**Statistics in R Assessment**

*Background*

Tree budburst timing is influenced by individual, species-specific, and environmental factors. Genetic variation causes individual trees to vary in budburst in response to uncertain environmental conditions (Zohner et al., 2017). Further, larger and older trees are thought to bud earlier, however studies have shown this size relationship to be not consistent across species and habitats, for example in temperate forests (Makita et al., 2021; Liang & He, 2021). Species differences are suggested to confer sensitivity to climate variables that influence budburst, for example, temperate deciduous species’ budburst is highly variable in response to warmer spring temperatures whereas boreal conifers are less variable (Fu et al., 2015; Basler & Körner, 2012). Local adaptation in diverse forest types, such as boreal and temperate forests, suggests that trees within each population respond distinctly to climate cues, as observed in studies of black spruce and multispecies temperate forests (Partanen et al., 2018; Kikuzawa & Mizui, 2020). Climate is a critical factor, with warmer springs generally advancing budburst. However, mild winters may delay it if chilling requirements are not met (Vitasse et al., 2014). This complex interplay of factors emphasizes the importance of considering local and species-specific responses to understand tree budburst timing.

You have been given four datasets: phenology.csv, trees.csv; girth.csv and SilwoodWeatherDaily.csv. Please see the documents metadata.pdf and WeatherStation.pdf for information about these datasets. You need to do some data wrangling, such as merging of data frames. You can do this easily using the “merge” function in R and combine datasets using a common column name, such as “TreeID”. However, the whole point of this assessment is to get you performing statistical analyses and writing a statistical methods section and results section as you would see in a published research article **NOT** spending a large amount of time wrangling data.

Budburst has been assessed using an ordinal variable and there are lots of instances where the certainty of score is lacking, for example, “<1”. This poses a significant challenge for you as an applied statistician. You could choose to focus on a specific bud developmental stage (1=first sign of budburst), decide what to do with those where certainty seems to be lacking and convert the date to Julian date or day within a year, for example the second of January would get a value of 1, and use this number as your response variable.

From these datasets you need to devise a research and hypothesis(ses) you are going to investigate. We’d strongly recommend you do **ONE** sound statistical analyses, but you are free to do more if think this is appropriate. Here are some indicative research questions:

*Ideas for Research Questions*

* How repeatable is budburst?
* What are differences in budburst among tree species?
* Do larger trees budburst earlier or later than smaller trees?
* How does temperature impact budburst?

You can take these research questions to look at general patterns across the whole dataset, dig deeper into specific-species or genera, or look at interaction effects. These decisions are up to you.

*Expectations*

* You have a maximum of three pages of A4.
* You need to indicate clearly what your research question and hypothesis(ses) is/are.
* You need to write a statistical methods section and a results section as you would see in a paper.
  + TIPS: **Everything** in your statistical methods needs to be justified, and you need to relate your results back to the underlying biology/ecology **briefly**.
  + Don’t forget to write a descriptive statistics paragraph in your results.
* We’d recommend performing a linear model or a derivative – generalised linear model, linear mixed model, generalised linear mixed model etc. This means you will need to present a table of coefficients and a supporting figure for your analysis(ses). If you have more than one analysis, you can provide more tables and figures but be very wary of the page limit and figure size.
* You **DO NOT** need to provide or submit any code that you have used to do the analysis. We should be able to reproduce your analysis given what you have written in the statistical methods, therefore you might have to give some brief details of your data wrangling and how you have formed/calculated the variables you have modelled.

**Deadlines and Marking**

* Submit a pdf version of your write-up on Blackboard by 1pm on the 15th of November.
* The marking criteria to be used for this assignment will be the project marking criteria. See Silwood Handbook for this.
* Marks and feedback will be released on the 29th of November.

**References**

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* Fu, Y. H., Campioli, M., Deckmyn, G., & Janssens, I. A. (2015). Sensitivity of leaf unfolding to temperature, photoperiod, and climate warming in four temperate tree species. New Phytologist, 208(3), 626-635.
* Kikuzawa, K., & Mizui, N. (2020). Timing of bud burst and tree-leaf development in a multispecies temperate forest. Botanical Review, 86(1), 66-81.
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* Makita, N., Katoh, S., Tanaka, K., & Koike, T. (2021). Does ontogeny matter for the spring temperature requirement for bud burst of two coniferous species in cool-temperate forests? Frontiers in Forests and Global Change, 4, 123.
* Partanen, J., Koskela, J., & Leinonen, I. (2018). Common‐garden experiment reveals clinal trends of bud phenology in black spruce populations from a latitudinal gradient in the boreal forest. Plant Ecology, 219(5), 615-625.
* Pope, K. S., Da Silva, D., Brown, P. H., & DeJong, T. M. (2014). A biologically based approach to modeling spring phenology in temperate deciduous trees. Agricultural and Forest Meteorology, 198-199, 15-23.
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* Zohner, C. M., Mo, L., Renner, S. S., & Pau, S. (2017). Global patterns of leaf out phenology and climate drivers. New Phytologist, 216(2), 510-515.