Growth, survival and stem damages of planted larch and stone pine (1975–2003) in an avalanche release area at timberline in Dischmatal

Diploma thesis

Gesa Horak

September 2004

GIUZ (Geographical Institute of Zürich)

Growth, survival and stem damages of planted larch and stone pine (1975-2003) in an avalanche release area at timberline in Dischmatal

Gesa Horak

Rigistrasse 42

CH – 8712 Stäfa

Consultant: Dr. P. Bebi, Swiss Federal Institute of Snow and Avalanches, Davos.

Member of faculty: Prof. Dr. M. Schmidt, Geographical Institute, Zürich.

Preface

Knowing that a diploma thesis is the final part for my studies in geography, I wanted to get involved in a special and challenging topic. Accordingly I was searching for a subject where I could combine my keen interests in mountain ecosystems and my love for alpine sports. It was also imperative that I could be engaged in observing and recording the data myself.
By chance I met Dr. Peter Bebi from the Snow and Avalanche Institute in Davos. Dr. Bebi is the coordinator of the Stillberg afforestation. His enthusiasm and knowledge about mountain forests was contagious and the idea of doing my studies at Stillberg was born.
From July to September 2003 I gathered my field data at Stillberg. It was an exceptionally dry and sunny summer, which helped to carry out the sometimes difficult field work in the steep avalanche gully. Never ever did I regret my decision to get involved in this research project.

I want to thank Dr. Peter Bebi for granting me my freedom to pursue my own ideas, for his unrestrictive support and for his constructive criticiques.
I want to thank my parents for their financial and emotional support while writing my thesis and for the uncountable discussions and suggestions in the evenings.
I want to thank my boyfriend Michel Biffiger for giving up his summer vacation to assist me in collecting the field data. He never once complained about the innumerable trips to Stillberg or the measuring of the trees on end. His continuous spirit contributed a lot to the success of this diploma thesis.
I want to thank Christoph Buser from the Statistical Advice Centre of the Federal Institute of Technology (ETH) in Zürich for his unselfish effort and his commitments to tackle and resolve every upcoming statistical problem.
I want to thank Don Bachman from the Centre for Snow and Avalanche Studies in Colorado for his critical review of my thesis and for polishing up the English text.
I want to thank Pierre Vanomsen from the Department of Forestry of the Federal Institute for Technology (ETH) for providing the data of his diploma thesis.
I want to thank Prof. Dr. M. Schmidt from the Geographical Institute of Zurich for reviewing my thesis.

Contents

	Summary	8
Chapter 1	**Introduction**	10
	1.1. Subalpine mountain forests and afforestations above timberline	10
	1.2. The interaction of snow and plants	12
	1.3. Objectives and research questions	15
Chapter 2	**Study area**	17
	2.1. History of the Stillberg afforestation (1955 - 2003)	17
	2.2. Site conditions	19
	2.2.1. General site parameters	19
	2.2.2. Microtopography on Stillberg	21
	2.3. Planting method of the main experiment	24
Chapter 3	**Methods**	26
	3.1. Database	26
	3.2. Recording of data	28
	3.3. Analysis and evaluation of data	32
Chapter 4	**Results**	35
	4.1. Survival of trees between 1975 and 2003	35
	4.2. Survival and growth of larch and stone pine in an avalanche release area since 1995	41
	4.3. Stem damages in an avalanche release area	50
	4.3.1. Comparison of damaged and undamaged trees 1995 – 2003	50
	4.3.2. Stem damages of stone pine since 1995	53
	4.3.3. Stem damages of larch since 1995	56
	4.3.4. Model for stem damages	62
Chapter 5	**Discussion**	65
	5.1 Survival and growth of larch and stone pine in the avalanche release area	65
	5.1.1. Survival of larch and stone pine	65
	5.1.2. Growth of larch and stone pine	70
	5.2. Stem damages in the avalanche release area	71
Chapter 6	**Conclusion**	75
Chapter 7	**References**	78
	Appendix	84

Figures

1	View from the opposite valley side on Stillberg	1
2-4	Impressions of survival conditions on Stillberg	2
5	Schematic illustration of snow movements	13
6	Overall view of the Dischmatal near Davos to the east	18
7	Terrain model of the study site (5ha) with the superimposed frame of 4052 square units	21
8	Map of afforestation after planting in 1975. Each square unit was afforestated with either *Pinus cembra*, *Pinus mugo* or *Larix decidua*. In each square unit (3.5 x 3.5 m) 25 trees	25
9	Tree survival of larch, mountain pine and stone pine 1975-1995	25
10	Sampling order in 2003: 4 strips, altogether 77 stone pine and 74 larch square units	28
11	The position of the trees within one square unit, at the maximum 25 trees. The distance between the trees amounts to 0.7 x 0.7m	29
12	Measuring of the tree height with the double meter and the diameter with the sliding callipers. The borders of this stone pine square unit are marked out with rubber band	30
13	Stone pine tree with a stem breakage	31
14	Larch with ripped off branch by an avalanche	31
15	Larch with a splitting at the stem base	31
16	Interpretation of a box-plot	34
17	Survival rate of larch and stone pine 1975 – 2003	35
18	Ratio of planted stone pines in 1975 and number of trees still alive in 2003 distributed among the main relief sites	36
19	Ratio of planted larches in 1975 and number of trees still alive in 2003 distrib-uted among the main relief sites	36
20	Development of the survival rate of larch in relation to the four main relief types since 1975	37
21	Development of the survival rate of stone pine in relation to the four main relief types since 1975	38
22	Survival chances for stone pine in relation to altitude and topography in 2003	38
23	Survival chances for larch in relation to altitude and topography in 2003	39
24	Development of mean tree height of larch and stone pine since 1975	39
25	Number of surviving stone pines per square unit in 2003	42
26	Tree height distribution of stone pine in 1995, 1999 and 2003	43
27	Tree diameter1 distribution of stone pine in 1999 and 2003	43

28	Number of surviving larches per square unit in 2003	44
29	Mean tree height distribution of larch in 1995, 1999 and 2003	45
30	Mean tree diameter1 distribution of larch in 1995, 1999 and 2003	45
31	Median value of diameter1 and diameter2 of the 1037 larches recorded in 2003	46
32	Cross sections of stem diameters of larch and stone pine	47
33	Mean tree height of larch in 2003 is 47% higher than that of stone pine	47
34	Distribution of tree height and diameter1 of stone pine and larch in 2003	48
35	Mean diameter1(measured in direction of the slope gradient) of damaged and undamaged trees 2003	50
36	Mean diameter2 (measured in direction of the contour lines) of damaged and undamaged trees 2003	51
37	Mean tree height of damaged and undamaged trees in 2003	51
38	Percentage of total damaged trees distributed on the four main sites 2003	52
39	Number of stem damages in the four relief types in 1995, 1999 and 2003	53
40	Mean diameter1 (measured in direction of the slope gradient) of undamaged and damaged stone pines 2003	54
41	Mean diameter2 (measured in direction of the contour lines) of damaged and undamaged stone pines 2003	55
42	Diameters of broken or split stone pine stems in 2003. Observed stem damages of stone pine trees in dependence of the two diameters, measured in the direction of the slope gradient (diameter 1) and in direction of the contour lines (diameter 2)	56
43	Number of stem damages in the four relief types in 1995, 1999 and 2003	57
44	Mean tree height of damaged and undamaged larches in 2003	58
45	Mean diameter1 (measured in direction of the slope gradient) of undamaged and damaged larches in 2003	59
46	Mean diameter2 (measured in direction of the contour lines) of damaged and undamaged larches in 2003	59
47	Diameters of broken or split larch stems in 2003. Observed stem damages of stone pine trees in dependence of the two diameters, measured in the direction of the slope gradient (diameter 1) and in direction of the contour lines (diameter2)	60
48	Damage pattern and damage height on the stem of a larch (for better view only the section stem base up to 1m is illustrated)	61
49	Tree classification model for stem damages	64
50	Autochthonous stone pine stocking on the ridge, square unit No. 1860	66

51	Chances of survival in the avalanche gully are strongly influenced by *Calamagrostis villosa* and avalanche impacts	67
52	Clusters of closely growing larches (“Rotten”)	68
53	Larch growing at Stillberg in May 2004	74

Tables

1	Site conditions in the study area Stillberg	19
2	Summary of the ecological location facts and the four main relief types at Stillberg	23
3	Age, tree height and provenances of the planted trees in 1975	24
4	The four main relief sites with the respective plant communities	29
5	Number and distribution of square units in the four sampling strips	29
6	Number of square units and trees alive for the analysis in 2003	32
7	Tree height and stem diameter broken down by altitude and topography	40
8	Number of trees, mean tree height and diameter in 1995, 1999 and 2003	41
9	Percentage of stem-damaged trees in 1995, 1999 and 2003	50
10	Damage frequency in the four main relief types 2003	52
11	Percentage of damaged pines in 1995, 1999 and 2003	53
12	Frequency of stem damages on the four relief types in 1995, 1999 and 2003	54
13	Percentage of damaged trees in 1995, 1999 and 2003	57
14	Frequency of stem damages in the four relief types in 1995, 1999 and 2003	58
15	Variables removed on each step from the model	62
16	Variables which contribute to the explanation of the model for stem damages	63
17	Characteristics of the two tree species	69

Summary

This study was carried out at the Stillberg afforestation near Davos in Eastern Switzerland, which is situated above the actual timberline on a North-East exposed, steep slope at an altitude of 2000-2230m a.s.l. The afforestation was planted in 1975 as part of the interdisciplinary research initiative "Restoration of the Upper Forestzone". Objective of this project was to develop biologically and technically suitable and financially tolerable procedures for afforestations in avalanche starting zones at timberline (Kampfzone).
In 1975, about 90'000 tree seedlings (*Larix decidua* Mill., *Pinus mugo* Turra and *Pinus cembra* L.) were planted in a regular pattern (in square units with 25 trees of one species in the plot) on the five hectare Stillberg afforestation area which extends on the conspicuously structured slope. Its topography comprises downhill running ridges, Northern slopes, Eastern slopes separated by avalanche gullies. This ecologically small-scale site heterogeneity is also exposed to several crucial climatic factors such as radiation, wind and snow and their complex interactions.

Research objectives of this diploma thesis are first the assessment of growth, development and survival of planted larch and stone pine in the avalanche release area since the planting in 1975 and second, the assessment of stem damages since 1995 in particular the damage frequency and pattern.

In 2003, 151 square units (77 with stone pine and 74 with larch) in four sampling strips across two avalanche paths were surveyed; thereby repeating surveys of 1995 and 1999. The parameters tree height, stem diameters and stem damages were measured of 112 living stone pines and 1037 larches. The evaluation of data was emphasized for the different growth conditions in the four main relief sites. Two statistical methods (logistic regression model, tree model) were used to determine the influence of different site factors on the probability of stem splittings and breakages.

Since 1975, the survival rate of the two investigated coniferous species is completely different: in 2003, ten times more larches (64% of originally 1628 larches) than stone pines (6% of originally 1769 planted pines) have remained viable in the harsh conditions in this avalanche release zone near timberline.
The growth conditions vary considerably, due to the strongly structured topography. At present, the larches are in general over 50cm taller than the stone pines. The nearly 30 year-old larches have a mean tree height of about 162cm and a stem diameter of 5cm, whereas stone pine have reached a tree height of 111cm and a diameter of 5.8cm.

In steep terrain, snow movements (especially snow creeping and gliding) affect the growth and shape of stems. Sabre growth of the stems is a site influence, to which larch responds much more than stone pine. This observation is reflected in the diameter values. Statistically, larch diameter1 (measured in direction of the slope gradient) differs highly significant from diameter2, whereas the two diameter values of stone pine are about equal. Hence larch tends to have an oval stem cross section and consequently develops sabre-growth, whereas stone pine has a circular stem resulting with a straight stem.

The frequency of stem damages (splittings and breakages) at Stillberg has increased considerably since 1995. In 2003, on every fourth pine and on every 30th larch stem injury was observed. From the logistic regression model the following conclusion could be derived: the variables “diameter2” (measured in direction of the contour lines), “tree species” and “avalanche frequency per winter” are statistically highly significant for the probability of a stem injury. The tree model confirms this result, although the order of significance differs: the first split uses the variable “tree species” to partition the data into the two subsets “larch” and “stone pine”. For larch the subset is next divided by the variables “altitude” (< 2097m a.s.l) and the “diameter2” (> 7cm) whereas for stone pine the variables “diameter2” (> 6.5cm), “avalanche frequency” (> 8) and “inclination” (> 49˚) are decisive. In the statistical analysis’s, diameter2 was the most differentiating variable between damaged and undamaged trees. The critical period for stem damages is therefore defined by stem diameter2 values. This critical period can be defined quite distinctly and the size values are the same for both tree species (6.5cm – 10cm). Larch with its oval stem base (and the connected smaller diamater2 value) reaches the critical stem diameter (~6.5cm) later than stone pine. That may partly account for the fact that every fourth stone pine at Stillberg is already stem-damaged whereas the damage frequency of larch is much lower.

This study confirmed that the two coniferous tree species react differently to snow pressure. Therefore it is essential to study the impacts of snow and avalanches on trees, because they are the controlling parameters for the development and the composition of mountain forests.

1. Introduction

1.1. Subalpine mountain forests and afforestations above timberline

In the Alps, timberlines have been lowered through centuries of anthropogenic influences. Since the Middle Ages, the intensified logging and clearing of mountain forests for timber and the creation of pastures had caused the formation of new avalanche starting zones and paths. This required the relocation of farms and primitive measures for the protection of buildings (SCHNEEBELI and BEBI 2004). In the last years, pressure on mountain forests has grown, because of the increasing density of population, the expansion of infrastructure and tourist use. Due to this development in the Alpine valleys, the entire subalpine mountain forest is consequently considered to function as a protection forest (HAUSER 1970). One of the locally very important effects in mountain regions concerns the prevention of avalanches (SCHNEEBELI and BEBI 2004). ZÜRCHER (1973) found for the Swiss Alps, that one third of the avalanches starts below timberline in the forest belt, however two thirds of the avalanches start above actual timberline. Accordingly the subalpine area above present timberline is the critical ecotone for the release of avalanches.

LÖVE (1970) defines the subalpine zone as the natural belt below the treeless belt from the upper altitudinal treeline to the closed mountain forest. The "treeline" roughly marks a line of connecting the highest patches of forest within a given slope or series of slopes with similar exposure (KÖRNER 1999). The lower limit for the subalpine belt is where the trees have well-developed stems and crowns and cover more than 50% of the total ground surface. The definition of a "tree" is adopted from KÖRNER (1999) as an upright woody plant with a dominant above-ground stem that reaches a height of at least 3m, independently of whether reproduction occurs or not.

Both timber- and treeline depend on climatic factors (LÖVE 1970): temperature, air humidity and air pressure decrease with altitude, and on the other hand wind velocity, radiation, precipitation and duration of snow cover increase. In particular, inclination of slope and aspect determine the extent of the subalpine belt.

In the Alps, at 47 degrees north, the range of treelines can vary from 1600 to 2300m a.s.l. within short distances (KÖRNER 1999). He also states that since the 19^{th} century alpine treelines have repeatedly been found to coincide with mean air temperature of the warmest month of about 10C. ELLENBERG (1963) had already suggested counting the days with means of air temperature above 5˚C, and he found that 100 days fitted treeline positions in the Alps more accurately than warmest month means.

The study area for the present diploma thesis is at Stillberg in the Dischmatal in Eastern Switzerland. It is an afforestation in an avalanche release zone at an altitude of 2080-2230m a.s.l., which lies above the actual timberline.

Heavy grazing and other anthropogenic influences have gradually depressed the actual timberline for about 200m. Taking the two above mentioned definitions for treelines (KÖRNER 1999, ELLENBERG 1963) into account, the study area lies below potential treeline; for Stillberg the mean air temperature of the warmest month is 9.4˚C, whereas during 134 days a temperature above 5˚C was measured. Possibly, the upper end of the afforestation just reaches the natural treeline. Accordingly, a fundamental ecological condition for the success of high afforestations is fulfilled as expressed by FROMME (1963): "...reforestation in the subalpine zone of the Alps is difficult, frequently extremely problematical. High afforestations are only successful until the potential treeline is reached".

The aim of an afforestation in an avalanche release area is to reach the effectiveness of the young trees against the starting of avalanches as quickly as possible. This efficiency is when the trees have reached a height of one to two-times that of the snow height (FREY 1978).

The success of an afforestation is highly complex and is mutually influenced by all local ecological parameters. The most favourable sites for tree growth are in most cases ridges where in spring snow disappears early. Unfavourable, however, are troughs and depressions in the relief where the snow lasts much longer. In the inner part of an afforestation additional snow can be deposited, because trees at the borders of afforestation have an effect of snow drift structures (STERN 1978). The higher snow cover leads to mechanical damages and to later snow disappearance, which can lead to partial or total losses. Snow cover, in particular its height and movements becomes a dominant factor later on during subsequent stages of tree life (BLASER 1980). In high afforestations snow is the main damage factor besides frost drought (MAYER and OTT 1991).

The Stillberg study area is an avalanche starting zone, which means that unstable snow can be released to rapidly move downslope. About 80% of the avalanches start in the afforestation area and end below the afforestated area; there are only few avalanche releases above Stillberg. Accordingly the afforestation can be divided into avalanche release areas, avalanche paths, drifts, avalanche and drift free sites and locations where avalanche debris come to rest.

1.2. The interaction of snow and plants

At higher altitudes the period of snow cover persists, increasingly limiting the trees growth. Trees buried under a long lasting and deep snow cover are therefore subjected to microclimatic conditions that decisively influence their life functions (TRANQUILLINI 1978). At timberline snow has both beneficial and retarding effects upon survival and growth of trees. Favourable effects of snow cover are: reducing of browsing damages, insulation and subduing of low air and soil temperatures, protection against radiation damage, desiccation (especially in late winter) and frost drought. On the other hand detrimental influences because of persistent snow cover are fungal pathogens, the shorter growth period and mechanical damages through snow settlement, creep, glide and avalanche impact.

Development and evolution of the snowpack is mainly affected by the relief, the local geology, soil conditions, meteorological variables and the forest stand itself (KELLER 1978), and by the whole range of snow movements (RYCHETNIK 1986).

In addition to wind forces and vertical snow loads, trees on high mountain slopes are exposed to the mechanical forces originating from the snow cover on the inclined slope. The probability for malformation and destruction of trees is therefore much higher (SALM 1978). Two different types of snow forces act on forest vegetation. One occurs with avalanches and the other with the slow deformation of the undisturbed snow cover (snow settlement, creep and glide). MÖSSMER et al. 1997 describes these snow movements as follows (see Figure 5):

1) Avalanches: Avalanche formation is intimately linked to terrain features, notably slope exposure, steepness and the surface roughness (SCHNEEBELI and BEBI 2004). Forest stands stocking at slopes steeper than 30° inclination and snow heights over 50 centimetres are potentially endangered by avalanches which can start in the forest itself (MAYER and OTT 1991). The density of a forest cover and the size and distribution of forest gaps are regarded as the chief forest structural parameters influencing the triggering of avalanches in forested areas (SCHNEEBELI and BEBI 2004).

2a) Snow settlement: The intensity of snow settlement damages is strongly related with high snow cover. A late date of snow disappearance leads to longer lasting and thus detrimental snow settlement damages (IN DER GAND 1968).

2b) Snow creeping: Snow creep is the result of settlement movements of the snow cover on an inclined surface. Thereby the force of weight of the snow pack is effective in a slope-parallel and slope-vertical movement component. The slope-vertical movements decrease the snow height, the slope-parallel component causes the downhill-directed moving of the snow pack. The change of position is greatest at the surface of the creeping snow cover and decreases towards the basis. No movements take place in the underground of the cover. Snow creep can reach a velocity up to several centimetres per day.

2c) Snow gliding: The entire snow cover is subject to slow movement at the snow-ground interface. The speed reaches in general from several millimetres up to metres (under favourable conditions) per day. Sun-exposed, steep slopes with a smooth plant surface (e.g. grass carpet) are inclined to snow gliding. A slow moving snow cover exerts forces up to several tons and can damage branches, stems and roots. Gliding becomes more intensive with increasing snow height or with melt water lubrication at the interface.

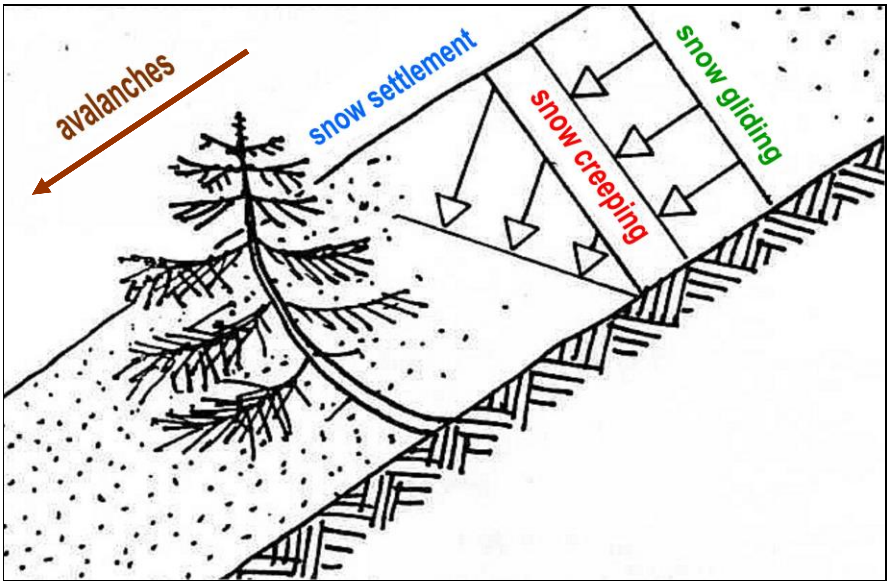

Figure 5: Schematic illustration of actual snow movements (MÖSSMER et al. 1997)

All movements in the snow cover are strongly influenced by the occurrence of trees. Settlement, creeping and gliding of the snow cover are progressively inhibited by increased stand age. When the trees are strong enough to withstand the creeping and gliding forces and their height exceeds that of the snow pack, they can stabilize effectively the snow cover and hence prevent avalanche release. The main effect of trees and forests on avalanche formation is through the modification of the snow's mechanical properties (SCHNEEBELI and BEBI 2004). Under these circumstances a double stabilization effect occurs (SALM 1978):

1. The effect of the canopy: compared with open sites generally less snow accumulates on the ground in closed stands. According to FREY (1977), the snow intercepted by tree crowns may amount to 5% to 30% of the total snow precipitation (depending on type of snow, intensity, succession of snow precipitation and on the type of forest canopy). A considerable portion of this intercepted snow sublimates directly from the branches in the tree crowns back into the atmosphere. Furthermore, the canopy disturbs the regular stratification of the snow pack because of inhomogeneous accumulation and snow falling occasionally from branches. Another relevant process is the modification of the radiation which causes different temperature regimes beneath and around trees and the reduction of near-surface wind speeds (SCHNEEBELI and BEBI 2004). This limits redistribution of snow and thus prevents greater accumulations in gullies and depressions.

2. Stems represent more or less rigid obstacles to retard the creeping and gliding snow cover. Consequently, the vegetation is exposed to the ground-parallel shearing stresses. The denser a forest, the more effective the reduction and therefore the greater the achieved stability.
It is a well-known phenomenon that all tree species develop a sabre formed bend above the stem base when exposed to repeated or continuous impact of snow creep, glide or weight (FREY 2001). The physical stress tolerance of the trees is directly reflected by the sabre-like form of the stems which finally also will be crucial for the tree stability. The tendency to develop sabre growth varies between the subalpine tree species (FREY 2001).
WAKABAYASHI (1978) describes the mechanism of "butt sweep" or “sabre growth” (Säbelwuchs) as follows: many fine roots are torn and the tree tilts slightly from high snow pressures. The butt often gets buried on the valley side in the soil and step by step the tree develops a more stable and thicker root system when the trunk support replaces the loss of roots. The development of butt sweep stops only after sufficient amount of butt has been buried and the adventive roots grow undisturbed.

In summary, the effects of plants on snow are influences in the accumulation pattern, the snow melt and on the movement of the snow cover (stabilization effect). Most important is the closed canopy in order to prevent forest avalanches (IN DER GAND 1978). Ecologically the physical influences of snow on plants are various and complex: depending on the snow height and its specific weight, snow either stimulates (balanced microclimate in winter) or retards plant growth (snow fungi, mechanical damages).

1.3. Objectives and research questions

Since the planting of the afforestation in 1975, large sets of ecological data have been recorded in the course of routine surveys and monitoring programs.

In two publications SCHÖNENBERGER, FREY and SENN (1988, 2001) of the Swiss Federal Institute for Forest, Snow and Landscape (WSL), have summarized the results from long term monitoring data of Stillberg between 1975 and 1995. Particularly the evaluation of survival, growth and ecology of larch, mountain pine and stone pine in the whole subalpine afforestation (see chapter 2.3) were the centre of attention.

Furthermore, stem damages (splittings and breakages) were monitored. Before 1995, damages on the planted conifers at Stillberg were not obvious and therefore neglected. In 1999, VANOMSEN presented his diploma thesis "Comparing study of stability of young stone pine and larch: Stem breakages and splittings in an avalanche release area in the afforestation Stillberg after a snow abundant winter".

For the first time, VANOMSEN evaluated stem damages between 1995 and 1999. He noted an increase and named several factors. First, the winter 1998 / 1999 was very snow-rich and the snow movements at Stillberg (probably) caused the damages. Furthermore, he concluded from the evaluation of his data that the variables "tree species", "stem diameter" and specific site parameters such as "topography" (ridge, Northern slope, avalanche gully, Eastern slope) and the "inclination of slope" have a significant influence on the probability and frequency for stem damages. There was no significant proof that radiation and altitude are factors responsible for stem injuries. The damage frequency of stone pine was higher than that of larch, but no tree-specific damage pattern could be derived.

VANOMSEN concluded that stem damages had occurred only on the largest tree specimens and accordingly at Stillberg, the critical age period for stem damages had only just started.

The present diploma thesis focuses on two different aspects of the Stillberg afforestation within two different time scales.

On the one hand, the survival and growth conditions of larches and stone pines in four strips in two avalanche paths are looked at. The plots are situated in the part of the afforestation without avalanche prevention constructions; the sampling order reflects therefore natural growth conditions in an avalanche release area. Especially the influence of the two parameters "altitude" and "topography" (ridge – Northern slope – avalanche gully – Eastern slope) on survival and growth of the two conifers since 1975 is studied under different aspects.

On the other hand, VANOMSEN's conclusions were taken as a starting point. Four years have elapsed since his publication. More trees will have reached the critical period for stem damages and additional parameters could be taken into consideration and different statistical methods to evaluate the field data could be tested.

The following research questions and hypothesises stand in the centre of this assessment:

● Did the frequency of stem damages change during the last four year period (1999 – 2003)? Between 1995 and 1999 the damage frequency had increased sevenfold.

- → Hypothesis 1: The damage frequency has increased since 1999. In 2003 even more trees have reached the critical age where stems lose the elasticity and therefore are more susceptible to stem injuries caused by snow impacts.

● Are stem damages depending on tree height and / or stem diameter or are they correlated to other parameters like avalanche frequency and / or altitude?
In 1999, VANOMSEN proved statistically that stem damages depend on diameter1 (measured in the direction of the slope gradient), tree species, topography and inclination of the site. The variables diameter2 (measured in direction of the contour lines), snow height and avalanche frequency were not taken into consideration.

- → Hypothesis 2: the variables snow height, avalanche frequency and consequently altitude contribute to the damage probability of trees.

● Do larch and stone pine have a tree-specific damage pattern?
In 1999, larch was less susceptible to stem injuries as compared to stone pine, but no tree-specific damage picture could be detected.

- → Hypothesis 3: larch is less susceptible to stem damages than stone pine because of its higher stem elasticity. Accordingly, the stem of larches tends to split and the less flexible pole of stone pine is prone to stem breakages.

2. Study area

2.1. History of the Stillberg afforestation (1955 – 2003)

In the Alps, disastrous avalanches during the winter 1951/1952 led to extensive discussions in Switzerland over causes and potential measures to avoid damages to forests and infrastructures and future loss of lives. The interdisciplinary research initiative "restoration of the upper timberzone" was initiated to develop biological and technical suitable and financially feasible procedures for afforestations in avalanche starting zones within the timber- and kampfzone. The main aims of this research program were

- to investigate the ecology of high elevation afforestations and the environmental factors which limit tree viability
- to evaluate the factors which determine the natural upper forest limit
- to establish suitable biological and technical procedures in avalanche starting zones and to re-establish the timberline zone following anthropogenic impacts during former centuries.

Since 1955 the main study site of this challenging and highly complex research program was the Stillberg area near Davos, Ct. Grisons. The location at Stillberg is a typical avalanche release area. It is situated on a North-East exposed, steep slope at an altitude of 2000-2230 m a.s.l. This elevation is about 150m above the actual timberline in the subalpine–belt (Kampfzone).

On this long term experimental site the following silvicultural and ecological questions were at the centre of the research activities (SENN & SCHÖNENBERGER 2001):

- Which are the main location factors determining success or failure of an afforestation under difficult ecological circumstances?
- Which microsites are in general favourable or unfavourable, and what are the limits of afforestation?
- Which are the most important damages on young planted trees and the causes for loss?
- How do the risks change in time and space in relationship to location and seasonal weather conditions?

Figure 6: Overall view of the Dischmatal near Davos to the east (HORAK 1963)

After taking the ecological situation into account, various tree species and plant techniques were tested during the 1960s and early 1970s. Finally, the main experiment was started in summer 1975 with the planting of 92'000 trees (see chapter 2.3). The intensive monitoring period of surveying the planted trees followed during the next 20 years; after 1995, monitoring of the afforestation was reduced.
Between 1976 and 1995, the survival of individual trees was checked in all square units each year. Furthermore, in permanent sub-samples in the lower middle and upper third of the study area, tree height was measured once a year, the general vitality condition of the trees was scored, the type of damage and mortality causes were determined.

During the vegetation period, the study area is fenced in, in order to exclude browsing damages by wild and domesticated ungulates. In winter and early summer the site is accessible for wild ungulates (particularly chamois) and black grouse (SENN 1999).

2.2. Site conditions

2.2.1. General site parameters

Climatic, ecological and geomorphic site factors of the study area are summarized in Table1:

Table 1: Site conditions in the study area Stillberg (modified with data by SCHÖNENBERGER 1975)

Location:	Stillberg afforestation, Dischmavalley near Davos
Coordinates:	09°52´E, 46°47´N
Size of afforestation area:	5 ha
Elevation:	2080 – 2230m a.s.l.
Slope exposition:	NE
Slope inclination:	between 35° – 50°
Topography:	strongly structured in four relief types: exposed ridges, shady Northern slopes, sunny Eastern slopes and avalanche gullies
Bedrock:	acidic gneiss covered with slope debris
Soil types:	mainly podzols and ranker
Humus forms:	mainly raw humus and moder
Mean precipitation:	1050 mm (maximum in July: 131 mm)

Annual temperature amplitude:	15.2°C
Mean air temperature:	1.4° C
Mean daily air temperature:	in July: 9.4° C, in January: -5.8° C
Radiation:	maximum in May; annual course of global radiation: on Eastern slopes period of positive balance (warmth profit) two month longer as compared to Northern slopes
Duration of sunshine:	during vegetation period (May 15 – September 30) 27-79% of the astronomical possible sunshine duration is possible, due to differences in terrain and seasonal sun position
Vegetation period:	134 days (mean temperature above 5°C)
Wind intensity:	minimum in February, maximum in June; main direction during vegetation period: local south – west wind patterns
Days of frost:	137 per year
Days of ice (temp. below 0˚C):	80 per year
Average max. snow depth:	146 cm (60cm at ridges, 420cm in avalanche gullies)
Mean seasonal snow cover:	6.5 months (2.5 months at ridges, up to 9 months at Northern slopes)
Mean annual date of snow disappearance:	21st of May (extreme values : 23rd of April , 8th of June respectively)
Avalanches:	avalanche starting zone with 9 pathways; on average 42 (minimum: 24, maximum: 77 avalanches) avalanches per winter within the research area (all types except big powder snow avalanches)
Vegetation:	heavily linked with surface relief; in addition an altitude gradient is recognizable; mainly dwarf shrub communities: on ridges *Cetrario - Loiseleurietum* (8% of study area), in Northern slopes *Empetro - Vaccinietum* (33%), in avalanche gullies *Calamagrostietum villosae* (8%), in Eastern slopes *Junipero - Arctostaphyletum* (12%) and at the foot of the slope *Rhododendro - Vaccinietum* (30%).

2.2.2. Microtopography on Stillberg

The strongly structured slope of the afforestation includes a small-scale heterogeneity of climatic factors. BEDNORZ et al. (2000) stated that micro-topography is the main factor determining the microclimatic conditions and correspondingly the distribution of plant communities and humus forms.

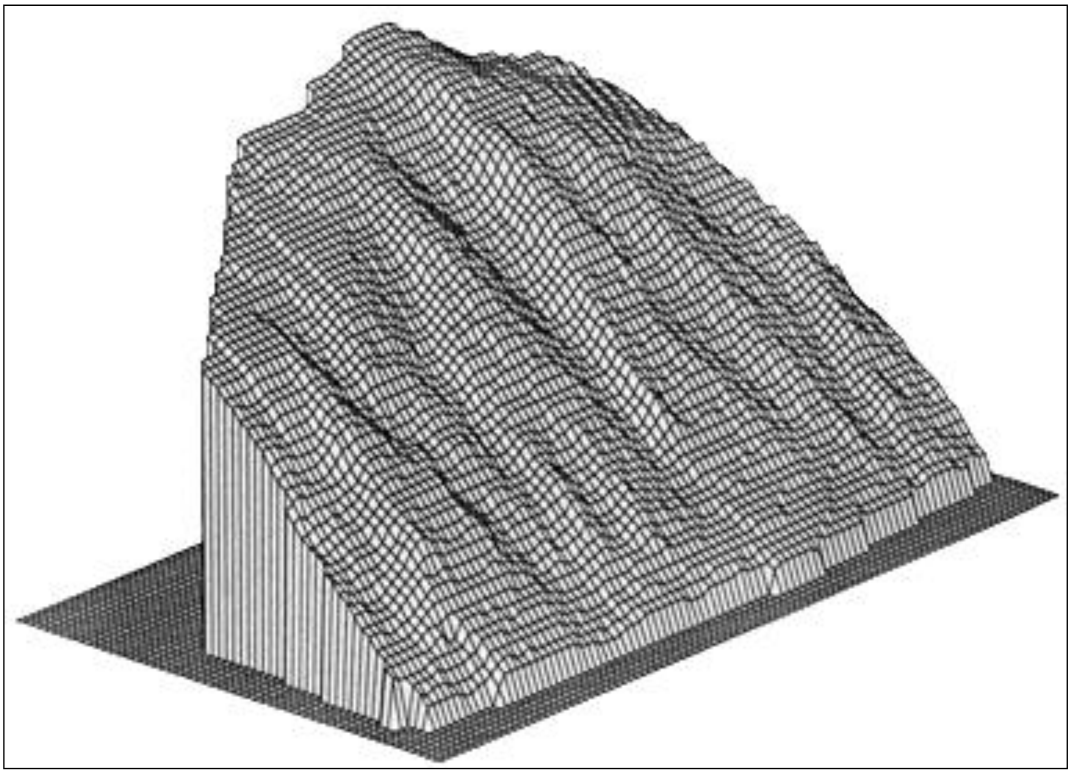

Figure 7: Terrain model of the study site (5ha) with the superimposed frame of 4052 square units (SCHÖNENBERGER und FREY 1988)

At Stillberg the microclimate was decisive for the success of the afforestation (TURNER, SCHÖNENBERGER und HÄSLER 1882). Eastern slopes have the advantage of higher influx of radiation and accordingly three to four degrees higher soil temperatures, an average of five weeks of earlier snow melt, five to ten days longer vegetation period and a 20% (4 weeks) longer season for net primary production as compared to the Northern slopes.

Ridges at Stillberg are characterized by wind exposure and therefore in winter are often snow-free which leads to frost in deep soil layers. Due to the sparse snow cover, the date of snow disappearance is early, which is the prerequisite for the occurrence of the two plant communities *Empetro- Vaccinietum- cetrarietosum* and *Cetrario- Loiseleurietum- cetrarietosum* to grow on the shallow ferro-humic podzols. Lack of snow, soil frost and high wind velocities are responsible for occasional frost drought.

Northern slopes: an ecologically crucial feature on Northern slopes is the low radiation and temperature. They are shadowy, snow abundant due to wind deposition and drifts. Soils consist of various podzols with raw humus and the plant cover (*Empetro- Vaccinietum*) is adapted to endure the long snow cover lasting for 4-6 months. For the planted trees, however, problems like fungal pathogens and a short vegetation period are closely linked with the late snow melt.

Avalanche gullies: the most determining factor in avalanche gullies is rapid snow movement and its impact. Depending on the avalanche activity the date of snow disappearance is early or late. In general, there is occasional soil frost and radiation is average. On ferric podzols with acid mull *Calamagrostietum villosae* grows in abundance which suppresses most other plants and the seedlings of the planted trees. Trees suffer from competition, snow pathogens and avalanche impact.

Eastern slopes are both sun-exposed and wind sheltered and therefore they have the benefit of high influx of energy during the vegetation period. On the other hand, radiation damages and local overheating are risks of losses. Because of the strong radiation, snow disappearance is early and the thermophilic plant communities *Junipero- Arctostaphyletum juniperetosum* and *Empetro- Vaccinietum- cetrarietosum* occupy these slopes. Brown podzolic soils with moderate raw humus are found on this location.

Table 2: Summary of the ecological location facts and the four main relief types at Stillberg (BLASER 1980; SCHÖNENBERGER 1975; SCHÖNENBERGER ET AL. 1988)

	ridge	**Northern slope**	**gully**	**Eastern slope**
Radiation	average	low, particularly in the steeper parts	average	high
Wind	high velocity	intermediate	calm	intermediate
Temperature (mean value in July)	15°C	15°C	15°C	25°C; maximum temperature peaks over 40°C
Snow cover	poor, in winter often snow-free (wind erosion), deep soil frost	snow accumulation due to snow drift, soil frost	abundant, high avalanche activity, seldom soil frost	abundant (due to drift) to poor, soil frost
Snow disappearance	Early because of low snow cover	late because of low radiation	early or late depending on avalanche deposits	Early because of strong radiation
Soils	shallow ferro-humic podzols	mosaic of various podzols, raw humus	ferric podzols, acid mull	brown podzolic soils, moderate raw humus
Vegetation	*Empetro- Vaccinietum- cetrarietosum, Cetrario- Loiseleurietum-cetrarietosum*	*Empetro- Vaccinietum hylocomietosum*	*Calamagrostietum villosae*	*Junipero- Arctostaphyletum -juniperetosum - callunetosum, Empetro-Vacinietum- cetrarietosum*
Risk for planted trees	frost drought, extreme wind exposure	late snow melt, short vegetation period, prone to fungal pathogens	avalanche impact, vegetation competition, fungal diseases	radiation damages, overheating, frost drought

2.3. Planting method of the main experiment

Before planting in 1975, the experimental area was divided into 4052 square units of 3.5 x 3.5m; on one third of the Stillberg temporary avalanche constructions made of wood were set up. Main purpose of the snow rakes is prevention of avalanche condition development which was determined to be essential for the success of the afforestation.

About 90’000 tree seedlings were planted in a regular pattern on the five hectare large Stillberg afforestation area. Seedlings (all pot plants) of three different tree species were implemented: one year old larch (*Larix decidua* Mill.), three year old mountain pine (*Pinus mugo* Turra) and five year old stone pine (*Pinus cembra* L.).

Table 3: Age, tree height and provenances of the planted trees in 1975

	Age	**Mean tree height (cm)**	**Seed provenances and altitude of mother trees**
larch	1	2	Sils-Maria, Switzerland 2050m a.s.l.
mountain pine	3	10	Briancon, France 2150m a.s.l.
stone pine	5	14	Avers, Switzerland 2050m a.s.l.

In each square unit 25 trees of one species were planted in rows of five (20’000 plants per hectare) unless boulders or experimental equipment made planting impossible. Within the square unit the distance between the single trees amounted to 0.7 x 0.7m. The tree species changes every square unit and in the row below the tree species pattern was moved one square field to the left (see Figure 8).

For each square unit following parameters were recorded: altitude, inclination of slope, global radiation, date of snow disappearance, avalanche frequency, number of snow-free days in winter, wind velocity, soil type, humus form and plant community.

Further, the air and soil temperatures as well as precipitation are recorded since 1975 at intervals of 10 minutes in a meteorological station situated at 2090 m a.s.l. within the study site.

As expected, the results of the experiments proved the pronounced horizontal structure of all these location parameters; in the horizontal the location factors vary significantly within short distances whereas the changes in the vertical direction have been less pronounced (SENN & SCHÖNENBERGER 2001).

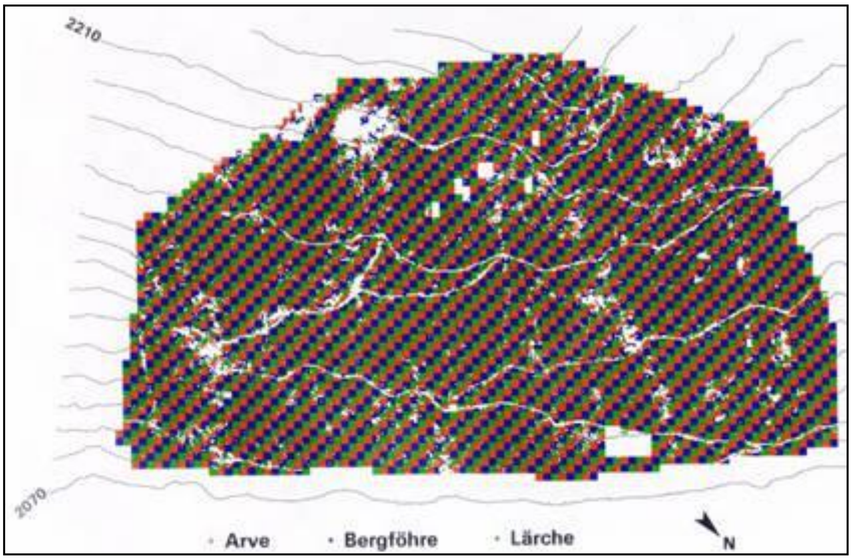

Figure 8: Afforestation map after planting in 1975. Each square unit was afforestated with either *Pinus cembra* (red), *Pinus mugo* (blue) or *Larix decidua* (green). In each square unit (3.5 x 3.5 m) 25 trees

The success of the Stillberg afforestation can be assessed by the survival rate of the trees during the first twenty years. In 1995 71.5% of larch, 32.5% of mountain pine and 15.6% of stone pine have actually survived. During this time period, the order of precedence in performance changed three times. In the first years larch suffered great losses because of its small size (2 cm) and the fierce competition by *Calamagrostis*. Three years after the planting the mortality rate of the two evergreen tree species (stone and mountain pine) rose significantly due to the attack of parasitic fungi. These pathogens did not affect larch and therefore it could take over the lead of success since the early 80s.

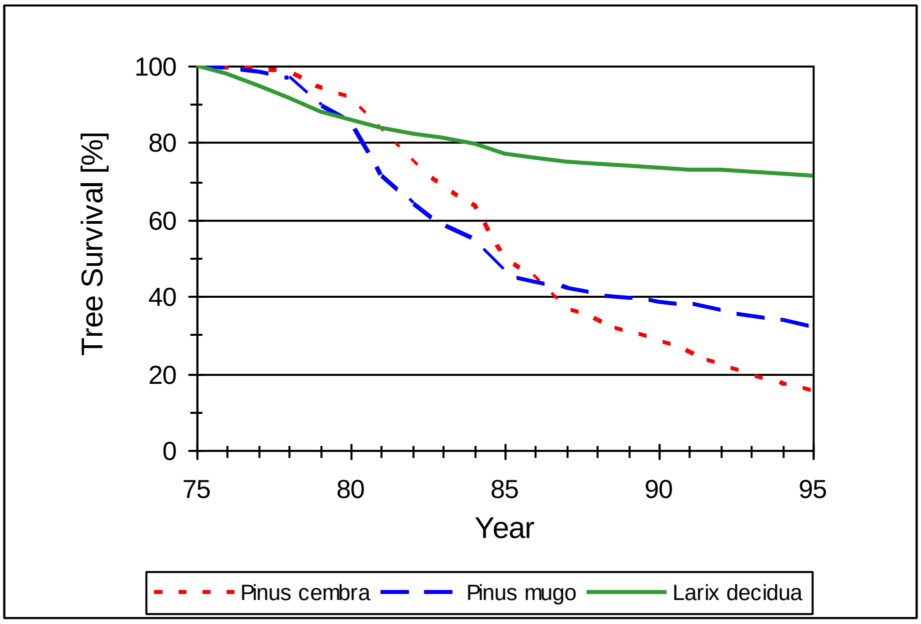

Figure 9: Tree survival of stone pine, mountain pine and larch 1975 – 1995

3. Methods

3.1. Database

To evaluate the research questions, following data was used in the different subchapters of "results":

- chapter 4.1: survival and growth of the trees since 1975
- number of trees alive and tree height in 1975, 1979, 1982, 1985 and 1990 (10 year monitoring of SLF (Swiss Federal Institute for Snow and Avalanche Research) and WSL (Swiss Federal Institute for Forest, Snow and Landscape))
- number of trees alive and tree height in 1995 (SLF and WSL)
- number of trees alive and tree height in 1999 (VANOMSEN)
- number of trees alive, tree height, diameter1 and diameter2 (definition see. chapter 3.2) in 2003

- chapter 4.2: survival and growth of the trees since 1995
- number of trees alive, tree height and diameter1 in 1995 (SLF and WSL)
- number of trees alive, tree height and diameter1 in 1999 (VANOMSEN)
- number of trees alive, tree height, diameter1 and diameter2 in 2003

- chapter 4.3: stem damages since 1995
- tree height, number and kind of damages in 1995
- tree height and diameter1, number and kind of damages in 1999
- tree height, diameter1, diameter2, number and kind and position of damages in 2003
- altitude, inclination, soil, radiation and date of snow disappearance was derived from a GIS-database of the monitorings of SLF and WSL
- Avalanche frequency: The avalanches of every winter are digitalized in the ArcView – GIS 3.3 program. The different avalanche events of every year counted over the 151 square units and the number of avalanches between 1975 and 2003 were totalled. Unfortunately, the avalanche data of winter 2001 and 2002 are missing. The data point was number of avalanches per square unit. Counting the avalanches per single tree was eliminated as too time-consuming. Therefore a certain lack of precision within the square units can not be excluded, since it is observed that not every avalanche hit always all trees within the unit. The resulting variable is "avalanche impact per winter" and not the total number of avalanches e.g. 24 means that the square unit was hit every winter since 1975 at least once.

- Snow height: Over 400 snow stakes measure the snow level at Stillberg. There are regularly distributed over the whole afforestation. Every stake measures the snow height for 16 square units (surface of 196m2), that means every 14m possible height differences are recorded. The levels were regularly read off three times per month from October to May. For this study, the data of the 26 relevant stakes was extracted. The measured values from the middle of every month of four selected years were taken (1975, 1980, 1985 and 1990). After forming a mean snow height per winter the four mean winter values for the 26 stakes were transformed into one mean snow height per stake.

Although the same sample strips were used in 1999 (VANOMSEN) and 2003, there are some differences in the recording pattern:

- the tree number was not recorded in 1999, thus a direct comparison of a single tree is not possible
- diameter2 was not recorded in 1999
- the height of recent stem damages was not measured in 1999
- the “old” (definition see. chapter 3.2) damages were 1999 not separated into stem breakage and stem splitting

3.2. Recording of data

The field work for the present diploma thesis took place from July to September 2003.
The order of sampling is replicated on the diploma thesis of VANOMSEN (1999) in order to compare the data of 1999 and 2003. Therefore this study only considers the two tree species *Larix decidua* and *Pinus cembra*; the third planted species *Pinus mugo* is not taken into consideration, because it does not grow autochthonous in the Dischmatal.

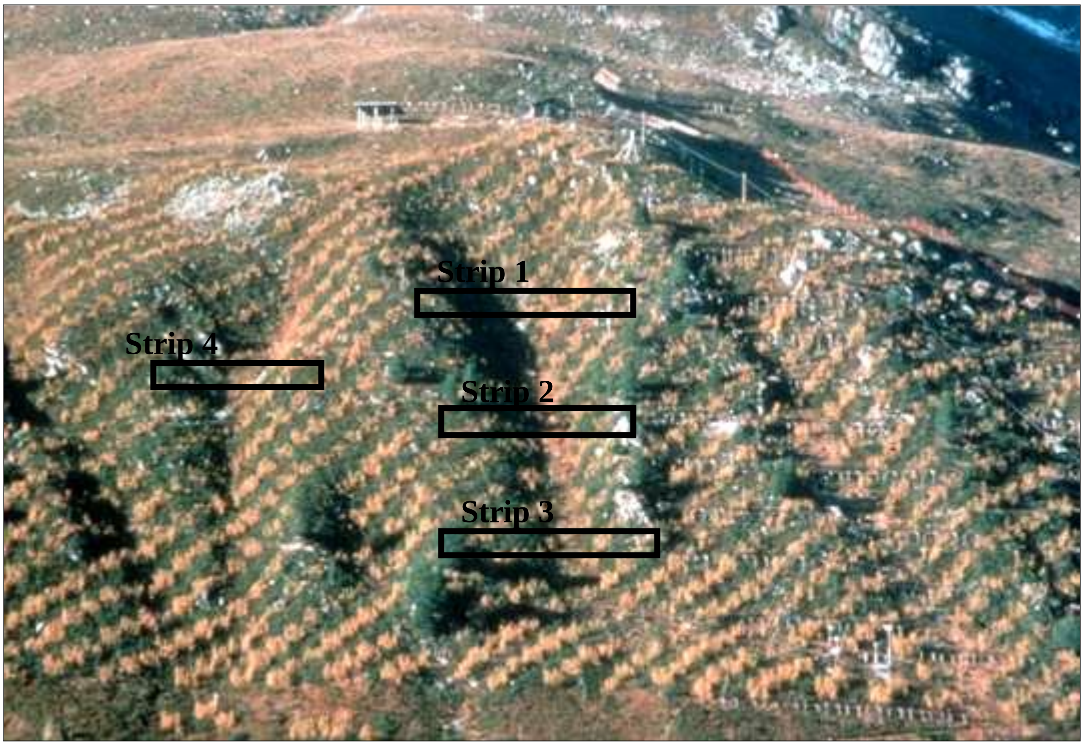

Figure 10: Sampling order in 2003: 4 strips, altogether 77 stone pine and 74 larch square units (WASEM 2000)

The sample units are within two avalanche paths in the part of Stillberg without avalanche constructions: on the one hand there is the "big avalanche gully" containing three sampling strips (2180m, 2140m and 2100m a.s.l.) and on the other hand the "small gully" contains the fourth strip at an altitude of 2150m a.s.l. (see Figure 10).
VANOMSEN recorded in 1999 a second strip in the small gully, but the lack of stem damages during field work 2003 led to the decision to abandon this fifth strip in favour of other analyses.
All four strips start and end on ridges. Hence, all four main relief types are represented within one strip: ridge – Northern slope – avalanche gully – Eastern slope – ridge. This order of sampling considers the aspect difference in the horizontal and the altitudinal differences in the vertical. The distribution of the 159 square units into the four main relief types was done by means of an already existing GIS database. Deciding were the plant communities which

change for every exposition (see Table 4). This classification was checked and reviewed in the field.

Only 151 square units in these four strips were used for recording data: 77 square units of *Pinus cembra* and 74 square units of *Larix decidua* (Table 5):

Table 4: The four main relief sites with the respective plant communities

Empetro- Vacinietum cetrarietosum	ridge	39 square units
Empetro- Vaccinietum hylocomietosum	Northern slope	54 square units
Calamagrostietum villosae	avalanche gully	28 square units
Junipero- Arctostaphyletum juniperetosum	Eastern slope	38 square units

Table 5: Number and distribution of square units in the four sampling strips

	Altitude (m a.s.l)	Number of square units	
		larch	**stone pine**
Strip 1	2180	19	19
Strip 2	2140	19	20
Strip 3	2100	22	21
Strip 4	2150	14	17

On Stillberg, the four corners of each square unit are marked out with a metal post about 10cm high. It was sometimes quite difficult or impossible to find these marks either because of the abundant vegetation (for example in the gullies with *Calamagrostis villosa*) or because the posts had been ripped away by avalanches. When located, a rubber band was stretched to the posts in order to determine the position of each living tree (ideally 25).

If any trees were alive than following parameters were recorded:

- tree species: larch or stone pine
- tree number: 1 -25 (see. Figure 11)

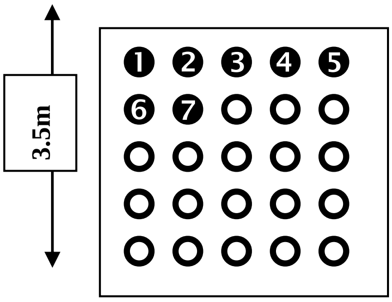

Figure 11: The position of the trees within one square unit, at the maximum 25 trees. The distance between the trees amounts to 0.7m.

- <u>tree height</u>: the tree height was measured to the last years shoot to avoid including the height increase during the sampling period. Measurements were done in centimetre-precision in order to consider the often sabre formed stem growth of the trees. If one tree had developed two stems, then the higher one was taken for recording.
- <u>diameter1</u> and <u>diameter2</u>: the diameter was measured twice per tree at soil level (assuming no deformation at the stem base; otherwise the next higher, undamaged spot was used) with a sliding calliper in millimetre-precision; once measured in the direction of the slope gradient (diameter1) and once in direction of the contour lines (diameter2) to include the non-centric stem diameter differences (compression wood, sabre growth). Larch trees with a height less than 50cm were excluded from diameter measurement; because this height is below the threshold of stem damages (stems are too elastic).

Figure 12: Measuring of the tree height with the double meter and the diameter with the sliding callipers. The borders of this stone pine square unit are marked out with rubber band

- <u>kind of damage</u>:

  The recording of the damages was confined to avalanche damages. Browsing damages from wild ungulates or black grouse were not recorded. Damages of rocks as a potential factor can be excluded from this study site, except for random rocks in avalanches. The recorded damages include stem breakages, stem splittings (fibre-parallel) and ripped off branches. The minimum diameter of a ripped off branch was confined to 1cm, otherwise the damage was not considered.

The damages were classified into old and recent injuries. The classification attribute was resin flux. An old injury distinguishes itself from a new wound by lack of resin flux, advanced healing and weathering.

Figure 13: Stone pine tree with a stem breakage

Figure 14: Larch with ripped off branch by an avalanche

Figure 15: Larch with a splitting at the stem base

- <u>height of new stem damages</u>:
  If the stem damage was recent (see definition above) than the height of the damage was also measured.

3.3. Analysis and evaluation of data

In summer 2003, 151 square field units were recorded. A total of 1149 trees were measured according to the parameters explained in chapter 3.1. For the analysis of survival all 151 square units were used, for evaluations of growth 36 of the 77 stone pine and 72 of the 74 larch square fields could be used (see Table 6). The difference is caused by square units with no trees left.

Table 6: Number of square units and trees alive in 2003

	stone pine	**larch**	**total**
number of square units	77	74	151
Number of square fields with no trees left (2003)	41	2	43
Number of square fields used for growth analysis	36	72	108
trees alive in 2003	112	1037	1149

The statistical analysis was carried out with the S-plus 2000 program (CLARK and PREGIBON 1992). Neither the height nor diameter data was normally distributed; therefore all tests used are for non-parametric data. Considering the big difference of the larch and stone pine data set (1037, respectively 112 trees alive in 2003), a second larch data set with n = 112 was generated to be able to compare the two samples. To consider the different conditions on the main relief sites, the 112 larch trees were not picked out at random, but rather the relief type and the altitude of the living stone pines was born in mind. Therefore the closest larch square unit to a living stone pine was selected and one larch was chosen by chance. This second larch data set was used to verify critical values for the statistical tests.

- To locate significant differences between two data sets, the Wilcoxon rank-sum test was used. It tests whether two data sets of observations come from the same distribution. The alternative hypothesis is that the observations come from distributions with identical shape but different locations.

- For the model of stem damages, a logistic regression model was used (chapter 6, HASTIE and PREGIBON 1992). Logistic regressions are capable of analysing the effects of one or several independent variables, discrete or continuous, over a dichotomic (presence / absence) or polychotomic dependent variable (BRITO et al. 1999). A multivariate logistic regression was constructed to ascertain the effect of different explanatatory variables (predictors) which make a tree susceptible to damage. The response variable is dependant of the explanatory variables; in this case the binary variable was “damaged” (is the tree stem-damaged, yes or no). With the function “Binary Logistic Regression: Backward Stepwise” the model was reduced to the variables which have an influence on the probability for stem injuries. The model was not used as a quantitative estimation, but to reveal qualitative trends. One of the problems and also source of error is the spatial autocorrelation of the data, which is in regression analysis sometimes ignored. Spatial autocorrelation has the effect of reducing the number of independent observations, which can lead to a loss of power of the model since observations are influenced by neighbouring areas that tend to have similar conditions (BRITO et al. 1999). In this study, autocorrelation is a non- negligible factor, because at Stillberg some of the variables (e.g. radiation, date of snow disappearance) have been recorded for the whole square unit (25 trees) and not for the single tree.

- To check and confirm the logistic model, a classification tree algorithm used in the S-plus statistical package was employed. Classification trees use a set of independent variables to predict class memberships; a tree is constructed by recursively partitioning a data set into purer, more homogeneous subsets (HANSEN et al. 1995). Once the tree partitions the data into new subsets, entirely different relationships using other predictor variables can be defined to split the new subsets. Trees can aid in reducing the dimensionality of data sets, showing the interactions of the independent variables in describing the dependent variable. In this study, this allows for the reduction of the data set to those variables which most aid in predicting stem damages. Trees provide a hierarchical and nonlinear classification method and are suited to handling non-parametric data as well as categorical or missing data (HANSEN et al. 1995).

- For the graphic visualization, diagrams in Microsoft Excel and box-plots in S-plus were used. The box-plot displays the variability of the median and it can have variable widths to represent differences in the sample sizes (see Figure 16). The median (black dotted line in box-plots) is the middle value of a data set which was previously sorted from smallest to highest value. The median value is resistant against outliers and the best estimated value for prognoses, because it has the smallest mean absolute error. 50% of the data lies within both sides of the median value.

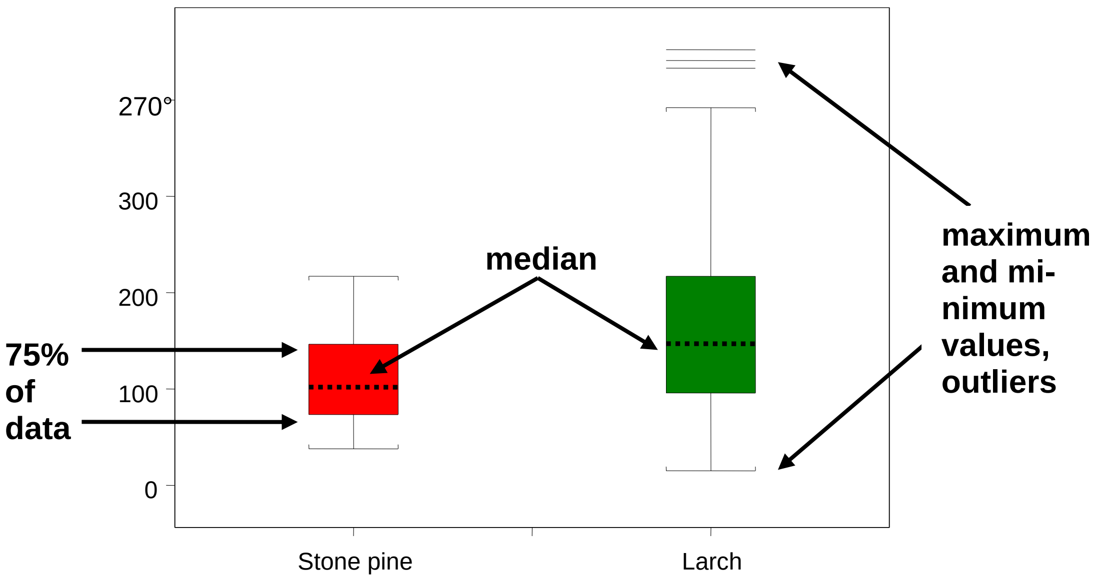

Figure 16: Interpretation of a box-plot

4. Results

4.1. Survival of trees between 1975 and 2003

In 1975, 1769 stones pines and 1628 larches were planted in 151 square fields which were used as basic sampling units. In 2003, 112 stone pines and 1037 larches were still alive, meaning that 6.3% of the stone pines, and 63.6% of the larches, have survived the first 28 years after planting.

The decline of the mortality rate of stone pine and larch developed in different ways (see Figure 17). Stone pine survived the first years with insignificant losses. After four years the steady decrease of number of living trees began and continues until now. By contrary, larch suffered quite a few losses at the beginning of the afforestation due to low height (2cm). The period 1985 – 1999 was extraordinarily stable with a loss of only 74 trees. Since 1999 a slight increase of mortality is recognized.

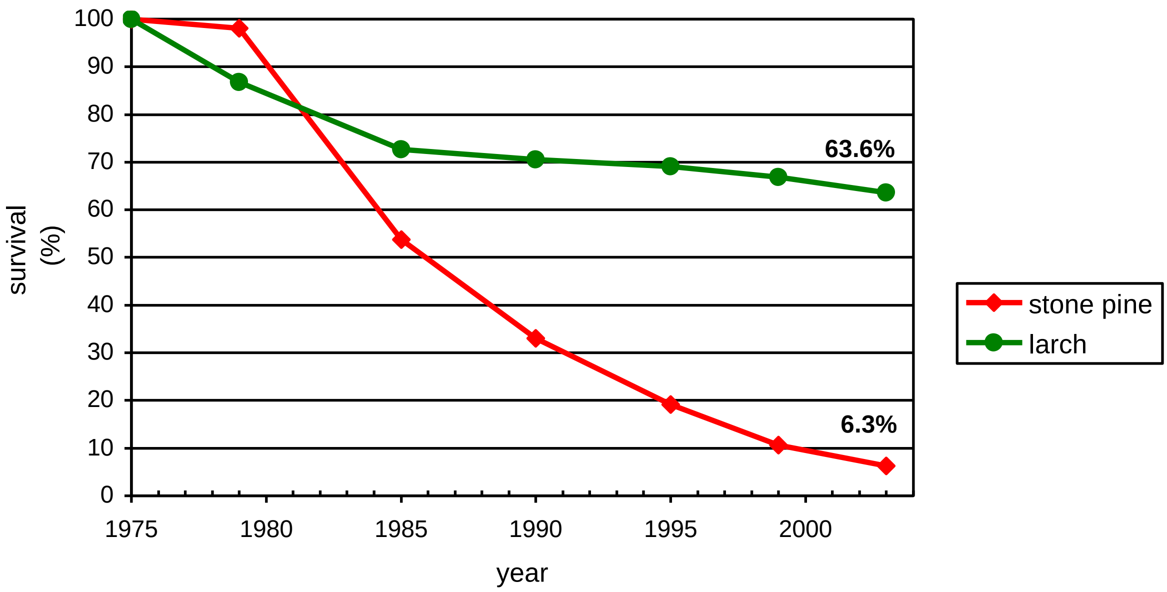

Figure 17: Survival rate of larch and stone pine 1975 – 2003

Dividing the sample units into the four main relief types, the survival rates are quite unevenly distributed. Considering the ratio of planted trees in 1975 and the number of trees still alive in 2003, the favourable growth sites for stone pine and larch differ noticeably.

From the ecological point of view, the Eastern slope is by far the most adequate site for stone pines (see Figure 18). 14% of the trees have survived the 28 years since planting. On the other three main sites tree survival was clearly lower: 8% of the pines on the ridges, 2% on the Northern slopes and a mere 0.7% in the gullies are still alive.

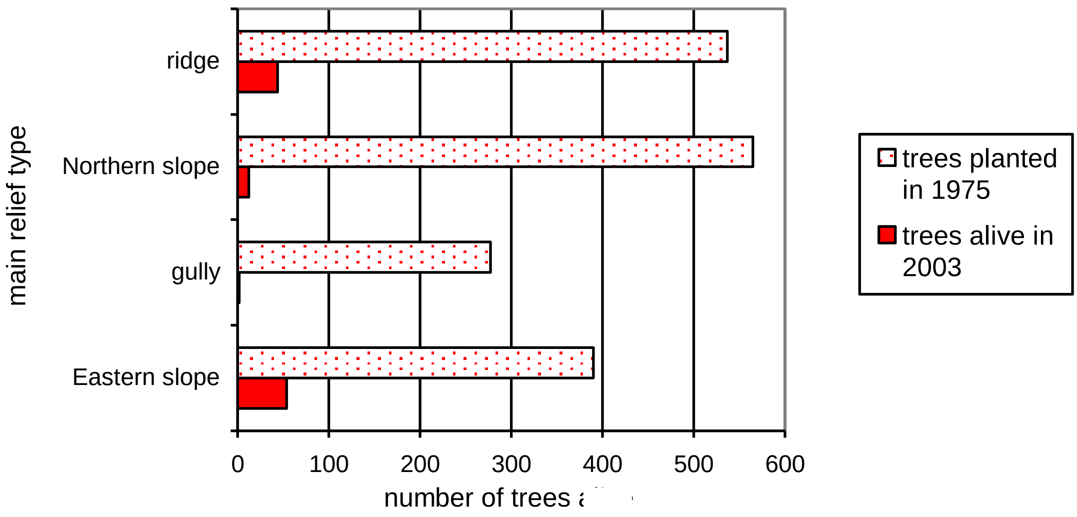

Figure 18: Planted stone pines in 1975 and number of trees still alive in 2003 distributed among the main relief sites

As seen in Figure 19, larch prefers locations on the ridges (77% survival) and on the Eastern slope (73%). On the Northern slope, however, there were slightly more losses, but still 68% of the trees have endured. The mechanical snow impacts in the gullies are obviously not suitable for larch. Only 31% of the 281 planted larches outlived the harsh conditions in the gully.

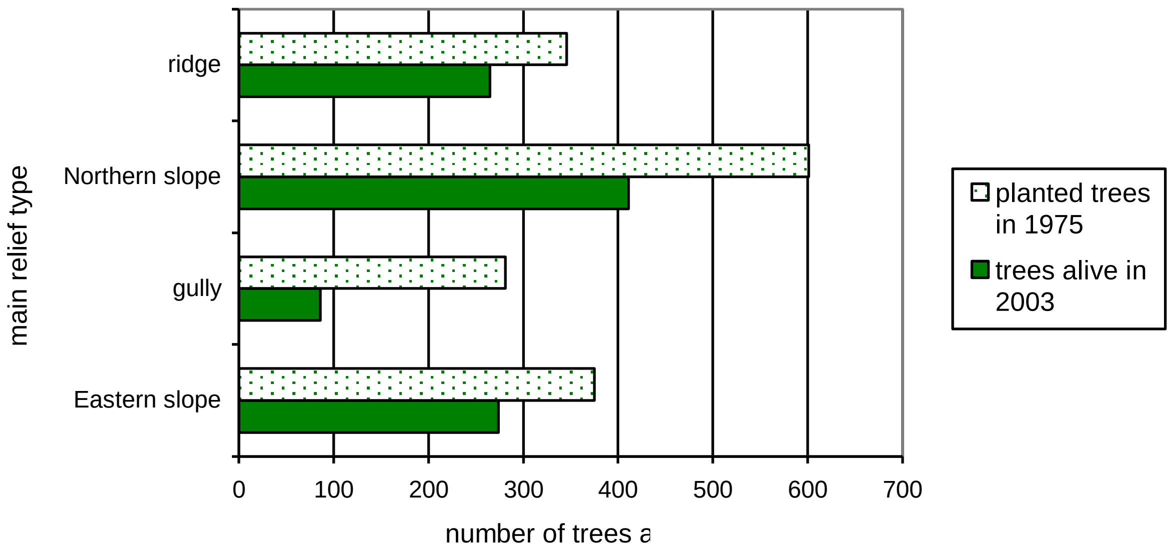

Figure 19: Planted larches in 1975 and number of trees still alive in 2003 distributed among the main relief sites

The influence of the topography or the microclimate has varied in course of time and varies also between the two coniferous tree species. Since 1975, the development of the survival rate of larch is more or less the same in all four main relief types (see Figure 20). With other words, on a long-term scale, the successful establishment of larch obviously does not depend on a certain aspect or topographical site.

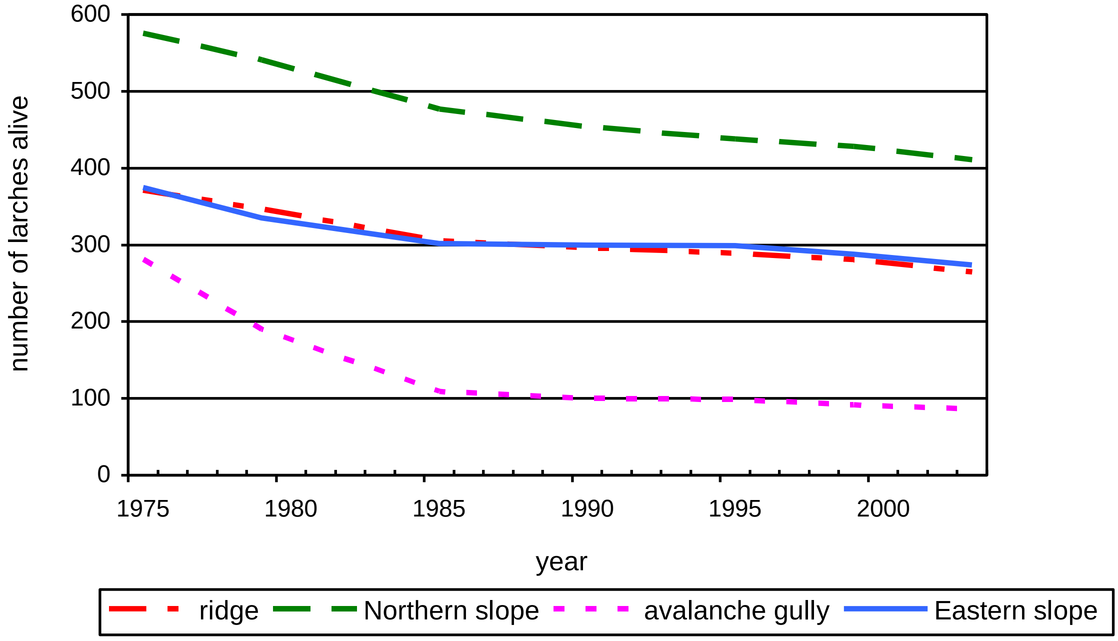

Figure 20: Development of the survival rate of larch in relation to the four main relief types since 1975

On the other hand, stone pine has a different survival pattern (see Figure 21). Depending on the age period, the influence of the microhabitat is more or less pronounced. A few years after planting, the ridges and the Northern slopes were the first main sites where the conditions for stone pines turned worse, expressed in the decreasing survival rate. In the Eastern slopes and the avalanche gully this initial decrease of trees was much more moderate. Between 1985 and 1990, most of the trees in the avalanche gully did not survive whereas on the other three main relief types, the survival rate stayed on a higher level. Since 1995, the survival rates on all four main sites continue with the same tendency. Until summer 2003, the influence of the microhabitat has continuously decreased and the survival rate is found down on the low level of 0 to 50 trees independently of topography.

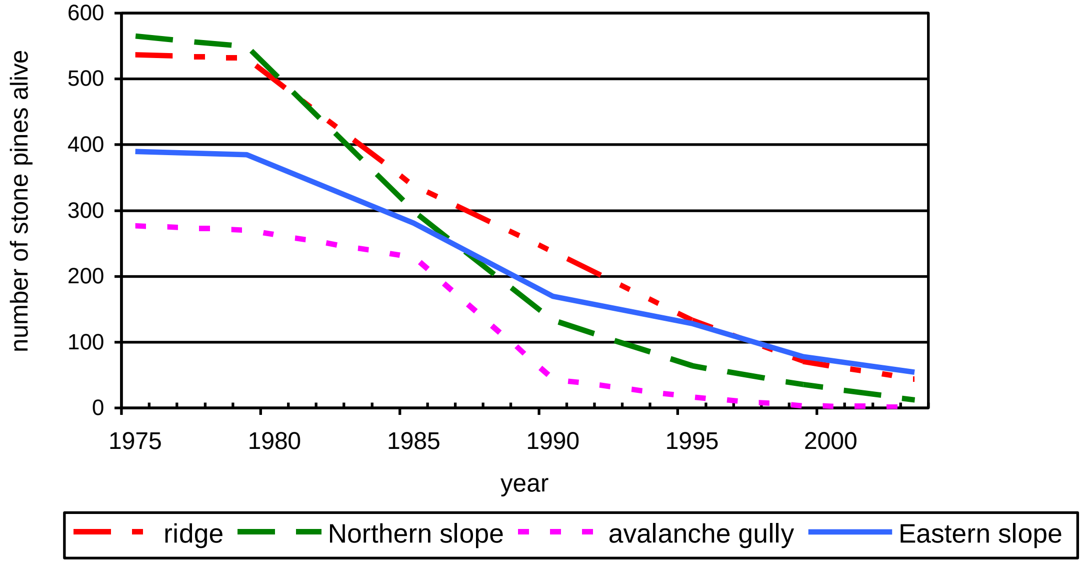

Figure 21: Development of the survival rate of stone pine in relation to the four main relief types since 1975

If not only the four main relief types, but also the altitude (the three sampling strips (1-3) in the “big gully” lie at an altitude of 2180m, 2140m and 2100m a.s.l.) as a further parameter is taken into account, the survival percentage look as follows. The most favourable location for stone pine is still the Eastern slope, but the extreme variation of survival in dependence on altitude is clearly visible in Figure 22. At the highest sampling strip 16% of the trees in the Eastern slope survived, in the middle strip 29% and at the strip at the lowest elevation none of the pines survived. On the ridges and on the Northern slope, the altitudinal differences are not as pronounced as on the Eastern slope. Life chances for pines growing in the gully are better in the highest strip-1, because avalanche impacts decrease further up the starting zone.

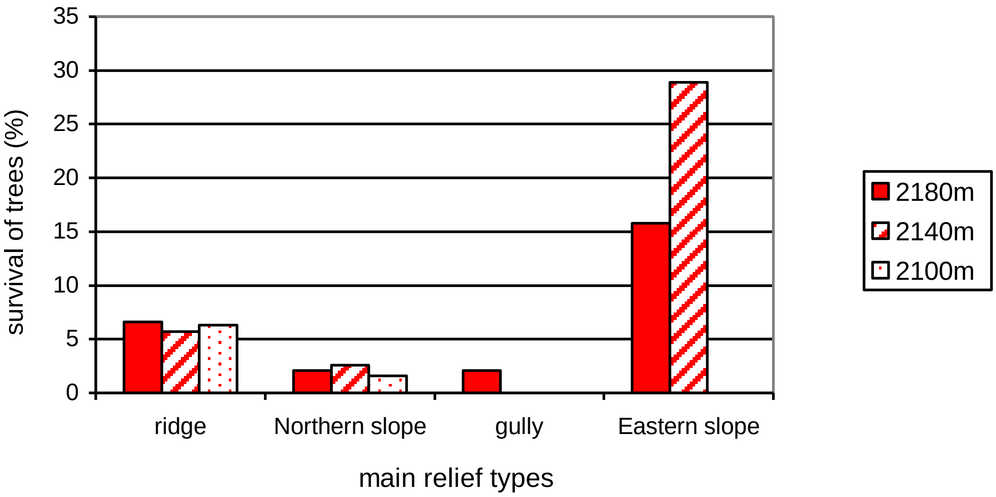

Figure 22: Survival chances for stone pine in relation to altitude and topography in 2003

The result obtained for larch is much more balanced. Best chances are in strip-2 on the ridges with 88% (see Figure 23). The larches on the Eastern slope are, contrary to the result of stone pines, quite indifferent to the parameter "altitude". The only main site where the altitudinal factor is clearly pronounced is the Northern slope. There is a great difference of survival chances in the highest and lowest strip. The tendency for poor survival is comparable to that of stone pine in the avalanche gully (strip-3).

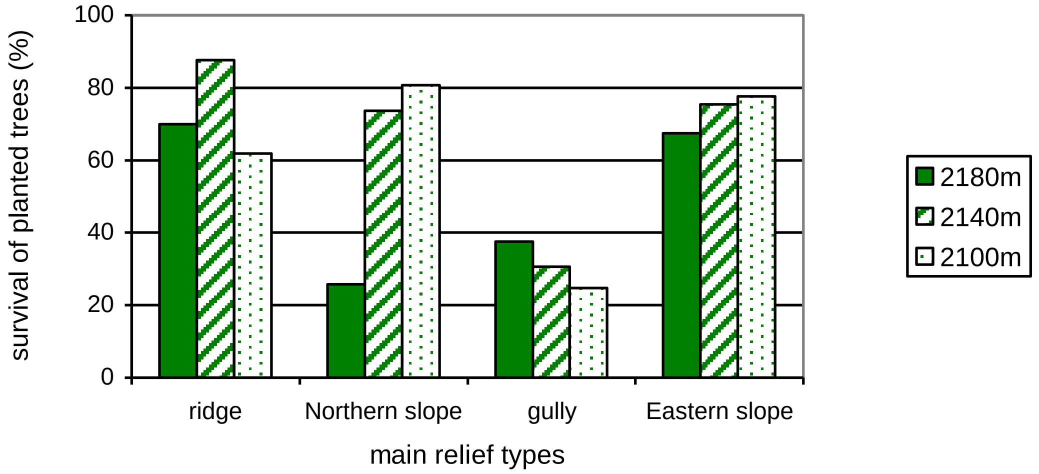

Figure 23: Survival chances for larch in relation to altitude and topography in 2003

The comparison of Figure 22 and 23 shows that survival chances vary considerably according to main relief types, altitude and tree species. Focussing now on the trees still alive, it is interesting to look at these parameters in relationship with the growth conditions. Figure 24 illustrates the general height growth of the two tree species since the planting and in Table 7 the values of tree height and diameters are broken down by altitude and main relief types.

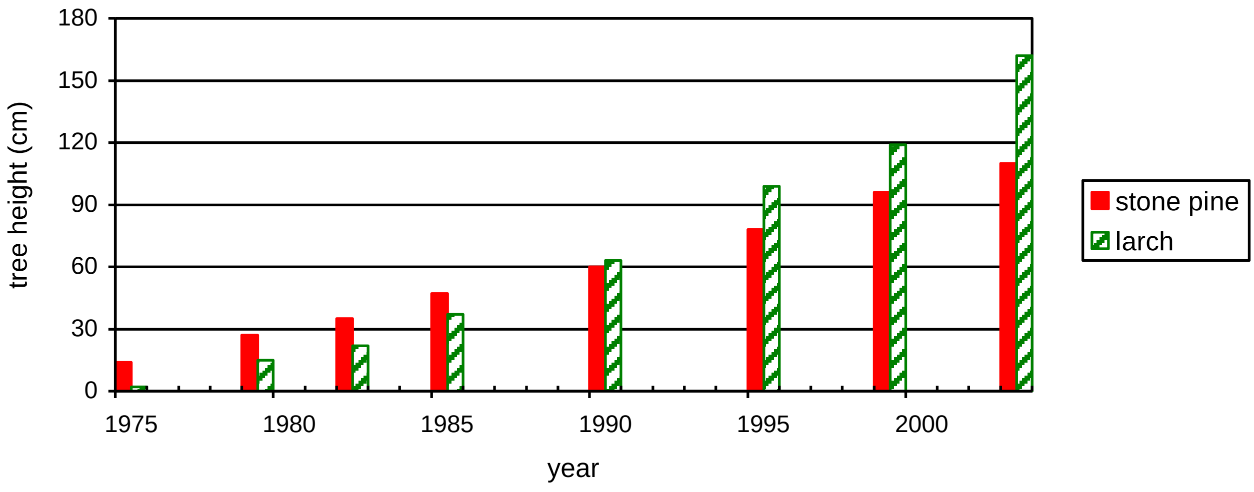

Figure 24: Development of mean tree height of larch and stone pine since 1975

In 1975, larch was planted with a mean tree height of only 2cm, whereas stone pine measured about 14cm (see Figure 24). During the first ten years, pine could keep its height lead over larch. In 1990, larch had made up its minor planting size and now it is overtaking stone pine (60cm) by 3cm. Since then, the growth difference has become more and more pronounced and has reached a maximum of 52cm (+47%) in 2003.

The development of tree height and stem diameter of the 33 year-old stone pines and the 29 year-old larches turned out quite differently. Although the parameter ”topography“ is much more pronounced than the parameter “altitude” (80m of difference between strip-1 and strip-3), limitations and favours of growth can be recognized in both horizontal and vertical direction (see Table 7). In general, both tree species grow best on the sunny Eastern slope which is expressed by the greatest values for tree height and stem diameters.

At a closer look, larch seems to prefer the lower sites in sample strip-3, because, independent of the relief type, all trees reach there a height of over 200cm. Higher up on the slope, the larches are decidedly smaller and reach their minimum height on the ridge in strip-1 with only 78cm (-72% compared to maximum of 280cm on the Eastern slope). The same pattern is observed for the diameter values, although the trees on the upper ridge have only a 52% smaller diameter1 than those of the lower Eastern slope.

The growth pattern for stone pine differs in that as the most favourable location seems to be the Eastern slope, independent of altitude; the microenvironment is more decisive. The pines have reached here a height of over 100cm and diameters of 6-8cm. Comparing these values to those of ridge and Northern slope, where the trees are up to 56% smaller and 60% more slender, the difference is quite evident.

Table 7: Tree height and stem diameter broken down by altitude and topography. Green: minimum and maximum values for larch. Red: minimum and maximum values for stone pine.

	Ridge		**Northern slope**		**Gully**		**Eastern slope**	
	Larch	**Pine**	**Larch**	**Pine**	**Larch**	**Pine**	**Larch**	**Pine**
Strip1 (2180m)								
Height	**78**	93	116	-	153	-	167	114
Diameter1	**3.6**	5.4	5.2	-	5.9	-	5.6	7
Diameter2	**3.4**	4.4	4.7	-	5.4	-	4.9	6.5
Strip2 (2140m)								
Height	98	**68**	103	70	186	-	213	**156**
Diameter1	3.9	**3.1**	4	3.2	5.5	-	5.8	**7.9**
Diameter2	3.5	**3**	3.6	3	4.9	-	5.0	**7.8**
Strip3 (2100m)								
Height	230	90	206	-	200	-	**280**	-
Diameter1	6.5	5	5.8	-	6.1	-	**7.5**	-
Diameter2	5.6	4.4	5.2	-	5.6	-	**6.5**	-

4.2. Survival and growth of larch and stone pine in an avalanche release area since 1995

The evaluated sample set relates to the same 151 square units as in 1995 and 1999, i.e. 74 square fields were planted with larch and 77 with stone pine. In 1995 the sampling data took 1137 larches and 314 stone pines into consideration (see Table 8). Four years later 1109 larches were still alive (-2.5%) whereas stone pine had suffered losses up to 43% (180 trees). In 2003 only 112 (-38%) stones pines remained and the larch stand decreased to 1037 trees (-7%).

Table 8: Number of trees, mean tree height and diameter in 1995, 1999 and 2003

	1995			1999			2003		
	larch	pine	total	larch	pine	total	larch	pine	total
number of trees n	1137	314	1451	1109	180	1289	1037	112	1149
mean tree height h (cm)	99	78	95	119	96	116	162	111	157
standard deviation s_h (cm)	53	34	50	59	39	57	87	47	85
mean tree diameter d_1 (cm)	-	-	-	3.5	4.5	3.7	5.3	6.0	6.0
standard deviation s_{d1} (cm)	-	-	-	1.7	1.9	1.8	2.3	2.7	2.7
mean tree diameter d_2 (cm)	-	-	-	-	-	-	4.7	5.5	5.1
standard deviation s_{d2} (cm)	-	-	-	-	-	-	2.0	2.5	2.3
number of square units without surviving trees	1	9	10	1	26	27	2	41	43

Stone pine: In 2003, 41 of the 77 (53%) fields have no surviving trees. That means an increase of “all-dead” square units of nearly 2/3 within four years. As can be seen in Figure 25, one to three trees survived in 30% of the square units and there are at the most ten trees alive per square unit. Since 1995 only in 9% of the square units no tree losses have been observed. Those are equally distributed among the Eastern and Northern slopes.

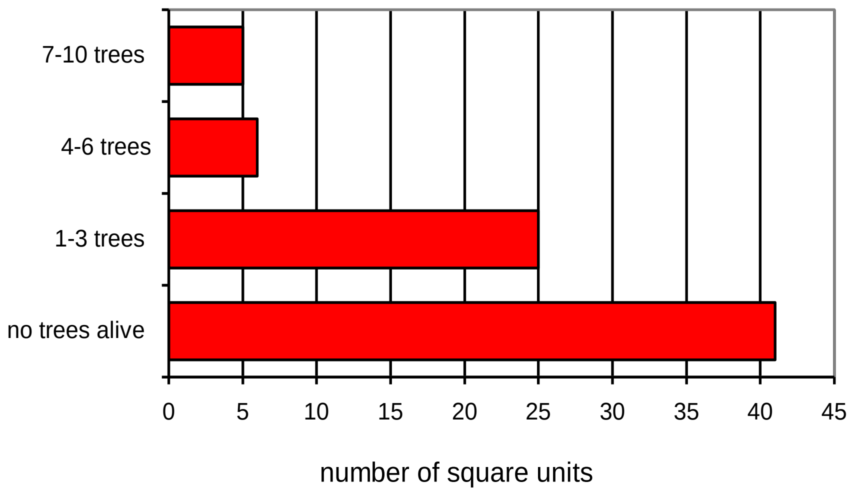

Figure 25: Number of surviving stone pines per square unit in 2003

In 2003, the proportion between fields with no trees left and fields with trees still alive can not be related to the main relief types as expected: 0.5 in the avalanche gullies, 0.3 in the Northern, 0.2 on the ridges and 0.2 in the Eastern slopes. But looking back at the different time periods the following interesting changes took place. In 1995, the square units with no trees left are divided between the most unfavourable sites for tree growth, namely Northern slopes (40%) and avalanches gullies (60%). In 1999, the all-dead units were still allotted to the gullies (40%), but also to the Northern (35%) and the Eastern slopes (25%). In the last four years the lethal locations moved on to the Northern slopes (50%) and the ridges (50%).
Between 1995 and 1999 the highest degree of losses was found on the Eastern slopes (50%) and on the ridges (50%). Since 1999 still another change occurred: most of the new losses are found in square units situated in the Eastern slopes (60%) and the Northern slopes (40%).

The distribution of tree heights in 1995, 1999 and 2003 of stone pine is shown in Figure 26 (the formation of classes resulted in 10% - columns, meaning that the total amplitude of values was divided into ten equal parts. Therefore the height of each column is an allotment by percentage of the whole sample (Figure 18, 19, 21 and 22). The culmination class shifts continuously to the right. In 1995 over 30% of the total sample data (314 stone pines) were located in the 45–66cm class and in 2003 the majority of the trees (21%) is in the 89–110cm class. The greatest change took place in the upper classes as expected. In 1995 only 3% of the trees measured more than 155cm, in 2003 that group increased to 19%.

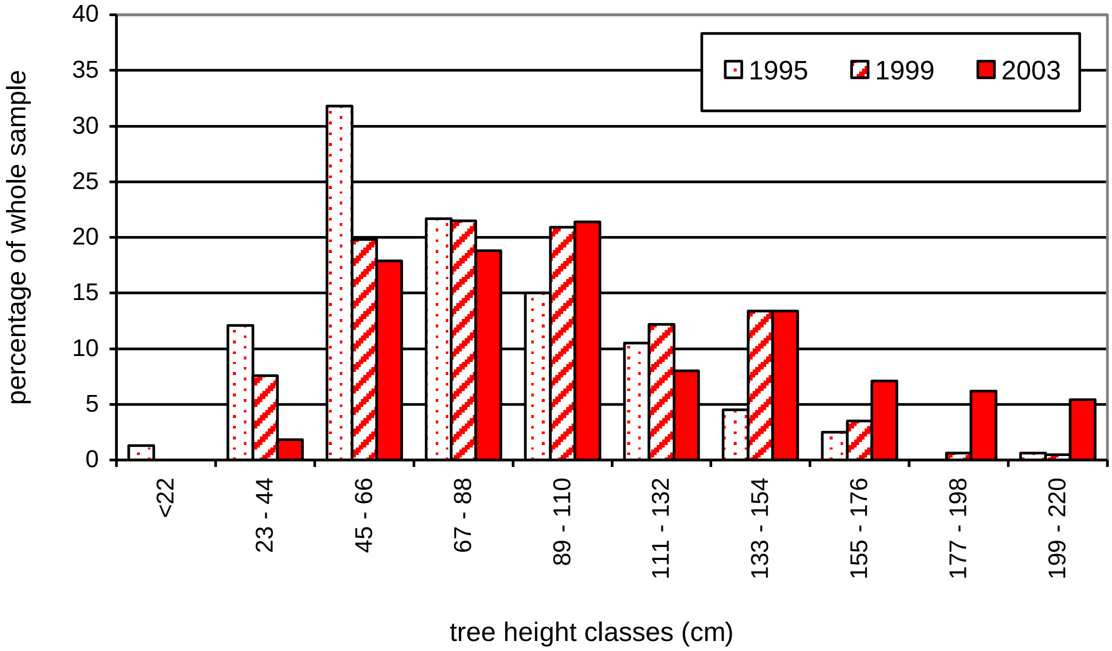

Figure 26: Tree height distribution of stone pine in 1995, 1999 and 2003

The tree diameter was only recorded in 1999 and 2003. In 1999 the largest part of the sample (32%) was found in the 3.1–4.5cm class. Four years later, 25% of the samples had shifted to the 4.6–6.0cm class (see Figure 27).

Comparing the mean values of diameter1 (measured in direction of the slope gradient) and diameter2 (measured in direction of contour lines) with the Wilcoxon rank-sum test (n=112; p-value = 0.1938) no significant difference was visible.

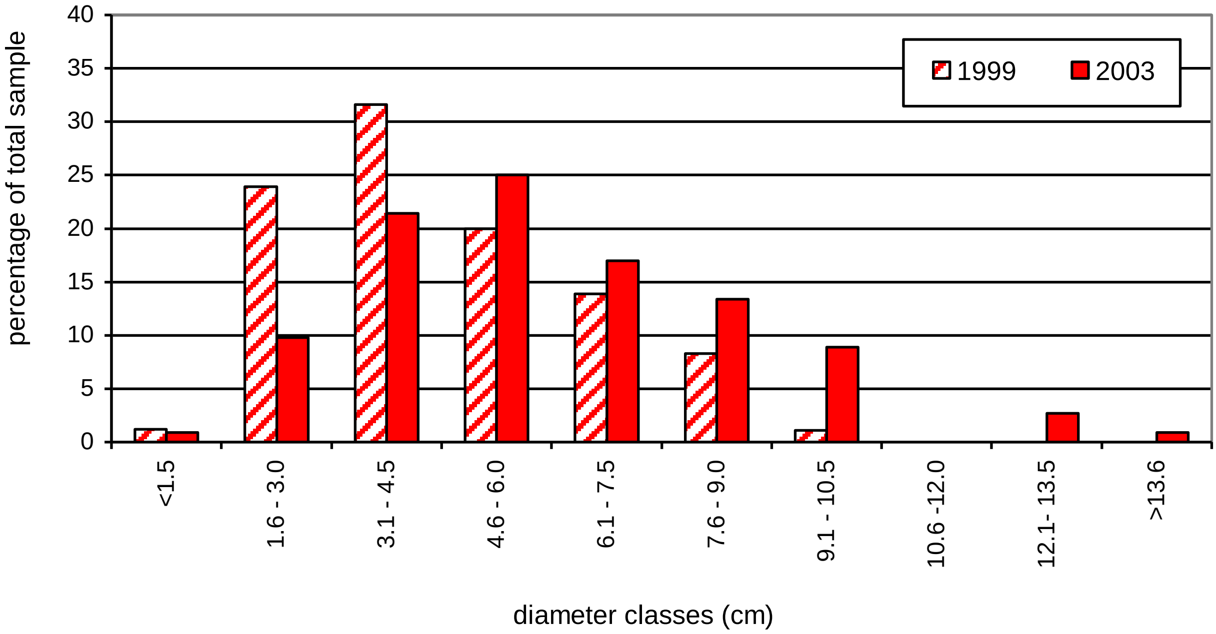

Figure 27: Tree diameter1 distribution of stone pine in 1999 and 2003

Larch survived much better than stone pine. Between 1995 and 2003, only one hundred trees died. In other terms, the mortality rate 95-99 was only 3%, increasing to 7% since 1999. Since 1995 there was no change in 45% of the square units in the number of trees alive. Focussing on the last four years, it is even 66% of the square units where no change occurred. The only losses took place in a few square units on the Eastern slopes.

In 1999, only one square field had no trees left; in 2003 it was two (3%), respectively.

Unlike the stone pine square fields, on 20% of the larch fields more than 20 of the 25 planted trees survived (see Figure 28). Since the planting in 1975, most of the square fields (31%) had losses between 5 to 9 trees.

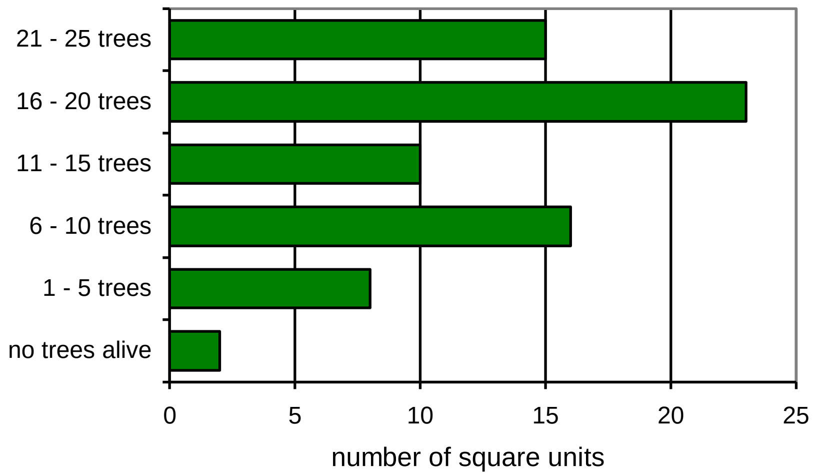

Figure 28: Number of surviving larches per square unit in 2003

The distribution of tree heights of larch is shown in Figure 29 for the period 1995 to 2003. In 1995 over 30% of the total sample data was located in the 46–90cm class; in 2003 the largest part of the trees (22%) is in the 91–135cm class. The greatest changes took also place in the upper classes. In 1995, only 0.1% of the trees measured over 270cm whereas in 2003 that fraction increased to 13%.

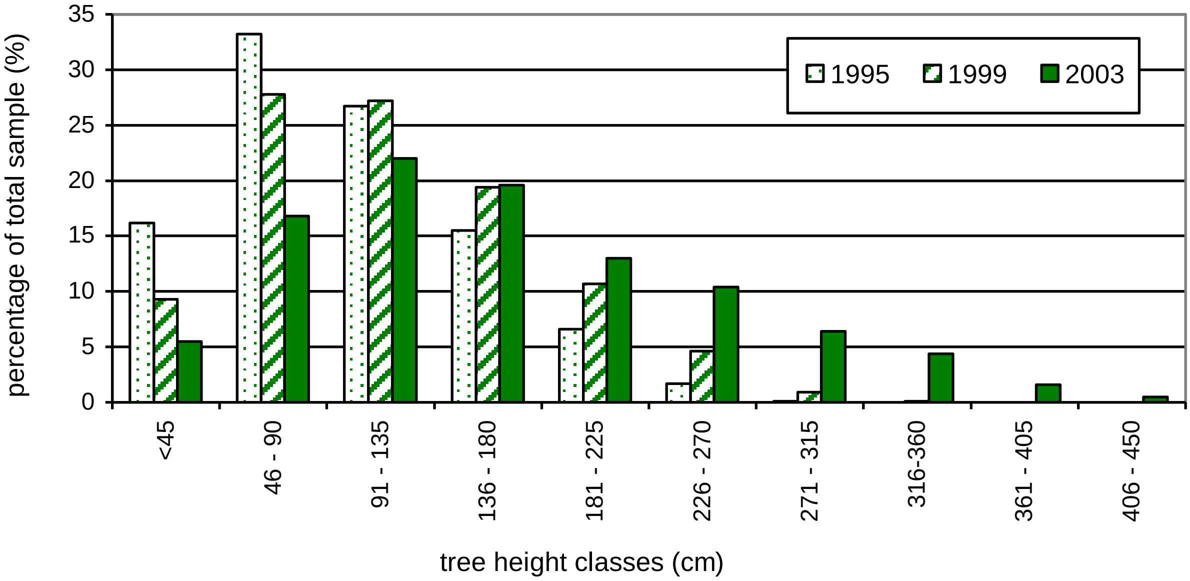

Figure 29: Mean tree height distribution of larch in 1995, 1999 and 2003

Looking at the mean stem diameter1, in 1999 over 35% of the total sample data (1037 larches) was located in the 1.6–3.0cm class (see Figure 30). Four years later 25% of the samples had shifted to the 3.1–4.5cm class. In 2003 the diameter of 35% of the trees measured more than 6cm as compared to the 11% in 1999.

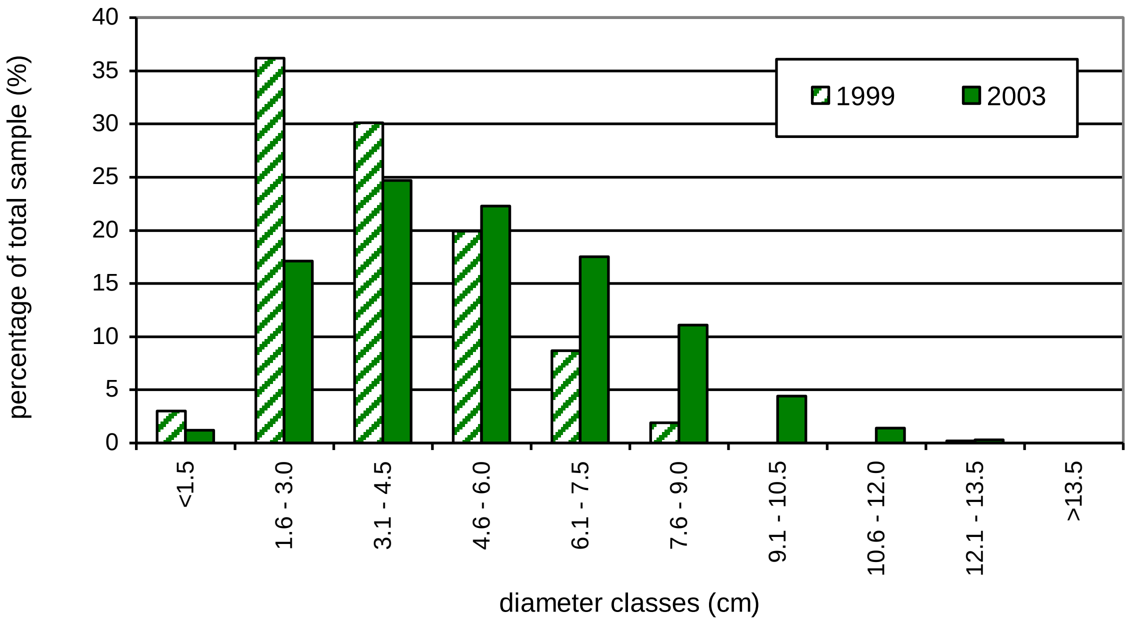

Figure 30: Mean tree diameter1 distribution of larch in 1995, 1999 and 2003

Contrary to the result of stone pine, the difference of the mean values of the two diameters is highly significant with both larch data sets (Wilcoxon rank-sum test: n_{larch} = 1037, n_{pine} = 112, p-value = 0 and n_{larch} = 112, n_{pine} = 112, p-value = 0.0078). The median (black dotted line in Figure 31) of diameter1 amounts to 5.4cm and that of diameter2 to 4.7cm, meaning that on average the cross section at stem base of larch is by 0.7cm (10%) not circular.

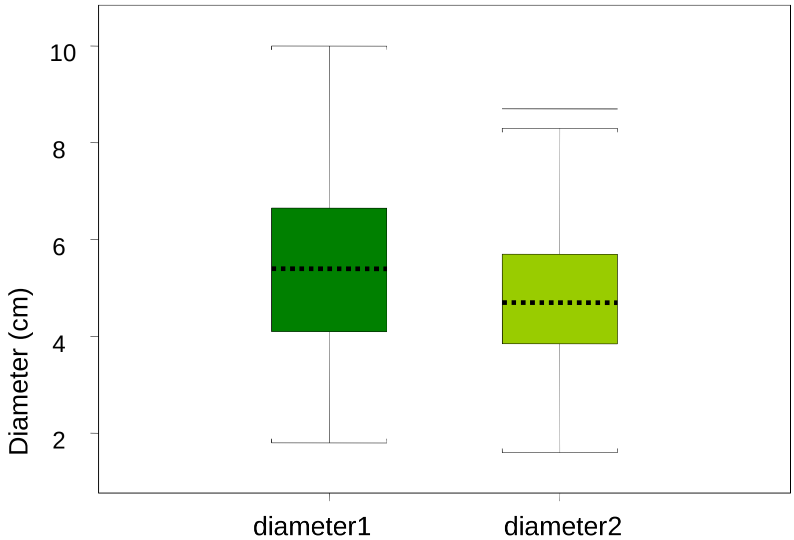

Figure 31: Median value of diameter1 and diameter2 of the 1037 larches recorded in 2003

The above mentioned result of the two diameter measurements of larch and stone pine is illustrated in Figure 32. Looking more closely at the cross sections of larch, the relation between diameter1 and diameter2 varies regarding different parameters: altitude, number of avalanches, mean snow height and date of snow disappearance do not influence the ratio of the two diameters, meaning that diameter2 is 10% smaller than diameter1. Inclination and four main relief types, however, show a varying influence on diameter2: On the ridges diameter2 is only 9% smaller than diameter1, whereas on the Eastern slopes diameter1 and diameter2 differ by 12%. No particular influence was observed in the avalanche gully and the Northern slopes. On slopes exceeding 35°, diameter2 is 11% smaller than diameter1, whereas on slopes below 35°, diameter2 is only 5% smaller. Hence, on steep slopes with snow pressure larch develops an oval stem base, i.e. the longer axis is in the falling line so as to reduce the impact surface for snow pressure. The stem of stone pine by contrary does not adapt to the snow forces, it is still more or less circular.

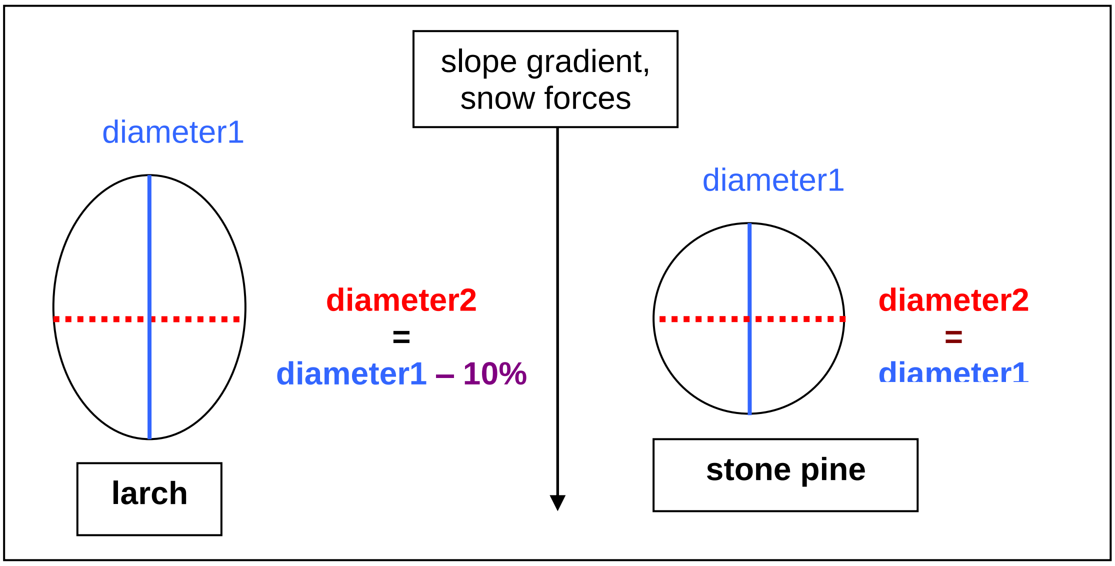

Figure 32: Cross sections of stem diameters of larch and stone pine

The comparison of the diameter of stone pine and larch shows that pine has not a significantly larger diameter (Wilcoxon rank sum-test: n_{larch} = 112, n_{pine} = 112, p-value = 0.5828). In 2003 the mean tree height of larch of 162.3cm is significantly higher than the 110.8cm (-47%) of stone pine (Wilcoxon rank-sum test: n_{larch} = 1037, n_{pine} = 112, p-value = 0.00 and n_{larch} = 112, n_{pine} = 112, p-value = 0.00).

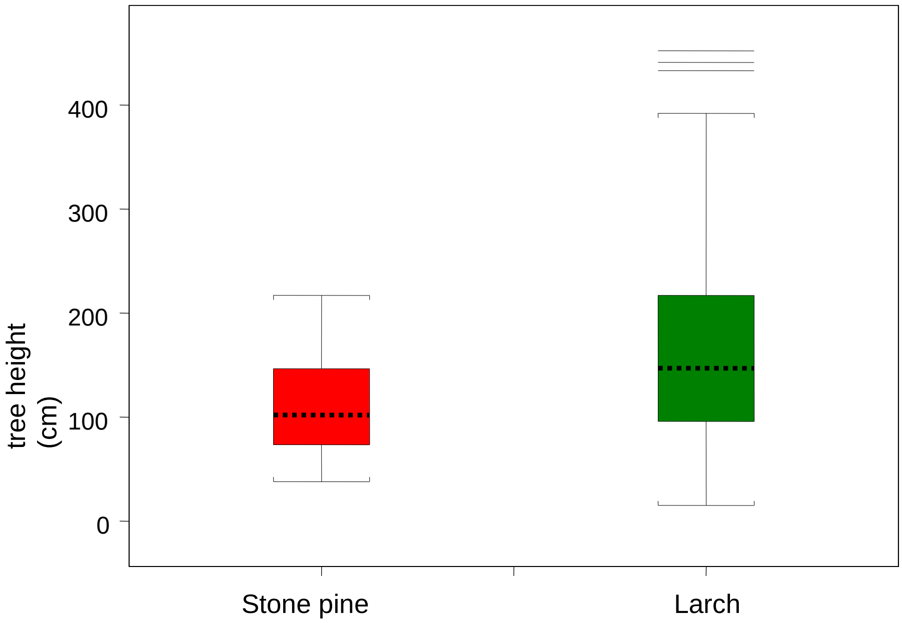

Figure 33: Mean tree height of larch in 2003 is 47% higher than that of stone pine

The difference in tree height between larch and stone pine increased from 21.3cm (1995) to 22.7cm (1999) to 51.5cm in 2003. Within the tree species, stone pine recorded 32.7cm growth in eight years, that's an average annual growth rate of 4.1cm as compared to 7.9cm of larch (+92%).

In general the standard deviation for tree height and diameter has an increasing tendency, meaning that the data scatters more and the variation width rises. In 1999, the range of the tree height was 15 to 368cm. In 2003, this range has increased from 15 to 452cm (+23.5%) whereas the difference between smallest and largest diameter1 rose from 9.1cm in 1999 to 15cm (+64.8%) in 2003.

The summary of the results of tree height and diameter1 for both tree species is illustrated in Figure 34. The growth tendency for stone pine is thickset, meaning that it has a large diameter compared to its size. On the other hand, larch is taller and more slender. Hence, stone pine tends to have the larger stem diameter values, whereas larch invests rather in tree height growth. This trend can also be measured with the "slender value" which consists of the tree height (h) and the diameter (d_1) measured at the tree base.

The mean slender value is the reciprocal value of the gradient (VANOMSEN 1999). The values of larch and stone pine are generally low and vary between h/d_1 20 and h/d_1 50. In 1999 the value of stone pine amounted to 25 (larch: 40), in 2003 it had decreased to 22 (larch: 41). The trend of the last four years confirms the above- mentioned statement that stone pine trees get more thickset and larch trees get taller.

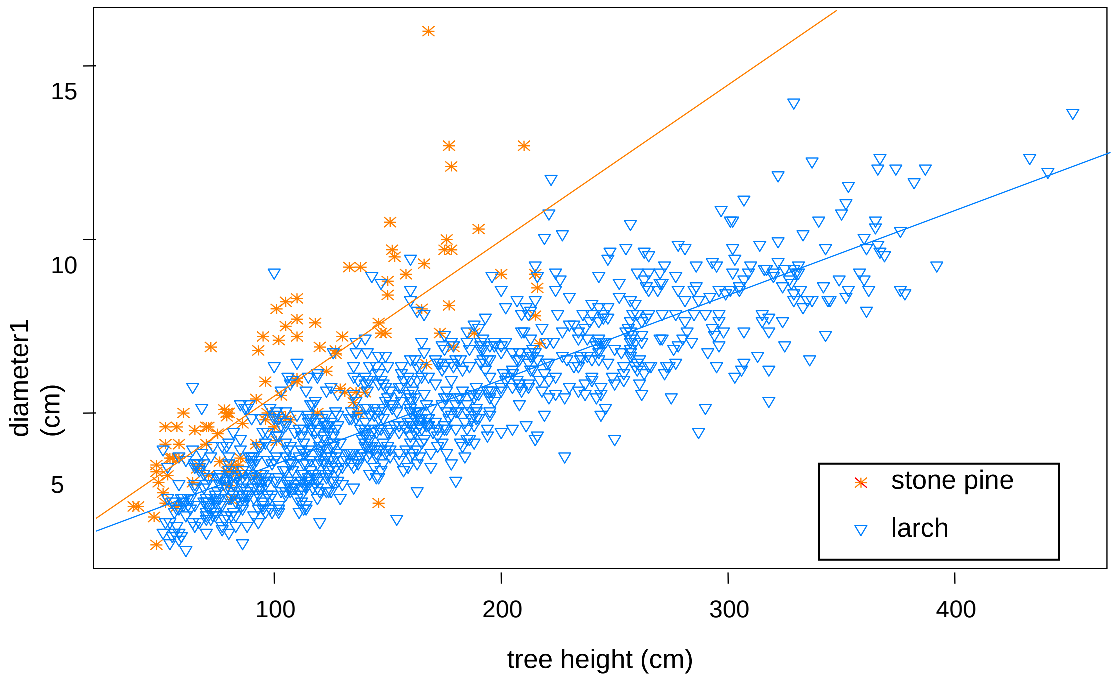

Figure 34: Distribution of tree height and diameter1 of stone pine and larch in 2003

The simple linear regression line illustrates the correlation between tree height and diameter1 (see Figure 34) for both tree species. The lines of the two tree species differ significantly and the different growth tendencies of larch and stone pine are clearly recognizable.

The correlation of tree height and diameter1 is positive. The coefficient of determination R^2 (Rsq) is a measure of the proportion of the variability in one variable that is accounted for by variability in another. The maximum value for R^2 is 1.0, meaning that all measured value lie on a single straight line. In 2003 the correlation for pine was 0.62 and that of larch 0.74, which means that 62%, respectively 74% of the variability is accounted for by the model.

4.3. Stem damages in an avalanche release area

4.3.1. Comparison of damaged and undamaged trees 1995 – 2003

In 1995, only 0.9% of the stone pines and larches had suffered from a stem damage. Four years later, the percentage of damage had increased to 6.9% (see Table 9). In 2003, 1037 larch and 112 stone pines trees were recorded. From this total number of 1149 living trees 53 were damaged with either a stem break or stem splitting (multiple damages of different kind on the same tree were counted twice). Dividing this number through the surviving trees, 4.6% of the trees were damaged. This 4.6% relate to 2% (25 trees) of the larches and 25% (28) of the stone pines.

Table 9: Percentage of stem damaged trees in 1995, 1999 and 2003

	1995	**1999**	**2003**
Number of stems	1451	1289	1149
Number of stem damages	13	89	53
Damaged trees in %	0.9	6.9	4.6

The total percentage of damaged trees has increased sevenfold in the first four years of the period 1995 – 2003. After 1999 the damage frequency decreased to 4.6%.
From the comparison of damaged and undamaged trees following results could be derived: as a general rule the damaged trees are taller and larger than the undamaged. Examining the values of the two diameters measured, an apparent difference of damaged and undamaged trees is recognizable. Figure 35 illustrates the difference of mean diameter1 which is highly significant (Wilcoxon rank-sum test: $n_{damaged}$ = 53, $n_{undamaged}$ = 1096, p-value = 0.00). In 2003 the damaged trees measured on average a diameter1 of 7.4cm. With an average diameter1 of 5.3, the undamaged trees showed a 40% (+2.1cm) smaller diameter.

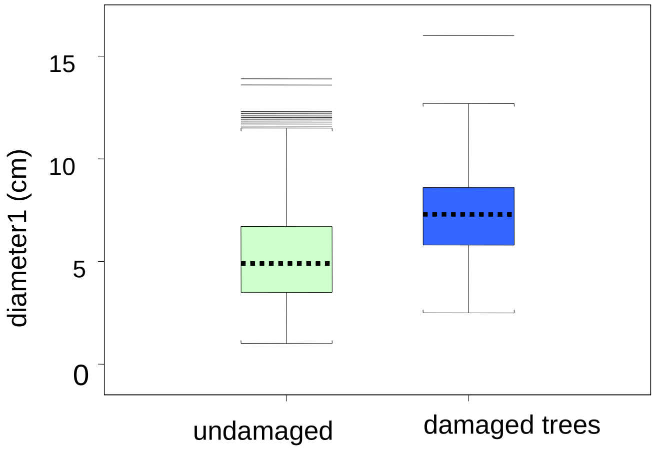

Figure 35: Mean diameter1 (measured in direction of the slope gradient) of damaged and undamaged trees 2003

The mean diameter2 (see Figure 36) differs even more: damaged trees (7cm) are 46% larger than the undamaged (4.8cm). (Wilcoxon rank-sum test: $n_{damaged}$ = 53, $n_{undamaged}$ = 1096, p-value = 0.00).

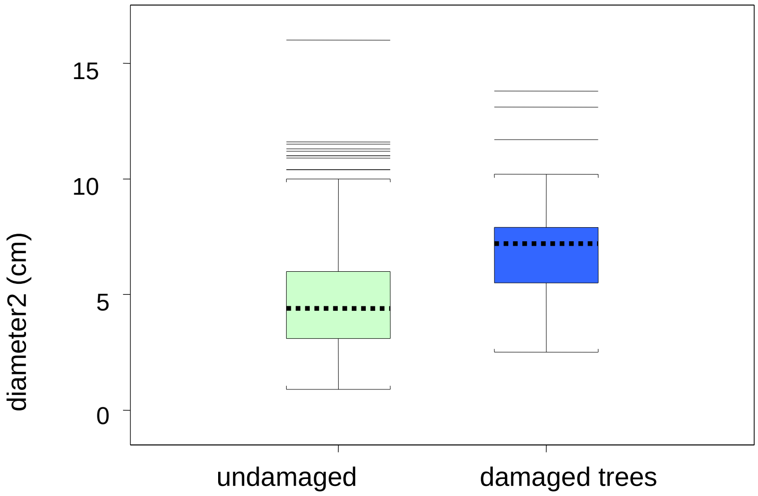

Figure 36: Mean diameter2 (measured in direction of the contour lines) of damaged and undamaged trees 2003

Examining the mean tree height of damaged (166cm) and undamaged (132cm) trees, the difference is highly significant (Wilcoxon rank sum test: $n_{damaged}$ = 53, $n_{undamaged}$ = 1096, p-value = 0.0011). The damaged trees are 26% (+34cm) taller than the undamaged. But comparing the median of the two groups in Figure 37, the difference of the two medians is not clearly visible and therefore it does not seem to be relevant. Accordingly the tree height is not as decisive as parameter as stem diameter.

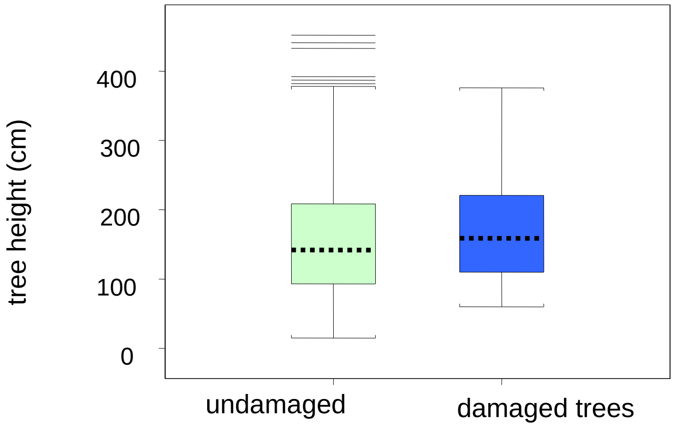

Figure 37: Mean tree height of damaged and undamaged trees in 2003

Allotting the damaged trees to the four main relief types, following damage pattern is visible (see Figure 38). Eastern slopes are most susceptible to stem injuries: in 2003, 66% of all stem damages occurred there. The Northern slope follows with 23%, the ridges with 7% and the gully with 4%.

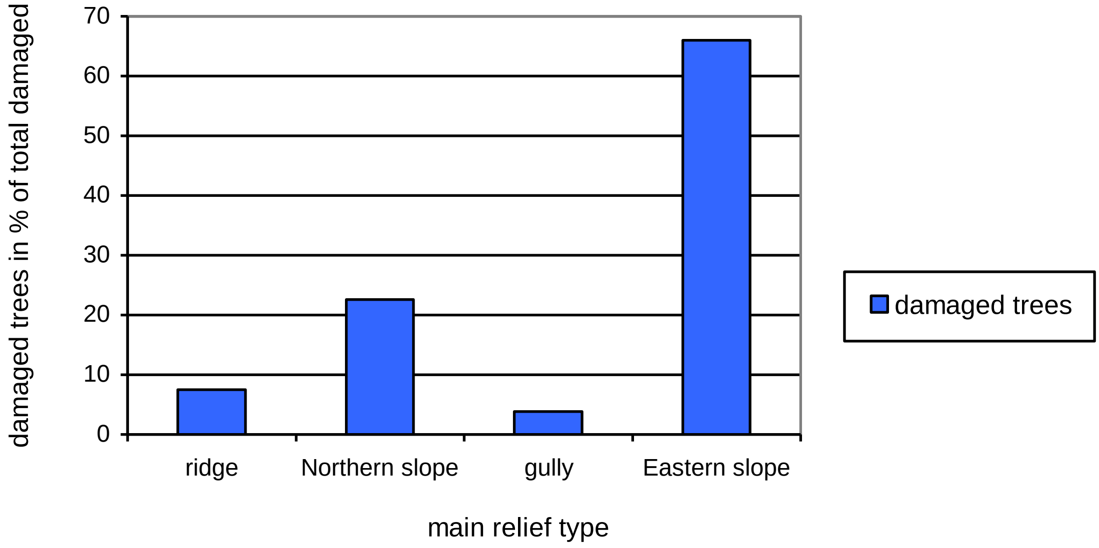

Figure 38: Percentage of total damaged trees distributed on the four main sites 2003

If the number of living trees at every main relief type is taken into consideration, the damage frequency looks as follows:

Table 10: Damage frequency in the four main relief types 2003

main relief type	number of trees alive	Number of damaged trees	damage frequency
ridge	309	4	1.3%
Northern slope	423	12	2.8%
avalanche gully	88	2	2.3%
Eastern slope	328	35	10.7%

On the Eastern slopes, the highest injury rates were observed; every tenth tree suffered from a stem damage. On the other three main relief sites the problem of stem damages as a factor for losses or reduced growth seems insignificant (1-3%). In the avalanche gully, only 88 trees are still alive unlike the other main relief types. Therefore, the damage frequency is quite low.

4.3.2. Stem damages of stone pine since 1995

The development of the percentage of damaged stone pines since 1995 is illustrated in Table 11. In 1995, 2.9% of the stone pines in the four sampling strips suffered from a stem damage. During the next four years, this rate increased to 28%, meaning that nearly every third tree was stem-damaged. In 2003 this rate decreased to every fourth tree that had a broken or split stem.

Table 11: Percentage of damaged pines in 1995, 1999 and 2003

	1995	**1999**	**2003**
Number of stems	314	180	112
Number of stem damages	9	54	28
Damaged trees in %	2.9	30	25

To get a better impression of the sites where stone pines get stem-damaged, we now focus on the number of damaged trees distributed among the four relief types (see Figure 39). It is clearly recognizable that the topography plays a decisive part: since 1995, the trees on the Eastern slope suffered the biggest impact of stem damages. The ridge location seems to be less affected of injuries since 1999. As always, the values of the gully are not representive because of the small stem number still alive.

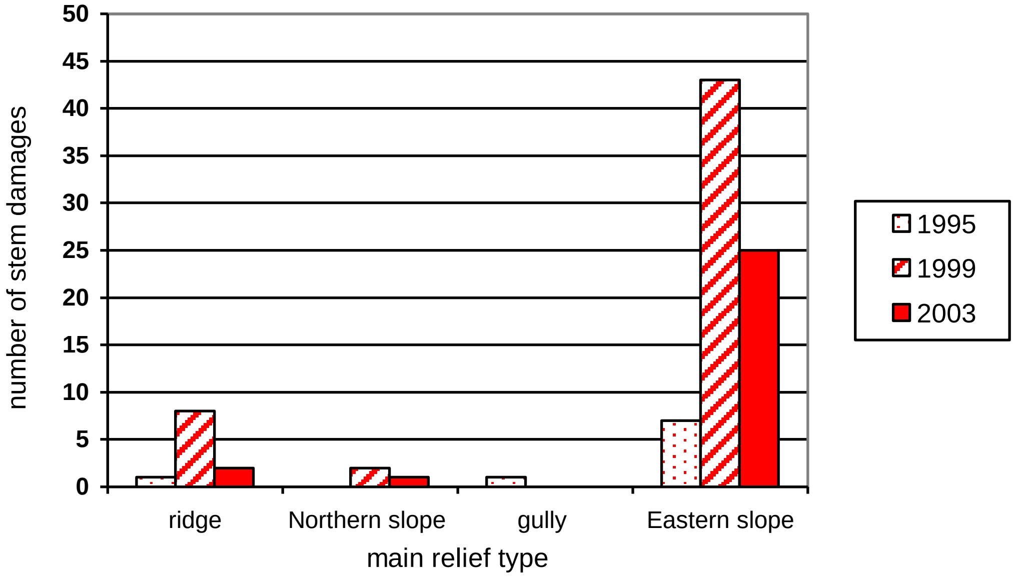

Figure 39: Number of stem damages in the four relief types in 1995, 1999 and 2003

The damage percentages in relation to the trees still alive are listed in Table 12: both the ridge- and Eastern slope sites have grown saver since the peak in 1999.

In the gully, no trees are left, so no reasonable answer can be given. The only main relief type which still shows an increasing damage-curve is the Northern slope. In 1995, no trees were stem-damaged; in 1999 nearly six percent of the trees were injured. In the last four years, the rate of increase was smaller than in the period 95-99, but still further increased to 8% happened.

Table 12: Frequency of stem damages on the four relief types in 1995, 1999 and 2003

	Damaged trees in % of all **1995**	Damaged trees in % of all **1999**	Damaged trees in % of all **2003**
ridge	0.8	11.3	4.5
North	0	5.6	8.3
gully	6.3	0	0
East	5.5	55.1	46.3

Comparing the damaged and undamaged stone pines, following results have been obtained. The mean tree height (137cm) of the damaged pines is 34% larger than the mean tree height of 102cm of the undamaged trees; the difference between the two heights is highly significant (Wilcoxon rank-sum test, $n_{damaged} = 28$, $n_{undamaged} = 84$, p-value = 0.0011).
Diameter1 of the damaged trees differs significantly from diameter1 of the undamaged trees (Wilcoxon rank-sum test, $n_{damaged} = 28$, $n_{undamaged} = 84$, p-value = 0.00). The median (dotted line in Figure 40) of undamaged pines amounts to 4.9cm, whereas diameter1 of the damaged pines reaches a value of 7.5cm.

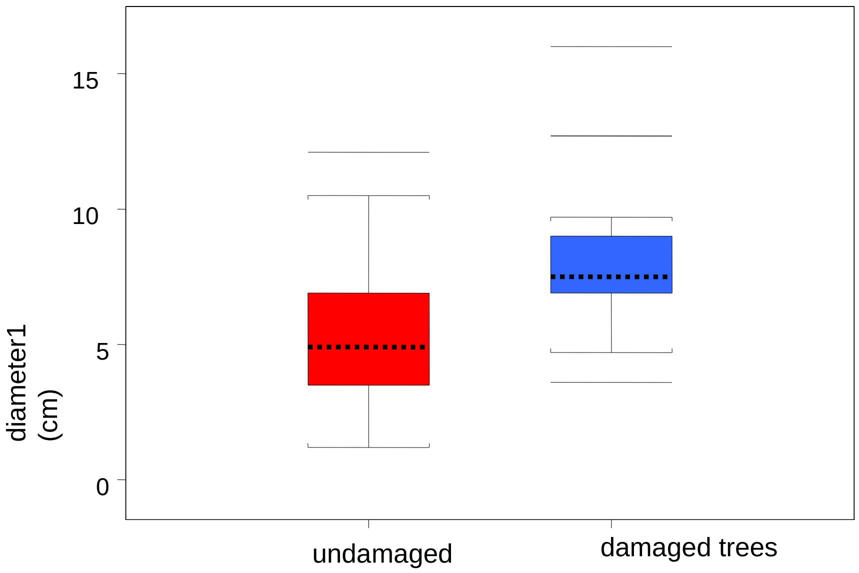

Figure 40: Mean diameter1 (measured in direction of the slope gradient) of undamaged and damaged stone pines 2003

Diameter2 is also highly significant different (Wilcoxon rank-sum test, $n_{damaged}$ = 28, $n_{undamaged}$ = 84, p-value = 0). The damaged stone pines have a 48% larger diameter1 and a 57% greater diameter2 than the undamaged.

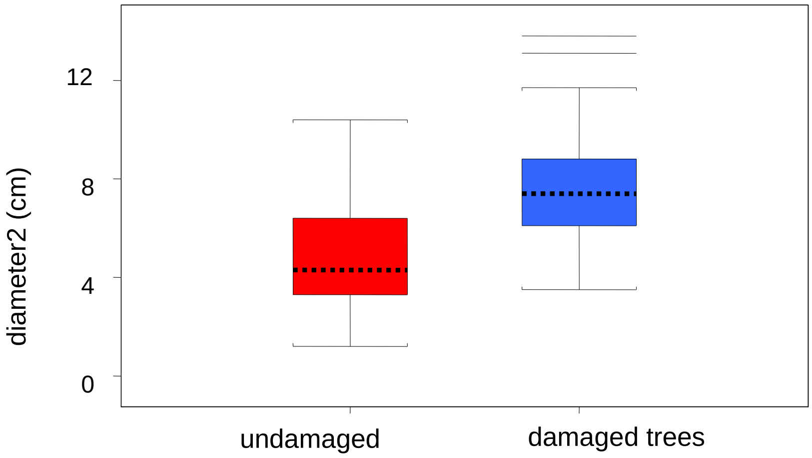

Figure 41: Mean diameter2 (measured in direction of the contour lines) of damaged and undamaged stone pines 2003

So far we have seen that the main relief type plays a decisive role for the frequency of stem damages and that there is a significant difference of tree heights and tree diameters between damaged and undamaged stone pines. In a next step, the damaged trees are extracted and the two diameters are looked at more precisely, because as seen above, this parameter seems to differ the most from the undamaged pines.

The different kinds of stem damages are illustrated in Figure 42. Two groups are formed: the stem splittings and the stem breakages (for definition see chapter 3.2). The stem breakages are located quite closely in a cluster, which ranges from 7.0-10cm for diameter1 and from 6.0–10cm for diameter2. In Figure 42, the mean diameter values of the undamaged trees are also plotted, so as to be able to define the critical range for stem breakages. This mean diameter amounts to 5.4cm for diameter1 and 4.9cm for diameter2. Broken trees have clearly larger diameters than unbroken trees. A different picture results from the stem splittings. Stem splittings happen earlier in “tree life”, because the values for both diameters are smaller than those of stem breakages. The values are much more scattered and there are outliers. The critical age for trees starts already when the stem reaches a diameter1 of 5cm and ends with 10cm or with 16cm, when the outliers are included. The critical values for diameter2 are situated between 5 -16.0cm or regarding the outliers from 4.0–14.0cm. Interesting is the aspect that some of the values for splittings are below those of the mean diameter of undamaged trees. So potentially all these trees lie in the critical zone for stem splittings, but other parameters such as the main relief type are more decisive than the tree diameter.

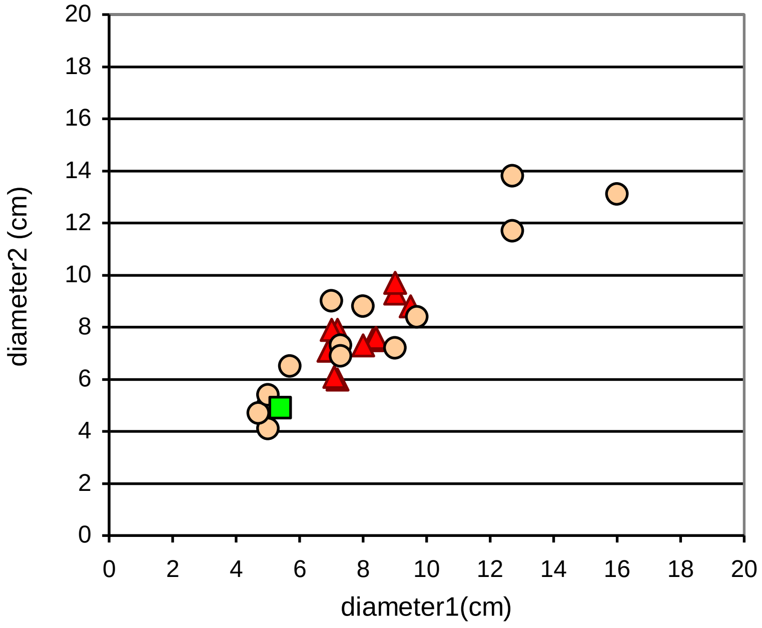

Figure 42: Diameters of broken or split stone pine stems in 2003. Observed stem damages of stone pine trees in dependence of the two diameters, measured in the direction of the slope gradient (diameter 1) and in direction of the contour lines (diameter 2)

○ stem splitting ▲ stem breakage ■ mean diameter of undamaged pines

In order to track the development of the splitting- and breakage-frequency, the data of 1995 and 2003 is compared. In 1995, 1% of the stone pines had a stem breakage and 2% a stem splitting. Eight years later 10% of the trees had a broken and 15% a split stem.

4.3.3. Stem damages of larch since 1995

The development of the percentage of damaged larches since 1995 is illustrated in Table 13. In 1995, only 0.4% of the trees in the four sampling strips suffered from a stem damage. During the next four years this rate increased eightfold to 3.2%. In 2003, the rate decreased again to 2.4%. Comparing the result of stone pine, where every fourth tree is damaged, only one of 26 larches has a broken or split stem.

Table 13: Percentage of damaged trees in 1995, 1999 and 2003

	1995	1999	2003
Number of stems	1137	1109	1037
Number of stem damages	4	35	25
Damaged trees in %	0.4	3.2	2.4

To get a better impression of the sites most susceptible to stem damages, the number of damaged trees is distributed among the four relief types (see Figure 43). Relating to the frequency of damaged trees on the different main relief types, there have been a few changes in the last eight years. In 1995, the larches in the avalanche gully and on the Eastern slope suffered the equal impact of stem damages. In 1999 on all four relief types stem damages were recorded. Both the Northern and Eastern slopes were highly susceptible to damages. In the last four years, the number of stem damages has decreased in all main sites except the ridges where it remained stable.

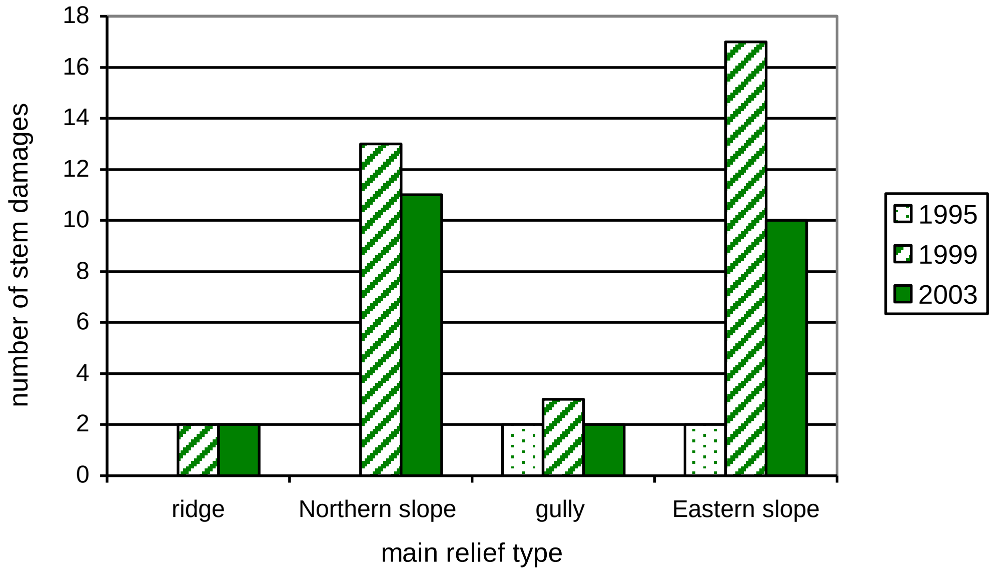

Figure 43: Number of stem damages in the four relief types in 1995, 1999 and 2003

Regarding the damage percentage, bearing the number of trees still alive in mind, all main relief sites except the ridges have been less affected by stem damages since the peak in 1999. Especially on the Eastern slopes the percentage of damaged larches has decreased (-2%). The only main relief type which still shows an increasing damage-curve is the ridge. In 1995, no trees were stem-damaged; in 1999, 0.7% of the trees were injured. In the last four years there was a slight increase to 0.8%.

Table 14: Frequency of stem damages in the four relief types in 1995, 1999 and 2003

	Damaged trees in % of all **1995**	Damaged trees in % of all **1999**	Damaged trees in % of all **2003**
ridge	0	0.7	0.8
Northern slope	0	3.0	2.7
gully	2.0	3.3	2.3
Eastern slope	0.7	5.9	3.9

Comparing this last result to stone pine, there is a difference between the two conifers. In 2003, larch has the highest number of stem damages in the Northern slopes whereas stone pine suffers most damages in the Eastern slopes. But if keeping the development since 1995 in mind, following pattern arises. The Northern slopes are the only main relief types where the damages frequency is still increasing for stone pine, whereas it is the ridges for larch.

Comparing the damaged and undamaged larches with each other, following observations resulted. The damaged larches (225cm) are 39% taller than the undamaged trees (161cm); the difference between the two heights is highly significant (Wilcoxon rank-sum test, $n_{damaged}$ = 25, $n_{undamaged}$ = 1012, p-value = 0.0018).

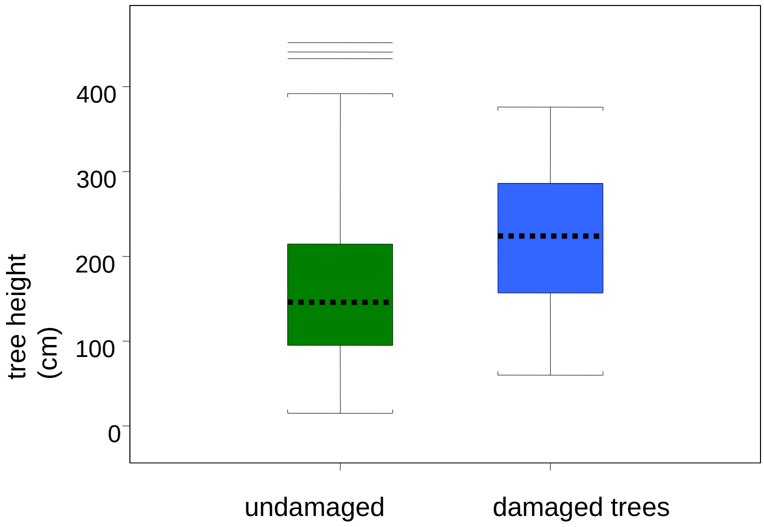

Figure 44: Mean tree height of damaged and undamaged larches in 2003

Diameter1 of the damaged trees differs significantly from diameter1 of the undamaged trees (Wilcoxon rang-sum test, $n_{damaged}$ = 25, $n_{undamaged}$ = 933, p-value = 0.0003). The median (dotted line in Figure 45) of undamaged larches amounts to 4.9cm whereas diameter1 of the damaged larches reaches a value of 7.1cm.

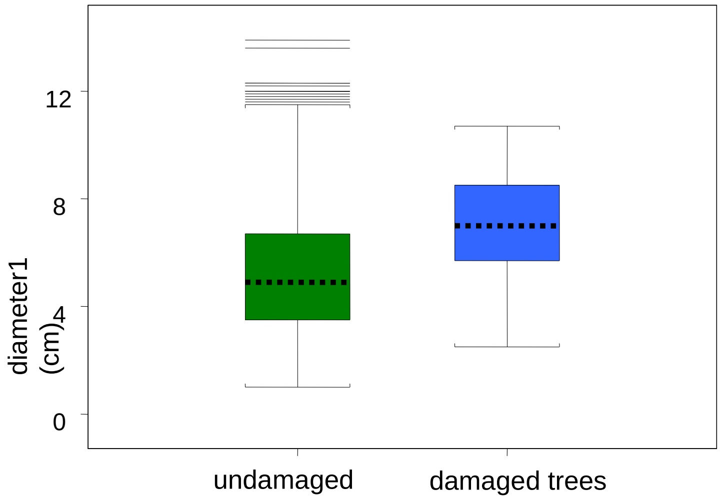

Figure 45: Mean diameter1 (measured in direction of the slope gradient) of undamaged and damaged larches in 2003

Diameter2 is also highly significant different (Wilcoxon rang-sum test, $n_{damaged}$ = 25, $n_{undamaged}$ = 933, p-value = 0). The damaged larches have a 37% larger diameter1 and a 40% larger diameter2 than the undamaged.

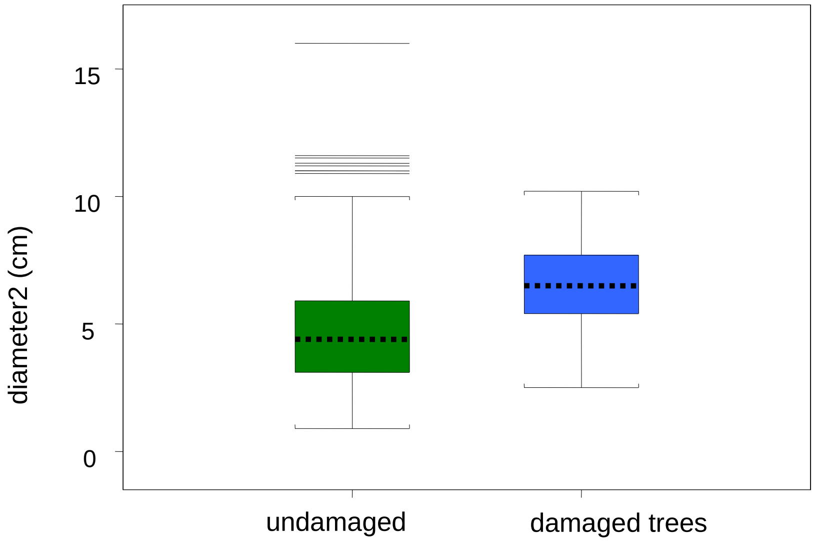

Figure 46: Mean diameter2 (measured in direction of the contour lines) of damaged and undamaged larches in 2003

The comparison of damaged and undamaged larches and stone pines turned out very similar. With both tree species, the difference of tree height, diameter1 and diameter2 between damaged and undamaged trees is highly significant. Damaged stone pines are 34% taller, had a 48% larger diameter1 and a 57% larger diameter2 than the undamaged pines, whereas damaged larches are 39% taller, had a 37% larger diameter1 and 41% larger diameter2 than the undamaged. The damaged trees of both species distinguish most with diameter2 from the undamaged.

In Figure 47, the diameter values of split and broken larches are plotted. Both kinds of stem damages are restricted to a range of diameters between 5–11cm for diameter1 and from 5-10cm for diameter2. The mean diameter of the undamaged larches lies with 5.2cm for diameter1 and 4.7cm for diameter2. The values of the stem breakages lie above that mean diameter of undamaged trees whereas stem splittings occur also below this mean diameter. The critical range for splittings starts already when the stem reaches a diameter1 of 5cm and ends with 11cm. The critical values for diameter2 are situated between 5 and 10cm. The critical range for stem breakages seems to be smaller: the values of diameter1 and diameter2 lie between 5.5cm and 8.5cm.

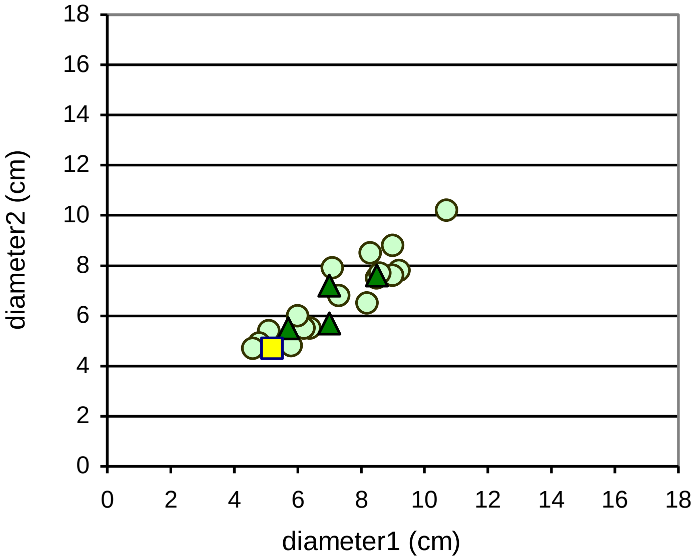

Figure 47: Diameters of broken or split stone pine stems in 2003. Observed stem damages of stone pine trees in dependence of the two diameters, measured in the direction of the slope gradient (diameter 1) and in direction of the contour lines (diameter 2); ○ stem splitting ▲ stem breakage ■ mean diameter of undamaged larches

Comparing the critical stem diameter values of stone pine and larch, it is clearly visible that the main damage period for both tree species lies between a diameter of 6 and 10cm. Values of the diameters of broken trees are clustered, those of split stems vary in a wider range.

In order to follow the development of the splitting- and breakage-frequency of larch, the data of 1995 and 2003 is compared. In 1995, 0.3% of the larches had a stem breakage and 0.1% a stem splitting. Eight years later, 0.5% of the trees had a broken and 2% a split stem. The frequency for a stem damage has increased insignificantly (stone pine: tenfold), whereas the frequency for stem splittings has doubled (stone pine: sevenfold).

Another difference between stem splittings and breakages is the height of damage on the stem. The splittings occur at an average height of 23cm above ground whereas the breakages have a mean height of 86cm. A larch at Stillberg with an average height of 162cm is prone to split at the stem base on the valley side at about 25cm above soil level, higher up the stem at about 80cm breakages domineer. To complete the "damage pattern" of a single tree, branches ripped off by avalanches can be found on the uphill side of the stem at an average height of 92cm (see Figure 48).

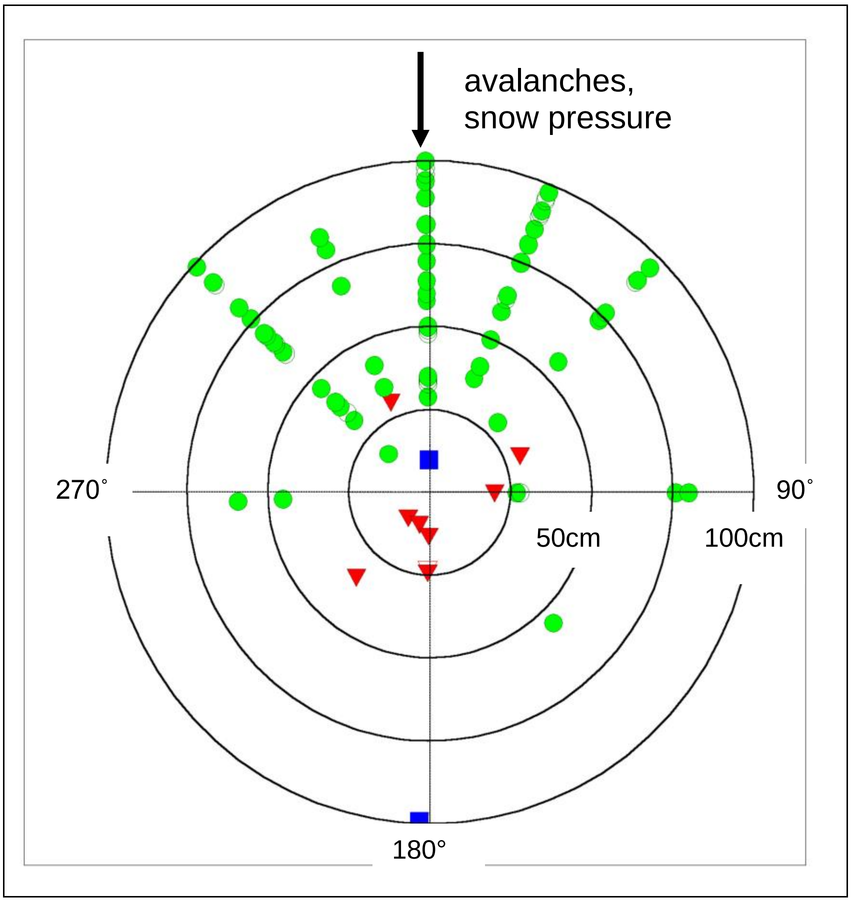

Figure 48: Damage pattern and damage height on the stem of a larch. This figure was done with the larch data of the lowest strip in the avalanche gully. The damages were measured in degrees and exposition. For a better view, only the cross section from stem base up to 1m is illustrated. Most of the stem breakages occur higher than 1m above ground, and therefore do not appear in this figure.

●: ripped off branches ■: stem breakage ▲: stem splitting

4.3.4. Model for stem damages

Which variables influence the damage probability for a tree? To answer this question a logistic regression model (see chapter 3.3) was constructed which predicts the probability of a stem damage in dependency of the most important tree- and site parameters. The model consists of following variables:

- Dependent: damaged (binary: stem damage, yes or no)
- Explanatory categorical: tree species, four main relief types, radiation
  Explanatory continuous: tree height, diameter1, diameter2, avalanche frequency, mean snow height, altitude, inclination of site, date of snow disappearance

The model was simplified with a stepwise reduction of variables (Backward Stepwise Likelihood Ratio). The one variable which influences the model the least (no significance) is removed from the model. This procedure is repeated until only variables remain in the model which contribute to the explanation of the model. In this case six steps were necessary and accordingly six variables were eliminated (see Table 15). Step 1 removed the variable "snow height" from the model. In the next steps "altitude", "tree height", "inclination" and "date of snow disappearance" were excluded. All these variables do not affect the damage probability of a tree.

Table 15: Variables removed on each step from the model

Variables not in the Equation (Variables removed on each step)		
Step	Variable	Sig.
2	snow height	0.741
3	altitude	0.685
4	tree height	0.496
5	inclination	0.408
6	date of snow disappearance	0.195

After the last step following variables, which contribute considerably to the explanation of the model, were left in the model (see Table 16): diameter2 (measured in direction of the contour lines), tree species, avalanches, radiation, diameter1 and main relief type. Only four of these variables are statistically significant; these are: diameter2, tree species, avalanches and radiation. I exclude the variable "radiation" from my reflections, because the significance threshold is barely reached and secondly the variable is subjected with a certain lack of precision and autocorrelation (with main relief types).

Table 16: Variables which contribute to the explanation of the model for stem damages (B: value. S.E: standard error. df: degrees of freedom)

Variables in the Equation				
Step 6	B	S.E.	df	p-value
diameter2	1.058	0.336	1	**0.002**
tree species	2.054	0.687	1	**0.003**
Avalanches	0.178	0.083	1	**0.033**
Radiation	-15.93	30.66	9	0.048
diameter1	-0.547	0.302	1	0.070
Main relief type	-24.12	59.76	3	0.814

In the following, I only want to consider more closely the three variables which are highly significant and accordingly the most influencing concerning the likelihood for stem damages.
Taking an error probability of 5%, the variables “diameter2”, “tree species” and “avalanches” are all significant. Hence, the model defines with three explanatory variables the probability for stem damages.
The tree classification model certifies the results of the logistic regression model. Figure 49 illustrates the hierarchical, shrunken structure of the tree. Starting at the root, the first node uses the variable “tree species” to split the data into two subsets. Hence, one subset relates to larch, the other to stone pine. The highest damage probability for both tree species is reached with the following two paths: the larch data set uses “altitude” next to split yet again the data, the last node uses diameter2. Larch trees below an altitude of 2097m a.s.l and a diameter larger than 7cm have a stem damage probability of 0.6. The stone pine subset uses “diameter2” already at the first split, then it uses “avalanches” and the last node is split by the variable “inclination”. Stone pines have a damage probability of 100% if diameter2 exceeds 6.5cm, at least every third winter an avalanche occurs and the inclination is steeper than 49˚.
The variables “diameter2”, “tree species” and “avalanches” are represented in both models whereas the tree-specific explanatory variables “inclination” and “altitude” are only found in the tree classification model.
Comparing the two tree species, the damage probability differs: for larch, no variable combination is found where the damage probability reaches a 100 percent probability.

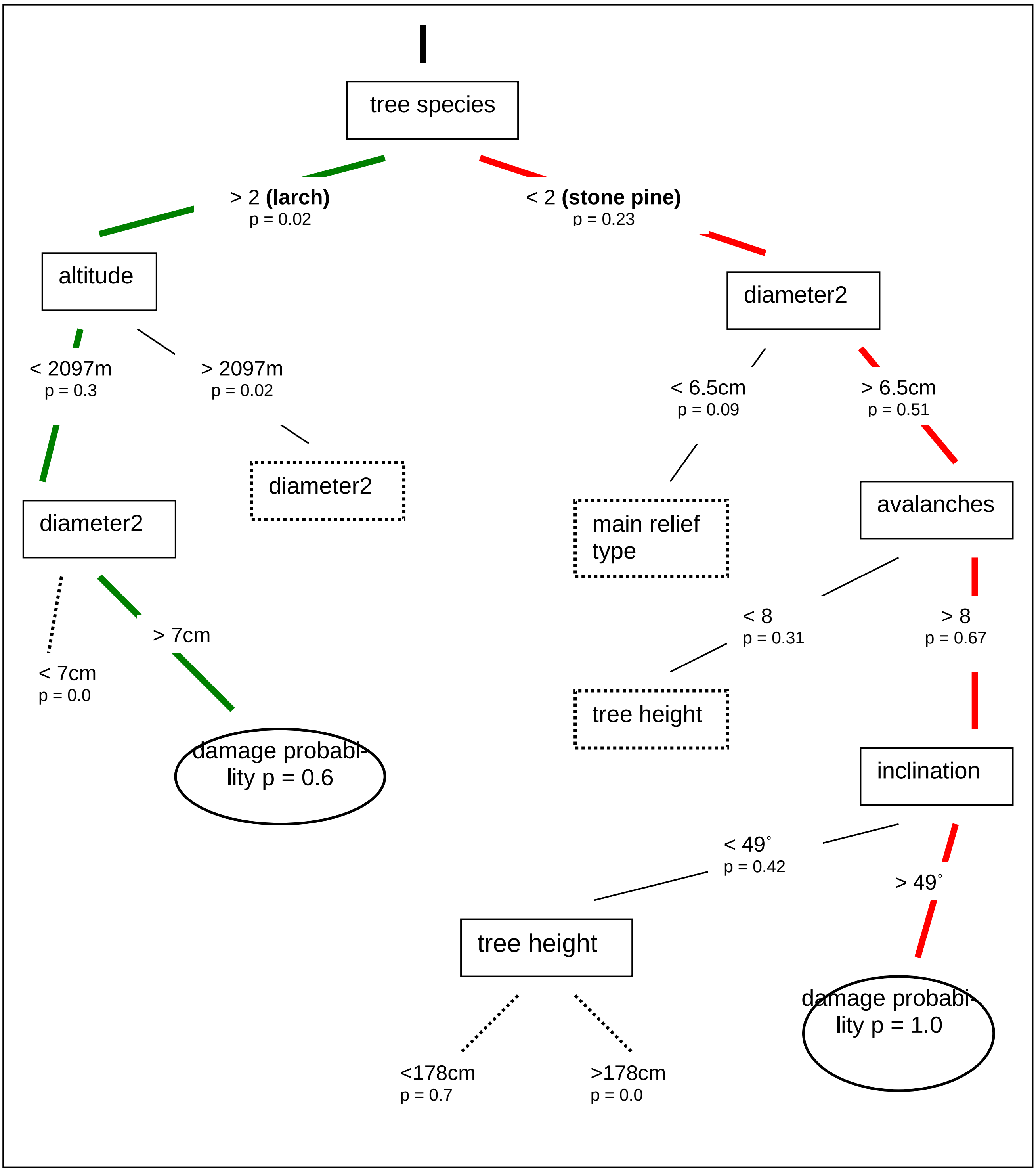

Figure 49: Tree classification model for stem damages. (Marked out is the path where the damage probability is highest: red = stone pine, green = larch. Dotted lines indicate that the model splits the data into further branches, but they are statistically no longer significant; p = damage probability of each branch)

5. Discussion

5.1. Survival and growth of larch and stone pine in the avalanche release area

5.1.1. Survival of larch and stone pine

Since 1975 the survival rate of larch and stone pine had developed completely different (see chapter 4.1, Figure 17). 28 years after planting, ten times more larches than stone pines are alive. This result is quite interesting, because first, on acid soils stone pine dominates the highest locations in the continental inner Alps (AULITZKY and TURNER 1982). The area of optimal growth lies between 1700 and 2300m a.s.l. The Stillberg afforestation is situated in this altitudinal range (2080 – 2230m a.s.l.). And second, stone pine was the only local conifer which inhabited the ridges of the Stillberg area before planting. This fact coincides with reports published by TRANQUILLINI (1979) which say, that *Pinus cembra* is confined to the ridges and is completely absent from intervening depressions. BISCHOFF (1984) is more precise with his statement for avalanche release areas: stone pines are confined to rocky ridges high up on the slope, because presumably there are less or no damaging impacts due to avalanche activities.

These autochthonous pines at Stillberg are about 200 years old and therefore considerably taller than the planted pines (see Figure 50). The local pines also indicate that the conditions for survival and growth for stone pines in the afforestation are possible and competitive in ecologically adequate niches. It is therefore surprising that only 6% of the 1769 planted pines are still alive. These are mostly found in their natural habitat, namely on the snow-poor Eastern slopes and ridges. But even on these sites, the pines did not fulfil the expectations: only 14% of the trees on the Eastern slopes, respectively 8% on the ridges have survived. In this case, the topographical factor does not have a positive influence on the survival rate (see Figure 21). The meagre survival in the other two main relief types does not surprise. In the through-like shape of the avalanche gully there are snow movements, and late date of snow disappearance and the with it connected fungal diseases on the Northern slopes do not meet the ecological preferences of stone pine: in the gullies a mere 0.7% of the planted trees, respectively 2% in the Northern slopes, subsisted under these harsh conditions. In one of the next hard winters even those last survivors will probably cease to exist.

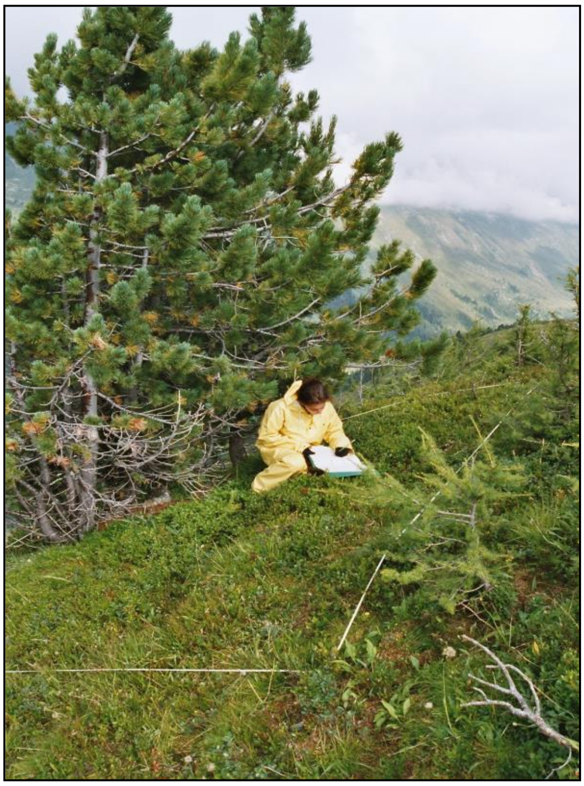

Figure 50: Autochthonous stone pine stocking on the ridge, square unit No. 1860

In 1975, in 77 square units 1769 stone pines were planted. In 2003, 41 square units had no trees left and in the remaining 36 fields at the maximum ten trees have survived. Considering that each square unit was routinely planted with 25 trees, this result is actually quite devastating. By comparison, in 74 square units 1628 larches were planted and in 15 units 21-25 trees and in 22 units between 16 and 20 trees have survived.
The survival rate of larch (63%) is unexpectedly high. In nature, larch stocks on a variety of microsites. Therefore the micro relief offers for the establishment of larch more favourable and more numerous locations than for stone pine(see Figure 20). Figure 19 illustrates this fact clearly: 77% on the ridges, 73% on the Eastern slopes and 68% of the trees on the Northern slopes have survived. The avalanche gullies are the only main relief type where the planting success is expressed by the low survival rate of 31%. The fierce competition with *Calamagrostis villosa* is probably the reason why many of the small, light-demanding larch saplings have been eliminated in the first years (see Figure 51).
In the Alps, larch is normally not represented at the highest elevations, because of its susceptibility to frost drought; stone pine is extremely frost-resistant and its needles are well adapted against desiccation. This fact is reflected in Figure 23. The altitudinal decrease of the survival rate is especially pronounced in the Northern slope, where the low radiation rate with increasing altitude is particularly visible: in the lowest strip-3 81% of the larches are still alive whereas 80m higher in strip-1 only 26% of the planted trees have survived.

In one main relief type – the avalanche gully - this principle is not obvious. There the altitudinal parameter is overruled by the mechanical impacts of snow and avalanches which lead to an increase of survival chances with altitude.

Figure 51: Chances of survival in the avalanche gully are strongly influenced by *Calamagrostis villosa* and avalanche impacts

Different authors (AULITZKY 1963, IN DER GAND 1968, FREY 1977, AULITZKY und TURNER 1982) describe another fact for the absence of larch in steep mountain slopes near timberline: in steep terrain, moving snow (especially snow creeping and gliding) affects the growth and shape of stems (see Figure 32). On slopes exceeding 35°, diameter1 is 13% larger than diameter2 whereas on slopes with an inclination less than 35°, diameter1 is only 5% larger. Sabre growth of the stems is a site modification, to which larch is much more susceptible than stone pine. MÖSSMER (1994) studied young larches in steep mountain slopes and discovered that only one out of three trees had a straight and upright pole. With increasing tree height sabre formed stems have been the rule.

The tendency to develop sabre growth varies between both deciduous and coniferous tree species and therefore it is essential to bear that fact in mind when choosing the tree species for an afforestation. FREY (2001) constructed an index which describes the tendency of a tree species to develop sabre growth. The index extends from 0 (no sabre) to 10 (very strong sabre). Spruce has the lowest index of 3; willow and birch are on top of the ranking with the highest value of 7.4. The two investigated tree species differ: FREY (2001) gives an index of 3.6 for stone pine and 4.8 for larch. Accordingly, sabre growth is more often observed with larch. These index values are supported by my evaluation in chapter 4.2. Trees under snow pressure react with compression wood and consequently with a sabre-growth to prevent the stem from tilting to the valley side.

This reinforcement of the stem resistance goes along with a non-centric stem cross section. In my sample data, the difference of stem cross sections between the two tree species is reflected by the two following diameter values (see Figure 32): larch diameter1 differs statistically highly significant from diameter2, whereas the two diameter values of stone pine are equal. Hence, larch tends to have an oval stem cross section (especially on slopes exceeding 35˚) and consequently develops sabre-growth, whereas stone pine has a circular stem resulting with a straight stem. Due to its susceptibility for sabre-growth, the use of larch in afforestations near timberline is said to be restricted to slopes with less than 35˚ inclination (AULITZKY und TURNER 1982). In my four sample strips, the inclination of slope lies between 33˚ and 57 ˚, but sabre-growth does not seem to be a limiting factor for the survival of larch (see chapter 5.1.2). Obviously, larch is well adapted and thus suited for planting in snow rich and steep locations. In addition larch is favoured by the fact that snow fungi can not harm them, because the needles are shed in autumn.

At Stillberg, another advantage for larch results out of the planting pattern. Out of the originally 25 trees planted in one larch square unit, in general 15 to 20 trees have survived and grow now in clusters. These clusters have the advantage, that the trees protect each other from damaging influences such as avalanches (see Figure 52). If the trees are high enough, they may even be able, first, to break the power of a small avalanche and second, to divert the flow of the snow around the colony.

BISCHOFF (1984) reported that he discovered an accumulation of pure larch stands alongside of avalanche paths, particularly in the inner Alps. There they occupy this preferential position, because their branches and crown are bare of needles and are therefore less affected by air turbulences caused by avalanches. Accordingly larch has the capacity to settle and to survive in avalanche release zones. Stone pines get established and thrive only in the interior of the protective shield of surrounding larches.

Figure 52: Clusters of closely growing larches (“Rotten”)

While doing field work in summer 2003, I observed several times that the trees in the uppermost row in the cluster of larches show stem damages whereas the remaining trees in the compact cluster were unharmed. On the other hand, it is important to remember that under natural conditions, larch is a light-demanding species and tends to grow solitary and not in clusters (“Rotte”). The future will demonstrate whether or not the disadvantages of these very closely clusters, e.g. competition, outweigh the function of avalanches protection, which has predominated until now.

For reforestation in avalanche starting zones, larch and stone pine are suitable tree species in ecologically adequate locations (MAYER und OTT 1991):
Young larches grow fast and therefore reach comparatively quickly the height when their stems can stabilize the snow. Its only disadvantage is the proneness for snow creeping and gliding (sabre growth). On the other hand, the densely branched and evergreen stone pines are reported to influence the snow distribution and interception which are important factors to prevent the starting of avalanches on and near ridges. Unfortunately they are much less adapted to snow and avalanches. In addition the extremely slow growth prolongs its exhibition to and stress caused by pathogenic fungi.

Table 17: Characteristics of the two tree species (MAYER und OTT 1991)

Characteristics	**Larch**	**Stone pine**
Avalanche stability	good	medium-good
Danger of gliding snow	high	low
Snow interception	low	high
Influence of snow equalization	insignificant	good
Wound healing	very good	good
Youth growth	fast	slow

MÖSSMER (1994) describes the different characteristics to evaluate the resistence of trees as follows: growth form, elasticity, winter bareness, bending strength and resistance against mechanical damages are the most important parameters for a tree to survive the forces of snow creeping and gliding. Larch is one of the hardiest and toughest conifers in the Alps, and in addition, its mechanical properties are excellent (BOSSHARD 1982). The wood of stone pine is soft, fibrous, light and not lasting (BOSSHARD 1982).

5.1.2. Growth of larch and stone pine

Stem diameter growth decreases with altitude just as total height and leaf growth (MAYER 1978). Concerning larch (see Table 7) this data is supported by my own observations: the largest altitudinal difference in my sample is 80m between strip-1 and strip-3. Larches in strip-1 are 40 to 60% smaller than in the lower strip-3. Converting this percentage value in meters, it amounts to 0.5-1.5m tree height difference per 80m altitudinal difference. This value lies clearly below the values of MAYER (1978) who measured above 1800m a tree height decline of 3 to 5m with every 100m in altitude. The range of these values varies considerably, mainly because of the influences of topography. In 2003, the tree height decrease in relationship with altitude was particularly visible on the ridge site. It seems that the altitudinal parameter plays a decisive role, whereas in the other three main relief types other factors are more important.

The same pattern is found for stem diameter growth, although various site factors influence diameter growth so that its correlation with altitude is less strong than with height growth (TRANQUILLINI 1979). Larches in the highest strip have only a 5 to 30% smaller diameter than larches in the more favourable lowest strip. This result is supported by the observations of DÄNIKER (1923) and OSWALD (1969) who state: "…diameter increment does, however, appear to decline less with altitude than height growth".

At Stillberg, the comparison of tree growth between the two coniferous tree species comes out in favour for larch, although larch had the disadvantage of a smaller planting size as compared to stone pine. It is a well-known fact that the growth of stone pine, especially in the first years, is extremely slow and reaches after 20 years a height of 60 to 90cm only (MAYER and OTT 1991). In the Stillberg afforestation, mean tree height of the 20 year-old trees amounted to 60cm. Ten years later, they measured in general 96cm at 2140m a.s.l. whereas OSWALD (1963) reported that 30 year-old pines at 2190m a.s.l. had reached already a height of 110cm.

MAYER and OTT (1991) define the yearly growth rate between 3.4 to 8.3cm of young stone pine as very low. The mean growth rate of the Stillberg pines lies with 4.1cm within these values. The larches grow with 7.9cm per year nearly twice as fast, although their annual assimilation period is much shorter as compared to the evergreen stone pine. This disadvantage is compensated by the more than double assimilation rate of larch needles (TRANQUILLINI 1979).

In 2003, the height lead of the 29 year-old larches amounted on average to 52cm as compared to the 33 year-old stone pines. But regarding tree height, FROMME (1963) emphasizes that stone pines will finally match the height of larches after 30 to 40 years of age.

5.2. Stem damages in the avalanche release area

Stem damages are especially in the subalpine belt important. FREY (1977) refers to a "second critical age period" for the trees when the elasticity of the stem has already declined, but the resistance of bending of the stem does not yet withstand all impacts.

The number of damages is strongly related to high snow cover and mechanical impacts. Common damages through snow movements (avalanches, creeping and gliding) are stem breakages, stem splitting and broken off branches. The practical consequences are that small damages and in particular the sum of all damaging factors endanger, in the course of time, the success of the afforestation (FREY 1977).

First, I want to discuss the development of the damage frequency since 1995 (see Table 9 and 13): the general course of the curve is for both tree species the same. In 1995, practically no stem injuries were observed. In the period 1995 to 1999, the frequency for a stem damage increased markedly (eight to ten times) and reached a climax in 1999. The extraordinary winter 1998 / 1999 shows what a disastrous effect an event outside of the normal can have on the afforestation. After the peak in 1999, the damage frequency decreased by about 20%. This surprising result could be related to different causes. 1. Either the trees have outlived the most critical age period or the snow impacts were less intensive during the last years or the critical sites are already devoid of trees. 2. Another possibility of explanation would be the exclusion of the "worst case scenario" of 1999. Then, the course of the damage frequency would probably correspond to the natural occurring rate of injuries, because the trees at Stillberg begin to reach the critical age period where they are susceptible to stem damages.

Although the development of the damage frequency looks the same for both conifers, the level of damage is strikingly different: in 2003 every fourth stone pine is stem-damaged whereas only every 30th larch is injured.

In pertinent literature, the critical heights for stem breakages are reported to vary between one to five meters: AULITZKY AND TURNER (1982) argue that the stems of trees with less than 1m crownheight are normally just bend and not broken. SCHILCHER (1964) found the critical height to be 2 to 4m whereas for ZENKE (1985) trees between 2 and 5m are affected. MAYER and OTT (1991) emphasized that trees in the range between 1-5m are destroyed by avalanche effects either entirely or partly through stem breakage.

Looking at my data of 2003, the tree height of the damaged trees seems to be subject to considerable variations. For both tree species, the smallest values lie around 75cm. An increased occurrence and thus accumulation of stem damages starts beyond the height of one meter. Defining the upper limit of height for damages on trees is difficult, because not many larches and none of the stone pines so far have reached a height over three meters.

Statistically well proven is the fact that 82% of the damaged larches and 83% of the stone pines are taller than the average, undamaged trees. However, the results of the regression and tree classification model have shown, tree height is not a decisive criterion for the probability of a stem damage. Quite often the leader of stem has been trimmed or broken off by an avalanche and therefore the tree height does not correspond to its potential (original) height.

FREY (1977) mentions that breakages on the stem occur mostly near ground level or between 0.75m and 1m above ground. At Stillberg, the position of recent damages was recorded only in 2003. Therefore a conclusive answer is not possible, because only three larches and three stone pines showed recent stem breakages. The height above ground varied between 0.2m and 1.50m, with the mean value at about 0.80m. I think that the actual position of breakages can only be correlated with the height of snow. In an avalanche release area, only the top of a tree, poking through the snow cover, is susceptible to stem breakage whereas the rest of the stem and its branches are protected by the snow pack. In afforestations at high altitudes, the critical limit of snow height is determined by FREY (1977) with 50-100cm. With other words, the presence or absence of the tree species appears frequently to be a matter of "enough but not too much snow" (ARNO 1984).

A more differentiated statement can be given for the height (position) of stem splittings. The values for nine stone pines and 16 larches fluctuate between 0.2 and 0.4cm (the average about 0.25m). The range for the height values of splittings is much smaller than those of the breakages. It seems that the mechanical weak point is situated near the base of the stem, regardless of snow cover height. Possibly, sabre-shape is tightly connected with loss of stem flexibility and thus enhances the susceptibility for stem splittings. The observed location of the splitting, always on the valleyside at the stem base of a tree (see Figure 48), certainly correlates with the weakest point in a sabre-formed stem. Also the large number of split larch stems does support my assumption (see chapter 5.1.1)

The critical period for stem damages is defined more precisely with stem diameter values. The same conclusion was expressed by MEARS (1975) and JOHNSON (1987). Those authors circumscribed the susceptible age period for trees with a stem diameter between 10 and 14cm or greater than 6cm, respectively. But out of these two publications it is not clear if diameter values are measured in direction of slope gradient (diameter1) or contour lines (diameter2). Evaluating my data, both statistical models show that diameter2 is the most decisive factor concerning stem damages, independent of tree species. It is also interesting to see that the critical stem diameter can also be defined quite clearly, and the size values are the nearly the same for both tree species. In general, the critical sector for both stem splitting and breakage begins when the stems of young trees reach diameters around 6cm and the risk of damage is getting lower in trees with a stem diameter of 9cm to 10cm (see also chapter 4.2. figure 42 and 47). The tree classification model gives precise diameter2 values for both tree species: 6.5cm for stone pine respectively 7cm for larch. The risk of stem splittings, however, starts earlier in tree life, but also lasts for a longer period of time than in the case of stem breakages. Especially stone pine shows a very narrow value range for breakages, namely with stem diameters between 6 and 10cm. The values of the splittings are much wider dispersed and particularly at the higher end of the range there are outlier values. It is open to speculation that trees with a sabre-formed stems suffer from a certain lack of stability at the base throughout their lives.

Looking at Figure 42 and 47, the mean diameter value of the undamaged trees is also plotted. With both tree species it is found at the lower end of the period when damages (splittings) begin. Hence, the critical period for stem damages has just started at Stillberg and based on the presented data, within the next years an increase in damage frequency can be expected.

Diameter2 of damaged larches was significantly larger (+41%) than for undamaged larches. The same fact is valid for stone pine, diameter2 of damaged pine is even 57% bigger. The logistic regression model revealed that diameter2 is the paramount factor for the likelihood of stem damages. This result makes sense, because diameter2 is directly exposed to all kinds of snow forces (see Figure 32). Hence, diameter2 is more critical for stem damages than diameter1. It is therefore important to measure the stem diameter not only in direction of the slope gradient, but more important also in direction of the contour lines! Another interesting fact can be deducted from these pair of diameter values. I found the cross sections of larch to be oval (main axis in the direction of the slope gradient; see also Figure 32), but round for stone pine. If this observation is related to diameter2, an interesting biological aspect arises: larch with its oval stem base (and the connected smaller diamater2 value) reaches the critical stem diameter (~6cm) later than stone pine. That may partly account for the fact that every fourth stone pine is already stem-damaged whereas the damage frequency of larch is much lower. According to this hypothesis, the damage frequency of larch should is going to increase within the next years when more larches reach the critical stem diameter2.

Keeping this critical diameter2 value of 6cm in mind, it does not surprise that most of the stem damages (66%) have been observed on the Eastern slopes. VANOMSEN (1999) made the same observation: the Eastern slopes are the only main relief type where growth conditions are favourable, so that the trees have reached the required stem diameters. On the other main relief sites, only individual tree specimens are large enough. Accordingly it must be taken into account that in the coming years the stem damage frequency will also increase on the ridges and the Northern slope. Probably the same explanation is valid for the variable “altitude” in the tree classification model. The larches in the lower part of Stillberg have better growth conditions (see Table 7) than those on the higher slopes. Therefore, diameter2 values exceed the critical 7cm above all below the 2097m a.s.l which are calculated by the tree model. On the other hand, the variables "inclination" and "avalanches" which are decisive for stem damages with stone pines seem to be indifferent to this growth parameter. It makes sense that with increasing avalanche frequency the damage probability increases also. The increase of injuries in steeper slopes (> 49˚) is probably connected to the increase of snow movements and snow pressure.

The binary regression model has a certain weakness concerning the autocorrelation which plays a decisive role in the planting pattern of the Stillberg afforestation. Therefore the results of the regression model are only taken as an approximate value. On the other hand, the results of the regression model are confirmed by the results of the tree classification model. Hence, the results of the regression model obtain certain validity despite of the mentioned problem of autocorrelation.

Figure 53: Larch growing at Stillberg in May 2004

6. Conclusion

Since 1975 the survival rates of larch and stone pine were completely different. In 2003, 64% of the 1628 planted larches were still alive, whereas only 6% of the 1769 planted stone pines had survived. This result was quite interesting, because stone pine was the only local conifer which inhabited the rocky and exposed ridges of the Stillberg area before the afforestation has been established. This result indicates that the conditions for survival and growth for stone pines in the afforestation are possible only in ecologically adequate niches. The planted pines still alive, are found mostly in their "natural" habitats, namely on the snow scoured Eastern slopes and ridges. But even on these sites, the pines did not fulfil the expectations: only 14% of the trees on the Eastern slopes, respectively 8% on the ridges have survived. The microrelief provides favourable conditions for establishment and survival of larch on more numerous locations than for stone pine, which is shown by the much higher survival rates. Larch survived best on the ridges with 77%, the least success is observed in the avalanche gullies with 31%. In general, larches prefer the lower sites (the factor "altitude" is paramount) whereas pines prefer locations higher up on the slope with less snow impact (the microsite is paramount).

The nearly 30 year-old larches have a mean tree height of about 162cm and a stem diameter of 5cm, whereas stone pine have reached a mean tree height of about 111cm and a stem diameter at the base of 5.8cm. Stem diameter growth decreases with altitude just as total tree height growth, but it declines less with altitude than height growth. Larches are in the highest sampling strip (2180m a.s.l.) 40 to 60% smaller than in the lowest strip (2100m), whereas stem diameters measure only 5 to 30%.

In steep terrain, snow movements (especially snow creeping and gliding) affect the growth and shape of stems. Sabre growth of the stems is a site modification, to which larch responds much more than stone pine. This observation is reflected in the diameter values. Statistically, larch diameter1 differs highly significant from diameter2, whereas the two diameter values of stone pine are about equal. Hence, larch tends to have an oval stem cross section and consequently develops sabre-growth, whereas stone pine has a circular stem resulting in a straight stem.

The results of the logistic regression model and the tree classification model show that the critical period for stem damages is actually defined by stem diameter2 values. It is remarkable that this critical period can be defined quite distinctly and the size values are the same for both tree species. In general, the critical period for both stem splittings and breakages begins when the stems of young trees reach a diameter around 6cm and statistically the risk of damage is getting lower in trees with a stem diameter of 9cm to 10cm. The risk of stem splittings begins earlier in tree life, but also lasts for a longer period of time than for stem breakages.

The height of stem injuries on the stem follows a certain pattern: A tree at Stillberg is prone to split at the stem base on the valley side at about 25cm above soil level, whereas higher up the stem at about 80cm breakages dominate. Branches ripped off by avalanches can be found on the uphill side of the stem at an average height of 92cm.

The originally envisaged objectives and research questions can be answered as follows:

- Hypothesis 1: The damage frequency has increased since 1999. In 2003 even more trees have reached the critical age where their stems loose the elasticity and therefore they are more susceptible to stem injuries caused by snow impacts.

Hypothesis 1 proved not to be true. The damage frequency did not increase since 1999. The following explanations are possible. Either the trees have outlived the most critical age period or the snow impacts were less intensive during the last years, or the critical sites are already devoid of trees. Another possibility of explanation would be the exclusion of data of the "extraordinary winter 1999". Then the course of the damage frequency would probably closely correspond to the natural occurring rate of injuries.

- Hypothesis 2: the variables snow height, avalanche frequency and consequently altitude contribute to the damage probability of trees.

The logistic regression model revealed that diameter2 is the paramount factor for the probability of stem damages for both tree species. This result makes sense, because diameter2 is directly exposed to all kinds of down-hill snow forces. In addition, it is statistically proved that the parameter "tree species" and "avalanche frequency" also significantly explains the occurrence of damages. In the tree classification model, the variables "altitude" and "inclination" are also decisive, but only on a tree-specific level.

- Hypothesis 3: larch is less susceptible to stem damages than stone pine because of its higher stem elasticity. Accordingly, the stems of larches tend to split, but the less flexible poles of stone pine are prone to stem breakages.

Larch is less susceptible to stem damages. In 2003, only every 30th larch is injured whereas every fourth stone pine is stem-damaged. The damage pattern for these two tree species is not clearly defined. For both conifers, stem breakages and splittings have been observed. Larch is characterized by a higher rate of split stems (assumably connected with the loss of stability at the sabre-like stem base. By comparison, since 1995 the frequency for breakages in stone pine has increased tenfold and that for splittings sevenfold.

Both larch and stone pine are regarded as suitable and adequate tree species for reforestation in avalanche starting zones. In this study this fact can not be confirmed for stone pine, whereas larch is successfully established in all topographic realms, except for the avalanche gully. With only 2 surviving stone pines and 86 larches, the gaps in the avalanche gully are too big to prevent effectively the release of avalanches. Unfortunately, there is no data of stem damages available to compare the performance of the two conifers in the western part of Stillberg with constructions to stop avalanches. Thus, it can be speculated only whether the over-all success of the afforestation would have been better with snow rakes. Based upon my experiences in the field, I assume that the evaluation quality is actually hampered by the layout of the regularly patterned plots. If the topographical conditions, the local plant associations and the ecological preferences of the planted trees would have been taken into consideration, the survival certainly would have been better.

To end this report, I look to the years ahead and I dare to predict the following scenario for the future of the afforestation at Stillberg:
If the trend of serious damages and mortal casualties of the now 33 year-old stone pines continues as in the last four years, then there will be no pines left in year 2010. Under these circumstances, my thesis may be the last interim report, because exactly 40 years after the planting in 1975, the last stone pines will have disappeared from the scene.
The prognosis for larch looks better. I assume that the larches will manage to survive all kinds of snow-related catastrophes. In particular those trees which are established in clusters in order to withstand together more efficiently the damaging forces of avalanches and snow creeping. This scenario is true until that point in time where the competition within clusters gains the upper hand and only the strongest individuals will survive.

7. References

AMMER, U. und MÖSSMER, E.-M. (1986): *Technische Massnahmen gegen Schneebewegungen zum Schutz von Aufforstungen und Naturverjüngungen in Gebirgslagen*. Mitteilungen aus der Staatsforstverwaltung Bayern 43, München.

ARNO, S. F. (1984): *Timberline*. Mountain and Arctic Forest Frontiers. The Mountaineers, Seattle.

AUER, C. (1947): *Untersuchungen ueber die natuerliche Verjuengung der Lärche im Arven-Lärchenwald des Oberengadins*. Mitteilungen der Schweizerischen Anstalt fuer das forstliche Versuchswesen 25 (1): 7-140.

AULITZKY, H. (1963): *Bioklima und Hochlagenaufforstung in der subalpinen Stufe der Inneralpen*. Separatabdruck aus der Schweizerischen Zeitschrift für Forstwesen 1/2: 1-25.

AULITZKY, H. und TURNER, H. (1982): *Bioklimatische Grundlagen einer standortsgemässen Bewirtschaftung des subalpinen Lärchen-Arvenwaldes*. Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 58 (4): 327-579.

BEDNORZ, F.; REICHSTEIN, M.; BROLL, G.; HOLTMEIER, F. und URFER, W. (2000): *Humus Forms in the Forest-Alpine Tundra Ecotone at Stillberg (Dischmatal, Switzerland)*: Spatial Heterogeneity and Classification. Arctic, Antarctic and Alpine Research 32 (1): 21-29.

BISCHOFF, N. (1984): *Pflege des Gebirgswaldes*. Leitfaden für die Begründung und forstliche Nutzung von Gebirgswäldern. Eidgenössische Drucksachen- und Materialzentrale, Bern.

BLASER, P. (1980): *Der Boden als Standortsfaktor bei Aufforstungen in der subalpinen Stufe (Stillberg, Davos).* Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 56 (3).

BOSSHARD, H.H. (1982): *Holzkunde 1*. Mikroskopie und Makroskopie des Holzes. 2., überarbeitete Auflage. Birkhäuser, Basel.

CHAMBERS, J. & HASTIE, T. (1992): *Statistical Models in S*. Chapman & Hall, Boca Raton.

DÄNIKER, A. (1923): *Biologische Studien über Baum- und Waldgrenze, insbesondere über die klimatischen Ursachen und deren Zusammenhänge*. Vierteljahresschrift Naturforschende Gesellschaft Zürich (68): 1-102.

ELLENBERG, H. (1963): *Vegetation Mitteleuropas mit den Alpen in kausaler, dynamischer und historischer Sicht*. Ulmer, Stuttgart.

FOWLER, J.; COHEN, L. and JARVIS, P. (1998): *Practical Statistics for Field Biology*. John Wiley & Sons, Chichester. 2nd edition.

FREY, W. (1977): *Wechselseitige Beziehungen zwischen Schnee und Pflanze – eine Zusammenstellung anhand von Literatur*. Mitteilungen des Eidgenössischen Institutes für Schnee- und Lawinenforschung 34.

FREY, W. (1978): *Über das Abbiegen von Stämmen junger Lärchen durch Schneedruck*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 183-204.

FREY, W. (2001): *Forstliche Sanierung von Lawinenanrissgebieten*. Praxisbezogene Untersuchungen aus den Schweizer Alpen. Bündnerwald: 72-80.

FRIEDEL, H. (1952): *Gesetze der Niederschlagsverteilung im Hochgebirge*. Sonderdruck aus "Wetter und Leben" 4 (5-7): 73-86.

FRIEDEL, H. (1966): *Verlauf der alpinen Waldgrenze im Rahmen anliegender Gebirgsgelände.* Ökologie der alpinen Waldgrenze. Symposium Innsbruck. Mitteilungen der forstlichen Bundesversuchsanstalt Wien: 83-172.

FROMME, G. (1963): *Über das Wachstum von Junglärchen auf subalpinen Standorten im Ötztal und Paznauntal (Tirol).* Zentralblatt für das gesamte Forstwesen 80: 135-174.

HORAK, E. (1963): *Pilzökologische Untersuchungen in der subalpinen Stufe der Rätischen Alpen (Dischmatal, Graubünden)*. Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 39 (1): 5-111.

IN DER GAND, H. (1968): *Aufforstungsversuche an einem Gleitschneehang.* Ergebnisse der Winteruntersuchungen 1955/56 bis 1961/62. Mitteilungen der Schweizerische Anstalt für das forstliche Versuchswesen 44: 229-326.

IN DER GAND, H. (1978): *Verteilung und Struktur der Schneedecke unter Waldbäumen und im Hochwald*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 97-122.

IN DER GAND, H. (1980): *Der Beitrag der Schnee- und Lawinenforschung zum Waldbau auf extremen Standorten (Lawinenschutzwald).* Proceedings of the IUFRO meeting in Thessaloniki, Athen: 215-236.

JOHNSEN, E. A. (1987): *The relative importance of snow avalanche disturbance and thinning on canopy plant populations*. Ecology 68: 43-53.

KELLER, H. M. (1978): *Snow cover in forest stands*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 17-30.

KÖRNER, C. (1998): *A re-assessment of high elevation treeline positions and their explanation*. Oecologia 115: 445-459.

KÖRNER, C. (1999): *Alpine Plant Life*. Functional Plant Ecology of High Mountain Ecosystems. Springer, Berlin.

KRONFUSS, H. (1966): *Schneelage und Ausaperung an der Waldgrenze.* Ökologie der alpinen Waldgrenze. Symposium Innsbruck. Mitteilungen der forstlichen Bundesversuchsanstalt Wien: 207-241.

KUOCH, R. (1970): *Die Vegetation auf Stillberg (Dischmatal, Kanton Graubünden).* Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 46 (4): 329-342.

KUOCH, R. und AMIET, R. (1970*): Die Verjüngung im Bereich der oberen Waldgrenze der Alpen*. Mitteilungen der Schweizerische Anstalt für das forstliche Versuchswesen 46 (4): 159-328.

LEIBUNDGUT, H. (1978): *Zur Eröffnung des Seminars über Gebirgswald und Lawinen*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 7-16.

LÖVE, D. (1970): *Subarctic and subalpine: where and what?* Arctic and Alpine Research 2 (1): 63-73.

MAYER, H. (1978): *Ökosystem Lawinenschutzwald*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 281-300.

MAYER, H. und OTT, E. (1991): *Gebirgswaldbau, Schutzwaldpflege*. Ein waldbaulicher Beitrag zur Landschaftsökologie und zum Umweltschutz. Gustav Fischer, Stuttgart. 2., vollständig neu bearbeitete Auflage.

MEARS, A. (1975): *Dynamics of dense-snow avalanches interpreted from broken trees*. Geology: 521-523.

MÖSSMER, E.-M. (1998):*Ohne Schutzwald geht's bergab*. Stiftung Wald in Not 9, Bonn.

MÖSSMER, E.-M. (1994): *Pioniereigenschaften von Gehölzen in schneegleitgefährdeten Schutzwaldlagen im montanen und subalpinen Bereich der Bayerischen Kalkalpen*. Forstliche Forschungsberichte München 140.

MÖSSMER, E.-M.; AMMER, U.; DINSER, K.; HILDEBRANDT, M.; HOLST, U.; KAINZ, M. und WALD, K. (1997): *Handbuch zur Sanierung von Schutzwäldern im bayerischen Alpenraum*. Herausgeber: Bayerische Staatsforstverwaltung.

NÄGELI, W. (1971): *Der Wind als Standortsfaktor bei Aufforstungen in der subalpinen Stufe (Stillbergalp im Dischmatal, Kanton Graubünden).* Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 47 (2): 7-57.

OSWALD, H. (1963): *Verteilung und Zuwachs der Zirbe in der subalpinen Stufe an einem zentralalpinen Standort*. Mitteilungen der forstlichen Bundesversuchsanstalt Mariabrunn 60: 437-499.

OTT, E. (1978): *Present state of mountain forests, consequences for their avalanche protection function, silvicultural measures*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 321-330.

PFISTER, F.; WALTHER, H.; ERNI, V. und CANDRIAN, M. (1987): *Walderhaltung und Schutzaufgaben im Berggebiet*. Berichte der Eidgenössischen Anstalt für das forstliche Versuchswesen Birmensdorf 294.

PRUTZER, E. (1966): *Die Niederschlagsverhältnisse an der Waldgrenze.* Ökologie der alpinen Waldgrenze. Symposium Innsbruck. Mitteilungen der forstlichen Bundesversuchsanstalt Wien: 173-205.

REISIGL, H. und KELLER, R. (1999): *Lebensraum Bergwald*. Alpenpflanzen in Bergwald, Baumgrenze und Zwergstrauchheide. Spektrum, Heidelberg. 2. Auflage.

RYCHETNIK, J. (1986): *Snow cover disappearance as influenced by site conditions, snow distribution and avalanche activity*. International Symposium on avalanche formation, movements and effects in Davos: 103-105.

SALM, B. (1978): *Snow forces on forest plants*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 157-182.

SCHILCHER, C. (1964): *Erschwernisse bei Hochlagenaufforstungen*. Allgemeine Forstzeitung Wien 75 (21/22): 237-238.

SCHNEEBELI, M. & BEBI, P. (2004): *Hydrology: Snow and Avalanche Control*. In: Burley, J., Evans, J. and Youngquist. Encyclopedia of Forest Science, Elsevier, London: 397-402.

SCHÖNENBERGER, W. (1975): *Standortseinflüsse auf Versuchsaufforstungen an der alpinen Waldgrenze (Stillberg/Davos).* Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 51 (4): 357-428.

SCHÖNENBERGER, W. und FREY, W. (1988): *Untersuchungen zur Ökologie und Technik der Hochlagenaufforstung*. Forschungsergebnisse aus dem Lawinenanrissgebiet Stillberg. Schweizerische Zeitschrift für Forstwesen 139 (9): 735-820.

SENN, J. (1999): *Tree mortality caused by Gremmeniella abietina in a subalpine afforestation in the central Alps and its relationship with duration of snow cover*. European Journal for Pathology 29: 65-74.

SENN, J. und SCHÖNENBERGER, W. (2001): *Zwanzig Jahre Versuchsaufforstung Stillberg:* Überleben und Wachstum einer subalpinen Aufforstung in Abhängigkeit vom Standort. Schweizerische Zeitschrift für Forstwesen 152 (6): 226-246.

STERN, R. (1978): *Distribution of snow and damages by snow in an afforestation area in the subalpine zone at the "Sonnenberg" near Haggen / Tyrol*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 145-156.

TRANQUILLINI, W. (1978): *Der Einfluss der Schneedecke auf die Lebensvorgänge von Forstpflanzen*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 123-138.

TRANQUILLINI, W. (1979): *Physiological Ecology of the Alpine Timberline*. Tree existence at high altitudes with special reference to the European Alps. Springer, Berlin.

TURNER, H. (1966): *Die globale Hangbestrahlung als Standortsfaktor bei Aufforstungen in der subalpinen Stufe*. Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 42 (3): 7-78.

TURNER, H.; HÄSLER, R. und SCHÖNENBERGER, W. (1982): *Contrasting microenvironments and their effects on carbon uptake and allocation by young conifers near alpine treeline in Switzerland*. Proceedings of the IUFRO meeting in Corvallis, Oregon: 22-30.

TURNER, H. und TRANQUILLINI, W. (1985): *Establishment and Tending of Subalpine Forests:* Research and Management. Berichte der Eidgenössischen Anstalt für das forstliche Versuchswesen 270.

VANOMSEN, P. (1999): *Stammbrüche und –spaltungen in Lawinenanrissgebieten in der Versuchsaufforstung Stillberg (Graubünden) nach einem schneereichen Winter*. Vergleichende Untersuchung der Stabilität junger Arven (Pinus cembra L.) und Lärchen (Larix decidua L.). Diplomarbeit des Departements Forstwissenschaften, ETH Zürich.

WAKABAYASHI, R. (1978): *Deformation and damage to forest plants by snow forces*. Mountain forests and avalanches. Proceedings of the IUFRO meeting in Davos: 205-209.

ZENKE, B. (1985): *Der Einfluss abnehmender Bestandesvitalität auf Reichweite und Häufigkeit von Lawinen*. Forstwissenschaftliches Zentralblatt 104.

ZÜRCHER, U. (1973): Der Wald in der Raumplanung. Mitteilungen der Schweizerischen Anstalt für das forstliche Versuchswesen 49.

Appendix

Recorded data 2003: 112 stone pines and 1037 larches

1 = square unit number

2 = tree species (1= stone pine, 3 = larch)

3 = tree number (1 – 25)

4 = topography (1 = ridge, 2 = Northern slope, 3 = avalanche gully, 4 = Eastern slope)

5 = tree height in cm

6 = diameter1 in cm (measured in the direction of the slope gradient)

7 = diameter2 in cm (measured in the direction of the contour lines)

8 = stem damaged (0 = no, 1 = yes)

9 = stem breakage (0 = no, 1 = yes)

10 = breakage height (only recorded with new injuries)

11 = stem splitting (0 = no, 1 = yes)

12 = splitting height (only recorded with new injuries)

13 = number of ripped off branches

14 = height of ripped off branch No. 1 (only recorded with new injuries)

15 = height of ripped off branch No. 2

16 = height of ripped off branch No. 3

17 = height of ripped off branch No. 4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1644	1	16	2	71	4.6	4.2	0					1				
1646	3	1	2	94	4.8	4	0									
1646	3	7	2	118	5.3	5.3	0									
1646	3	12	2	85	3.9	3.4	0									
1646	3	16	2	136	7	5.7	1	1		1						
1646	3	19	2	147	8.7	6.3	0									
1646	3	22	2	106	3.9	3.4	0									
1646	3	23	2	64	5.7	5.5	1	1		0						
1646	3	24	2	119	6	5.7	0					5				
1647	1	12	2	65	4.5	3.5	0					2				
1652	3	1	3	36			0									
1652	3	2	3	140	5.8	4.7	0									
1652	3	3	3	123	3.7	3.3	0					1				
1652	3	4	3	122	4.6	4.3	0									
1652	3	5	3	140	5.1	4	0					1				
1652	3	7	3	43			0									
1652	3	8	3	163	5.9	4.9	0									
1652	3	10	3	85	4.2	3.8	0									
1652	3	12	3	141	6.7	5.9	0					1	80			
1652	3	13	3	186	6.3	5.3	0									
1652	3	14	3	100	9	9.3	0									

1652	3	18	3	260	9	9.5	0					3				
1652	3	19	3	320	8.9	8.6	0					6	147	165	180	
1652	3	20	3	185	7.3	5.5	0									
1653	1	16	4	79	5	4.1	1	0		1		4	47			
1655	3	1	4	244	5.5	4.5	0					1				
1655	3	2	4	116	4.8	4.3	0									
1655	3	3	4	219	6.1	4.4	0									
1655	3	4	4	50			0									
1655	3	5	4	98	2.5	2.4	0									
1655	3	7	4	235	6.6	5.9	0					3				
1655	3	9	4	180	5	4.7	0									
1655	3	10	4	167	4.6	3.9	0									
1655	3	11	4	160	8.2	7.9	0					2				
1655	3	12	4	112	4.3	4	0									
1655	3	13	4	90	3.7	3.8	0									
1655	3	15	4	195	4.9	4.2	0					2				
1655	3	16	4	148	5.1	4.7	0					2	159			
1655	3	18	4	193	6.2	5.4	0					2				
1655	3	21	4	113	3.8	3	0									
1655	3	22	4	166	4.7	4.4	0									
1656	1	6	4	70	4.6	4.4	0					1	26			
1656	1	7	4	76	3.6	3.5	1	0		1		1	44			
1656	1	8	4	95	7.2	6	1	1	18	0		1				
1656	1	9	4	110	7.7	7.9	1	1		1						
1656	1	22	4	101	8	7.3	1	1	69	0						
1658	3	1	4	109	4.4	4.1	0									
1658	3	2	4	100	6.3	5.8	0					1				
1658	3	4	4	82	4.4	4.7	0					1				
1658	3	6	4	91	3.7	3.1	0					1	18			
1658	3	7	4	88	5.1	4.3	0									
1658	3	8	4	108	5.9	5	0									
1658	3	9	4	69	3.5	3.3	0									
1658	3	11	4	140	7.1	5.4	0					1				
1658	3	12	4	105	3.3	3.1	0									
1658	3	14	4	92	3.6	3.3	0									
1658	3	15	4	86	2.6	2.4	0									
1658	3	16	4	120	4	3.6	0					1				
1658	3	17	4	116	4.5	4.4	0									
1658	3	18	4	80	3.5	3.6	0									
1658	3	21	4	65	2.8	2.5	0									
1658	3	22	4	41			0									
1748	3	2	2	80	3.7	3.6	0									
1748	3	7	2	113	4.5	3.7	0					1	13			
1748	3	14	2	85	3.2	3	0									
1748	3	16	2	99	3.5	4	0									
1748	3	17	2	123	4.9	4.4	0					1	90			
1751	3	13	3	83	3.1	2.7	0									
1751	3	14	3	70	2.3	2.5	0									
1751	3	24	3	121	4.8	4	0					1	104			
1752	1	3	3	103	5.5	5	0					2	44			
1752	1	24	3	66	3.4	2.9	0					2				
1754	3	1	4	126	3	2.9	0					1				
1754	3	2	4	195	5.4	4.6	0					1				
1754	3	3	4	132	3.6	3	0					2				
1754	3	5	4	155	3.6	3.1	0									
1754	3	9	4	103	2.7	2.4	0									
1754	3	17	4	171	4.7	4.3	0					2				
1754	3	18	4	188	4.9	4.2	0									
1754	3	23	4	224	9	7.6	1	0		1	23	1				

1757	3	7	4	182	5.4	5.2	0									
1757	3	13	4	80	4.1	3.7	0									
1757	3	19	4	243	8.9	8.7	0					2	95	116		
1757	3	24	4	258	7.8	7.2	0					3	155	183		
1758	1	1	4	105	8.2	7.2	0					1	80			
1758	1	2	4	120	6.9	6.4	0					6	105			
1758	1	6	4	55	3.7	3.6	0					2				
1758	1	8	4	80	5	5	1	0		1	40					
1758	1	13	4	52	4.6	4	0					3				
1760	3	1	1	60	2.3	1.9	0									
1760	3	4	1	94	4	3.7	0					1				
1760	3	5	1	19												
1760	3	6	1	80	3.7	3.6	0									
1760	3	7	1	93	2.2	2.2	0									
1760	3	8	1	69	2.8	2.7	0					1	23			
1760	3	10	1	63	2.5	2.6	0									
1760	3	11	1	55	2.4	2.2	0									
1760	3	12	1	122	4.2	3.9	0									
1760	3	13	1	58	3.7	3.6	0									
1760	3	14	1	72	2.1	1.9	0									
1760	3	15	1	69	3.2	2.8	0									
1760	3	16	1	45												
1760	3	18	1	176	5.4	5	0									
1760	3	19	1	35												
1760	3	20	1	102	4.8	4.9	1	0		1	31	1	15			
1760	3	21	1	66	3.5	3.9	0									
1760	3	22	1	59	2.5	2.6	0									
1760	3	23	1	60	2.5	2.5	1	0		1	18					
1760	3	24	1	61	3.6	3.3	0									
1760	3	25	1	90	3.6	3.5	0									
1844	3	1	1	100	4.8	5.4	0					2				
1844	3	2	1	76	2.9	2.6	0									
1844	3	3	1	93	4	3.9	0									
1844	3	5	1	154	5	4.3	0									
1844	3	6	1	36												
1844	3	7	1	62	2.3	2.1	0									
1844	3	8	1	43												
1844	3	9	1	150	6.3	5.9	0					1				
1844	3	10	1	94	3.2	2.9	0									
1844	3	11	1	64	3.9	3.4	0									
1844	3	12	1	105	2.6	3	0									
1844	3	13	1	76	2.5	2.4	0									
1844	3	14	1	76	3.2	3	0									
1844	3	15	1	140	6	6	0									
1844	3	16	1	41			0									
1844	3	18	1	70	2.1	2.1	0									
1844	3	19	1	149	5.7	4.6	0					2				
1844	3	22	1	135	6	6	1	0		1	46	4	30			
1844	3	23	1	74	2.6	2.6	0									
1844	3	24	1	105	5	4.2	0									
1850	3	25	3	118	4.7	4.3	0									
1853	3	1	4	160	9.4	8.1	0									
1853	3	2	4	160	6.5	5.3	0					1				
1853	3	3	4	116	5.2	4.7	0					1	100			
1853	3	4	4	116	3.3	3.2	0									
1853	3	5	4	200	5.6	4.8	0					1				
1853	3	6	4	296	6.9	5.7	0									
1853	3	7	4	163	7.9	6	0									
1853	3	8	4	181	5.4	5.7	0					4				

1853	3	9	4	96	2.9	2.5	0									
1853	3	11	4	264	7.7	6.6	0					2	90			
1853	3	12	4	166	6.7	5.7	0									
1853	3	13	4	53	3.4	2.8	0									
1853	3	14	4	99	2.1	2.2	0									
1853	3	16	4	67	3.4	2.2	0									
1853	3	17	4	165	4.1	3.7	0									
1853	3	18	4	185	7	5.8	0									
1853	3	19	4	142	4.2	3.8	0									
1853	3	20	4	257	7	6.7	0					1				
1853	3	21	4	125	4.7	4.3	0					1				
1853	3	23	4	218	7.4	5.9	0									
1853	3	24	4	175	6.8	6.5	0									
1853	3	25	4	232	7.5	6.8	0									
1856	3	1	4	134	3.5	3	0									
1856	3	2	4	151	3.9	3.2	0									
1856	3	3	4	129	2.5	2.4	0									
1856	3	8	4	134	5	4.5	0									
1856	3	12	4	124	3.3	2.6	0									
1856	3	16	4	205	6.7	5.6	0									
1856	3	17	4	187	5.5	4.4	0									
1856	3	18	4	160	3.7	3.5	0									
1856	3	20	4	212	5.7	5.6	0									
1856	3	23	4	259	8.1	7.1	0					2				
1856	3	24	4	162	5	4.3	0									
1856	3	25	4	112	3.9	3.6	0					1				
1857	1	2	4	175	9.7	8.6	0					1				
1857	1	3	4	102	7.1	6.2	0					2				
1857	1	5	4	110	8.3	7.5	1	1		0		1				
1857	1	6	4	215	7.8	7.6	0					3	114	130		
1857	1	8	4	153	9.5	8.8	1	1		0		2	118	118		
1857	1	9	4	150	8.8	8.9	0					1	58			
1857	1	10	4	152	9.7	8.4	1	0		1		1				
1857	1	21	4	151	10.5	10.4	0					3	86	86		
1857	1	22	4	110	6	5.8	0					2				
1859	3	2	1	89	5.2	4.5	0									
1859	3	3	1	34			0									
1859	3	4	1	43			0									
1859	3	5	1	57	1.7	1.9	0									
1859	3	8	1	67	3.3	2.6	0									
1859	3	9	1	51	3.9	3.2	0									
1859	3	14	1	41			0									
1859	3	15	1	53	2.5	2.4	0									
1859	3	17	1	65	3.4	3.5	0									
1859	3	23	1	86	2.3	2.5	0									
1946	3	4	2	90	4.8	3.8	0					1				
1946	3	8	2	160	5.9	5	0					1	43			
1946	3	12	2	136	6.7	6.1	0					1				
1946	3	16	2	174	6.9	7.2	0					1	70			
1946	3	17	2	108	3.5	3.3	0					1				
1946	3	21	2	173	6.4	5.5	1	0		1	13	1				
1949	3	1	3	125	3.7	3.8	0									
1949	3	3	3	100	4.9	5	0									
1949	3	4	3	79	3	2.9	0									
1949	3	8	3	97	4.4	4	0					1				
1949	3	9	3	71	3.1	2.8	0					1				
1952	3	1	3	392	9.2	8.7	0					3				
1952	3	2	3	247	9.4	7.7	0					1	182			
1952	3	3	3	209	7.3	6.3	0									

1952	3	4	3	186	6.8	6.3	0					1	89			
1952	3	5	3	200	8.5	7.1	0									
1952	3	7	3	219	10	8.4	0									
1952	3	8	3	92	3.1	2.6	0									
1952	3	9	3	160	4.3	3.7	0									
1952	3	10	3	91	2.8	2.3	0									
1952	3	14	3	190	7.4	6	0									
1952	3	15	3	248	9.6	9.6	0					2				
1952	3	17	3	208	6.5	6.3	0									
1952	3	18	3	68	5.1	4.4	0									
1952	3	20	3	120	4	4.2	0									
1952	3	24	3	270	8.7	7.9	0					3	171			
1955	3	1	4	452	13.6	16	0					6	292			
1955	3	3	4	227	6.6	5.7	0					1				
1955	3	4	4	243	7	5.8	0					2				
1955	3	5	4	194	4.5	4.1	0									
1955	3	8	4	336	6.5	5	0									
1955	3	9	4	163	3.5	2.9	0									
1955	3	10	4	217	5.9	4.6	0					1				
1955	3	12	4	325	6.9	6.4	0					3				
1955	3	13	4	329	8.2	7.2	0									
1955	3	15	4	176	5	4.6	0									
1955	3	17	4	163	4.5	3.8	0									
1955	3	22	4	193	7.7	6.3	0									
1955	3	24	4	192	7.1	5.6	0					1				
1956	1	20	4	110	5.9	5.8	0					5	66	79	86	
1956	1	23	4	140	5.6	5	0					5	86	98	98	103
1958	3	1	4	160	8.5	7.2	0					4				
1958	3	3	4	165	7	5.8	0					1				
1958	3	4	4	224	8.5	6.6	0									
1958	3	5	4	140	5.1	4.3	0									
1958	3	6	4	296	8.5	7	0					3				
1958	3	7	4	216	8.9	7.7	0					3	54	132		
1958	3	8	4	207	8.2	8	0					2	139			
1958	3	9	4	160	5.3	4.5	0					1				
1958	3	10	4	138	3.7	3	0									
1958	3	11	4	134	4.8	4	0									
1958	3	12	4	142	5.9	4.3	0					3	73			
1958	3	13	4	202	8	6.2	0					5	109	148		
1958	3	14	4	162	6.5	5.6	0									
1958	3	15	4	229	6.5	7.4	0									
1958	3	18	4	193	6.2	5.3	0									
1958	3	20	4	146	5	4.5	0									
1958	3	21	4	247	8	6.5	0					3	100	149		
1958	3	23	4	222	11.7	11	0					1				
1958	3	25	4	135	6.3	5	0									
1959	1	6	1	130	7.2	5.6	0					1	78			
1959	1	10	1	60	5	4.5	0									
1959	1	13	1	96	4.8	3.2	0					2	56			
1959	1	14	1	70	4.1	4.1	0					4	36	41		
1959	1	19	1	81	3.5	3	0					1				
1959	1	20	1	118	7.6	6	0									
2628	1	10	1	100	4.6	4.5	0					1				
2628	1	15	1	48	3.3	3.2	0					2				
2630	3	1	1	120	3.8	4.7	0					3				
2630	3	2	1	163	3.9	3.8	0									
2630	3	3	1	93	3	2.8	0					1				
2630	3	4	1	110	4.9	4.4	0									
2630	3	5	1	203	6	5.7	0					3				

2630	3	6	1	91	3.5	3.5	0									
2630	3	7	1	82	2.1	2.2	0									
2630	3	8	1	100	3	2.6	0					1				
2630	3	9	1	96	3.1	3	0					1				
2630	3	10	1	114	3.8	4	0									
2630	3	11	1	54	1.8	1.7	0									
2630	3	12	1	113	3.2	2.8	0									
2630	3	13	1	75	2.5	2.4	0					3	34			
2630	3	14	1	96	2.1	1.9	0					2				
2630	3	16	1	155	4.4	3.6	0					1				
2630	3	17	1	112	3	3	0					1				
2630	3	19	1	86	2.5	2.5	0									
2630	3	20	1	109	2.9	2.8	0									
2630	3	21	1	245	7.8	6.5	0					1				
2630	3	22	1	172	6.4	5.7	0					1				
2630	3	23	1	144	3.4	3.5	0					1				
2630	3	24	1	208	5.7	5.7	0					2				
2630	3	25	1	99	3.5	3	0					2	27			
2631	1	2	1	119	5	5	0									
2631	1	3	1	85	3.7	3.4	0					1	47			
2631	1	4	1	123	6.2	6.4	0					1				
2631	1	5	1	135	5.3	4.5	0					2	63			
2631	1	11	1	84	3.5	3.3	0					2				
2631	1	16	1	67	3.5	3.4	0					1				
2631	1	17	1	58	4.1	3.6	0					1				
2631	1	23	1	57	4.6	3.7	0					2	20			
2633	3	3	2	110	2.5	2.5	0					1				
2633	3	4	2	67	1.8	1.7	0									
2633	3	5	2	224	5.5	5	0									
2633	3	7	2	151	4.4	3.8	0									
2633	3	9	2	77	2.3	2	0									
2633	3	10	2	178	5.9	5	0									
2633	3	11	2	94	2.8	3.3	0									
2633	3	12	2	148	4.8	4.3	0									
2633	3	15	2	160	5	4.5	0									
2633	3	17	2	209	7.8	6.2	0					4	100			
2633	3	18	2	155	5.7	4.9	0					1				
2633	3	19	2	136	3.6	3	0					1				
2633	3	21	2	86	2.8	2.5	0									
2633	3	22	2	42												
2633	3	23	2	132	3.8	3.5	0					1				
2633	3	24	2	86	2.2	2.2	0									
2633	3	25	2	127	4.5	4	0					1	78			
2636	3	5	4	244	5.7	5.4	0									
2636	3	9	4	147	3.9	3.1	0									
2636	3	10	4	270	9	7.5	0									
2636	3	13	4	243	7.1	5.9	0					1				
2636	3	15	4	148	4.8	4.3	0									
2636	3	19	4	330	9	8.8	1	0		1	24	2				
2636	3	22	4	215	8.2	6.5	1	0		1		1				
2636	3	23	4	142	4.9	4.2	0									
2636	3	24	4	238	6.6	6.5	0									
2636	3	25	4	350	10.7	9.3	0					2				
2637	1	7	4	216	8.6	8.3	0					1				
2637	1	8	4	138	9.2	7.5	0					3				
2637	1	13	4	147	7.3	7.3	1	0		1	31	2				
2637	1	18	4	92	5.4	4.1	0					3				
2727	1	19	1	86	4.7	4.7	1	0		1		1				
2729	3	2	1	140	4.5	4.1	0									

2729	3	3	1	189	4.8	4.5	0					1				
2729	3	5	1	168	6	5	0					2				
2729	3	7	1	175	5.4	4.8	0					1				
2729	3	8	1	110	4.9	4	0									
2729	3	10	1	72	2.3	2.1	0									
2729	3	11	1	141	5.9	5.4	0					2	52			
2729	3	12	1	175	4.5	4	0									
2729	3	13	1	144	3.9	3.6	0					1				
2729	3	14	1	86	1.2	1.2	0									
2729	3	16	1	152	5.2	4.5	0					2				
2729	3	17	1	208	6.7	6.2	0					1				
2729	3	18	1	147	4.5	4.3	0									
2729	3	19	1	95	3.2	3.2	0					1				
2729	3	20	1	147	3.3	3.1	0									
2729	3	21	1	163	5	4.5	0					2				
2729	3	22	1	146	4.5	4.2	0					2				
2729	3	23	1	205	4.5	4.3	0									
2729	3	24	1	149	6.6	6	0					2				
2729	3	25	1	178	7	6.7	0					3	99			
2730	1	6	2	92	3.2	3.1	0					3				
2730	1	24	2	57	2.3	2.3	0									
2732	3	2	2	117	3.2	2.9	0									
2732	3	3	2	221	5.4	5	0					4	76			
2732	3	4	2	120	3.1	3.2	0					1				
2732	3	5	2	74	2.1	2.4	0									
2732	3	8	2	196	5.6	5	0									
2732	3	20	2	171	6.5	5.5	0									
2732	3	24	2	127	3.7	3.6	0									
2732	3	25	2	153	4.6	4.2	0									
2735	3	2	3	80	3.3	3.2	0									
2738	3	1	4	265	7.8	7.6	0					2	59			
2738	3	6	4	194	6.5	6.2	0					2	48			
2738	3	7	4	214	6.8	6.9	0					4				
2738	3	10	4	143	8.9	7.2	0					4	43	46		
2738	3	11	4	245	7.7	6.2	0					1				
2738	3	12	4	238	7.1	6	0					2	48			
2738	3	13	4	142	6.3	5.3	0					4	39	74		
2738	3	16	4	149	5.3	4.9	0									
2738	3	17	4	315	7.8	6.2	0					1				
2738	3	18	4	154	5	4	0					1	50			
2738	3	21	4	107	3.6	3.6	0					1	44			
2738	3	22	4	165	4.8	5.1	0					1	114			
2738	3	23	4	144	5.1	4.5	0					1				
2738	3	24	4	106	2.9	3.5	0					1				
2738	3	25	4	191	7	6.1	0					1	97			
2826	1	1	1	149	7.3	6	0					4				
2826	1	6	1	53	3.2	2.9	0					4				
2826	1	7	1	93	6.8	5.6	0					4				
2826	1	11	1	96	5.9	5.2	0					3				
2826	1	13	1	79	4.9	4.3	0					1				
2826	1	16	1	97	5	4.3	0					3				
2826	1	21	1	107	4.8	4	0					4				
2828	3	1	1	141	5.1	4.9	0					2				
2828	3	3	1	77	4	3.9	0									
2828	3	4	1	122	4.3	4.3	0					1				
2828	3	5	1	44			0									
2828	3	6	1	124	4.6	4.6	0					1				
2828	3	8	1	166	5.5	5.2	0					1				
2828	3	9	1	87	3.2	2.4	0									

2828	3	10	1	82	2.6	2.1	0									
2828	3	11	1	92	3.1	2.5	0									
2828	3	12	1	156	5.3	4.8	0					1	110			
2828	3	14	1	129	4.1	3.7	0									
2828	3	15	1	115	4.9	3.9	0					1				
2828	3	16	1	157	5.9	4.9	0									
2828	3	17	1	93	2.8	2.3	0									
2828	3	19	1	37			0									
2828	3	20	1	112	3.2	3.5	0									
2828	3	21	1	142	4	3.8	0					4	76	95		
2828	3	23	1	87	3	2.9	0									
2828	3	25	1													
2829	1	10	1	92	4.1	3.4	0					2				
2829	1	16	1													
2831	3	14	2	56	2.1	1.5	0									
2831	3	16	2	163	6.3	5.5	0									
2831	3	19	2	74	2.4	2.3	0									
2831	3	22	2	252	8.7	7	0									
2831	3	23	2	76	3.1	2.1	0					1				
2831	3	25	2	26			0									
2834	3	2	3	70	2.9	2.8	0									
2834	3	3	3	50			0									
2834	3	5	3	178	6.4	5.7	0					1				
2834	3	11	3	130	3.6	3.4	0					1				
2834	3	12	3	179	6.3	5.7	0					1				
2834	3	16	3	205	6.1	5.5	0									
2834	3	25	3	188	7.5	5.6	0					4				
2835	1	19	4	146	7.6	7.2	0					2				
2835	1	25	4	150	8.4	7.6	1	1		0		8				
2837	3	1	4	98	5.1	4.5	0					2				
2837	3	2	4	221	10.7	10.2	1	0		1		3				
2837	3	3	4	146	5.8	4.9	0					3	50			
2837	3	4	4	77	3.1	2.7	0									
2837	3	5	4	87	5.1	4.1	0									
2837	3	6	4	145	6.3	8	0					1				
2837	3	7	4	126	4	3.6	0					4	61	70		
2837	3	8	4	102	4.3	3.5	0									
2837	3	9	4	115	4.8	3.8	0									
2837	3	10	4	73	4	3	0									
2837	3	11	4	107	5.8	5.8	0					2				
2837	3	12	4	106	6	4.9	0									
2837	3	13	4	75	3.1	3.2	0									
2837	3	15	4	137	5.9	5	0					1				
2837	3	16	4	105	4.6	4.3	0					1				
2837	3	18	4	125	5.7	5	0									
2837	3	19	4	107	4	4	0					2				
2837	3	20	4	79	4	3.3	0									
2837	3	21	4	115	4.7	3.6	0									
2837	3	22	4	146	6.6	6.4	0					4				
2837	3	23	4	115	6	4.6	0									
2837	3	24	4	80	3.2	2.4	0									
2837	3	25	4	70	2	1.7	0									
2928	1	1	1	52	4.1	3.4	0					1				
2928	1	15	1	85	3.2	3	0					3				
2930	3	2	2	133	4.8	4.5	0					1				
2930	3	3	2	61	2	2	0									
2930	3	4	2	114	3.5	3.2	0									
2930	3	5	2	44												
2930	3	6	2	88	2.6	2.4	0									

2930	3	7	2	22												
2930	3	9	2	165	6.3	5.4	0					2	65			
2930	3	10	2	301	10.5	9	0									
2930	3	11	2	133	3.8	3.1	0					1				
2930	3	12	2	126	4.3	3.7	0									
2930	3	13	2	18			0									
2930	3	14	2	50			0									
2930	3	15	2	164	3.7	3.7	0									
2930	3	16	2	200	6.7	6.1	0					1				
2930	3	17	2	215	9.2	7.6	0									
2930	3	18	2	78	1.9	1.5	0									
2930	3	19	2	114	3	2.7	0									
2930	3	20	2	160	5.1	5	0									
2930	3	23	2	166	7.8	7	0					1	42			
2930	3	25	2	55	1.4	1.3	0									
2936	3	13	4	124	4.4	3.8	0									
2936	3	1	4	210	7.3	6	0									
2936	3	2	4	148	4.1	4.3	0					3	59	75	78	
2936	3	4	4	208	6.5	5.5	0					3				
2936	3	5	4	213	7.9	7.1	0									
2936	3	7	4	80	2.5	2.3	0									
2936	3	8	4	151	5.6	4.7	0									
2936	3	9	4	195	5.6	4.6	0					1				
2936	3	10	4	146	4.8	5.6	0					2	86	113		
2936	3	11	4	160	4.1	3.6	0									
2936	3	12	4	243	6.8	5.9	0									
2936	3	14	4	100	3.6	3.2	0									
2936	3	15	4	148	5.8	5.7	0									
2936	3	16	4	123	4.6	3.3	0					1	62			
2936	3	17	4	192	6.8	7.4	0									
2936	3	18	4	122	4	4	0									
2936	3	21	4	107	2.8	2.4	0									
2936	3	22	4	152	5.1	4.4	0									
2936	3	23	4	197	6.9	6.7	0					1				
2937	1	11	1	105	4.9	4	0					2				
2937	1	12	1	49	3	2.8	0					5				
3045	1	24	1	75	4.4	3.8	0					2				
3047	3	1	2	74	2.6	2.5	0									
3047	3	2	2	140	4	3.7	0									
3047	3	3	2	72	2.5	2.3	0					1				
3047	3	4	2	43			0									
3047	3	5	2	91	2.5	2.3	0					1				
3047	3	6	2	120	3.8	3.5	0									
3047	3	7	2	90	3.2	2.8	0					1				
3047	3	10	2	54	1.2	1.5	0									
3047	3	12	2	117	4.8	5	0									
3047	3	16	2	117	5.2	4.2	0									
3047	3	25	2	136	5.3	4.8	0					1				
3048	1	14	2	64	3	2.6	0					3				
3050	3	1	2	85	3	3.1	0					2	5	76		
3050	3	2	2	15			0									
3050	3	3	2	33			0									
3050	3	4	2	24			0									
3050	3	5	2	159	6	5.5	0									
3050	3	6	2	95	2.3	2.5	0									
3050	3	8	2	22			0									
3050	3	10	2	36			0									
3050	3	11	2	79	2.8	2.5	0									
3050	3	12	2	139	4.2	3.8	0									

3050	3	13	2	58	1.3	1.4	0									
3050	3	14	2	157	4.6	4.7	1	0		1						
3050	3	15	2	190	5.5	4.9	0					1				
3050	3	16	2	65	2.3	2.1	0									
3050	3	17	2	102	3.1	2.8	0									
3050	3	18	2	46			0									
3050	3	19	2	137	4.9	4	0									
3050	3	22	2	50			0									
3050	3	23	2	69	2.4	2.4	0									
3050	3	24	2	108	3.3	3	0									
3053	3	1	3	230	5.7	6.2	0					5	118			
3053	3	2	3	256	7.4	6.3	0									
3053	3	5	3	191	6.4	6.1	0									
3053	3	6	3	114	2.9	2.5	0									
3053	3	10	3	140	4.7	4	0									
3053	3	11	3	167	4.8	4.2	0									
3053	3	14	3	240	6	5.5	0					4	68			
3053	3	15	3	114	2.3	2.3	0									
3053	3	19	3	185	5.2	4.5	0					1				
3053	3	20	3	188	5.4	4.6	0									
3054	1	3	4	190	10.3	8.8	0					4	100	109	118	
3054	1	4	4	158	9	7.2	1	0		1	12	5	62			
3054	1	7	4	188	7.3	6.7	0					4				
3054	1	16	4	131	5.6	4.8	0					5	74	81		
3054	1	18	4	127	6.7	6.4	0					2				
3056	3	1	4	175	4.6	3.9	0					1				
3056	3	3	4	242	5.4	4.4	0					1				
3056	3	6	4	205	5.7	5.2	0					1				
3056	3	16	4	212	5.8	4.7	0					1				
3056	3	17	4	254	6.3	5.5	0					1				
3056	3	18	4	195	6	5.3	0					1				
3056	3	21	4	119	2.5	2.6	0					1				
3056	3	22	4	99	2.6	2.5	0									
3057	1	8	1	51	2.7	3	0									
3057	1	13	1	52	2.4	2.7	0									
3057	1	16	1	38	2.3	2.2	0									
3059	3	1	2	52	1.8	1.7	0									
3059	3	2	2	160	4.7	4.1	0									
3059	3	3	2	107	2.7	2.6	0									
3059	3	4	2	81	2	1.8	0									
3059	3	5	2	45			0									
3059	3	7	2	122	4.7	3.7	0					2	75			
3059	3	8	2	118	4.4	4.7	0					3	47	55		
3059	3	9	2	44			0									
3059	3	10	2	177	4.8	4.5	0					1				
3059	3	11	2	201	6.1	5.5	0					3	87			
3059	3	12	2	94	3	2.6	0									
3059	3	13	2	180	6.5	5.4	0									
3059	3	14	2	192	6.5	5.5	0					1				
3059	3	16	2	202	7	5.8	0					1				
3059	3	17	2	102	2.1	2	0									
3059	3	18	2	144	4.5	3.7	0									
3059	3	19	2	115	3	2.8	0									
3059	3	20	2	271	8.7	8.2	0									
3059	3	21	2	114	3.8	3.5	0									
3059	3	22	2	221	6.4	5.3	0					2				
3059	3	23	2	246	7	5.8	0									
3059	3	24	2	150	4	3.6	0									
3059	3	25	2	185	5	4.2	0					1				

3146	3	8	1	91	2	1.7	0									
3146	3	9	1	119	3.5	3.3	0									
3146	3	10	1	119	6.1	5.1	0					2				
3146	3	11	1	115	2.9	3	0									
3146	3	12	1	95	2.2	2.2	0									
3146	3	13	1	47			0									
3146	3	15	1	119	4.2	4.3	0									
3146	3	16	1	124	2.7	2.8	0									
3146	3	17	1	35			0									
3146	3	21	1	73	2	1.9	0									
3146	3	22	1	16			0									
3146	3	24	1	48			0									
3149	3	1	2	35			0									
3149	3	2	2	45			0									
3149	3	3	2	42			0									
3149	3	4	2	23			0									
3149	3	5	2	95	3	2.9	0									
3149	3	9	2	58	2.9	2.4	0					1	18			
3149	3	10	2	48			0									
3149	3	11	2	90	3.1	3.1	0									
3149	3	13	2	50			0									
3149	3	15	2	62	2.5	2.5	0									
3149	3	16	2	111	3.7	3.2	0									
3149	3	19	2	65	2.9	2.7	0									
3149	3	20	2	70	1.9	2.3	0									
3149	3	21	2	32			0									
3149	3	22	2	37			0									
3149	3	24	2	70	2.5	2.2	0									
3149	3	25	2	82	2.9	2.7	0									
3150	1	9	2	80	2.9	2.9	0					2				
3150	1	12	2	79	3.3	3.5	0					4				
3155	3	17	4	168	4.6	4.4	0									
3155	3	1	4	188	4.1	3.7	0					3				
3155	3	2	4	187	4.8	4.3	0									
3155	3	3	4	150	4.4	3.6	0									
3155	3	6	4	266	6.3	5.6	0					1				
3155	3	7	4	282	7.3	6.3	0					1				
3155	3	8	4	162	4.4	3.6	0									
3155	3	11	4	219	4.9	4.5	0									
3155	3	12	4	122	4.2	3.3	0									
3155	3	14	4	221	5.9	4.9	0					1	75			
3155	3	15	4	140	4.1	3.3	0									
3155	3	16	4	262	7.6	6.1	0					2	103			
3155	3	19	4	156	6.1	4.7	0					1				
3155	3	20	4	223	7	6.2	0									
3155	3	21	4	278	6.9	5.9	0					1				
3155	3	23	4	227	7.3	6	0									
3155	3	24	4	183	5.6	5.1	0									
3156	1	2	4	105	7.5	7.6	0									
3156	1	8	4	78	5.1	4.8	0					1				
3156	1	21	4	102	7.1	6.1	1	1	83	1	51	3				
3158	3	1	1	104	3.3	2.8	0									
3158	3	4	1	189	5	4.6	0					1				
3158	3	6	1	72	3.7	3.3	0					1	42			
3158	3	7	1	105	3.7	3.1	0									
3158	3	11	1	155	5.5	4.7	0									
3158	3	12	1	118	3.1	2.7	0					1				
3158	3	14	1	243	7.6	7.1	0					1				
3158	3	15	1	135	3.4	3.4	0					1				

3245	3	2	1	65	3.5	2.9	0									
3245	3	4	1	126	6.7	5.6	0									
3245	3	5	1	135	5.5	5.2	0									
3245	3	6	1	124	3.2	2.9	0					3				
3245	3	7	1	122	3.6	3.9	0									
3245	3	9	1	111	4.5	4.1	0					1				
3245	3	10	1	116	3.6	3.3	0									
3245	3	11	1	120	2.7	2.7	0					2				
3245	3	12	1	101	4.3	4.1	0									
3245	3	14	1	49			0									
3245	3	15	1	85	5.2	4.1	0									
3245	3	16	1	114	5.6	5.1	0									
3245	3	17	1	89	3.7	3.6	0					1				
3245	3	18	1	115	3.9	3.1	0									
3245	3	19	1	95	2.4	2.4	0					1				
3245	3	20	1	41			0									
3245	3	21	1	74	2	1.9	0									
3245	3	22	1	75	2.7	2.3	0									
3245	3	23	1	36			0									
3245	3	25	1	39			0									
3246	1	1	1	82	3.3	3.5	0					2				
3246	1	7	1	146	2.4	2.1	0					1	35			
3246	1	16	1	48	3.5	3.4	0									
3248	3	1	2	36			0									
3248	3	2	2	60	2.4	2.1	0									
3248	3	3	2	35			0									
3248	3	4	2	81	3.1	3	0									
3248	3	5	2	130	3.4	3.1	0									
3248	3	6	2	28			0									
3248	3	7	2	34			0									
3248	3	9	2	27			0									
3248	3	10	2	57	2.2	2	0									
3248	3	11	2	85	2.4	2	0									
3248	3	12	2	147	5.9	5	0					1	129			
3248	3	13	2	168	6	5.4	0									
3248	3	14	2	45			0									
3248	3	15	2	50			0									
3248	3	16	2	74	2.5	2	0									
3248	3	17	2	136	4.8	4.1	0									
3248	3	18	2	95	4.4	3.9	0									
3248	3	20	2	48			0									
3248	3	21	2	81	2.7	2.5	0					1				
3248	3	22	2	135	2.8	2.6	0					1	51			
3248	3	23	2	234	7.3	6.4	0									
3248	3	24	2	90	3.5	2.8	0									
3248	3	25	2	76	2.3	2.2	0									
3251	3	1	2	89	2.6	2.2	0									
3251	3	2	2	171	5.8	4.9	0					1	119			
3251	3	6	2	183	6.2	5.5	1	0		1	15	1				
3251	3	7	2	107	3	2.5	0									
3251	3	12	2	26			0									
3251	3	16	2	175	7.2	6.8	0					3				
3251	3	17	2	146	6.1	5.7	0									
3251	3	21	2	38			0									
3251	3	22	2	174	6.2	5.2	0									
3251	3	23	2	140	4.3	4	0									
3254	3	1	4	257	7.1	7.9	1	0		1	15					
3254	3	2	4	225	7.8	6.7	0					4	54			
3254	3	3	4	161	4.6	4.6	0									

3254	3	4	4	183	4	3.4	0									
3254	3	6	4	151	4.5	3.8	0									
3254	3	7	4	176	5.6	5.2	0									
3254	3	8	4	128	4.6	4.4	0					1				
3254	3	9	4	257	6.7	5.4	0									
3254	3	11	4	276	6.8	5.7	0									
3254	3	12	4	195	5	4	0					1				
3254	3	14	4	274	6.3	5.4	0					2				
3254	3	15	4	257	6.8	5.8	0									
3254	3	16	4	296	7.8	6.1	0					1				
3254	3	17	4	303	6	5.3	0									
3254	3	18	4	314	9.8	8.7	0									
3254	3	19	4	83	2.4	1.6	0									
3254	3	20	4	169	3.8	4.4	0					1				
3254	3	21	4	240	8.1	6.4	0									
3254	3	22	4	250	5.8	4.8	1	0		1	12					
3254	3	24	4	366	9.8	7.7	0					1				
3254	3	25	4	285	7.8	7.8	0									
3255	1	5	4	72	6.9	7.1	1	1		0		1				
3255	1	7	4	178	12.1	10.4	0					5	98	101		
3255	1	11	4	177	8.1	7.7	0					1	45			
3255	1	18	4	127	6.8	6.4	0					3	63	82		
3255	1	21	4	166	9.3	7.9	0									
3255	1	22	4	176	10	10	0					6	123			
3255	1	23	4	129	5.7	6.5	1	0		1		2				
3257	3	1	1	70	2.5	2.2	0									
3257	3	2	1	125	4	3.5	0					1	35			
3257	3	3	1	200	6.9	6.3	0					3	83			
3257	3	4	1	101	5	4.5	0					1				
3257	3	5	1	127	5	4.4	0									
3257	3	6	1	114	2.9	2.8	0									
3257	3	7	1	112	2.4	2.6	0					2				
3257	3	8	1	141	3.7	3.5	0									
3257	3	9	1	172	4.3	4.2	0									
3257	3	10	1	161	5.6	5.3	0					1				
3257	3	13	1	188	4.6	5.1	0					1				
3257	3	14	1	61	2	2.1	0									
3257	3	15	1	119	2.8	2.5	0									
3257	3	16	1	26			0									
3257	3	18	1	113	3.5	3.2	0					2				
3257	3	22	1	58	2.2	1.7	0									
3257	3	23	1	48			0									
3257	3	24	1	195	6.5	6.1	0									
3257	3	25	1	138	4.5	3.9	0									
3345	1	11	1	54	3.7	3.3	0									
3347	3	1	1	71	2.3	2	0									
3347	3	2	1	166	4.2	3.9	0									
3347	3	3	1	128	5.5	5.1	0									
3347	3	4	1	63	2.2	2	0									
3347	3	5	1	105	4.7	3.9	0									
3347	3	6	1	64	1.8	1.7	0									
3347	3	7	1	50			0									
3347	3	8	1	99	3.5	3.2	0									
3347	3	9	1	93	2.6	2.5	0									
3347	3	10	1	65	2.9	2	0									
3347	3	12	1	70	2.4	2.4	0									
3347	3	13	1	34			0									
3347	3	14	1	126	4.1	3.7	0									
3347	3	15	1	39			0									

3347	3	16	1	107	3	3.1	0									
3347	3	17	1	103	4.6	3.9	0									
3347	3	18	1	99	3.5	2.8	0					1	57			
3347	3	19	1	126	3	3	0					1				
3347	3	20	1	141	5.6	6	0					2	55	76		
3347	3	21	1	96	3.1	2.9	0									
3347	3	22	1	103	5.6	4.8	0									
3347	3	24	1	141	4	3.3	0									
3347	3	25	1	98	4	3	0									
3348	1	4	2	71	3.2	2.8	0					2				
3348	1	9	2	58	3.7	3.3	0									
3350	3	1	2	213	6.6	6.2	0					3	140			
3350	3	2	2	150	4	3.1	0									
3350	3	3	2	172	4.5	3.9	0									
3350	3	4	2	178	4.9	4.3	0									
3350	3	5	2	96	4.1	3.7	0									
3350	3	6	2	97	3.6	2.8	0									
3350	3	9	2	46			0									
3350	3	10	2	180	4.5	4	0									
3350	3	12	2	167	4.6	3.9	0									
3350	3	14	2	128	3	3	0									
3350	3	15	2	161	3.8	4.4	0									
3350	3	16	2	45			0									
3350	3	17	2	144	4.9	3.9	0					1	65			
3350	3	18	2	123	2.7	2.7	0									
3350	3	19	2	101	3	2.5	0									
3350	3	21	2	120	3.9	3.5	0					1				
3350	3	22	2	58	2.2	2	0									
3350	3	23	2	120	3.6	3.1	0									
3350	3	24	2	156	5.7	4.7	0									
3350	3	25	2	50			0									
3353	3	3	3	119	3	2.7	0					2	102			
3353	3	4	3	205	6.2	5.5	0									
3353	3	5	3	189	5.5	5	0									
3353	3	8	3	208	5.2	4.5	0					1	117			
3353	3	9	3	128	4.9	4.2	0					1				
3353	3	13	3	191	6.8	5.8	0					2				
3353	3	14	3	197	7	5.7	0					3				
3353	3	15	3	212	6.4	5	0					1				
3353	3	19	3	239	7.6	6.8	0									
3353	3	20	3	174	5.2	4.7	0					1				
3353	3	21	3	160	5.4	5.1	0					1	132			
3353	3	24	3	250	6.8	6	0									
3354	1	3	4	217	7	9	1	0		1		6	188			
3354	1	4	4	210	12.7	13.8	1	0		1	30	2				
3354	1	7	4	137	5	5.4	1	0		1		3	100			
3354	1	10	4	110	7.2	7.9	1	1		0		2				
3354	1	13	4	167	6.4	6.3	0					1				
3354	1	14	4	173	7.3	6.9	1	0		1	27	1				
3354	1	15	4	200	9	9	1	1		0		4				
3354	1	18	4	178	9.7	9.3	0					3				
3354	1	19	4	165	8	8.8	1	0		1	2	4	119			
3354	1	20	4	215	9	9.7	1	1		0		4				
3354	1	24	4	179	6.9	7	0					2	90			
3356	3	1	1	123	5.6	4.6	0									
3356	3	2	1	139	3.8	4.4	0									
3356	3	3	1	37			0									
3356	3	6	1	113	4.1	3.4	0					1				
3356	3	7	1	68	3.8	4.3	0									

3356	3	10	1	15			0									
3356	3	11	1	143	4.4	3.8	0									
3356	3	12	1	35			0									
3356	3	13	1	46			0									
3356	3	16	1	134	3.8	3.3	0									
3356	3	17	1	86	3.3	3.2	0									
3356	3	18	1	36			0									
3356	3	20	1	33			0									
3356	3	21	1	152	5.1	4.9	0									
3356	3	22	1	101	3.7	3.2	0									
3356	3	23	1	61	2	1.9	0									
3356	3	24	1	39			0									
3356	3	25	1	47			0									
4445	3	1	1	65	1.7	1.6	0									
4445	3	2	1	88	2.5	2.4	0									
4445	3	3	1	160	5.3	4.8	0					1				
4445	3	4	1	232	6.3	5.6	0					2				
4445	3	5	1	257	6.6	5.5	0					3	121	123		
4445	3	6	1	58	1.5	1.3	0									
4445	3	7	1	124	2.7	2	0									
4445	3	8	1	88	1.7	1.7	0									
4445	3	9	1	116	3.3	3.3	0									
4445	3	10	1	278	9.8	8	0					2				
4445	3	13	1	48			0									
4445	3	14	1	130	2.9	2.5	0									
4445	3	15	1	93	1.8	1.6	0									
4445	3	17	1	125	3.6	3.2	0					1	92			
4445	3	18	1	127	3.4	2.7	0									
4445	3	19	1	149	3.8	3.1	0					1				
4445	3	20	1	183	6.2	5.6	0					2	61			
4445	3	22	1	120	1.8	1.7	0									
4448	3	2	2	252	8.3	7	0					4	75	96	131	131
4448	3	5	2	324	7.6	7	0					2	272			
4448	3	6	2	332	8.5	7	0					1				
4448	3	7	2	259	6.3	5	0									
4448	3	8	2	342	8.6	7.4	0									
4448	3	9	2	307	11.1	8.6	0									
4448	3	10	2	277	6.4	5.3	0									
4448	3	11	2	284	7	6.5	0					1	130			
4448	3	12	2	287	4.4	4.1	0									
4448	3	13	2	244	4.9	4.2	0									
4448	3	14	2	302	9	7.5	0									
4448	3	16	2	367	12.3	11.6	0									
4448	3	17	2	189	5.7	4.9	0									
4448	3	18	2	216	4.3	3.5	0									
4448	3	19	2	88	2.7	2.4	0									
4448	3	20	2	188	4.1	4	0					1				
4448	3	22	2	335	8.2	7.9	0					2	109			
4448	3	23	2	313	6.6	6.4	0					1				
4448	3	24	2	265	6.3	5.8	0									
4448	3	25	2	287	8.2	6.7	0					1	121			
4449	1	5	2	101	4.2	3.6	0					1				
4451	3	1	2	168	4.8	4.5	0									
4451	3	2	2	97	3	3	0									
4451	3	4	2	107	3.5	3.4	0									
4451	3	6	2	83	2	2	0									
4451	3	9	2	109	2.8	3	0									
4451	3	10	2	70	1.5	1.3	0									
4451	3	11	2	112	2.6	2.5	0									

4451	3	12	2	122	3.5	3.5	0									
4451	3	13	2	77	1.7	1.6	0									
4451	3	14	2	169	5.1	4.9	0									
4451	3	16	2	112	2.8	2.7	0					1	100			
4451	3	18	2	190	4.8	4.2	0									
4451	3	19	2	124	3.2	2.9	0					2	58			
4451	3	20	2	200	6.9	6.4	0					2	120			
4451	3	22	2	116	3.6	3	0									
4451	3	23	2	102	2.2	2.2	0									
4451	3	24	2	195	6.9	5.9	0					2				
4451	3	25	2	145	3.8	3.3	0									
4454	3	1	4	265	9.5	8.2	0					3				
4454	3	2	4	209	5.6	5.2	0									
4454	3	3	4	277	8.9	8.2	0					1				
4454	3	4	4	98	2.2	2.1	0									
4454	3	5	4	234	7.1	5.9	0					1				
4454	3	6	4	77	1.6	1.5	0									
4454	3	7	4	275	5.4	4.5	0					1				
4454	3	8	4	240	6.5	5.9	0									
4454	3	9	4	291	6.7	5.4	0									
4454	3	10	4	293	9.3	8	0									
4454	3	11	4	243	6.5	6	0									
4454	3	12	4	327	8.8	7.6	0					1				
4454	3	13	4	331	9.2	7.8	1	0		1		1	181			
4454	3	14	4	290	5.1	5.4	1	0		1	30					
4454	3	15	4	349	8.8	7.2	0					2				
4454	3	16	4	265	9	7.3	0									
4454	3	18	4	315	7.6	5.9	0									
4454	3	19	4	228	3.7	3.2	0									
4454	3	20	4	305	8.6	7.5	0					1				
4454	3	21	4	305	8.5	7	0					4				
4454	3	22	4	247	7.7	6.5	0									
4454	3	23	4	369	9.5	8.8	0					1				
4457	3	1	1	260	7.8	6.7	0									
4457	3	2	1	155	4.6	3.5	0									
4457	3	3	1	297	10.8	8.1	0					2	128			
4457	3	6	1	257	7.3	6.3	0									
4457	3	7	1	254	6.1	5.5	0									
4457	3	8	1	325	9.1	7.9	0									
4457	3	9	1	228	5.4	4.5	0									
4457	3	10	1	237	7.4	6	0									
4457	3	11	1	262	7	5.5	0									
4457	3	12	1	235	6.5	6	0									
4457	3	13	1	227	6.6	5.4	0					2	59	110		
4457	3	15	1	240	5.9	4.9	0									
4457	3	16	1	306	6.2	5.7	0									
4457	3	17	1	318	7.7	5.8	0									
4457	3	18	1	237	5.5	4.4	0									
4457	3	19	1	318	6.2	5.6	0					1				
4457	3	21	1	253	6.7	5.9	0					1				
4457	3	22	1	255	9.7	7.6	0									
4457	3	23	1	154	1.9	1.8	0									
4457	3	24	1	303	9.4	8.8	0									
4457	3	25	1	220	7	7.1	0					1				
4458	1	24	1	102	4.9	4.5	0									
4458	1	25	1	177	12.7	11.7	1			1	10	2				
4460	3	1	2	263	8.8	7.1	0									
4460	3	5	2	242	6.9	6.1	0									
4460	3	7	2	271	7.1	6.6	0									

4460	3	10	2	353	11.5	11	0									
4460	3	11	2	302	10.5	10	0									
4460	3	12	2	290	7.8	6.5	0									
4460	3	13	2	296	7.6	7.2	0									
4460	3	14	2	307	7.3	7	0									
4460	3	16	2	125	2.7	2.7	0									
4460	3	17	2	234	5.6	5	0									
4460	3	18	2	260	6.2	5.7	0									
4460	3	19	2	261	6.5	6.5	0									
4460	3	20	2	236	7.8	6.1	0									
4460	3	21	2	331	9	7.7	0									
4460	3	22	2	264	7.7	6.8	0									
4460	3	24	2	158	4.5	4	0									
4460	3	25	2	234	6.3	5.9	0									
4545	1	16	1	48	1.2	1.2	0									
4545	1	17	1	40	2.3	2	0									
4545	1	21	1	81	2.5	2.2	0									
4545	1	24	1	47	2	1.7	0									
4547	3	2	2	258	7.2	6	0					1				
4547	3	3	2	298	7.3	5.7	0									
4547	3	4	2	365	10.3	8.2	0									
4547	3	5	2	246	5.1	4.2	0					1				
4547	3	7	2	224	6	4.7	0									
4547	3	8	2	317	9.1	8.1	0									
4547	3	9	2	345	8.2	7.8	0									
4547	3	10	2	360	10	7.9	0									
4547	3	11	2	214	6.6	5.1	0					1				
4547	3	12	2	295	9.2	7.4	0					1				
4547	3	13	2	250	4.2	4.7	0									
4547	3	14	2	185	4.2	3.8	0									
4547	3	15	2	293	7.4	6	0									
4547	3	16	2	169	3.4	3.2	0									
4547	3	17	2	162	4.8	4.4	0									
4547	3	19	2	178	3.5	3.5	0					1				
4547	3	20	2	328	8.7	8	0									
4547	3	24	2	213	7.1	5.9	0					1				
4547	3	25	2	79	2	1.9	0									
4550	3	1	2	142	3.8	3.5	0									
4550	3	2	2	179	6.9	5.3	0									
4550	3	4	2	145	4.4	4	0									
4550	3	5	2	142	3.2	2.7	0									
4550	3	6	2	117	2.8	2.6	0									
4550	3	7	2	128	3.3	2.9	0									
4550	3	8	2	135	3.8	3.8	0									
4550	3	9	2	156	6.3	5	0									
4550	3	11	2	46			0									
4550	3	12	2	48			0									
4550	3	13	2	151	5.2	4.6	0									
4550	3	14	2	263	9.6	9.2	0									
4550	3	15	2	64	1.8	1.9	0									
4550	3	16	2	240	7.8	6.6	0					1	164			
4550	3	17	2	181	5	3.9	0					2				
4550	3	18	2	214	6.2	5.2	0					1				
4550	3	19	2	146	3.1	3	0									
4550	3	20	2	159	5.5	4.5	0									
4553	3	4	3	110	6.4	5.8	0									
4553	3	7	3	230	8.3	7.6	0					1	137			
4553	3	9	3	216	6.5	6	0					1				
4553	3	11	3	211	8	7.2	0					1				

4553	3	12	3	145	3.1	2.6	0									
4553	3	14	3	106	3	2.9	0									
4553	3	17	3	207	5.9	5.2	0									
4553	3	23	3	208	6.7	7.1	0					3				
4556	3	1	4	272	9.2	7.6	0									
4556	3	4	4	164	5	4.5	0									
4556	3	5	4	378	8.4	7.6	0					3				
4556	3	6	4	329	13.9	9.5	0									
4556	3	7	4	224	5.5	4.2	0									
4556	3	8	4	263	6.1	6	0									
4556	3	9	4	292	8.3	8.5	1	0		1	24	1	162			
4556	3	10	4	280	7.1	6	0									
4556	3	11	4	176	4.5	4.5	0									
4556	3	12	4	360	8.8	7.9	0									
4556	3	13	4	278	8.5	7	0					1				
4556	3	14	4	358	9	7.4	0					2	248			
4556	3	15	4	182	4.1	3.5	0									
4556	3	16	4	353	8.5	7.2	0									
4556	3	17	4	80	1.5	1.2	0									
4556	3	18	4	262	5.5	5	0									
4556	3	19	4	352	8.3	6.9	0									
4556	3	20	4	361	7.9	7.7	0					1				
4556	3	21	4	329	9.1	7.9	0					1	154			
4556	3	22	4	376	8.5	7.5	1	0		1	23					
4556	3	23	4	362	8.5	6.8	0									
4556	3	24	4	187	4.8	3.4	0									
4556	3	25	4	387	12	11.3	0									
4559	3	2	2	158	3.9	3.7	0					1	35			
4559	3	3	2	260	6.4	5.5	0									
4559	3	4	2	159	4.7	4	0					1				
4559	3	5	2	150	4	4.1	0									
4559	3	6	2	352	11	10	0									
4559	3	7	2	105	4.1	3.6	0					1	56			
4559	3	8	2	247	6.4	5.4	0									
4559	3	9	2	294	7.2	7	0									
4559	3	10	2	285	8.5	8.1	0					1	96			
4559	3	11	2	281	8.2	6.8	0									
4559	3	12	2	310	9.2	8.2	0									
4559	3	14	2	281	9.7	7.4	0									
4559	3	16	2	318	5.3	5.2	0									
4559	3	17	2	125	3	2.6	0									
4559	3	18	2	320	9	7.2	0					1				
4559	3	19	2	220	6.4	6.1	0									
4559	3	20	2	316	9.1	7.3	0									
4559	3	21	2	207	6.5	6	0									
4559	3	22	2	196	8.9	7.9	0									
4559	3	23	2	255	7.3	6.8	1	0		1	30	1				
4559	3	24	2	170	4.4	4	0									
4559	3	25	2	165	6	5	0									
4646	3	1	2	59	1.4	1.3	0									
4646	3	2	2	48			0									
4646	3	3	2	111	2.1	2	0									
4646	3	5	2	56	1.5	1.4	0									
4646	3	6	2	37			0									
4646	3	7	2	50			0									
4646	3	8	2	51	1.5	1.3	0									
4646	3	18	2	182	6.5	5.2	0					5	41			
4646	3	20	2	197	5.3	5	0					2				
4646	3	21	2	74	2.4	2.4	0									

4646	3	22	2	119	4.5	3.7	0					2				
4646	3	23	2	262	7.2	6.9	0					1				
4646	3	24	2	307	8.8	7.7	0					5	76			
4646	3	25	2	257	8.2	7.1	0					2				
4649	3	12	2	148	3.5	3.2	0									
4649	3	14	2	226	8.8	9.9	0									
4649	3	15	2	163	2.7	2.7	0									
4649	3	17	2	333	10.1	9.1	0					1	84			
4649	3	21	2	200	5.7	4.8	0					1				
4649	3	22	2	114	2.2	2	0									
4649	3	23	2	271	7.1	5.9	0									
4649	3	24	2	243	8	6.3	0					1	121			
4649	3	25	2	441	11.9	11.5	0									
4652	3	1	3	243	6.7	6.7	0									
4652	3	6	3	281	7.6	6.6	0					6	91	132	145	
4652	3	8	3	213	6.2	5.9	0					1				
4652	3	9	3	180	5.2	4.6	0					3	108	115	121	
4652	3	20	3	159	3.4	3.9	1	1	10	1	10					
4652	3	21	3	72	1.9	1.7	0									
4652	3	22	3	191	6.9	6.7	0					1				
4655	3	1	4	257	7.6	6.9	0									
4655	3	2	4	344	8.2	7.5	0									
4655	3	3	4	433	12.3	8.9	0									
4655	3	4	4	264	8.6	7.8	0									
4655	3	7	4	337	8.2	8.6	0									
4655	3	9	4	208	5.8	5.3	0									
4655	3	10	4	257	10.4	9.2	0					2	154			
4658	3	1	1	367	9.6	8.9	0									
4658	3	3	1	374	12	9.7	0					1				
4658	3	4	1	382	11.6	9.5	0					2				
4658	3	5	1													
4658	3	7	1	318	7.3	6.7	0									
4658	3	9	1	273	6.3	5.6	0									
4658	3	10	1	337	12.2	9.6	0									
4658	3	15	1	215	6.7	6.3	0									
4658	3	20	1	322	9.3	8.3	0									
4658	3	21	1	254	5.9	4.9	0									
4658	3	22	1	361	9.7	8.5	0									
4658	3	25	1	376	10.2	9.3	0									
4659	1	25	1	133	9.2	7.8	0					2				
4745	3	1	2	125	3.4	3	0									
4745	3	2	2	50			0									
4745	3	3	2	237	5.8	4.8	0									
4745	3	4	2	211	4.6	3.7	0									
4745	3	5	2	115	3.1	2.6	0									
4745	3	6	2	184	3.7	4	0									
4745	3	7	2	46			0									
4745	3	8	2	164	4.6	4.1	0									
4745	3	9	2	200	4.4	4.3	0					1				
4745	3	11	2	77	1.6	1.4	0									
4745	3	12	2	114	2.8	2.4	0									
4745	3	13	2	185	4.5	3.7	0									
4745	3	14	2	186	4.2	3.7	0									
4745	3	15	2	128	3	2.9	0									
4745	3	16	2	136	4.8	4.3	0									
4745	3	17	2	175	6.3	4	0									
4745	3	18	2	333	8	7.6	0									
4745	3	19	2	184	4.7	4.9	0									
4745	3	20	2	212	6.7	5.1	0									

4745	3	21	2	174	4.1	3.6	0									
4745	3	22	2	151	3.7	3	0									
4745	3	23	2	157	3.3	3.4	0									
4745	3	24	2	292	8.3	6.7	0					2				
4745	3	25	2	270	7.1	6	0									
4746	1	7	2	168	16	13.1	1	0		1	20	2	104			
4748	3	2	2	97	2.6	2.6	0									
4748	3	3	2	249	6	5	0									
4748	3	4	2	145	3.7	3.3	0									
4748	3	5	2	265	8.5	7.5	0									
4748	3	6	2	83	1.7	1.9	0									
4748	3	7	2	143	4	3.3	0									
4748	3	8	2	277	7.8	6.6	0									
4748	3	9	2	299	8.4	7.3	0					1				
4748	3	10	2	324	8.6	7.5	0									
4748	3	11	2	155	3.8	3.5	0									
4748	3	12	2	118	3.2	3	0									
4748	3	13	2	150	5.4	4.3	0									
4748	3	14	2	140	4.4	3.8	0									
4748	3	15	2	245	7	7	0					1				
4748	3	16	2	102	2.3	2.1	0									
4748	3	17	2	81	2.5	2.1	0									
4748	3	18	2	113	2.2	2	0									
4748	3	19	2	259	7	6.3	0									
4748	3	20	2	272	6.1	6.1	0					1				
4748	3	21	2	329	8.4	7.5	0					1				
4748	3	25	2	176	3.8	3.5	0									
4749	1	6	2	136	5.6	5.2	0					2				
4751	3	1	2	286	9.2	7.9	0									
4751	3	3	2	105	2.6	2.2	0									
4751	3	6	2	162	5.4	5.1	0									
4751	3	7	2	302	9.7	7	0					1				
4751	3	8	2	123	3.1	3.1	0					1				
4751	3	9	2	230	7.5	6.9	0					5	110	123	149	
4751	3	11	2	172	4	3.5	0									
4751	3	12	2	137	3.5	3.1	0									
4751	3	13	2	309	9	8.3	0					1				
4751	3	14	2	164	4.8	4.1	0									
4751	3	15	2	61	1	0.9	0									
4751	3	16	2	227	10.1	9	0					1				
4751	3	17	2	180	3	2.9	0									
4751	3	18	2	165	4.5	4	0									
4751	3	19	2	194	4.3	3.8	0									
4751	3	21	2	286	8.6	7.7	1	0		1	34	1	167			
4751	3	22	2	301	8.5	7.1	0									
4751	3	23	2	261	5.8	5.3	0									
4751	3	24	2	128	3.8	3.5	0									
4754	3	9	3	189	5.1	4.7	0									
4754	3	15	3	212	7.8	6.4	0									
4754	3	19	3	291	6.7	7	0									
4754	3	25	3	343	9.7	8.7	0									
4757	3	10	1	366	12	10.9	0									
4760	3	1	2	271	7.8	7	0									
4760	3	2	2	340	10.5	10	0					1				
4760	3	3	2	202	5.9	5.1	0									
4760	3	6	2	295	6.3	6.3	0									
4760	3	7	2	307	6.4	6.1	0					1	76			
4760	3	10	2	322	9.9	8.4	0					3				
4760	3	11	2	50			0									

4760	3	12	2	105	2.7	2.8	0					1				
4760	3	13	2	218	5.6	4.7	0									
4760	3	14	2	167	5.2	4.5	0									
4760	3	15	2	194	5.6	4.5	0									
4760	3	18	2	365	10.5	9.8	0									
4760	3	19	2	215	4.2	3.9	0									
4760	3	20	2	322	11.8	11.2	0					5	98			
4760	3	21	2	269	8.5	7.6	1	1	99	1	99	2				
4760	3	23	2	343	7.2	6.5	0					1	159			
4760	3	24	2	244	7	7.2	1	1	150			1				