



# THE EFFECTS OF SOIL PARENT MATERIAL AND NITROGEN FERTILIZATION ON WOOD QUALITY OF DOUGLAS-FIR IN THE PACIFIC NORTHWEST

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## INTRODUCTION

Wood is an inherently variable substance, its properties are subject to wide variations brought about by the physiology of the tree and the external factors affecting its growth.

Douglas-fir is the predominant plantation species native to the Pacific Northwest. It is widely valued as an important tree species in forest management because of its high volume timber production and the rapid growth rates on established stands; additionally, it is a premium timber resource for structural application.

Nitrogen is consistently the most limiting factor to the growth of forests. Decades of observations in tree growth response to fertilization practices indicate that soil nitrogen tends to be limiting in the Pacific Northwest, and research has shown coastal Douglas-fir will respond to 224 kg ha<sup>-1</sup> application about 2/3 of the time.

However, the impact of the site and management on Douglas-fir wood quality is unclear, especially the effects of soil parent material (SPM) and fertilization treatment. This study is focusing on understanding the several wood quality respects in response to the four SPM types and nitrogen fertilization.

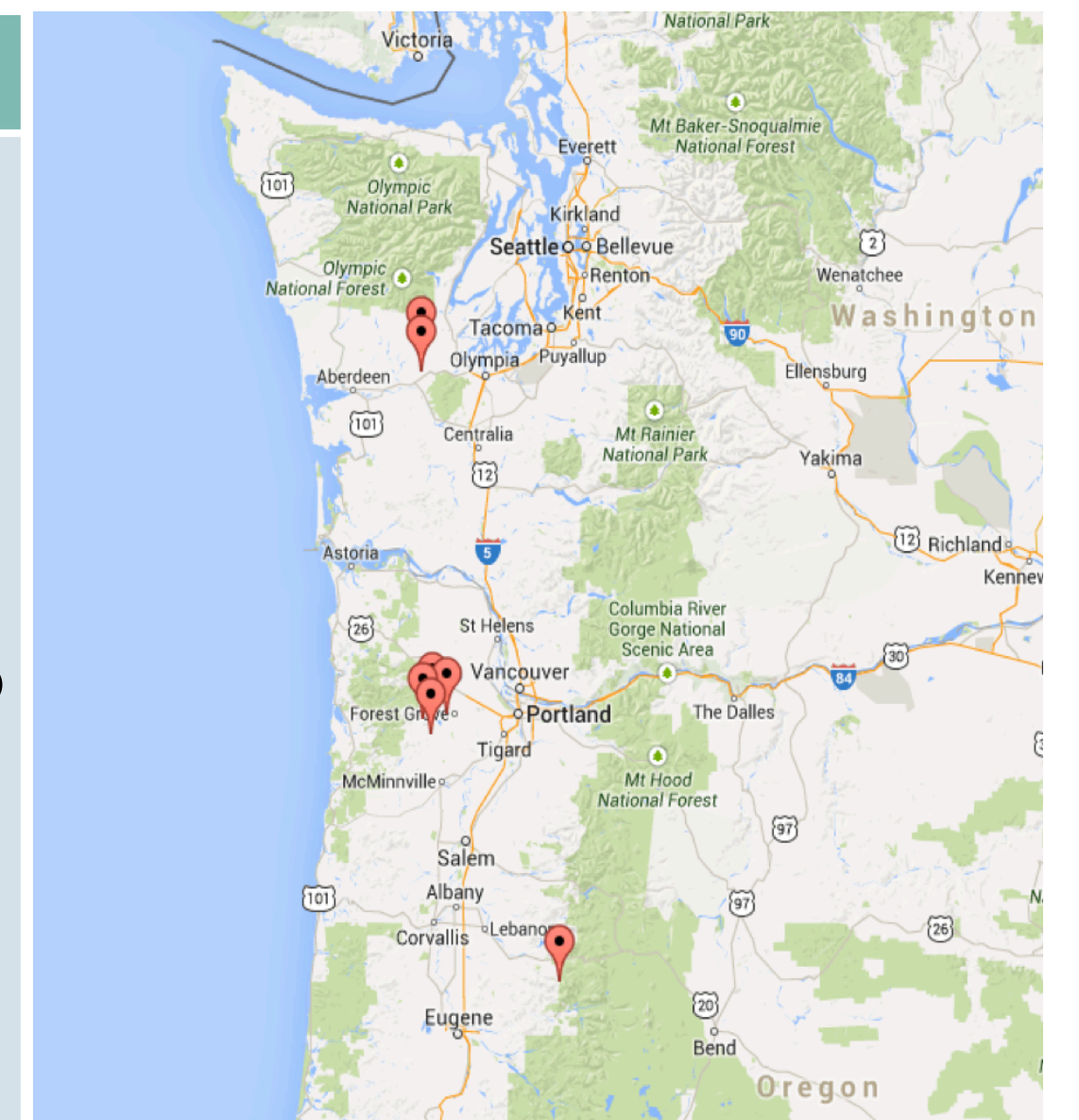


Figure 1. Geographical distribution of installations in the Pacific Northwest. Google Map



Figure 2. Sense felled tree for log resonance measurement.



Figure 3. Wood disks cut from sample trees.

## METHODOLOGY

Seven sites were selected from western Washington and western Oregon for the analysis, including four types of soil parent material, Glacial, Sedimentary, Igneous, and the Mixed (Sedimentary and Igneous). At the time of installation establishment, trees were fully measured and trees with similar DBHs were paired up. Thereafter, selected dominant and co-dominant trees within a pair were randomly assigned to be either treated with nitrogen fertilizer (urea 224kg ha<sup>-1</sup>) or not to be as control trees.

At five installations, increment cores were extracted at breast height from selected pairs. At the other two installations, after obtaining tree sonic measurements, trees were felled and bucked sequentially, segments were sensed with an acoustic resonance instrument Director<sup>®</sup> Hitman-200 to obtain log resonance acoustic velocity. Disks were cut from each felled tree at predetermined heights(stump, breast height, height up to 5.03 m, and top with diameter of 10 cm). Sixty eight (68) Douglas-fir trees were assessed in total.

## RESULT

Douglas-fir quality responses were statistically analyzed using analysis of covariance (ANCOVA) in R Studio<sup>®</sup>, Version 0.98.953 (R 3.0.0) with split plot design. Replication at whole plot level was the individual study site under the same SPM category; replicates at split plot level were the paired-tree samples. ANCOVA can help to reduce variability from measurable stand parameters, in this study, featuring site elevation, site index, soil effective depth of A-horizon, breast height age and stand density. Results suggest additional nitrogen has influential negative impact toward four respects of wood quality, namely modulus of elasticity, specific gravity, latewood percentage, and rings per inch. Though SPM type was determined to have no significant impact, we discovered trees sampled from Glacial SPM sites were characterized with the densest wood. Nevertheless, tree growth assessments (including diameter at breast height, height, and volume) indicate Douglas-fir grew on Glacial sites failed to take advantage of nitrogen fertilization.

Trees were felled and disks were obtained at two study sites (the Mixed and Sedimentary site). It is clear that wood quality declines as the height from the ground increases. Besides, fertilization treatment consistently decreases rings per inch by enhancing Douglas-fir lateral growth; as for the specific gravity and latewood percentage results, fertilized trees had stiffer wood on the trees' upper section, unfertilized trees had stronger wood for lower sections.

Both tree sonic acoustic velocity (TSAV) and log resonance acoustic velocity (LRAV) were obtained at two sites where trees were felled. Additional nitrogen enhanced TSAV and LRAV results for both the Mixed and Sedimentary SPM sites. Furthermore, a strong correlation between TSAV and LRAV was seen ( $R^2 = 0.92$ ), TSAV was 8% higher than LRAV in butt log segment.

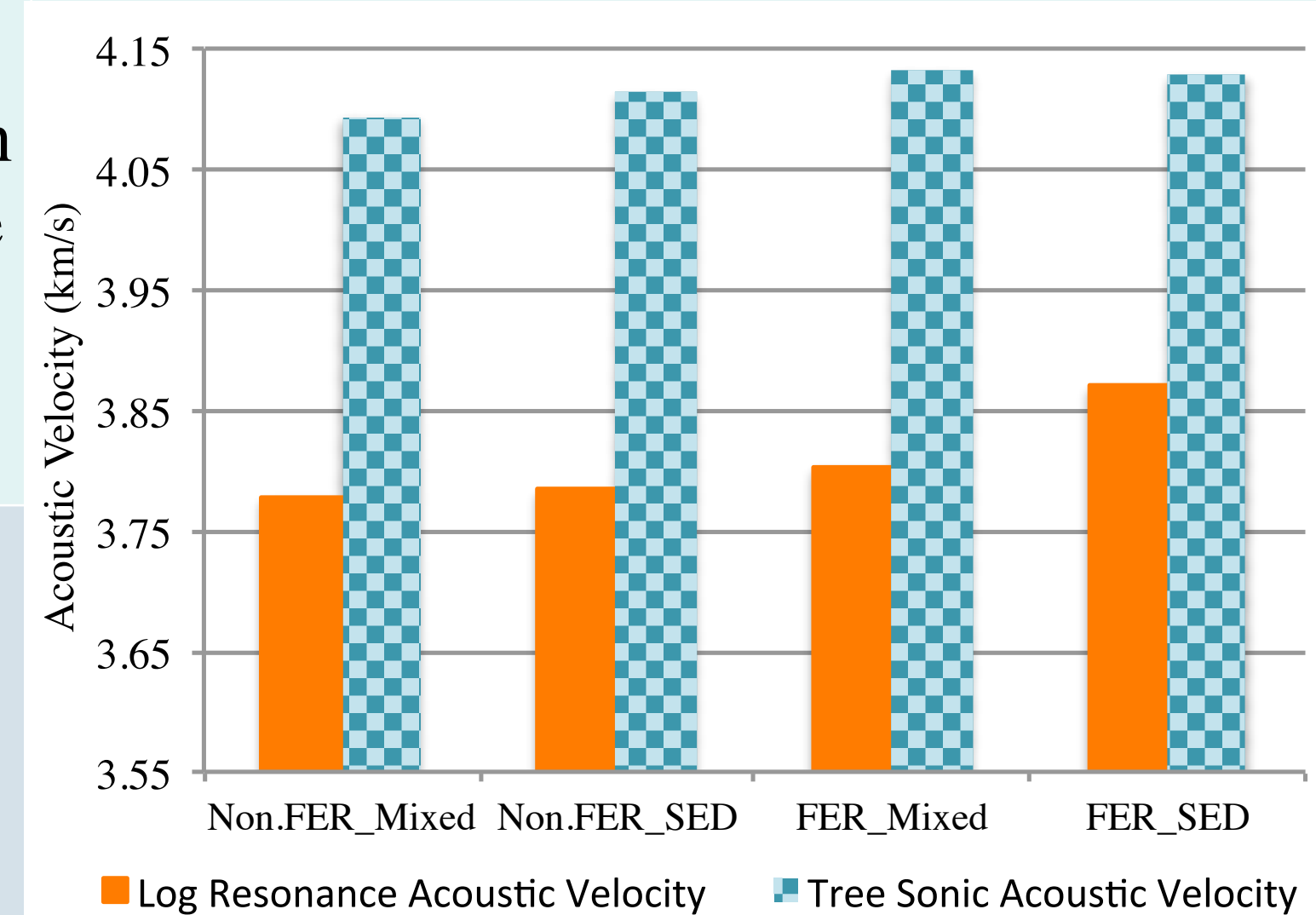


Figure 7. Butt log LRAV and TSAV

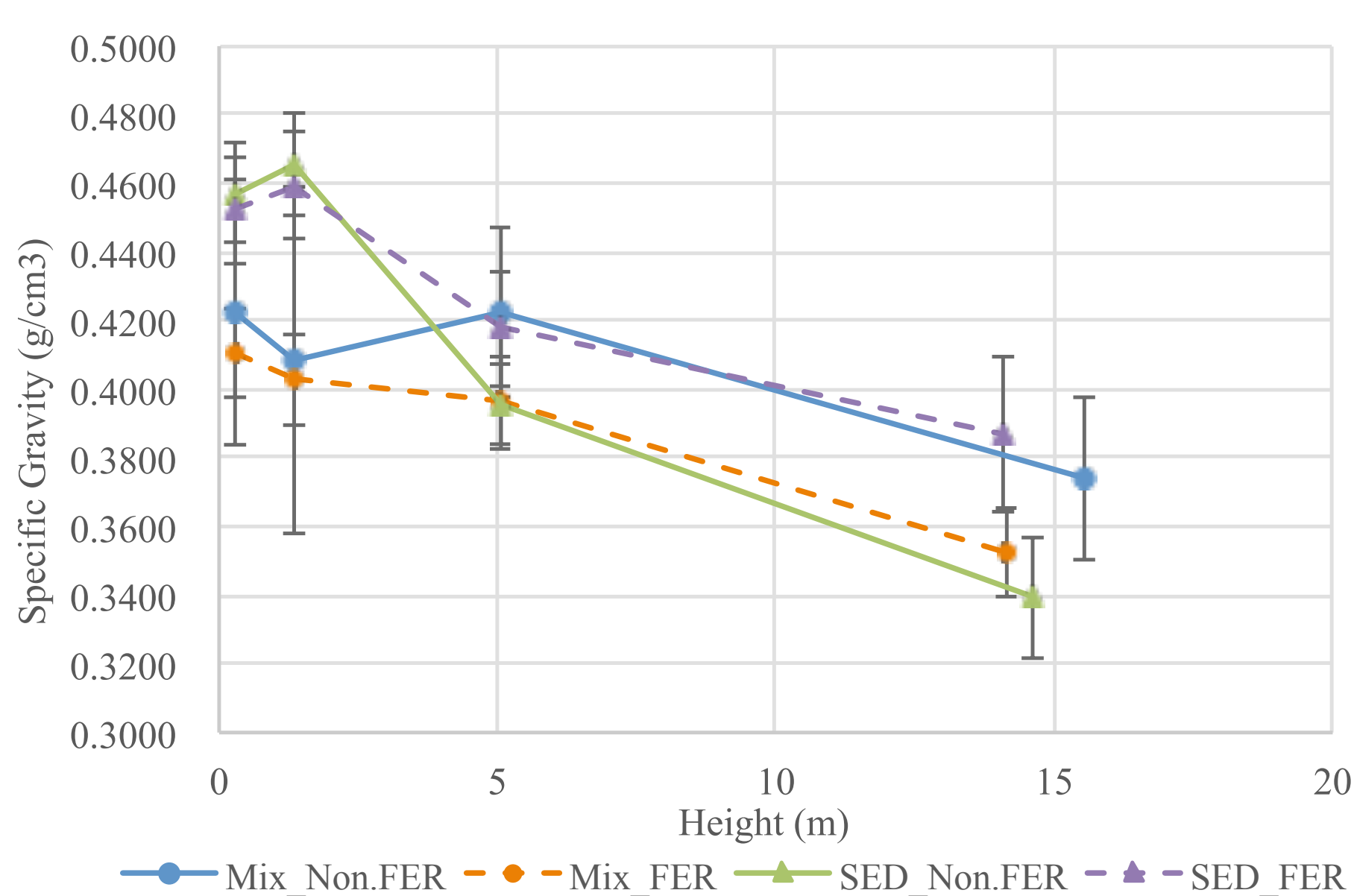


Figure 4. Specific gravity along height as related to Soil Parent Material and fertilization treatment, vertical bars represent the standard errors.

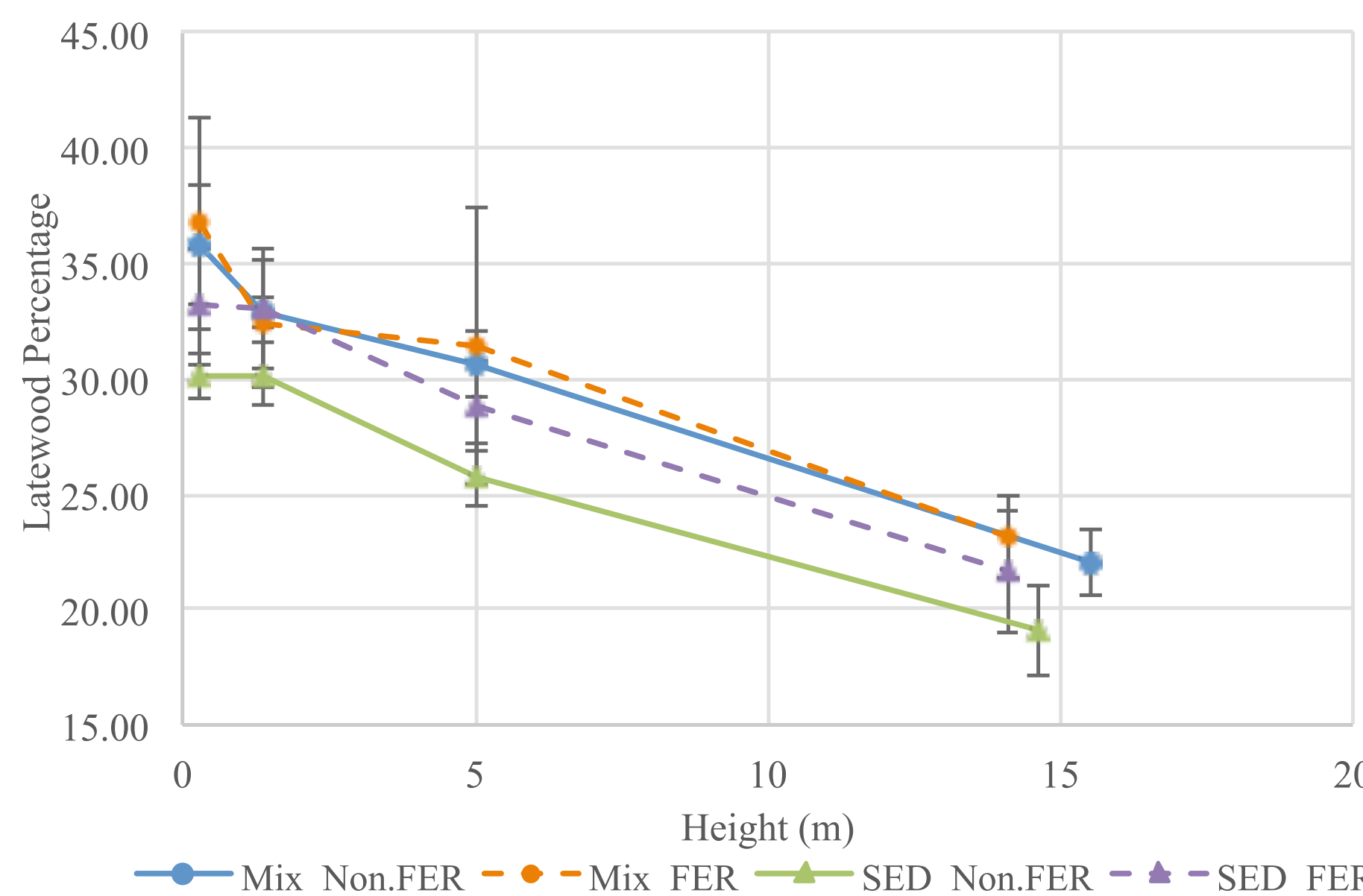


Figure 5. Latewood percentage along height as related to Soil Parent Material and fertilization treatment, vertical bars represent the standard errors.

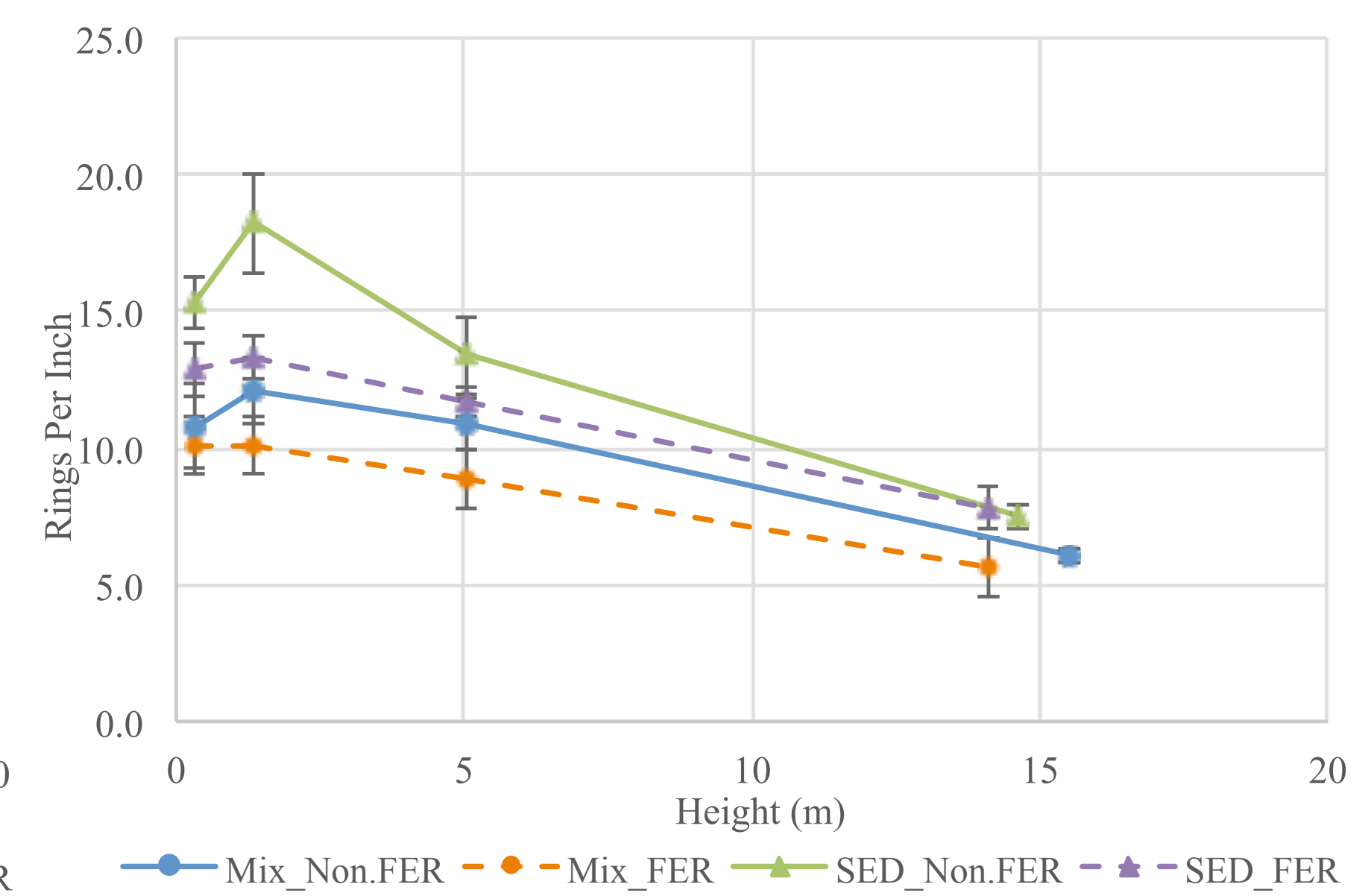


Figure 6. Rings per inch along height as related to Soil Parent Material and fertilization treatment, vertical bars represent the standard errors.

## CONCLUSION

SPM types had no significant effect on any aspect of quality assessed in this study, but fertilization had a generally negative effect on modulus of elasticity, specific gravity, latewood percentage, and rings per inch at measured breast height region. From a whole tree standpoint, fertilization did not necessarily decrease specific gravity and latewood percentage for the upper section. A strong correlation between TSAV and LRAV was detected while TSAV was generally 8% higher than LRAV.

## ACKNOWLEDGEMENTS

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