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The Ant and the Grasshopper: contrasting responses and behaviors to water stress of riparian trees along a hydroclimatic gradient

International Congress in Ecology and Evolution (SFE²)| Lyon, 22 October 2024

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Pierre Lochin, Julien Godfroy, Baptiste Marteau, Hervé Piégay, Sara Puijalon

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Riparian forests, an endangered ecosystem

Ecosystem service	Herbs/grass	Forest	Wet forest	Wetlands	ES Importance High to Low
Providing habitats	High	High	High	High	High to Low
Filtering/storage of particles	High	Medium	High	High	
Fixation storage	Medium	High	High	High	
Erosion control	High	Medium	High	High	
Providing habitats for native pest control agents	High	High	High	Unknown	
Flow regulation - The capacity of vegetation to retain water and release it slowly	Medium	Medium	High	High	
Removal of nutrient in runoff	Medium	High	Medium	High	
Landslide	Low	High	High	Low	
Pollination	High	High	Low	Low	
Evaporative cooling by urban riparian trees	Low	High	High	Low	
Standing crop of woody biomass	Low	Medium	Medium	Low	
Seeds, spores and harvestable genes	Unknown	High	Unknown	Unknown	
The capacity of riparian vegetation to reduce frequency, spread or magnitude of fires	Unknown	Unknown	Unknown	High	
Standing crop of non-woody biomass	Low	Low	Low	Medium	
Harvestable volume of wild berries or other	Low	Low	Low	Low	
Seed and propagule dispersal	Unknown	Unknown	Unknown	Unknown	

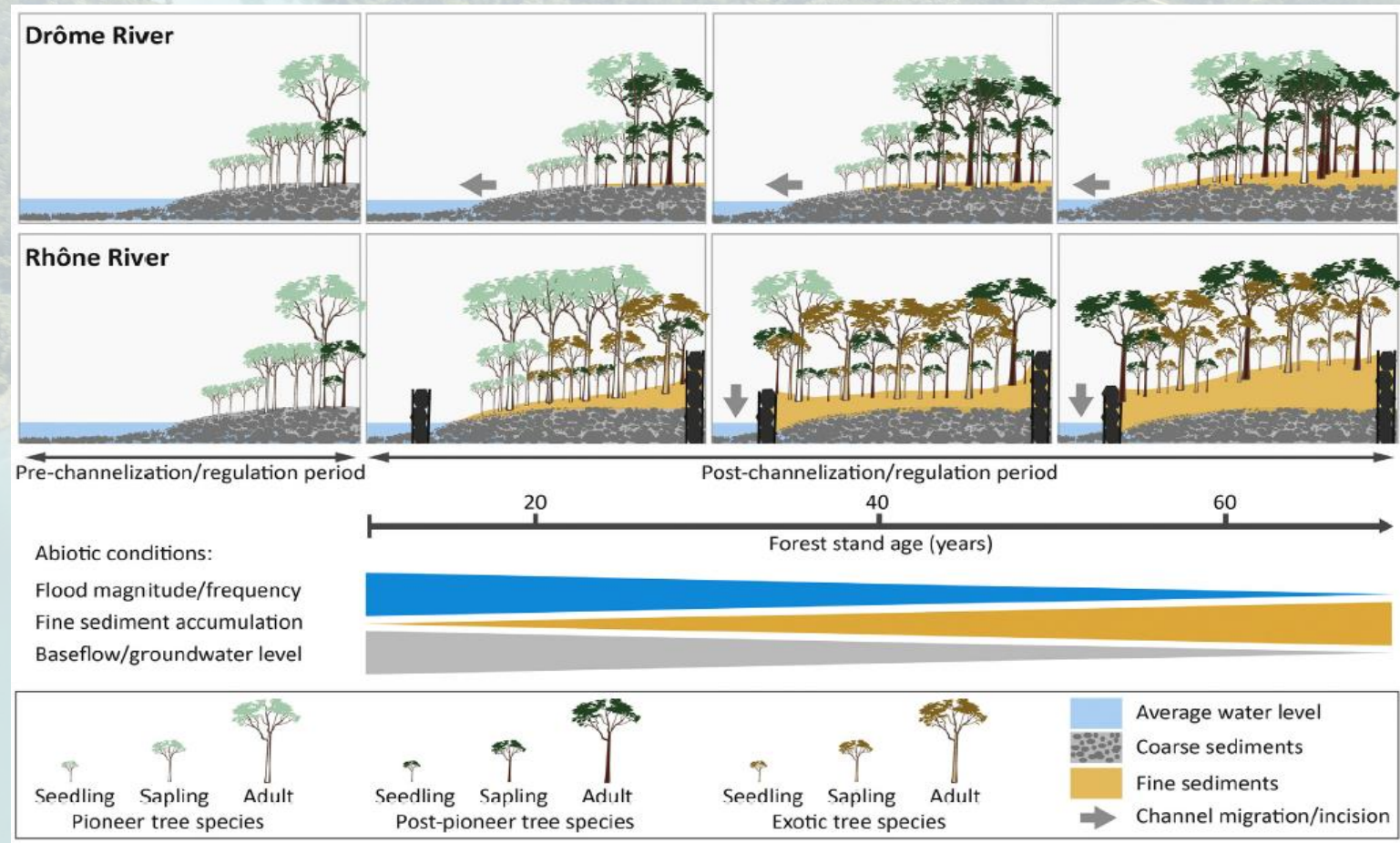
Riis et al., 2020



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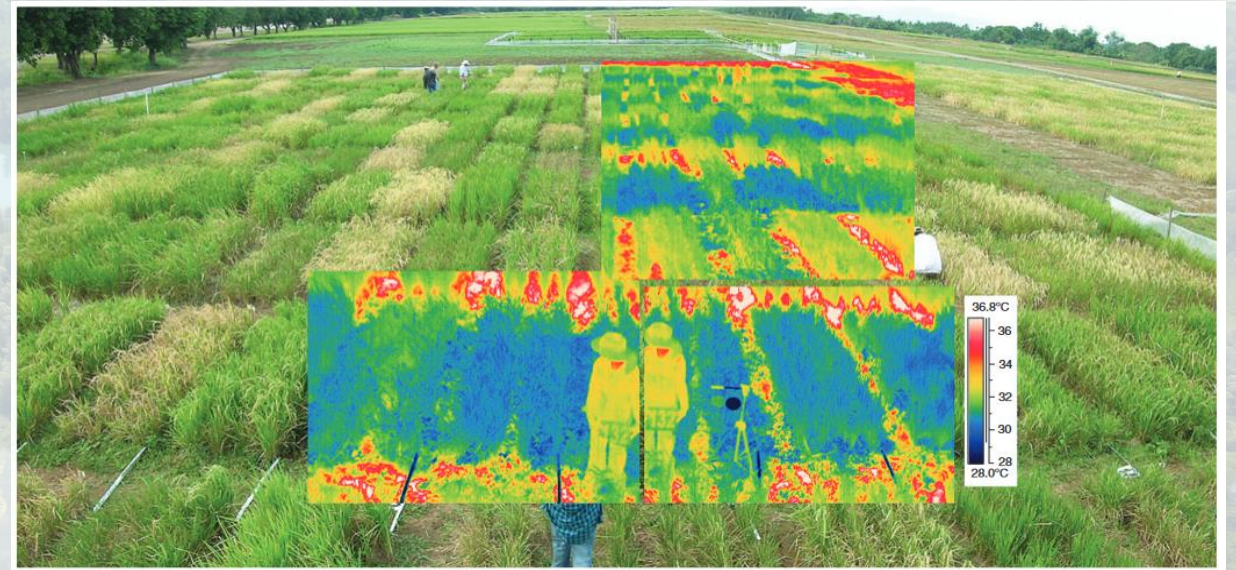
Riis et al., 2020



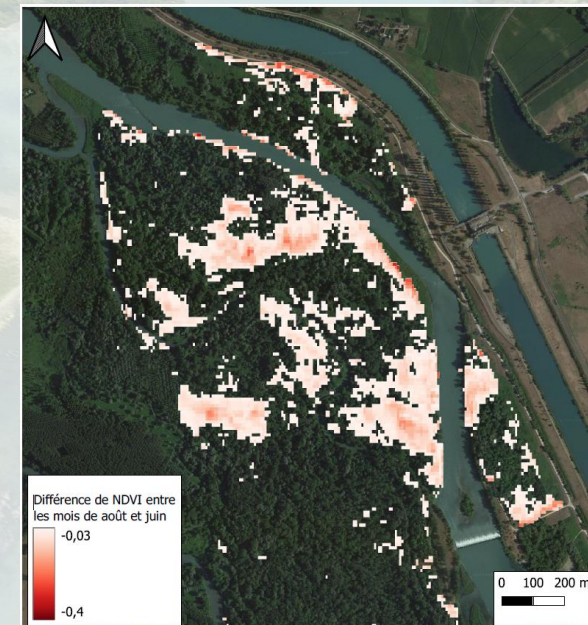
Janssen et al., 2020

Remote-sensing, a useful toolbox

Référence	Capteur Vecteur	Série Temporelle	Objectif
(Neale <i>et al.</i> , 2011)	<u>Thermique</u> <i>Aéroporté</i>		Estimer l'évapotranspiration des communautés forestières.
(Fu and Burgher, 2015)	<u>Landsat</u> <i>Satellite</i>	X	Utiliser le NDVI pour évaluer la réponse de la forêt riveraine aux contraintes climatiques (précipitations) et hydrologiques (débits, crues, nappe)
(Milani <i>et al.</i> , 2019)	<u>Hyperspectral</u> <i>Aéroporté</i>		Prédire la distribution de stratégies CSR au sein de communautés de saules par imagerie hyperspectrale.
(Lurtz <i>et al.</i> , 2020)	<u>Landsat</u> <i>Satellite</i>	X	Relation entre évapotranspiration des peuplements et la profondeur de la nappe.
(Cieżkowski <i>et al.</i> , 2020)	<u>Landsat</u> <i>Satellite</i>	X	Comparer des indices optiques et thermiques pour détecter le stress.
(Mayes <i>et al.</i> , 2020)	<u>Landsat</u> <i>Satellite</i>	X	Comprendre l'usage en eau des communautés ripariennes par imagerie thermique.
(Kibler <i>et al.</i> , 2021)	<u>Hyperspectral</u>	X	Évaluer l'impact de la sécheresse sur la santé et la mortalité de la forêt riveraine. Calibration hyperspectrale pour la série temporelle Landsat.
	<i>Aéroporté</i> <u>Landsat</u> <i>Satellite</i>		
(Guerra-Hernández <i>et al.</i> , 2021)	<u>Multispectral</u> <i>Drone</i>		Évaluer l'état de santé d'aulnes glutineux dans un secteur où ils sont affectés par un pathogène.



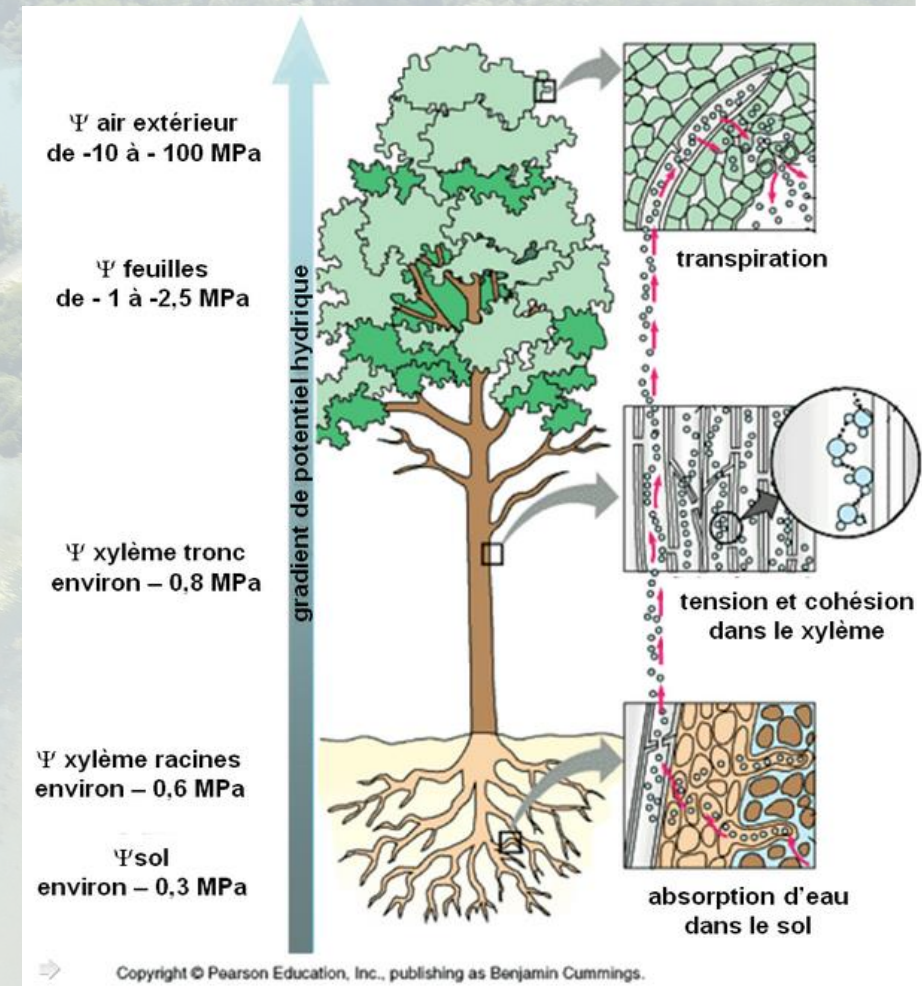
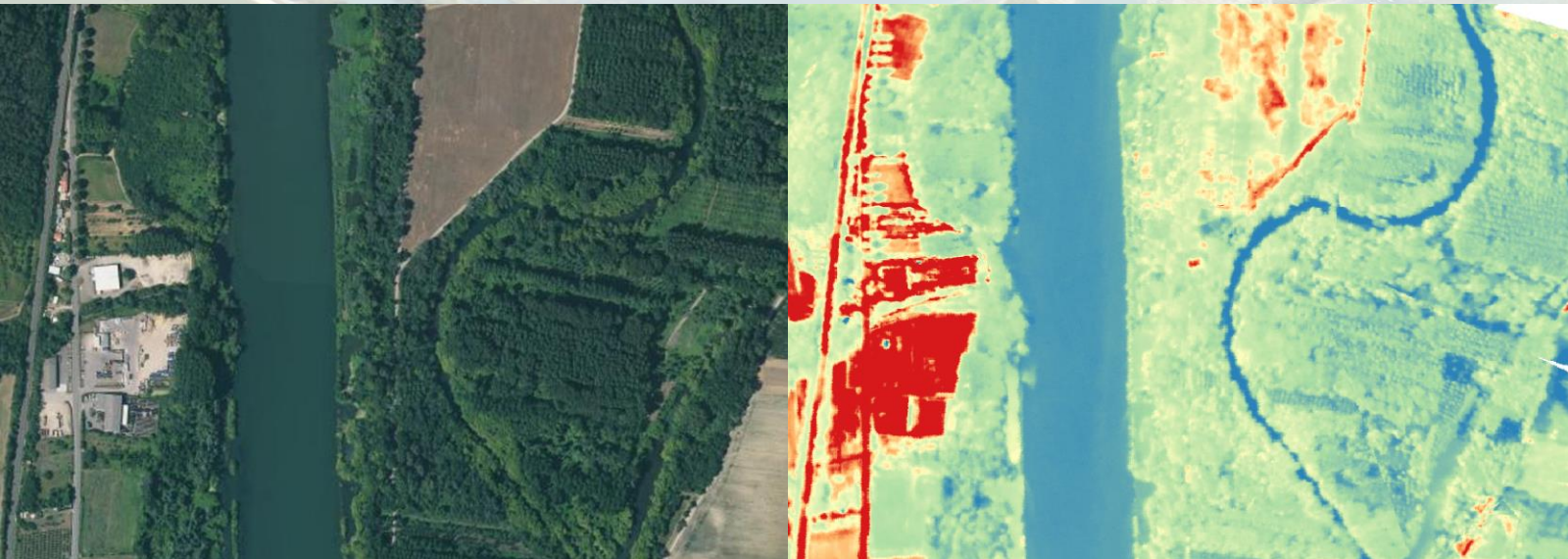
Jones et al., 2009



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Objective and hypothesis

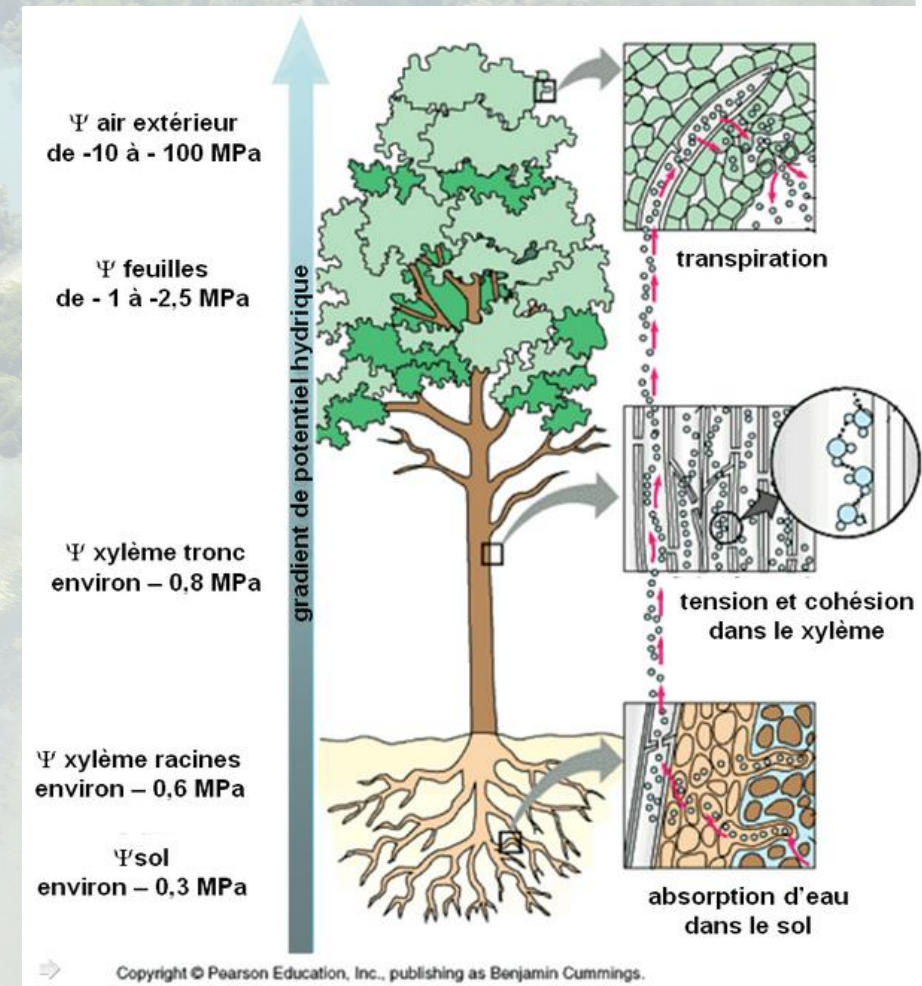
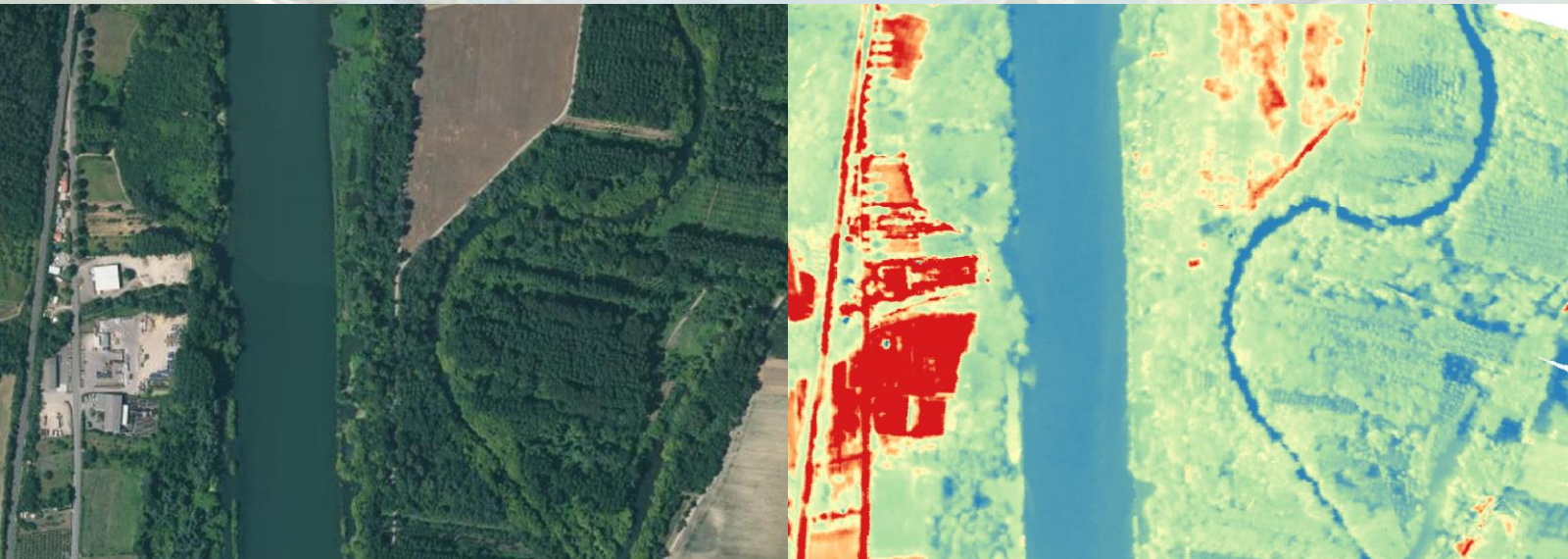
Assessing response of riparian tree to seasonal drought across a hydroclimatic gradient and two approaches: ecophysiology and remote-sensing



Objective and hypothesis

Assessing response of riparian tree to seasonal drought across a hydroclimatic gradient and two approaches: ecophysiology and remote-sensing

H1: Trees with weak access to water have a strong drought response

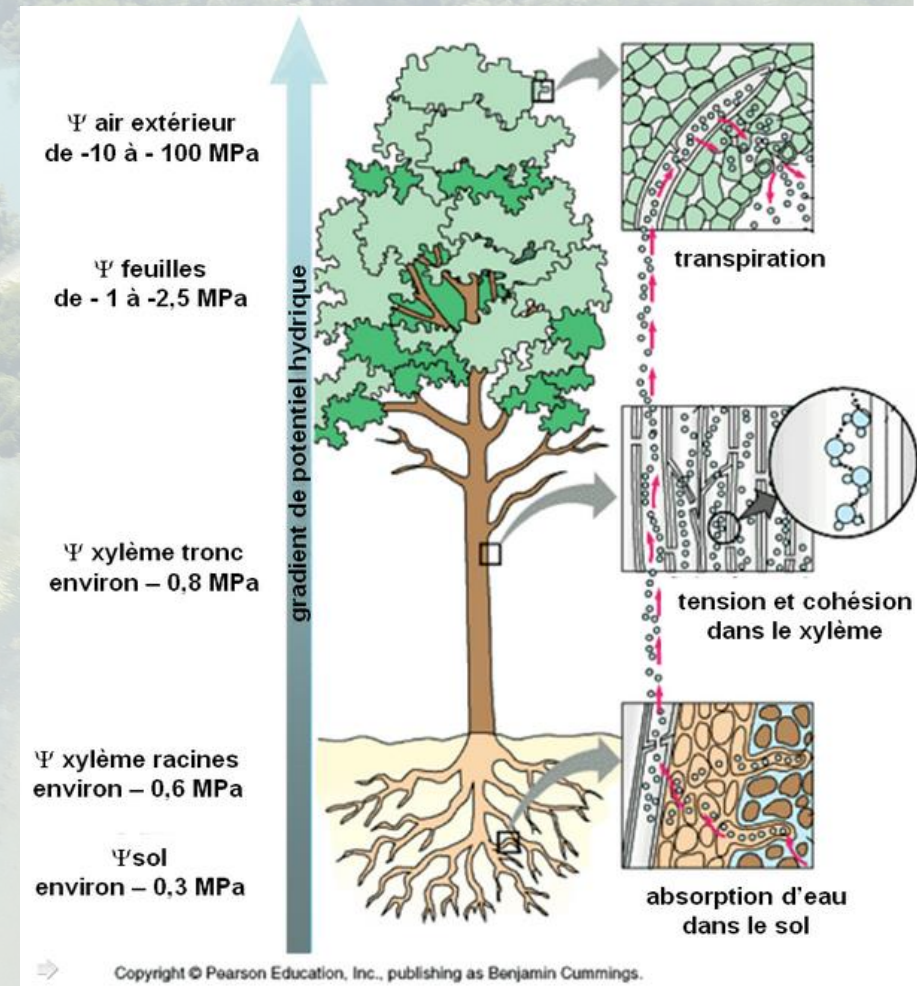
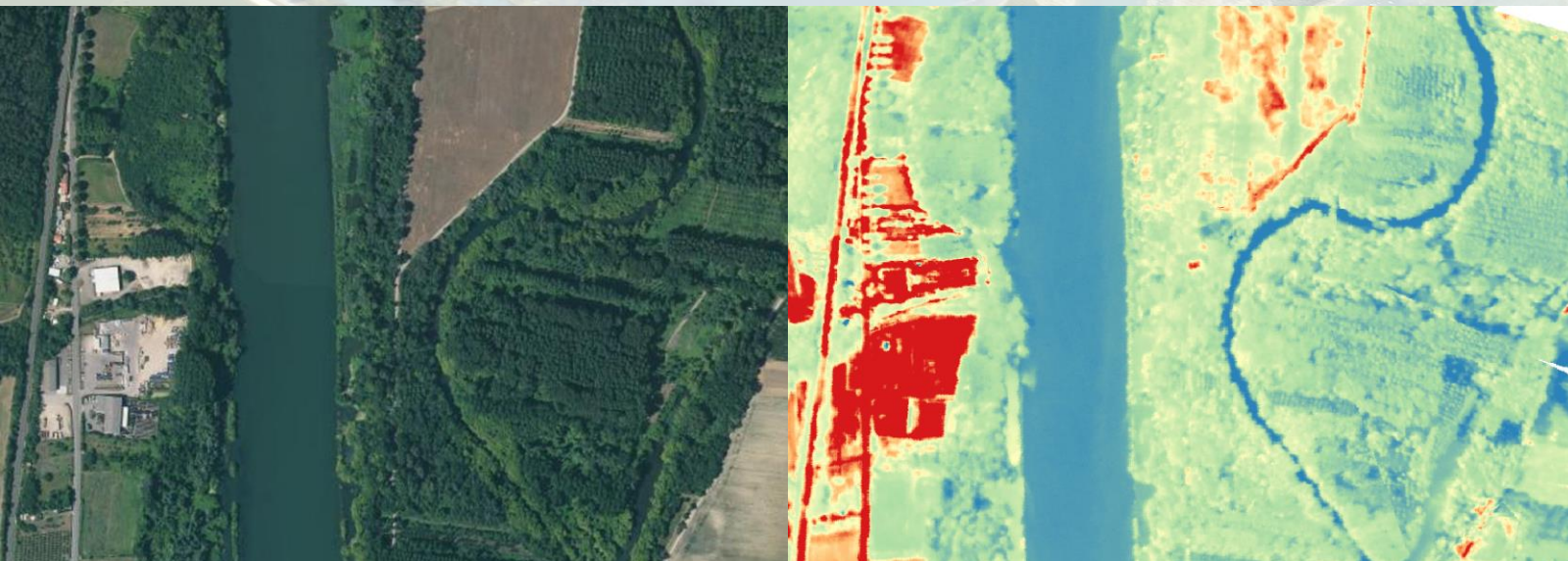


Objective and hypothesis

Assessing response of riparian tree to seasonal drought across a hydroclimatic gradient and two approaches: ecophysiology and remote-sensing

H1: Trees with weak access to water have a strong drought response

H2: Trees from drier sites (south) have a stronger response to drought



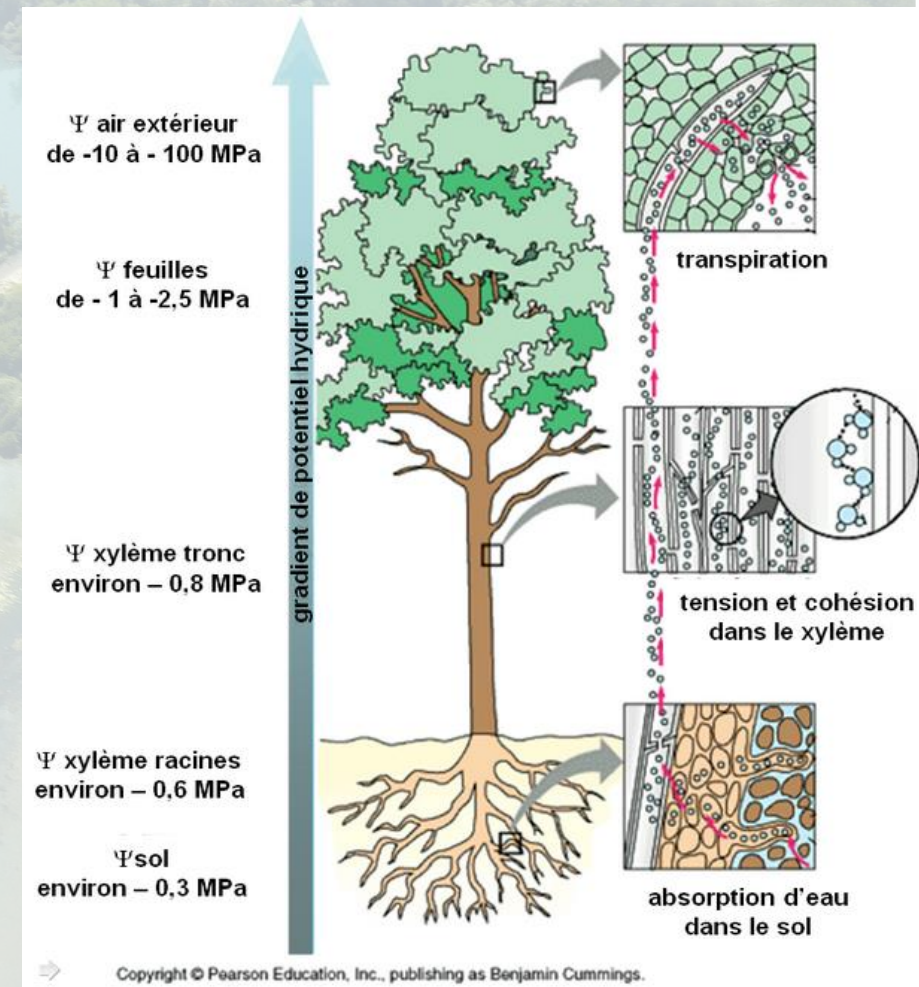
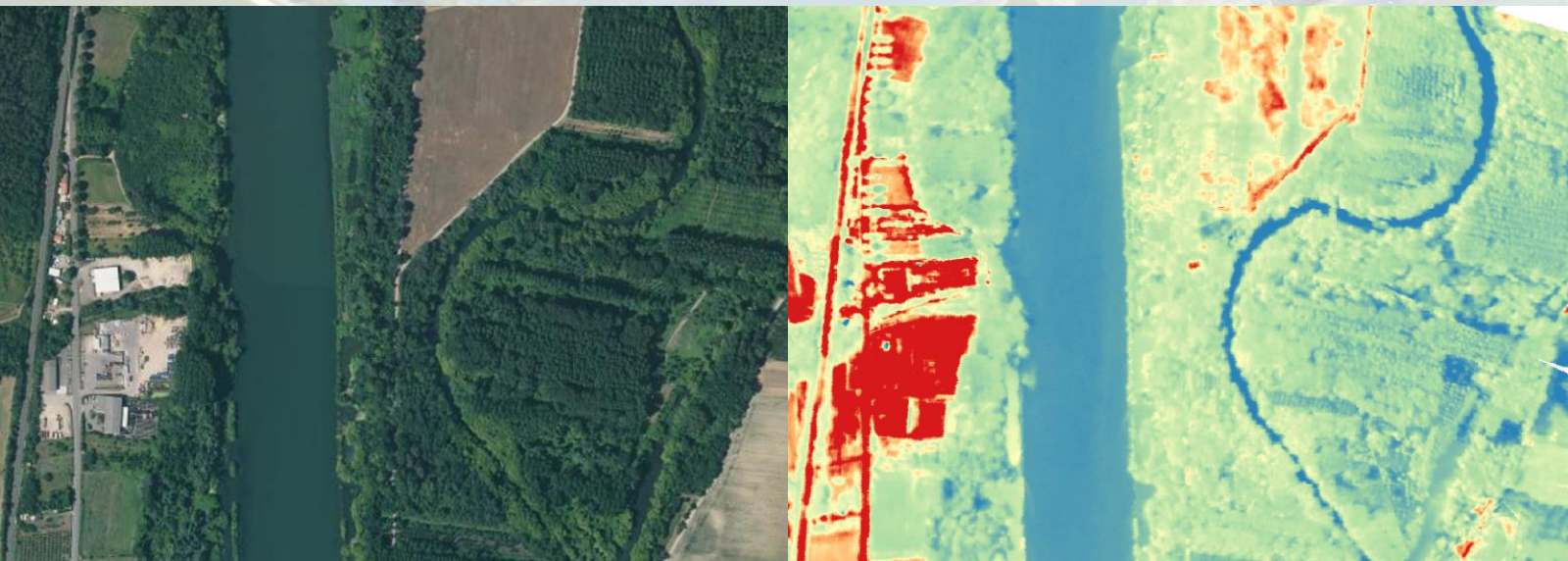
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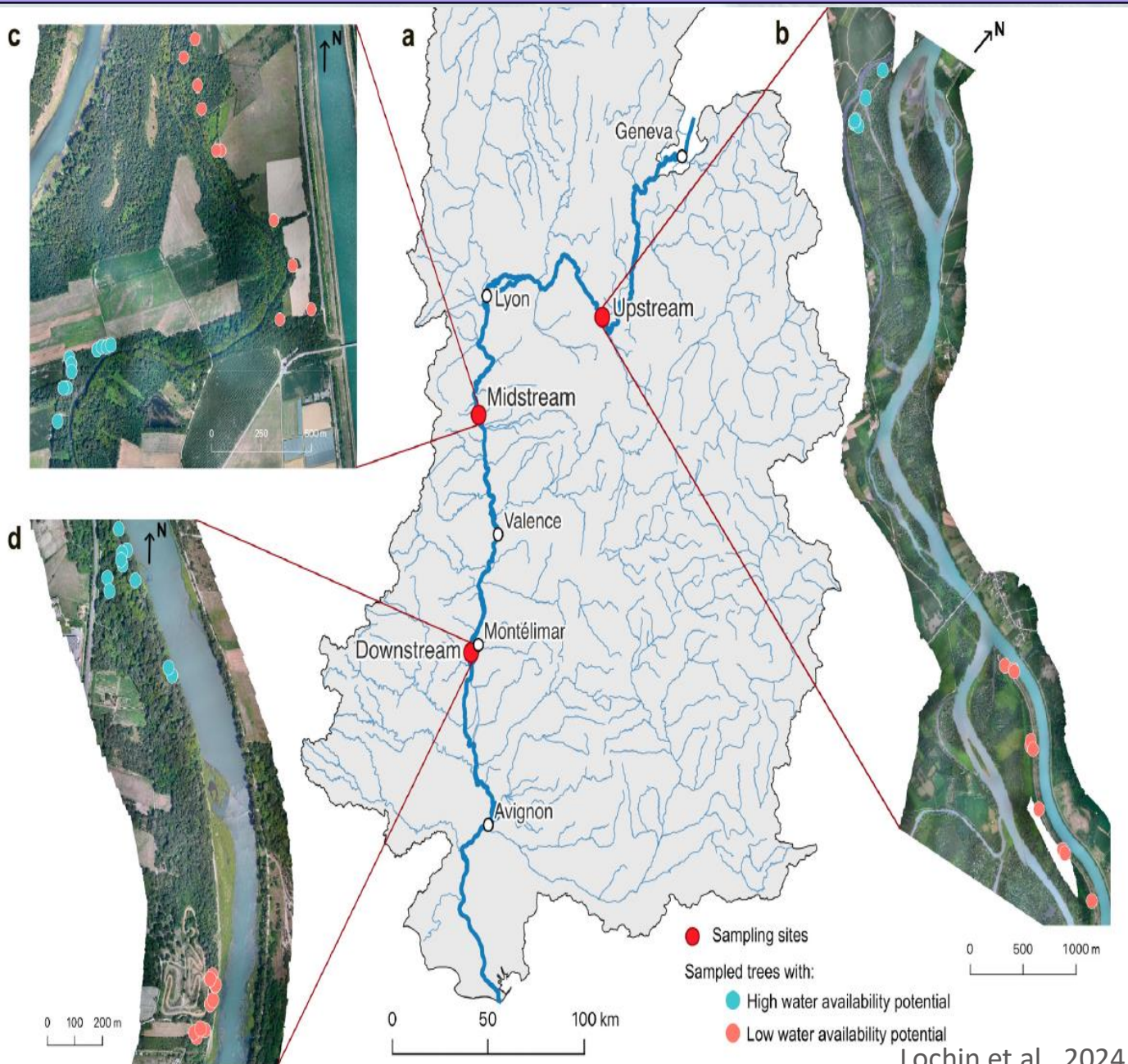
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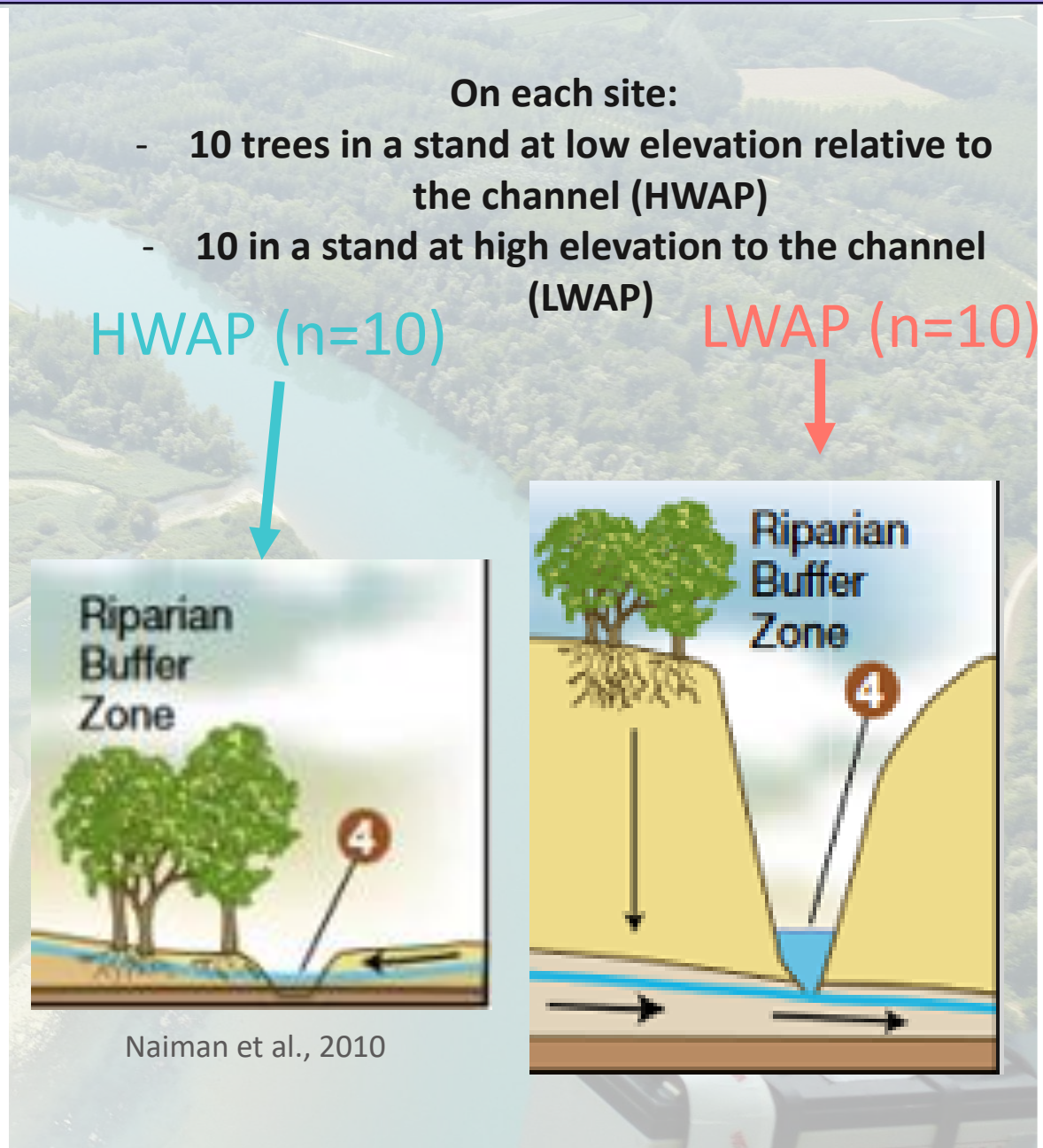
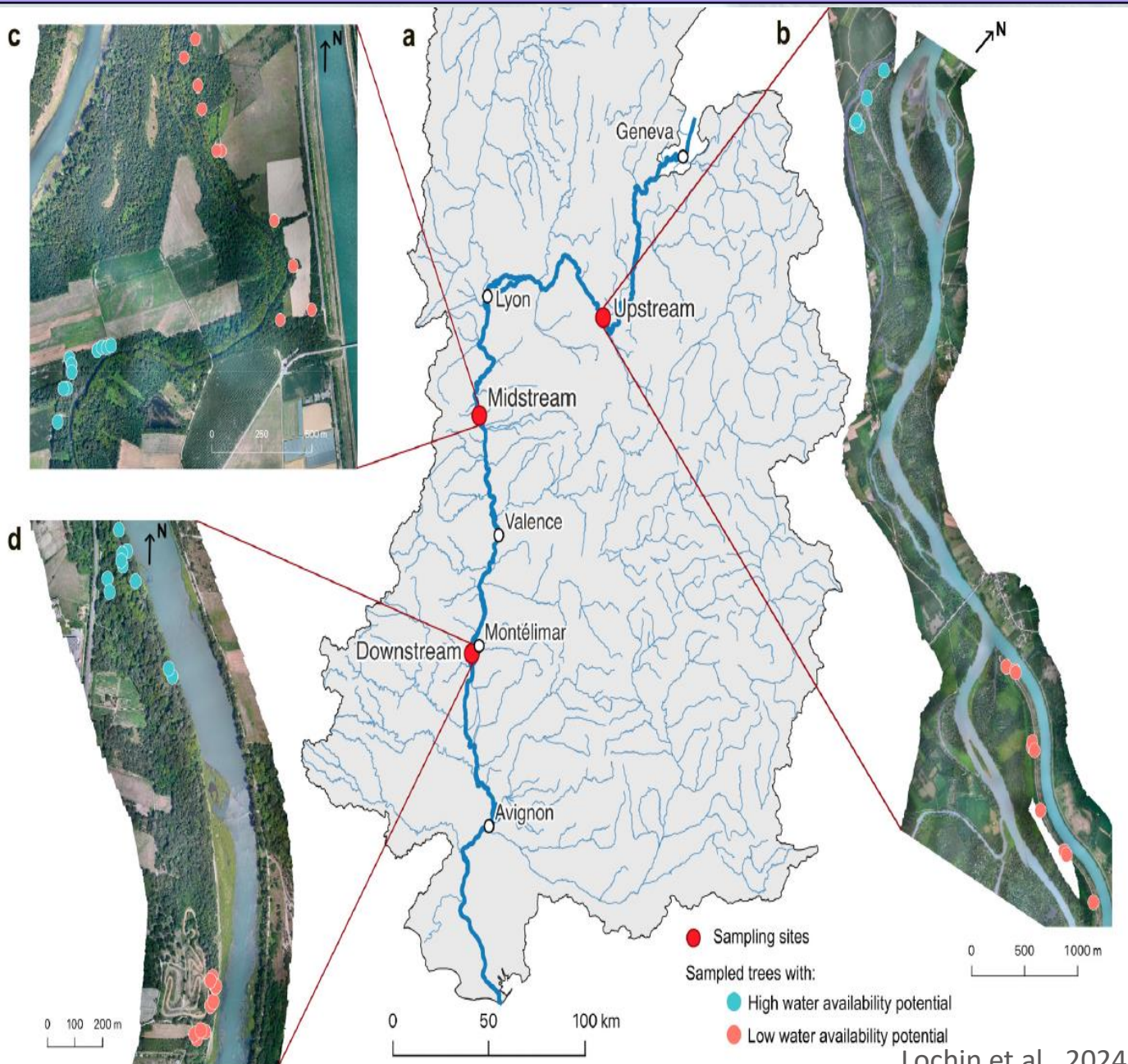
H3: Ecophysio and remote-sensing provide complementary evidence for deeper characterization of tree responses to drought



Studied sites



Studied sites



Measures on each site

Minimal water potential (Ψ_m)



Measures on each site

Minimal water potential (Ψ_m)



Intrinsic water use efficiency (WUE_i)



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$\delta^{13}C$
phloème



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Measures on each site

Minimal water potential (Ψ_m)



Intrinsic water use efficiency (WUE_i)



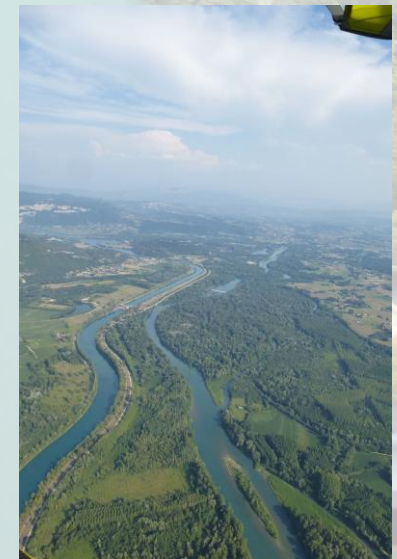
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Thermal infra-red (TIR) data



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Results



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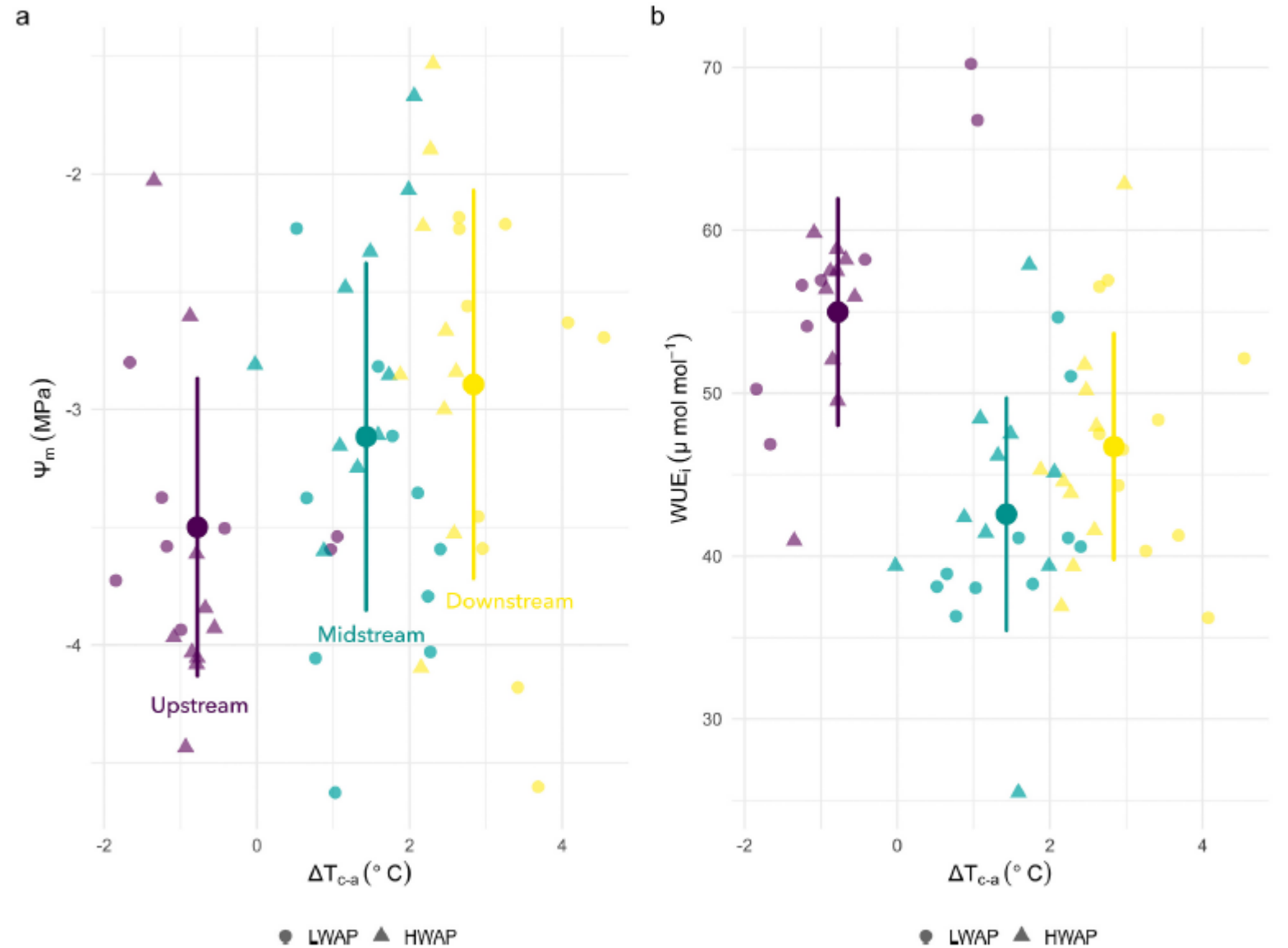
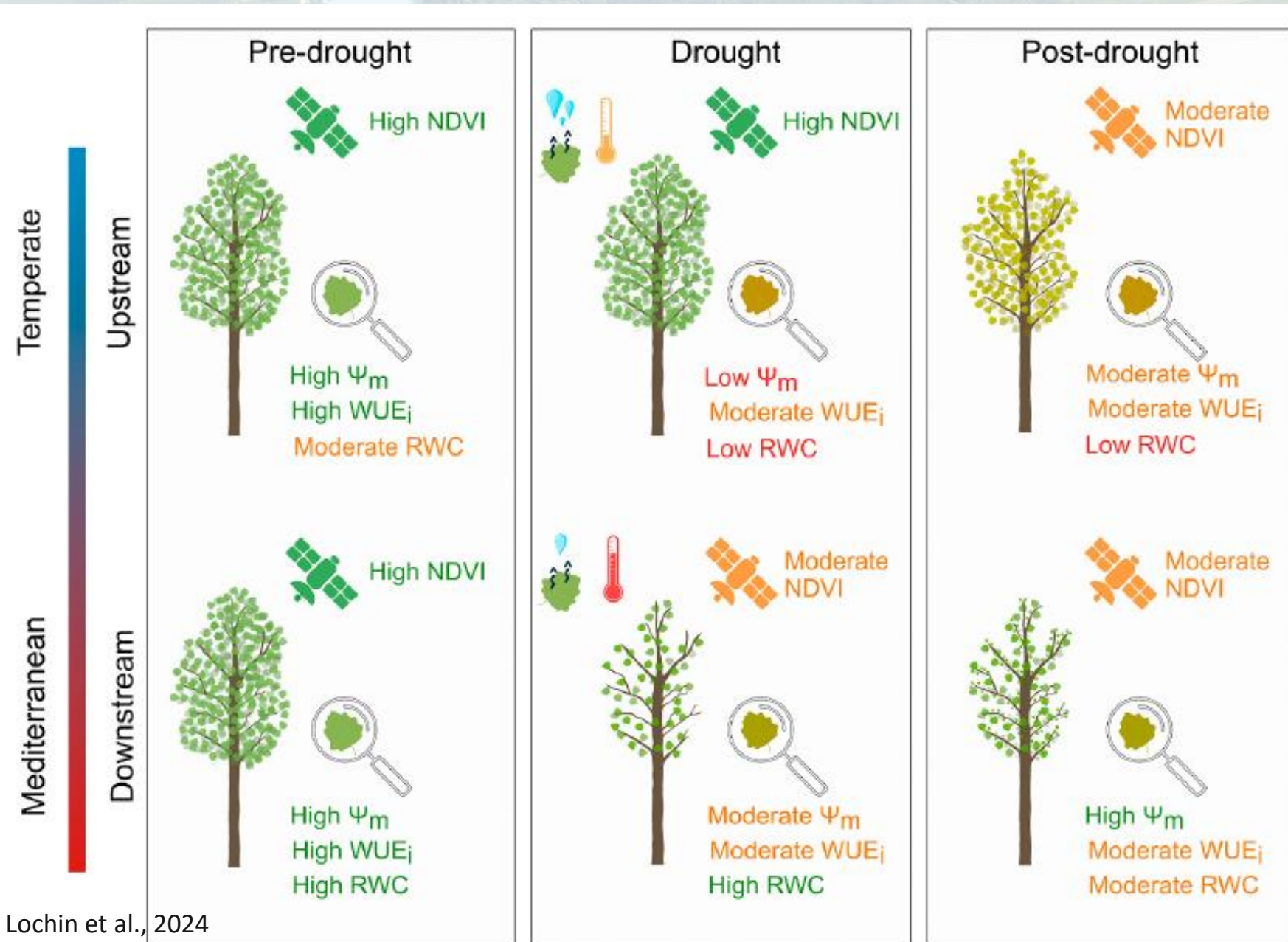


Fig. 7. Scatterplot of (a) minimum leaf water potential and (b) water use efficiency against the difference between canopy temperature and air temperature (ΔT_{c-a}) for each site (upstream, midstream, downstream). Small dots represent individual values for each tree, while large dots represent site averages. Differences in shape represent the forest stands of each individual. Colors are for site identification only.

Discussion



Conclusion and perspectives

- Remote-sensing is a promising tool for monitoring riparian forest



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Conclusion and perspectives

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- Even if remote-sensing helps to upscale ecophysiological measurements, both appear necessary to understand the stand response to drought



Conclusion and perspectives

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- Even if remote-sensing helps to upscale ecophysiological measurements, both appear necessary to understand the stand response to drought
- Need to explore the dynamic of the stand response



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Conclusion and perspectives

- Remote-sensing is a promising tool for monitoring riparian forest
- Even if remote-sensing helps to upscale ecophysiological measurements, both appear necessary to understand the stand response to drought
- Need to explore the dynamic of the stand response
- Abilities to detect threshold values leading to reduced stand functioning?



A warm thank to:

Project participants:



Antoine Vernay



Sara Puijalon



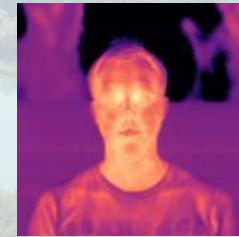
Christelle Boisselet



Pierre Lochin



Hervé Piegay



Baptiste Marteau



Jérôme Lejot



Kristell Michel



Julien Godfroy



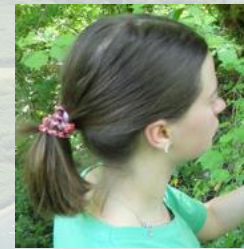
Flavie Gerle



David Lafleuriel



Pauline Malherbe



Camille Gauthier



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Thank yo for your attention !

Any questions ?



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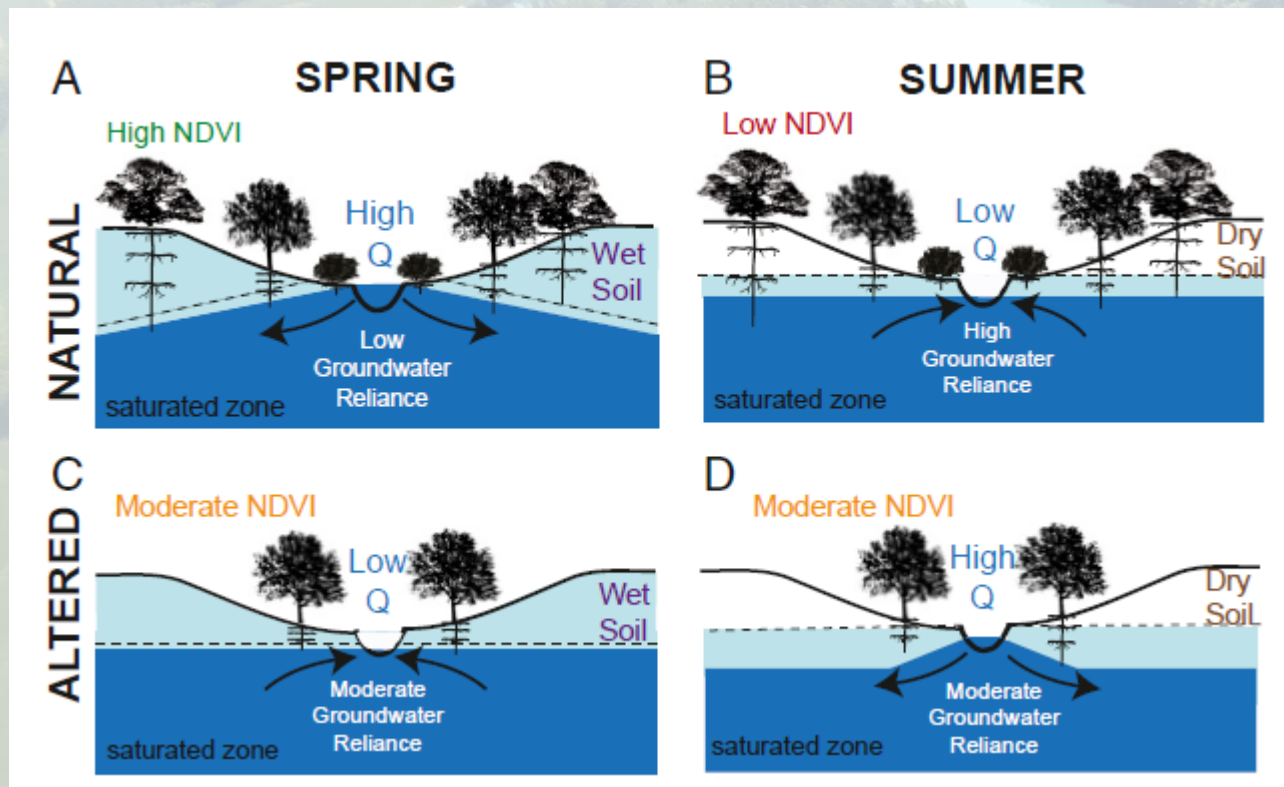
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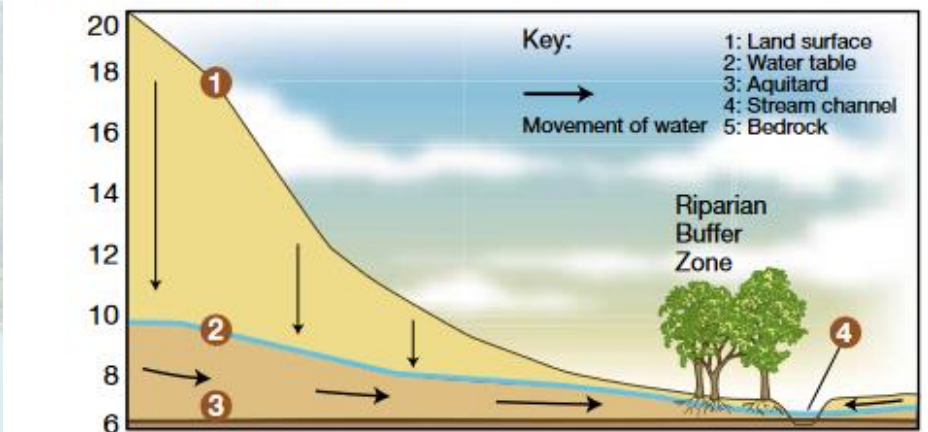
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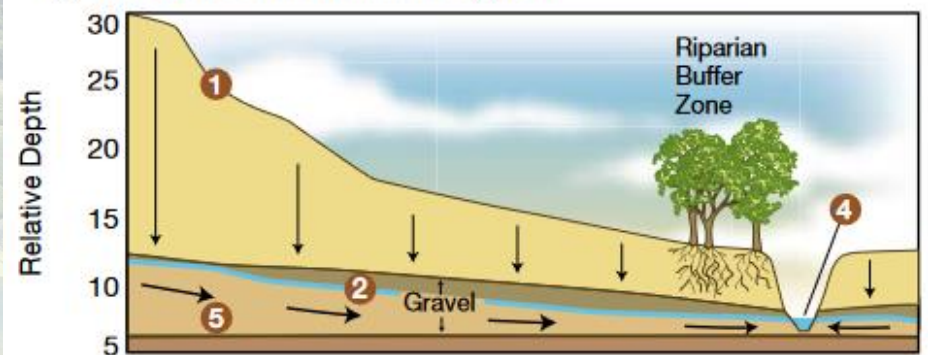


Rhode et al., 2021

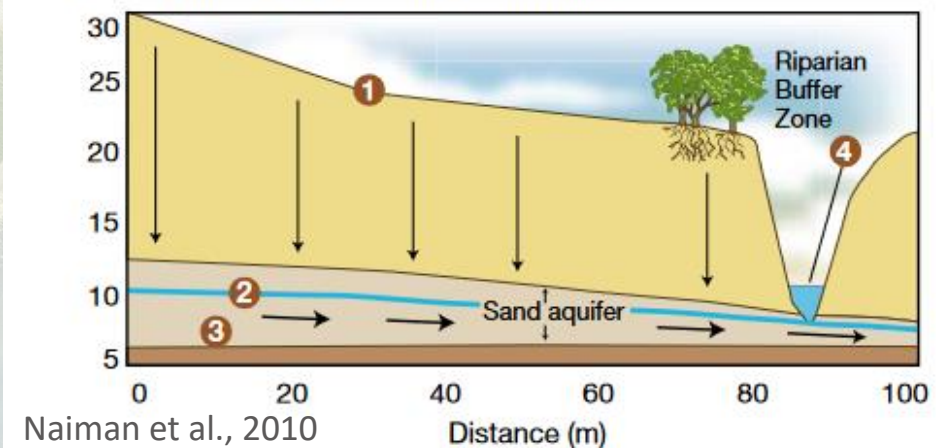
(a) Shallow confining water



(b) Bedrock overlaid with coarse gravel



(c) Deeply incised channel and a sand aquifer



Naiman et al., 2010

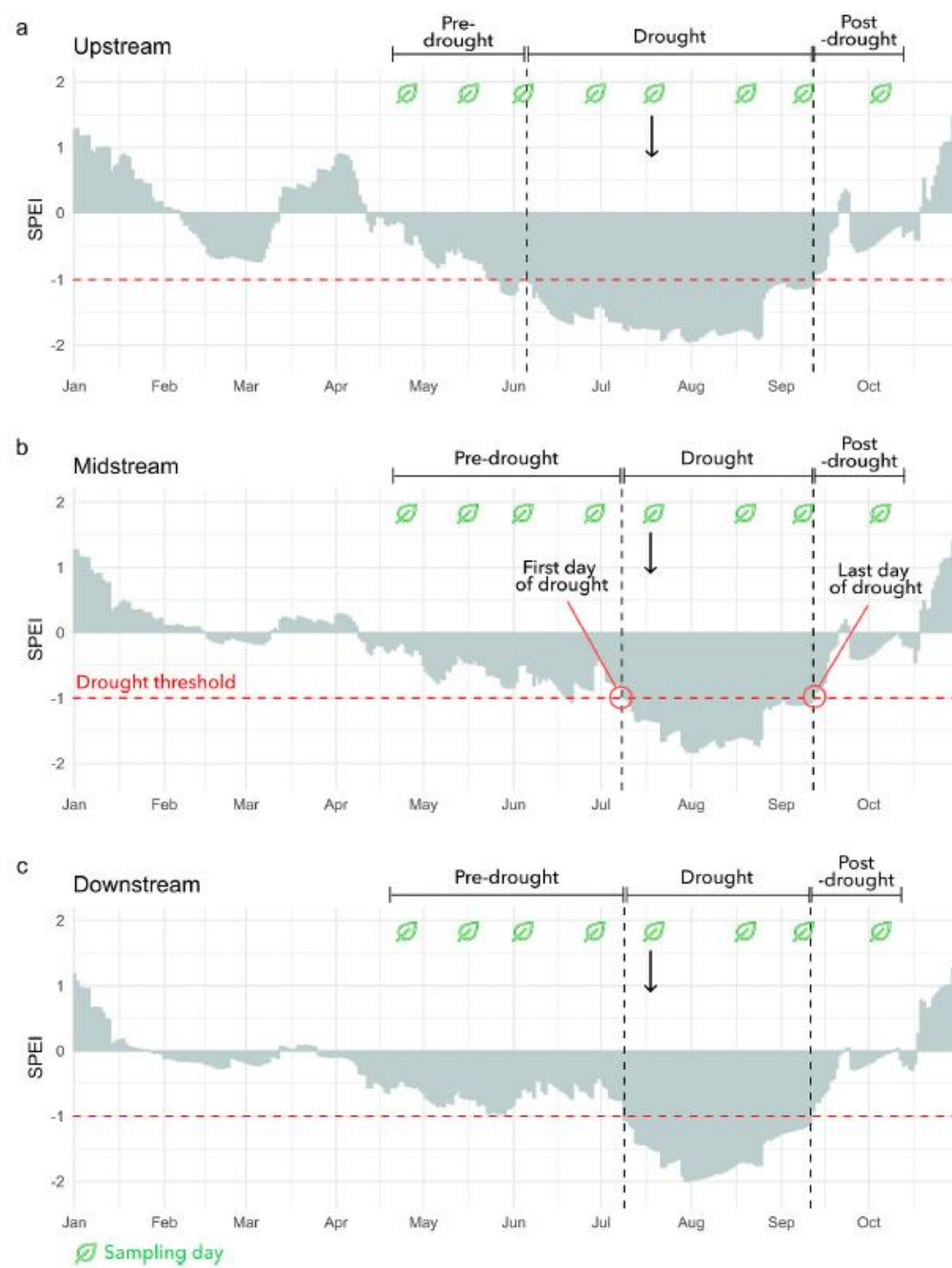
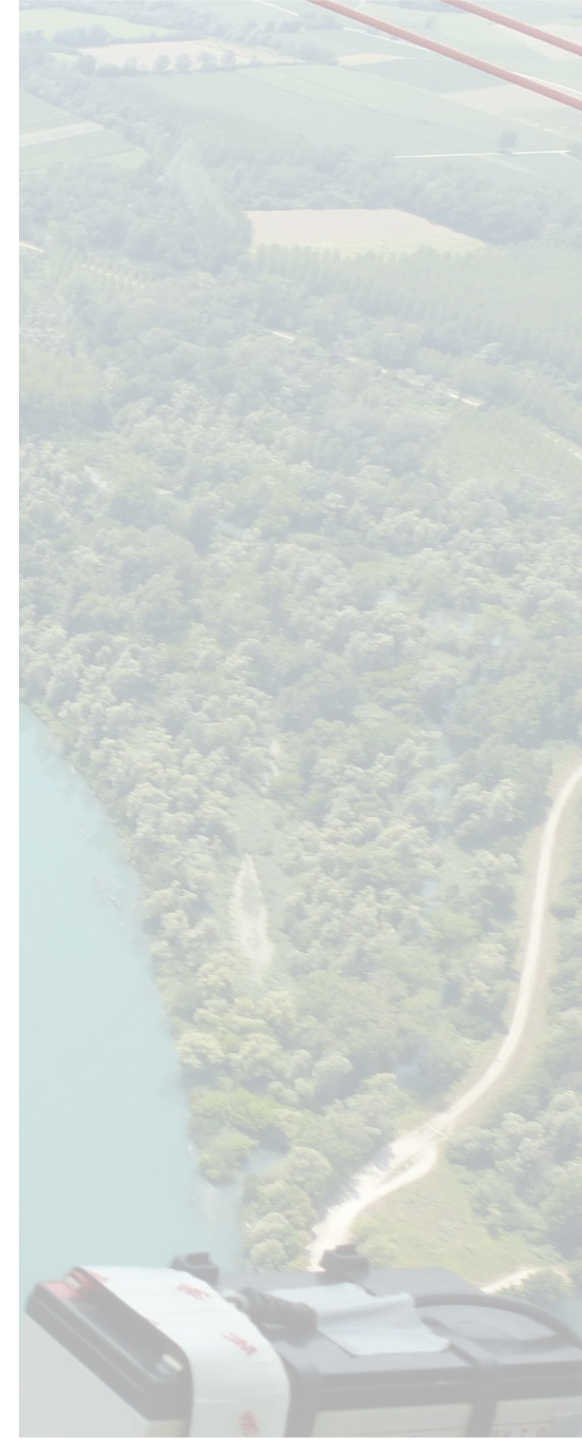


Fig. 2. Evolution of the 30-day SPEI from January 1 to October 31, 2023 at the three sites. The two black dotted lines represent the start and end dates of drought at each site, while the red dotted line represents the drought SPEI threshold. Green leaves indicate the days on which samplings were conducted, and black arrows indicate the thermal survey.



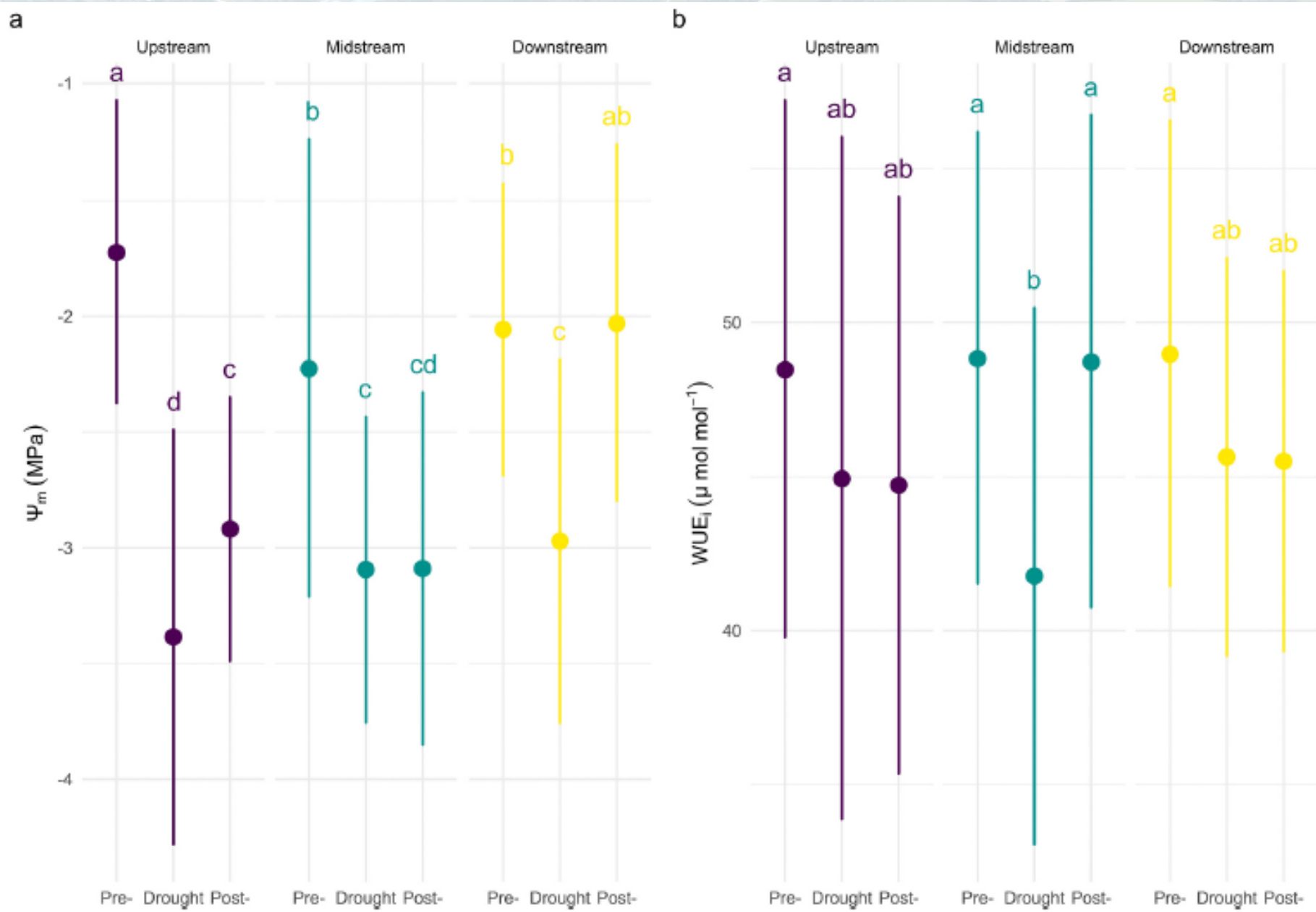


Fig. 3. Means and standard deviations of (a) minimum leaf water potential (Ψ_m) and (b) intrinsic water use efficiency (WUE_i) over each drought phase among the three sites. Colors indicate site identification only. Means by sites and periods without common letters were significantly different at the 95 % confidence level ($p < 0.05$) in Tukey's HSD post hoc tests.

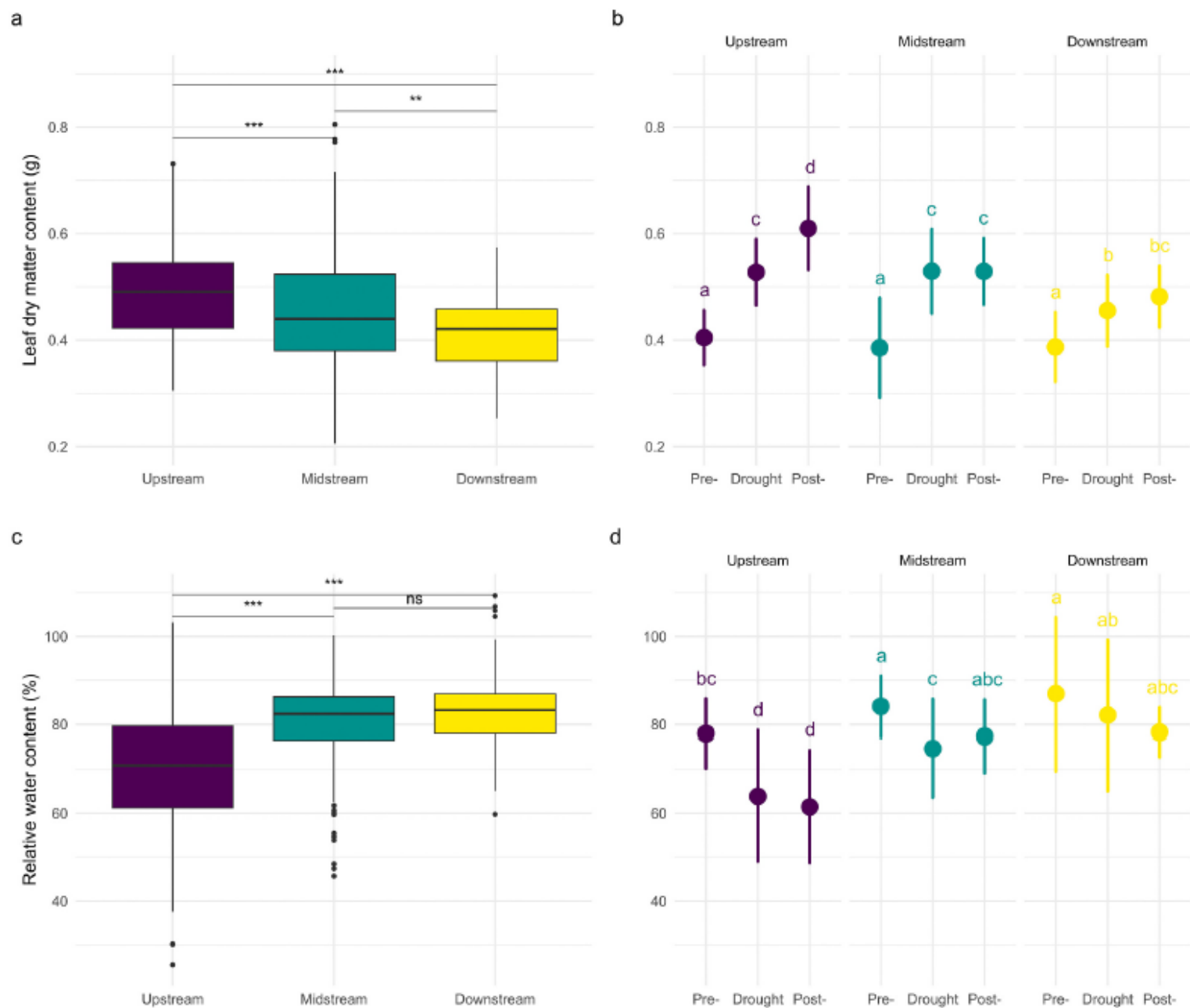


Fig. 4. Boxplots of (a) leaf dry matter content (LDMC) and (c) relative water content (RWC) by site (upstream, midstream, downstream). Mean and standard deviation of (b) LDMC (d) and RWC for each drought phase and site. Colors are for site identification only. * indicates that the difference between means of each site is statistically significant according to post-hoc pairwise comparison, where *** indicates $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$, and ns = $p > 0.05$. Means without common letters were significantly different at the 95 % confidence level ($p < 0.05$) in Tukey's HSD post hoc tests.

