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Description of the Northern Tyrolean Limestone Alps with the Help of the Parameters from the Austrian Forest Inventory

By

K. SCHADAUER¹⁾

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S u m m a r y

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Using data obtained from the Austrian Forest Inventory, the Northern Tyrolean Limestone Alps are judged with regard to the structure of their forests, stem damage, an regeneration. Due to the high share of protection forests found in this area, it is necessary to take into account special protection forest parameters to be able to assess potential risks. Since 1992, for instance, one has tried to use the data of the Austrian Forest Inventory to describe wide-spread risk factors that affect the stability of protection forests. It turned out that insufficient regeneration, for instance due to the negative influence of browsing, represents a high risk in the (partly over-mature) protection forests of that area.

I n t r o d u c t i o n

For more than 30 years investigations have been systematically carried out in the Austrian forests on the basis of a sampling grid under the Austrian Forest Inventory. Both the timber resources (e.g. timber reserves, increment, composition of tree species, accessibility) and the temporary conditions and current changes of the "forest ecosystem" (site factors, vegetational surveys, dead wood, etc.) have been surveyed according to fixed assessment criteria (FEDERAL FOREST RESEARCH CENTRE 1994).

¹⁾ Institute of Forest Inventory, Federal Forest Research Centre, Seckendorff-Gudent-Weg 8, A-1131 Vienna, Austria.

According to the new division of the ecoregions by KILIAN & al. 1994 the Northern Tyrolean Limestone Alps are situated in the ecoregions 2.1 (northern frontier of the Alps - western part) and 4.1 (northern intermediate Alps - western part). Fig. 1 shows area and location of the Austrian Forest Inventory tracts.

AUSTRIAN FOREST INVENTORY

Location of tracts 1986/90

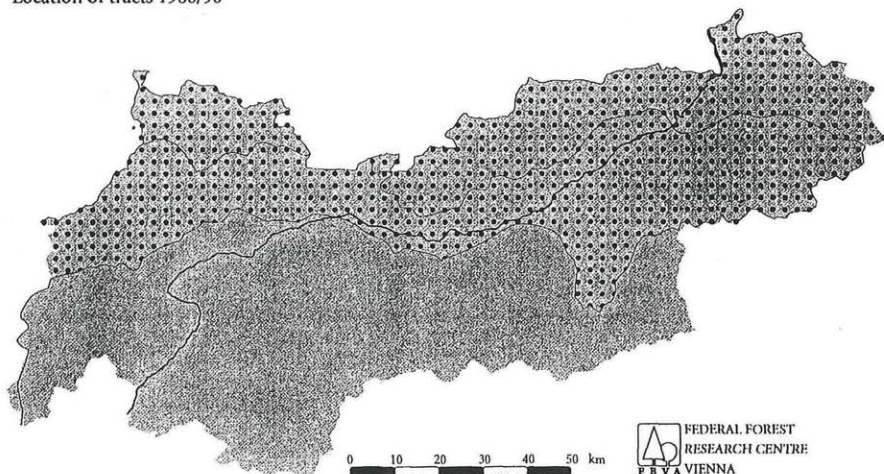


Fig. 1. Location of ecoregions 2.1 and 4.1 and of the tracts of the Austrian Forest Inventory 1986/90 in the Northern Tyrolean Limestone Alps.

The area includes the project area of Achenkirch and is relatively uniform in its geoclimatic features. As the area is described with the help of data from the Austrian Forest Inventory, the investigation area is in the north delimited by the Austrian border, although the parts of the Limestone Alps adjoining in the north show similar geological and climatic conditions.

The Northern Tyrolean Limestone Alps are characterized by a high percentage of protection forests, which is mainly due to the strong relief energy and the consequently extreme site conditions.

According to the Austrian Forest Act of 1975 protection forests are defined as forests either fulfilling a protective function or to be protected that are located on sites which, due to the erosive forces of wind, water and gravity, are particularly endangered on steep slopes, landslides and around the timber line. In the Northern Tyrolean Limestone Alps protection forests include mainly stands on sites endangered by severe erosion and karst formations and forests on rocky, jagged sites where the conditions for afforestation are particularly difficult.

M e t h o d

By means of the Austrian Forest Inventory parameters are surveyed which describe risks to be taken into account esp. in protection forests (with or without commercial yield). The following parameters will be interpreted:

The age structure is an important criterion of risk assessment in protection forests, as mature stands (> 140 years) lose their protective function more and more. (In protection forests without commercial yield, no such investigations have been made; also, they would not have been possible or useful in all cases, as predominantly uneven-aged stands are found there, which complicates arial age classifications.)

Stem damage is a significant factor in connection with risk assessment. It allows stems to be penetrated by fungi; the resilience of the wood and, consequently, the stability of the logs is impaired. In connection with the Austrian Forest Inventory one distinguishes between browsing damage and damage due to timber harvesting and rockfall. (In protection forests without commercial yield that factor was not examined.)

Also the regeneration of protection forests with and without commercial yield is a criterion which allows conclusions in respect of (medium- or long-term) risks. In that connection the intensity of the damage caused by browsing and pasturing plays an important part. (In how far regeneration is completely prevented through the browsing of young seedlings cannot be judged from the investigations of the Austrian Forest Inventory.)

The present evaluation refers to the investigation periods of 1986/90 and 1992/93. Fig. 1 shows the location of the investigation tracts of 1986/90 (distance between tracts: 2.75 km, each tract consisting of four sample plots which were arranged in a square of 200 m x 200 m). The described area includes 508 investigation tracts with 1730 forest sample plots.

As it is only since 1992 that the surveys have included protection forests without commercial yield, data from the first two years of investigation of the current inventory period had to be used for calculations regarding the entire protection forest. As a consequence of the lower density of the tracts (only 364 sample plots), their statistic worth is certainly lower.

In the Northern Tyrolean Limestone Alps, the Austrian Forest Inventory distinguishes between the operational forms of the production forest and the protection forest with or without commercial yield; in connection with the Inventory, the term "protection forest" follows essentially the definition of the Austrian Forest Act of 1975, but includes two different forms: Protection forests with commercial yield are defined as forests where maximum stability of the stands has to be conserved. As opposed to this, protection forests without commercial yield are characterized by the fact that economic management is impossible either because of the inaccessibility or due to the important protective function which would be at risk in case of economic utilization. Protection forests without economic yield include stands on extremely meagre sites (FEDERAL FOREST RESEARCH CENTRE 1981).

For the risk assessment, parts of the evaluations contained in the Forest Function Plan (FEDERAL MINISTRY OF AGRICULTURE AND FORESTRY 1993) were used. Serving as an overall silvicultural planning, the Forest Function Plan is "to describe the status of forests in the entire Federal Republic, to define the main functions of forests (commercial, protective, beneficial, and recreational functions) and, with a view to the future, is to contribute to the sustainable and optimum conservation of all forest functions". As opposed to the surveys under the Austrian Forest Inventory which uses samples; the Forest Function Plan is based on complete surface assessments made by the district forest services. In the present paper the areas with protective functions which are affected by bark-peeling and browsing damage are described.

Results and Discussion

Percentage of forested area

The Northern Tyrolean Limestone Alps include an area of approximately 380,000 ha; about 26,000 ha (68 %) thereof are covered by forests. This percentage is rather high compared to that of the Austrian Alps, which may be due to the lower altitudes above sea (accordingly, the percentage of unforested sites at high altitudes is lower in the Northern Tyrolean Limestone Alps than it is in the [higher] Central Alps) and the low population density. The soils are partly very shallow, which, together with the oceanic climate, are unfavourable conditions for agricultural utilization. The percentage of forested land is therefore naturally high. About 50 % of the forested area is located at altitudes between 1000 m and 1400 m a.s.l.; on sites below and above that altitude the percentage of forested land is much lower (Fig. 2).

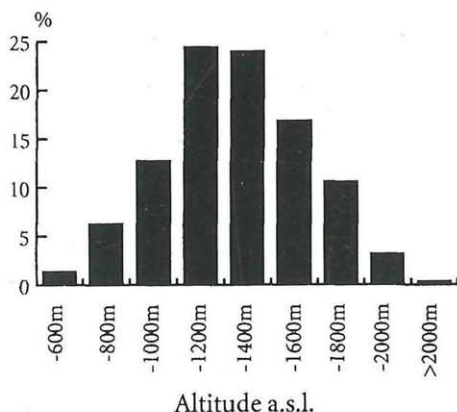


Fig. 2. Percentage of forested area at the different levels of altitude of the Northern Tyrolean Limestone Alps.

Operational forms

In the Northern Tyrolean Limestone Alps, 42 % of the total area are covered by protection forests, the major part thereof (27 %) being protection forests without commercial yield (Fig. 3). The percentage of protection forests of the entire territory of the Austrian Federal Republic is comparably lower (19 %).

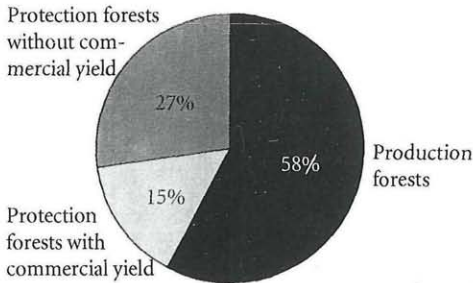


Fig. 3. Percentage of the operational forms of production forests, protection forests with and without commercial yield in the Northern Tyrolean Limestone Alps.

As everyone will expect because of the definition of the term "protection forest", the percentage of protection forests found in the Northern Tyrolean Limestone Alps augments with increasing altitude (from approx. 15 % on sites up to 1000 m to 85 % on the uppermost sites; Fig. 4).

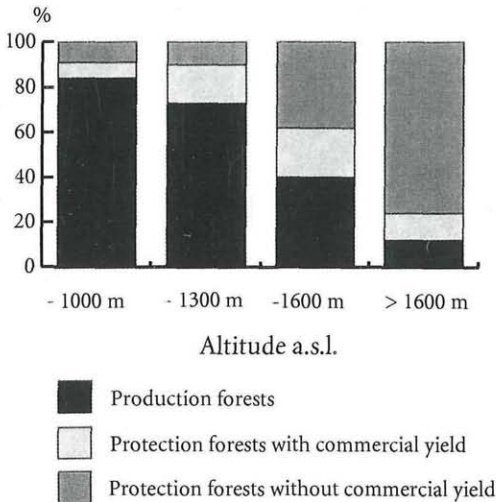


Fig. 4. Percentage of the different operational forms at the different levels of altitude of the Northern Tyrolean Limestone Alps.

Tree species and communities of tree species

Percentage of the individual tree species on forested areas

For the assessment of a forest area, the occurring tree species and their composition are essential. In production forests, the share of spruce is 72 %, while it is only 39 % in protection forests without commercial yield. Dwarf pine is

significant only in protection forests without commercial yield, where its share is 36 %. Beech is the second most frequent species both in production forests (9 %) and in protection forests with commercial yield (14 %). The percentage of larch (and, to a lower extent, also that of cembran pine) is higher in protection than in production forests; as opposed to this, the percentage of fir is lower in protection forests (Table 1).

Table 1. Percentage of tree species found under the different operational forms of the Northern Tyrolean Limestone Alps (In brackets: < 1400m / > 1400 m; *: Not surveyed).

Tree species	Production forests (%)	Protection forests with commercial yield (%)	Protection forests without commercial yield (%)
Norway spruce (<i>Picea abies</i>)	72 (70/88)	65 (56/80)	39 (2/37)
European silver fir (<i>Abies alba</i>)	8 (9/2)	5 (7/1)	4 (5/3)
European larch (<i>Larix decidua</i>)	2 (2/5)	6 (4/10)	5 (1/8)
Scotch pine (<i>Pinus sylvestris</i>)	3 (4/1)	5 (7/0)	2 (5/0)
Cembran pine (<i>Pinus cembra</i>)	0 (0/3)	2 (1/6)	1 (1/1)
Common beech (<i>Fagus sylvatica</i>)	9 (10/2)	14 (21/2)	5 (11/0)
Other broadleaved species	6 (6/0)	3 (4/1)	6 (7/6)
Green elder (<i>Alnus viridis</i>)	-*	-*	2 (1/3)
Dwarf pine (<i>Pinus mugo ssp. mugo</i>)	-*	-*	36 (27/42)

By the division of Table 1 into two levels of altitude, the upper limit of the ranges of beech and fir are taken into account. Up to medium altitudes of the Northern Tyrolean Limestone Alps those two species represent a high percentage and partly have a protective function. The mixed stands belong to the spruce-fir-beech communities, which are naturally widely represented in that region. The markedly lower percentage of beech in production forests < 1400 m compared to protection forests with commercial yield is a consequence of anthropogenous influence through the cultivation of spruce.

Communities of tree species

About 60 % of the entire forested area are covered by pure conifer stands (stands with one or several conifer species). Stands including predominantly broadleaved trees are found on approx. 13 % of the area only; protection forests without commercial yield contain almost no broadleaved trees (Fig. 5) at all.

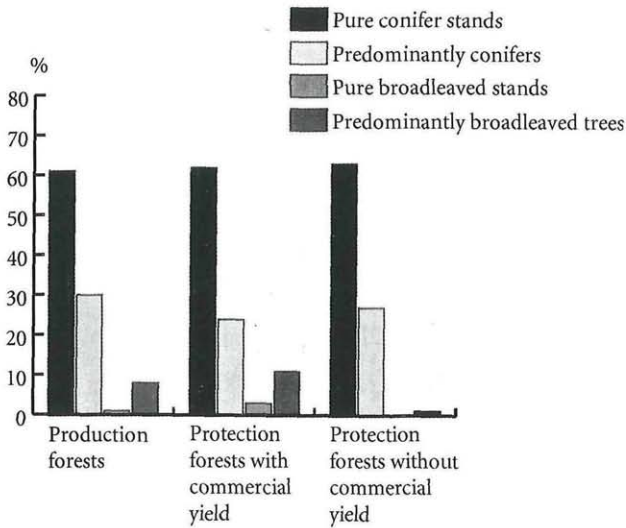


Fig. 5. Percentage of broadleaved and conifer stands, by operational forms.

Differences in the species communities of pure conifer stands in connection with operational forms appear mainly by the high percentage of dwarf pine in protection forests without commercial yield (Table 2) so that pure spruce stands are replaced by mixed spruce and dwarf pine or pure dwarf pine stands.

Table 2. Composition of species (%) in pure conifer stands of the Northern Tyrolean Limestone Alps (*: Not surveyed).

Composition of species	Production forest (%)	Protection forest with commercial yield (%)	Protection forest without commercial yield (%)
Pure spruce stands	61 %	52 %	16 %
Spruce - larch	9 %	13 %	13 %
Spruce - pine	6 %	8 %	0 %
Spruce - dwarf pine	-*	-*	34 %
Pure dwarf pine stands	-*	-*	19 %
Others	24 %	27 %	18 %

With 35 % the percentage of pure stands with only one tree species is markedly lower in protection forests without commercial yield than it is in protection forests with commercial yield (52 %) or in production forests (61 %). The protective function of mixed stands is usually higher than that of pure stands although in natural succession pure stands represent the final phase of certain forest communities (MAYER 1976). This means that the protective function is reduced by nature; silvicultural interventions are necessary to maintain species compositions that fulfil the protective function.

Diversity of the woody plants

Based on the surveys carried out under the Austrian Forest Inventory it is possible to describe the species composition and the number of woody plants (trees and bushes) occurring together, which will also contribute to the knowledge about biodiversity. It appears that the percentage of areas covered by only one timber species augments for all operational forms with increasing altitude, while the percentage with more than ten species decreases with altitude. As opposed to this, production forests (which represent the main form at lower altitudes) are with 5.3 species per sample plot a little bit poorer in diversity than protection forests without commercial yield (which are dominant at higher altitudes) with 5.7 species (Fig. 6). This shows clearly that greater scantiness of species is the result of human influence, which plays only a minor role in protection forests without commercial yield.

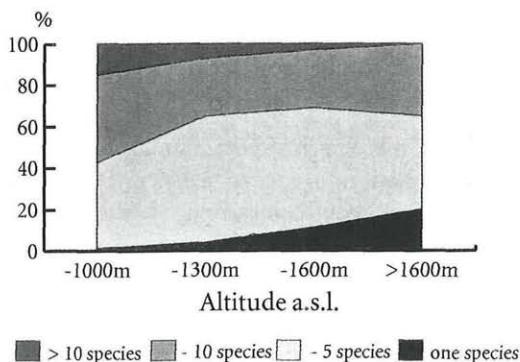


Fig. 6. Distribution of the number of species (%) of the woody plants found at the individual levels of altitude of the Northern Tyrolean Limestone Alps (for all operational forms).

Risk potential

Age structure

The distribution of age-classes in production forests corresponds approximately to that of the entire Federal Territory of Austria and shows a maximum in the young age-classes. There are only few stands aged more than 140 years (Fig. 7); nevertheless the share of those stands is with 13 % significantly above the all-Austrian average (5 %). In protection forests with commercial yield 30 % of the forests are older than 140 years, while all other age-classes are represented only at 6 - 11 % each (Fig. 8).

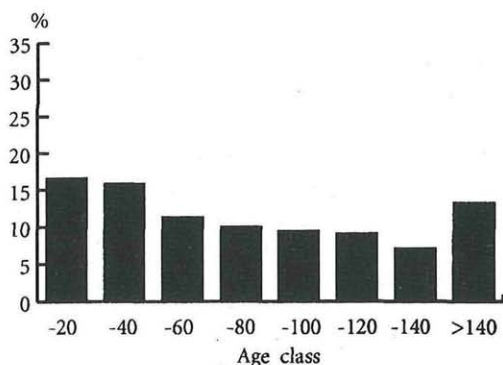


Fig. 7. Age-classes (%) in production forests of the Northern Tyrolean Limestone Alps.

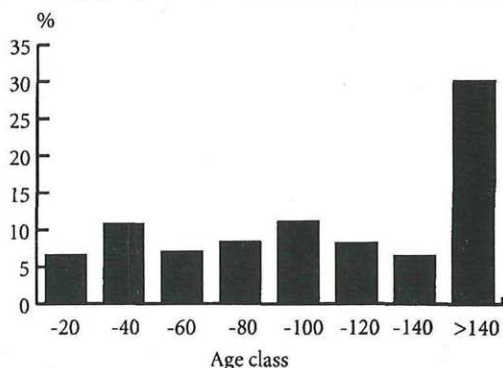


Fig. 8. Age classes (%) in protection forests with commercial yield of the Northern Tyrolean Limestone Alps.

In protection forests with commercial yield the percentage of stands aged over 140 years increases with altitude from approx. 13 % at low altitudes to about 46 % at locations above 1,600 m (Fig. 9). This increase is partly the result of the slower growth at high altitudes.

Stem damage

Bark - peeling damage: On about 15 % of the area bark-peeling damage was found; no significant difference was determined between the operational forms of the production forest and the protection forest with commercial yield. Bark-peeling damage is significantly below the all-Austrian average (20 %),

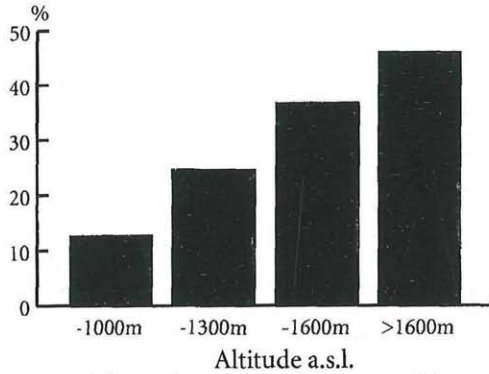


Fig. 9. Percentage of the total area covered by trees of the age-class > 140 years in protection forests with commercial yield, by levels of altitude.

particularly in the bark-peeling centres of Styria and in the south of Lower Austria (up to 46 %; FEDERAL FOREST RESEARCH CENTRE 1993; Fig. 10).

Also the evaluation under the Forest Function Plan shows that bark-peeling damage plays only a minor role in the Northern Tyrolean Limestone Alps (Fig. 11).

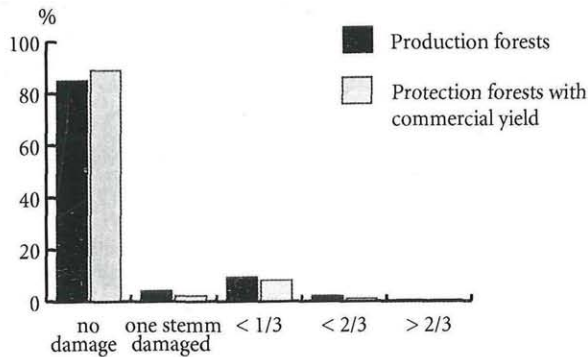


Fig. 10. Percentage (%) of the total area affected by bark-peeling damage in production forests and protection forests with commercial yield, by intensity.

FOREST FUNCTION PLAN

Areas of protective function

Impairments due to bark-peeling damage

-  no impairment
-  Bark-peeling damage

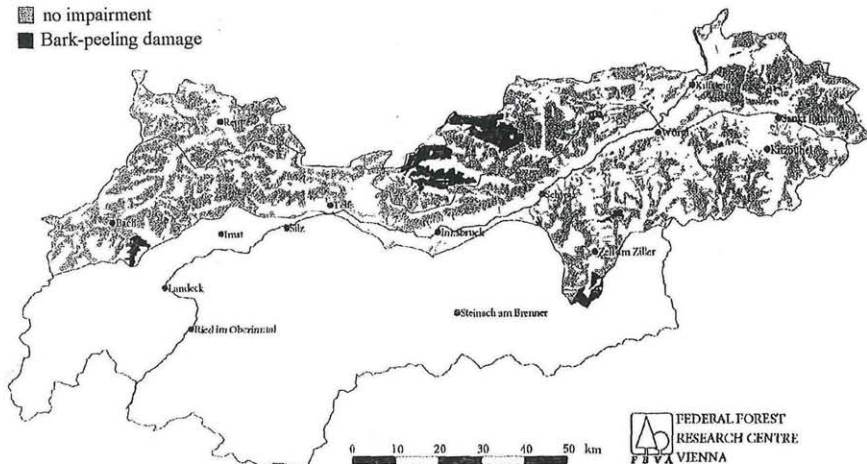


Fig. 11. Impairments due to bark-peeling damage on areas having a protective function according to the Forest Function Plan.

Damage caused by harvesting and rockfall is of much greater significance in the Northern Tyrolean Limestone Alps than bark-peeling damage. In protection forests with commercial yield only 28 % of the forested area are free from damage (Fig. 12); on 33 % of the total area more than one third of the stems were damaged. In protection forests, 85 % thereof are caused by rockfall, which is therefore the main cause of stem injuries, while only 15 % of the damage is due to timber harvesting.

That high percentage of damage caused by rockfall is typical of the Austrian Limestone Alps and can be explained by the strong relief energy; the difficult conditions for the construction of silvicultural and public roads, which frequently require blasts, increase the frequency of rockfalls.

Regeneration in protection forests with and without commercial yield

Although regeneration would be necessary on approx. 50 % of the total area covered by protection forests, it is found on only 15 % of the area; on the remaining 35 % no regeneration is effected. Nevertheless the regeneration situation in the protection forests of the Northern Tyrolean Limestone Alps is still slightly better than it is in other Austrian areas covered by protection forests.

With 85 %, natural regeneration is dominant in protection forests.

About 20 % of the areas under regeneration are browsed by more than 50 %; 20 % are browsed by up to 50 %, and 60 % are not at all impaired by browsing. (As there are only 13 protection forest observation plots under

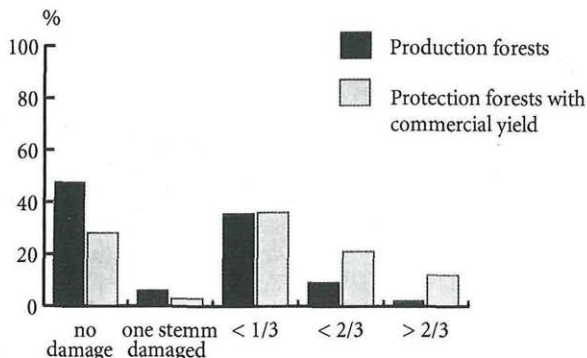


Fig. 12. Percentage of the total area affected by damage through harvesting and rockfall in production forests and protection forests with commercial yield, by intensity.

regeneration, detailed statements about browsing damage are not possible.) Compared to all-Austrian observations that high percentage is, however, still below average. It is remarkable that the damage caused by browsing is only moderate, as 38 % of the protection forests are still used for pasturing (which is far above the Austrian average of 25 %).

Also the results from the Forest Function Plan regarding areas with protective functions after damage by browsing show that despite the use of different investigation methods less than half of the areas covered by protection forests are affected by browsing (Fig. 13).

Conclusions

Seeing the different criteria for protection forests, which express stability and therefore the ability to maintain or restore the ecological balance, 53 % of the protection forests of the Northern Tyrolean Limestone Alps are considered as being stable. According to the assessment criteria of the Austrian Forest Inventory (FEDERAL FOREST RESEARCH CENTRE 1994) half of the protection forests will maintain their protective function over the next 20 years even without the taking of any silvicultural measures; on 33 % of the total area, the protective function will, however, be impaired, and on the remaining 14 % rehabilitation measures are urgently necessary.

Those surveys of the Austrian Forest Inventory show that without any human intervention large parts of the protection forests of the Northern Tyrolean Limestone Alps are or will over the next 20 years be, severely impaired in their protective function. If the protective function is to be maintained, special importance must be attached to natural regeneration, which means primarily that the stress caused by browsing and forest pasturing must be reduced.

FOREST FUNCTION PLAN

Areas of protective function

Impairments due to browsing

□ no impairments

■ browsing damage

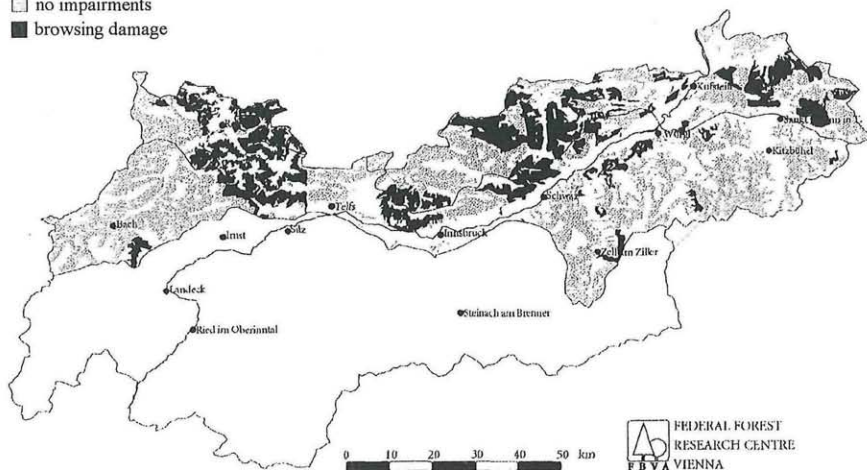


Fig. 13. Impairments due to browsing on areas having a protective function according to the Forest Function Plan.

Summary

The Northern Tyrolean Limestone Alps include an area of approximately 380,00 ha; about 68 % of that land are covered by forests. As 80 % of that area are located at altitudes above 1000 m, the protective function of the forests is of special importance.

The percentage of mixed forests is higher in protection forests (59 %) than it is in production forests (39 %). Protection forests are particularly endangered through their high percentage of mature and over-mature stands with poor regeneration; on 35 % of the area covered by protection forests the required regeneration measures are missing.

Regarding the damage surveyed by the Austrian Forest Inventory, browsing by game and grazing animals plays an important part. As far as stem damage is concerned, rockfall is dominant in protection forests. (On 33 % of the area covered by protection forests more than one third of the trees are affected by damage due to rockfall.) Bark-peeling damage, mainly by red deer, was found on 15 % of the areas.

On about half of the area covered by protection forests rehabilitation measures are required to restore sufficient stability over the medium term.

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