Sensitivity of Mediterranean Riparian Forests (Rhône River, France) to Climate Driven Water Availability

Department of Earth & Environmental Sciences, University of St Andrews
In partnership with University of Stirling and CASE Partner Centre National de la Recherche Scientifique, CNRS (France)

Supervisory Team
- Michael Singer, St Andrews
- Jens-Arne Subke, Stirling
- Hervé Piégay, CNRS (CASE Partner)

Key Words
stable isotopes, dendrochronology, δ13C, climate change, ecohydrology, drought stress

Overview

There is an increasing body of research documenting increased water use efficiency by trees in response to rising atmospheric CO₂. It has been suggested that this increased efficiency would yield more water in the root zone and therefore, higher continental runoff. However, none of these studies has thus far constrained the impact that climate has had on water availability at the root zone, irrespective of rising CO₂. In many ecosystems, plant-available water is becoming limited as soils dry out due to lower precipitation, as evaporation rises under warmer temperatures, and as water tables decline. Since there are limits to plant adaptations to moisture limitation, a decline in climatically-driven water availability may prove damaging or fatal, particularly to trees in forests that are vulnerable to water stress. Additionally, increases in the spatial footprint of climatically controlled water stress could potentially drive shifts in species composition and ecological functioning over large forested areas of the globe.

Riparian floodplain forests in Mediterranean-type climates (hot/dry summer, cold/wet winter) are particularly sensitive to water stress and projected trends in regional hydrology over the coming decades may create irreversible consequences for this ecologically important, yet fragile, vanishing biome. Climate fluctuates year on year and this impacts how much water is available to trees in riparian forests. Tree growth directly responds to such water availability, particularly for Mediterranean species, but the ecohydrological relationships under a fluctuating climate between water availability and tree water use and growth are poorly understood.

These factors raise a fundamental, yet unanswered, Earth system science question, which is the key to predicting evolution of forests over broad regions: How do forest trees in water-limited ecosystems respond to fluctuating levels of root zone moisture and how will such ecohydrological relationships be affected by projected climate changes over the coming decades?
The PhD student will conduct field work at various sites along the Rhône River in beautiful SE France and will conduct laboratory analyses on isotopes in tree-ring cellulose at St Andrews. The goal is to quantify and clarify how seasonal variability in water sources and availability corresponds to annual isotopic signatures recorded within tree rings. Water stress associated with drought is of particular interest and current theory of how this expressed in carbon isotopes remains undeveloped. Such understanding will improve efforts to characterise past climatic influences on tree growth over large areas and to predict growth responses to changing climate within individual trees, across forest stands, or even over broad regions.

Methodology

This project will involve extensive spring/summer fieldwork at several sites along a major climatic gradient in SE France to obtain tree cores and conduct field characterization of site conditions and forest health. While in France, the student will be based at CNRS (CASE partner) in Lyon. Back in St Andrews, the PhD student will develop dendrochronology for sampled trees and extract cellulose from rings by established methods for isotopic analysis of $\delta^{13}$C. This will provide information on the efficiency of water use in response to water availability (currently being examined in a separate PhD project via $\delta^{18}$O analyses and modelling). The proposed research is expected to provide new metrics for assessing riparian forest health in response to varying water availability and drought stress.

Timeline

In Year 1, the PhD student will conduct a literature review, embark on an extensive field season, develop dendrochronologies for two co-occurring tree species and work in the laboratory to extract cellulose and analyse $\delta^{13}$C in annual tree rings. Year 2 will consist of additional field and laboratory work, analysis of climatic data, and the use of mechanistic models of isotopes in tree ring cellulose. Year 3 will include additional field and lab work, but will place the largest emphasis on analysing all data and writing up all the research into the thesis. Year 3 will also be the time to present the research at major international conferences such as AGU in San Francisco and/or EGU in Vienna. The expectation is that the student will generate several peer review publications in this research, and there is great potential for them to be in high profile journals.

Training & Skills

In this research project, the PhD student will gain several important skills including various types of field work, isotope dendrochronology, time series analysis of climate data, mechanistic modelling of tree water use. In addition, the student will be encouraged to participate in various training workshops within and outside of NERC.

References & Further Reading


Further Information

Please email: michael.singer@st-andrews.ac.uk