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Effect of burial by sand on Scots pine (*Pinus sylvestris* L.) radial growth on seacoast wooded dunes at Cape Kolka, Latvia

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Abstract

Scots pine is a widely distributed species in Latvia, stress tolerant and able to grow in poor habitats. It is the dominating species of seacoast wooded dunes. Dunes in the Cape Kolka area are characterized with moving sand, resulting in stem burial of pines growing close to the beach. Main burial events are thought to occur during major storms, particularly as in 1967 - 1969. The aim of the study was to evaluate the effect of burial and climatic factors on radial growth. Samples from pines growing along the seaside under different levels of sand burial were collected. Tree-ring width series were crossdated and detrended chronologies were established. To evaluate growth relationships with climate correlation analysis was performed. Release/suppression analysis was performed to evaluate burial effect. Burial affected radial growth both in unburied and buried parts of stem. Under deep burial (more than 0.6 m) the occurrence of missing tree-rings increased. Radial growth since storms of 1967 - 1969 declined in pines blown over with sand. No major release periods were observed. Unburied pines also showed growth suppression dominating over release, especially during the last forty years, which might be related with erosion of the Kolka coast, changing the abiotic factors. Late winter and early spring temperatures were the main climatic factors affecting Scots pine growth of unburied trees, but buried trees (parts of stems) showed weaker reaction to extreme temperatures. Precipitation had an insignificant influence, presumable due to a well-drained soil and sufficient available moisture.

Key words: dendroecology, *Pinus sylvestris*, radial growth, sand burial in costal dunes, Scots pine.

Introduction

Wooded seacoast dunes are characterized by environmental factors changing in time and space (Moreno-Casasola 1986). Also they are a protected habitat in the EU (92/43/EEC 2180). Wind-induced coastal erosion and moving sand often causes complete or partial burial of plants (including trees) under certain conditions, even causing plant death (Moreno-Casasola 1986; Maun 1998). The burial effect can be divided in two types: high frequency with low intensity and catastrophic burial. A low intensity burial event is common for sandy coastal habitats, mainly affecting plants (mostly grasses) growing on the beach, foredunes and primary dunes (Moreno-Casasola 1986; Maun 1998; Dech, Maun 2006). Occasionally sand drift can reach secondary dunes, where pine and other woody plants are present causing their burial (Moreno-Casasola 1986; Maun 1998; Eberhards

2003), although these burials are still low intensity. Catastrophic burial events occur with low frequency, on occasions when larger quantities of released sand are available and strong wind forces drifts and deposites the sand material deeper inland into secondary dunes. Such situations are seen at the seacoast dune habitats during severe storm periods when dune vegetation is damaged, thus releasing sand material, and in wandering dunes where sand is weakly fixed (Marin, Filion 1992; Ulsts 1998; Eberhards 2003). Usually catastrophic burial events result in a thick layer of sand deposits. Burial effect in coastal dunes overall also depends on relief. Moving dunes (coastal or inland) that bury trees with a thick layer of sand often cause a deficit of water or abundance of soil moisture (if climate and microrelief are rich in water) resulting in reduction of photosynthesis, even resulting in a burial-intolerant plant death (Alestalo 1971; Schweingruber 1996; Maun 1998).

Scots pine does not form adventitious roots and should be considered as intolerant to burial. The buried parts of the stem maintain transport functions from roots, but radial growth can decrease depending on depth of burial through stem respiration and oxygen available for the root system (Alestalo 1971; Dech, Maun 2006).

Burial changes soil physical, physicaly-chemical, chemical (Jury, Horton 2004) and ecological characteristics: decreases soil oxygenation (influencing cambium during growth period), decreases deeper soil layer temperature (also making it more constant), increases or decreases moisture depending on site specifics, affects biotic factors such as mycorrhizal relations and the influence of pathogenic organisms, resulting in physiological stress and a decrease of growth in burial-intolerant species such as Scots pine (Alestalo 1971; Lavigne 1996; Schweingruber 1996; Maun 1998; Hartmann et al. 2000; Wimmer 2002; Larcher 2003; Mancuso, Marras 2003). Burial can change tree-ring formation in stems, as burial influences location of the stem bending point, resulting in reaction wood formation in different sections of stem. With low water stress and temperate climate conditions (temperatures), competition factors should play the main role in overall growth variation with burial as an additive effect occurring occasionally (Schweingruber 1996; Kuuluvianen et.al. 1998; Larcher 2003). Nevertheless, sometimes in intolerant woody plants under burial growth improvement can be observed in relation to release from competition after forest fire or forest clearing (also medium intensity natural disturbance) (Marin, Filion 1992).

Burial may also affect wood anatomy. Growth in buried parts of the stem becomes more similar to root growth as larger vessels are produced, despite strong reduction of tree ring size, observed in coniferous trees (*Picea glauca*) and common oak (*Quercus robur*) (Cournoyer, Filion 1994; den Ouden et al. 2007). Thus, in addition to effect on tree ring width, wood anatomy might also change due to drift sand and dune activity study.

Under strong burial (up to 4.2 m or 80 % of height) Scots pine was observed to form narrow or no tree-rings and produce significantly less biomass (Alestalo 1971; Dech, Maun 2006). The burial effect is not permanent: after sand deposit removal (erosion) growth rate can increase to normal (Alestalo 1971). Another coniferous tree species – white spruce (*Picea glauca*), on subarctic dunes in Hudson Bay, Quebec, Canada reacted similarly by strongly reduced stem radial growth under burial and showed normalization after erosion (Marin, Filion 1992; Cournoyer, Filion 1994), indicating that growth patterns can be a useful tool for determining past dune activity. Dech and Maun (2006) investigated burial effect in a dune habitat on several artificially planted woody plant species, and concluded that burial-tolerance differs among species and is directly connected with species and adventitious root formation ability. The authors suggested Scots pine as a burial-intolerant species, which linearly decreases biomass formation (growth) as the sand deposit layer thickens.

A strong storm in January 2005 strongly eroded the coastal dunes along the Baltic sea coast at the Cape Kolka, uncovering buried parts of stems of pines, making it possible to estimate burial depth and obtain samples at different height above the base of stem from parts of stems that were previously buried. The majority of pines were completely washed out and fallen. The main catastrophic burial events in Kolka should be related to storms, because sand material normally is fixed by vegetation and usual wind force doesn't transport it very deep into land (Moreno-Casasola 1986; De Raeve 1989; Maun 1998; Eberhards 2003). A catastrophic burial event in the last hundred years at Kolka coast is thought to have occurred in a severe storm in the period of 1967 - 1969, when coasts (foredunes) were severely eroded, coastal habitats were strongly degraded and significant quantities of sand material released and drifted into land burying part of coastal forests (Eberhards 2003)

The aim of the study was to determine the effect of sand burial on radial growth of Scots pine at Cape Kolka. The goals of the study were to compare tree ring chronologies obtained from buried and unburied trees, compare chronologies obtained from buried trees at different heights above the base of stem, and to compare the influence of climatic factors on growth of trees buried at different depths. Release and suppression analysis was also used to suggest when major burial events might have occurred.

Materials and methods

Study area and sampling plots

The study was carried out in northwestern Latvia, Slītere National park, Cape Kolka (Fig. 1). The sampling territory is mostly covered with boreal dry pine forests. Microrelief is formed by dune ridges and interdune depressions, with height 4 to 10 m above sea level

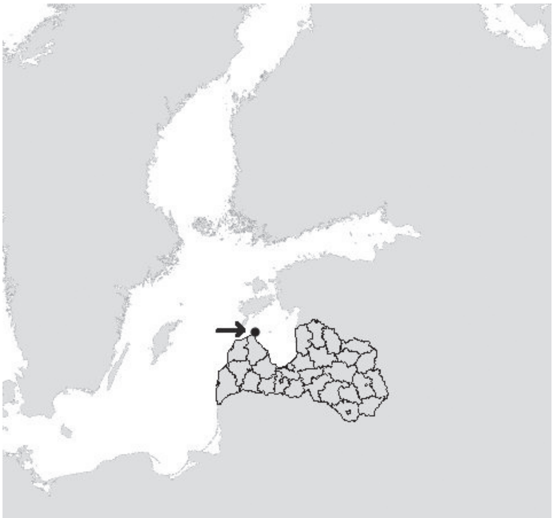

Fig. 1. Sampling territory.

(Eberhards 2003). The soil is sandy, poor in nutrients. In the former USSR regime, the territory was a restricted border zone with a very low anthropogenic influence (only military personal and few local villagers). Forest logging for the last hundred years has remained at a very low level.

High frequency low intensity burial at Kolka was common during the entire last century (Eberhards 2003). Nowadays the effect of burial still remains, only it is not lasting, as sea mostly erodes the Kolka coast forming a bluff, also slowing sand drift into land and forest burial (Ulsts 1998). Woody plants in wooded seacoast dunes in Kolka do not suffer a water deficit or abundance, because groundwater is available (Eberhards 2003) and soil drainability avoids abundance of water in shallower horizons and the sea moderates the microclimate. Moderate burial levels in the study site allow photosynthesis (branches and top of trees are not buried). Nowadays erosion processes still remain uncovering previously buried pines (mostly dead for a long time).

Three sampling plots were established: two along the beach (250 × 10 m) with trees buried at different depth and a control sampling plot (20 × 20 m) approximately 200 m away from the beach, where no burial effect on trees was observed. All sampling plots were covered with pine forest. Sampling plot coordinates are shown in Table 1.

Sampling and measurement

At the control site dominant trees were cored using a Pressler increment corer. In sites along the beach all trees were cored or stem discs were taken, depending on stem diameter (trees with diameter more than 5 cm were cored). Increment cores were taken at 0.3 m height above stem base (closest possible position to base of stem) from all trees and additional two or three cores were taken from strongly buried (burial depth more than 0.6 m) trees 1.3 m above stem base. Stem discs from smaller trees were obtained 0.3 m above stem base. We ensured that at least one core from each tree had a direct hit into stem pith. Increments and stem discs were collected in summer periods of 2005 and 2006 (control tree group). In the control sampling plot cores were taken from living trees, in sampling plots near the beach mostly dead trees lying on sand were cored.

For every buried tree burial depth was measured according to the margin where epiphyte or soil organism presence and sand debris were visible (margin was clearly visible in the field).

In the laboratory cores were dried and glued in a fixation plank, gradually sandpapered (sandpaper roughness from 150 to 400) and cleared from sawdust. Prepared cores were scanned using a digital scanner (HP Scanjet 8200) with resolution 1200 dpi in 16-bit color depth (RinnTech 2002). Tree ring widths were measured using the program Lignovision v. 1.36, manually placing tree ring borders for the best quality. In the study the whole tree ring widths (summing early and late wood widths) were used.

Table 1. Coordinates of sampling plots

Sampling plots	Coordinates (center of the plot) LKS92(x; y)
Sampling plot 1 (slightly buried trees)	57°45'30.4"N; 22°35'46.8"E
Sampling plot 2 (strongly buried trees)	57°45'25.9"N; 22°34'52.6"E
Control plot (unburied trees)	57°45'14.8"N; 22°34'52.5"E

Mathematical processing

Tree ring series were divided into four groups according to burial depth and sampling height: (i) control group – unburied trees cored at 0.3 m above stem base; (ii) slightly buried (burial depth less than 0.3 m) – trees cored at 0.3 m above stem base; (iii) strongly buried cored at stem base (0.3 m above stem base, burial depth more than 0.6 m); (iv) strongly buried cored 1.3 m above stem base (burial depth more than 0.6 m). Tree ring series with minimum length of 40 years were used in further analysis.

The COFECHA program was used for measurement quality control and crossdating with segment length of 40 years and lag 20 (Holmes et al. 1986; Cook, Briffa 1990; Grissino-Meyer 2001). Tree ring series were detrended and chronologies were calculated with ARSTAN. In further analysis mean tree ring widths and residual chronologies were used (Holmes et al. 1986; Cook, Krusic 2005).

Signatures of relationships of climatic factors to chronologies were determined with Pearson linear correlation analysis (Sokal, Rohlf 1981; Fritts 2001) and also using the program Dendroclim2002 for the whole available reference period (Biondi, Waikul 2004).

To evaluate growth dynamics before and after storms of 1967 - 1969 linear regression lines based on tree ring widths for 30-year periods before and after storms of 1967 - 1969 were constructed. Slopes of the regression lines were compared using the "comparison of regression lines analysis" method in the Statgraphics plus v.2.1 program (Sokal, Rohlf 1981; Manugistics 1996).

To compare radial growth tendencies and synchronicity among groups Gleichläufigkeit (GLK) indices were calculated (Esper et al. 2001). To evaluate abrupt growth changes in the stand that were maintained for a longer period release/suppression analysis was conducted (Baker, Bunyavejchewin 2006). Growth changes with relative values more than 25 % were included in the analysis. We considered as significant those relative values of release and suppressions that exceeded 20 % of stand (group) tree number.

Climatic data was obtained from the Latvian Environment, Geology and Meteorology Agency for the Kolka Meteorological Station, [missing data for the Second World War period (1941 - 1945) was replaced by modeled estimates based on Riga Station data]. Absolute minimal, maximal and average temperatures for months and seasons, and precipitation sums for months and seasons were used. October, November and December climatic data were considered and used as next year parameters.

Results

In the study 177 samples from 128 trees were collected; after crossdating and quality verification 105 samples from 73 trees were selected for further analysis. Numbers of samples collected and used for building chronologies are shown in Table 2.

Crossdating showed that many samples had missing tree rings and growth within groups was variable. For chronology construction data series showing at least $r = 0.25$ correlation with the COFECHA master series were included. Reference periods for groups with first five years cut are shown in Table 2. Minimal reference period was 103, maximal 142 years. Samples taken from strongly buried trees from the base of stem showed the shortest reference period due to wood rot.

For each group mean tree ring widths were calculated (Fig. 2). To evaluate changes in

Table 2. Numbers of samples suitable for further analysis and reference periods

	Control (burial absent)	Slightly buried	Strongly buried at stem base	Strongly buried 1.3 m above stem base	Other samples/ trees	Total
Burial depth (m)	0	< 0.3	> 0.6	> 0.6	[0.3; 0.6]	
Number of samples	42	37	25	54	19	177
Number of trees	15	37	25	32	19	128
Reference period	145 (2006-1862)	112 (2005-1894)	105 (2005-1901)	107 (2005-1899)	110 (2005-1896)	
Number of samples after crossdating and quality control	36	17	18	34	0	105
Number of trees after crossdating and quality control	13	17	18	25	0	73
Reference period after crossdating and quality control	142 (2004-1863)	109 (2004-1896)	103 (2004-1902)	106 (1899-2004)	0	

growth of sample groups after storms of 1967 - 1969 linear regression lines for periods of 1935 - 1964 and 1965 - 1994 were constructed (Fig. 3) and trend line slopes were compared (Table 3) (slopes differ when p-values < 0.05). The slopes of regression lines did not significantly differ among sample groups in the 30-year period before the storms of 1967 - 1969. In the period after the storms trend line slopes significantly differed among sample groups, showing a decline in radial growth in strongly buried sample groups. The control group showed no decline, while the slightly buried group only non-significantly declined in radial growth after storms.

Mean tree ring width series and ARSTAN chronologies among sample groups were compared using correlation analysis. Calculated correlation coefficients shown in Table 4 are significant at a = 0.05. The highest correlations were observed between samples taken from the same trees at different heights (strongly buried sample groups). To evaluate radial growth synchronicity GLK indices were calculated for sample groups (Table 4).

To analyze relations of radial growth with climate correlation analysis was performed, based on ARSTAN residual chronologies (Fig. 4). Correlations significant at p = 0.05 are shown in Table 5. In total 23 climatic factors showed significant correlations.

Significant correlation of late winter and early spring average temperatures with radial growth was common for all sample groups. The influence of February average temperature on growth was observed in all sample groups and showed the highest correlation coefficient values among average temperature factors. The same was observed for extreme (maximal and minimal) temperatures. The strongly buried at stem base sample group overall showed weaker relations to extreme temperatures. Precipitation sums showed little influence, as one significant correlation with June precipitation in the strongly buried at stem base sample group was found.

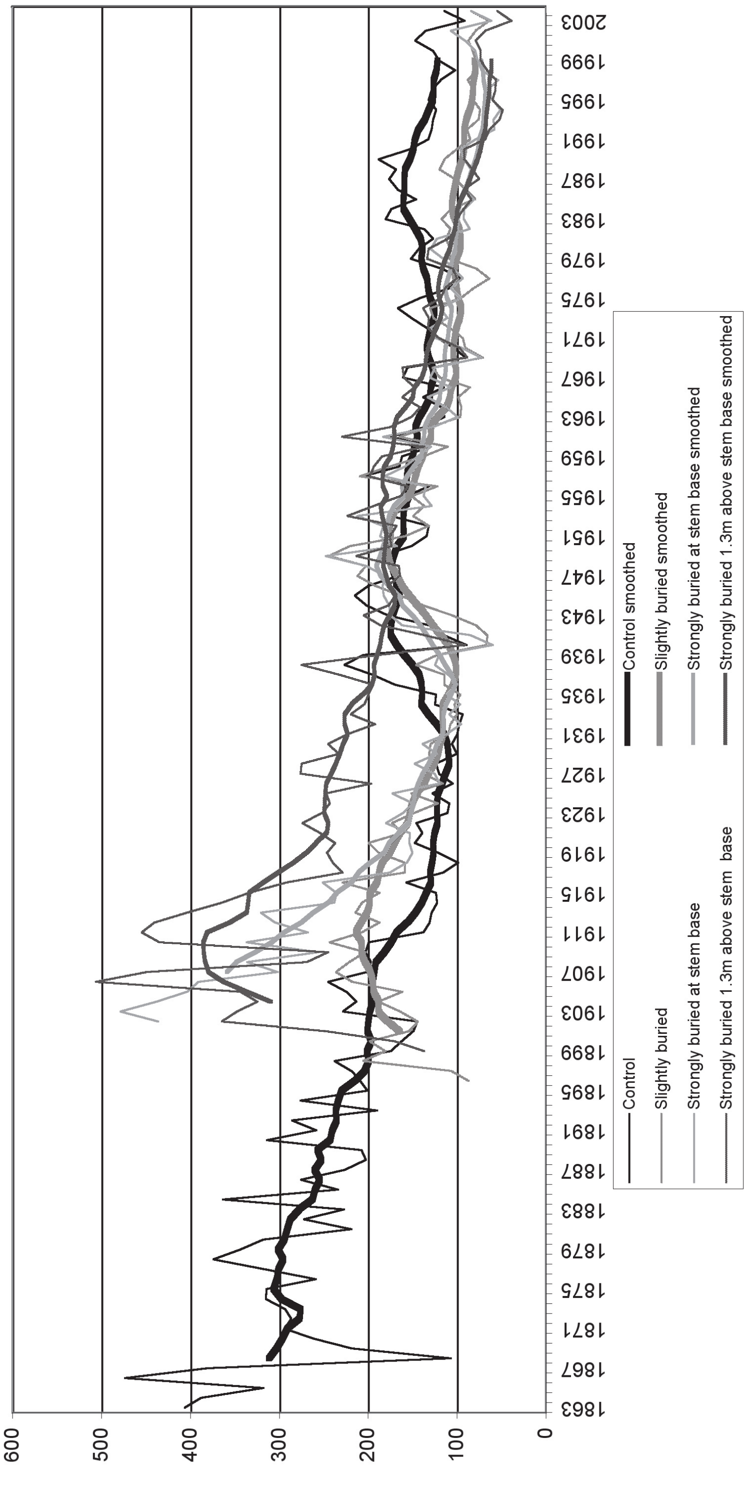

Fig. 2. Mean tree-ring width (0.01mm) series of groups (smoothing – 11 years).

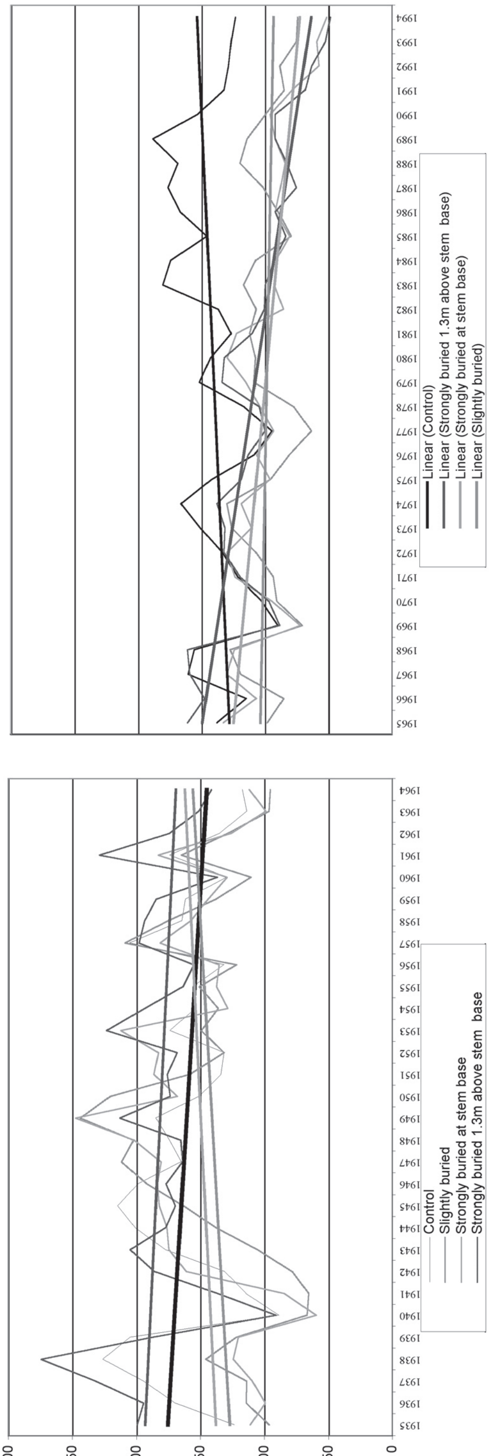

Fig. 3. Mean tree-ring widths (0.01 mm) and regression lines of sample groups for periods of 1935 - 1964 and 1965 - 1994.

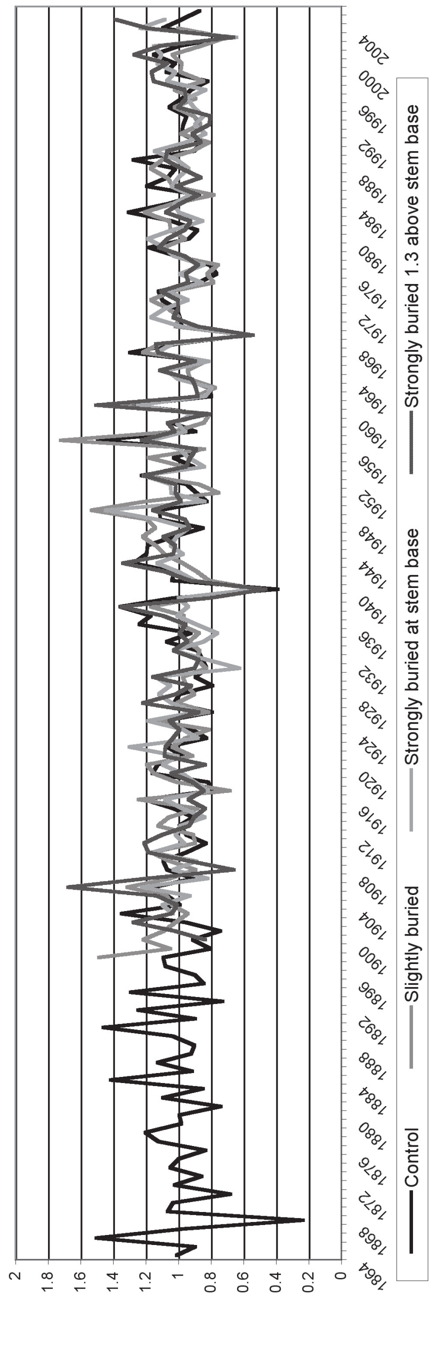

Fig. 4. Detrended (ARSTAN residual) chronologies for sample groups.

Table 3. Comparison of regression line slopes (p-values shown) among sample groups for periods 1935 - 1964 and 1965 - 1994 (before and after storms of 1967 - 1969)

	Slightly buried	**Strongly buried at stem base**	**Strongly buried 1.3 m above stem base**
Before storms of 1967 - 1969			
Control	0.0938	0.1024	0.8215
Slightly buried		0.9023	0.1378
Strongly buried at stem base			0.1378
After storms of 1967 - 1969			
Control	0.0605	0.0001	0.0000
Slightly buried		0.0067	0.0000
Strongly buried at stem base			0.0222

Table 4. Correlation coefficients (r) between sample groups for mean tree ring widths and ARSTAN chronologies, and Gleichläufigkeit (GLK) index values (mean tree ring widths compared)

Mean tree ring widths/ ARSTAN chronologies/ GLK	**Slightly buried**	**Strongly buried at stem base**	**Strongly buried 1.3m above stem base**
Control	0.50 / 0.66 / 0.77	0.54 / 0.57 / 0.81	0.44 / 0.55 / 0.74
Slightly buried		0.74 / 0.58 / 0.67	0.72 / 0.55 / 0.68
Strongly buried at stem base			0.89 / 0.64 / 0.83

Release/suppression analysis (Fig. 5, 6) shows that the periods of abrupt changes of radial growth (absolute relative value compared to previous 10-year period more than 25 %) differ strongly among sample groups. In general, growth suppression was more common than growth release in all sample groups. Thus, in all of the groups, 5-year periods where 20 - 40 % of trees show a 25 % or more long-term suppression of growth were quite common. Sample groups where the burial effect was low had some release events, but still suppression dominated (not shown). Strongly buried sample groups showed dominantly suppression (Fig. 6).

Discussion

The occurrence of missing tree-rings in coastal habitats (dune forest) under the influence of sand burial is related with a growth decline, when woody plants form very narrow (sometimes too narrow to identify) rings (Marin, Filion 1992). Heterogeneity of radial growth is related with environmental factor variation: topography, spatial distribution of trees with different wind influence (Maun 1998). Crossdating of control samples was less complicated (than in buried sample groups) as no burial effect was detected and abiotic factors were likely similar for trees in the sampling plot.

Growth of Scots pine in Cape Kolka area can be characterized as unstable, wavy. Growth patterns of the sample groups (Fig. 2) before storms of 1967-1969 were similar, as an aging effect was observed (growth decline with time) and fluctuation of tree-ring

Table 5. Statistically significant correlations (r) between sample group ARSTAN residual chronologies and climatic factors

		Control	Slightly buried	Strongly buried 1.3 m above stem base	Strongly buried at stem base
Average temperatures	Dec				0.19
	Jan	0.30	0.27	0.28	0.28
	Feb	0.43	0.37	0.45	0.34
	Mar	0.41	0.32	0.44	0.28
	Apr	0.27	0.24	0.35	0.33
	Jul				−0.17
Minimal temperatures	Sep			0.28	
	Dec			0.28	
	Jan	0.29	0.27	0.29	
	Feb	0.35	0.27	0.37	0.27
	Mar	0.38		0.39	
	Apr			0.34	0.28
	Winter	0.30	0.30	0.33	0.25
	Spring	0.39		0.40	
	Season	0.32	0.28	0.34	0.23
Maximal temperatures	Jan		0.26		
	Feb	0.24	0.31	0.35	0.33
	Mar		0.30	0.32	
	May	0.27	0.35		
	Autumn	−0.28			
	Winter		0.32		0.26
	Spring	0.26	0.33		
Precipitation sums	Jun				0.34

widths in a large scale was comparable. A growth decrease in all sample groups in 1941 was related with extremely low winter temperatures especially in January and February.

Wider tree-ring formation in the strongly buried sample groups at 1.3 m compared to 0.3 m above base could be explained by rapid growth in length followed by stem thickening (Schweingruber 1996). A decline of growth in buried trees after burial in storms of 1967-69 is suggested, as was also observed in other areas (Alestalo 1971; Marin, Filion 1992). For pines growing in places where burial was absent or minimal the tree-rings even showed increasing trends, maybe due to climate change (Fig. 3).

Correlation analysis and GLK values (Table 4) showed that the highest similarity between tree-ring series was for the strongly buried tree groups sampled at different heights. Thus the burial influences the whole stem radial growth, not only the buried parts. Dech and Maun (2006) conducted experimental burial on saplings of several tree species growing in dune habitats and concluded that Scots pine can not change biomass

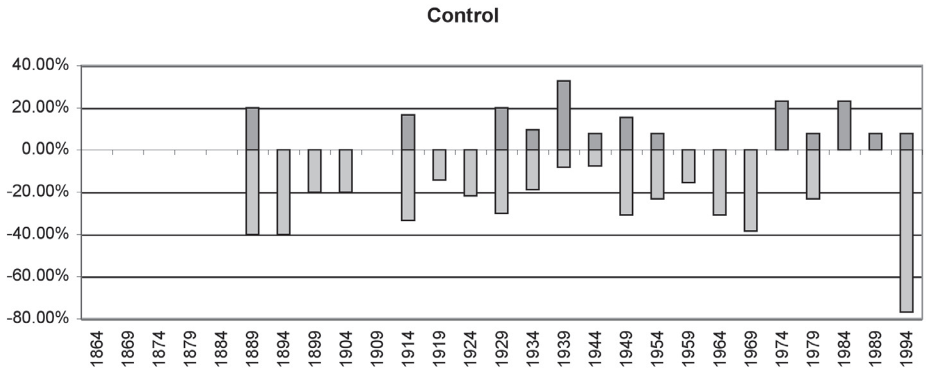

Fig. 5. Release/suppression (% of trees) of radial growth of control sample group.

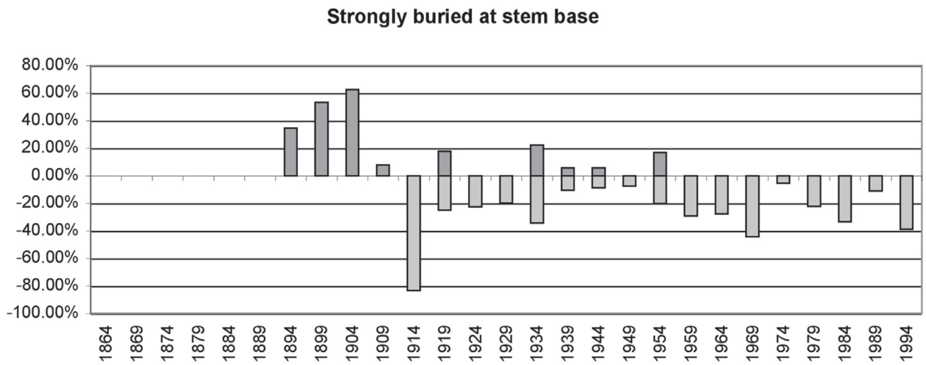

Fig. 6. Release/suppression (% of trees) of radial growth of group of strongly buried samples cored at base of stem.

allocation, thus buried parts grow at the same rates as unburied parts. Maun (1998) also suggested that burial influences the growth of the whole plant. The most differing radial growth patterns were between unburied and buried trees, which indicate the influence of burial.

Growth relations with climatic factors (Table 5) in all sample groups show the main characteristics found previously for Scots pine in Latvia on dry soils: positive correlations with winter and early spring average temperatures (Elferts 2007). The same relations with winter and spring temperatures were also observed in Poland (Sudetic mountains), for Scots pine growing on dry mountain slopes (Wilczynski, Skrzyszewski 2002). Trees with stems buried more than 0.6 m (strongly buried sample groups) show additional factors such as December, July and September temperatures and June precipitation. A relation with June precipitation is common for northwestern Latvia (Elferts 2007), which was observed only in the strongly buried group cored at stem base. We suggest that these signatures have remained from the period when growth could be considered as normal. However, the other groups did not show this relation. The observed negative effect of July temperature might occur via promotion of pathogenous organism activity, as soil temperature rises under burial conditions in July. Also higher soil temperatures in the buried part could cause heat shock thus suppressing growth (Pichler, Oberhuber 2007).

Buried trees showed fewer relations with extreme temperatures (usually representing short periods of influence), which can be explained with sand burial reacting as a buffer softening extreme climatic expression (Maun 1998). Radial growth of strongly buried trees at stem base showed less and weaker relations compared to growth of strongly buried cored 1.3 m above stem base. Differences could be caused by expression of climatic signal under burial at various heights of stem: growth rates should remain the same in buried and unburied parts of stem (Dech, Maun 2006), but tree-ring widths might have slightly different ratios, thus effecting correlation.

Release/suppression analysis showed that in all groups, 5-year periods were common in which 20-40% of trees showed suppressed growth for at least 10 years. This suggests a generally harsh environment for the seacoast pines: wind damage, salt spray, and winter desiccation. The control sample group (Fig. 5) showed growth release and suppression during the entire reference period, but the occurrence of suppression was more common. Strong growth suppression in 1994 - 1999 was most likely caused by coastal erosion when a rather wide part of the coast was washed off (Eberhards 2003), thus changing growth conditions via salinity (salt drift from sea) and the influence of wind (Larcher 2003). Release in strongly buried sample group (Fig. 6) before 1910 can probably be explained by the young age of the trees. The strong suppression in the 1910 - 1920 in this group likely represents a growth decline after the rapid growth of saplings.

The effect of sampling height on ring width for pines buried by sand is minimal. There is rather high similarity (GLK, correlation coefficients) between strongly buried sample groups (Table 3), which agrees with Chin and Wang (2005) who found no significant differences of radial growth in samples taken at different heights above (0.3 m and 1.3 m) stem base from another coniferous tree species - white spruce *Picea glauca*.

In conclusion, radial growth in dune habitats especially under burial conditions is variable, and missing rings occur often. Growth patterns between buried and unburied trees and parts of trees are quite similar (according to GLK and correlation coefficients). The main relations with climatic factors (late winter and early spring temperatures) remain, but the reaction to extreme temperatures under burial is more moderate; precipitation in dune habitats at Kolka plays an insignificant role. The coastal environment has regular events causing suppression of pine growth, particularly severe storms.

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Apbēršanas ar smiltīm ietekme uz parastās priedes (*Pinus sylvestris* L.) radiālo augšanu jūras krasta kāpu mežā Kolkas raga apkārtnē Latvijā

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Kopsavilkums

Parastā priede ir plaši izplatīta suga Latvijā un tai piemīt augsta stresa tolerance un spēja augt arī nabadzīgos biotopos. Tā ir dominējošā suga piekrastes kāpās. Kolkas raga apkārtnes kāpās noris smilšu pārplūde, kas ieputina pludmales tuvumā augošo priežu stumbrus. Uzskatāms, ka lielākā ieputināšana notiek spēcīgās vētrās, tādās kā bijušas 1967 - 1969 gados. Pētījuma mērķis ir novērtēt ieputināšanas smiltīs un klimatisko faktoru ietekmi uz priedes radiālo augšanu. Pētījumā ievāca paraugus no priedēm, kas auga pie pludmales un kuru stumbri bija ieputināti dažādā dziļumā. Gadskārtu platumu rindas šķērsdatēja un izveidoja detrendētas hronoloģijas. Lai noteiktu saistības ar klimatiskajiem faktoriem, veica korelācijas analīzi. Ieputināšanas ietekmes novērtējumam veica augšanas uzlabošanās un kritumu (release/suppression) analīzi. Ieputināšana smiltīs ietekmēja radiālo augšanu gan ieputinātajās, gan neieputinātajās stumbru daļās. Spēcīgas ieputināšanas gadījumā (dziļāk par 0.6 m) iztrūkstošo gadskārtu skaits palielinājās. Kopš 1967. - 1969. gada vētrām radiālā augšana ieputinātajām priedēm samazinājās, būtiski augšanas uzlabojumi netika konstatēti. Neieputinātie koki arī uzrādīja biežāku augšanas samazināšanos it īpaši pēdējo četrdesmit gadu laikā, kas iespējams saistīts ar Kolkas piekrastes eroziju un abiotisko faktoru maiņu. Ziemas beigu un pavasara sākuma temperatūras parādīja nozīmīgākās saistības ar neieputināto koku radiālo augšanu, ieputinātajos kokos (stumbru daļās) novērotas vājākas saistības ar ekstrēmajām temperatūrām. Nokrišņiem netika konstatēta būtiska ietekme viegli pieejamā mitruma un ūdens caurlaidīgās augsnes dēļ.