*Larix sukaczewii*)			
Sort 25 - 26	Östteg (Sweden)	63° 48'	5
Silver birch (*Betula pendula*)			
Sort 27	Åboliden (Sweden)	63° 56'	115
Sort 28	Åboliden (Sweden)	63° 56'	115

species were planted in spring of 1994, with seedlings which grew up in 60 cm^3 containers, most of them two years old. The rest of the seedlings were one year old when planted.
Before planting, the soil was mechanically scarified.
During the first year, about 6% of the seedlings died and were replanted with new seedlings, most of them of the same age and provenances as the ones planted in 1994; thus, the stand remains even-aged.
In the area, each parcel is composed by 18 rows of 18 trees each one, planted on a pattern of 2 x 2.3 m. The total number of trees in the studied area is 9720.
Each one of these three blocks contains the ten studied species, which are: *Pinus sylvestris, Picea abies, Betula pendula, Pinus banksiana, Picea mariana, Abies lasiocarpa, Larix sukaczewii, Pinus contorta, Abies sibirica* and *Picea glauca*; so there are three even-aged stands of each species in the study.
Parcels belonging to the same block were situated close together, so effects of abiotic factors were minimized.
Until the date of sampling, in October of 2009, no treatment were performed on the area; that means that trees were not pruned or fertilised during these years. As well, the area have not been affected by any great storm, wind or any diseases.

Sampling

The stands were 15 years old (2009) at sampling. The detailed description of the stands location can be found in Figure 2. For every single tree in the studied area, the following measurements were taken: number of tree, species, diameter, state of tree (standing, cut, missing, wind) and three different levels of damage; the different types of damage or other anomalies were also codified. Sixteen standing trees were randomly selected on each plot to measure on them some other features as: total tree height, height on the base of live crown and bark thickness.

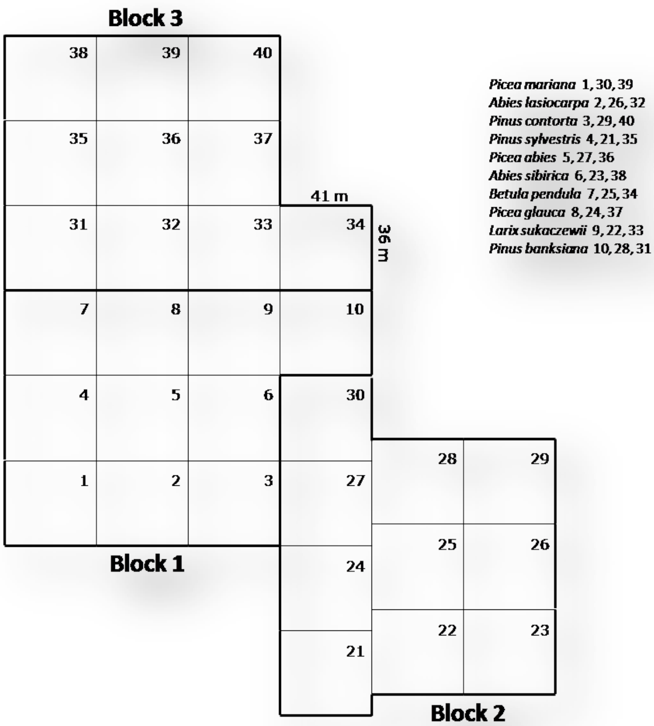

Figure 2. Distribution of parcels on the studied area

Statistical analysis

Regression lines for each species in each parcel were performed relating tree height with its respective diameter, of those trees whose height was measured. Knowing the diameter of each single tree in the area and its corresponding regression line, one was able to obtain all heights for the trees in each parcel. Survival rate and basal area for each species was also calculated for each parcel. Trees smaller than 1,3 meters were not used to calculate average heights.

Descriptive statistics presented are of original untransformed data. Two-Way ANOVA was performed separately for each parameter using the following model:

$$Y_{ij} = \mu + B_i + T_j + e_{ij}$$

where $\boldsymbol{Y_{ij}}$ is the response variable, $\boldsymbol{\mu}$ is the overall mean, $\mathbf{B_i}$ is the block effect, $\mathbf{T_j}$ is the effect of the treatment and $\mathbf{e_{ij}}$ is the error term. Multiple comparisons were made with Tukey's test to detect differences between treatments at 5% level of significance. Statistical analysis was performed using SAS 9.2 software package.

Results

The relationship between diameter and height was estimated by linear regression analysis; square errors ranged from 0,80 to 0,97. Mean values of dominant height were calculated, as well as mean height and mean diameter (Table 2).

Table 2. Mean height and diameter values for each species. The standard deviation is shown within parentheses.

Species	Dominant height (dm)	Mean height (dm)	Mean diameter (mm)
Abies sibirica	20,6 (5,47) ^{c}	19,02 (6,03) ^{b}	15,7 (10,4) ^{c}
Abies lasiocarpa	22,41 (4,3) ^{c}	18,80 (5,29) ^{b}	17,5 (10,5) ^{c}
Picea abies	19,91 (4,52) ^{c}	17,74 (4,98) ^{b}	16,6 (10,5) ^{c}
Picea mariana	29,80 (3,18) ^{c}	23,77 (5,8) ^{b}	23,2 (10,7) ^{c}
Picea glauca	23,16 (3,23) ^{c}	20,37 (4,31) ^{b}	17,0 (10,2) ^{c}
Pinus banksiana	42,11 (2,8) ^{b}	36,81 (5,44) ^{a}	53,0 (19,8) ^{a}
Pinus contorta	48,04 (3,83) ^{ab}	40,82 (6,78) ^{a}	57,5 (18,1) ^{a}
Pinus sylvestris	42,14 (3,91) ^{b}	35,03 (7,26) ^{a}	50,3 (19,3) ^{ab}
Larix sukaczewii	53,25 (8,42) ^{ab}	39,50 (12,45) ^{a}	38,7 (22,3) ^{b}
Betula pendula	55,72 (7,4) ^{a}	42,60 (11,53) ^{a}	38,5 (20,9) ^{b}

Note: tree species with different letters are statistically different based on Tukey's test

Dominant height values ($F_{9,18}$ = 36,86, p < 0.001) varied considerably among species, ranging from 19,91 to 55,72 dm at 15 years. The ANOVA revealed significant differences among the top species and the following ones. As well, Abies and Picea species showed the lowest values for these parameter and also for mean height ($F_{9,18}$ = 29,66, p < 0.001). In those two parameters coefficients of variation were low (less than 0,3).

Mean diameter ($F_{9,18}$ = 36,28, p < 0.001) values were statistically different among species. Genus Pinus showed the largest diameters (about 5 cm) whereas Abies and Picea species had the thinnest trees in the study. For this parameter, standard deviations were higher, what is also stated by higher CV (between 0,3 and 0,6).

Survival rate ($F_{9,18}$ = 9,831, $p < 0.001$) was significantly different between species. The Tukey's HSD indicated that *Pinus banksiana* had similarly lower survival rate compared to the other studied species (Table 3).

Table 3. Mean survival rates per each species (%). The standard deviation is shown within parentheses.

Species	Survival rate
Abies sibirica	90,4 (2,2) [ab]
Abies lasiocarpa	91,7 (5,3) [a]
Picea abies	94,7 (4,3) [a]
Picea mariana	92,8 (1,9) [a]
Picea glauca	90,1 (2,1) [ab]
Pinus banksiana	76,4 (4,8) [c]
Pinus contorta	91,8 (2,6) [a]
Pinus sylvestris	80,4 (5,1) [bc]
Larix sukaczewii	94,9 (0,7) [a]
Betula pendula	95,5 (0,9) [a]

Note: tree species with different letters are statistically different based on Tukey's test

With the values of diameter it was possible to calculate the corresponding basal area (Figure 3) and where different letters mean statistical differences based on Tukey's test.

Significant differences were found out for basal area ($F_{9,18}$ = 19,40, $p < 0.001$) as well. *Pinus contorta* showed the largest basal area, whereas Abies and Picea species had the smallest values.

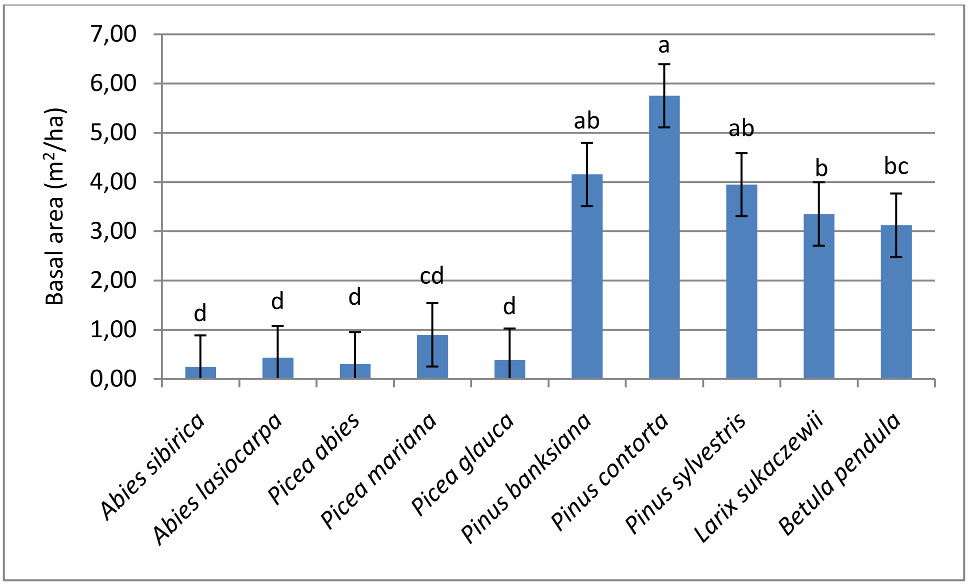

Figure 3. Mean basal area (m^2/ha) for each species

Discussion

Fifteen years after planting, big differences can be seen among the ten species in the measured features. In the case of height, which is perhaps the best estimate of the productivity of the site (Longpré et al., 1994), something expected from the beginning was that pioneer species grew faster than the rest at this age. Thus, birch was the species with highest height growth, regarding to its pioneer nature (Tham, 1994). Same strategy seems to be used by exotic species as *Larix sukaczewii* and *Pinus contorta.* These two species were the first foreign species planted in Sweden (von Segebanden, 1992; Martinsson, 1994). They could be of interest for forest owners that prioritize shorter rotations. Wood quality of lodgepole pine could in some features even be better than Scots pine, at the same age (Persson, 1993).

The next species with higher heights were *Pinus sylvestris* and *Pinus banksiana.* Three of these five species, with higher height after 15 years, were foreign species. If the above mentioned, short rotations, were used as the most common silvicultural practice in Northern Sweden, then larger number of exotic plantations could be established due to the fast growing of these foreign species. Before using these fast growing species other things also have to be considered e.q. frost tolerance, survival and resistance to diseases.

Although to establish these species in a larger scale, regulations made out by the Swedish Forest Agency has to be followed and also to be approved by the Agency.

For *Picea mariana*, higher dominant height was expected according to Weng et al. (2010), who stated that seedlings of black spruce would reach 53 to 64 dm after 15 years; despite this, has to be borne in mind its slow-growing nature. Instead, height values for *Picea glauca* and *Picea abies* were the ones expected, according to the Alberta Forest Service (1985) and Jonsson (2001), respectively.

All dominant height values had low standard deviations according to low coefficients of variation (less than 0,2), but in the case of *Abies sibirica*, which is higher (about 0,3); this can be explained due to high range of heights and high number of trees smaller than 1,3 m.

Genus Pinus showed the largest diameter in the study; the three species had diameters between 5 and 6 cm at breast height. This could be in a way supported by Lundqvist and Valinger (1996) who believed in the hypothesis that Scots pine trees can retain information on mechanical forces acting on the tree stem during dormancy, and respond to this during the following growth period. Thus, these trees may be strongly affected by winter conditions, and as a response could have bigger stems.

On the other hand, Abies and Picea species had the lowest diameters (and lowest basal area values), as well as the lowest values for height. This is because of their slow growing at young stages and under the shade of other species. But, we have to take into account that these values are for uncompleted rotations and, as Öyen and Tveite (1998) stated, growth potential of Norway spruce is usually twice as in Scots pine at mature stages. Ekö et al. (2008) reported that the ratio between Scots pine and Norway spruce was 60% in Southern Sweden and close to 1 in the northern part.

In the case of *P. glauca,* it had small diameters, as well as, small height growth (compared to other species), which agrees with Eis et al. (1983), about its slow growth at juvenile stages.

Survival rates were high in most species, but in *P. banksiana* (76,4%) and *P. sylvestris* (80,4%). Although Scots pine has high adaptability to different site conditions, Fries (1991) already stated its lower survival rate compared to *P. abies* (94,7%), which seems to base its strategy on making big stems, with slow growth and high survival rates.

Both *P. glauca* (90,1%) and *A. lasiocarpa* (91,7%) have had high survival rates; the former species seems to had overcome any shrub competition regarding at what Eis et al. (1991) stated about its low survival when competing with shrubs.

Pinus contorta had one of the highest values of survival rate and also the top value for basal area. The values for this latter parameter coincide with the top species in dominant height, due to basal area is a measure performed at breast height and not many trees of low height growth species reached 1,3 m. For instance, in *P. abies* 50% of trees didn't reach after fifteen years 1,3 m tall. The same percentage of *Abies sibirica* trees didn't reach this height either.
Instead, species with high basal area as *P. contorta*, *L. sukaczewii* and *B. pendula* had respectively, 1%, 7% and 2%, of the trees reaching 1,3 m. So, basal area feature at this young stage, is more directly proportional to the number of trees with height higher than 1,3 m than not the diameter of each species. In fact, this is a parameter which should not be used at this stage if we are not sure that all species have the same percentage of trees reaching breast height.
The results from this study should be interpreted with caution, one trial is not enough to come up with conclusions which can be used in the future to choose species on reforestation. For instance, Egnel and Leijon (1999) worked on 4 different sites to describe the survival and growth of seedlings of *Pinus sylvestris* and *Picea abies*. Beyond this, Elfving (1996) studied 91 plantations of Norway spruce to report its yield capacity. In a same way, these results cannot be extrapolated to all Northern Sweden due to different climate conditions.
New tree species can contribute to more efficient wood production but is often seen as a threat to natural forest ecosystems and biodiversity. It is important to examine what constitutes the real conflict between a sustainable exploitation of nature and the introduction of new tree species (Rosvall et al., 1996).
Knowledge of the new tree species is still to inadequate to enable them to be used on a large scale in other than experimental purposes. Exceptions seem to be, however, lodgepole pine and possibly Russian larch.
By building up knowledge of tree species that could be used in Sweden and provide a degree of preparedness for seed supply and seed improvement it would increase the future freedom of action. This freedom of action is needed to meet an increased demand for renewable natural resources and eventually changed global environmental conditions (Rosvall et al., 1996).

Acknowledgements

First of all I would like to thank my supervisor Hans Sjögren for the chance he gave me of doing my thesis with him and also for his effort even when he was really busy. Thanks also to Lars Lundqvist and Björn Elfving for their support.

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