Radial Variation of Mechanical and Physical Properties of Black Spruce Cell Wall Determined by Nanoindentation and Silviscan

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Background

- The nanoindentation technique determines the mechanical properties of a material at the submicron and nanoscale levels;

- Nanoindentation is increasingly used for wood: Wimmer et al. 1997; Gindl and Schöberl 2004; Gacitúa et al 2007; Xing et al. 2009; Yin et al. 2011; Bustos et al. 2011; Valenzuela Carrasco 2011;

- Silviscan technique is based on X-ray absorption and diffraction to determine wood density and microfribril angle. It does not provide a direct measurement of the cell wall mechanical properties;

- Variation of wood density and mechanical properties from pith to bark is known but less data are available on the variation of the corresponding cell wall properties, especially for black spruce.

Objectives

1. Determine the modulus of elasticity and hardness of black spruce (*Picea mariana*) latewood cell wall secondary layer by nanoindentation from pith to bark;

2. Determine the relationship between wood density and microfibril angle determined by the Silviscan technology, and the cell wall properties determined by nanoindentation.

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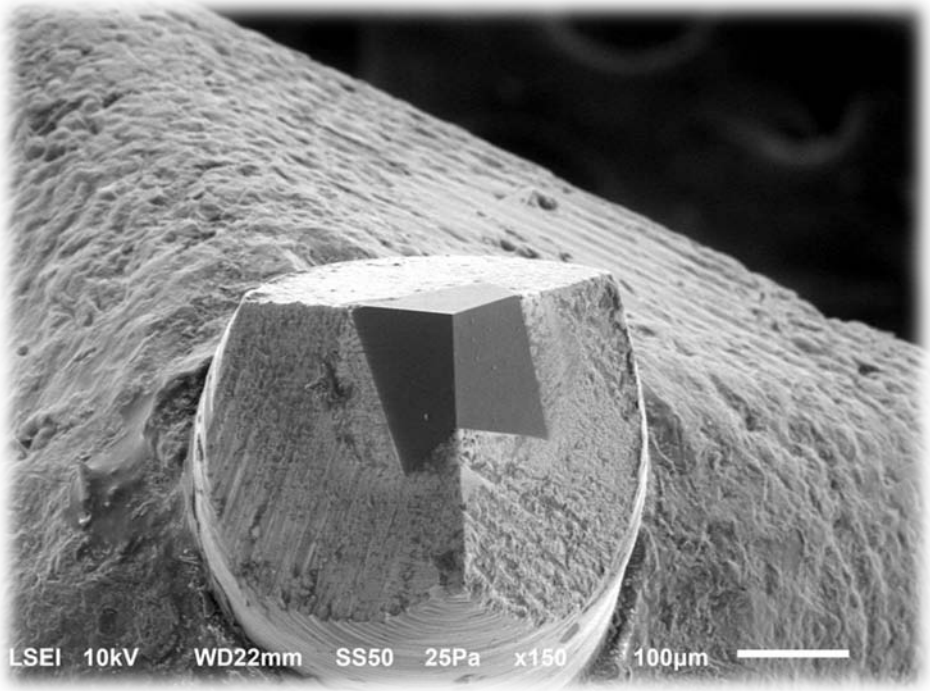
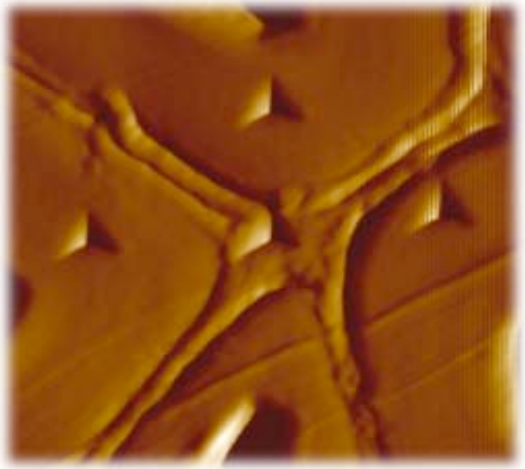
Material and Methods

Nanoindentation technique





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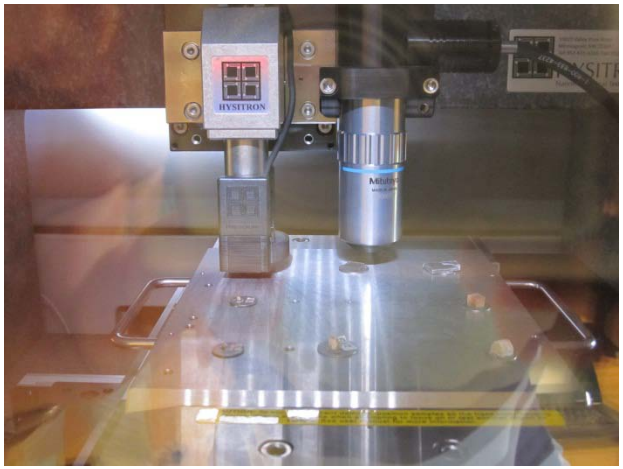
Material and Methods

Nanoindentation technique



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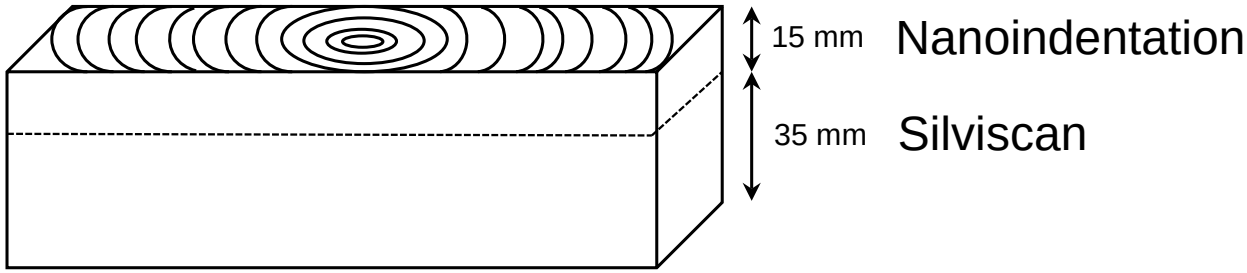
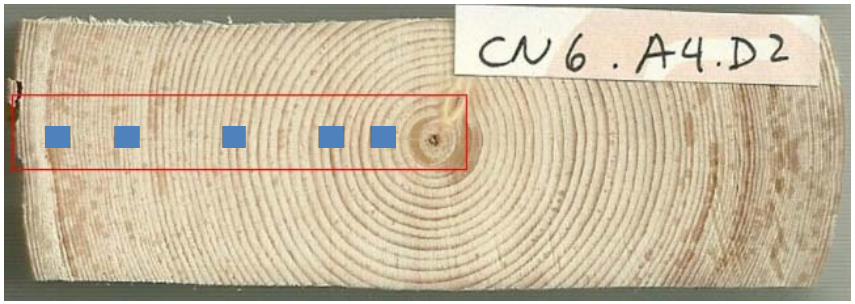
Material and Methods

Samples preparation





- 3 mm x 3 mm samples were cut at 5, 10, 20, 35 and 50 years of cambial age;
- Specimens were embedded with Spurr epoxy resin;
- Silviscan analysis was done at FPInnovations, Vancouver, Canada.

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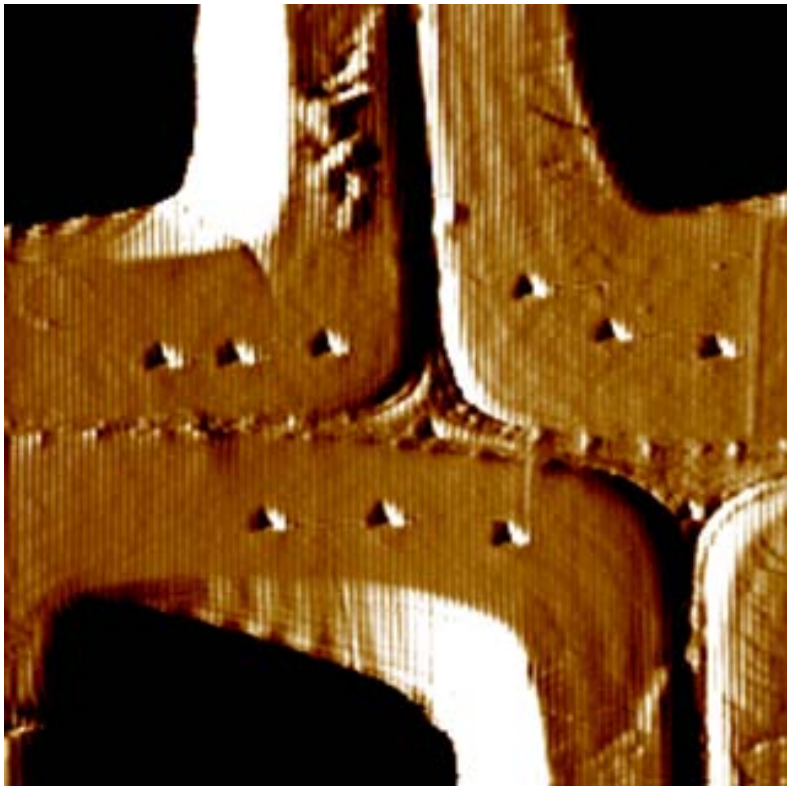
Material and Methods

Indentations in the latewood S2 layer



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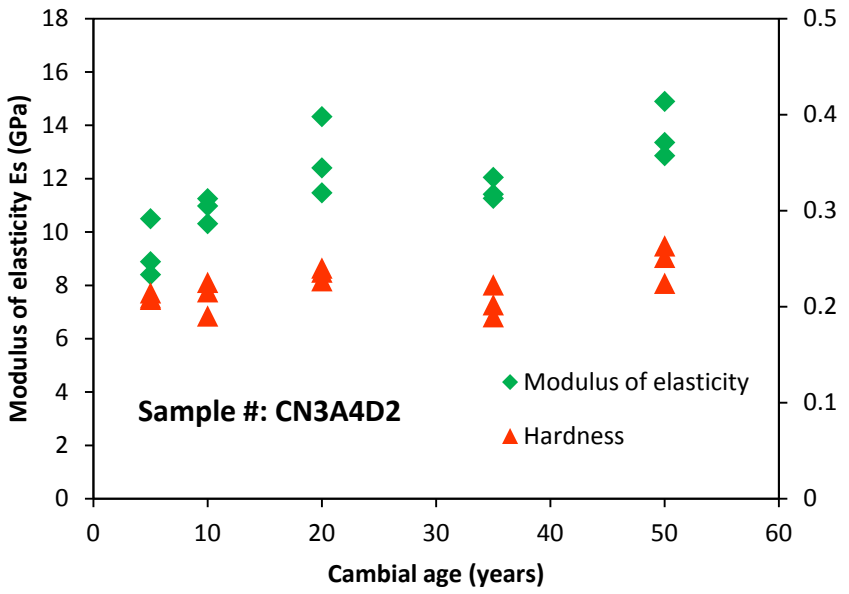
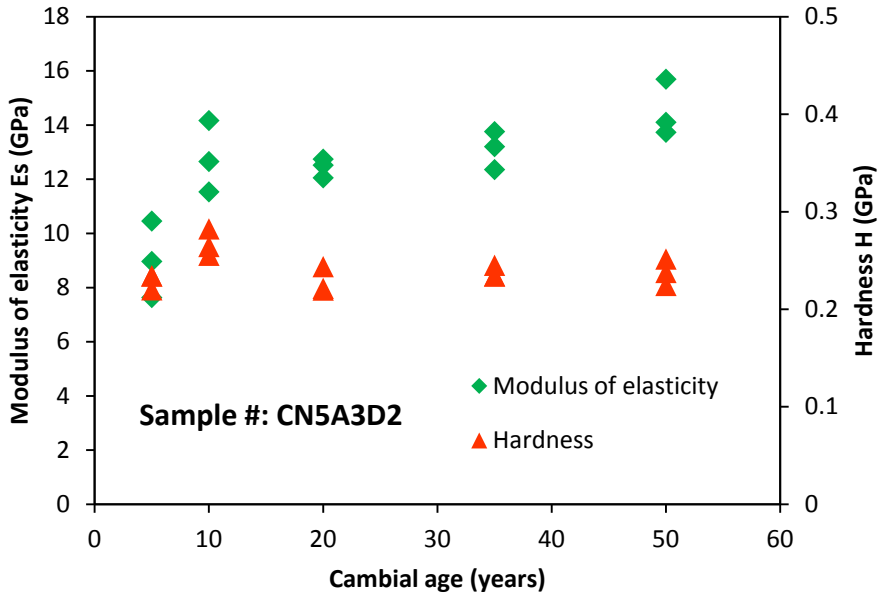
Results and Discussion

Cell wall modulus of elasticity and hardness determined by nanoindentation





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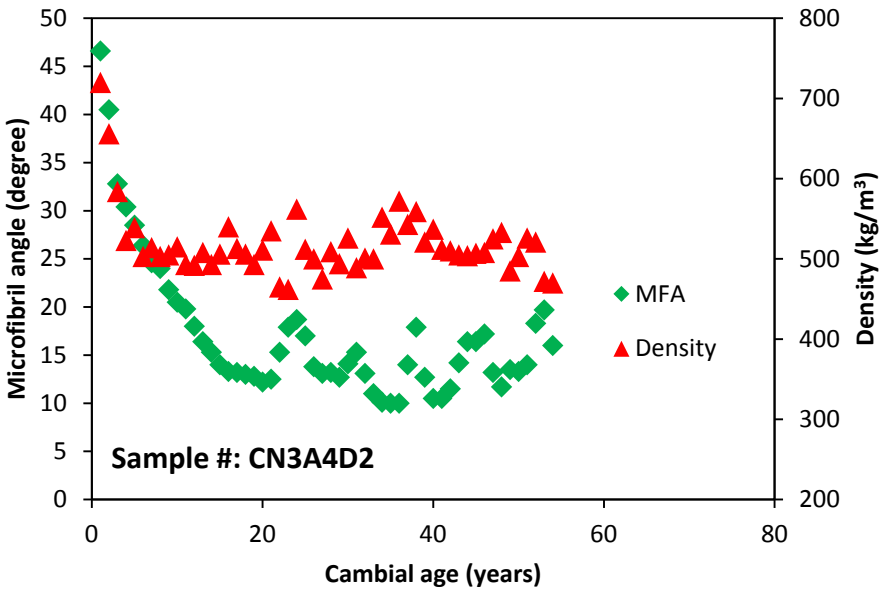
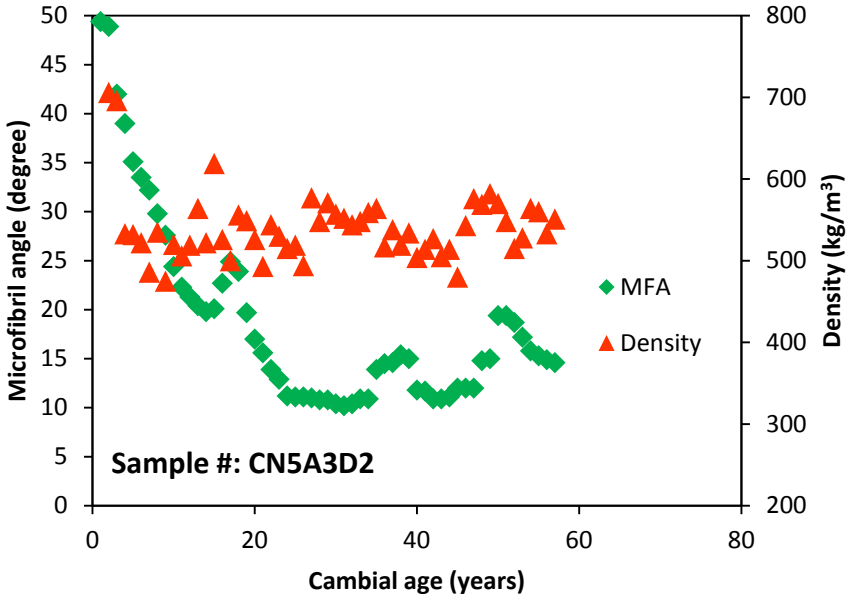
Results and Discussion

Microfibril angle and average growth ring density determined by Silviscan





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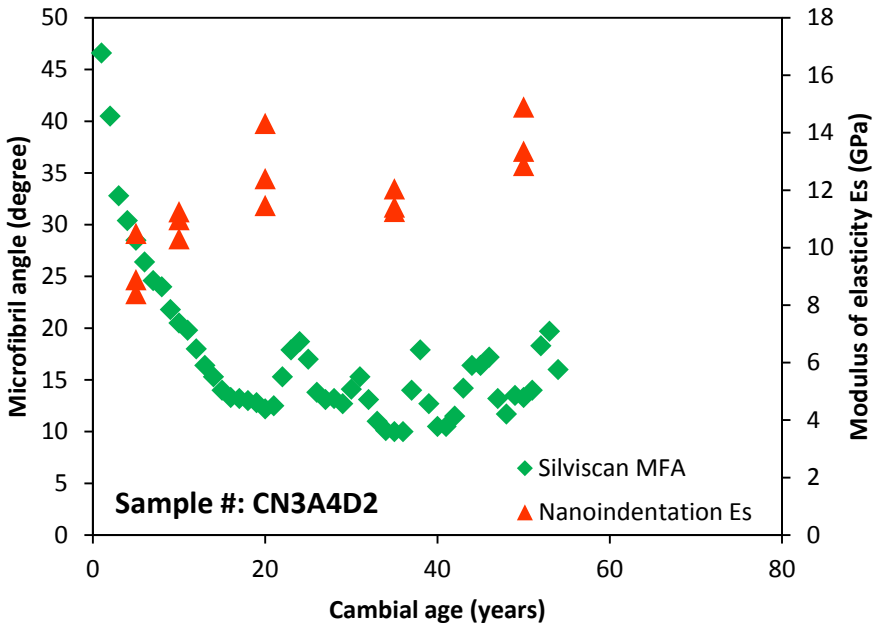
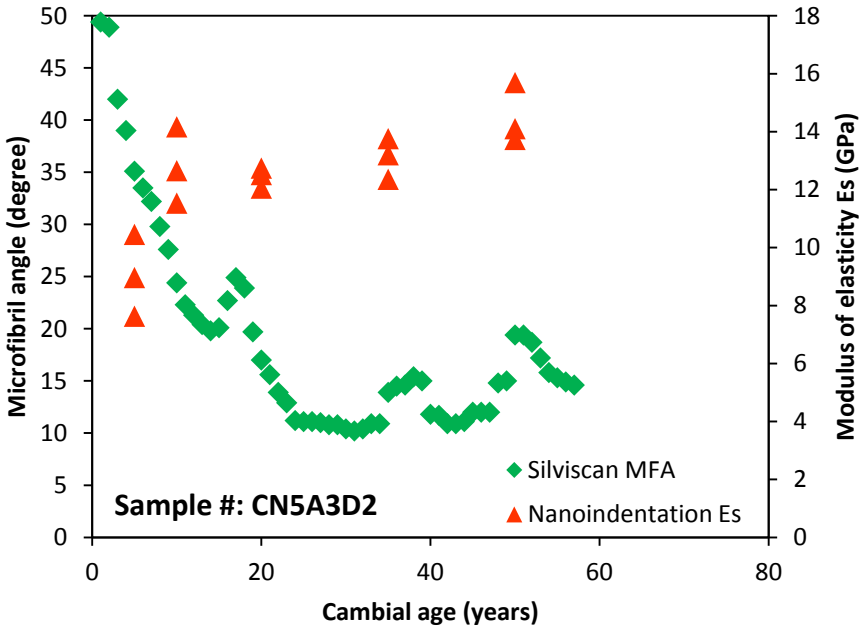
Results and Discussion

Microfibril angle determined by Silviscan and cell wall modulus of elasticity determined by nanoindentation





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Conclusions

1. Latewood cell wall modulus of elasticity had the tendency to increase from the pith to a cambial age of about 20 years in the juvenile wood zone. It stabilized or varied slightly from 20 years and over in the mature wood zone;

2. Latewood cell wall hardness did not vary significantly from pith to bark;

3. Microfibril angle and cell wall modulus of elasticity varied inversely from pith to bark and appeared to be correlated.

Statistical analysis of the data is required to quantify the tendencies described in this paper. It is currently in process.

Thank you!

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