Tending of oak trees during sapling and pole stage

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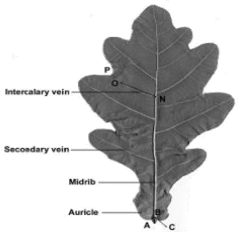
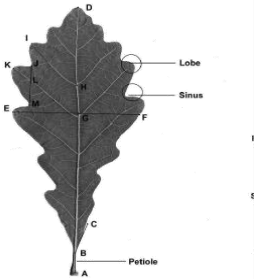
Content of the presentation:

1. Differences between *Q. robur* and *Q. petrea*
2. Features of oaks influencing the tending methods
3. Other factors influencing the tending methods
4. Tending in sapling stage (methods of cleannings)
5. Tending in pole stage (thinnings), silvicultural guidelines
6. Oak prunning
7. Is it possible to incorporate oaks growing under Scots pine into next generation of stand?

1. Differences between *Q. robur* and *Q. petrea*

	Q. robur (pedunculate)	*Q. petrea* (sessile)
Cimate	more continental	oceanic, warmer climate, doesn't like cold winters
Requirements	more light, moisture and fertility	less light, moisture and fertility
Habit	more prone to forks	less prone to forks
	main stem less persistent through crown	more persistent central stem through crown



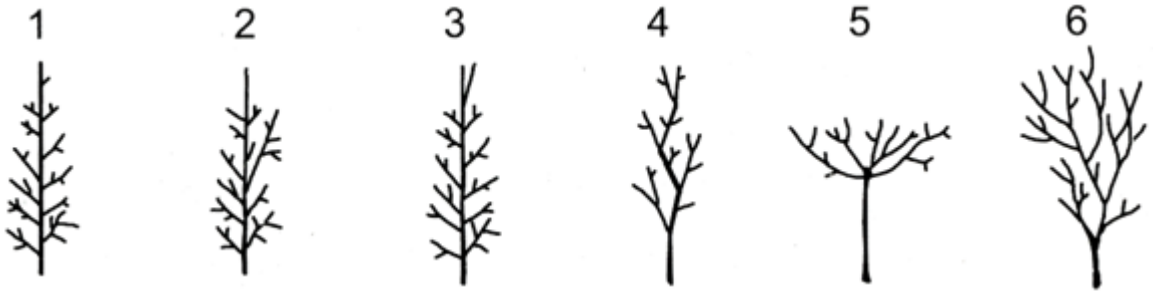


2. Features of oaks influencing the tending methods

- **phototropic tendencies** – trunk crookedness („soft spine"), but it corrects the defects;
- with age, oaks require more and more light (**more light-demanding**) - slowly responds to late release, easily dominated by other species growing under favorable conditions (beech, hornbeam, pine, birch);
- it tends to create **eccentric crowns** and **wolf trees**; flexible crown
- it keeps leaves during winter time – snow damages;
- high sensitivity to frosts;
- it needs stem shelters (hornbeam, lime, beech in 2nd layer);
- self-prunning in dense stands
- **epicormic shoots** from adventitious or dormant buds;
- **the timber value depends on ring width but more important is even diameter growth**

2. Features of oaks influencing the tending methods

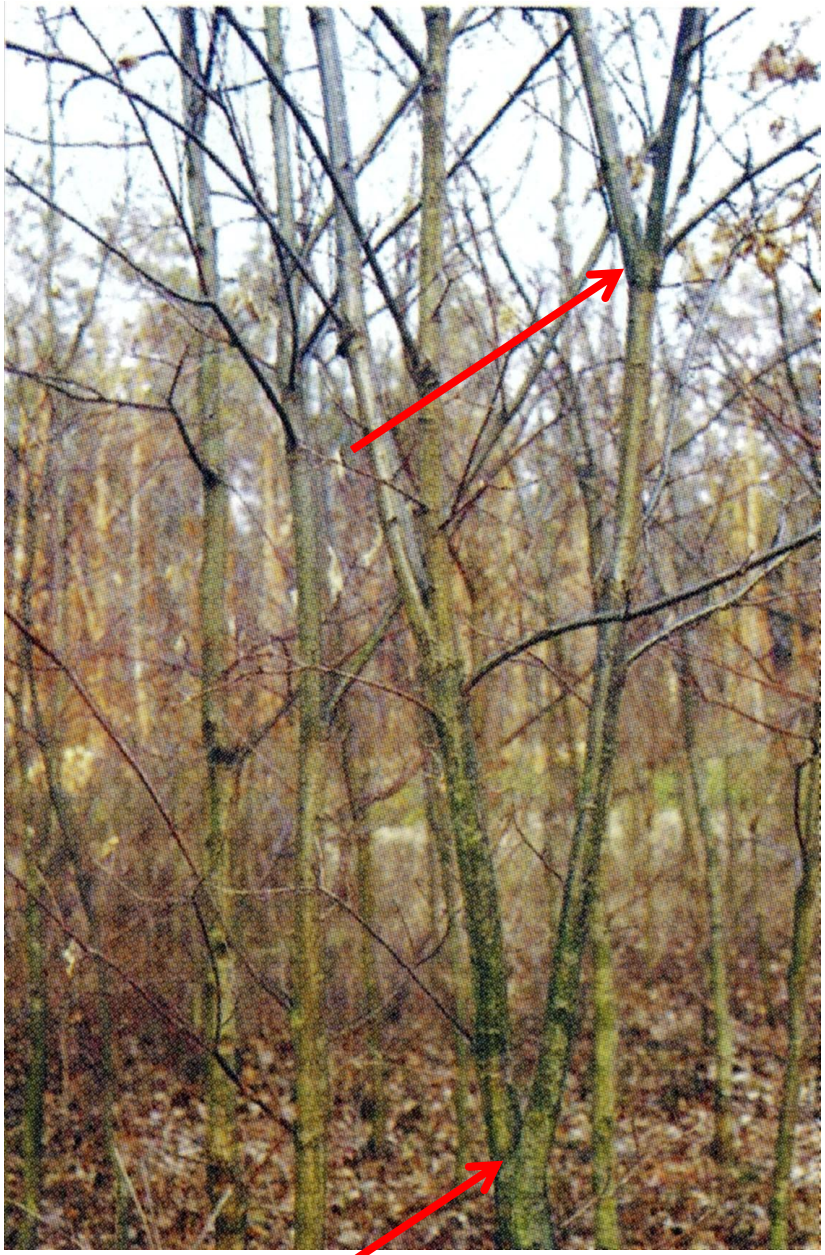
The types of crown shape of *Q. petrea* [Gockel 1995]

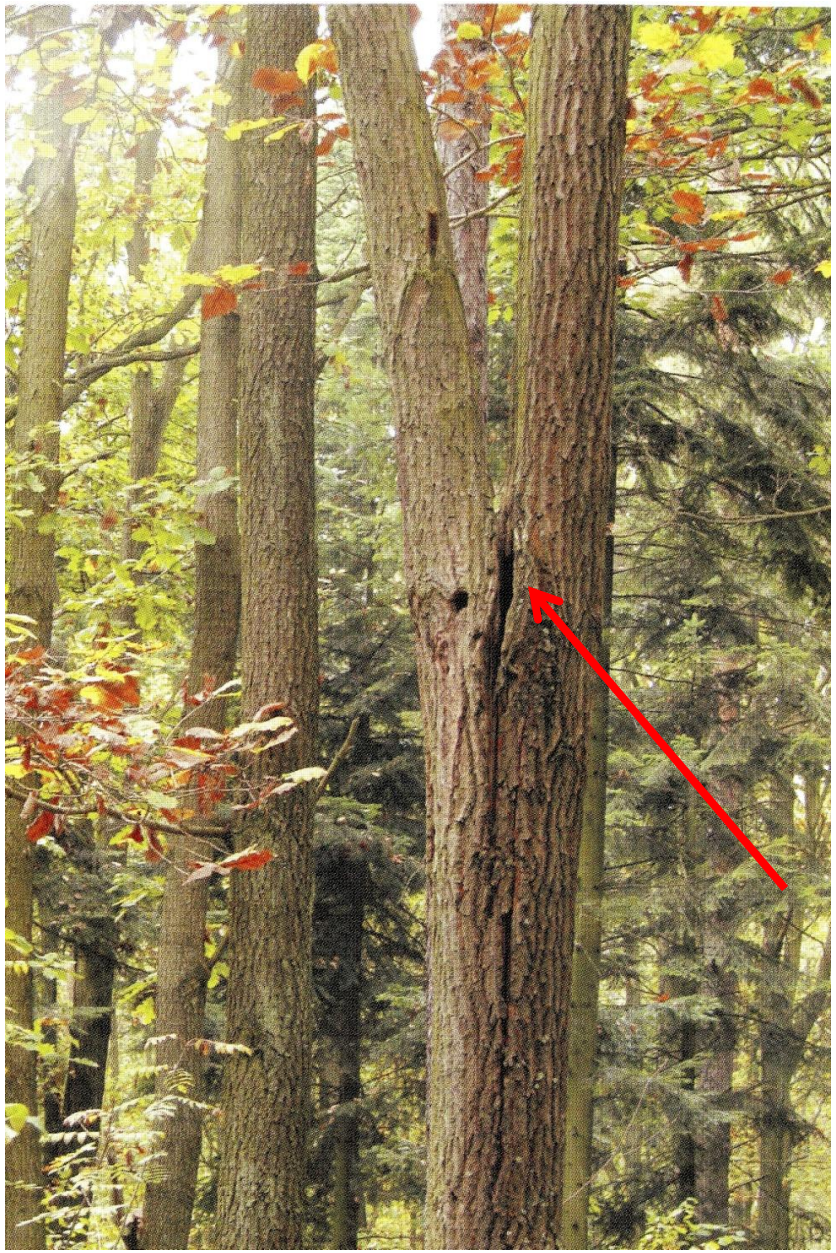


1) single stem
2) forked but tendency to single stem
3) single stem with tendency to forked
4) repeatedly forked
5) bushy
6) irregularly branched

The types of stem shape of *Q. petrea* [Gockel 1995]

1) straight, 2) slightly crooked, 3) crooked, 4) very crooked, 5) curved





3. Other factors influencing the tending methods

- genetic value of oak population
- site condition (climate, soils)
- method of regeneration (natural or planted)
- method of creation of the 2nd layer of the stand

  (understory – beech, hornbeam, lime)
- the silvicultural aim of the stand production (sawn timber, **veneer**)
- economic conditions and cost of treatments (cost-effectiveness)

4. Tending in sapling stage

Sapling stage:

oaks between: **1.3 m of height – 6.9 cm of dbh**

Three categories of oak thickets in sapling stage:

Categories A, B, C →

Criteria for distinguishing categories:
- **site conditions**,
- **quality of regeneration** (structure, wolf trees, density etc.),
- **stand function** (productive, timber assortment, protection).

Individual selection

negative selection	positive selection
- sick, dying - damaged during wood extraction - suppressed - defective - unwanted admixtures	- when individual quality features are revealed - in thickets of bad quality (few good quality oaks) - to promote valuable admixtures

Category A

Site conditions
Proper

Origin
Individuals with inherited defects are not present (possibly occasionally)

Dense thickets
Little height diversification
Three layers in thicket

Initial state
Very good quality,
Small number of wolf trees

Silvicultural aim
Keeping high quality,
Protection against slimming,
Retention of the bottom layer

Treatment
Negative selection in the upper and middle layer

Site conditions
Proper

Category B

Origin
There are some individuals with inherited (?) defects (multiple forks)

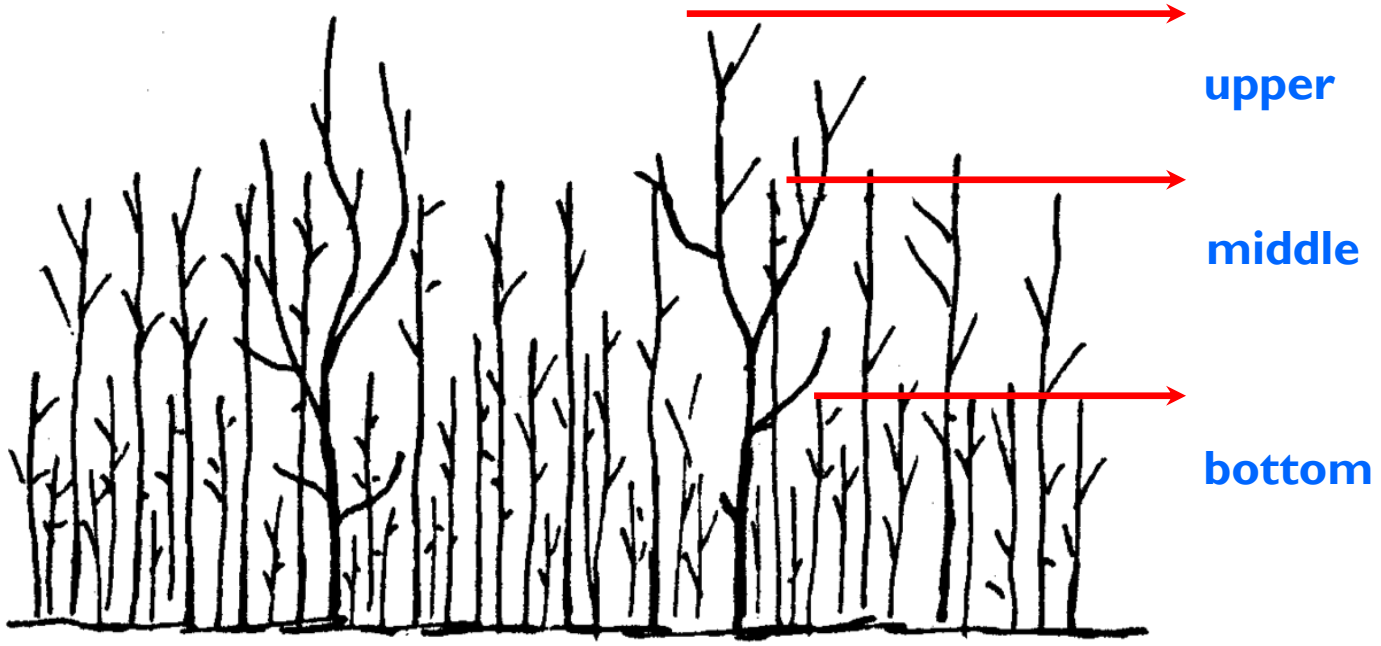
Three layers in thicket
The upper layer without closure

Initial state
Some wolf trees, surplus of admixtures (expansiveness) (pine,birch, hornbeam, beech), sprout specimens

Silvicultural aim
Increase the share of valuable assortments

Treatment
Cutting (neutralization) of wolf trees, some admixtures, sprouts
Levelling tree heights

Layers in sapling stage (natural origin)



When to start intervention?

- As early as possible when some older and higher oak trees are present in regeneration.
- Most often – at the beginning of sapling stage (1.3 m height)
- Every 5 years

Which layer?

- Upper layer:

  alignment of the crown canopy,

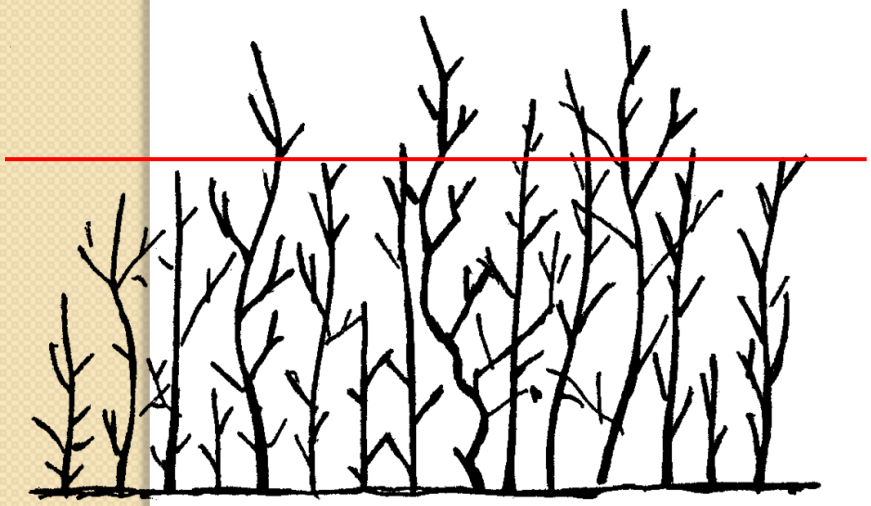
  tree topping of older or faster growing oaks, wolf trees

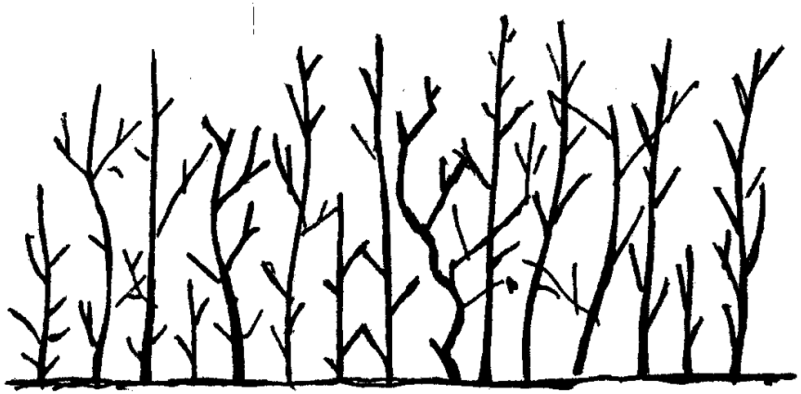
- Middle layer:

  cutting only to keep admixtures (beech, hornbeam, lime)

The first entry – <u>in upper layer</u>

- the future stand will come from middle layer
- main emphasis on height equalization
- bottom layers and admixtures (hornbeam, lime, beech) shade oak trunks
- **admixture of fast growing pine and birch can not excessively competes with oak**





Intensity of cutting

After treatment canopy closure should be **0.9 – 1.0**

7000 trees/ha,

possibly 1000 good quality oaks/ha promoted (positive selection)

Photo: T. Andrzejczyk [2009]

Selection method

- individual tree selection,
- negative selection, later positive selection earlier in B than in A category,
- good quality oaks should be promoted which are less in B than in A category,
- mild assessment of defects,
  - small curvatures in youth improves very well later
  - forks in youth disappear in 30% of trees later

In category B treatment can not be omitted

Within positive selection admixtures trees species (beech, hornbeam, lime) should be released.

In future they will be in the bottom layer of stand and shelter oak trunks.

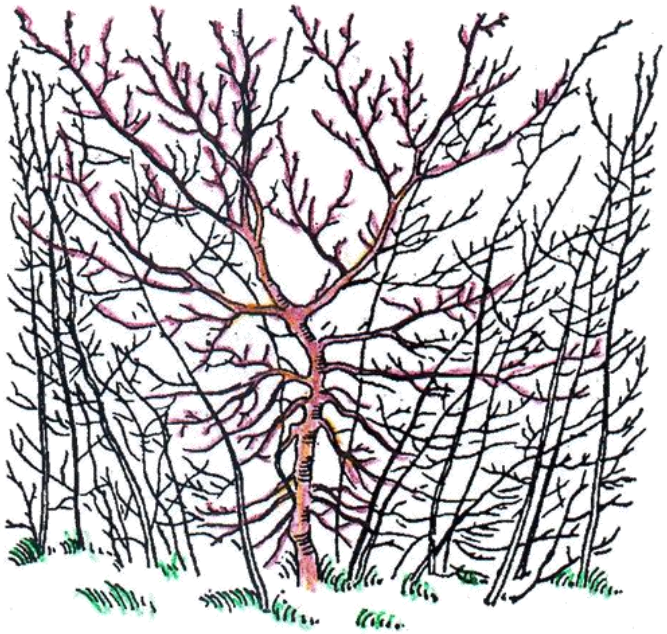
Before treatment

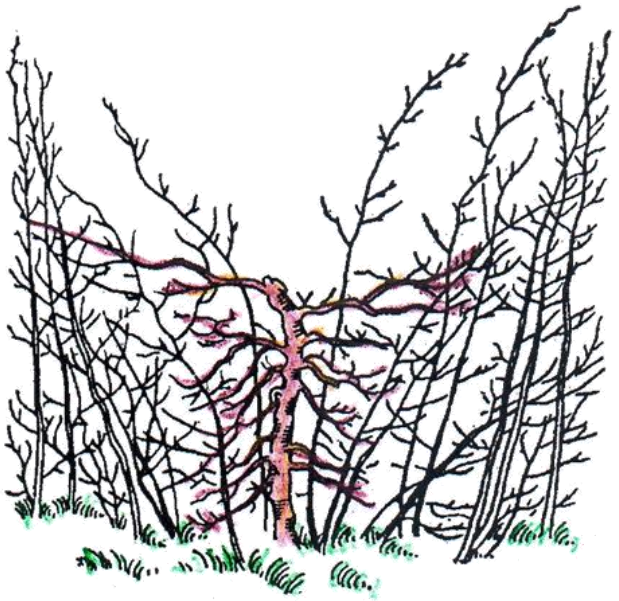
Photo: T. Andrzejczyk [2009]

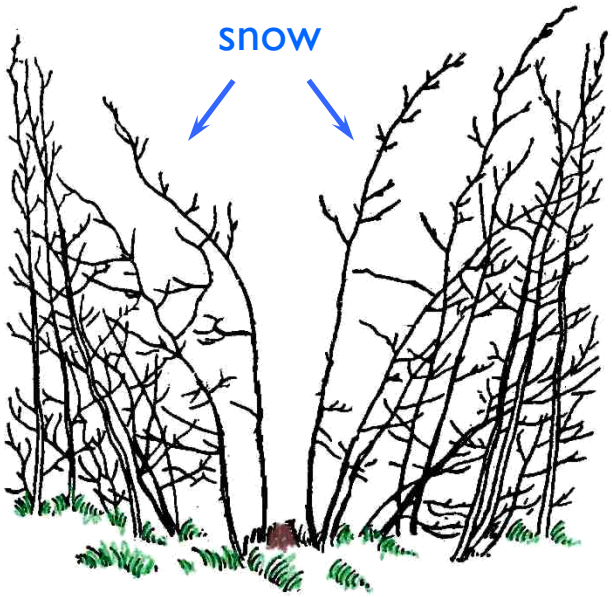
After treatment

In loose planted oak regeneration pioneer species can be used to stimulate height increment

Tree topping (pollarding)







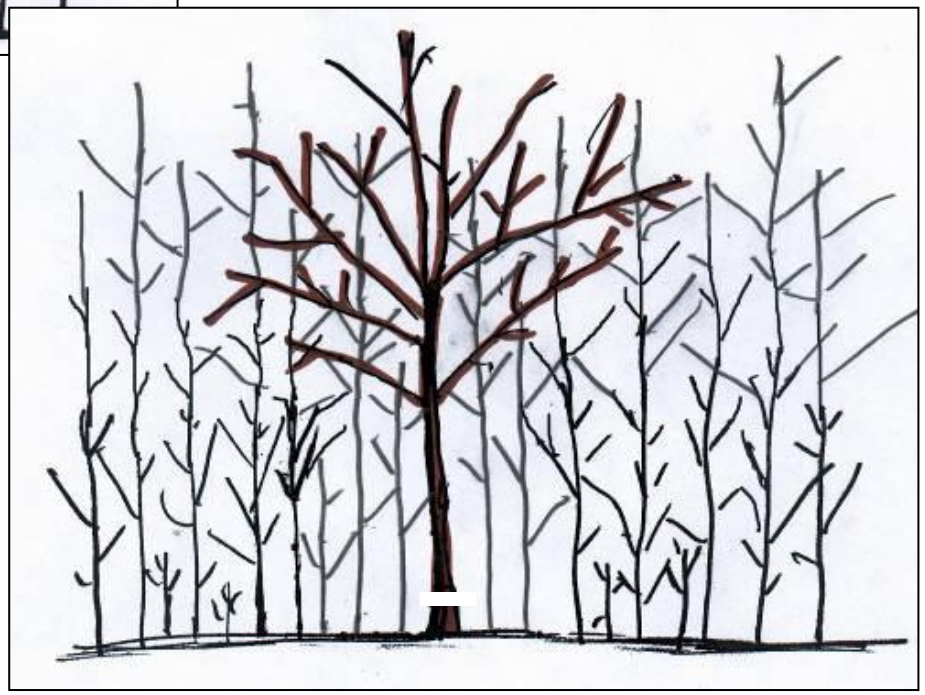
to keep density
to keep understory (natural prunning)
support (snow) [Ilmurzyński E. 1969]

Tree topping (pollarding)

Prunning

At low conopy closure – it is necessary to prun or shape the crown of wolf trees while keeping density

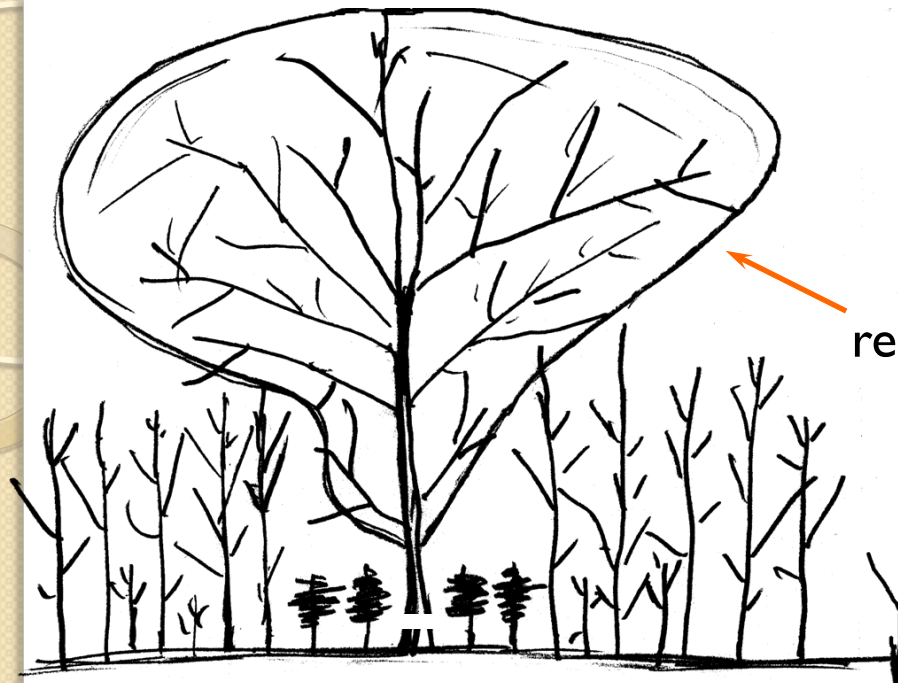
Girdling



This is a protection against gap formation

Support (snow)

Girdling



removal

Shelter for shade-tolerant

Category C

Site conditions
Improper,
poorer sites,
severe site conditions

Origin
Individuals with inherited defects may be frequent

Loose thickets with small gaps
Tree height diversified

Initial state
Stands regenerated in a wrong way, long lasting shelter, bad quality

Silvicultural aim
Treatments are not able to radically improve quality

Treatment
Moderate negative selection, positive selection

1. Treatment in category C is justified in stands where:
    a. productive function is important,
    b. loss of stability is at risk or
    c. the stand should be prepared to future conversion
2. **Treatment is not necessary in stable and vigorous stands with protection function.**

When to start intervention?

- ❑ As early as possible
- ❑ Every 10 years

Treatment in upper layer

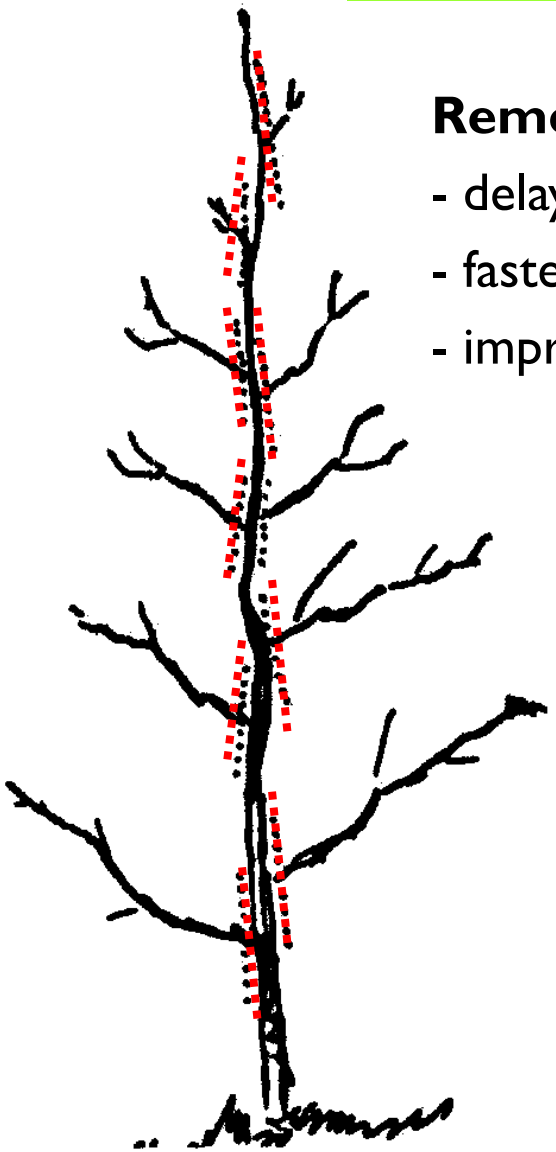
Selection method

- individual tree selection,
- negative selection but positive selection as soon as possible due to small number of good quality oaks,
- neutralization only of some part of wolf trees so as to regeneration keeps canopy closure,
- promotion of valuable admixtures by positive selection.

Intensity of cutting

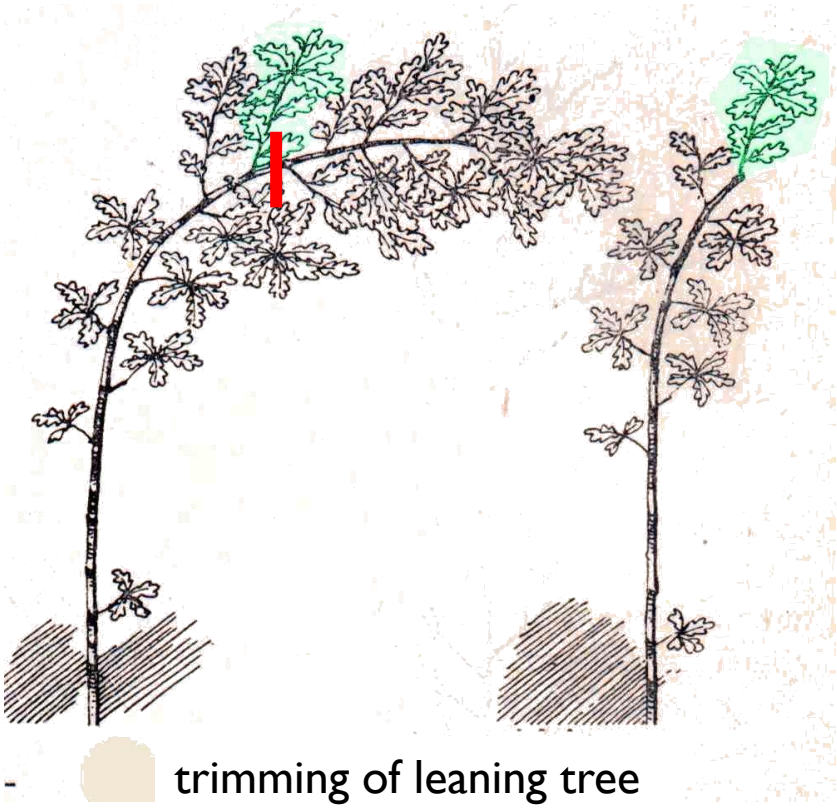
After treatment canopy closure should be **1.0**
Groups and clusters of wolf trees shouldn't be loosened
Intensity not requiring recurrence less than 10 years

Caring for a single tree



Removal of side branches (singling)

- delayed development of the leader bud by 2-3 weeks
- faster height increament
- improvement of stem quality



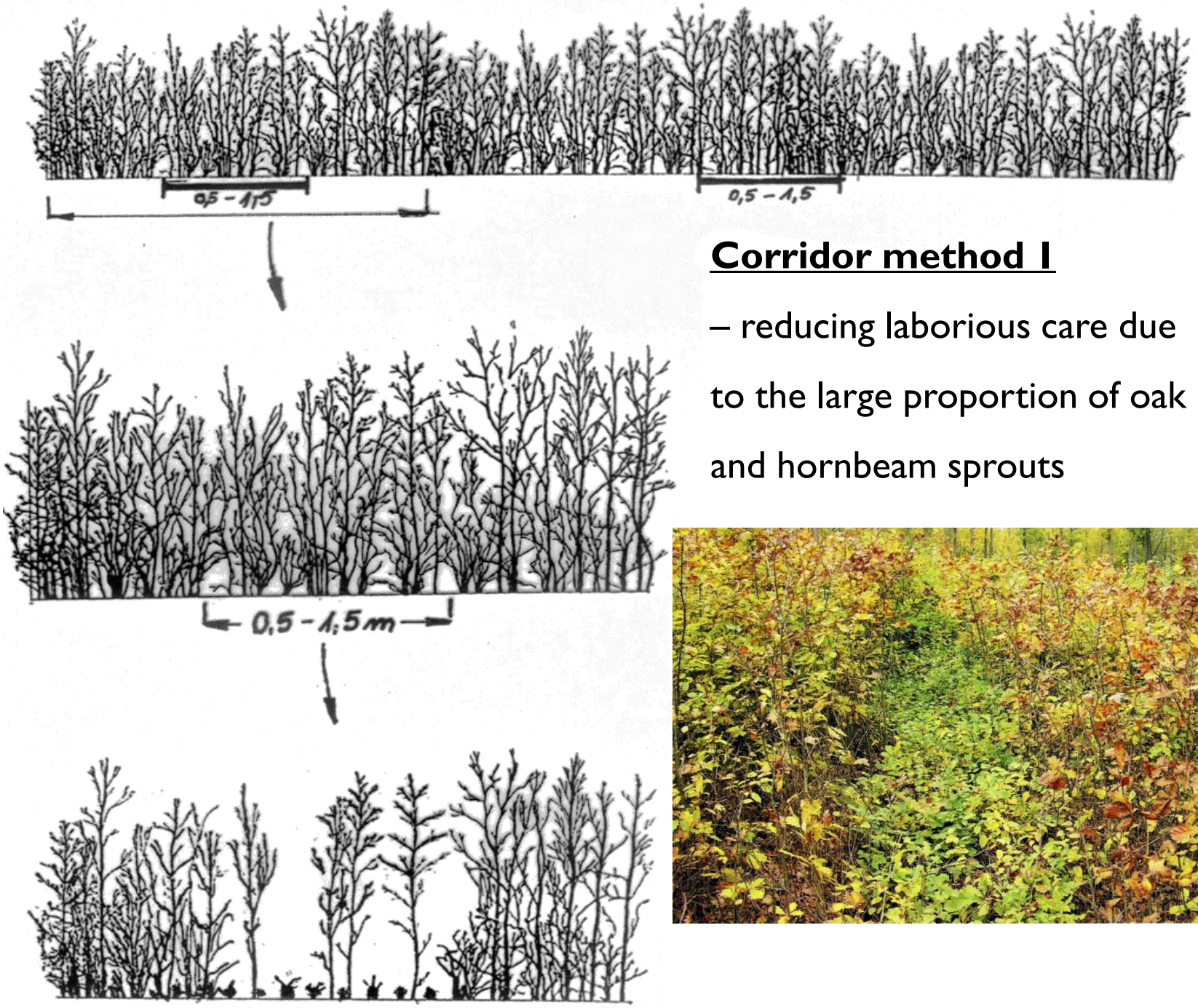
- trimming of leaning tree

Stumping back

- to stimulate a vigorous initial shoot from dormant buds,
- to improve poorly formed oaks

<u>Cutting stem of few years old seedlings</u>

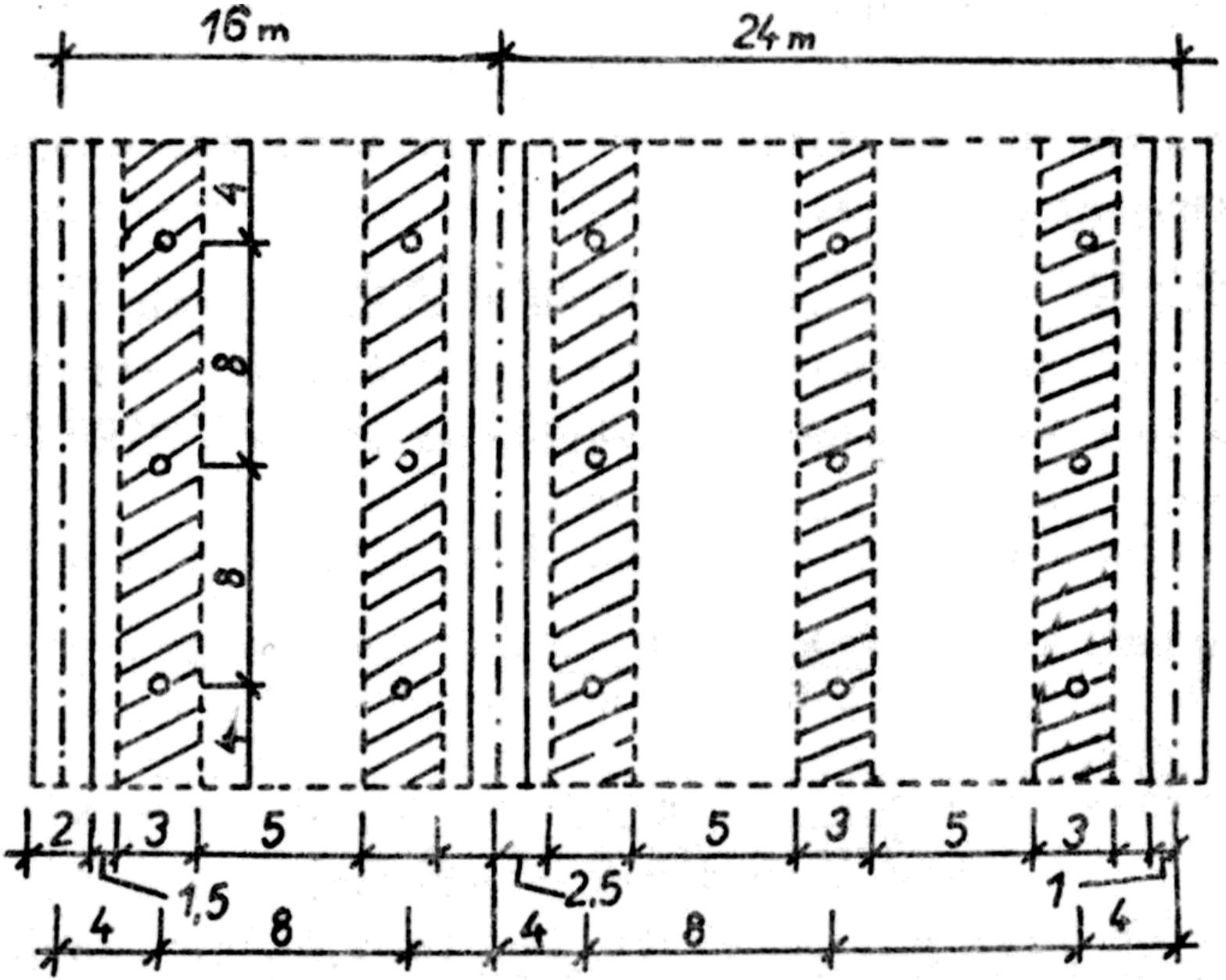
- well rooted,
- above root neck,
- root neck 1.5-2.0 cm
- slant cut



Corridor method I

– reducing laborious care due to the large proportion of oak and hornbeam sprouts

Treatment rationalization – oak, beech (100-150 crop trees)



Gubka K., Saniga M.: Navody na cvičenia z pestovania lesa. VŠLD Zvolen, 1982.

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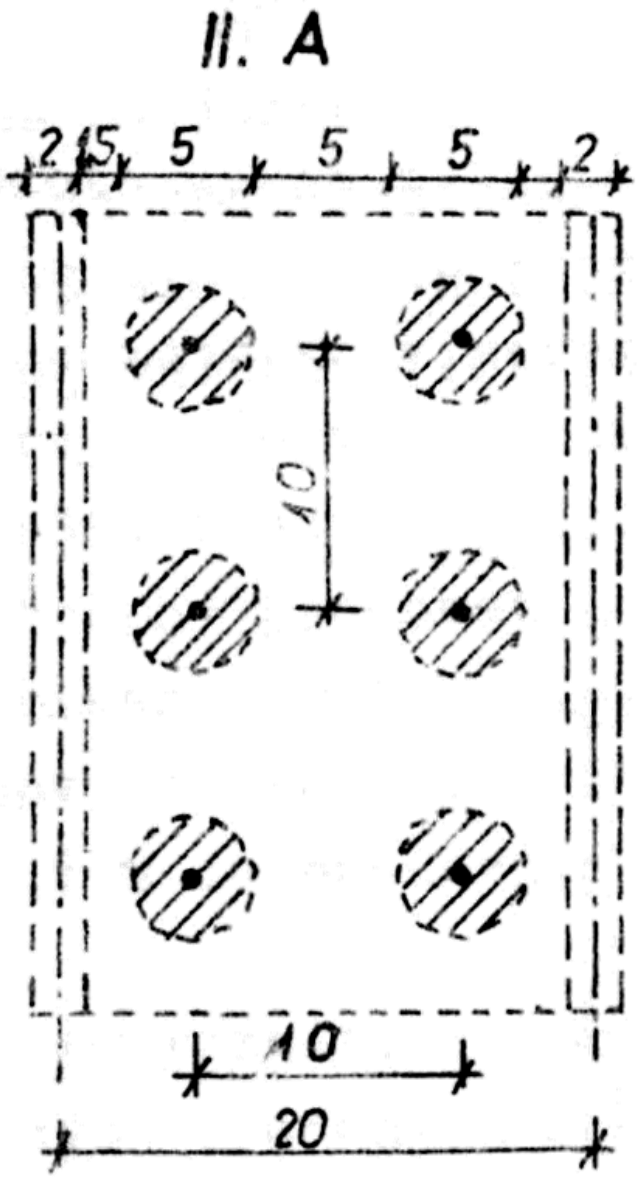

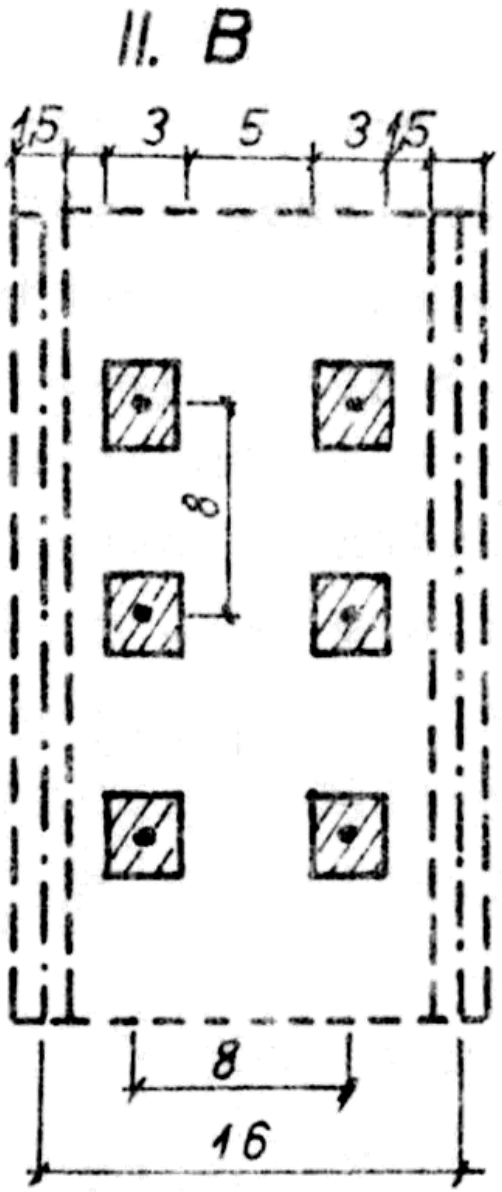

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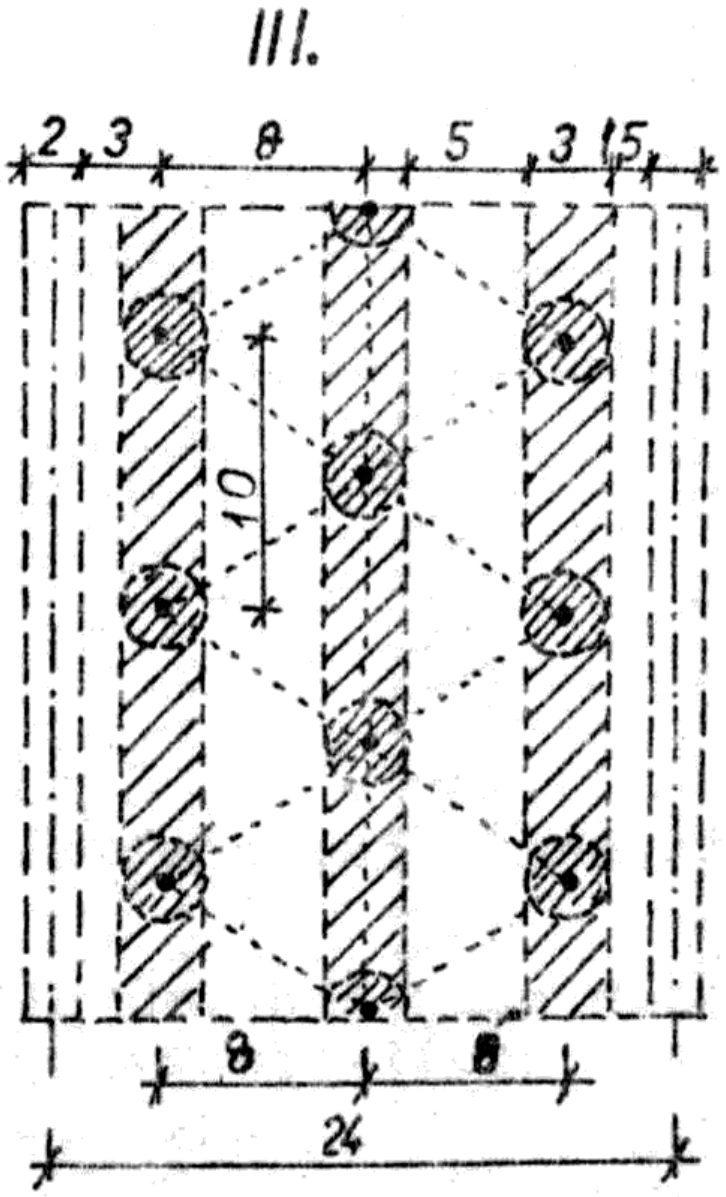

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5. Tending in pole stage (thinnings), silvicultural guidelines

Pole stage:

oaks between:

7.0 cm – 20.0 cm of dbh – EARLY THINNING (E)

21.0 cm – 35.0 cm of dbh – LATE THINNING (L)

Type		Method Silvicultural target	Intensity		Specific features
E	L		E	L	
Crown thinning	Crown thinning	Various intensity of crown thinning Veneer - rotation 240 Valuable timber - rotation 160-200 Sawn timber - rotation 120-150	Moderate	Moderate	• at beginning about 1000 good oaks, • prunned up to 8-10 m (H_{dom} 14-18 m) • crop trees from main canopy of stand • crown should be developed at younger age, later not effective – epicormic shoots • live crown ratio: 30 - 40% • mild evaluation of curvatures and branching (E) • evenly crown growth, constant growth conditions – **equal ring widths** • bottom layer: **hornbeam**[1], lime[2], beech[3] – proper crown closure of main canopy • prunning $D_{1,3} \leq 15$ cm (20-40 years old) • thick branches with heartwood (5-6 cm) shouldn't die (rot)

Uniform, regular diameter increment
Understory (bottom layer) !!!

Additional remarks:

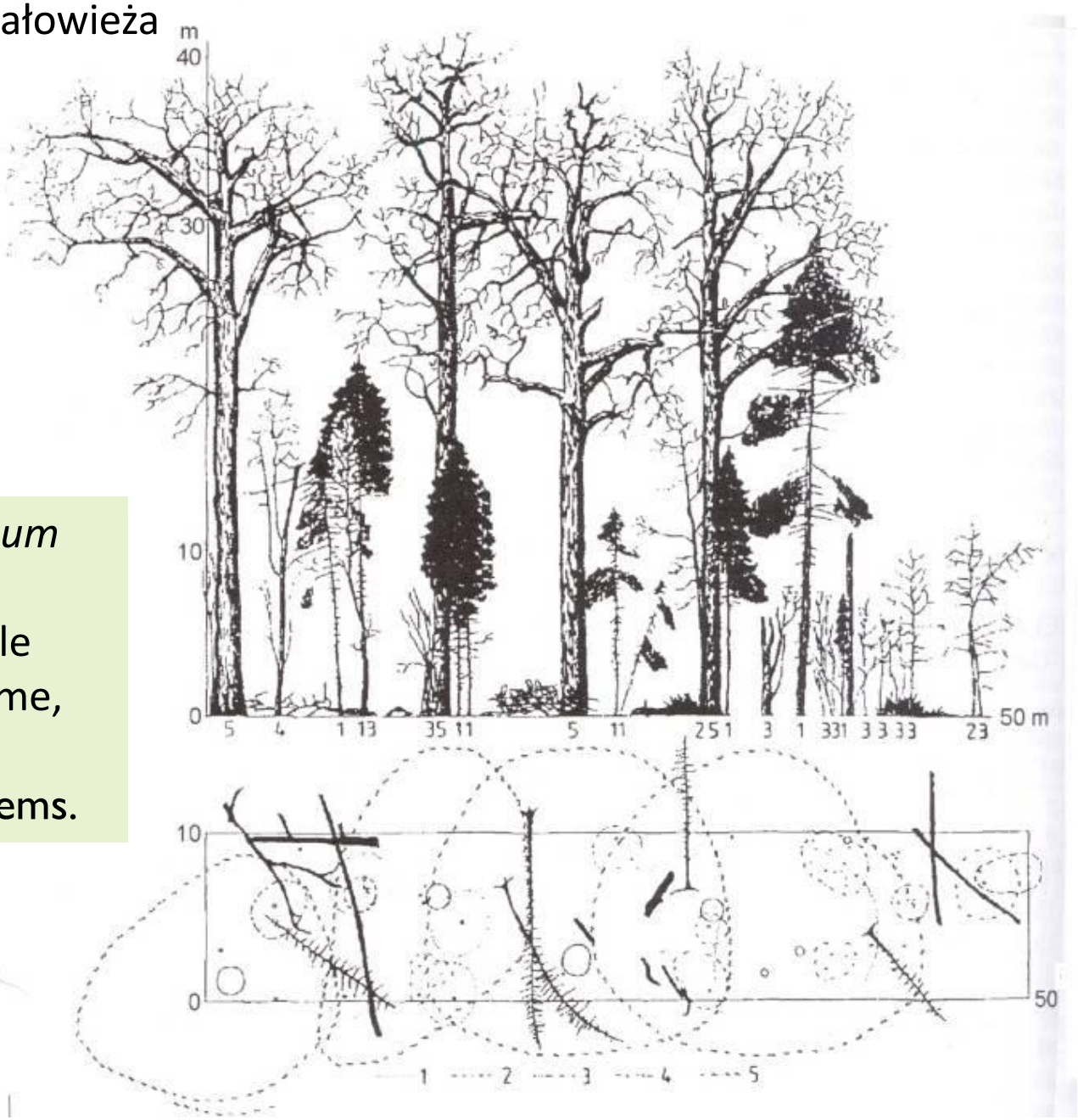
- **Strong reaction of trees to treatments at an early age**, a small reaction in the older,
- **Low ability to extend crown width in middle and old age,**
- The moment of correct assessment of the silvicultural target is late - in the phase of pole stage - clearly shaped the main canopy
- The real market value of valuable oak in the last half-century **has increased by 50%** when of other species has fallen
- What is important - is the ring widths (new technologies) and, especially, the **uniformity of the widths**
- **Increase the share of high value timber (veneer) by about 10% causes the increase of timber stand value by about 50%.**

Curvatures of oak stems [Andrzejczyk 2009]

Natural forest in Białowieża with hornbeam in understory

Tilio –Carpinetum typicum

Natural forest in Białowieża



Tilio –Carpinetum caricetosum remotae

Oak in upper story, in middle and understory - spruce, lime, hornbeam and ash.

Very good quality of oak stems.

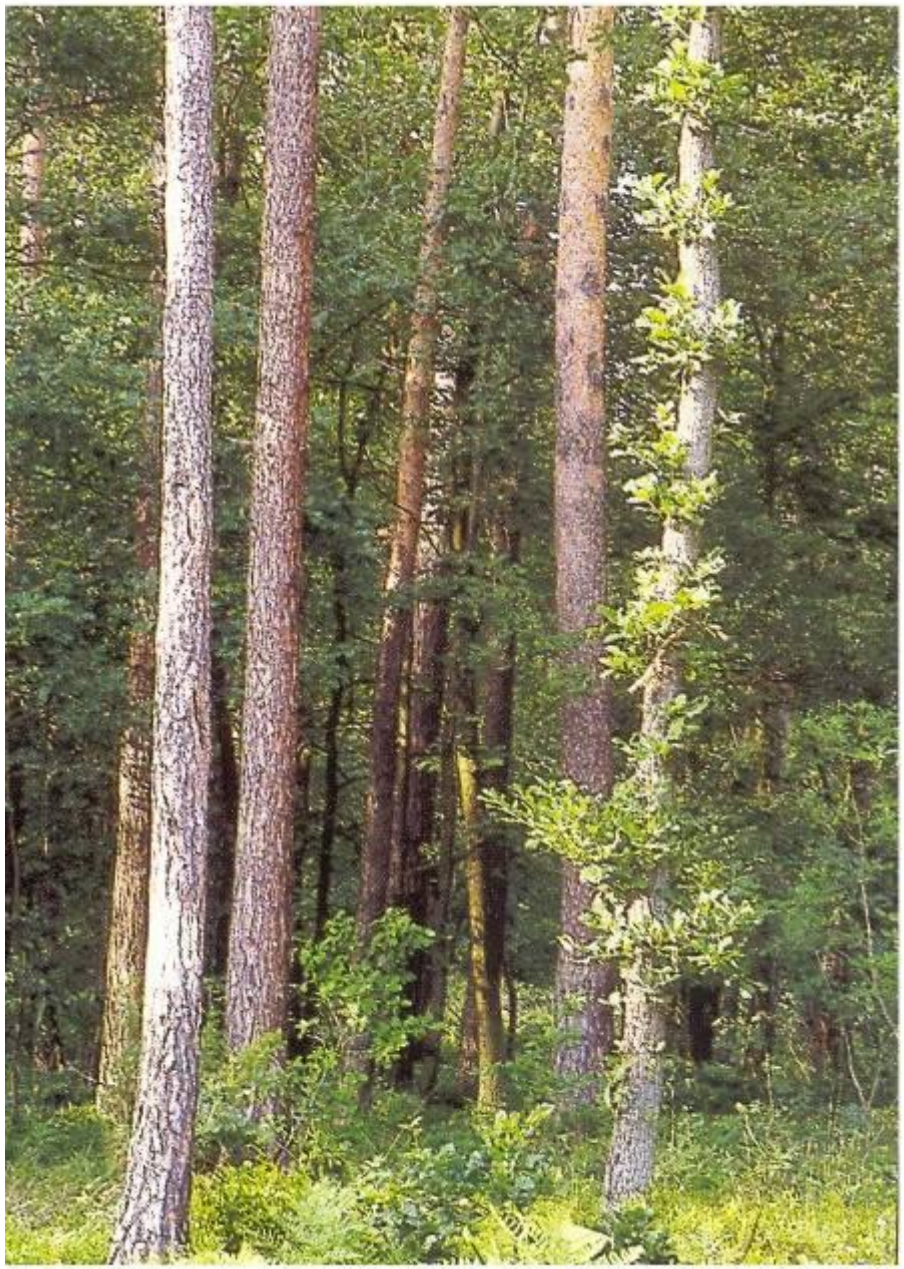
Natural forest in Białowieża

Photo: M. Pach

Natural forest in Białowieża

Photo: M. Pach

Many epicormic branches appear on uncovered oak stem



Many epicormic branches appear on uncovered oak stem

Hornbeam understory in pole oaks [Andrzejczyk 2009]

Silvicultural guidelines – 5 thinning regimes

I. Thinning according to Asmman's natural stocking density (basal area); moderate thinning
II. Valuable (high-value) oak timber
III. Veneer timber
IV. Sawn timber
V. Free growth

I. Natural stocking density

Selective thinning

Crown thinning

In Poland from 1961r.

Modification of Schädelin's thinning

Early and late thinning

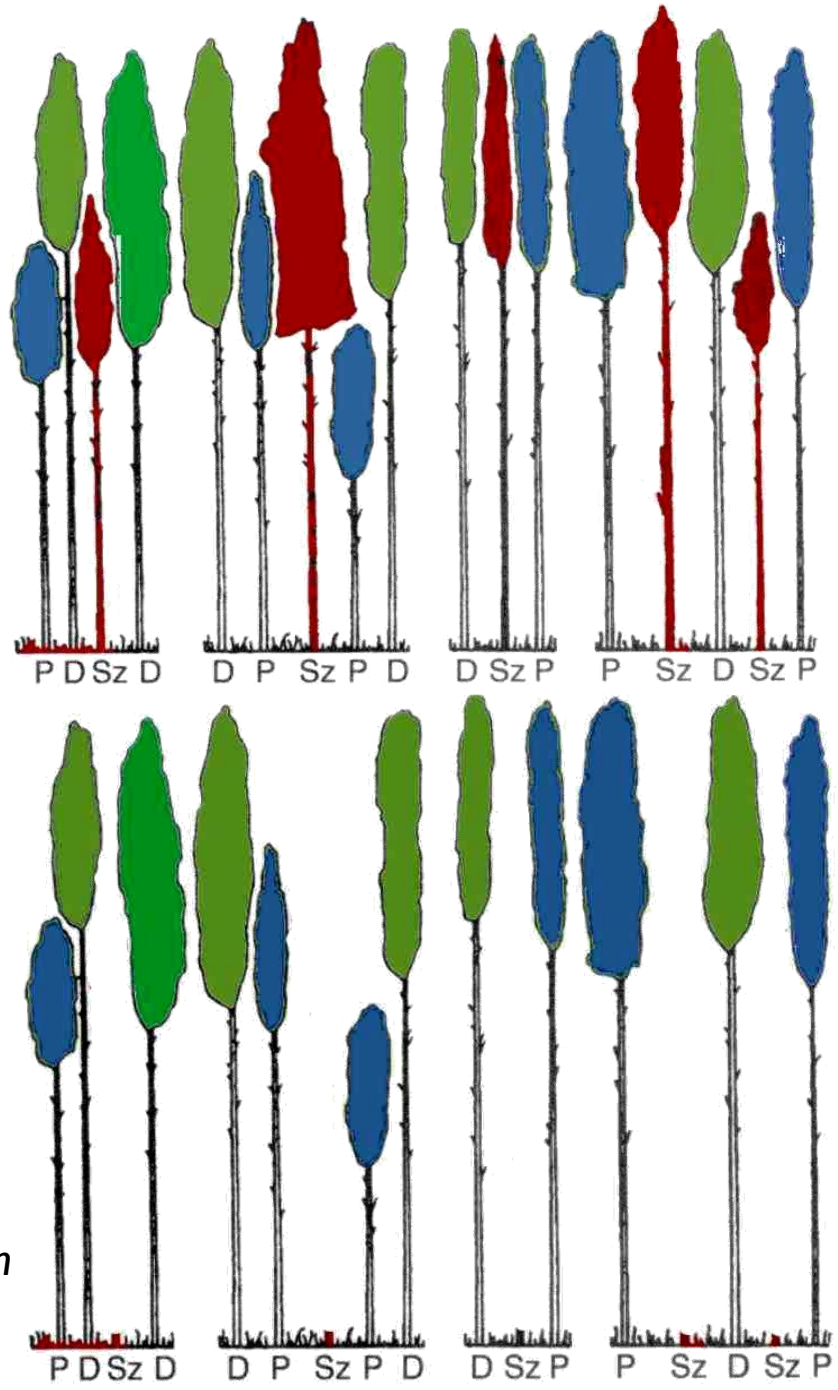
D - crop tree (green)
P - subordinate tree (blue)
Sz – competitor (red)

Critical natural stocking density

For oak stands:

0.75 – younger stands ≤ 60
0.80 – older stands > 60

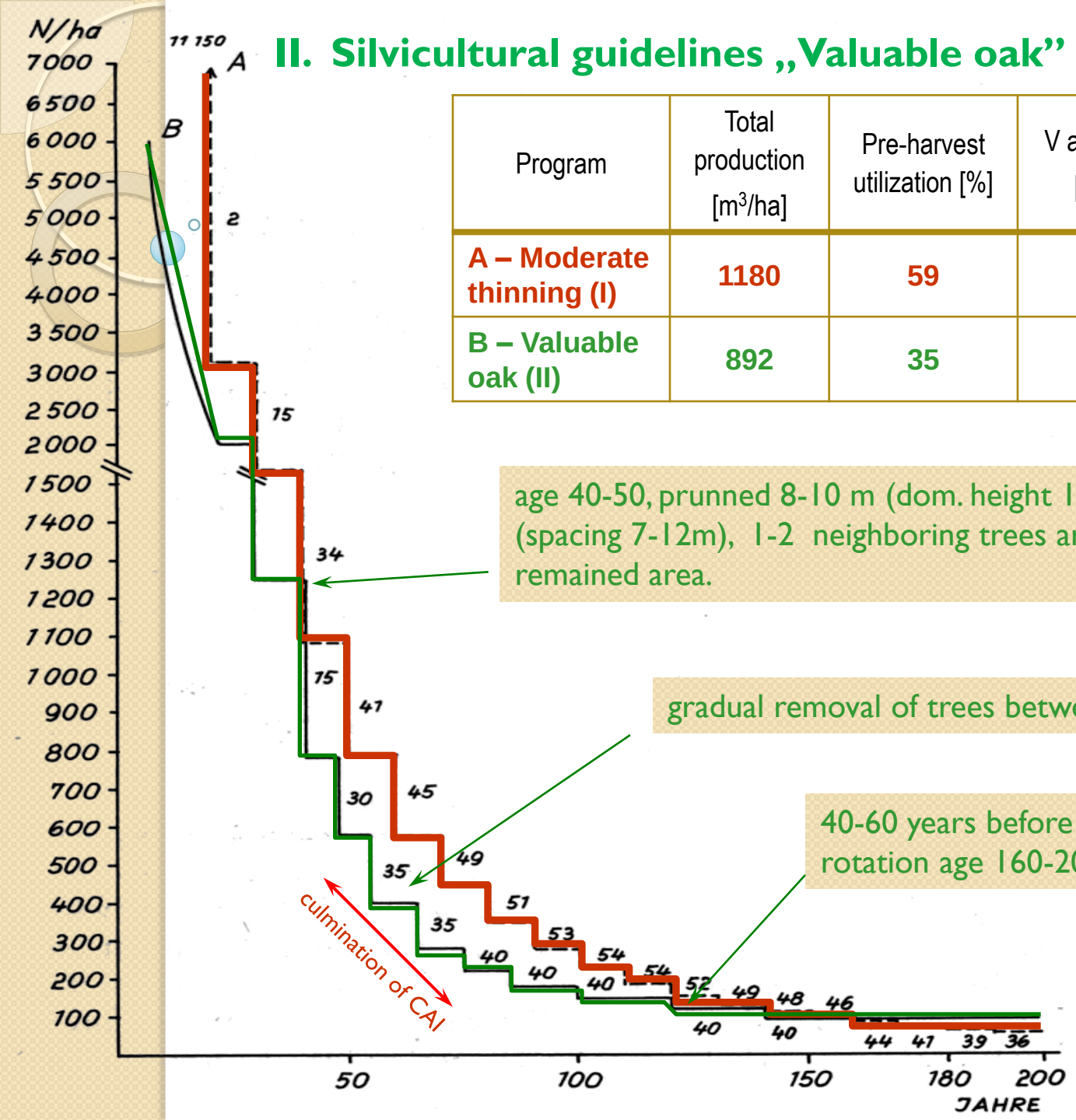
Critical *– at least 95% of potential maximum volume increment for a site can be achieved*



In the pole stand (40-50 years) it is possible to make final marking of crop trees – 100-120 trees per ha [Andrzejczyk 2009]

II. Silvicultural guidelines „Valuable oak" Baden-Wirttemberg

Program	Total production [m^3/ha]	Pre-harvest utilization [%]	V at age 180 [m^3/ha]	$D_{1,3}$ at age 180 [cm]
A – Moderate thinning (I)	**1180**	**59**	**482**	**63**
B – Valuable oak (II)	**892**	**35**	**577**	**68**



age 40-50, prunned 8-10 m (dom. height 14-18m), 80-100 crop trees (spacing 7-12m), 1-2 neighboring trees are cut, without cuts on the remained area.

gradual removal of trees between crop oaks

40-60 years before harvest no any cuttings, rotation age 160-200, target $D_{1,3}$ about 70 cm

III. Valuable oak timber – VENEER [Evans 1984, Andrzejczyk 2009]

- **dbh ≥ 60 cm**

- **straight stem, no occlusions, shake, rot, knots or other faults,**

- **growth rate is unimportant (4-5 mm wide rings are accepted as 1-2 mm wide),**

- **EVEN GROWTH is very important (at least 3 rings per 1 cm)**

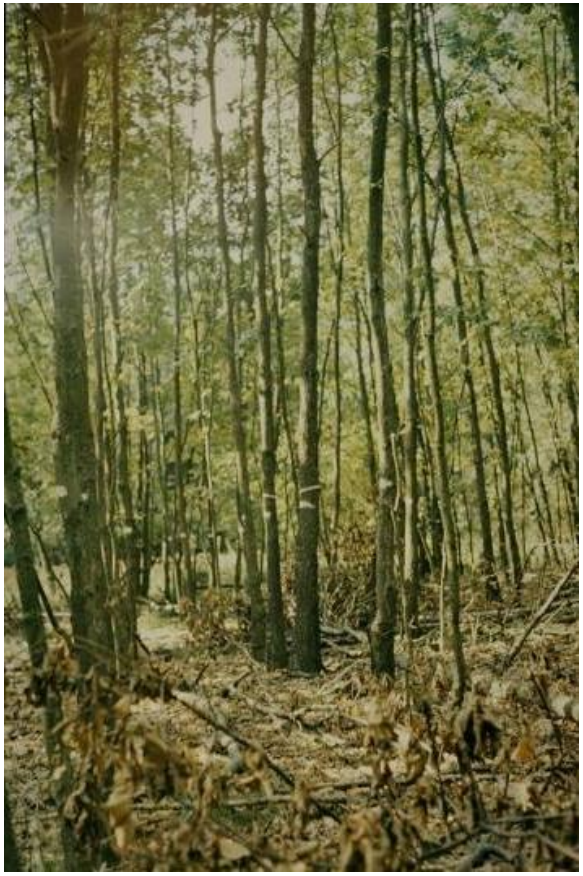
III. Veneer timber (Spessart)

1 - high density at young stage of development,

2 - careful selective thinning in favor of the best trees,

3 – above 100 years (the 2nd half of rotation cycle) opening up of the canopy, stimulating crown development,

4 – rotation age 250 years, $D_{1,3}$ 60-70 cm, ring widths 2 mm, min 100 trees/ha



Oak stand in Spessart with beech understory

Narrow, annual rings of equal width.

IV. Sawn timber

- in stand where coppice or coppice with standard methods were used or
- in less suitable site coondiition;
- irregularity of ring widths (high share of late wood)

Procedure:

- permanent interruption of canopy closure (intense high thinning) to enable crown development;
- dense understory consisting of shade tolerant species;
- timber about **60 cm** of dbh at rotation age **120-160**;
- losses in total yield should be compensated by high value of saw timber.

V. Free growth model

1 – very heavy thinning to entirely free crowns from competition at the age of 20-40 (height > 8m);

2 – selection of the best trees (60-80 oaks/ha), evenly spread through the stand;

3 – total release of oak crowns every 5 years, no cuts between selected oaks;

4 – prunning, removal of epicormic branches;

5 – rotation age 100 years, $D_{1,3}$ 60 cm, rings about 4 mm, loss in tootal yield about 30-40%

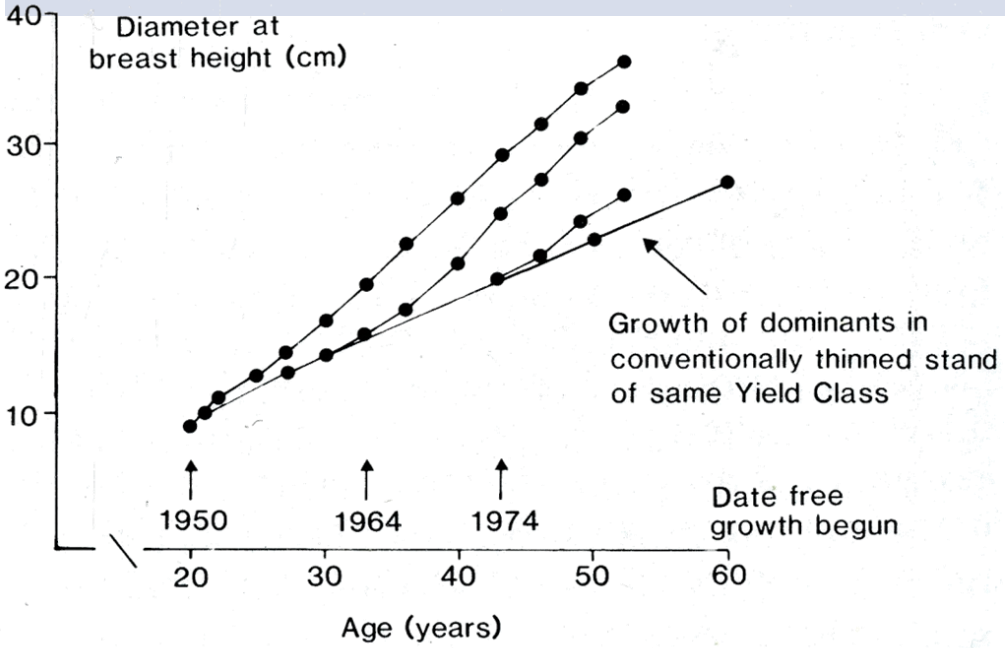


Figure 17.3 Responses to free growth up to 1983 in diameter increment of oak at Crumbland, Tintern Forest. Free growth has been applied to trees starting at three different ages – 20, 33 and 43 years. [Evans 1984]

Figure 17.2 Oak managed using free growth. Age 53 years, diameter breast height 36.7 cm. (*A10608*)

6. Oak prunning

The proces of natural prunning is more difficult than in other broadleaved.

Oaks are sensitive to injuries but they react to prunning well.

- ❑ Mean time to heal the wounds (knots up to 6cm) lasts **4-6 years**,
- ❑ Wounds **up to 1 cm** are healed in **90%** after **2 years**,
- ❑ Prunning significantly **increases the share of high quality timber**,
- ❑ The risk of infection appers in **thick branches with heartwood**.

Procedure:

- ➢ **65-120 trees/ha** are recommended to prune
- ➢ **up to 6,5 m** in two entries
- ➢ **all dead branches** (just after dying),
- ➢ live branches up to **3-4 cm** (6 cm),
- ➢ don't leave any part of branches – couse rot inside stems or frost cracks

Roomy establiished and pruned oak stands are financially superior to conventionally managed oak stands [Beinhofer 2010].

7. Is it possible to incorporate oaks growing under Scots pine into next generation of stand?

Introduction

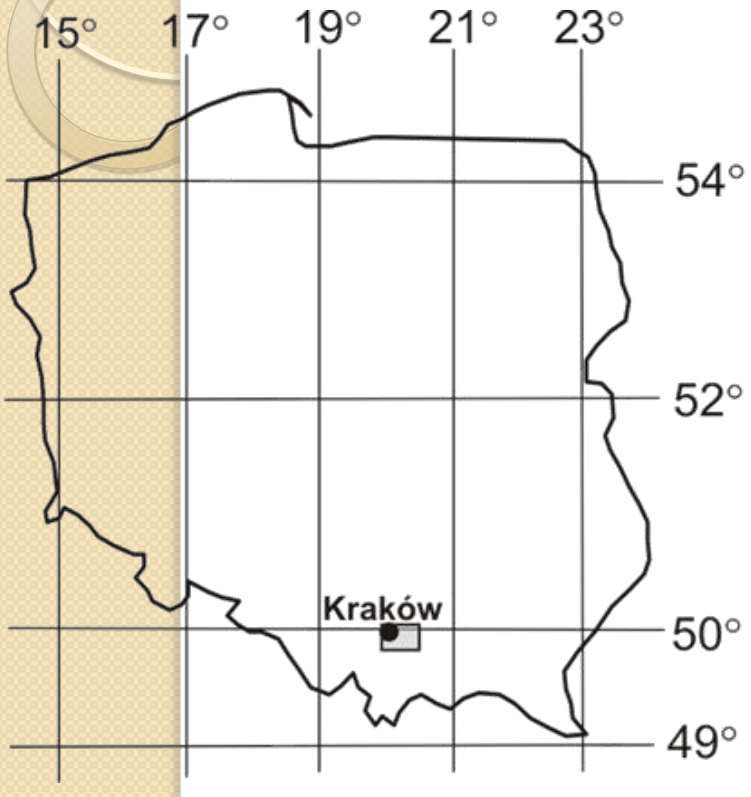
In the past, mixed forests with pine (*Pinus* sp.) and oak (*Quercus* sp.) as the main tree species has been converted into pine monoculture (now **58,5%** of Polish forests).

The phenomenon of widespread occurring of broadleaved tree species, including oak, under the canopy of pine stands have been observed. Natural oak regeneration has been, to a great extent, facilitated by the **jay** (*Garrulus glandarius*).

The aim of the study was to determine:

1) the numbers of **all** and **valuable** Pedunculate (Sessile) oaks in the understorey of mature pine stands;
2) their distribution in studied stands;
3) silvicultural treatments that can be applied during conversion of pine stand to mixed stand using of natural oak regeneration.

Study site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17°
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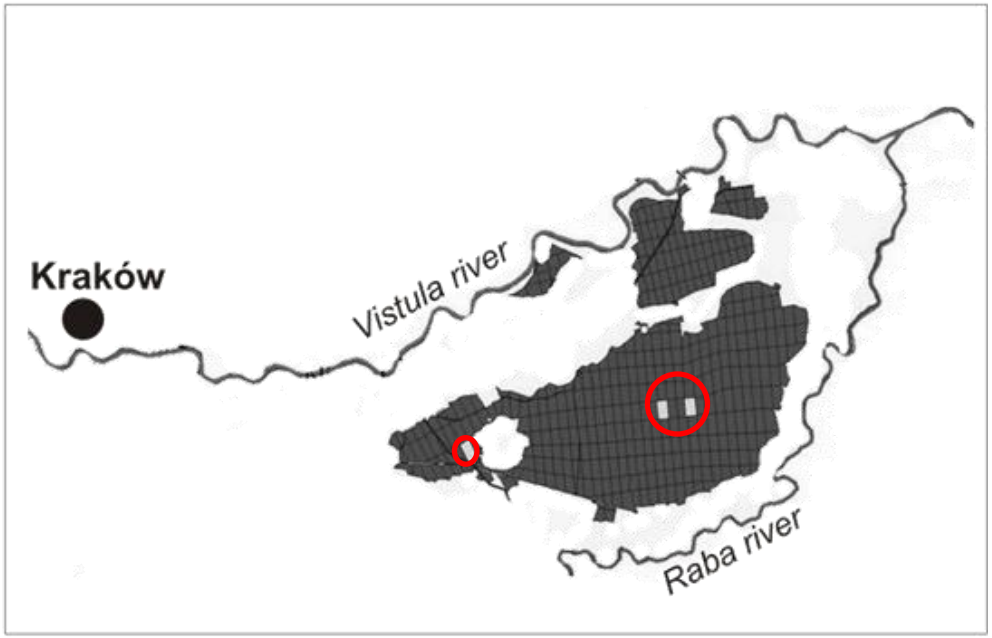
21°
23°
54°
52°
50°
49°
Kraków


Kraków
Vistula river
Raba river

Methods

- series of sample plots were established in a **50x50 m base grid**, no nearer than 30 m to the stand edge,
- two concentric circles **– 0.05 ha (dbh>=7 cm) and 0.01 ha (height)**.
- the most valuable trees were selected according to the following features:
  - **good height tendency (conical crown top) with ability to grow into the upper stand layer;**
  - **good vitality;**
  - **live crown length more than 30% of tree height and**
  - **regular crown projection**.
  - the criteria of trunk quality were very rigorous because they assumed bole sections of **2.5 m in length, with one-sided curvature not exceeding 4 cm/1 m** (PN-92/D95008, 1993).

In each forest compartment **nine oaks were drilled at the DBH**: three trees from the beginning, middle (the most numerous diameter class) and end of the observed range of diameters at DBH.

In each forest compartment, measurements were taken on **28 sample plots**, a total area of **1.4 ha**, in the parts of the forest where cutting activities have not been undertaken during last 10 years.

Results

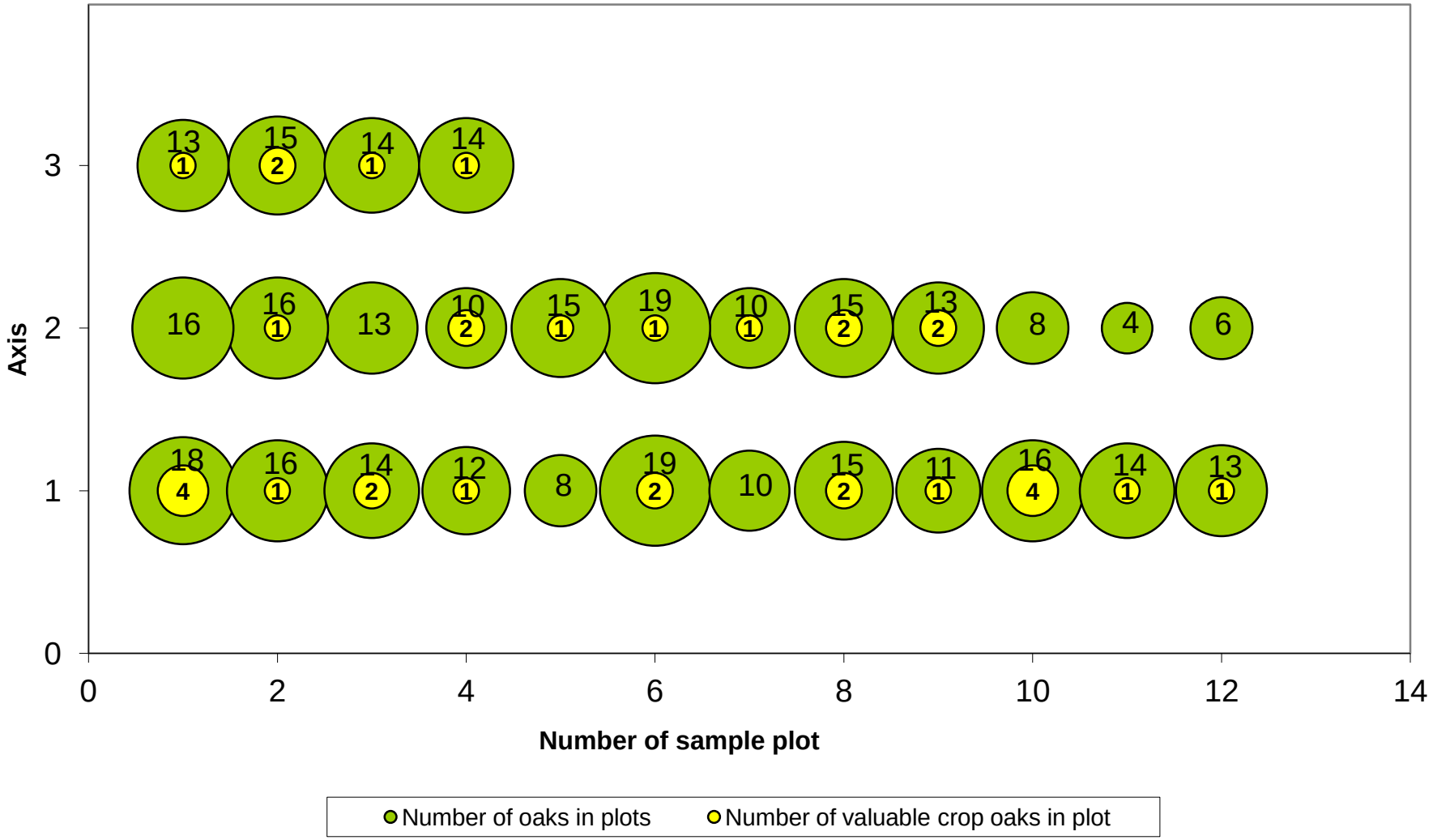
		152b	156f	298f
Age	**pine**	**100**	**135**	**100**
	oak (the most numerous diameter class)	**40–67 (46)**	**34–89 (63)**	**32–76 (52)**
DBH [cm]	pine	41	43	47
	oak (valuable)	19 (24)	26 (27)	22 (29)
Height [m]	pine	24	28	25
	oak (valuable)	19 (20)	20 (21)	19 (22)
Number of pines [trees/ha]		211	111	120
Basal area of pines [m^2/ha]		26.4	16.6	21.8
Stocking index of pine stand[1]		0.81	0.55	0.67
Growing stock [m^3/ha]		436	340	340

[1] Stocking index: relation of actual basal area [m^2/ha] of pines in the stand to the basal area m^2/ha of a closed stand referring to a yield table [Szymkiewicz 2001]

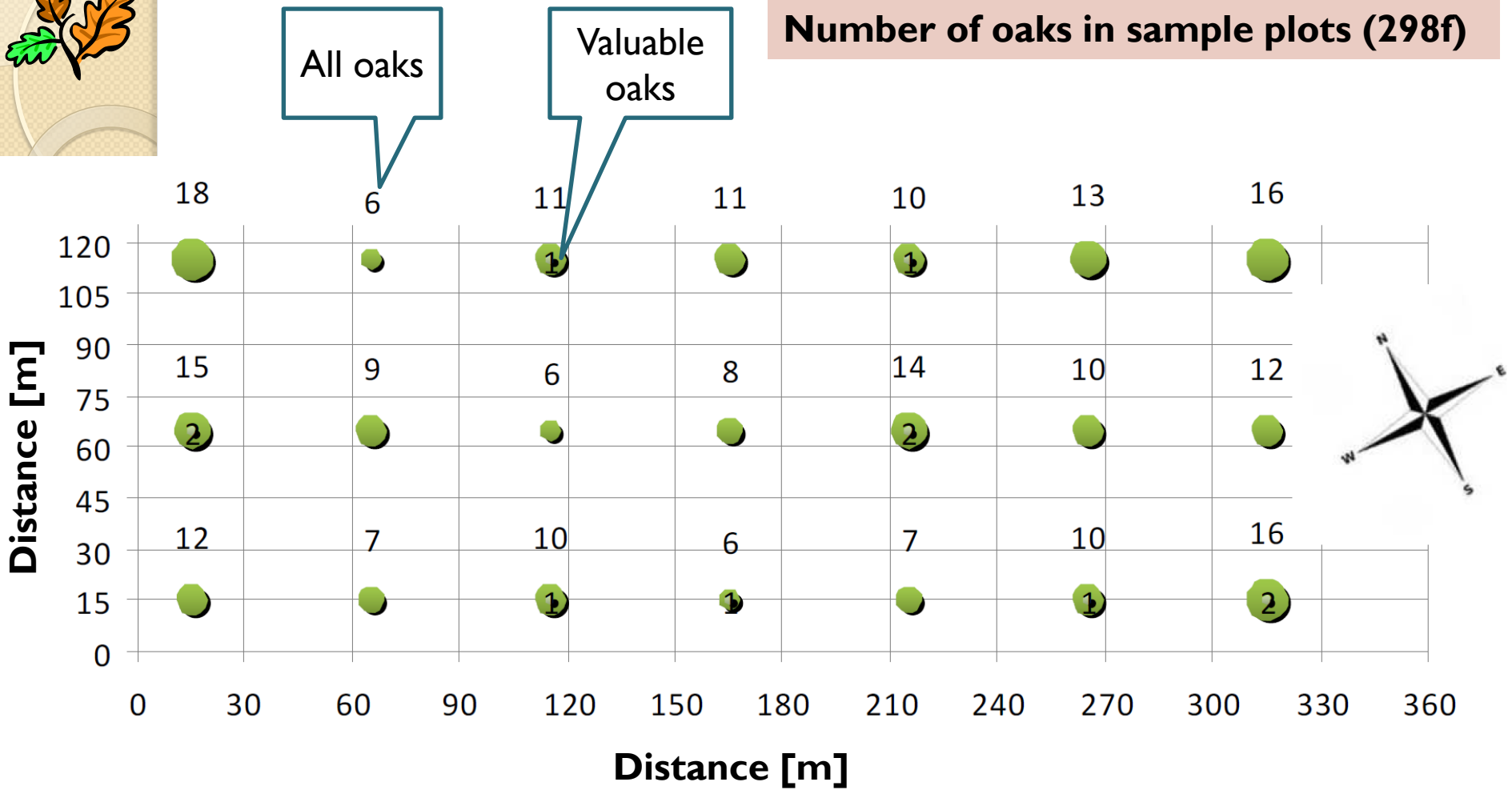
Results

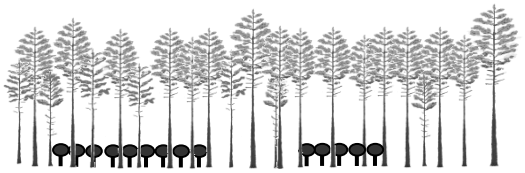
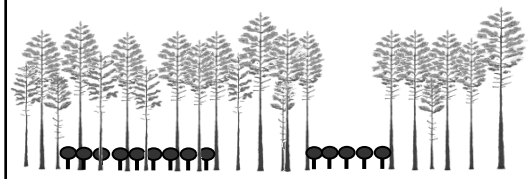
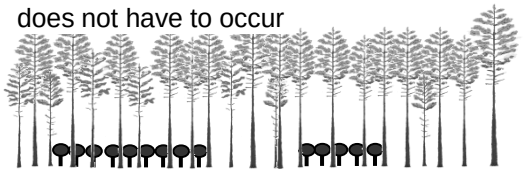
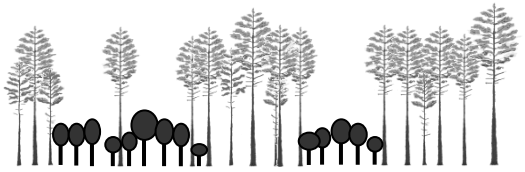
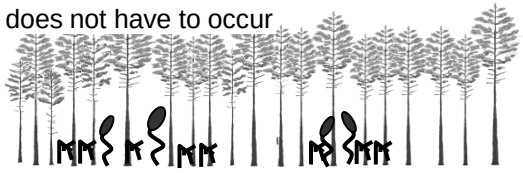
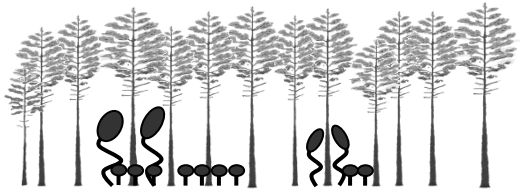
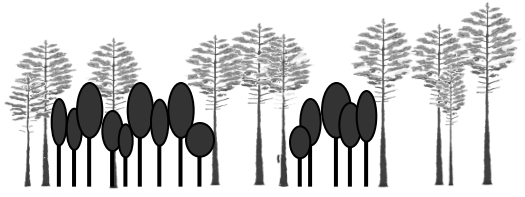
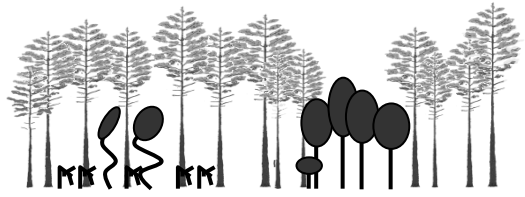
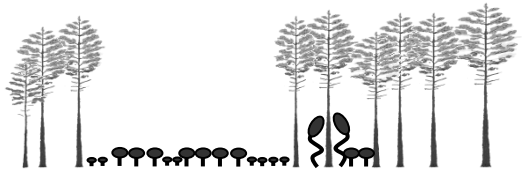
		152b	156f	298f
Target species composition of artificial regeneration [%]		40 *Pinus*, **30 *Quercus***, 15 *Fagus*, 15 *Alnus*	60 *Pinus*, **30 *Quercus***, 7 *Fagus*, 3 *Carpinus*	40 *Pinus*, **30 *Quercus***, 15 *Betula*, 10 *Larix*, 5 *Tilia*
Current species composition [%] (all oaks)		69 *Pinus*, **18 *Quercus***, 13 *Alnus*	62 *Pinus*, **31 *Quercus***, 7 *Betula*	77 *Pinus*, **23 *Quercus***
Number of oaks [trees/0.05 ha]	all (average)	**4–19 (13)**	**3–20 (10)**	**6–18 (11)**
	valuable	**0–4**	**0–9**	**0–2**
Number of oaks [trees/ha]	all	**265**	**196**	**216**
	valuable	**26**	**18**	**11**

Number of oaks in sample plots (152b):
Green – all oaks
Yellow – valuable oaks



Number of oaks in sample plots (298f)



	Option I	Option II	Option III
pine stand 60 years old			does not have to occur 
pine stand 80 years old	 cuts before the culmination of height increment of oak. Important - homogeneity of light conditions in the surroundings about 50% of full light		does not have to occur  
mature pine stand 100 years old			
advantage	to significantly advance age (by about 60 years) of oak in the next oak-pine stand	if regeneration appears several times in small gaps, age structure is beneficial from the standpoint of the dispersion of potential biotic and abiotic threats on various stand development phases	considerable tending opportunities and favourable growth conditions, minimizing the development of curvatures. Shoots from dormant buds (epicormic shoots) will also be less frequently produced
limitation	reduction in basal area of pine stand below a critical level of stocking index (0.8) (Assmann 1961); and loss of production can be significant	The share of oaks growing on the periphery of small gaps, and exposed to rapid environmental change affecting growth conditions (eg. direct insolation), will be high	Adoption only this option significantly reduces the proportion of oak regeneration incorporated into the species composition of the next generation under the pine canopy. It does not take into account the difference in rotation age of pine and oak

Regardless of the variant of the procedure, in the mixed forest broadleaved forest habitat, where the production function of the oak is important, hornbeam, linden and beech should be introduced as an understorey of the future oak stand. The smaller the density of oaks, and the smaller the group size, the more important it becomes.

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RESEARCH ARTICLE

Crookedness of pedunculate oak (*Quercus robur* L.) growing under a canopy of Scots pine (*Pinus sylvestris* L.)

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Natural regeneration of pedunculate oak growing under a canopy of Scots may be used for conversion into a mixed or predominantly broadleaved forest. From an economic perspective it is desirable that the oaks have straight stems. In this paper we present a case study for analysing oak stem curvature and its causes. The study was conducted in a mature pine stand with understorey oaks of age ca. 60 years in Poland. The oaks were classified into two main groups as either straight or crooked. The following variables were measured or assessed for the oaks: (1) stem curvature (crookedness), total tree height, diameter at breast height (DBH) and some tree crown characteristics, (2) the growth of DBH and height in each year of the life of each tree and (3) the competitive pressure of surrounding trees. Durable stem curvatures were formed at the culmination of the height increment. The first 20 years of the life of the oak were crucial in terms of stem quality. The annual height increment was larger in the years when the curvature was formed than in adjacent years. The factors that caused crooked stems were the same for straight and crooked oaks, but the magnitude of the response was different. When planning the conversion of Scots pine into oak, full overhead light should be provided as early as possible, but not later than 20 years since the establishment of the regeneration.

Keywords: stem curvature; understorey; height increment; stand conversion

Introduction

In the past, forest mesotrophic habitats comprising either mixed conifer forest or mixed broadleaved forest (Trampler et al. 1994) with pine (*Pinus* sp.) and oak (*Quercus* sp.) as the main tree species were strongly distorted by the introduction of the pine monoculture (Kenk &

including oak, regenerating under the canopy of pine stands (Mosandl & Kleinert 1998; Mosandl & Küssner 1999; Kint et al. 2009) and especially pine forests on mesotrophic habitats (Zerbe 2002). Oak seeds are mainly sown by the Eurasian Jay (*Garrulus glandarius* L.; Mosandl & Kleinert 1998) and small rodents, including

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