Static stability of forest stands in the seventh altitudinal vegetation zone in Slovakia

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ABSTRACT: Models evaluating static stability (resistance to breaking or uprooting of trees caused by wind, snow or ice) of forest stands in the seventh altitudinal vegetation zone were determined. The empirical material came from 180 research plots (High Tatra and Low Tatra Mountains) established within the research project *Research on Methods for Mountain Forest Management Based on Sustainable Development*. Static stability was characterized by the slenderness ratio that was calculated from the mean height and diameter of target trees. Then the particular forest stands were categorized with regard to slenderness ratio, mean diameter and absolute site class using either tables or graphic models. Particularly, four static stability classes were made up: 1 – very good, 2 – good, 3 – sufficient, and 4 – insufficient. Practical application of the models is shown for forest stands grown in the area of Vajsková and Lomnistá valleys.

Keywords: Norway spruce; wind firmness; slenderness ratio; static stability classes

The seventh altitudinal vegetation zone (AVZ; spruce zone) covers an area of 41,177 ha, slightly more than 2% of the total Slovak forest area. This AVZ is mostly covered by the forest site type characterized as *Sorbeto-Picetum* (68% of its area). The seventh AVZ is located at an altitude from about 1,250 to 1,600 m. Mean annual temperatures are between 2 and 4°C. Annual sums of precipitation range from 1,100 to 1,600 mm. Most forest stands are categorized as protective forests that fulfil mainly public-beneficial functions (LESOPROJEKT 2002).

The original forests were mostly made up of sparse stands or groups of trees with Norway spruce as a dominant tree species, although dense mountain pine stands also occurred at higher altitudes within this AVZ. In addition, except spruce and mountain pine, in the High Tatra and Low Tatra Mountains, some forests are composed of European larches and cembra pines, while also sycamore maples and mountain ashes grow in the seventh AVZ. The height and diameter growth of trees is limited strongly by extreme climatic conditions and rather short growing seasons. Tree crowns of conifers are very long, their branch and needle mass in the upper tree parts is often reduced by frequent winds (flag-like crowns). The stems are strongly taped with large root swellings.

Scientists' attention has been focused on forest ecosystems growing in the seventh AVZ (the term "mountain forests" is often used for them as well) mainly with regard to worsening health conditions of trees. Decline of forests on some plots located in the seventh AVZ was demonstrated through monitoring of forest health that is performed by the staff of the Forest Research Institute Zvolen. For instance, a significant rise in ozone concentration with altitude was observed. High ozone concentration, nitrogen and sulphur depositions accumulating in the soil, climatic extremes and some other harmful agents, individually or in combination, cause the weakening of forest ecosystems or even their collapse (BUCHA 2002). The results obtained by the staff of the Institute for Forest Management Planning Zvolen – Lesoprojekt also showed that as much as 90% of the forest area in the seventh AVZ were considered as endangered by air pollution of different intensities (the A, B, and C zones having high, medium and low concentrations of air pollution, respectively). The C zone with a low air pollution load, i.e. existing growth conditions allow spruce trees to survive no more than 60 years, is the most frequent in this AVZ.

Recently, mainly the issues of reclamation measures (e.g. liming and fertilizing) in forests of the seventh AVZ weakened by air pollution or other agents have been studied. Effect of ipidofauna on stand structure development in mountain forests was analysed by STOLINA (1969). KONÔPKA (1973) studied the static stability (the term was used mostly in the former Czechoslovakia to quantify the resistance of trees to breaking and uprooting caused by wind, snow or rime) of mountain forests. A research project dealing with methods for mountain forest management based on principles of sustainable development has been running in the Forest Research Institute Zvolen under leadership of Dr. Martin Moravčík in the last four years. Part of it, a particular sub-project *Protection of Mountain Forests Against Main Kinds of*

Harmful Agents (coordinated by Prof. Július Novotný) dealt also with static stability issues.

Previous research results concerning static stability in Norway spruce can be summarized as follows:

Resistant stands have observable variability of diameter, height, and volume structure, long and symmetrical crowns. In contrast, unstable stands have low variability of these parameters and rather short and often asymmetrical crowns.

Static properties of particular trees in stands with high variability of diameter, height and volume are better than in those with low variability of the parameters. For instance, comparison of stands damaged by wind and those which resisted to the same storms showed these values (KONÔPKA 1973):

Static characteristics	Stands damaged by wind	Undamaged stands
Crown proportion index (%)	47	78
Height of centre of gravity expressed from stem length (%)	68	47
Slenderness ratio	0.83	0.72

In the particular spruce stands, the best static characteristics were recorded for the thickest and usually also highest trees (i.e. dominant and co-dominant ones).

The aim of the paper is to define static stability of spruce stands growing in the seventh AVZ. Another aim is to determine criteria for objective evaluation of static stability in these particular spruce stands.

MATERIALS AND METHODS

The empirical material came from 180 research plots established in the seventh AVZ (High Tatra and Low Tatra Mountains) by the staff of the Forest Research Institute Zvolen in the framework of Research Project *Research on Methods for Mountain Forest Management Based on Sustainable Development* (MORAVČÍK et al. 2002). Designs of the plots and measurement methods common in the Slovak forest inventory practice were used (ŠMELKO et al. 1996). The research plots represented forest stand conditions typical of the seventh AVZ (especially particular forest site types) as well as diameter and age structures of stands (JANKOVIČ 2000). Part of the research plots was linked to the system used for the monitoring of forest conditions ICP Forest established in the 16 × 16 km net. Research plots were arranged on a 500 × 1,000 m grid. The plots were circular with the size between 200 and 1,000 m^2, containing a minimum number of 25 trees.

Mensurational data from 15–30 dominant and co-dominant spruce trees were obtained on each plot. These trees were labelled as "target trees" (representing the most vital and stable component of forest stand). The information on diameter at breast height ($d_{1.3}$) and tree height (h) was used to calculate slenderness ratio by the formula ($h/d_{1.3}$) × 100. The values of absolute site classes for spruce (representing tree height at the age of 100 years) were determined. Mean values of slenderness ratio for the particular plots were fitted with regard to mean values for diameter and according to the groups of absolute site classes (≤ 16, 18–22, ≥ 24). Hence, fitted (reference) values of slenderness ratio for target spruces with respect to their mean diameters and absolute site classes were available. Since the real mean values for slenderness ratios in the stands dispersed broadly along the fitted line, standard deviation was calculated (Sy) and used to delimit the particular static stability classes for spruce stands. The four static stability classes were made up:

Static stability classes	Interval of values for slenderness ratio
1. very good	$y < (\hat{y} - Sy)$
2. good	$y \leq \hat{y}$ and $y \geq \hat{y} - Sy$
3. sufficient	$y > \hat{y}$ and $y \leq \hat{y} + Sy$
4. insufficient	$y \geq \hat{y} + Sy$

$\hat{y}$ – fitted values of slenderness ratio
y – mean values of slenderness ratio in particular stands

These empirical models of static stability for mountain spruce stands (i.e. only for the seventh AVZ) are presented in both tabular and graphic form. To classify the static stability of particular stands using data from forest management plans a computer program was made up (programmed by Ivan Pôbiš, Forest Research Institute Zvolen). The program also ensures visualization of forest stands classified into particular static stability classes in a map form. A detailed procedure is as follows: mean values of diameter, tree height and absolute site class for the spruce stand are taken from data provided in the forest management plan. Consequently, the value of slenderness

Table 1. Values of slenderness ratio for target spruce trees on the research plots in the seventh altitudinal vegetation zone

Mean diameter of target trees (cm)	Absolute site class (tree height at age of 100 years) for spruce		
	16 and less	18–22	24 and more
10	0.731	0.771	0.778
20	0.672	0.721	0.741
30	0.613	0.671	0.704
40	0.554	0.621	0.667
50	0.495	0.571	0.630
Standard deviation	0.087	0.085	0.086

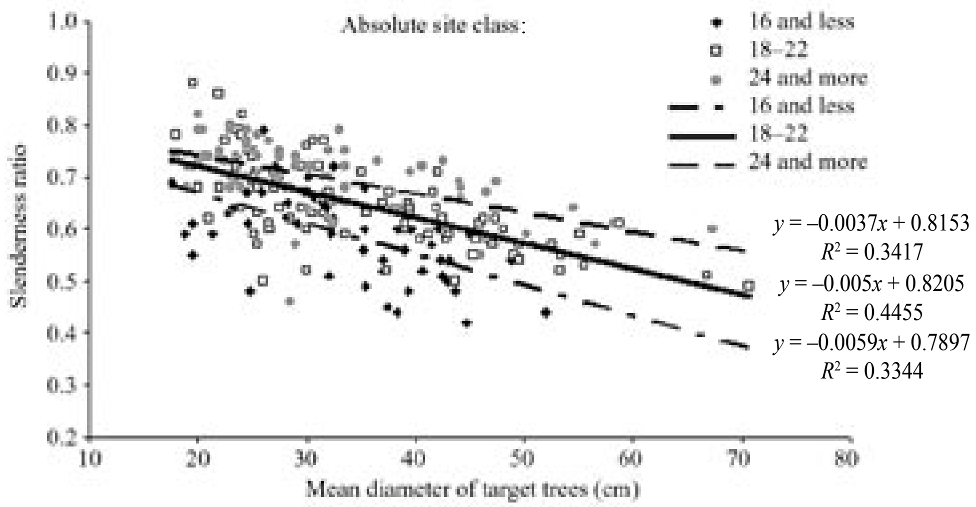

Fig. 1. Mean values of slenderness ratio for target spruce trees on the research plots in the seventh altitudinal vegetation zone with regard to their mean diameter fitted according to grouped absolute site classes

ratio is calculated. Static stability class for the particular spruce stand is determined according to Table 2 or Fig. 2, by using absolute site class, mean diameter and slenderness ratio as input data. Forest stands without spruce as the main tree species or those with mean diameter less than 10 cm are not classified.

As an example, we show the results of static stability classification for a complex of forest stands in Vajskovská and Lomnistá valleys (southern part of the Low Tatra Mountains). The mentioned computer program and data from recent forest management plan were used for the classification.

RESULTS

Empirical models of static stability for forest stands in the seventh altitudinal vegetation zone

The mean values of slenderness ratio for target spruce trees on the research plots respecting their mean diameter divided into groups of absolute site classes (≤ 16, 18–22, ≥ 24) are in Fig. 1. The fitting lines for correlations between the values of diameter and slenderness ratio are shown for the particular grouped absolute site classes as well.

The results show that the fitted values of slenderness ratio for target trees of spruces are significantly lower (i.e. higher resistance) in the worst site classes (16 and less) than in the best ones (24 and more).

The values of slenderness ratio for target spruce trees on the research plots in the seventh AVZ for different absolute site classes and mean diameters, as predicted by the fitted linear function are given in Table 1.

Slenderness ratio (fitted linearly) was lowest (0.495) for the group of site classes ≤ 16 having the mean stand diameter of 50 cm. The highest slenderness ratio (0.778) was determined for the group of site classes ≥ 24 with mean stand diameter of 10 cm. The values of standard deviations were between 0.085 and 0.087.

Empirical models of static stability for spruce stands growing in the seventh AVZ are shown in Table 2. The models are built up according to the grouped site classes (16 and less, 18–22, 24 and more) for four static stability classes: 1 – very good, 2 – good, 3 – sufficient, 4 – insuf-

Table 2. Empirical models of static stability for spruce stands in the seventh altitudinal vegetation zone (static characteristic: slenderness ratio of target spruce trees)

Grouped site classes	Static stability class	Mean diameter of target spruce trees (cm)						
		10	15	20	25	30	35	40
≤ 16	1 – very good	≤ 0.63	≤ 0.60	≤ 0.57	≤ 0.55	≤ 0.52	≤ 0.49	≤ 0.46
	2 – good	0.64–0.73	0.61–0.70	0.58–0.67	0.56–0.64	0.53–0.61	0.50–0.58	0.47–0.55
	3 – sufficient	0.74–0.82	0.71–0.79	0.68–0.76	0.65–0.73	0.62–0.70	0.59–0.67	0.56–0.64
	4 – insufficient	≥ 0.83	≥ 0.80	≥ 0.77	≥ 0.74	≥ 0.71	≥ 0.68	≥ 0.65
18–22	1 – very good	≤ 0.67	≤ 0.65	≤ 0.63	≤ 0.60	≤ 0.58	≤ 0.55	≤ 0.53
	2 – good	0.68–0.77	0.66–0.74	0.64–0.72	0.61–0.69	0.59–0.67	0.56–0.64	0.54–0.62
	3 – sufficient	0.78–0.86	0.75–0.83	0.73–0.81	0.70–0.78	0.68–0.76	0.65–0.73	0.63–0.71
	4 – insufficient	≥ 0.87	≥ 0.84	≥ 0.82	≥ 0.79	≥ 0.77	≥ 0.74	≥ 0.72
≥ 24	1– very good	≤ 0.68	≤ 0.66	≤ 0.64	≤ 0.62	≤ 0.61	≤ 0.59	≤ 0.57
	2 – good	0.69–0.78	0.67–0.76	0.65–0.74	0.63–0.72	0.62–0.70	0.60–0.68	0.58–0.67
	3 – sufficient	0.79–0.87	0.77–0.85	0.75–0.83	0.73–0.81	0.71–0.79	0.69–0.77	0.68–0.76
	4 – insufficient	≥ 0.88	≥ 0.86	≥ 0.84	≥ 0.82	≥ 0.80	≥ 0.78	≥ 0.77

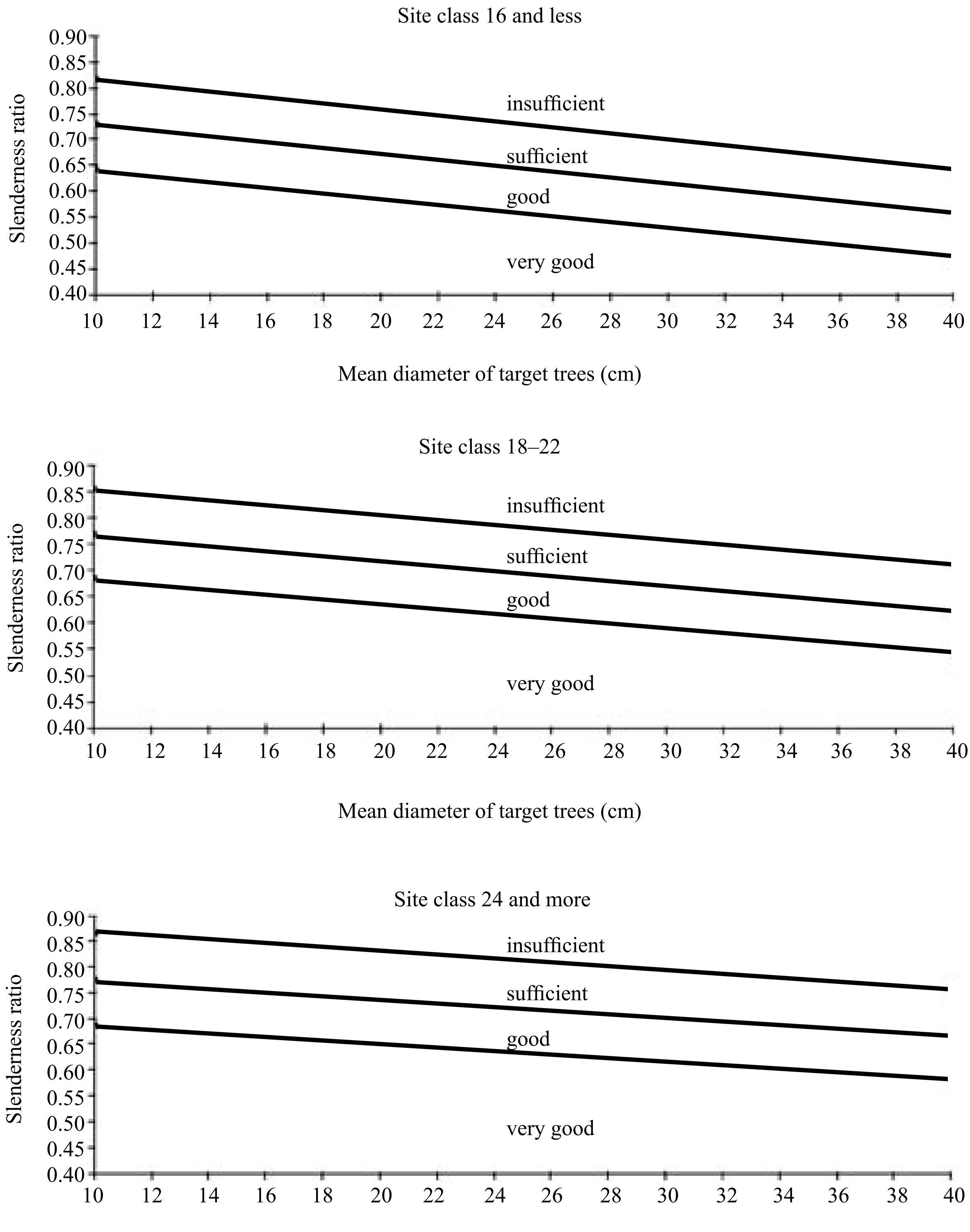

Fig. 2. Graphical models of static stability for spruce stands in the seventh altitudinal vegetation zone (static characteristic: slenderness ratio of target spruce stands)

ficient. These are defined by the intervals for the values of slenderness ratio in target spruce trees respecting their mean diameter class. The lowest value of slenderness ratio (0.46) was found in the group of site classes ≤ 16 with mean diameter of 40 cm. The highest one (0.88) was determined in the group of site classes ≥ 24 having the mean diameter of 10 cm.

Empirical models of static stability for spruce stands in the seventh AVZ are visualized in Fig. 2. The advantage of these graphic models in comparison with the

Table 3. Categorization of forest stands into static stability classes in Vajsková and Lomnistá valleys

Static stability classes	Number of forest stands		Forest stand area	
	(No.)	(%)	(ha)	(%)
0 – not categorized	39	13	63	6
1 – very good	133	43	540	49
2 – good	65	21	289	26
3 – sufficient	54	17	148	14
4 – insufficient	19	6	55	5
Altogether	310	100	1,095	100

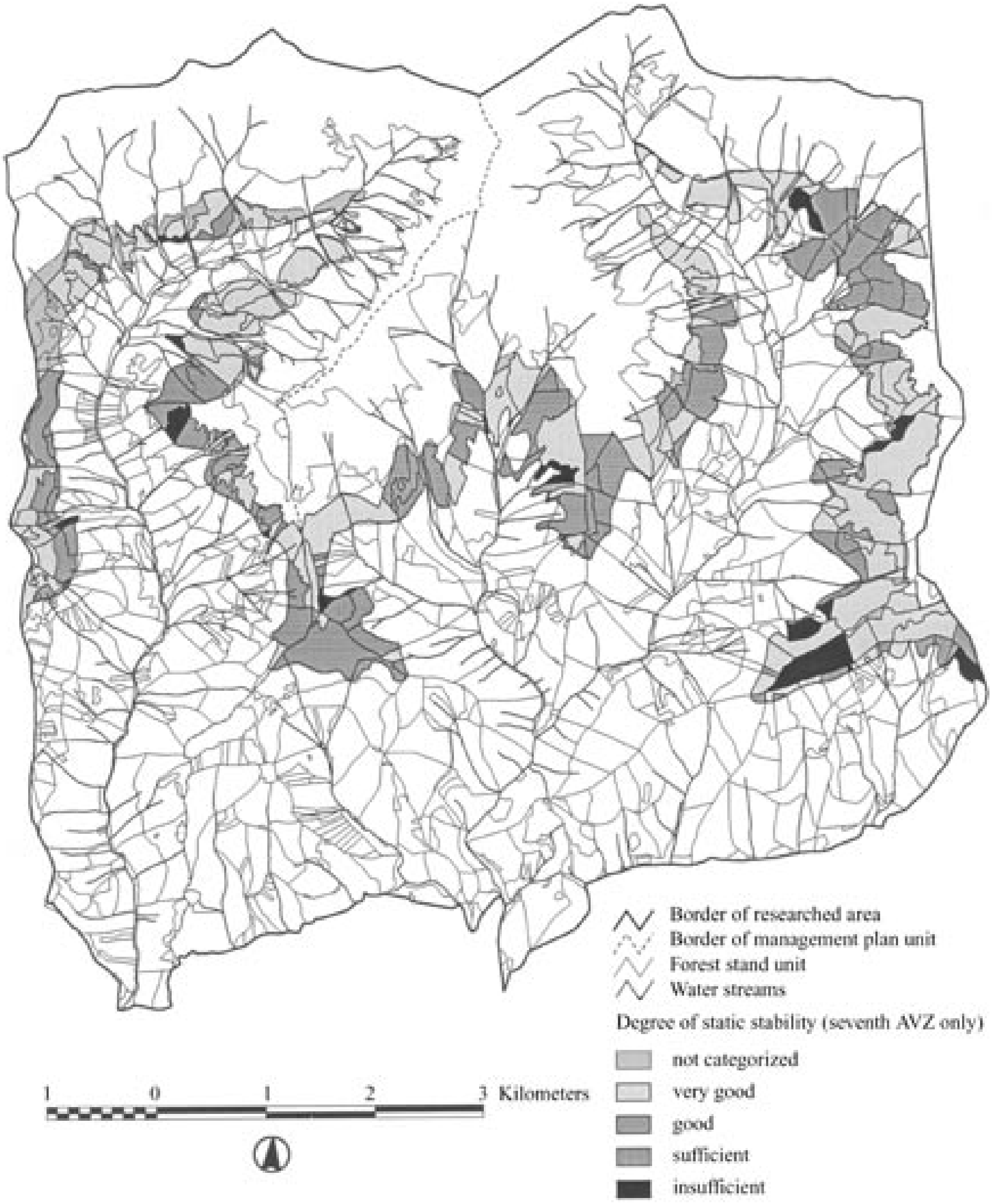

Fig. 3. Static stability of forest stands growing in the seventh altitudinal vegetation zone (Vajskovská and Lomnistá valleys)

table is a possibility of defining the static stability of forest stand very quickly for any mean diameter of target spruce trees.

Categorization of forest stands grown in the seventh altitudinal vegetation zone on an example of Vajsková a Lomnistá valleys

Forest stands with spruce as the main tree species located in the seventh AVZ in Vajsková and Lomnistá valleys were classified into the particular static stability classes (Table 3 and Fig. 3).

The results showed that out of the total number of forest stands (310) only 13% (39) were not categorized (without spruce as the main species or too young stands). Most forest stands were categorized as having very good or good static stability (198 forest stands representing 75% of total stand area). Only 19 forest stands (5% of the total stand area) showed insufficient static stability.

DISCUSSION

Several authors (e.g. KODRÍK 1983; KODRÍK, KONÔPKA 1971; VICENA et al. 1979; PRPIČ 1969) used only one characteristic to categorize the static stability of forest stands. Crown proportion index (proportion of crown length in tree height) or slenderness ratio were used most frequently. Later papers (KONÔPKA et al. 1987; KONÔPKA 1992, 1999) incorporated the typical changes with stand age or growth stage to characterize static stability. Thus both mentioned static characteristics were used in combination with mean stand diameter or age and site class (KONÔPKA 1999). However, these previous studies concerning the static stability of spruce stands in Slovakia were conducted at lower altitudes, mostly in the fifth and sixth AVZ. Significantly different courses of slenderness ratio with stand growth were observed from the data collected by HALAJ et al. in 1980 (data used for the construction of yield tables) in the seventh AVZ in comparison with lower altitudes. In the seventh AVZ, the course of slenderness ratio for spruce stands having the mean diameter between 10 and 40 cm showed an almost linear shape while in the AVZ of lower altitudes the shape was parabolic. Similarly, our empirical material showed that slenderness ratio for spruce stands in the seventh AVZ decreased linearly with increasing mean stand diameter (Fig. 2). Our particular values of slenderness ratio for target spruce trees in static stability 1 – very good, 2 – good, and 3 – sufficient are slightly lower than those from mountain forests found in the framework of building up the yield tables.

After analysing data from the research plots, we observed that the values for crown proportion index of many spruces were close to 100%. This was typical of sparse stands, stands with richly structured canopy or those growing on the edges of tree groups. The values of crown proportion varied only slightly and did not allow to set any suitable limits for the particular static stability classes. A different situation was found in some spruce stands, particularly man-made (even-aged) ones, which had rather short crowns. To effort to express the values of slenderness ratio in relation to stand age brought about another problem because of the occurrence of many old-growth tree groups. Hence, considering all these problems, to categorize the static stability of spruce stands in the seventh AVZ only slenderness ratio in dependence on mean stand diameter and site class was used for the models.

In general, some basic principles of protective silvicultural measures in spruce stands of the seventh AVZ should be followed. For instance, diameter and height differentiation of stands, spruces with long and symmetrical crowns, with taped stems, as well as resistant tree species (e.g. larch, beech, mountain ash) should be supported in all growth stages of stands. Young spruce stands should grow under sparse stocking to develop long crowns and taped stems. Natural regeneration should be maintained via soil preparation (mainly scarification). In the case of artificial regeneration, only trees of suitable provenance must be planted. Young forests should necessarily be protected from game damage at the exposed sites. The damaged trees that can become a pest focus (especially bark beetles and fungal diseases) should be removed from stands. Gaps in stands should be used for natural regeneration, enlarged continuously by cutting the most instable trees or tree groups. Regeneration procedures should be distributed in forest stands suitable for creating a mosaic structure with tree groups having a variety of growth stages. Forest management must support the natural tendency of mountain forests to build up clumps or groups of trees (such units usually have high static stability).

All protective silvicultural measures would regulate slenderness ratio in forest stands being categorized according to our models in class 1 or 2 (i.e. very good or good static stability).

CONCLUSIONS

The analysis of static stability in forest stands in the seventh AVZ proved the necessity to construct new empirical models that are different from those being used for the AVZ at lower altitudes. These models are characterized by:

– slenderness ratio as a suitable characteristic of static stability of spruce stands,
– values of slenderness ratio decreasing with increasing mean diameter in spruce stands,
– values of slenderness ratio lower for worse sites classes than for good ones.

To categorize the static stability classes in spruce stands (or those having spruce as the main tree species) of the seventh AVZ, tabular or graphical models can be used (Table 2 or Fig. 2).

The empirical models can be supportive in decision-making processes of forest management planning. Foresters can use them for the planning of protective and silvicultural measures in the particular forest stands. They can also be used to control the effectiveness of measures taken to increase the static stability of stands (e.g. after thinning).

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Statická stabilita lesných porastov v siedmom lesnom vegetačnom stupni na Slovensku

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ABSTRAKT: Odvodili sa modely hodnotiace statickú stabilitu (odolnosť voči vzniku polomov) porastov v siedmom lesnom vegetačnom stupni. Empirický materiál pochádzal zo 180 výskumných plôch (Vysoké a Nízke Tatry) založených v rámci výskumného projektu *Výskum metód obhospodarovania horských lesov na princípe trvale udržateľného rozvoja*. Statická stabilita sa charakterizovala štíhlostným kvocientom odvodeného z priemernej výšky a hrúbky cieľových stromov smreka. Výsledná statická stabilita jednotlivých lesných porastov sa potom určí podľa štíhlostného kvocienta, strednej hrúbky a absolutnej bonity pre smrek. Pritom sa použije buď tabuľková forma, alebo grafikony. Konkrétne sa vytvorili štyri stupne statickej stability: 1 – výborný, 2 – dobrý, 3 – vyhovujúci a 4 – nevyhovujúci. Praktické použitie modelov sa demonštrovalo na lesných porastoch v oblasti Vajskovej a Lomnistej doliny.

Kľúčové slová: smrek obyčajný; odolnosť voči polomom; štíhlostný kvocient; stupeň statickej stability

Smrekový, t.j. 7. lesný vegetačný stupeň (lvs) má výmeru 41 177 ha, čo predstavuje len o niečo viac ako 2 % z výmery lesov SR. Ide o nadmorské výšky približne od 1 250 do 1 550 m. Lesné porasty patria väčšinou do kategórií ochranných lesov, plnia teda v prvom rade verejnoprospešné funkcie. Pôvodné lesy v 7. lvs tvorili riedke porasty rozstupujúcich sa stromov a stromových skupín s prevahou smreka, striedajúcich sa v najvyšších polohách so súvislými porastami kosodreviny. Vo Vysokých a Nízkych Tatrách sa v tomto stupni vyskytuje ešte smrekovec opadavý a borovica limba. Ďalej tu môžu rásť ako stredne vysoké stromy javor horský a jarabina vtáčia.

Lesným porastom v 7. lvs sa začala pozornosť venovať najmä v ostatnom období v súvislosti s ich nepriaznivým zdravotným stavom. Upozornili na to hlavne výsledky monitoringu zdravotného stavu lesov. Problematikou ochrany lesov v 7. lvs sa zaoberali viacerí autori. Často išlo o riešenie a realizáciu nápravných opatrení v lesoch pod vplyvom imisií. V ostatných štyroch rokoch sa problematikou horských lesov intenzívne zaoberal kolektív pracovníkov LVÚ Zvolen v rámci vedeckotechnického projektu *Výskum metód obhospodarovania horských lesov na princípe trvale udržateľného rozvoja*. Jeho súčasťou bol tiež čiastkový projekt *Ochrana horských lesov proti hlavným škodlivým činiteľom*, v rámci ktorého sa riešila aj problematika statickej stability.

Cieľom príspevku bolo definovať statickú stabilitu smrečín rastúcich v podmienkach 7. lvs a ďalej vytvoriť kritériá pre objektívne zhodnotenie statickej stability jednotlivých smrekových porastov. Podklad na riešenie problematiky tvorilo 180 výskumných plôch založených v 7. lvs (Nízke a Vysoké Tatry) v rámci už uvedeného vedeckotechnického projektu. Zo súborov stromov (drevina smrek), na ktorých sa zisťovali taxačnodendrometrické parametre, sa na každej výskumnej ploche vybrali len nadúrovňové a úrovňové. Tieto sa pokladali za cieľové. Ich počet sa na výskumných plochách pohyboval od 15 do 30. Na každom strome sa zisťovala jeho hrúbka $d_{1,3}$ a výška. Z nameraných hodnôt sa na každej výskumnej ploche vypočítal priemerný štíhlostný kvocient (pomer výšky stromu k jeho hrúbke $d_{1,3}$). Ďalej sa určila bonita dreviny smrek. Priemerné hodnoty štíhlostného kvocienta cieľových stromov smreka sa matematicky vyrovnali v závislosti od ich strednej hrúbky podľa zoskupených absolútnych bonít ($\leq$ 16, 18–22, $\geq$ 24). Vznikli tým vyrovnané hodnoty štíhlostného kvocienta cieľových stromov smreka v závislosti od ich strednej hrúbky podľa zoskupených bonít. Pomocou vyrovnaných hodnôt štíhlostného kvocienta a smerodajnej odchýlky sa odvodili štyri stupne statickej stability lesných porastov: 1 – výborný, 2 – dobrý, 3 – vyhovujúci a 4 – nevyhovujúci. Empirické modely statickej stability lesných porastov (drevina smrek) v 7. lvs sa spracovali jednak v tabuľkovej, ako aj v grafickej forme. Na zatrieďovanie lesných porastov do stupňov statickej stability podľa údajov lesných hospodárskych plánov sa zostavil počítačový program. Konkrétny postup je takýto: z lesných hospodárskych plánov sa prevezmú údaje o drevine smrek: stredná hrúbka, stredná výška a bonita. Vypočíta sa štíhlostný kvocient. Podľa tab. 2, resp. obr. 2 na základe bonity, strednej hrúbky a hodnoty štíhlostného kvocienta sa odčíta stupeň statickej stability. Porasty, v ktorých sa drevina smrek nenachádza, prípadne sú vo veku, kde sa uvedené základné informácie neuvádzajú, sa do hodnotenia nezaraďujú.

Ako príklad riešenia sa uvádza zatriedenie lesných porastov do stupňov statickej stability v modelovom území Vajskovská dolina a Lomnistá dolina (Nízke Tatry). Použili sa tu platné lesné hospodárske plány a už uvádzaný program. Z výsledkov vyplynulo, že z celkového počtu 310 porastov sa nehodnotilo 39 (63 ha, t.j. 6 % z celkovej porastovej plochy). Najviac porastov (198) malo stupeň statickej stability 1 (výborný) a 2 (dobrý) (spolu 829 ha, t.j. 75 % porastovej plochy). 3. (vyhovujúci) stupeň statickej stability malo 54 porastov (148 ha, 17 %). Len 19 malo 4. (nevyhovujúci) stupeň statickej stability (55 ha, 5 %).

Treba uviesť, že pri konštruovaní stupňov statickej stability smrekových porastov v predošlých prácach (KONÔPKA 1990, 1999) sa vychádzalo najmä z výskumných plôch nižšie ležiacich lvs. Na odlišnú situáciu v 7. lvs upozornili už výsledky výskumu, ktoré vyplynuli z podkladových materiálov zhromaždených HALAJOM et al. v roku 1980, podľa ktorých priebeh hodnôt štíhlostného kvocienta je iný v horských polohách ako v nižších (KONÔPKA et al. 1987).

Z dvoch sledovaných ukazovateľov statickej stability porastov sa v 7. lvs neukázal ako vhodný podiel dĺžky koruny z celkovej výšky stromov (korunovosť). Pokiaľ majú porasty prirodzenú štruktúru, resp. na okraji skupín sú stromy (ak sú usporiadané mozaikovite), majú koruny dlhé až po zem. Výnimku tu tvoria umelé jednovrstvové porasty (s horizontálnym zápojom), kde sú koruny krátke. Taktiež určovanie hodnôt štíhlostného kvocienta podľa veku porastov naráža na problém dlhovekosti mnohých stromových skupín. Preto ako ukazovateľ statickej stability sa použil iba štíhlostný kvocient v závislosti od hrúbky a bonity.

Empirické modely statickej stability možno využiť pri hospodársko-úpravníckom plánovaní, ďalej v lesnej prevádzke pri plánovaní a realizácii pestovno-ochranných opatrení ako aj pri kontrole ich vplyvu na zvyšovanie statickej stability lesných porastov. Ide najmä o výchovné zásahy, ktoré môže lesný hospodár usmerniť tak, že sa zvýši alebo udrží požadovaný stupeň statickej stability.

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