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Corresponding patterns of site quality, decline and tree growth in a sessile oak stand

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Summary

This study focuses on two rarely studied aspects of oak decline: relations with site characteristics and effects on tree growth. The study was carried out in a 5.5 ha stand in Hungary which is strongly affected by oak decline. The nearly pure sessile oak (*Quercus petraea*) stand of mostly coppice origin was 90 years old at the beginning of the study. Within-stand site heterogeneity was described by the herbaceous vegetation. Four ecological site types were distinguished by the species composition of herbs, and characterized by the ecological indicator values of the species. Tree growth between 1987 and 1993 was measured, and tree vigour was estimated from visual characteristics five times between 1987 and 1993. Potential volume increment of declining trees was estimated with the growth rates of healthy trees of the same size. Volume increment loss caused by oak decline was also assessed. Significant positive relationships were found between tree vigour and tree size and between tree vigour and tree growth. The growth of seriously declining trees dropped to almost one-half of that of healthy ones. Growth reduction of living trees at the stand level amounted to 5.4%, whereas growth reduction of all trees, including those that died during the observation period, amounted to 19.9% of the potential growth. Tree size and growth were greater on better sites. A strong relationship was also found between tree vigour and site type, but sessile oak was more susceptible to decline at better sites.

1 Introduction

Forest decline has been widely reported throughout the world. Many different types of decline have been described and a series of hypotheses have been proposed about the possible causes (HUETTL and MUELLER-DOMBOIS 1993; INNES 1993; CIESLA and DONAUBAUER 1994). The health of forests has become an important issue of international scientific and public concern in the past two decades.

In Hungary, the most serious decline occurs in sessile oak (*Quercus petraea* (Mattuschka) Lieblein). This species is one of the most important deciduous tree species in the country, and is widespread throughout Europe. The National Forest Health Inventory (CSÓKA and SZEPESI 1995) indicated that, in 1994, the symptoms of decline (i.e. > 10% leaf loss and discoloration) were detected on 93% of all the trees surveyed. Oak decline is also widespread in Europe and on the American continent (SIWECKI and LIESE 1991; CIESLA and DONAUBAUER 1994; INRA 1994).

Most research and scientific debates have been conducted on the direct cause(s) of the decline but despite the intensive work, there has been no widely accepted explanation of the cause(s) (JAKUCS 1985; BORHIDI 1986; IGMÁNDY 1987; HARTMANN and BLANK 1992; CIESLA and DONAUBAUER 1994; VARGA et al. 1995).

This paper focuses on other, equally important, but mostly neglected aspects of oak decline. These are the following:

1. Is there any relationship between site quality and the susceptibility to decline of trees?
2. What is the effect of decline on the growth of the stand and sick trees?
3. Is there any site specificity in the relationships between the vigour and growth of trees?

The first question is more complex than, for example, simply asking whether trees are more susceptible to decline at extremely acidic sites, since it addresses the problem at a rarely studied fine (i.e. within-stand) spatial scale. At a regional scale, VÁRADI (1983) did not find any significant relationship between site quality and health status by analysing inventory data in Hungary. At a more local scale, STANDOVÁR (1993a, 1994) showed a significant association between the spatial patterns of site quality indicator herbs and those of the degree of tree decline within a single stand. Despite the extent and economic significance of oak decline, the second question has not yet been adequately addressed. This fact prompted INNES (1993; p. 475) to state in his comprehensive review of oak decline that 'given the recent deterioration in the crown condition of oaks in many areas, studies of increment are urgently required'.

SOMOGYI (1991a,b) showed that oak decline significantly decreases tree growth. The identification of the causes could not be achieved by comparing growth patterns of trees suffering from known harmful effects with those of oak decline. In these studies, tree ring analysis, which has been the most commonly used method of studying the effects of decline on growth (IGMÁNDY et al. 1986b; IGMÁNDY 1987; BODNER and INDOME 1988; HARTMANN and BLANK 1991; WAZNY et al. 1991), was applied. Because these analyses used samples representing only a limited number of individuals, they usually do not provide stand-level estimates of growth loss caused by decline.

The third question has been the least studied. One reason for this might be that it requires extensive data collection on site, tree vigour and tree growth characteristics. Simultaneously considering the effects of site and vigour on growth may shed more light on the importance of site in tree decline.

While decline and growth are relatively easy to record, site description is especially difficult at the within-stand scale used in this study, which was a component of the Völgyfő Project (STANDOVÁR 1988, 1993a). The project was originally initiated to study the significance of ecological indication by describing and ecologically interpreting herb layer vegetation patterns, and to study the links between these patterns and those of site and canopy characteristics. The existence of these links is implicitly supported by classical phytosociological schools (WHITTAKER 1962, 1978; SOÓ 1965; WESTHOFF and VAN DER MAAREL 1978) and the theory of forest types (CAJANDER 1926).

In this study, a similar ecological approach was applied at a much finer, within-stand scale. Within-stand site differences were described by classifying and ecologically interpreting the species composition of the herbaceous vegetation of the entire study area. To relate site, decline and growth, the vigour of all the tree individuals was observed and their growth was measured in a 6-year period.

2 Materials and methods

2.1 Study area

This study was carried out in a stand of 5.5 ha situated near Völgyfő in the Bükk National Park, Northern Hungary (48°58'N, 20°30'E), with elevation ranging from 450 to 600 m. The bedrock is Triassic dark grey shale with 30° inclination and limestone intercalation (BALOGH 1963). Because of possible erosion of shale, the soil-forming bedrock is limestone at the highest part of the area. The differences in bedrock are also reflected in the distribution of soil types and the range of pH. The top of the hill is covered by rendzina; differently eroded forms of illuviated brown forest soil occur elsewhere. Soil pH varies from 4.7 to 6.8 in the top layer (0–10 cm) and from 4.2 to 5.7 at 20–30 cm depth. Because there is no

meteorological station at the site, mean annual temperature of about 9°C and mean annual precipitation of 700 mm were extrapolated from the data of the nearest stations.

The area is covered by a 90-year-old (in 1987), nearly pure, even-aged sessile oak (*Q. petraea*) stand of mostly (over 95%) coppice-origin. On the top of the hill, turkey oak (*Quercus cerris*) thrives. The stand is strongly affected by oak decline. The stand developed under normal natural and silvicultural conditions. The last thinning took place in 1982. Seedlings and shrubs have grown intensively in the past 10 years partly as a result of the gaps opened by oak decline and because of the lack of browsing after the area had been fenced. The average diameter at breast height (d.b.h.) of sessile oak individuals was 26.7 cm in 1987, whereas mean height was 20.6 m. The yield class varied from III to IV, according to the VI-class system of BÉKY (1987).

A detailed description of the herb layer vegetation is presented by STANDOVÁR (1988, 1993b). Several species occur throughout the area. The most common examples are the following: *Calamintha clinopodium*, *Chrysanthemum corymbosum*, *Digitalis grandiflora*, *Fragaria vesca*, *Galium schultesii*, *Geum urbanum*, *Poa nemoralis*, *Viola silvestris*. Differences in the species composition of the vegetation types (VT) distinguished by numerical classification (Fig. 1) can be given as follows:

- VT1 is differentiated by the occurrence of species such as *Brachypodium pinnatum*, *Origanum vulgare*, *Primula veris*, *Serratula tinctoria*, *Veronica teucrium* and *Waldsteinia geoides*.
- VT2 is discriminated by the high abundance of *Fagetalia* (*Asperula odorata*, *Convallaria majalis*, *Dentaria bulbifera*, *Helleborus purpurascens*, *Sanicula europaea*, *Viola mirabilis*,) and disturbance indicator species (*Alliaria petiolata*, *Cardamine impatiens*, *Galium aparine*, etc.).
- VT3 has transitional characteristics between VT2 and VT4.
- VT4 is distinguished by the importance of *Calamagrostis arundinacea*, *Carex digitata*, *Carex montana*, *Cytisus nigricans*, *Hieracium lachenalii*, *Luzula albida* and *Viscaria vulgaris*.

2.2 Data collection

For the exploration and description of the vegetation, the whole area was covered by a grid of 354 contiguous quadrats of 12.5 × 12.5 m. Presence-absence data of all the 148 herbaceous species occurring in the area were recorded, yielding a binary matrix of 354 × 148.

Several non-floristic descriptors of the herbs were used to infer site quality from them. Temperature, humidity and acidity optima, as well as coenological fidelity of all species

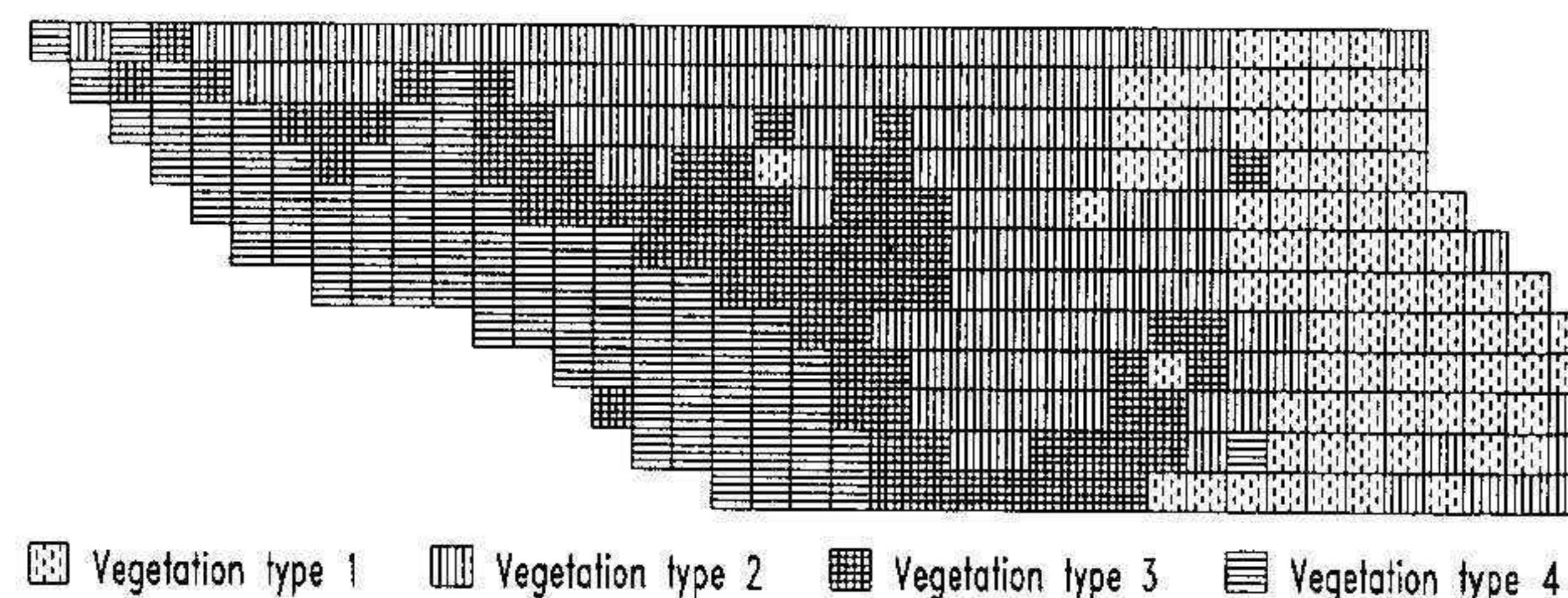


Fig. 1. Spatial distribution of the four vegetation types in the study area. (see Section 2.1)

were characterized. The actual values were used after ZÓLYOMI et al. (1967), who adapted the widely used and continuously developed system of Ellenberg (ELLENBERG 1952, 1988; ELLENBERG et al. 1992) as follows: T [thermophobic (1) to thermophilic (7); indifferent (0)]; W [xerophilous (0) to hygrophilous (11)]; R [acidophilic (1) to basophilic (5); indifferent (0)].

To record tree and stand growth, all the 2133 trees occurring in the area were marked and mapped in 1986 (KARAS and STANDOVÁR 1987). Their circumference at breast height was measured in late 1987 and 1993, whereas their height (TH) was measured in 1991.

Tree vigour was assessed in August in 5 years between 1986 and 1993. It was visually determined by using a vigour class (VC) system defined and described by IGMÁNDY et al. (1986a) and CSÓKA (1992):

- 5 the crown is thick, the leaves are dark green and there are no visible symptoms of illness of any kind;
- 4 the crown is slightly thinned out, the leaves are smaller and their colour is slightly brighter than normal; smaller branches have died;
- 3 leaf loss is considerable and thick branches of the crown have dried out; discoloration (from yellow to red) of the leaves is substantial;
- 2 the tree died in the year of a survey;
- 1 the tree died in previous years.

2.3 Data analyses

Relevés were grouped by using a hierarchical agglomerative classification method, namely, Ward's method (minimum increase of sum of squares) with Euclidean distance as resemblance function. The analysis was performed by using the SYN-TAX III package (PODANI 1988). After the vegetation types were obtained, each of them was characterized by the mean relative frequency of the ecological indicator values.

Of all the trees present in the area in 1986, there were 1992 sessile oaks with measurable dimensions. By their VC values, each tree was categorized into one of three groups: trees that died before 1987, those that died between 1987 and 1993, and those that remained alive until the end of the period investigated. Live trees were further classified into seven vigour clusters (VIGOUR). This classification was necessary to attach only one attribute of vigour to each tree. The number of clusters was arbitrarily chosen considering the sum of VC values (SUM-VC), and the manifold temporal patterns of tree vigour. VC was recorded in five years between 1986 and 1993, so SUM-VC varies between 15 and 25. The derived variable VIGOUR takes values as follows:

1. Chronically severely sick trees (SUM-VC = [15, 16], i.e. VC = 3 at least four times);
2. Severely sick trees (SUM-VC = [17, 18]);
3. Considerably sick trees (SUM-VC = [19, 21], and VC = 3 at least twice);
4. Chronically sick trees (SUM-VC = [19, 21] and VC = 4 at least four times);
5. Sick trees (SUM-VC = [19, 21] and VC = 3 maximum once and VC = 4 maximum three times);
6. Slightly sick trees (SUM-VC = [22, 23]);
7. Healthy trees (SUM-VC = [24, 25], i.e. VC = 4 maximum once).

Trees that had died of oak decline by 1993 were denoted by VIGOUR = 0 where they were included in the analysis.

Tree diameter in 1987 and 1993 (D87 and D93, respectively) was calculated from the circumference measurements. Actual volume of trees in 1987 and 1993 (V87 and V93, respectively) was estimated using a volume function of type $V = f(D, TH)$ with parameters for sessile oak in Hungary (KIRÁLY 1978). Since the vertical growth of trees over 90 years

old on the given site is already slow, TH measured in 1991 was used to calculate both V87 and V93. As a result, actual volume increment (V93_87) is slightly underestimated (at the given age, this underestimation does not exceed 10%). For trees that died before 1991, height was estimated from D87 using a diameter-height response curve. Relative volume increment (RELV93_87) was given as V93_87 normalized to V87.

Potential volume growth of non-healthy trees (VPOT), was estimated by using their V87 and the average growth of healthy trees of the same size. In the estimation of the growth of a tree, correction for the initial size of the tree was necessary because growth heavily depends on it. The growth of healthy trees, in relation to size, was estimated by a linear response function between variables V87 and V93_87, separately developed in each VT.

Absolute growth loss (ABSLOSS) was estimated for each non-healthy tree as VPOT - V93_87. Relative loss (RELLOSS), as a percentage, was calculated as the ratio of ABSLOSS to VPOT. The relationships between vegetation types, tree vigour and tree growth were studied by using Kruskal-Wallis test (H statistics), the non-parametric analogue of classical analysis of variance (CONOVER 1980). The analyses were performed by using the STATISTICA software package (STATSOFT 1983-94).

3 Results and Discussion

3.1 Ecological site types

The numerical classification of vegetation data resulted in four vegetation types. Their spatial distribution is shown in Fig. 1. Because site quality was inferred from the ecological indicator values of herbs, these floristically different vegetation types will be considered and referred to as ecological site types (EST). The floristic composition of EST1 indicates a relatively dry and the least acidic habitat. The species in EST2 and EST3 indicate the most mesic habitat. EST4 is the driest and the most acidic of all within the study area.

The ESTs obtained differed by the mean relative frequency of ecological indicator values of all the species. Reliability of this type of ecological indication is illustrated in Fig. 2, where the distribution of humidity optimum (W) indicator values is shown for those two

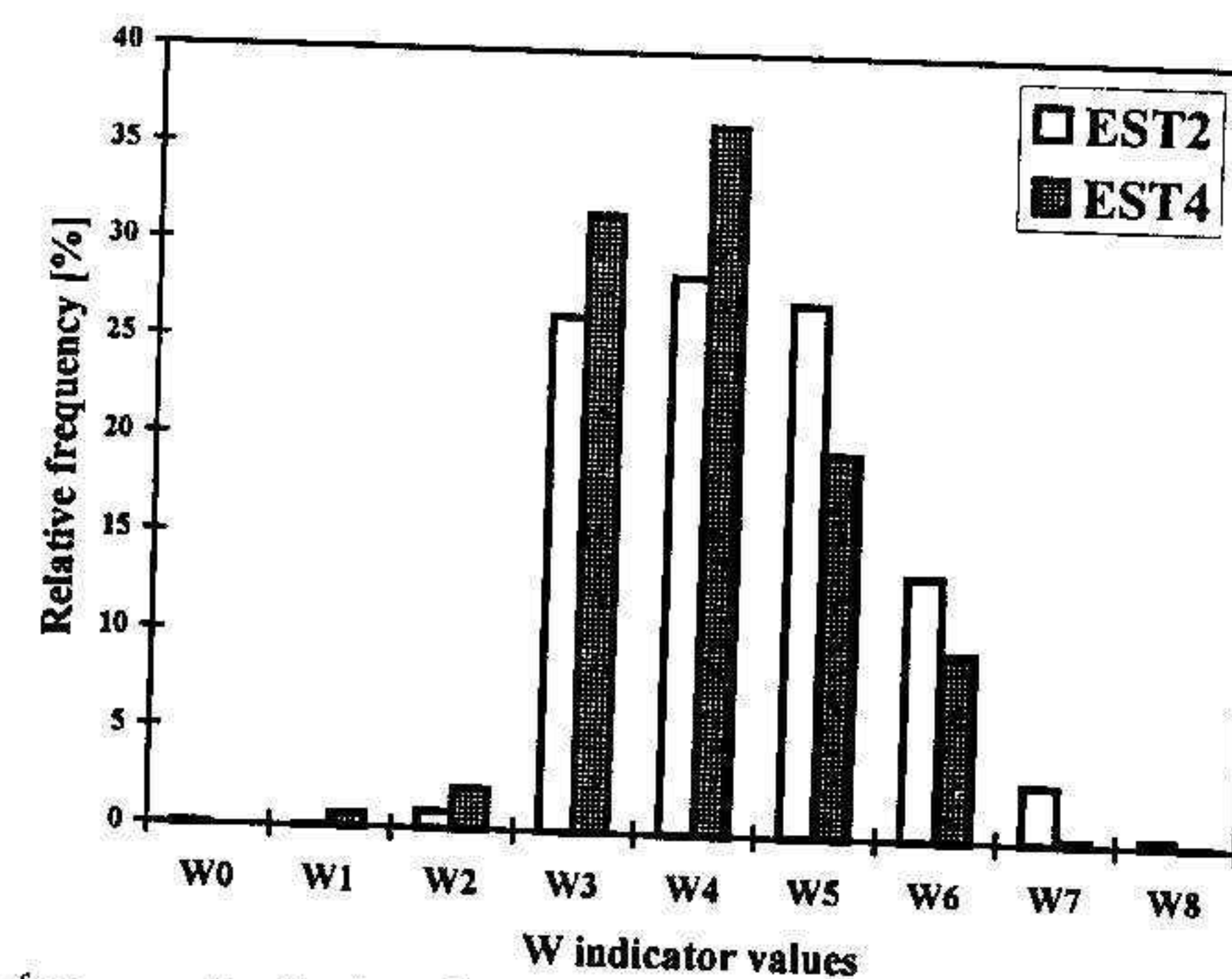


Fig. 2. Relative frequency distribution of W (humidity) indicator values in ecological site types (EST) 2 and 4

ESTs where STANDOVÁR and RAJKAI (1994) found significant differences in soil moisture status.

3.2 Tree vigour, size, growth and growth loss

The Kruskal–Wallis test showed a significant relationship between tree diameter in 1987 (D87) and tree vigour (VIGOUR, Table 1). In this analysis, those trees that died by 1993 were also included (VIGOUR = 0). The diameter of seriously sick trees (VIGOUR = 1–3) was significantly smaller than that of slightly sick or healthy trees, and the smallest trees are those that died by the end of the observations (Fig. 3).

A significant relationship was also found between actual volume increment (V93_87) and tree vigour (Table 1, Fig. 4), with the most sick trees (VIGOUR = 1–3) producing significantly smaller increments than the healthy ones. Estimated volume increment of trees in VIGOUR = 1 was slightly more than the half of potential growth. The relationship between absolute growth loss (ABSLOSS) and tree vigour showed a similar pattern (Table 2). The total, i.e. stand-level growth loss of living trees accounted for 5.4% of the potential increment of all living trees. This is the loss that would have taken place even if no tree had died. Assuming normal growth of the trees that died due to oak decline, a further loss of 37.8 m³ was estimated. Total growth loss thus amounted to 19.9% of all potential growth. The volume of dead trees was substantial, it was estimated as 203.3 m³, which was 17% of the total standing volume in 1987. This further increases the amount of timber in the area that was estimated as lost due to oak decline. However, the cumulative dead volume appears to be levelling off (1985–86 = 23.2 m³, 1992–93 = 4.5 m³).

Table 1. Kruskal–Wallis tests of the independence of variables describing tree size, tree growth, tree vigour and site quality

Variables	d.f.	n	H-statistics	Significance (p)
D87–VIGOUR	7	2056	166.93	<0.0001
V93_87–VIGOUR	6	1645	148.08	<0.0001
VIGOUR–EST	3	1645	26.85	<0.0001
V87–EST	3	1645	210.62	<0.0001
V93_87–EST	3	568	93.78	<0.0001
RELVOLGR–EST	3	568	5.85	0.1187
ABSLOSS–EST	3	1077	11.08	0.0113
RELLOSS–EST	3	1077	1.48	0.6865

Table 2. Actual and potential volume growth (V93_87 and VPOT, respectively) and relative growth loss (LOSS) in relation to tree vigour (VIGOUR)

VIGOUR	n	V93_87 (m ³)	VPOT (m ³)	LOSS (% of VPOT)
1	114	7.33	12.90	43.2
2	103	10.26	12.59	18.5
3	100	11.48	11.75	2.3
4	61	7.87	8.70	9.6
5	173	21.39	22.30	4.1
6	526	66.74	67.98	1.8
7	568	72.22	72.22	0.0
Total	1645	197.29	208.44	5.4

Patterns of site quality, decline and tree growth in a sessile oak stand

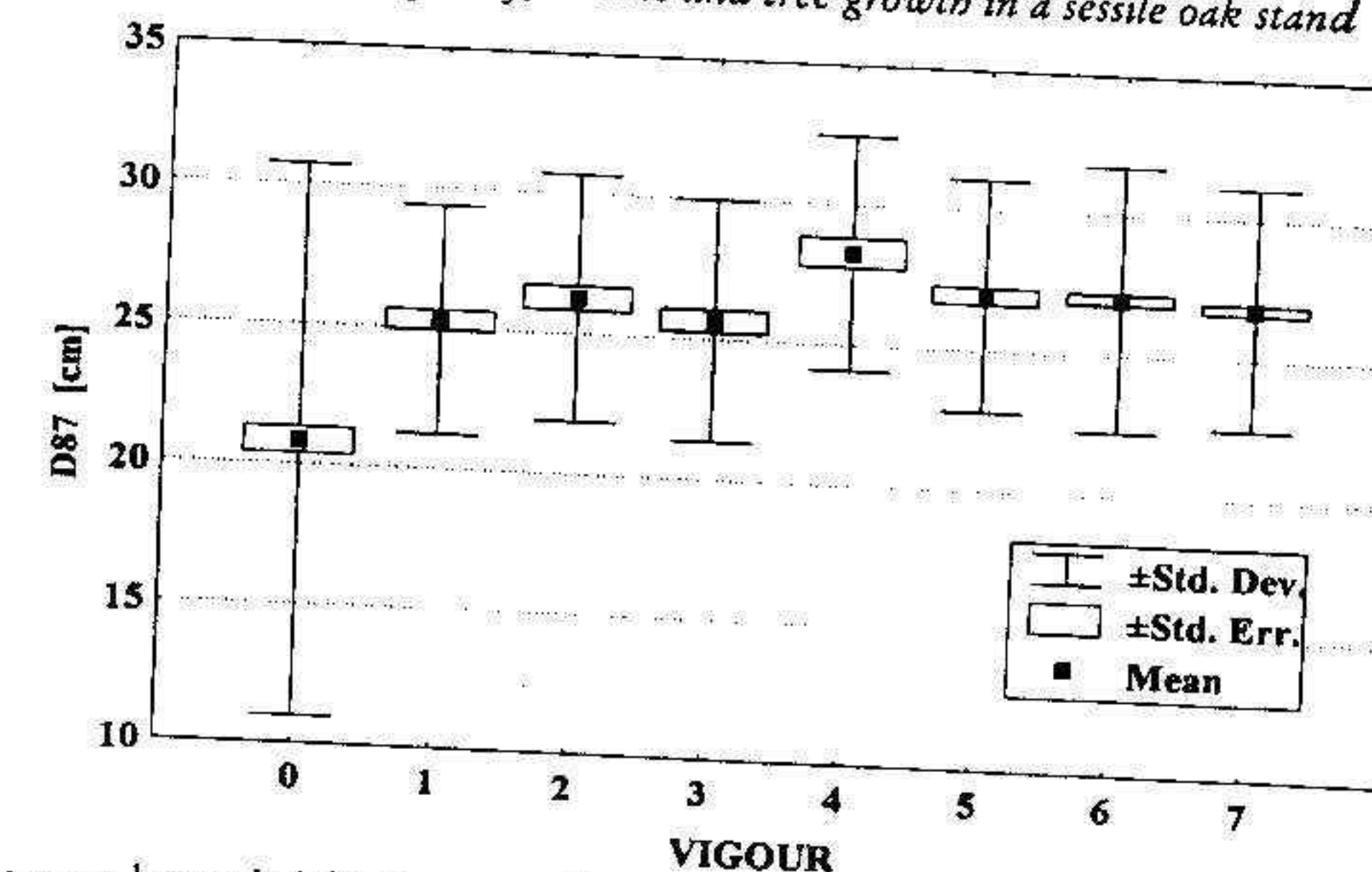


Fig. 3. Average breast height diameter of trees in 1987 (D87) in tree vigour classes (VIGOUR)

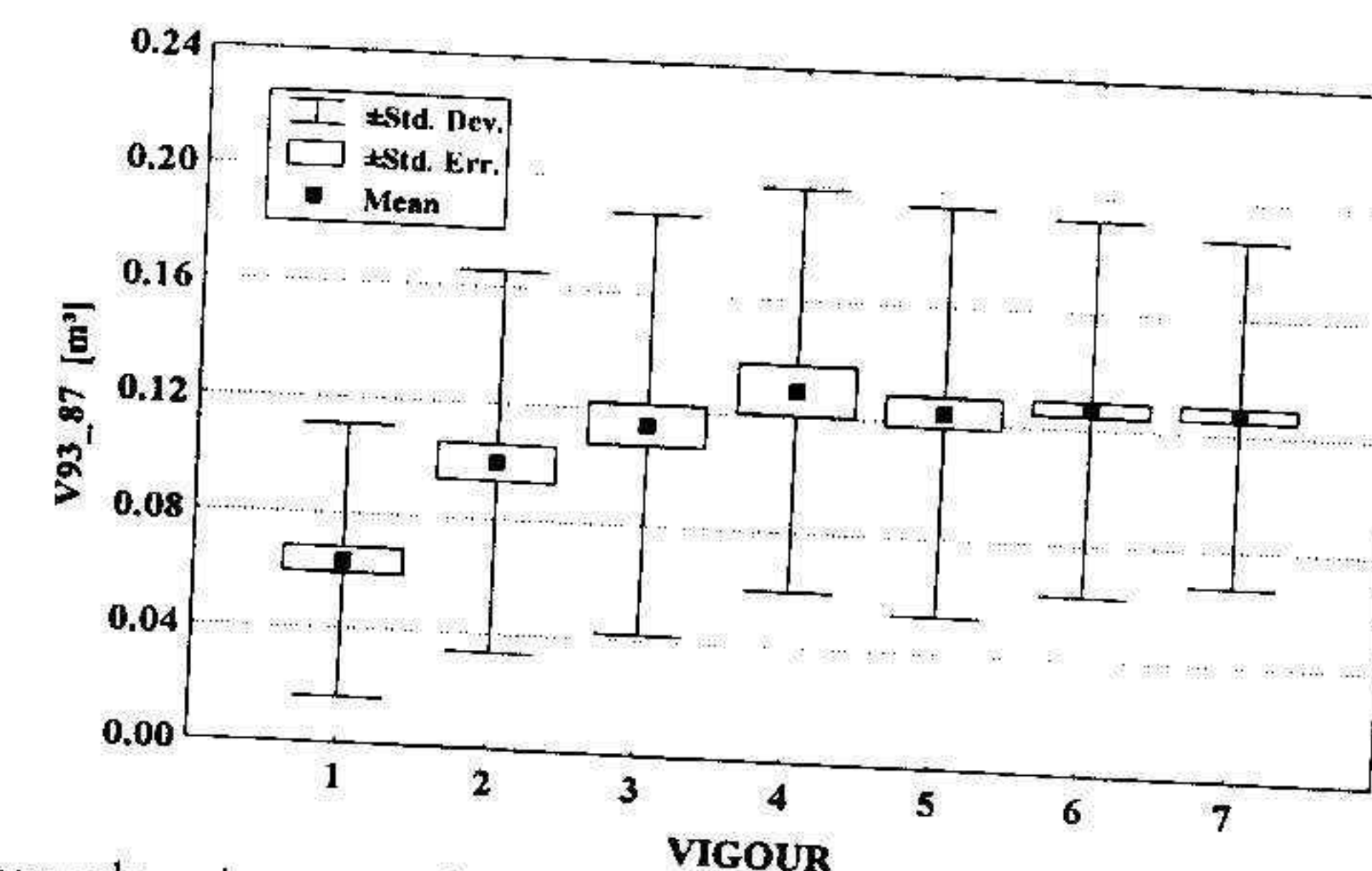


Fig. 4. Average volume increment of trees between 1987 and 1993 (V93_87) in tree vigour classes (VIGOUR)

3.3 Site effects on tree characteristics

The Kruskal–Wallis test showed a significant relationship between tree vigour (VIGOUR) and ecological site type (EST, Table 1). Thus, it appears proven that there are differences in the susceptibility of trees to decline at different sites. Since dead trees (VIGOUR = 0) were also included in the analysis, it can also be concluded that the relative frequency of dead trees is the highest in EST2, whereas it is the lowest in EST4 (Fig. 5). This means that, at this particular study area, sessile oak trees are healthier under less favourable site conditions (note that EST4 is the driest and most acidic).

The Kruskal–Wallis test showed that a significant relationship exists between EST and V87 (Table 1). This result conforms with prior expectations, since the average size of trees was considerably smaller in EST4, which was the least favourable site type (Fig. 6).

To verify whether this difference has changed with age, the relationship between ecological site type (EST) and actual volume increment (V93_87) was studied for all healthy trees (VIGOUR = 7). As Table 1 and Fig. 7 show, a significant relationship was found, and better site quality resulted in larger growth. Since tree growth depends heavily on size, it was also necessary to check whether relative volume increment (RELV93_87) was different

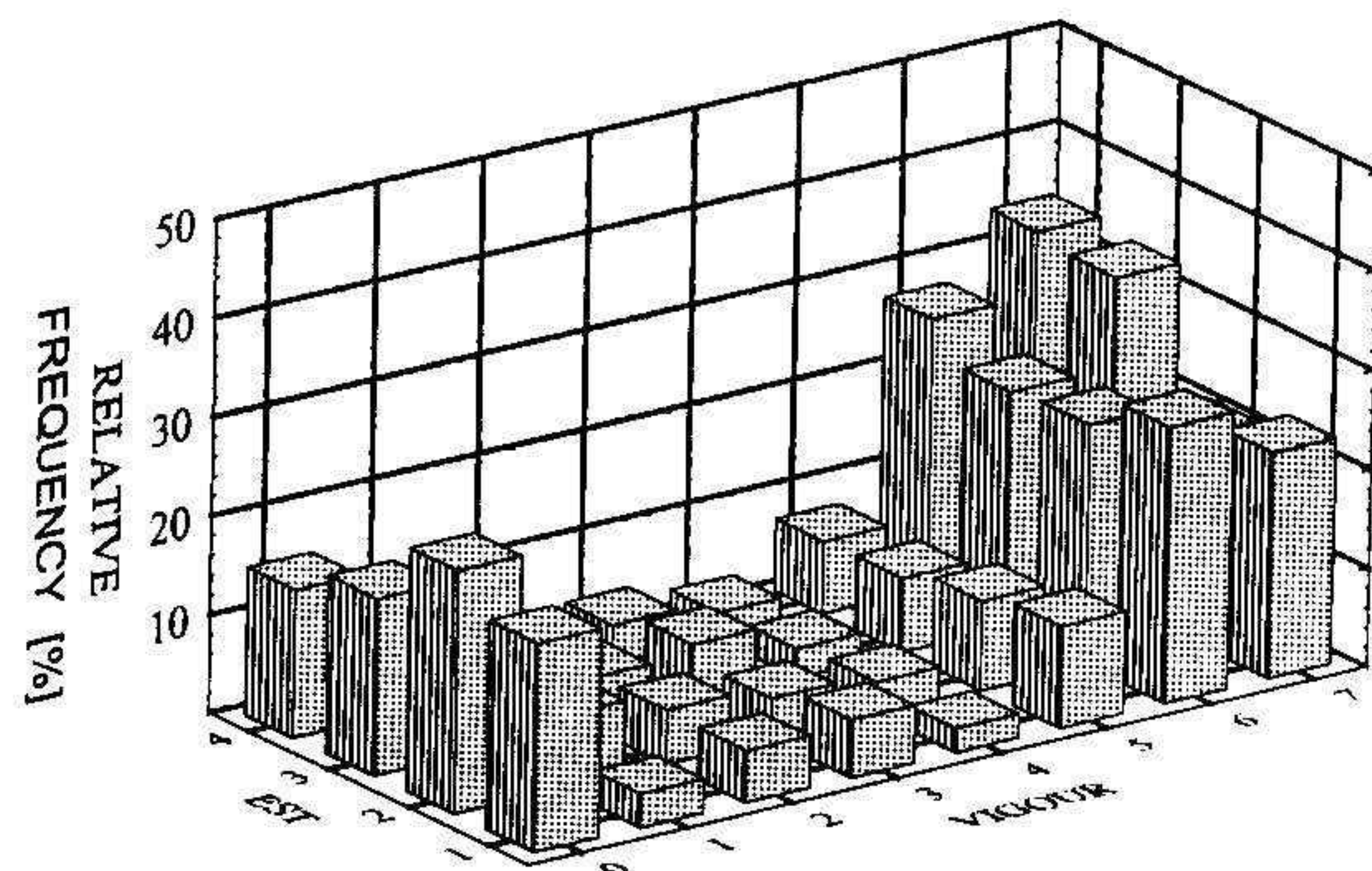


Fig. 5. Average relative frequency of trees by ecological site types (EST) in tree vigour classes

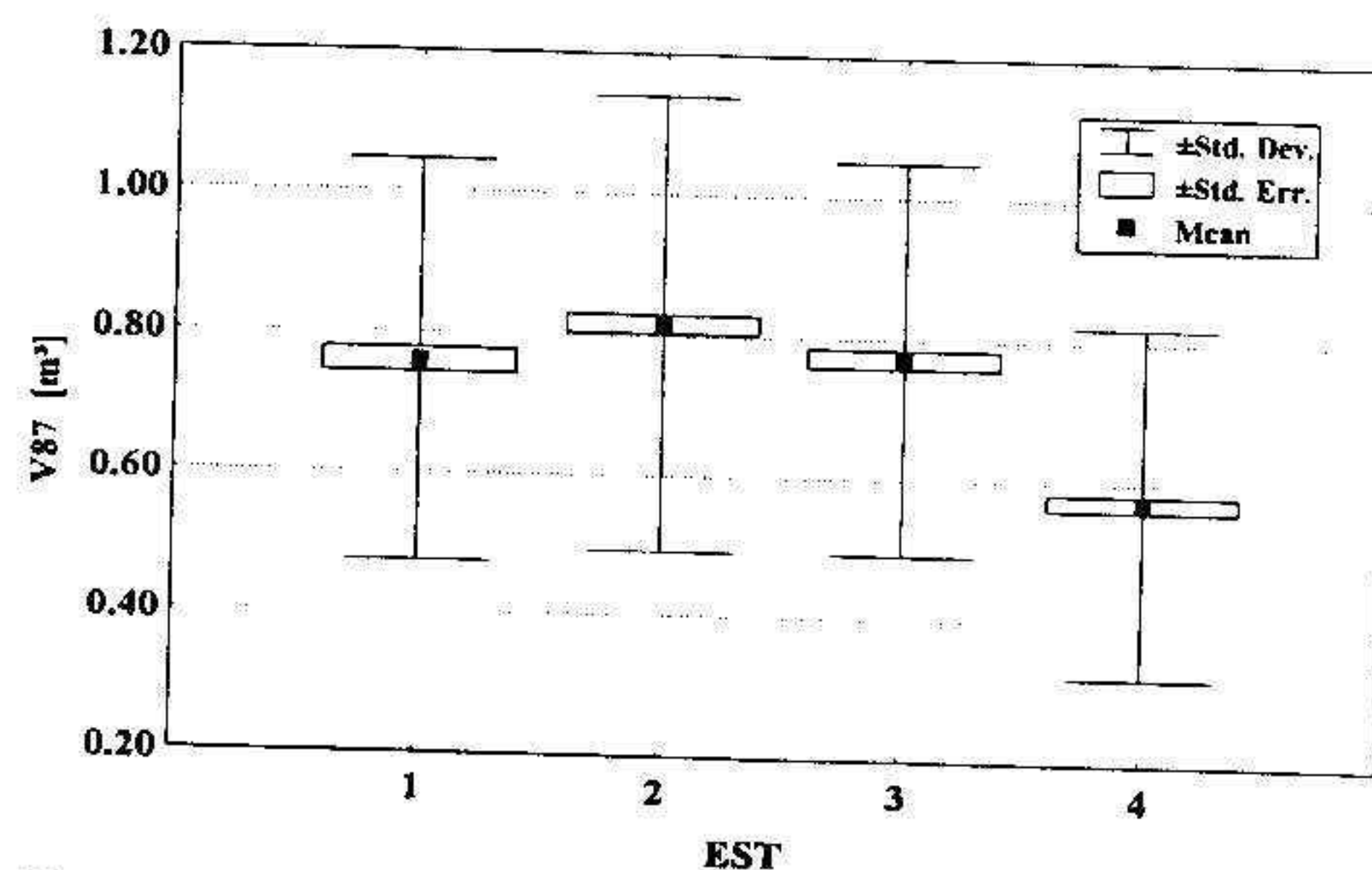


Fig. 6. Average volume of trees in 1987 (V87) in ecological site types (EST)

in each ecological site type (EST). No significant relationship was found in this analysis (Table 1), but as Fig. 8 shows, trees in EST4 appear to have smaller increments than in other ESTs.

A straightforward additional question was whether growth loss is different in the ESTs. The Kruskal-Wallis tests showed insufficient results. As Table 1 shows, ecological site type had a significant effect on absolute growth loss (ABSLOSS, Fig. 9), whereas this was not true for relative growth loss (RELLOSS). These results imply that the time span covered by this study was too short to detect the minute site-dependent differences in increment loss caused by oak decline. The significant relationship that exists between EST and ABSLOSS results from the dependence of growth on site quality (Fig. 7). The authors can neither prove nor disprove the existence of site effects on decline-induced increment loss. A successful study of this relationship would require either a larger sample size or longer study period (or both).

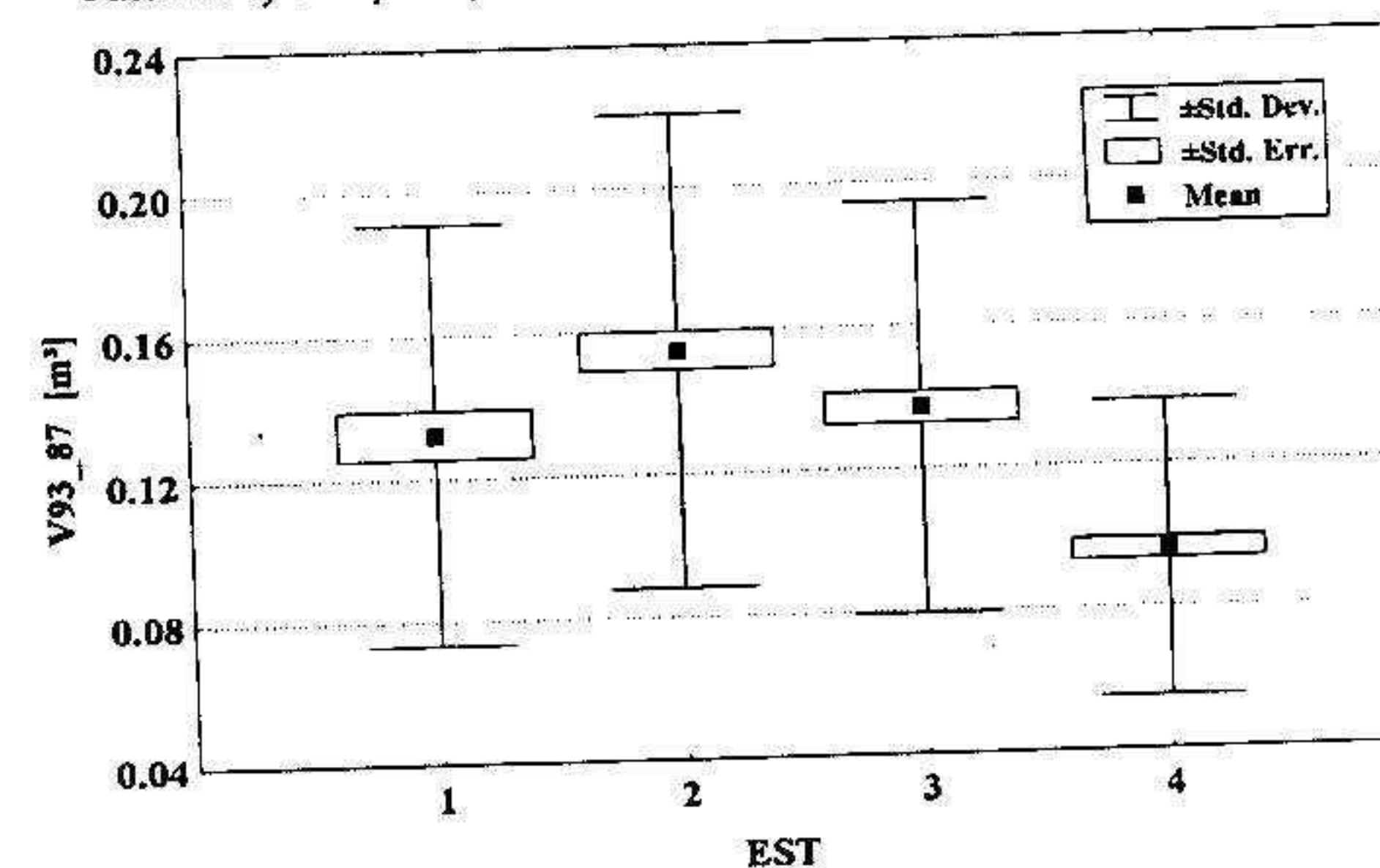


Fig. 7. Average volume increment of healthy trees (V93_87) in ecological site types (EST)

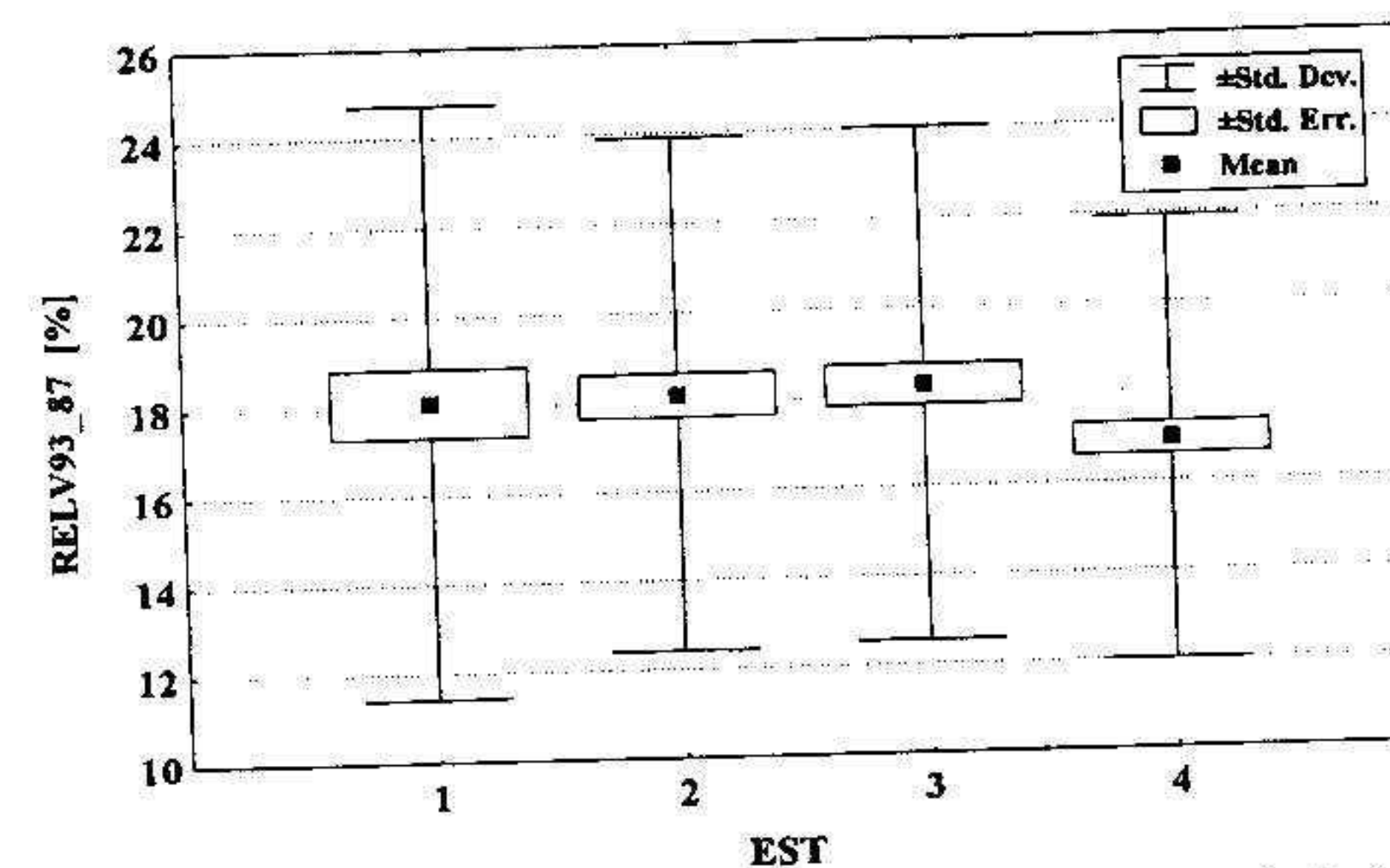


Fig. 8. Average relative volume increment of healthy trees (RELV93_87) in ecological site types (EST)

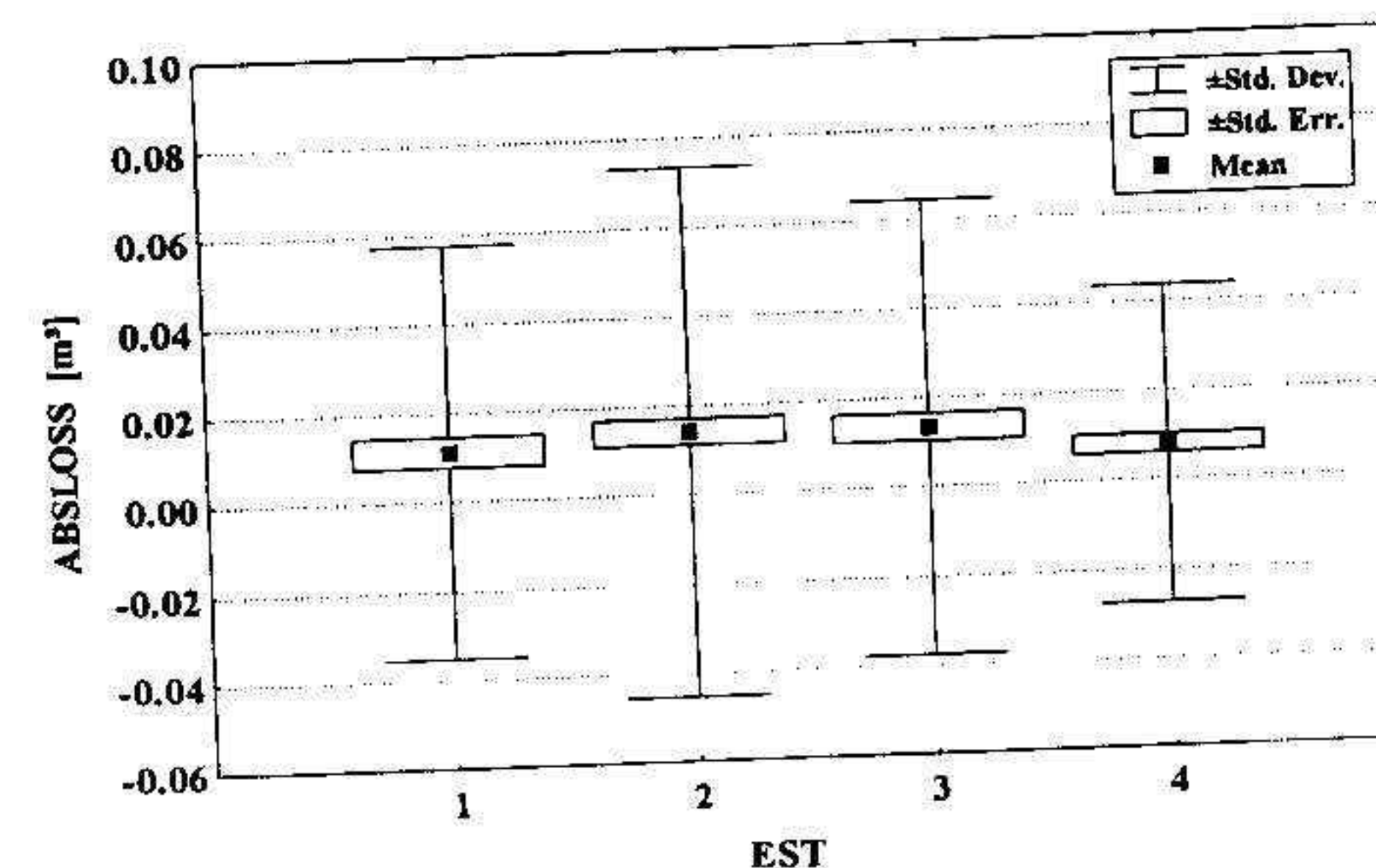


Fig. 9. Average absolute increment loss of sick trees (ABSLOSS) in ecological site types (EST)

4 Conclusions

From the results presented above, it follows that the estimated growth loss was considerable. In evaluating our estimates, it should be noted that the growth of healthy trees was used as reference since it was the only plausible technique. This may result in a biased estimate for two reasons. First, the growth of healthy trees may have increased owing to the decreased competition of neighbouring sick trees. Although this may well have happened, this increase is limited, because thinning effect is usually small in an old oak stand on a medium quality site (MAJER 1967). However, the extent of the increase is not known and it would be difficult to measure it. Therefore, stand-level growth loss estimates are not reliable and should be treated as possible maxima. This is similar to normal thinnings where the increase of growth in remaining trees is offset by the increment loss from removals. Even if growth loss is zero the dead tree volume is substantial. Second, it is possible that more sick trees can be found among the suppressed trees (Kraft class 3–5), and their growth loss may be partly explained by the reduced amount of light they receive. This hypothesis cannot be tested because height classes were not surveyed. However, the old stand had been thinned a few years before the beginning of the observations and the height differentiation is slow at this age. Therefore, the majority of the trees can be regarded as either dominant or codominant, so the effect of competition for light on growth loss is negligible.

The effects of site quality on tree size, growth and vigour were found to be significant. These results emphasize the reliability of ecological indication, especially if one considers that only presence/absence data of herb species were collected in the ca. 156 m² quadrats. Within the 5.5 ha study area the authors found that better (more humid and less acidic) site quality resulted in greater size and more intensive growth of oak trees.

The need to address site and stand heterogeneity at the within-stand-scale is clearer if the close relationship between site quality and oak decline is considered. It was demonstrated that the susceptibility to decline of trees is site-dependent. Our findings suggest that sessile oak is more susceptible to decline at more humid and less acidic sites, where growth is better, and which may be more suitable for other tree species, such as beech. This seemingly contradictory result can be viewed as a basis for further studies, and implicitly suggests the following biologically based and practically important question: are species more susceptible to diseases outside (or at the extremes) of their natural range?

Although no conclusions could be made as to the cause(s) of the disease, it can be stated that less favourable, often not inappropriate, site conditions represent stress for trees. Sound forest management can, and should, reduce this stress by considering site conditions and species' requirements.

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Résumé

Correspondance entre qualité stationnelle, dépérissement et croissance des arbres dans un peuplement de chêne sessile

Cette étude s'intéresse à deux aspects du dépérissement du chêne: les relations avec les caractéristiques stationnelles et les effets sur la croissance des arbres. L'étude a été conduite dans un peuplement de chênes de 5,5 ha en Hongrie, fortement dépérissant. Le peuplement était composé presque exclusivement

de rejets de *Quercus petraea* de 90 ans au début de l'étude. L'hétérogénéité interne du site a été décrite par la végétation herbacée. Quatre types écologiques ont été distingués d'après la composition et la valeur indicatrice des plantes. La croissance des arbres entre 1987 et 1993 a été mesurée et la vigueur a été estimée visuellement à cinq reprises durant cette période. L'accroissement potentiel en volume des arbres dépérissants a été comparé à celui d'arbres sains de mêmes dimensions. La perte en volume causée par le dépérissement a été évaluée. Une relation positive significative a été trouvée entre la vigueur et les dimensions des arbres et entre la vigueur et la croissance. La croissance des arbres très dépérissants était réduite de moitié par rapport à celle des arbres sains. La perte de croissance parmi les arbres encore vivants atteignait 5,4% alors que sur l'ensemble des arbres, y compris les arbres morts durant la période, elle était de 19,9% par rapport à la croissance potentielle. Les dimensions des arbres et leur croissance étaient supérieures sur les meilleurs sites. Une relation forte a aussi été trouvée entre la vigueur et le type de site, mais le chêne sessile était plus sensible au dépérissement sur les meilleurs sites.

Zusammenfassung

Zusammenhänge zwischen Standortqualität, Eichensterben und Baumzuwachs in einem Traubeneichen-Bestand

Die vorliegende Untersuchung konzentriert sich auf selten untersuchte Aspekte des Eichensterbens: die Beziehungen zwischen verschiedenen Standortmerkmalen und deren Effekte auf das Wachstum der Bäume. Die Untersuchung wurde in einem stark von Eichensterben betroffenen, 5,5 ha grossen Bestand in Ungarn durchgeführt. Der nahezu reine *Quercus petraea*-Bestand war zu Beginn der Untersuchung 90 Jahre alt und hatte sich aus Stockausschlägen entwickelt. Die Heterogenität innerhalb des Bestandes wurde mit Hilfe der krautigen Vegetation beschrieben. Anhand der Artenzusammensetzung der Krautschicht wurden vier ökologische Standorttypen unterschieden und durch die ökologischen Zeigerwerte der Arten charakterisiert. Zwischen 1987 und 1993 wurde das Baumwachstum gemessen, und die Baumvitalität wurde während dieser Zeit fünfmal visuell bonitiert. Die potentielle Volumenzunahme geschädigter Bäume wurde mit Hilfe der Wachstumsraten gesunder Bäume derselben Grösse geschätzt. Der durch das Eichensterben verursachte Zuwachsverlust wurde ebenfalls abgeschätzt. Zwischen der Baumvitalität und der Baumhöhe, sowie der Vitalität und dem Zuwachs wurden signifikant positive Beziehungen gefunden. Das Wachstum ernsthaft geschädigter Bäume verringerte sich im Vergleich zu den gesunden Bäumen fast auf die Hälfte. Auf der Ebene des Bestandes betrug der Zuwachsverlust der lebenden Bäume 5,4%; wurden die während der Untersuchungsperiode abgestorbenen Bäume mit einbezogen, betrug der Verlust gegenüber dem potentiellen Zuwachs 19,5%. Auf den besseren Standorten waren Baumhöhe und Zuwachs grösser. Auch zwischen der Baumvitalität und dem Standorttyp wurde eine enge Korrelation gefunden, dabei waren die Traubeneichen auf den besseren Standorten stärker vom Eichensterben betroffen.

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Corresponding patterns of site quality, decline and tree growth in a sessile oak stand

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Summary

This study focuses on two rarely studied aspects of oak decline: relations with site characteristics and effects on tree growth. The study was carried out in a 5.5 ha stand in Hungary which is strongly affected by oak decline. The nearly pure sessile oak (*Quercus petraea*) stand of mostly coppice origin was 90 years old at the beginning of the study. Within-stand site heterogeneity was described by the herbaceous vegetation. Four ecological site types were distinguished by the species composition of herbs, and characterized by the ecological indicator values of the species. Tree growth between 1987 and 1993 was measured, and tree vigour was estimated from visual characteristics five times between 1987 and 1993. Potential volume increment of declining trees was estimated with the growth rates of healthy trees of the same size. Volume increment loss caused by oak decline was also assessed. Significant positive relationships were found between tree vigour and tree size and between tree vigour and tree growth. The growth of seriously declining trees dropped to almost one-half of that of healthy ones. Growth reduction of living trees at the stand level amounted to 5.4%, whereas growth reduction of all trees, including those that died during the observation period, amounted to 19.9% of the potential growth. Tree size and growth were greater on better sites. A strong relationship was also found between tree vigour and site type, but sessile oak was more susceptible to decline at better sites.

1 Introduction

Forest decline has been widely reported throughout the world. Many different types of decline have been described and a series of hypotheses have been proposed about the possible causes (HUETTL and MUELLER-DOMBOIS 1993; INNES 1993; CIESLA and DONAUBAUER 1994). The health of forests has become an important issue of international scientific and public concern in the past two decades.

In Hungary, the most serious decline occurs in sessile oak (*Quercus petraea* (Mattuschka) Lieblein). This species is one of the most important deciduous tree species in the country, and is widespread throughout Europe. The National Forest Health Inventory (CSÓKA and SZEPESI 1995) indicated that, in 1994, the symptoms of decline (i.e. > 10% leaf loss and discoloration) were detected on 93% of all the trees surveyed. Oak decline is also widespread in Europe and on the American continent (SIWECKI and LIESE 1991; CIESLA and DONAUBAUER 1994; INRA 1994).

Most research and scientific debates have been conducted on the direct cause(s) of the decline but despite the intensive work, there has been no widely accepted explanation of the cause(s) (JAKUCS 1985; BORHIDI 1986; IGMÁNDY 1987; HARTMANN and BLANK 1992; CIESLA and DONAUBAUER 1994; VARGA et al. 1995).

This paper focuses on other, equally important, but mostly neglected aspects of oak decline. These are the following: