2.11 Representativeness of the Sample Grid

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2.11.1 Introduction

The Swiss National Forest Inventory established, like most of the European national forest inventories, permanent sample plots, which were repeatedly visited and measured. In contrast to these were temporary sample plots, which were only measured during one particular inventory. In a few of the cases, such as the French Forest Inventory, only temporary sample plots were used. Frequently, permanent as well as temporary samples were used during one inventory.

The terrestrial sample grid of the second Swiss National Forest Inventory was a subsample of the 1 km x 1 km grid (in the following referred to as 1-km-grid) of the first NFI. The samples were systematically located at the diagonal corner points of the first NFI grid, so that the resulting grid had a width of 1.44 km x 1.44 km (in the following referred to as 1.4-km-grid). (See Chapter 2.1.5, Table 4, BRÄNDLI and BRASSEL 1999.) The reduced sample size, and changes from forest to non-forest, created different categories of sample plots in the second NFI which were similar to the "sampling with partial replacement" (KÖHL 1994; WARE and CUNIA 1962).

The grid encompassed sample plots which were measured only in the first NFI because they changed from forest to nonforest (PF-0). Further permanent sample plots exist which were measured in both inventories (PF-A). The commonality between sample plots of types PF-0 and PF-A was that they were permanently marked as NFI sample plots with visible colored marks in order to find the sample in a later inventory. A third category encompassed samples which were newly established and measured only in the second NFI. These were sample plots that changed to forest in the second NFI (PF-B). In addition, new sample plots were also established (PF-C). They were located on a newly established systematic 4 x 4 km grid (in the following referred to as 4-km-grid), which was shifted in an x and y direction by 500 meters. The shift, with respect to the 1.4-km-grid, excluded the possibility of overlapping with the already existing grids.

The samples of the 4-km-grid were the main focus of this study, which dealt with how the visible permanent marks affected the manager's actions of those stands on which the sample plots were located. The marked sample plots could have influenced the forest service or the private forest owner in a certain way. This was ruled out for the new NFI2 sample plots, since it was not possible to predict that the sample plots of the National Forest Inventory would be established. It was conceivable that stands were treated with special care, or that less timber was cut when the stands clearly had "representative" characteristics. KÖHL (1990) draws attention to this problem and cites SCHMID-HAAS (1983). According to SCHMID-HAAS (1983) there is no guarantee that visible sample plots retain their representative characteristics. The objective of this study was to show whether or not certain sample plot or individual tree attributes were different on the marked sample plots in the first NFI versus the newly established ones. Confirming these considerations could have meant that stands with visible sample plots of the National Forest Inventory were managed differently than other stands. Certain results of the National Forest Inventory would have been biased in this case due to permanently marking the sample plots. These considerations were written here in the subjunctive on purpose, since a significant difference between the sample plot collective is not automatically a proof for a causal relationship. It is also possible that one or more covariables existed which partially or mainly influenced these differences. For a general discussion about methods of permanently marking refer to ZÖHRER (1980) and LÖTSCH *et al.* (1973).

2.11.1.1 Goal of the Study

The ultimate goal of this study was to investigate whether or not the visible marking of the permanent sample plots in the NFI influenced the manager significantly, which was manifested in the sample plot and individual tree attributes.
The following hypothesis was tested:

- Null hypothesis, H0: The marking has no effect on the manner in which the forest is managed. The results with respect to the test statistics between the marked and the non-marked sample plots are not significantly different.
- Alternative hypothesis, HA: The differences in the results or the test statistics are so obvious that they cannot be explained by chance alone.

This study here presents a first step in reaching this goal. Apart from the actual analysis of the data, the study evaluated whether the proposed question could be answered with the available data and, if necessary, how the methods could be improved.

2.11.2 Methods

The survey of compared attributes was conducted at different aggregation levels. Attributes which characterized a sample plot, as well as attributes which were assessed on sample plot elements (usually individual trees), had to be differentiated. The sample plot data were either measured or collected directly from the sample plot and its surroundings, or came from the inquiry at the forest service. The sample unit in the NFI was the sample plot. This was the reason that, in order to calculate estimators, the data of the individual elements such as volume and damage of trees, had to be summarized to sample plot figures.

If it was desired to compare the marked sample plots (PF-A) with the non-marked newly established areas (PF-B+C), certain properties of both of the collectives had to be considered. The so-called combined or joint sample plot grid consisted of sample plots, which were considered forest according to the NFI definition at both particular inventories (PF-A). The newly established samples (PF-B+C) were composed of samples especially established for the representative study (PF-C) and new ones that did not fulfill the forest definition criteria in the first NFI (PF-B).

Nothing is known about the history of the plots located on the new 4-km-grid, since in the first NFI no aerial photo interpretation was conducted in this grid. These new sample plots represent, unbiasedly, the state of the second NFI. The corresponding sample quantities had the same expected value as the sample PF-A. The sampling error was higher due to the smaller sample size. However, it was reasonable to assume that the new samples of the 1.4-km-grid (PF-B) had a lower growing stock compared to the sample of the joint grid. Young and open stands were present in this collective with a higher probability than in the joint grid. As a consequence of these considerations, it followed that the three collectives PF-A, PF-B and PF-C should be analyzed separately, and that comparing the tree data was only reasonable between the sample PF-A and PF-C.

In general, it was of interest to examine those attributes, which were assumed to be strongly dependent on the type of management. If the observed attributes were significantly different between the two samples, it could have been attributed to a different type of management, which was motivated by the visible marks of the sample plots. As already mentioned, other influential factors could also have played a role. But since the samples of the collective PF-A and PF-C were distributed systematically over the entire area of Switzerland, both collectives were expected to be influenced by these factors.

If marked sample plots were found in a stand, several different behavior patterns of a manager were conceivable, independent of a certain attribute. In general, a manager's behavior patterns toward a stand could be attributed to indifference. Otherwise intensive and carefully managed stands would be noticeable if the manager wanted to leave a good impression. A low intensive management style was also imaginable in order "not to destroy or disturb any research work". If the behavior was different, it was possible to detect it. And regardless of the direction the manager's behavior took, it could be tested for its significance. It was, therefore, important to find attributes which were influenced by these different behavior patterns.

2.11.2.1 Examined Attributes

(1) Growing stock

a) Comparison of the individual tree volume
b) Growing stock on the sample plot weighted by the tree expansion factor (See also equation 17, Chapter 3.2 and KAUFMANN and BRASSEL 1999)

Data for growing stock and changes in growing stock were of central importance in the NFI. In principle, it could be assumed that these groups of attributes were hardly influenced by the manager. It was nevertheless conceivable that during timber harvest, trees were intentionally left on the sample plots. If the manager would have behaved in this way, the estimated growing stock would probably have been higher from the marked samples than from the new unmarked sample plots. The data for the utilization would have shown the opposite reaction; however, they could not be compared, since the new sample plots did not have any data about the utilization.

(2) Damage

The attribute damage was subdivided into stem damage (exposed wood) and other damage. If there were damages from both groups, a tree counted towards the first group, "damage on the stem". Damages on the stem were mainly caused by harvesting damage or by falling rocks and avalanches. The proportion of the two classes of damage type and the proportion of the two categories of damage cause was investigated. If the markings had any influence, the marked sample plots were expected to have fewer stem and harvesting damages than the unmarked ones, due to increased efforts toward tending. No differences were expected for the damage caused by avalanches. At most, a more intensive wound treatment was conceivable, which allowed the stem damage to heal after many years. The later was, in principle, also possible for harvesting damage.

(3) Number of years after the last operation

This quantity was directly controlled by the manager and was a clear indicator of the influence the sample plot marks had. Two different behavior patterns were possible: (a) The manager thinned more regularly and more often than in other stands in order to create an optimal tending status. (b) The manager rarely intervened in stands that contained a sample plot in order not to disturb the sample plot. This possibility was already considered for the attribute growing stock.

(4) Protective measures against damage caused by game in the stands

Code	Description	Explanation
1	Unprotected	No protective measures against damage caused by game
2	Fenced	The plot center was located in a fenced in young growth stand
3	Individual protection	The young forest plants were individually protected (e.g., the buds were protected with chemical agents or hemp, etc. and individual protection with barbed wire or wire basket, etc.)

These attributes were recorded in the surroundings of the sample plot (interpretation area). For these attributes, similar possibilities applied as they did for the attribute (3) "last utilization". If marks had an influence, the protective measures were expected to be more frequent in the surrounding stands.

(5) Needs of silvicultural treatments in the protection forest NFI2 (See Chapter 3.6)

Code	Description
0–0.17	High need of silvicultural treatment
0.18–0.38	Average need of silvicultural treatment
0.39–0.62	Moderate need of silvicultural treatment
0.63–0.82	Low need of silvicultural treatment
0.83–1.00	Very low/no need of silvicultural treatment

For these variables it could also be assumed that if the sample plot marks influenced the managers, the need of silvicultural treatment was expected to be lower, which would have indicated a more careful management. The urgency of a silvicultural treatment was expected to be inversely proportional to the number of years since the last operation.

(6) Percentage of unregulated felling
This attribute characterized the percentage of resulting unregulated felling in 20% classes of the total fellings, and was assessed from the inquiry at the local forest service. The percentage of unregulated felling could have only been indirectly influenced by the manager, but over a longer period of time would have been an indicator for the care and efficiency of silvicultural treatments.

(7) Standing dead trees

Code	Description	Explanation
1	Present	More than 1 m^3 over 20 cm DBH present on interpretation area
2	Not present	Less than 1 m^3 over 20 cm DBH present on interpretation area

Standing dead trees were registered, provided that their DBH was greater than 20 cm and had more than 1 m^3 growing stock (corresponds to approximately 4 m^3/ha). The volume of standing dead trees was estimated. This attribute also gave some indication about the different treatment of the stands in which the NFI sample plots were established.

The following situation was expected if an influence was suspected:

a) On the marked areas less standing dead trees were expected, since their periodical removal is still regarded as a sign of "clean" forestry. This especially was expected in the private forests, since the behavior of the person responsible there is usually more conservative.
b) More standing dead trees existed because the sample plots were not to be changed or because leaving such trees standing had a positive influence on maintaining the biodiversity. The later situation was more expected in the public forest, where the idea about nature conservation was more likely to have a higher priority than monetary considerations.

There are still wide differences in opinions about how dangerous dry or dead trees are from a phytosanitary perspective, and how this is compensated by the value of natural conservation. In addition to this, the private forest owner weighs the cost of removing the sick or dead trees against the potential danger stemming from them. However, it was expected that the attribute "standing dead tree" – regardless of the possible behavior of individual groups or owner – was a differentiating attribute in general.

(8) Stand stability
The stand stability is the expected persistence of the relevant stand against disturbing influences over a 10-year period (Plateau, Jura, Pre-Alps) or a 20-year period (Alps, Southern Alps). For this, the condition or rather the mechanical stability of the stand was the only deciding factor. The expected development of the stand (e.g., from thicket to pole wood) must not be considered. The ecological stability (species diversity, provenance, closeness to nature, etc.) and long-term stability questions (problems with regeneration, sustainability, consequences of the soil and air pollution, etc.) were not considered either.

2.11.2.2 Stratification

Apart from the attributes introduced above, the collectives were also stratified according to the variables (a) ownership category, (b) mixture proportion and for the comparison of the individual tree volume by (c) main tree species. This procedure ensured that the variables were more homogeneous in the particular strata. This way it was clearer to detect a possible effect of the marks.

Since the actions of the private forest owner were based on attaching different importance to certain goals than the manager of the public forest, the component ownership had to be used for stratification. It can be supposed that the different economical strategies of the two ownership groups affect the attributes investigated here.

The mixture proportion was the estimated basal area proportion of the conifer trees to all trees. This measure serves as an indicator of the silvicultural goal for the surrounding stand and, therefore, is also supposed to influence the examined attributes. Conifer and broadleaf stands are usually managed with different measures according to the different goals.

Code	Description	Explanation
1	Pure conifer	91–100 % conifer*
2	Mixed conifer	51–90 % conifer
3	Mixed broadleaf	11–50 % conifer
4	Pure broadleaf	0–10 % conifer

* (basal area proportion)

For comparisons at the level of the individual tree, the data were not classified according to the mixture proportion, but were differentiated by the main tree species (1 spruce, 2 fir, 3 pine, 4 larch, 5 Swiss pine, 6 other conifers, 7 European beech, 8 maple, 9 ash, 10 oak, 11 chestnut and 12 other broadleaf).

2.11.2.3 Significance Test

After hypotheses were formed, significance tests supported the decision process by accepting or rejecting the proposed hypothesis. It was important for the formulation that the hypotheses were mutually exclusive and that all possible outcomes of the test statistic were covered. The selection of suitable tests took place after formulating the hypotheses and depended upon the scale and the distribution of the investigated variable. It is important to note for the selection of the tests that in each case two variables were compared, which were derived from two independent samples. In general, the effect of the visible marking (independent variable) with respect to the examined attributes (dependent variable) was studied.

Parametric Tests for Continuous Data on a Ratio Scale
For normal distributed continuous data, the t-test is used. For independent samples, the t-test examines whether the averages of both samples are significantly different. In order to check the assumption of normality, the Shapiro-Wilk statistic for small sample sizes ($n<2000$) and the Kolmogorov statistic for larger sample sizes are available in the statistic program SAS. The null hypothesis for both tests is: The underlying population is normally distributed. The alternative hypothesis is: The underlying population is not normally distributed (SAS INSTITUTE 1989).

Non-Parametric Tests for Ordinal Scaled and Not Normally Distributed Data
For the comparison of two independent samples that were on an ordinal scale, the U-statistic of the Mann-Whitney test (MWU test) was calculated (Equation 2). This test was also used if the continuous data were not normally distributed. The MWU test examines whether the rank sums of both samples are significantly different. According to STAHEL (1995), the power of the MWU test is higher than the t-test if the data deviates even slightly from a normal distribution.

Even if the data are assumed to come from a normal distribution it can be advantageous to use a non-parametric test in order to verify the decision to reject the null hypothesis. For large sample sizes (i.e., for $n_1 > 20$ and $n_2 > 40$), the U-statistic is approximately normally distributed. The null hypothesis can then alternatively be tested with the z-statistic. In all of these statistics, n_1 and n_2 denote the sample size for the smaller and larger samples respectively (p. 142, ZAR 1984). The z-statistic can be calculated according to the following formula:

$$z = \frac{|U - m_U| - 0.5}{s_U} \qquad (1)$$

where $m_U = \frac{n_1 n_2}{2}$, $s_U = \sqrt{\frac{n_1 n_2 (N+1)}{12}}$

and $U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R1$ (2)

n_1,n_2: sample size of the smaller/larger sample
N: n_1+n_2
$R1$: rank sum of the smaller sample

Goodness-of-Fit Tests for Nominal Scaled Data

The Pearson-chi-square goodness-of-fit test allows the comparison of the empirical frequencies to the expected frequencies. In the present case, this test was applied to study $2 \times r$ contingency tables (Table 1 and STOKES *et al.* 1997). More specifically, this test was applied to study whether the factor “marking” had significantly influenced the frequencies of the table cells, which is to say the range of classes of the investigated attribute. The null hypothesis of this test was accordingly defined by H0: There is no significant correlation between the treatment and the outcome.

The test statistic Q_P of the Pearson-chi-squared test is calculated according to:

$$Q_P = \frac{\sum_i \sum_j (n_{ij} - m_{ij})^2}{m_{ij}} \text{ where } m_{ij} = E\{n_{ij}|H_0\} = \frac{n_{i+} \cdot n_{+j}}{n}$$

, where n_{i+}, n_{+j}, n are the same as in Table 1.

The attributes studied here are usually on an ordinal scale. The exceptions were the frequencies of stem damages and the measures against game damage. To verify the test results, most of the attributes in Table 2 were presented in the ordinal as well as the nominal test category.

Table 1. Illustration of contingency tables.

	Response Variable Categories				
Group	1	2	..	r	Total
1	n_{11}	n_{12}	..	n_{1r}	n_{1+}
2	n_{21}	n_{22}	..	n_{2r}	n_{2+}
:	:	:		:	:
s	n_{s1}	n_{s2}	..	n_{sr}	n_{s+}
Total	n_{+1}	n_{+2}		n_{+r}	n

from (STOKES *et al.* 1997)

Table 2: Examined attributes and used significance test.

Attribute/Test	t-test (continuous)	MWU-test (ordinal)	Chisq test (nominal)
(1) Growing stock	x	x	
(2) Damage			x
(3) Last utilization		x	x
(4) Protection of regeneration against game damage			x
(5) Needs of silvicultural treatments		x	x
(6) Proportion of unregulated fellings		x	x
(7) Dead trees			x
(8) Stand stability		x	x

Multiple Tests

The main focus of the analysis presented here is the comparison between the marked and the unmarked sample plot grid of the National Forest Inventory. The general null hypothesis was always: The marking had no influence on the management of the surrounding stands. Here, the stratification according to ownership categories and mixture proportion made individual comparisons possible within the respective strata. The number of separate comparison *m* was determined by the product of the particular factor levels. For the stratification according to ownership and mixture proportion, *m* equals 8, since the factor ownership had two levels and the factor mixture proportion had four levels. Because of the multiple comparisons, the type-one error rate accumulates (p. 248 BORTZ 1993) and (p. 225 STAHEL 1995). The probability π, that with *m* individual tests the general null hypothesis is rejected falsely for at least one of the tests, is called "experimentwise error". It can be approximated by $\pi(k\ ?\ 1) = 1-(1-\alpha)^{m}$, where *k*= number of tests where H0 is rejected. The general null hypothesis is rejected with an error probability of α if the error probability of the individual test is less than $\alpha' = 1-(1-\alpha)^{1/m}$ (testwise error). The error α' can be approximated with the Bonferoni inequality by α' = α/*m*.

For α=0.05, the testwise error rate for the stratification amounted to α' = 0.0064 if both factors were used and to α' = 0.0051 if the category "no response" was also considered. In the case where the stratification was only carried out according to ownership categories, α' equaled 0.025.

Table 3. Number of sample plots and number of trees (growing stock) (Analysis unit: accessible forests without shrub forests).

	Number of sample plots	Number of trees	Collective
New sample plots, new established 4 x 4 km grid	733	8648	PF-C
New sample plots, 1.4 x 1.4 km grid	214	1104	PF-B
Sample plots on joined 1.4 x 1.4 km grid (data basis for change analysis)	5425	62249	PF-A
Total NFI2	6372	72001	PF-A+B+C

2.11.3 Results

A total of 6,372 sample plots were surveyed during the second NFI in accessible forest (without brushwood) (see also BRÄNDLI and BRASSEL 1999). Out of these, 733 sample plots (i.e. 8,648 trees) were in the new 4-km-grid (PF-C) and 214 "grown in" sample plots (1,104 trees) were in the 1.4-km-grid (PF-B). The data of these samples were compared with the already established sample from the 1.4-km-grid (5,425 sample plots, 62,249 trees).

The results of the significance test for the individual tree attributes (individual tree volume, standing volume and damages) were based on the comparison of the collective PF-A and PF-C. For the examination of the attributes sampled from the interpretation area, the collectives PF-A and PF-B+C were compared. Thus, the "grown in" areas were included here.

2.11.3.1 Standing Volume

The volume of the individual trees from both samples (Figure 1) was compared. The results were grouped according to the main tree species as well as according to the ownership category "public" and "private". Since the Shapiro-Wilk test always rejected the null hypothesis (Normal distribution), the usual t-test for independent observations was supplemented by the non-parametric MWU test. Table 4 shows the observed level of significance p>|z| of the z-statistic for the MWU test. Because of the accumulation of the α-error, both measurements were interpreted as significantly different if the p-value was higher than the testwise error rate which corresponded to an experimentwise error rate of 0.05. The correction of the error probability resulted in a testwise error value of α' < 0,00197 (m=2*13[1]=26) for the stratification according to the main tree species and the ownership category. In the case where the data were only stratified according to ownership and not to the main tree species, α' amounts to 0.0253. The results were significantly different for the public forest according to the Bonferoni inequality. The average merchantable timber volume was 1.11 m^3 on the unmarked plots, which was less than the marked plots at 1.17 m^3. Stratification according to the main tree species also resulted in significantly higher values for larch and fir on the marked plots. In the private forest, the trees in the category "other conifers" had a significantly lower average volume for the unmarked plots (nine trees). The 95% confidence interval shown in Figure 2 confirms these differences.

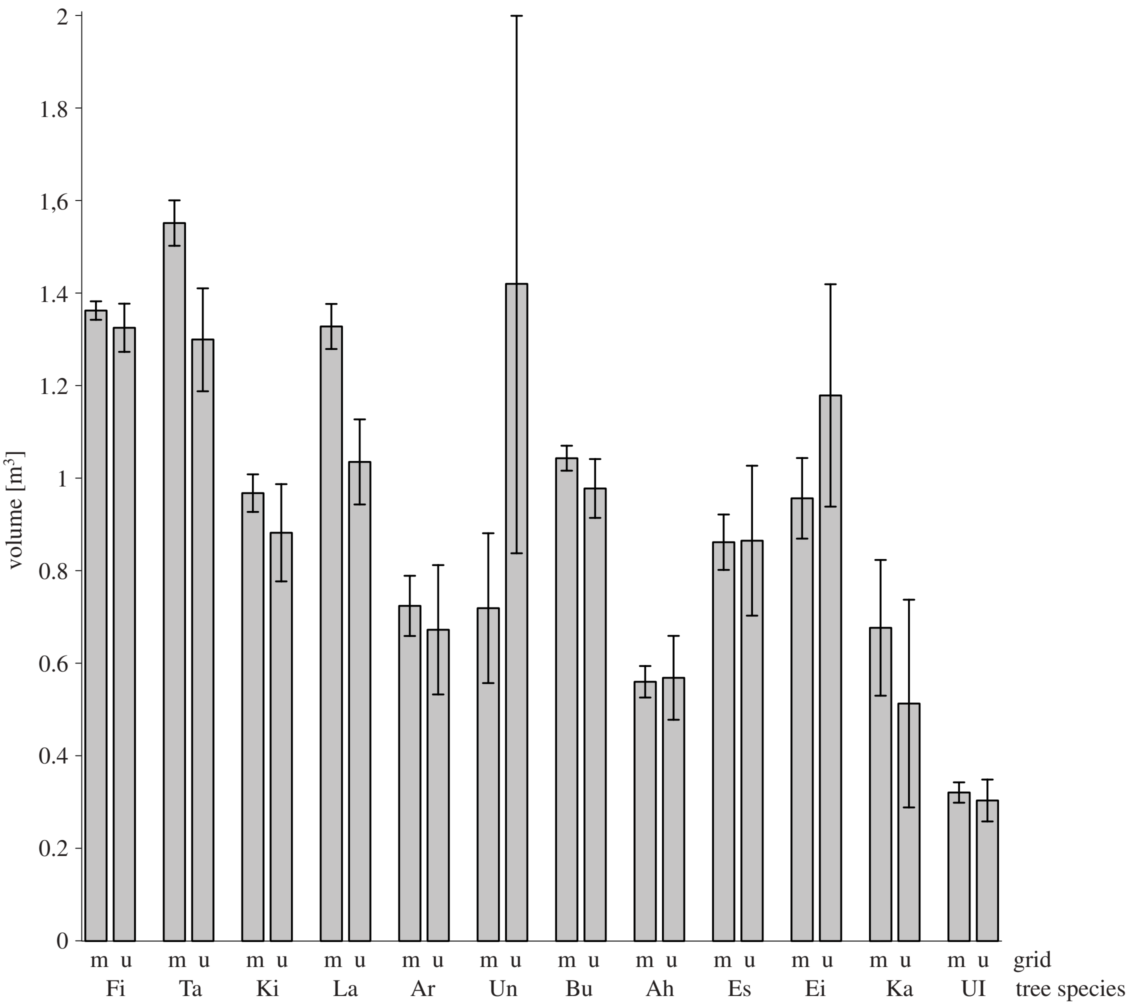


Figure 1a. Public forest: Average volume of individual trees with 95% confidence interval: separately by groups of tree species, and by joined marked 1.4 km grid (PF-A) (m) and newly established sample plots on the unmarked 4 km grid (PF-C) (u).

[1] The attribute "main tree species" was subdivided in 13 groups (inclusive the category "no data")

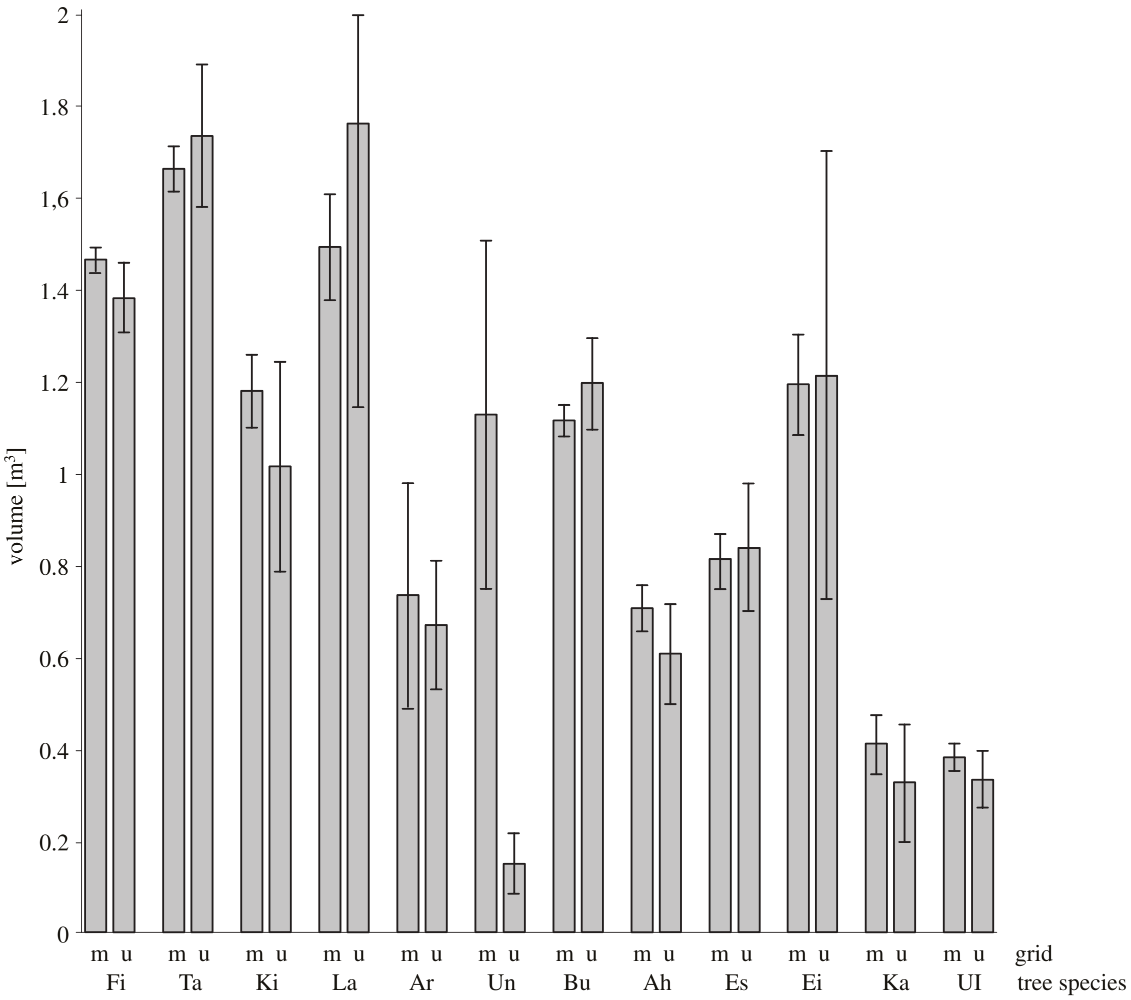


Figure 1b. Private forest: Public forest: Average volume of individual trees with 95% confidence interval: separately by groups of tree species, and by joined marked 1.4 km grid (PF-A) (m) and newly established sample plots on the unmarked 4 km grid (PF-C) (u).

Furthermore, the aggregated standing volume of the sample plots (Figure 2, Table 5) were compared. The attributes "ownership" and "mixture proportion" were the stratifying variables.

For this type of stratification, none of the tests indicated a significant difference for the testwise error value of $\alpha' < 0,0051$ ($m=2*5^2=10$). The results are shown in Figure 2 with the corresponding 95% confidence intervals.

[2] The attribute "mixture proportion" was subdivided in five groups (inclusive the category "no data")

Table 4. Descriptive statistics and test results for the comparison of the attribute volume of single trees, by ownership category and main tree species.

Tree species	Number of stems marked	Number of stems unmarked	Mean value marked	Mean value unmarked	Median marked	Median unmarked	Volume Prob > |Z| (MWU test)	
Public								
Spruce	17312	2638	1.36291	1.32572	1.0275	0.9095		
Oak	849	149	0.95707	1.17944	0.3650	0.3870		
Chestnut	361	78	0.67715	0.51344	0.1850	0.2025		
Other broadleaf	2690	323	0.32115	0.30391	0.1380	0.1340		
Fir	4018	598	1.55205	1.30043	1.1820	0.7860	0.0002	X
Scots pine	1961	279	0.96832	0.88260	0.6810	0.5600		
Larch	2404	416	1.32855	1.03575	1.1065	0.8995	0.0001	X
Cembran pine	521	104	0.72458	0.67294	0.4690	0.3680		
Other conifers	219	43	0.71963	1.42063	0.2010	0.4840	0.006	
Beech	7354	1045	1.04375	0.97837	0.5775	0.6050		
Maple	1247	195	0.56054	0.56907	0.3120	0.3020		
Ash	1039	145	0.86221	0.86548	0.4140	0.3910		
Public	39975	6013	1.16698	1.10692	0.680	0.621		
Total public		45988					0.0012	X
Private								
Spruce	8835	1119	1.46689	1.38431	1.2490	1.0740	0.0255	
Oak	527	37	1.19406	1.21522	0.7800	0.5530		
Chestnut	880	87	0.41055	0.32639	0.1070	0.1280		
Other broadleaf	1524	205	0.38091	0.33350	0.1650	0.1710		
Fir	3227	380	1.66385	1.73676	1.4330	1.4920		
Scots pine	525	53	1.18104	1.01508	1.0720	0.7200		
Larch	425	34	1.49403	1.76650	1.3460	1.4720		
Cembran pine	28	–	0.73425	–	0.4775	–		
Other conifers	67	9	1.12918	0.15111	0.2680	0.1300	0.0001	X
Beech	4151	461	1.11596	1.19788	0.7450	0.9370		
Maple	867	88	0.70615	0.60769	0.4420	0.4330		
Ash	1069	138	0.81512	0.83907	0.4780	0.4145		
Private	22125	2611	1.23695	1.26678	0.811	0.775		
Total private		24736						
Total		70724	1.1919	1.14139	0.729	0.665	0.001	X

X: significant in respects to the critical value of $\alpha = 0.05$. This 'experimentwise error' corresponds with a 'testwise error' of $\alpha' = 0.00197$ including missing observations and $\alpha' = 0.025$ when differentiated solely by ownership

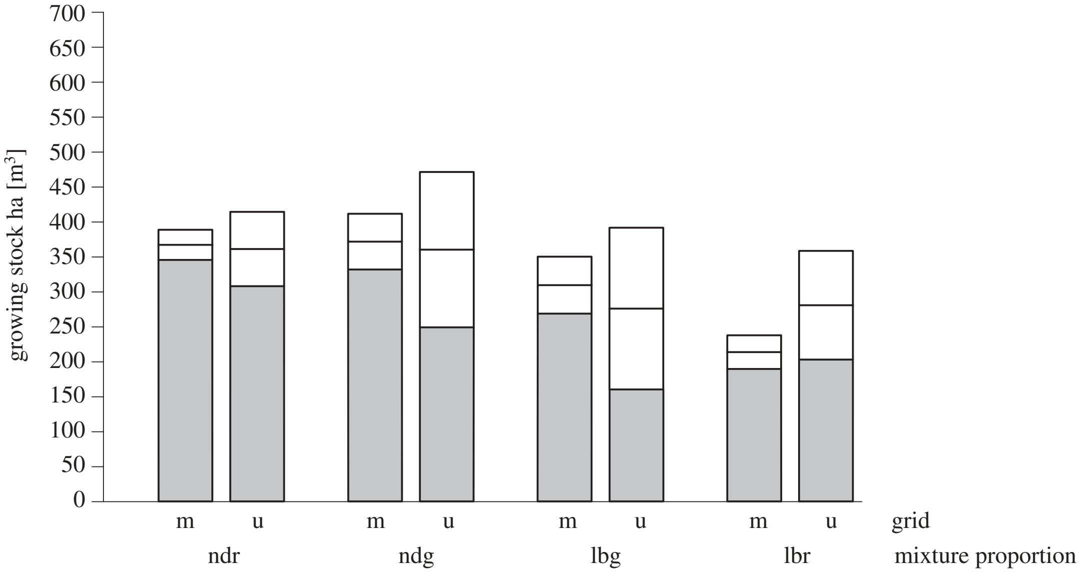


Figure 2a. Public forest: Growing stock per hectare, with 95% confidence interval, separately by ownership category, grid, and mixture proportion (mixture proportion: ndr: pure conifer 91–100% conifer; ndg: mixed conifer 51–90% conifer; lbg: mixed broadleaf 11–50% conifer: lbr: pure broadleaf 0–10% conifer)

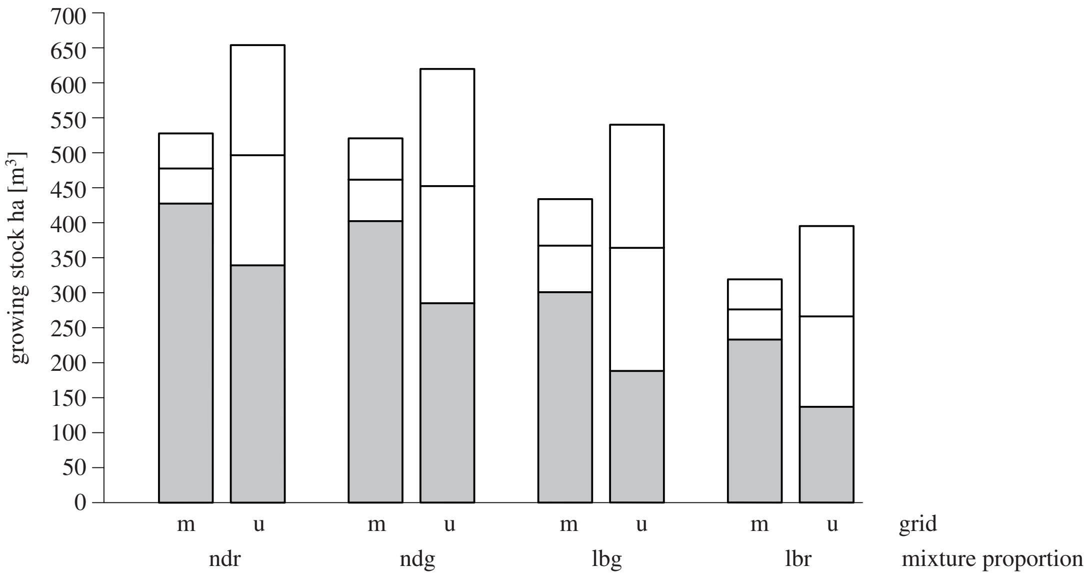


Figure 2b. Private forest: Public forest: Growing stock per hectare, with 95% confidence interval, separately by ownership category, grid, and mixture proportion (mixture proportion: ndr: pure conifer 91–100% conifer; ndg: mixed conifer 51–90% conifer; lbg: mixed broadleaf 11–50% conifer: lbr: pure broadleaf 0–10% conifer)

Table 5. Descriptive statistics for the comparison of growing stock per hectare by ownership category and mixture proportion.

	Sample plot	Sample plot *u*	Number of stems	Number of stems *U*	Growing stock / sample plot	Growing stock / sample plot *u*	Median	Median *u*
	marked	unmarked	marked	unmarked	marked	unmarked	marked	unmarked
Public								
No information	47	9	131	31	174.705	150.164	126.760	84.651
Mixed broadleaf	476	48	5045	442	316.226	286.742	289.900	187.824
Pure broadleaf	683	110	6395	1230	231.505	290.281	199.230	216.469
Mixed conifer	671	88	7596	980	378.390	358.259	356.820	256.409
Pure conifer	1785	268	20912	3347	370.040	367.130	327.970	266.355
Public	3662	523	40079	6030				
Total public		4185		46109				
Private								
No information	16		37		150.986		139.870	
Mixed broadleaf	252	33	2909	377	373.141	362.696	355.425	341.020
Pure broadleaf	360	42	4247	406	294.986	283.829	233.730	197.660
Mixed conifer	451	56	5851	715	462.227	474.313	434.465	429.595
Pure conifer	684	79	9116	1120	480.392	499.227	433.090	484.010
Private	1763	210	22170	2618				
Total private		1973		24788				
Public + private	5425	733	62249	8648				
Total		6158		70897				

2.11.3.2 Damages

The assessment regarding the influence of the marking on stem damage was typically a directional problem, because under the assumption of a significant influence stem damage, in general harvesting damage, were expected to be less frequent (HA). Since such damages were clearly not well regarded, it was obvious that an effect of the marking would result in the manager preventing careless timber removal if such a clearly visible sample plot was located in the stand.

The categories “no damage”, “stem damage”, and “other damage” were formed for the attribute “type of damage” in order to calculate the chi-square test. The corresponding categories for the attribute “cause of damage” were “no damage”, “timber harvest damage”, and “other causes of damage”.

When both of the collectives PF-A and PF-C were compared without stratification, a significant difference between both attributes was determined for the distribution of the three categories ($p > chisq = 0.001$). Contrary to what was expected, the proportions of trees with damage were slightly higher on the marked plots than on the unmarked plots. This was true for “stem damage” as well as for “other damage” (see Figure 4a). The situation was qualitatively identical for the attribute “cause of damage”. After stratification by ownership category and mixture proportion, the difference between the frequency of the three categories was not significant.

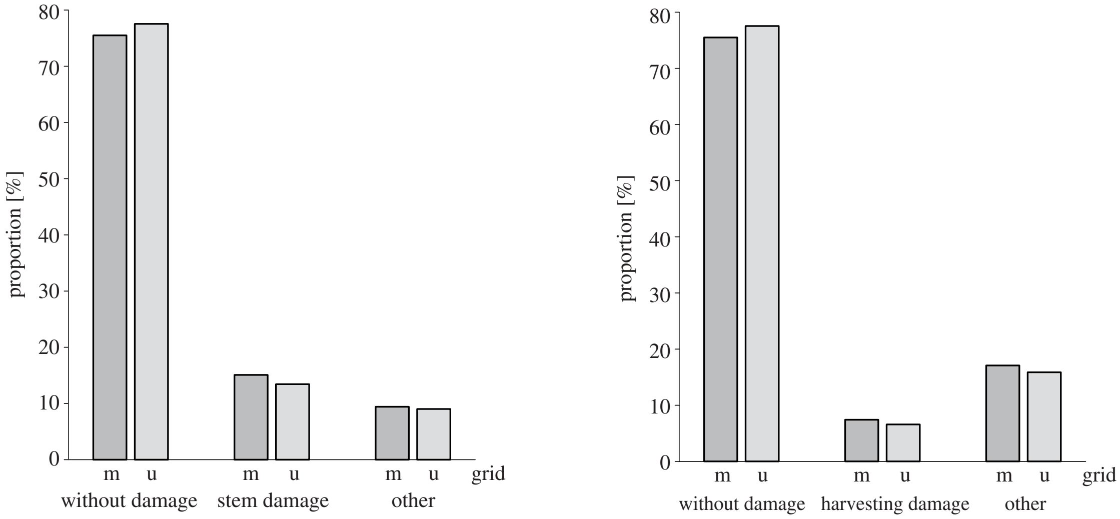


Figure 3. Type of damage

a) Frequency distribution of the attribute "type of damage" (group: all trees).

b) Proportion of stem damage to other damage (group: all trees with damage).

Also, the separate examination of the group of damaged trees showed higher frequencies of "stem" and "harvesting damages" for the marked plots. The differences, however, were only significant (p > chisq = 0,001) in the stratum "public/mixed broadleaf forest" (see Figure 4b, 5b). On the unmarked plots of this layer, 51.7% of the trees (46 out of 89 trees) were damaged during the timber harvest; however, the marked plots had only 35% damaged trees (445 out of 1,273 trees). No significant difference was found between the marked plots and the unmarked plots in any of the other strata.

According to the alternative hypothesis defined in the beginning, in the case of an influence, the proportion of timber harvest damage was expected to be less on the marked sample plots than on the unmarked ones. The overall result without any stratification demonstrated that the influence of this kind did not exist. The stratum "public/mixed broadleaf forest" was the only one with a significant difference between the marked and unmarked sample plot. The significantly higher stem damage proportions on the marked plots were possibly explained by one or more covariate attributes and by the large sample size. Without any further investigations, it is not possible to draw a conclusion about the effects of the marks.

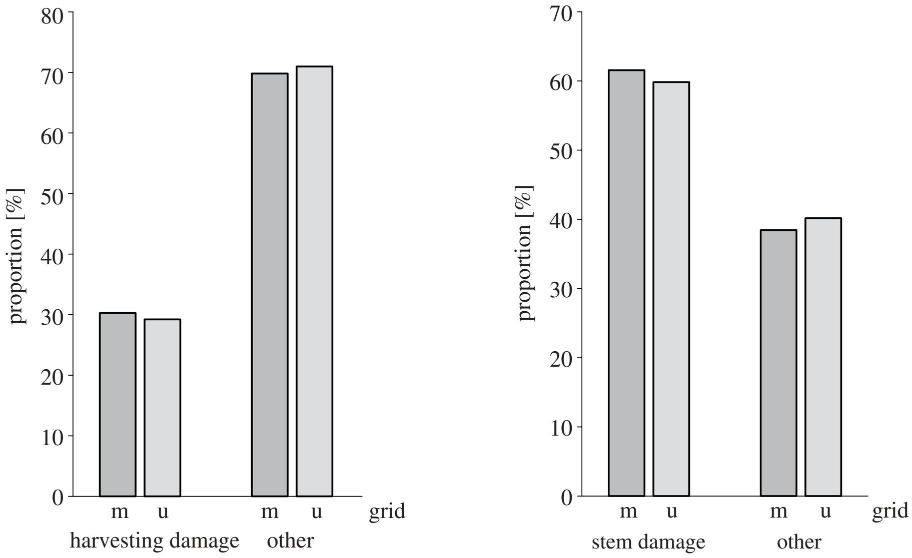


Figure 4. Cause of damage

a) Frequency distribution of the attribute "cause of damage" (group: all trees).

b) Proportion of harvesting damage to other cause of damage (group: all trees with damage).

2.11.3.3 Other Attributes

A significant difference between the marked and unmarked sample plots was only found for the attribute “need of silvicultural treatment in the protective forest” in the stratum “private forest/ mixed coniferous forest” (p > |z| = 0,002 MWU test).

The attributes “standing dead tree”, “stability”, “unregulated felling”, “protective measures”, and “last utilization” did not show in any of the cases a significant difference between the marked and the unmarked sample plots. Figure 5 shows the frequency distribution for the individual classes of the above mentioned attributes. In all of the cases, a weak and non-directed difference between the frequencies of the individual classes were seen.

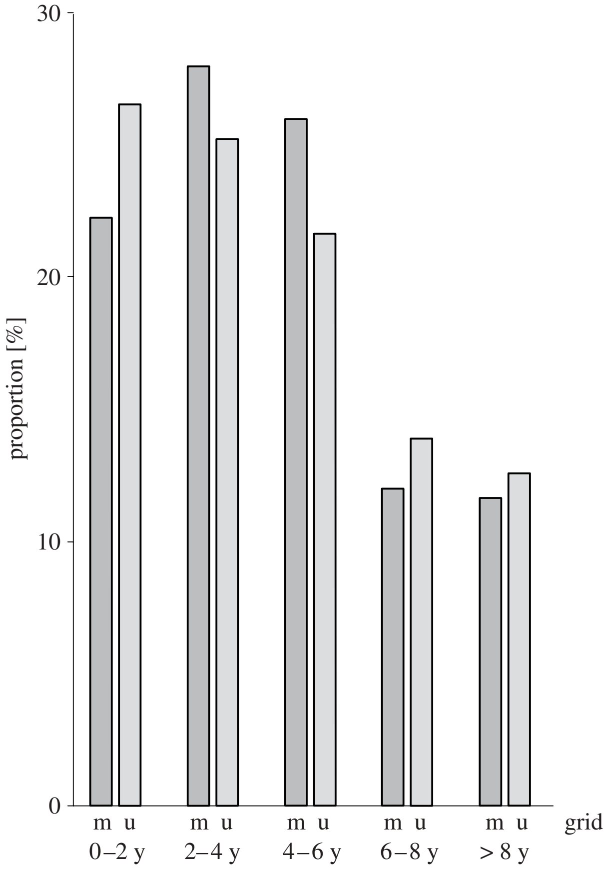
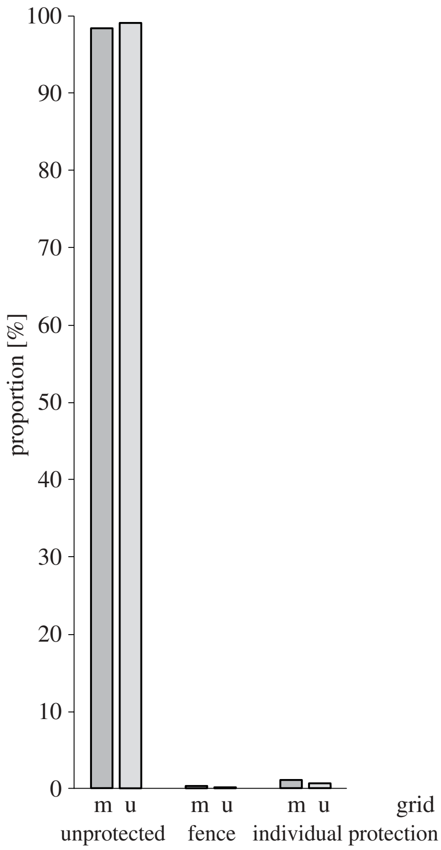
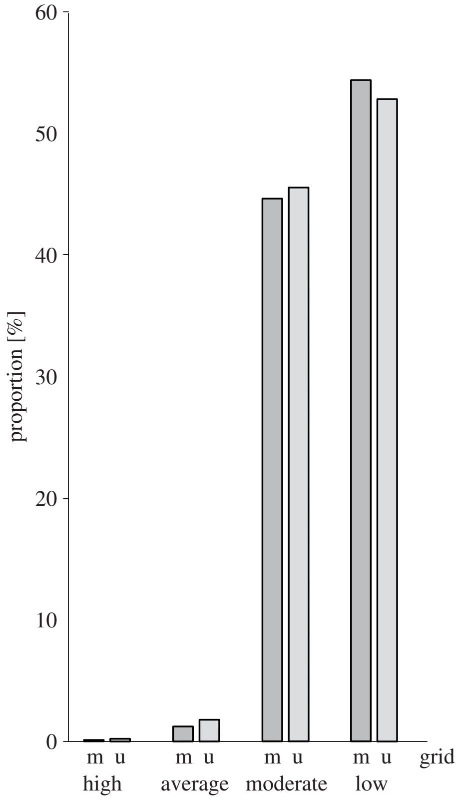


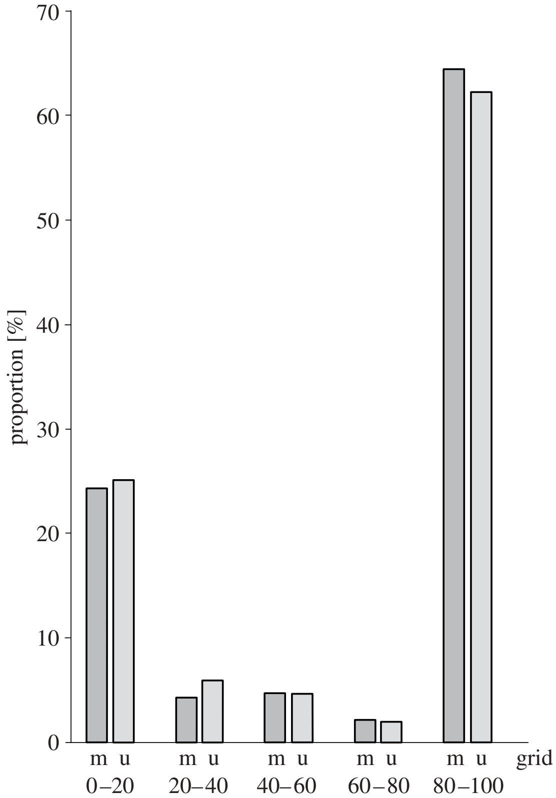
Figure 5. Frequency distribution of the analyzed attributes at an ordinal and nominal scale.
Attribute 3: Last utilization.



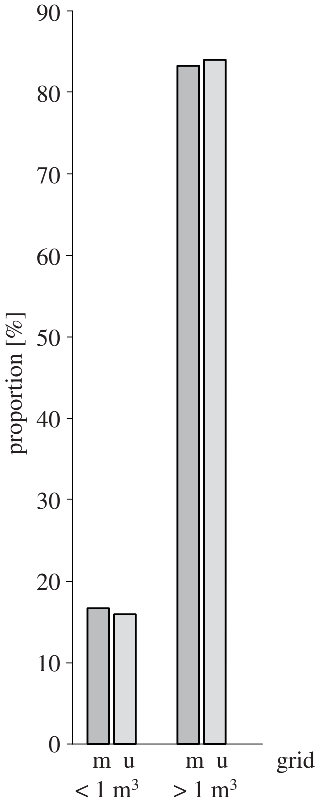
Attribute 4: Protection of regeneration against game damage.



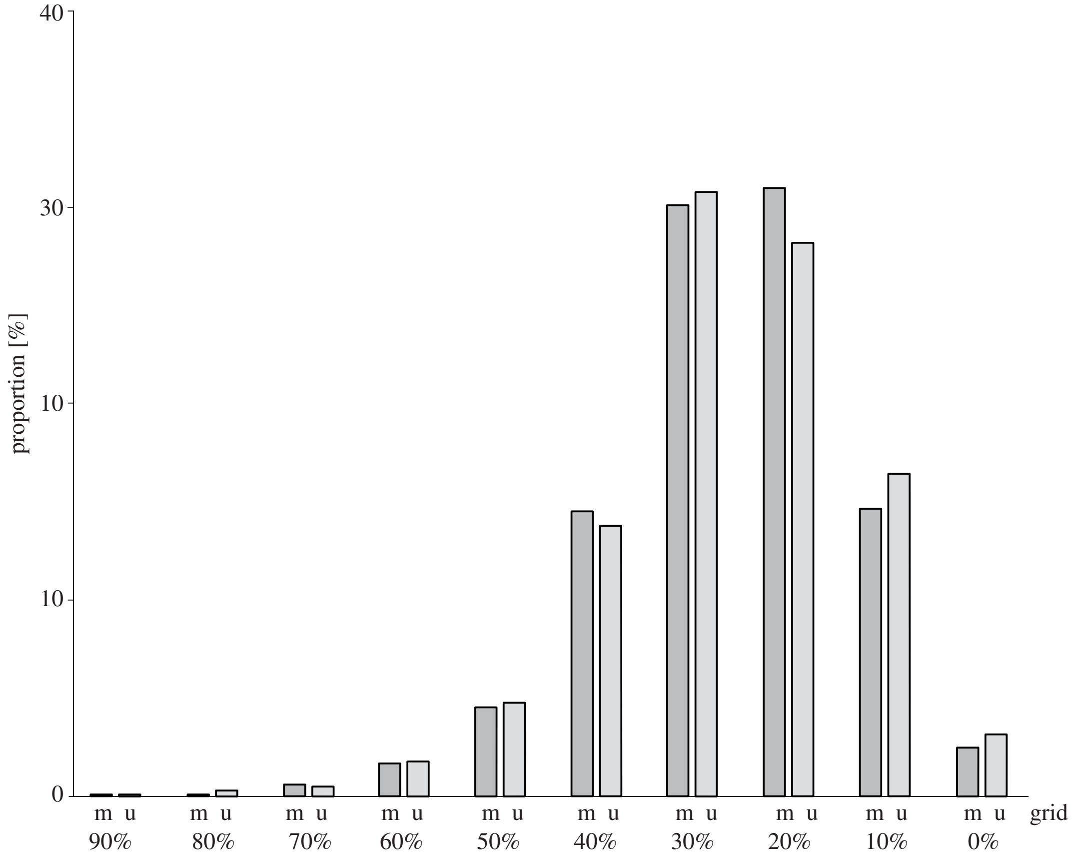
Attribute 5: Needs of silvicultural treatments.



Attribute 6: Proportion of unregulated fellings.



Attribute 7: Dead trees.



Attribute 8: Stand stability.

2.11.4 Discussion

The study about the representativeness of the NFI sample plots was supposed to show whether the managers behaved differently when they knew (based on the markings) that they were in a stand that held an NFI sample plot. The common null hypothesis was: The marks had no influence on the management. The corresponding alternative hypothesis was: The marks had an influence on the management, which was noticeable by significantly different statistical measures or test statistics. In the case where the marking of the sample plot had an influence, several different behaviors were possible. The most likely behavior was certainly that the sample plots and the surrounding stands, whenever possible, were excluded from any kind of forest activity. This meant that a sample plot was viewed as a kind of research facility or experimental area, which was not to be destroyed or influenced. It was also possible that the stands were influenced intentionally in order to present the forest enterprise at its best. The manager removed any signs of an incorrect forest practice (trees with harvest damage, etc.) or protected, particularly, such elements of a stand which increased the species diversity or the structural diversity, since these types of measures are now highly regarded. These two possibilities of contrary behavior presented a problem for the analysis, since they possibly offset each other in the data and, therefore, would not show an effect, even though the manager was influenced.

How can such different behavior be detected? Questioning the people in charge directly was not expected to give an honest answer or, in more statistical terms, to give an unbiased answer. Thus, attributes were studied which reflected the influence of the manager. Whether both populations (sample plot with and without marks) were significantly different was determined by statistical tests. The formulas, which were used to calculate the test statistics, indicated that the sample size played an important role in the calculation. In general, it is true that for a given rejection probability, the sensitivity (power) of the test increases with increasing sample size.

This means that already small differences in the averages, rank sums, or frequencies lead to a significant result. For large sample sizes, the calculation and interpretation of the confidence intervals are helpful, as they are presented here for the comparison of the volumes.

Significant differences were also possible when, apart from the discriminating attribute “marking”, other covariate parameters existed which influenced a certain attribute. By defining a linear model, it would have been possible to assess the effect of individual factors and of such covariates by means of an analysis of variance. But even the most complex model could have only tested those factors which were considered in the model. Thus, there was no guarantee that a certain model could reveal the ultimate cause of the differences.

The performed stratification of the data set in subunits for which the appropriate significance tests were calculated separately was a procedure which also tried to consider several factors (marking, ownership, and mixture proportions). The effect of these input variables could, in principle, be investigated with a three-factorial analysis of variance, which allows for the detection of the main effects of the factors and their interactions. A detailed interpretation of the main effects and of the interactions of the factors is relatively expensive. If a factor or certain interaction has a significant effect, it is further necessary to investigate which level of the factors or combinations caused the significant effect (BORTZ, 1993).

Due to the complexity of the procedure, the separate comparison for each stratum between the marked and the unmarked sample plots was preferred over the analysis of variance. The appropriate correction of the “experimentwise error” by the “testwise error” adjusted the α error accumulation that was caused by the multiple usage of the test.

An influence of the permanent marking of the sample plots was not verified in this study. The differences found here did not allow for the conclusion that the marked sample plots and their surrounding stands were treated significantly different. A bias of the inventory results was not apparent due to permanent and visible markings of the sample plots.

In order to investigate what kind of effect the factor “marking” could have with respects to the manager’s behavior, further studies are needed. These studies should show how strata can be formed with respect to other potential influential factors, so that the strata are as homogeneous as possible.

2.11.5 Literature

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