# Climate-controlled water availability to riparian forest trees

## Influence du climat sur la disponibilité en eau pour les arbres de forêt riveraine

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## RÉSUMÉ

Durant la saison de croissance, les forêts dépendent d'un approvisionnement adéquat en eau de la zone racinaire. En l'absence d'une telle disponibilité en eau, la croissance de la végétation peut être réduite par la fermeture des stomates pour éviter la perte d'eau (efficacité accrue de l'utilisation de l'eau). Ainsi, les conditions de sécheresse peuvent entraîner une croissance médiocre lors des années particulièrement sèches, et des déclins à long terme de la santé des forêts peuvent prévaloir en cas de sécheresse prolongée. Un défi majeur en matière de recherche et de gestion est de comprendre les variations des ressources en eau dans la zone racinaire et les réponses des forêts à la disponibilité de l'eau. Cette connaissance aiderait à prédire comment l'écohydrologie forestière pourrait réagir aux conditions de réchauffement / assèchement prévues dans de nombreuses régions à l'avenir. Si le stress hydrique physiologique pouvait être prédit sur la base de la quantification des variations de la disponibilité en eau à des profondeurs d'enracinement critiques, cela pourrait permettre d'améliorer les stratégies de gestion de l'eau visant à tirer profit des arbres forestiers. Notre groupe de recherche a développé un ensemble d'outils (analyse isotopique des anneaux de croissance, modélisation numérique des flux d'eau) pour étudier la disponibilité en eau liée au climat dans les forêts riveraines. Les forêts riveraines permettent d'étudier la variabilité de la disponibilité de l'eau souterraine à plusieurs profondeurs, où des drivers climatiques divergents peuvent opérer (régime de fonte des neiges en champ lointain vs équilibre local entre précipitations et évaporation).

## ABSTRACT

Forests depend on adequate supplies of root-zone water during the growing season. In the absence of such water availability, vegetation growth can be curtailed by stomatal closure to prevent water loss (increased water use efficiency). Thus, drought conditions can result in poor growth for particularly dry years, and long-term declines in forest health may prevail for prolonged dryness. A major research and management challenge is to understand variations root-zone water sources and corresponding forest responses to water availability. This knowledge would aid in prediction of how forest ecohydrology may respond to warming/drying conditions that are forecast for many regions in the future. If physiological water stress could be predicted based on quantification of variations of water availability at critical rooting depths, it might allow for improved water management strategies aimed at benefiting forest trees. Our research group has been developing a set of tools (tree-ring isotopic analysis, numerical modeling of water fluxes) to investigate climate-driven water availability to riparian forests. Riparian forests provide an opportunity to investigate the variability in subsurface water availability at multiple depths, where divergent climate controls may operate (far-field snowmelt regime versus near-field local balance between rainfall and evaporation).

## KEYWORDS

Drought, ecohydrology, forest health, isotopes, water cycle

# CLIMATE-CONTROLLED WATER AVAILABILITY TO RIPARIAN FOREST TREES

## 1.1 Water availability

Subsurface water in riparian zones is controlled by climate. Shallow soil moisture is affected by the balance between precipitaiton and evaporation, while deeper groundwater aquifers are affected by regional groundwater drainage and support from main river systems. The water balance in each of these critical floodplain stores is likely to vary through time according to the local expression of each of these climatic balances: far-field (snowmelt runoff regime) and near-field (precipitaiton/evaporation). Thus, tree rooting depth and floodplain material properties are important determinants of water sourcing by particular species (Fig. 1). The methods described here may enhance forest and water management in riparian zones along large rivers. Employing the combination of isotopes in water and tree rings with numerical modelling may enable water managers to design instream flow regimes for maximum benefits to both water users and terrestrial vegetation.They may also enable forest managers to identify threats to particular tree species or forest plots.

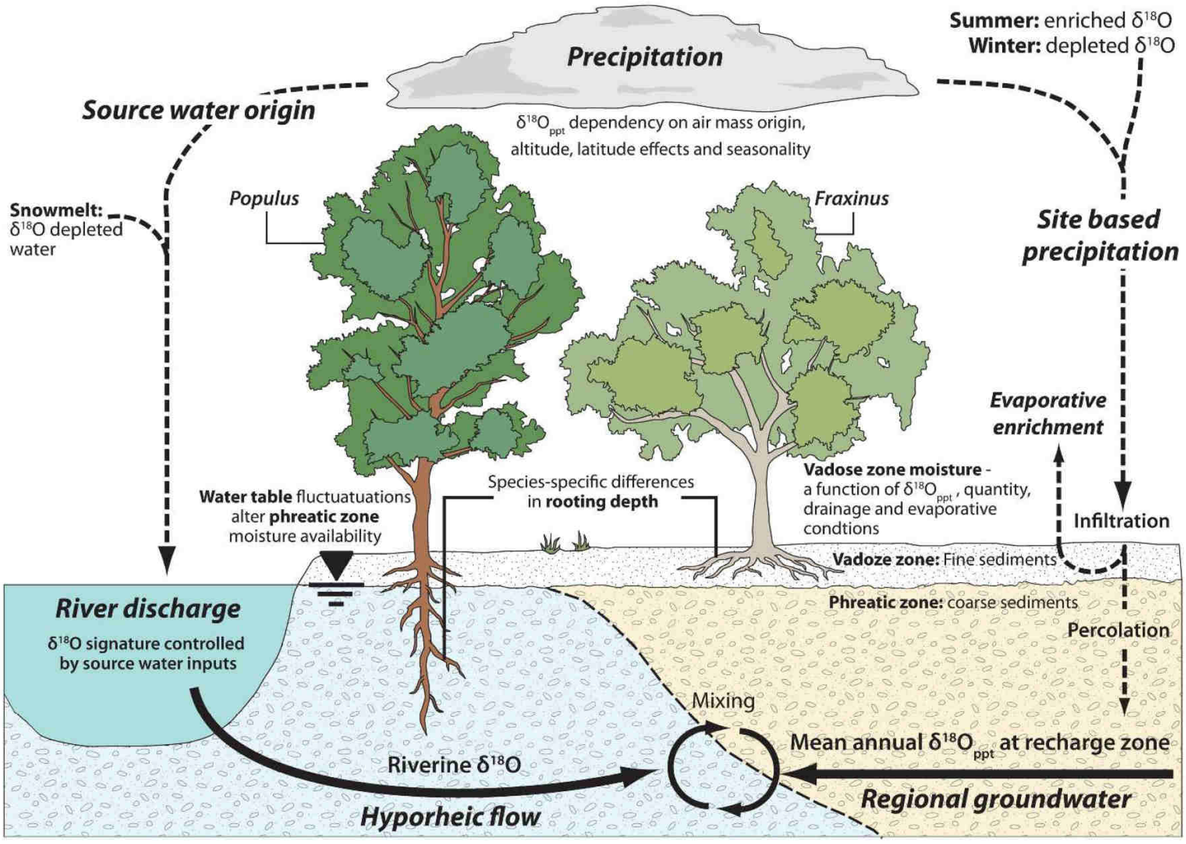


Figure 1: Conceptual diagram of isotope hydrology within the riparian zone. Common riparian species *Fraxinus excelsior* and *Populus nigra* are shown to have differing access to water sources which can be identified isotopically (Sargeant and Singer, 2016).

## 1.2 Model of water fluxes

We have developed a model that operates within river floodplains to explore the relative contributions of groundwater versus infiltrated precipitation within a complete depth profile. The model, HAUGHFLOW, combines Richards equation (infiltration into the unsaturated zone) with the Boussinesq equation (lateral subsurface flow into the saturated zone), to assess the time varying properties of moisture for a range of depths (Fig. 2).

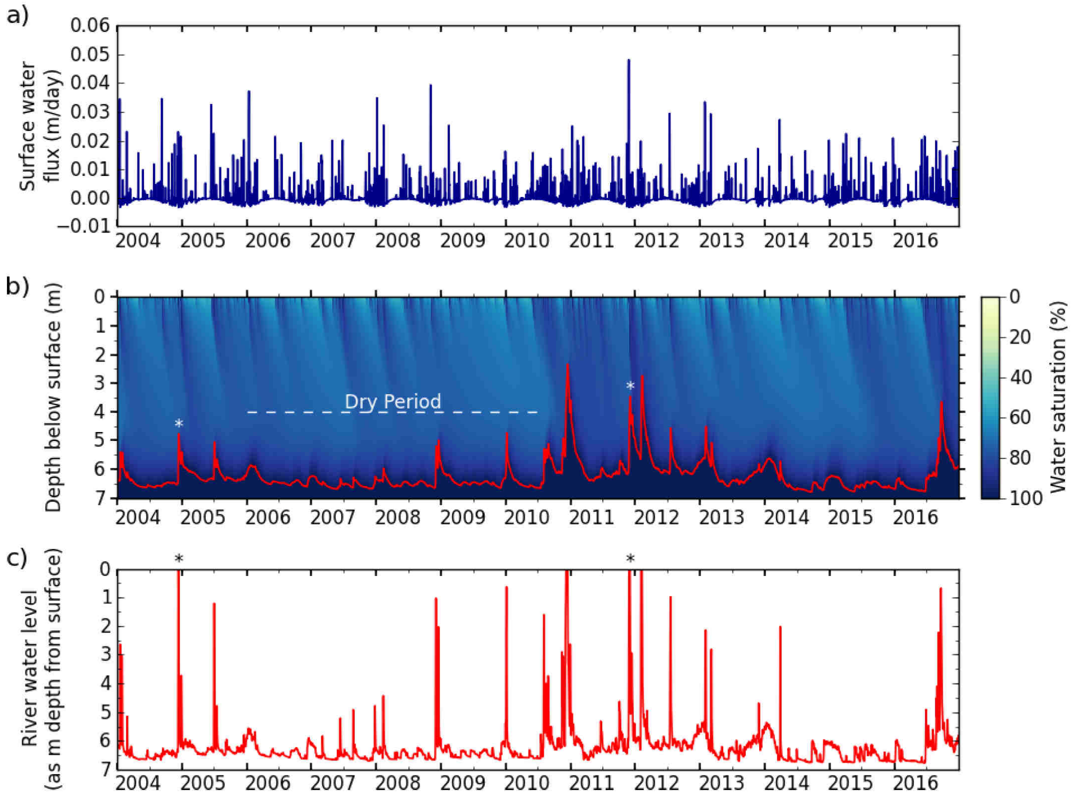


Figure 2: Example results using HAUGHFLOW showing the surface flux (a), saturation profile (b) and river stage (c) time series for a riparian site in Australia (Evans et al, 2018).

## 1.3 Isotopes

Isotopes in tree rings provide information on water use by trees on an annual or even subannual basis (Fig. 3). Our work in this area has detected contrasting water-use strategies by individual trees of different species within a forest site, and also for the same species across a strong hydroclimatic gradient. This method, combined with water flux modeling (Fig 2), provide a pathway for retrospectively assessing water source variation to trees and the corresponding impacts to tree health. This set of methods could be used a management tool to ascertain the potential impacts of climate change (warming/drying trends) to riparian forest health.

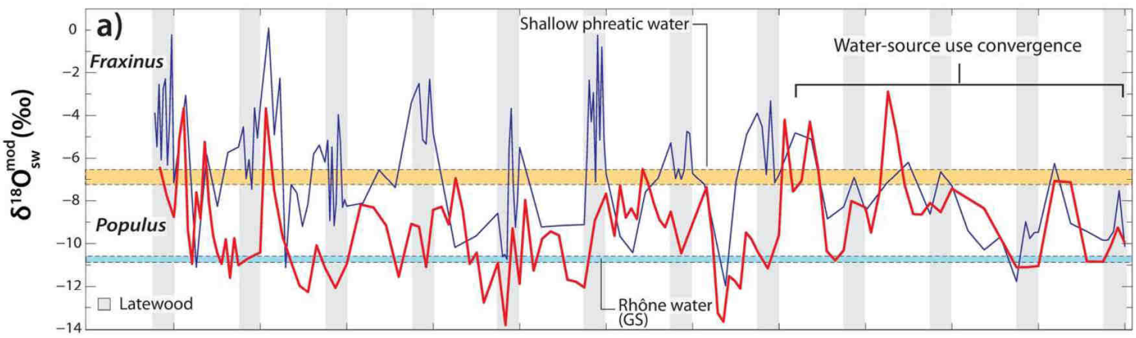


Figure 3: Time series of: (a) Modelled sub-annual tree isotopic source water values and mean Rhône River (growing season) and shallow phreatic water (growing season) $\delta^{18}O$; (Sargeant and Singer, 2016).

# LIST OF REFERENCES

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