Flexible open-source software for modelling wind disturbance and damage to trees and forests

Tom Locatelli\(^1\), Sophie Hale\(^1\), Bruce Nicoll\(^1\), and Barry Gardiner\(^{1,2}\)

\(^1\)Forest Research, Northern Research Station, Roslin, Scotland, UK
\(^2\)INRA - Unité EPHYSE, Villenave D'Ornon, France

Wind disturbance to forests extends across spatial and temporal scales and encompasses direct and indirect wind effects on the dynamics of forest ecosystems. It is detrimental to the provision of ecosystem services and reduces forest resistance and resilience to future natural disturbances. Historically, in the ecological and land-use scientific communities, forecasting the extent and probability of wind disturbance to forests has represented a serious challenge, with most studies electing to adopt qualitative or statistical approaches. The low degree of portability of statistical assessments of vulnerability to wind has limited their applicability and use, but it is recognised that they have a role in building hypotheses of the processes involved in wind damage that can be subsequently tested under experimental conditions. Results from tree stability experiments have contributed, in the last two decades, to the development of a mechanistic model of wind damage - ForestGALES. This is a process-based wind risk model that was originally created to inform the management of commercial forest plantations in the UK. Built on principles of forest science, physics, and ecology, ForestGALES requires a simple set of inputs and it has now been expanded to cover more than 20 common conifer species from across three continents, and multiple broadleaved species (e.g. Oak, Beech, Birch, and Eucalypts). Two methods of assessing vulnerability to wind damage are available in ForestGALES, one designed for application at stand level, and a novel approach that estimates vulnerability to wind at the individual tree within a stand – the latter allowing for use in complex forest stands, and for the effect of competition between trees in a stand. Until recently, ForestGALES was only available as desktop software and as an online tool as part of forest decision support systems (only for selected countries and species). These formats can be limiting for research and academic projects that aim to model and understanding wind disturbance dynamics across diverse landscapes, and that require a bespoke approach with a high degree of flexibility. To accommodate these broader requirements, ForestGALES has recently been redeveloped and released as a FOSS R package (“fgr”) that is fully customisable and easily integrated in R and modelling workflows and FOSS GIS frameworks. With this poster we present two exemplar studies of assessing wind damage risk to forested landscapes, one for each ForestGALES method (stand- and individual trees level), to showcase the capabilities and flexibility of the model in working with e.g. climate projection data, with other process-based models (e.g. 3PG) within an R modelling framework, and with LiDAR data, at the individual tree level.