

## Tree Rings and Forest Management Shaped by the Solar Cycle

V. Šimůnek<sup>(1)\*</sup>, Z. Vacek<sup>(1)</sup>, S. Vacek<sup>(1)</sup>, M. Švanda<sup>(2,3)</sup>, V. Hájek<sup>(1)</sup>, G. D'Andrea<sup>(1)</sup>

<sup>(1)</sup> Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Kamýcká 129, CZ – 165 21 Prague 6 – Suchbát, Czech Republic

<sup>(2)</sup> Astronomical Institute of the Czech Academy of Sciences, Fričova 298, 25165 Ondřejov, Czech Republic

<sup>(3)</sup> Astronomical Institute, Charles University, Faculty of Mathematics and Physics, V Holešovičkách 2, 18000 Praha, Czech Republic

\*Corresponding author: simunekv@fld.czu.cz

Forestry management in Central Europe heavily depends on one of its most important tree species, Norway spruce (*Picea abies* [L.] Karst.). However, these forests face significant disturbance cycles, characterized by large-scale calamities caused by natural factors such as drought, windstorms, and outbreaks of bark beetles. The interaction between natural conditions and tree growth, particularly in relation to salvage logging, has not been comprehensively studied. In Central European forestry, there is no well-defined concept linking cyclical calamities to forest health or tree growth. This study investigates timber harvests in the Czech Republic and their relationship to tree-ring growth in Norway spruce across six research sites. Salvage logging, the dominant form of harvesting, is closely tied to spruce forests, as Norway spruce is the most frequently logged tree during calamities. It refers to timber harvesting triggered by climatic disturbances, involving the removal of damaged or infested trees from the forest. The study analysis reveals a clear connection between tree-ring growth and timber harvesting cycles. Spruce timber harvests exhibit a strong correlation with the solar cycle, represented in this study through Sunspot Number data. In addition, the salvage logging shows a distinct relationship with the 11-year solar cycle, mediated by total solar radiation and seasonal temperature variations. Tree-ring series of Norway spruce indicate minimal growth one year prior to peaks in timber harvests. Furthermore, maximum harvests coincide with solar minima, while the lowest tree-ring growth precedes these harvest peaks. During periods of low timber harvests, tree-ring growth stabilizes at average levels, aligning with solar maxima. The study also finds that timber harvest cycles follow a common 11-year rhythm. This reveals the connection between solar activity, tree-ring patterns, and spruce logging. The relationship is from both direct and indirect effects of solar activity on Earth, influencing tree growth through climatic factors such as the North Atlantic Oscillation and seasonal temperature or precipitation fluctuations. This complex chain of influences has not been fully understood until now, yet its impact on forest management is evident. Norway spruce forests are economically valuable, and the effects of the 11-year solar cycle are deeply embedded in their management. This study provides new insights across various disciplines, offering opportunities to develop improved tools for predicting forest health and productivity. These findings may have practical applications not only in forestry but also in other sectors impacted by climate change, such as agriculture. Future research in this area could enhance our understanding of cyclical weather patterns affecting the Czech Republic and Central Europe, enabling better preparation and adaptation strategies to mitigate the effects of climatic fluctuations on natural and economic systems.

Keywords: Forest management / Sunspot number / Total solar irradiance / *Picea abies* (L.) Karst. / North Atlantic Oscillation

Publication: Šimůnek, V., Vacek, Z., Vacek, S., Švanda, M., Hájek, V., D'Andrea, G., 2024. Norway spruce forest management in the Czech Republic is linked to the solar cycle under conditions of climate change – from tree rings to salvage harvesting. Sp. Weather Sp. Clim. 14. [https://doi.org/https://www.swsc-journal.org/articles/swsc/full\\_html/2024/01/swsc230016/swsc230016.html](https://doi.org/https://www.swsc-journal.org/articles/swsc/full_html/2024/01/swsc230016/swsc230016.html)