LITHUANIAN FOREST RESEARCH INSTITUTE

Influence of Bioecological Factors on Scot Pine *(Pinus sylvestris l.)* Physical and Mechanical Wood Properties

Dr. Marius Aleinikovas

The goal of the work:

to research physical and mechanical properties of Scots pine *(Pinus sylvestris* L.) wood and consequently to estimate the influence of different bioecological factors on them.

- **The wood from the three forest sites – Na (normal humidity very poor site), Nb (normal humidity poor site) and Nc (normal humidity fertile site) was researched.**

- **In each forest site the stands were 40 - 60 and 90 – 110 year-old.**

- **The pine stands were divided into tree d_v groups: d_v – 0.3 (0.201 – 0.400), 0.5 (0.401 – 0.600) ir 0.7 (0.601 – 0.800) cm per year, when the age in maximum (A_k) was from 15 to 36 years.**

It was aspired that the pine stands chosen for wood analysis in each forest site could have as much familiar structure and identity character of stand growth as possible. The requirements were retained for using the mean diameter increment in maximum index (d_v) for classification of dominant trees growing in the corresponding pine forest sites.

The mean diameter increment in maximum index (cm per year) (Grigaliūnas, 2000):

$$d_v = D_{zr} /(A_{1,3} + n_1), \quad (1)$$

where: D_{zr} **– diameter in the maxima of** dv**, cm;**

$A_{1,3}$ **– the age of trees when a tree grows up to the DBH;**

n_1 **– the number of tree rings at DBH.**

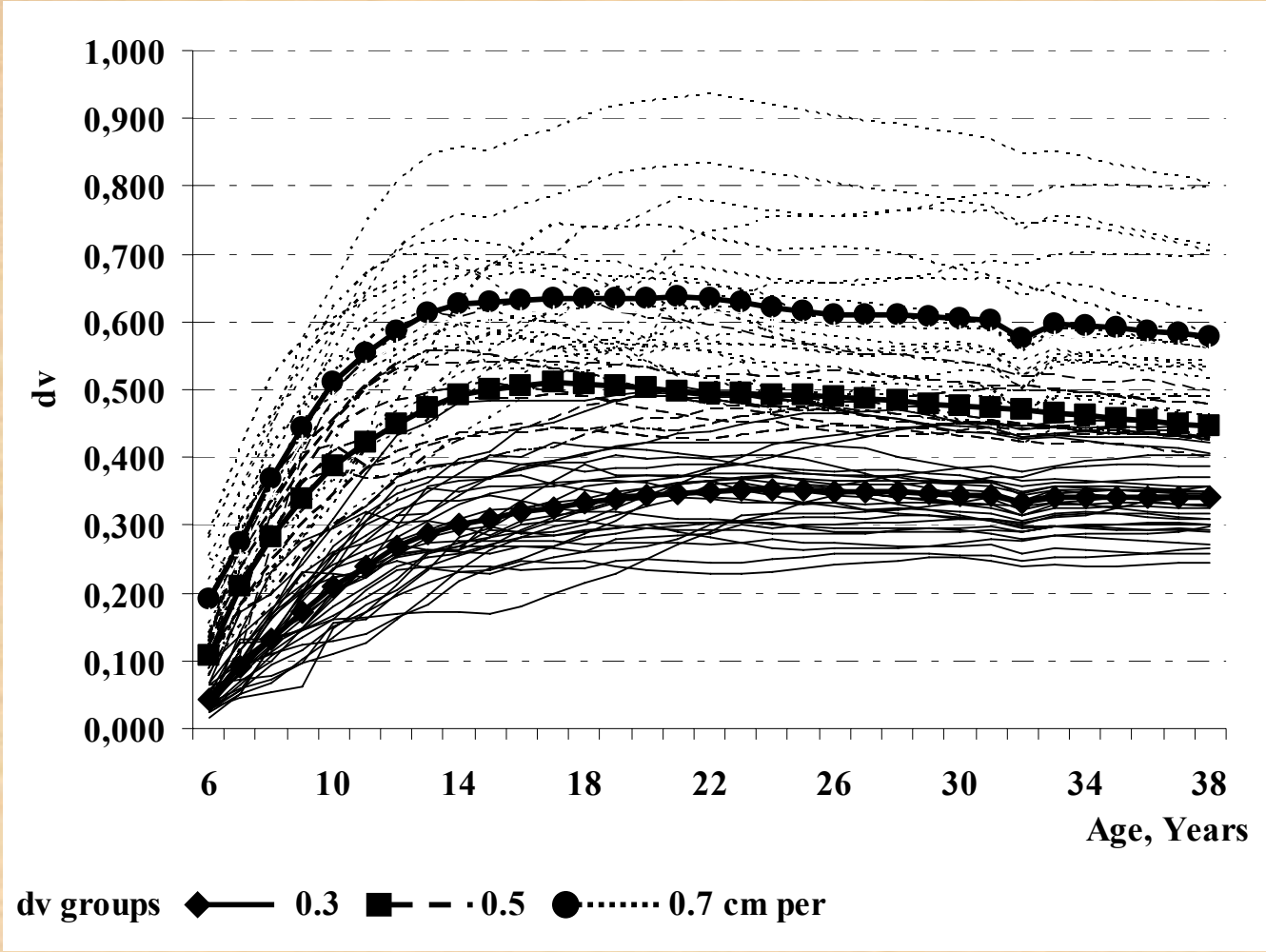
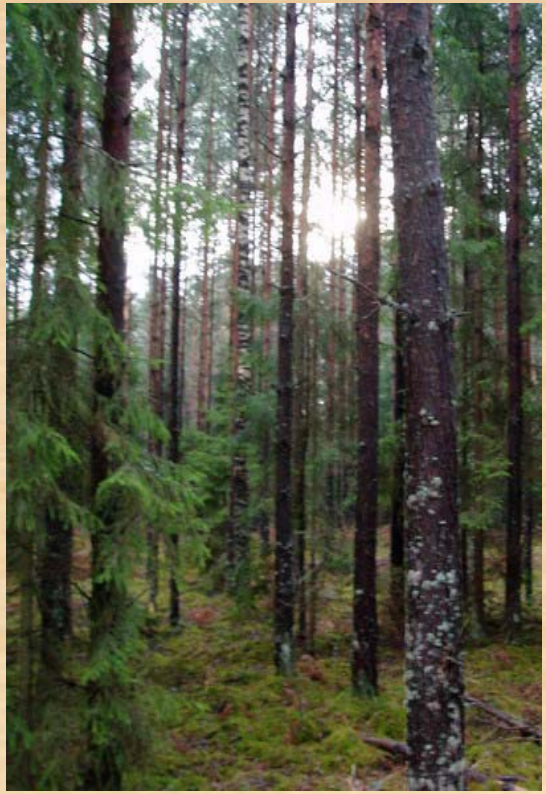


Figure 1. Arrangement of the mean diameter increments in maximum (*dv*) of dominating trees in different pine stands in different periods of age

d_v = 0.3 cm per years

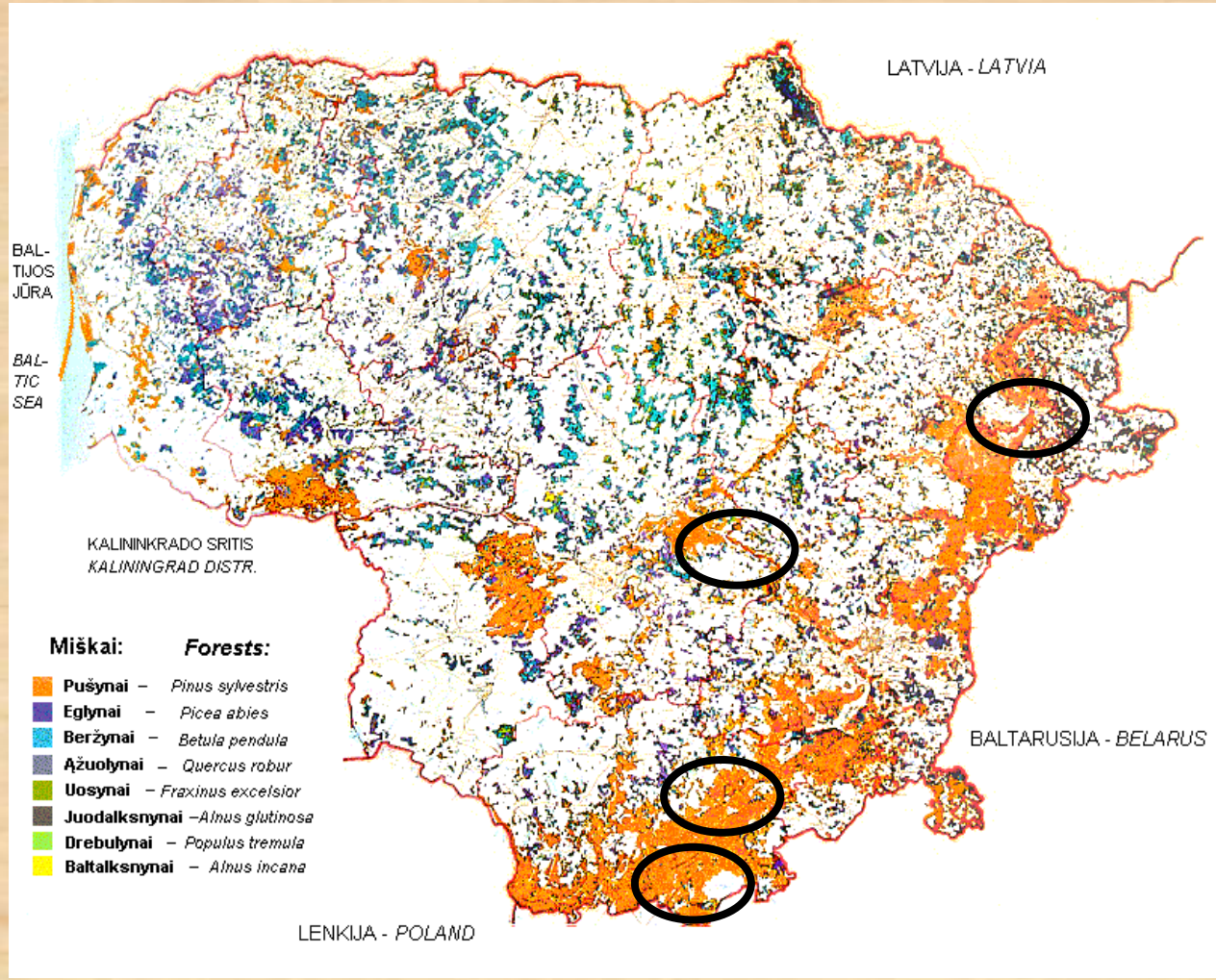


d_v = 0.5 cm per years

d_v = 0.7 cm per years

1 Fig. 40 years old pine stands with various d_v

- The width of annual rings,
- the percent of latewood,
- the wood density,
- the bending strength,
- compression strength along the grain.

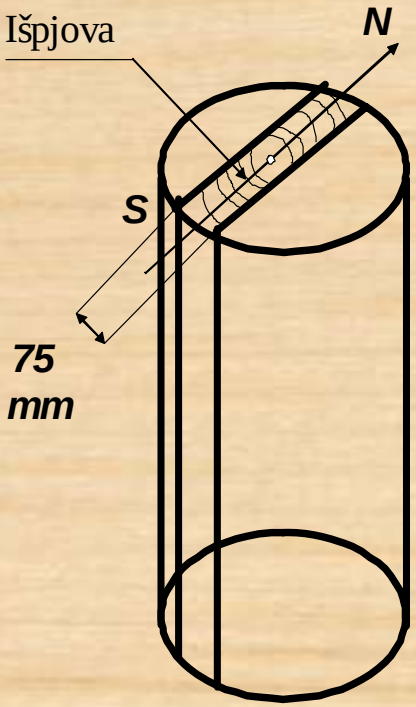


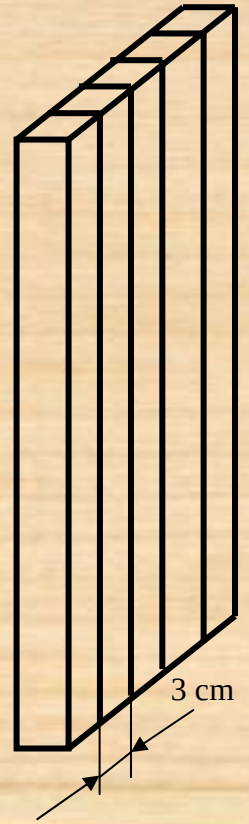
2 Fig. Stands locate area

In each stand there were 10 dominant trees selected and the wood bore samples were drilled at the 1.3 m height for measuring the width of annual rings, the percentage of latewood and the mean diameter increment in maximum (d_v) index.

After the d_v index and A_k had been determined in all wood bore samples, the average stand index d_v and age in maximum A_k were calculated. These indexes show the character of the stand growth in each forest site. The stands are relevant when the d_v index belongs to one of the three groups: 0.3, 0.5 and 0.7 cm per year, and age in maximum A_k is inter 15 - 36 years.

- **The study was conducted with the 2 m long butt logs from the cut sample trees**
- **While preparing the samples for analyses, the central part of each log of 75 mm in thick was cut. Including the pith, it was oriented along the North-South direction**



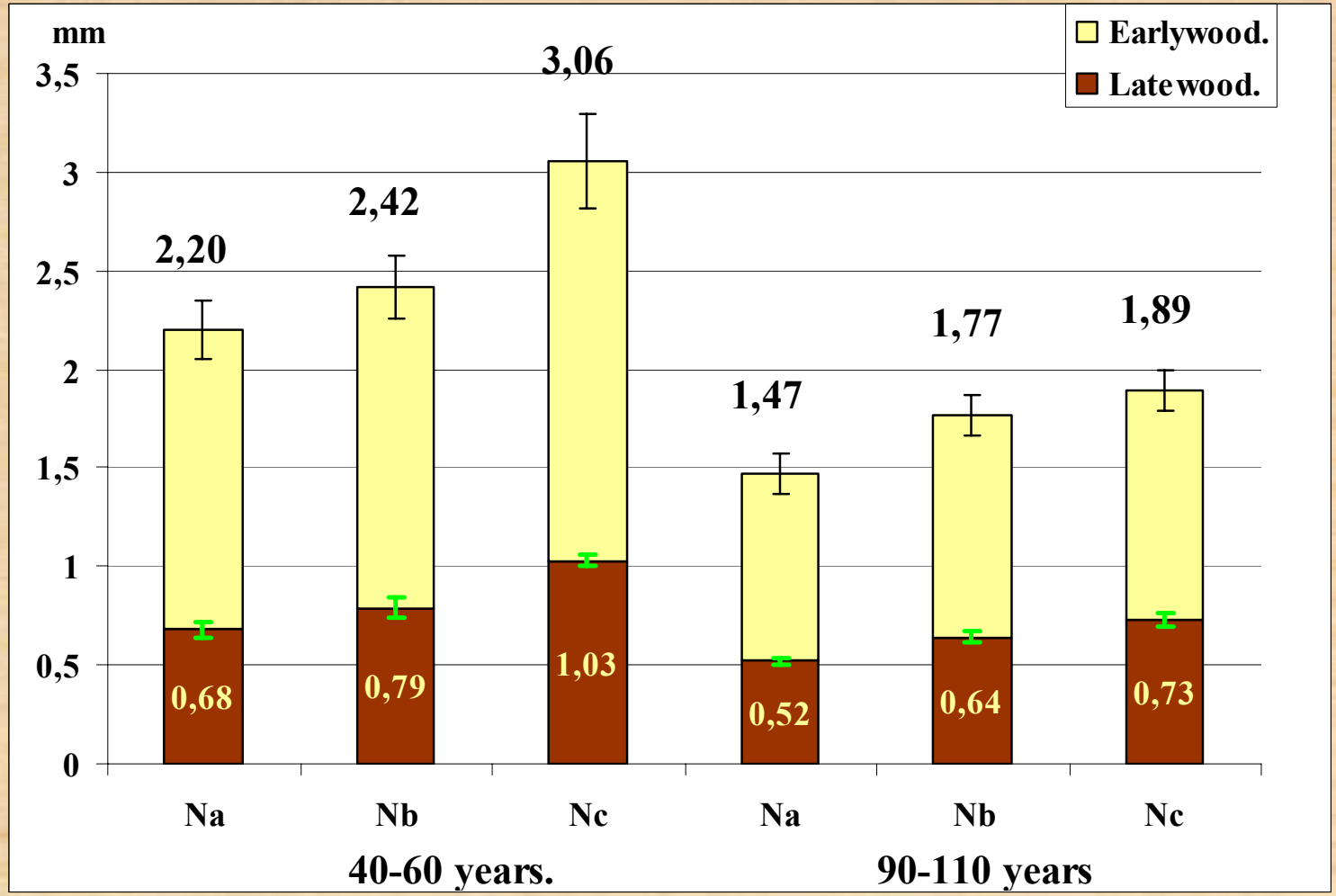


3 Fig. Preparing the samples

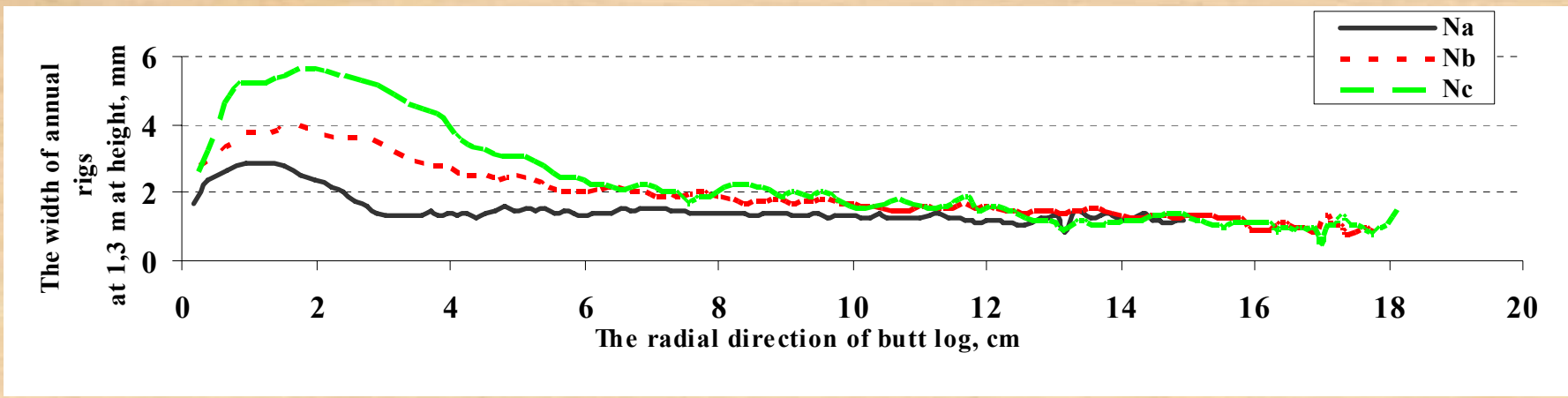
Totally 72 trees were cut. The 1477 samples for wood density, 2116 samples for bending strength in tangential direction as well as for compression strength along the grain were analysed. There were 5709 pine wood samples produced and estimated.

The Results

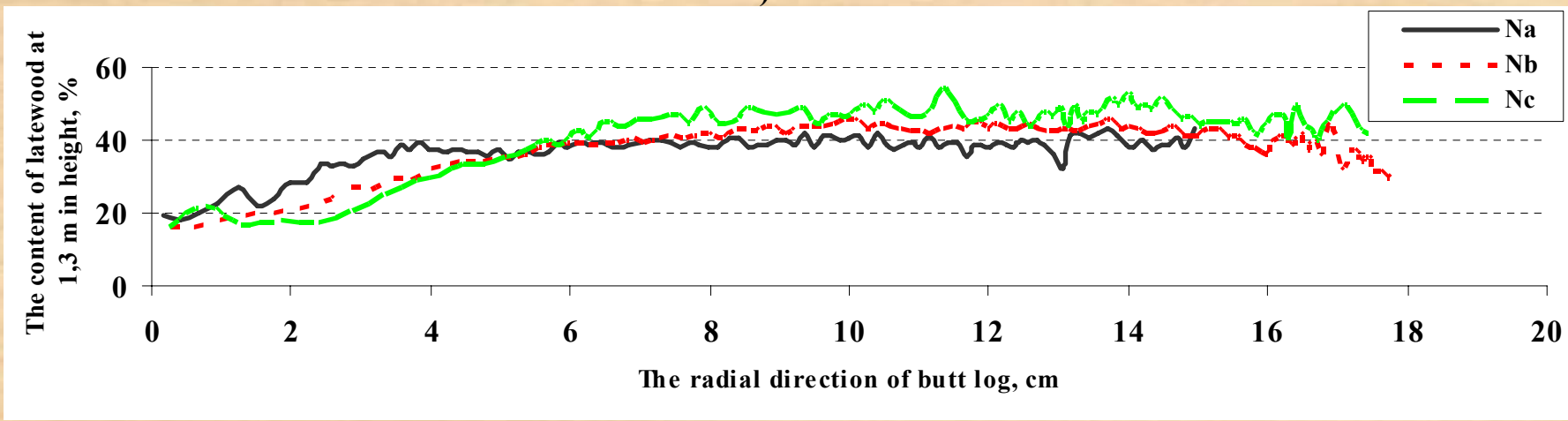
The analysis of width of annual rings and content of latewood in the annual ring



4. Fig. Dependence of width of pine annual rings and content of latewood in the butt log on forest site

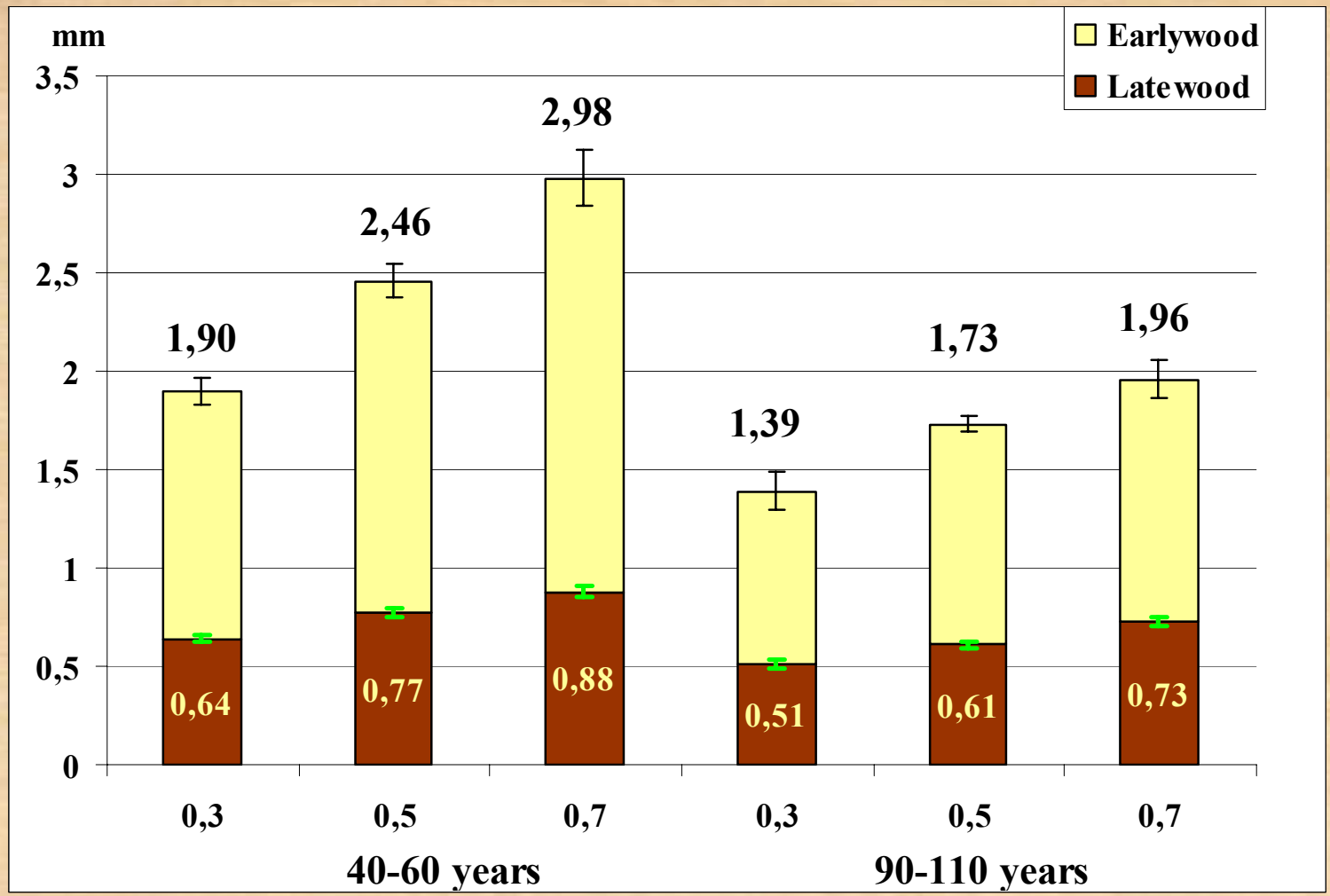


a)

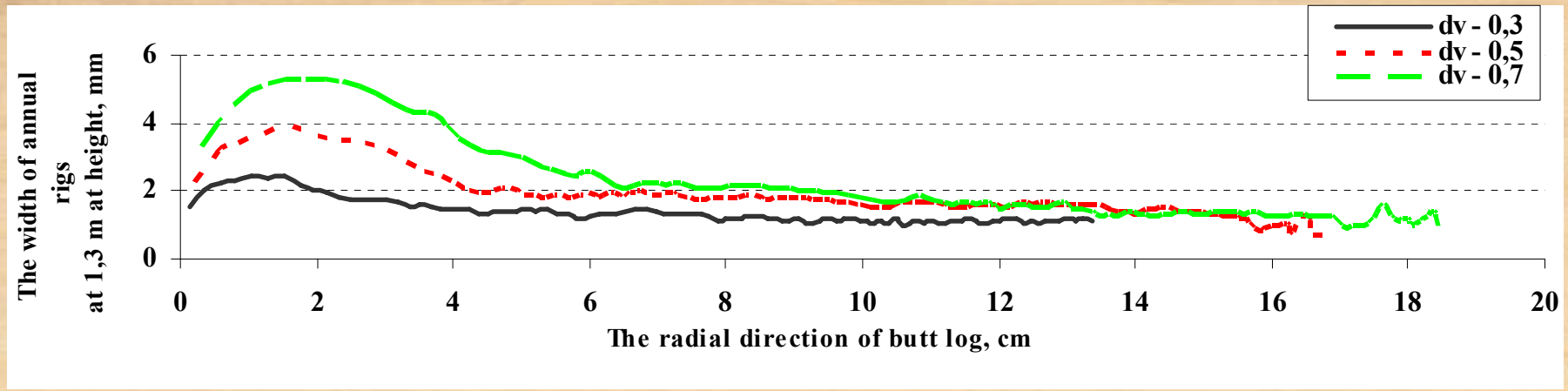


b)

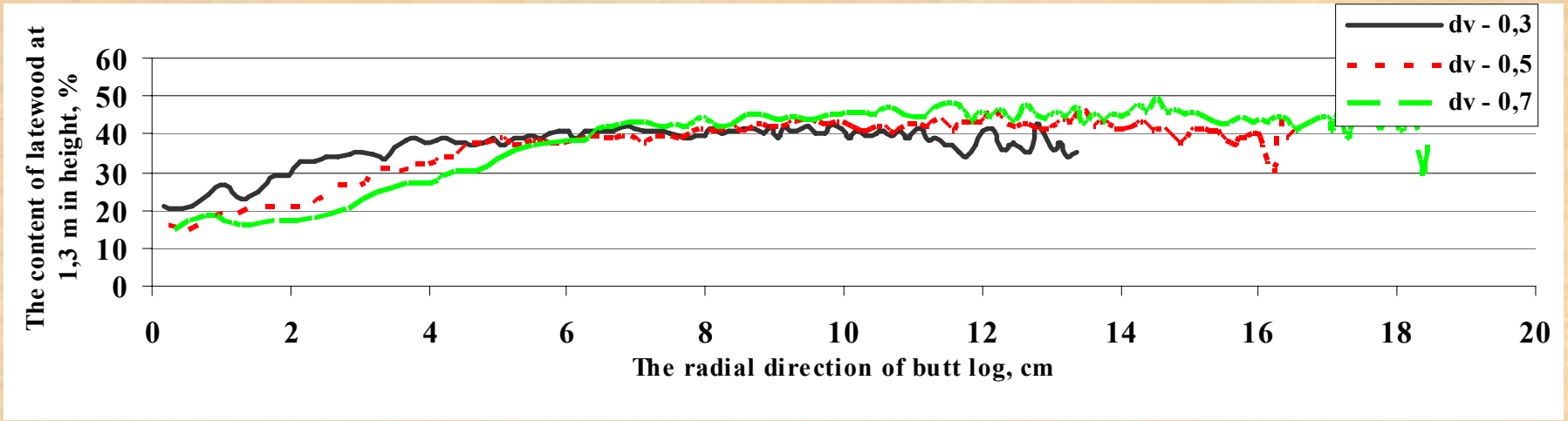
5 Fig. Dependence of fluctuation in width of pine annual rings (a) and latewood (b) in the butt log radial direction on forest site



6 Fig. Dependence of width of pine annual rings and content of latewood in the butt log on d_v



a)



b)

7 Fig. Dependence of fluctuation in width of pine annual rings (a) and latewood (b) in the butt log radial direction on d_v

Analyze of wood density

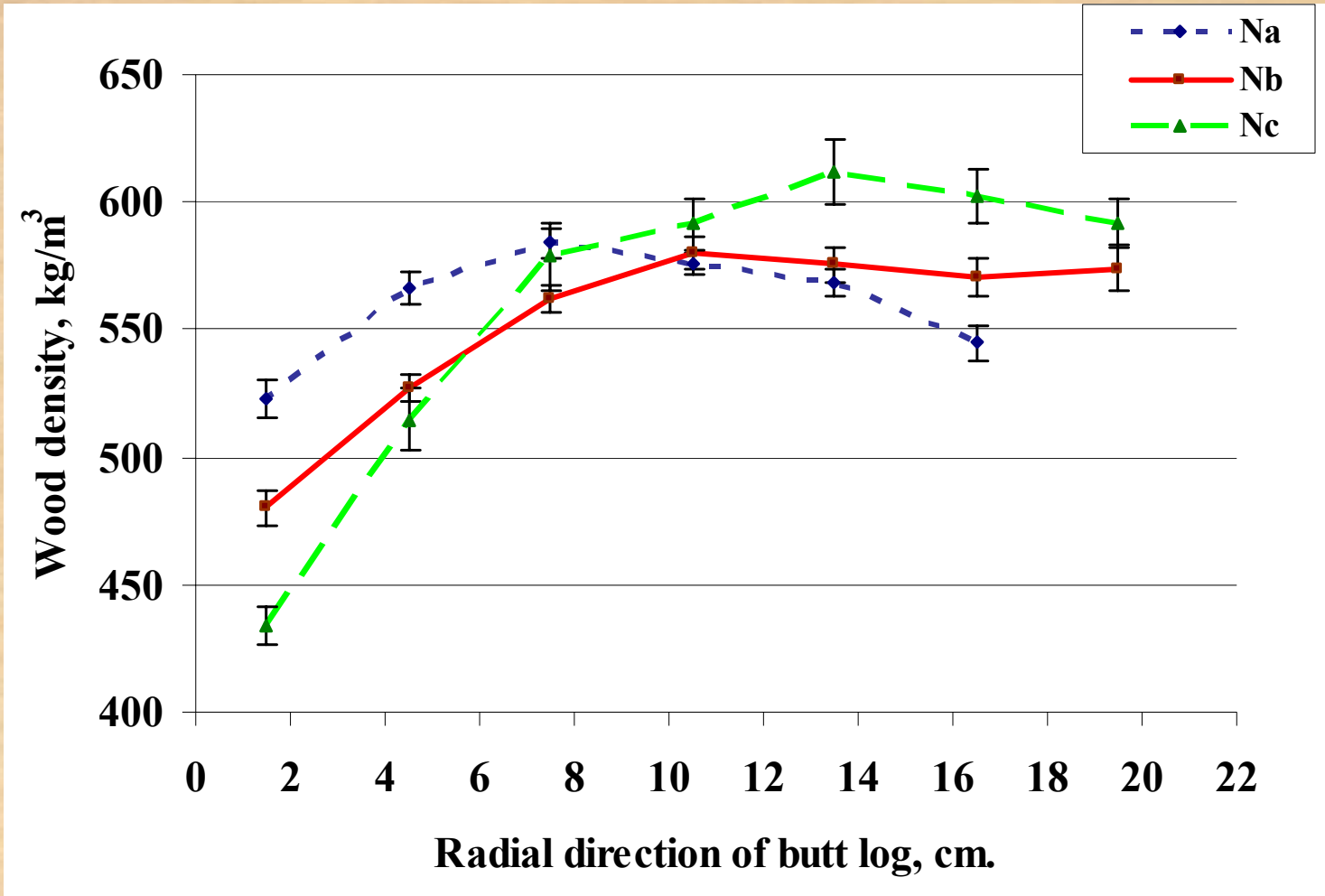
Average wood density, kg/m^3						
Age, year.	40 - 60			90 - 110		
Forest site	Na	Nb	Nc	Na	Nb	Nc
Average	538 ± 10.86	517 ± 7.55	504 ± 6.35	573 ± 11.21	563 ± 12.42	576 ± 7.46
		520 ± 9.91			570 ± 3.93	

a)

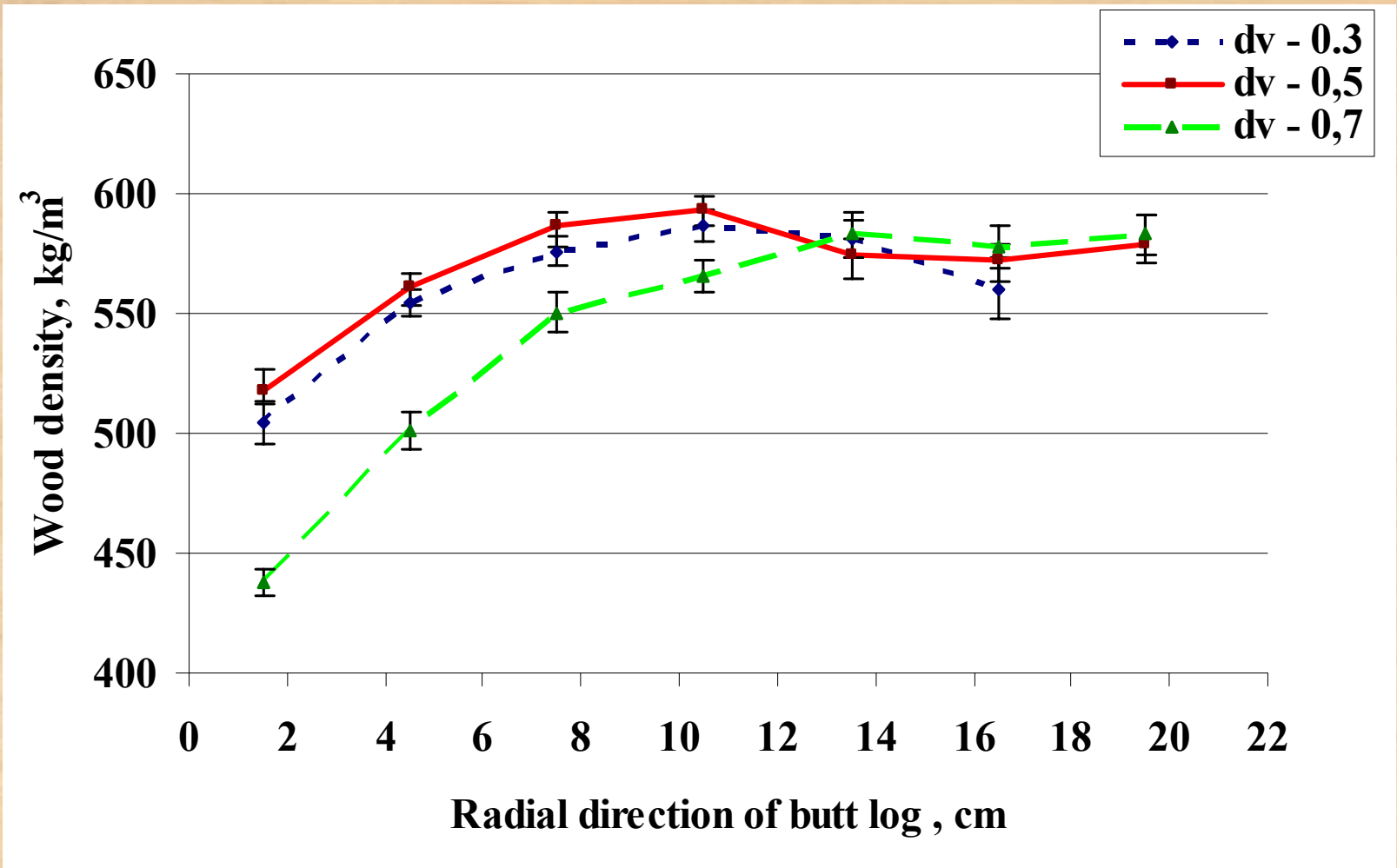
Average wood density, kg/m^3						
Age, year.	40 - 60			90 - 110		
d_v,cm per years	0.3	0.5	0.7	0.3	0.5	0.7
Average	519 ± 9.28	543 ± 10.60	503 ± 8.75	574 ± 13.89	579 ± 7.34	551 ± 13.17

b)

1 Table. Dependence of wood density of pine in the butt log on forest site (a) and on d_v (b)



8 Fig . Dependence of the variation of pine wood density in butt logs radial direction on forest site



9 Fig. Dependence of the variation of pine wood density in butt logs radial direction on d_v

Analysis of wood bending strength in tangential direction

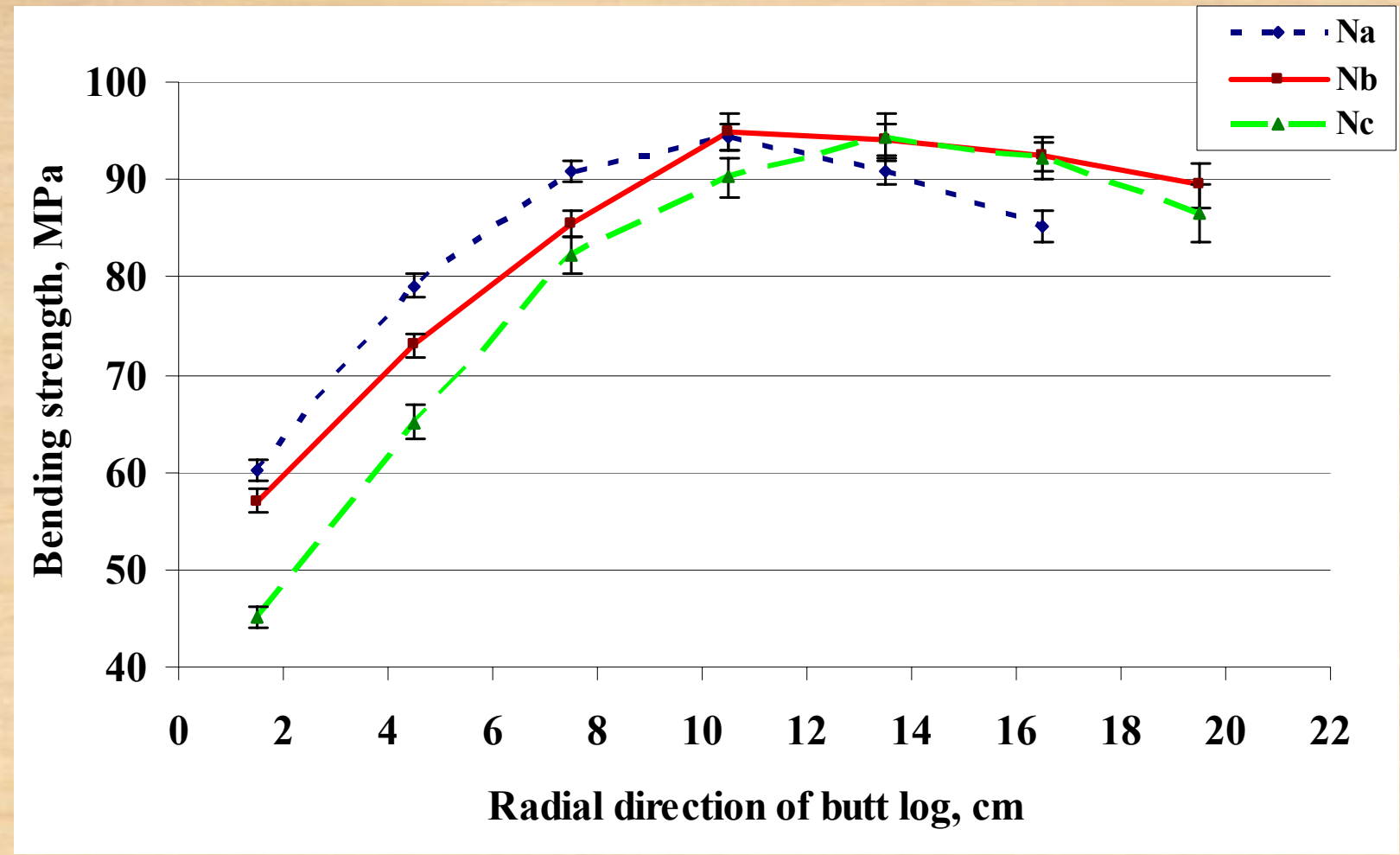
Analysis of wood bending strength in tangential direction, MPa						
Age, year.	40 - 60			90 - 110		
Forest site	Na	Nb	Nc	Na	Nb	Nc
Average	74.73 ± 3.40	74.00 ±2.32	67.83 ±5.39	84.99 ±1.86	85.48 ±2.93	80.77 ±1.90
	72.19 ± 2.19			83.75 ± 1.50		

a)

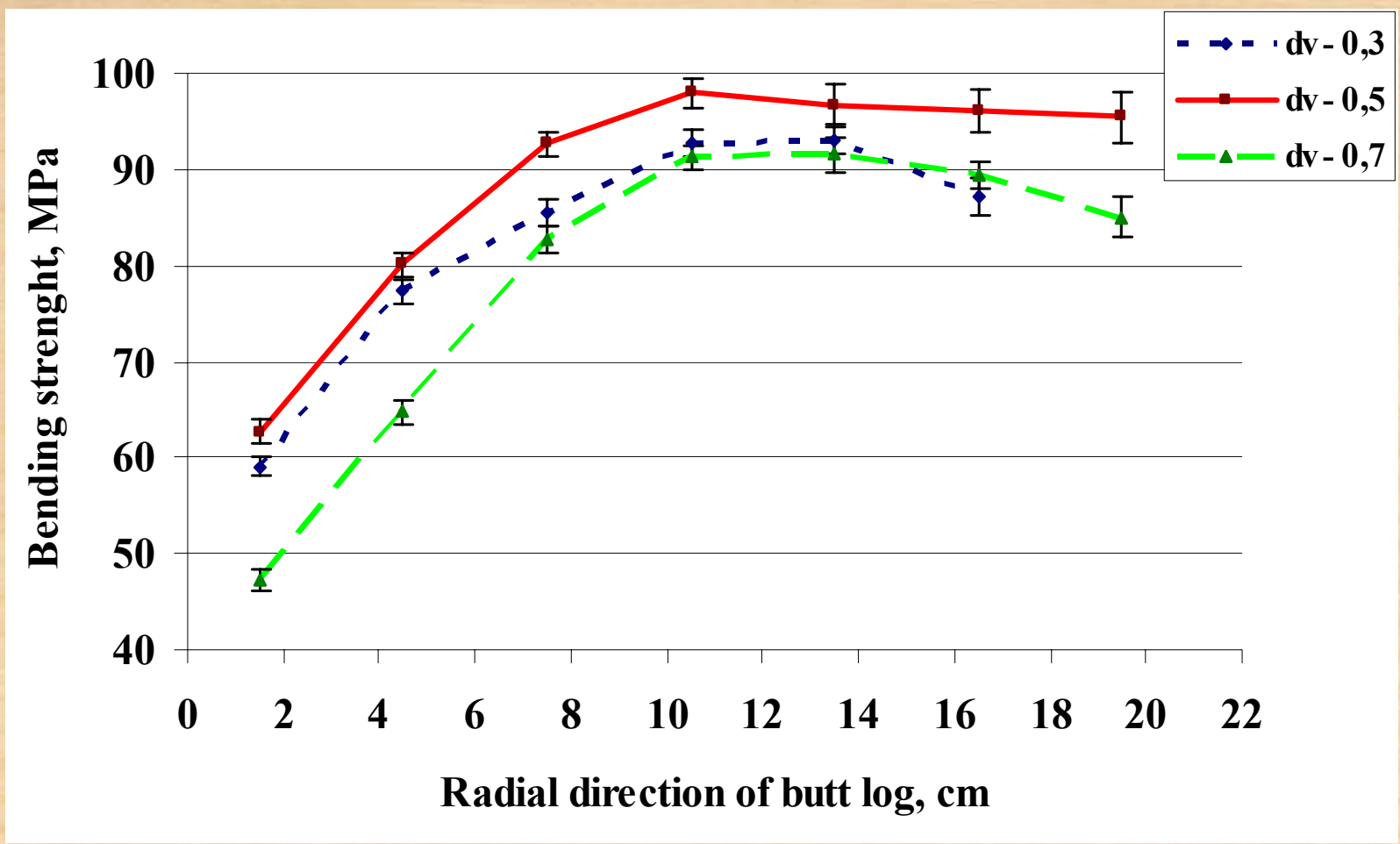
Analysis of wood bending strength in tangential direction, MPa						
Age, year.	40 - 60			90 - 110		
d_v, cm per year	0.3	0.5	0.7	0.3	0.5	0.7
Average	68.59 ± 1.94	80.27 ±2.30	70.78 ±3.10	84.78 ±2.20	89.66 ±2.3	79.16 ±1.13

b)

2 Table. Dependence of the variation of pine wood bending strength in radial direction in butt logs on forest site (a) and d_v *(b)*



10 Fig. Variation of the bending strength in tangential direction of pine butt logs radial direction depending on forest site



11 Fig. Dependence of the variation of pine wood bending strength in tangential direction of butt logs radial direction on d_v

Analysis of compression strength parallel to grain

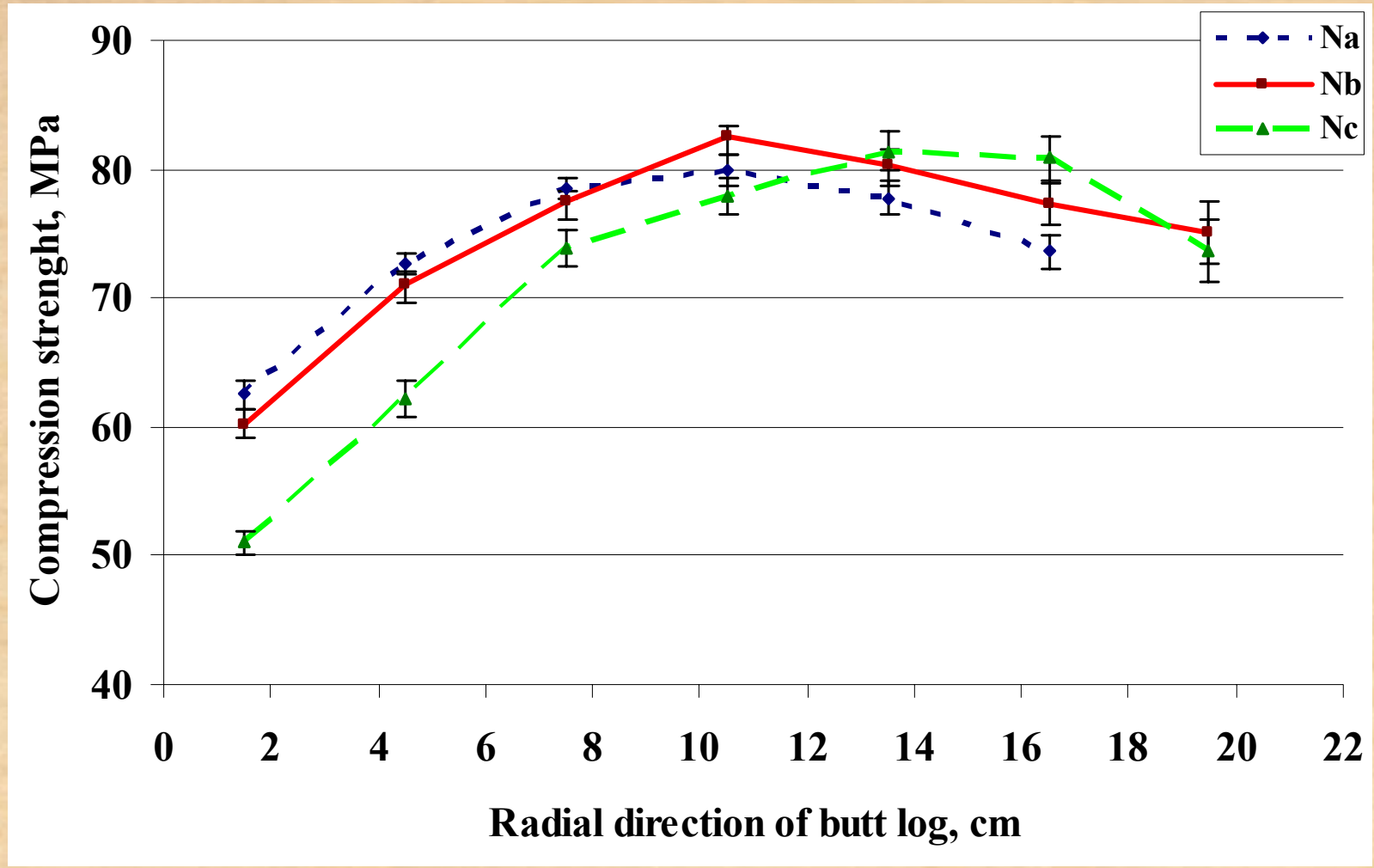
Compression strength parallel to grain, MPa						
Age, year.	40 - 60			90 - 110		
Forest site	Na	Nb	Nc	Na	Nb	Nc
Average	70.34±2.06	71.06 ±1.50	63.3 ±4.07	75.00 ±1.83	76.64 ±2.05	72.64 ±1.61
		68.26 ± 2.45			74.76 ± 1.15	

a)

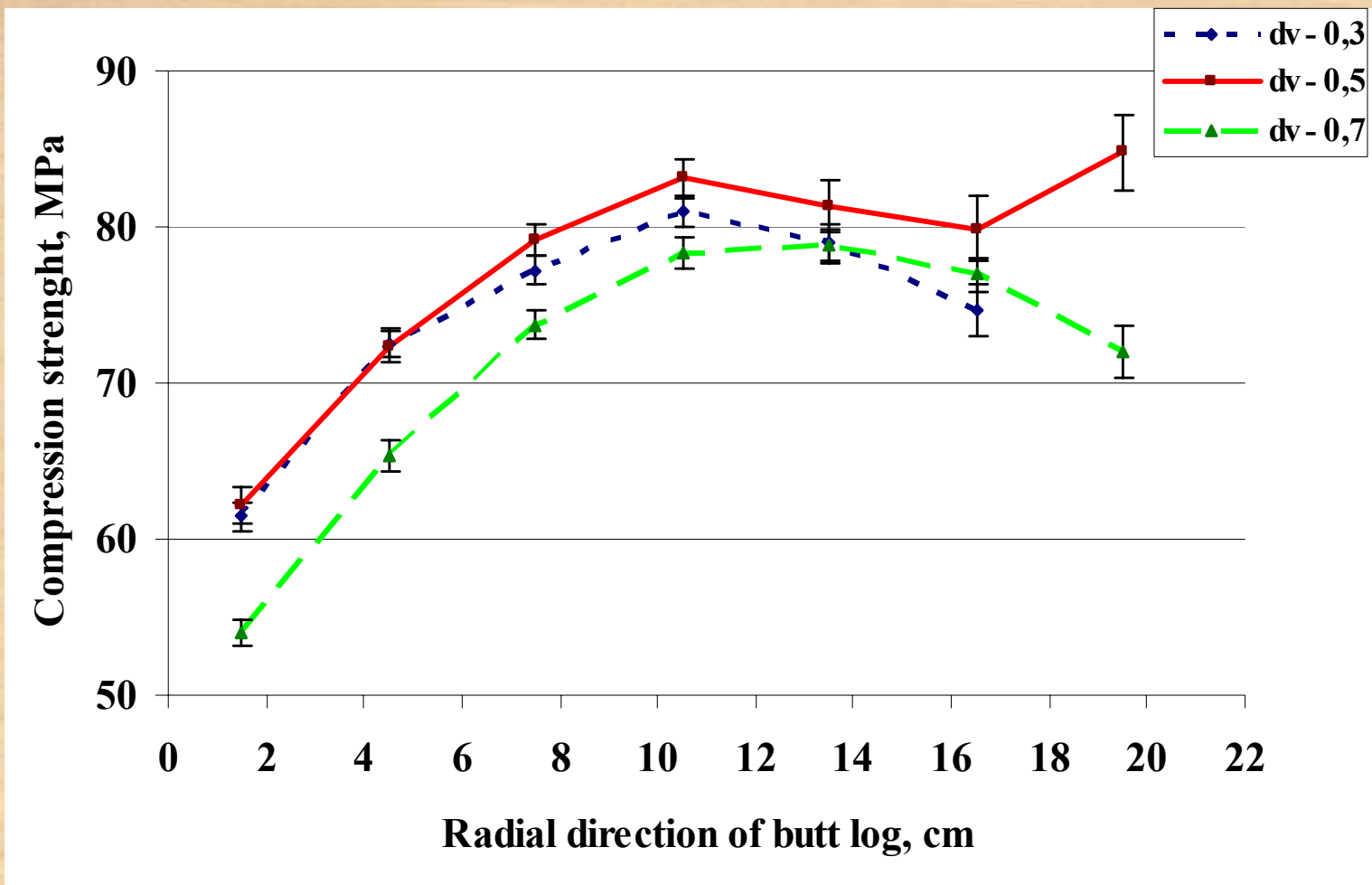
Compression strength parallel to grain, MPa						
Age, year.	40 - 60			90 - 110		
d_v, cm per year	0.3	0.5	0.7	0.3	0.5	0.7
Average	67.79±1.99	73.43 ±1.37	67.39 ±2.64	75.72 ±1.58	78.62 ±2.69	71.95 ±1.02

b)

3 Table. Dependence of the variation of pine wood compression strength in radial direction in butt logs on forest site (a) and d_v *(b)*



12 Fig. Dependence of the variation of compression strength parallel to grain in pine butt logs radial direction on forest site



13 Fig. Dependence of the variation of compression strength parallel to grain in pine butt logs radial direction on d_v

Wood properties						
Age, year	40 - 60			90 - 110		
Forest site	Na	Nb	Nc	Na	Nb	Nc
Wood density, kg/m^3	538	517	504	573	563	576
Bending strenght, MPa	74.73	74.00	67.83	84.99	85.48	80.77
Compression streght, MPa	70.34	71.06	63.37	75.00	76.64	72.64

4. Table Dependence of the variation of pine wood density, bending strength and compression strength on forest site

Wood properties						
Age, year	40 - 60			90 - 110		
dv, cm per year	0.3	0.5	0.7	0.3	0.5	0.7
Wood density, kg/m^3	519	543	503	574	579	551
Bending strenght, MPa	68.59	80.27	70.78	84.78	89.66	79.16
Compression streght, MPa	67.79	73.43	67.39	75.72	78.62	71.95

5. Table. Dependence of the variation of pine wood density, bending strength and compression strength on d_v

Conclusion

1. **Forest site, age and structure are the mane initials factors influencing physical and mechanical pine wood properties.**
2. **The absolute and relative content of latewood in the annual rings depends on forest site fertility (*F* – 181; *p* <0.01), stand age (*F* – 669; *p* <0.01) and is related with the mean diameter increment in maximum index (*dv*, cm per year), which is describing the stand structure and character of stand growth (*F* – 73; *p* <0.01).**

3. **The higher pine butt log wood density (538 kg/m^3) is estimated in Na forest site in 40-60 - year group, and Nc forest site in 90-110-year group (573 kg/m^3). Wood density is increasing from 6.10 to 12.5 % with increasing stand age in all forest sites. The dependence of wood density dynamic on the mean diameter increment in maximum (d_v) shows, that wood density is gradually increasing with age while stand reaches the index d_v of 0.5 cm per year. Up to 0.5 cm per year wood density is decreasing in all forest sites**
4. **The higher bending strength is estimated for pine butt log wood of Na and Nb forest site in both age groups (40-60 and 90-110 – year), 74.73 – 84.99 MPa and 74.0 – 85.48 MPa respectively. The wood bending strength is lower for pine of the Nc forest site. In the older pine stands the average bending strength are higher from 12.07 to 16.02 % in all forest stands. The maximum of bending strength reaches the pine stands with *dv* of 0.5 cm per year in both age groups.**

5. **The higher compressing strength has Nb forest site pine trees in both age groups (40-60 and 90-110 –year), 71.06 – 76.64 MPa respectively. The Na forest site pine trees have closely related strength (70.34 – 75.00 MPa) and Nc forest site pine trees have lower compression strength (63.37 – 72.64 MPa). The maximum of compression strength reaches the pine stands with *dv* of 0.5 cm per year in both age groups.**
6. **The wood density and strength properties in the radial direction in the Na forest site vary from 10.26 to 36.17 %. While in Nb and Nc forest sites these properties vary in wide range – from 17.09 to 39.82 % and from 29.2 to 52.18 %, respectively.**

THANK YOU FOR ATENTION