

## PhD PROPOSAL FOR THE DOCTORAL SCHOOL « Végétal, Animal, Aliment, Mer, Environnement »

### GENERAL INFORMATION

<b>Thesis title:</b> Ability of different tree species to reduce heat in cities under contrasting conditions of water availability.
<b>Acronym of the project:</b> UrbanTreeCooling
<b>Disciplinary field 1:</b> Agronomy <b>Disciplinary field 2:</b> Ecology
<b>Three keywords:</b> Tree, urban, adaptation
<b>Registration establishment:</b> Institut Agro Rennes-Angers
<b>Research unit:</b> EPHor Environmental Physics and Horticulture
<b>Name of the thesis director HDR (Accreditation to supervise research) required:</b> Pierre-Emmanuel Bournet  <b>Email address of the thesis director:</b> Pierre-Emmanuel.Bournet@institut-agro.fr  <b>Name of the thesis co-director (if applicable): HDR (Accreditation to supervise research) required:</b>  <b>Email address of the thesis co-director (if applicable):</b>  <b>Name of the thesis co-supervisor 1 (if applicable):</b> Sabine Demotes-Mainard  <b>Email address of the thesis co-supervisor 1 (if applicable):</b> sabine.demotes-mainard@inrae.fr  <b>Name of the thesis co-supervisor 2 (if applicable):</b> Sophie Herpin  <b>Email address of the thesis co-supervisor 2 (if applicable):</b> sophie.herpin@institut-agro.fr
<b>Contact(s) (mailing address and E-mail):</b> 2, rue Le Nôtre 49045 ANGERS
<input type="checkbox"/> <b>Doctoral school contest</b>  <input checked="" type="checkbox"/> <b>Interview</b>  <input type="checkbox"/> <b>Other (specify):</b>

## SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

### Socio-economic and scientific context: (10 lines)

The increase in heatwaves is encouraging cities to include vegetation in their climate plans. Trees reduce thermal discomfort thanks to the shade and transpiration they provide. However, not all species have the same cooling potential and little is known about how it changes in the event of a lack of water. The proposed thesis thus aims to understand the differences in cooling between tree species in cities based on soil water availability and their response to water stress. The objectives are to quantify variations in climate services, to identify the architectural and ecophysiological traits explaining these differences, and to determine simple indicators to predict these levels of services. The project will be based on a small-scale experimental installation as well as data already acquired in the city of Paris. The expected benefits are scientific (development of new knowledge), operational (support for city policies, help in choosing tree species) and educational (presentations in M2).

### Assumptions and questions (8 lines)

The thesis project will be based on the following hypotheses:

1. Climate services depend on the architectural, foliar and water features of trees, microclimatic conditions, and water availability in the soil, with certain elements being predominant.
2. The reduction in climate services caused by drought depends on the intensity and duration of the stress applied but also on the species considered and its phenology.
3. It is possible to identify indicators to characterize the climate benefit potential of tree species.

From which arise the scientific questions which will be addressed in the thesis:

1. How do climate services vary between species depending on water availability and climatic conditions?
2. What are the architectural and ecophysiological traits of species that best explain their service levels in these situations?
3. Can we, from these traits, identify reliable indicators, simple enough to be measured on urban trees, in order to be able to test them on a wider range of species?

### The main steps of the thesis and scientific procedure (10-12 lines)

The thesis will consist of four phases:

- From 2024 to 2027, development of transversal skills: appropriation and monitoring of the state of the art, communication in different formats, training, etc.
- In 2025, quantification of the climate services of 4 tree species during a summer season during short water deficits, search for specific traits involved in climate services and resilience. Experimental measurement campaign.
- In 2026, comparison of the behavior of 2 species in comfort and long water deficit, to study the “microclimate x water status” interaction of the tree and deepen the hypotheses from 1<sup>st</sup> phase. Experimental measurement campaign.
- In 2027, reinterpretation of the results of phases 2 and 3 to define indicators quantifying the capacity of species to provide climate services. Evaluation of these indicators on data obtained in cities in previous studies (Trees & Climate and ANR CoolTrees). Data analysis alone. Finalization of the thesis manuscript

### Methodological and technical approaches considered (4-6 lines)

The methodological approach will be based on two complementary experimental devices:

- a reduced-scale multi-species experimental system comprising 4 parallel streets 2.3 m wide by 14.4 m long, with 4 selected tree species. This device allows the comparison of the behavior of different species subjected to the same aerial and root conditions. It was set up as part of D. Canonne's thesis at the Institut Agro, and is managed by the PHENOTIC platform.
- Another full-scale experimental device in Paris as part of the Trees & Climate study provides data on 9 tree species between 2019 and 2022 in the soil, tree and atmosphere compartments. A first analysis of the results is in progress (thesis by J. Thierry). The data will be used to evaluate the indicators obtained from the reduced-scale device on adult trees, in the city, with common and complementary species.

### Scientific and technical skills required by the candidate

Expected scientific skills:

- The candidate must hold an engineering degree or a master's degree in agronomy or plant ecophysiology
- Additional knowledge in bioclimatology will be a plus.

Desired technical or transversal skills:

- Knowledge of environmental measurement techniques (aerial, plant and root compartment), taste for experimentation and data processing,
- Scientific reading and writing in English,
- Sense of initiative and organization

## THESIS SUPERVISION

<b>Unit name:</b> EPHor	<b>Team name:</b> EPHor
<b>Unit director name:</b> Patrice Cannavo	<b>Team director name:</b> Patrice Cannavo
<b>Mailing address of the unit director:</b> Institut Agro 2, rue Le Nôtre 49045 ANGERS	<b>Mailing address of the team director:</b> Institut Agro 2, rue Le Nôtre 49045 ANGERS
<b>Thesis director</b> Surname, first name: Bournet Pierre-Emmanuel Position: Professor Obtained date of the HDR (Accreditation to supervise research): 2008 Employer: Ministère de l'Agriculture Doctoral school affiliation: VAAME Rate of thesis supervision in the present project (%): 40% Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 80% Number of current thesis supervisions/co-supervisions: 2	
<b>Thesis co-director</b> Surname, first name: Position: Obtained date of the HDR (Accreditation to supervise research): Employer: Doctoral school affiliation: Rate of thesis supervision in the present project (%):	

<p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):</p> <p>Number of current thesis supervisions/co-supervisions:</p>
<p><b>Thesis co-supervisor 1 (if applicable)</b></p> <p>Surname, first name: Demotes-Mainard Sabine</p> <p>Position: researcher</p> <p>Accreditation to supervise research <input type="checkbox"/> yes <input checked="" type="checkbox"/> no If yes, date diploma received:</p> <p>Employer: Ministère de l'agriculture/INRAE</p> <p>Doctoral school affiliation: VAAME</p> <p>Rate of thesis supervision in the present project (%): 30%</p> <p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 30%</p> <p>Number of current thesis supervisions/co-supervisions: 1</p>
<p><b>Thesis co-supervisor 2 (if applicable)</b></p> <p>Surname, first name: Herpin Sophie</p> <p>Position: Assistant professor</p> <p>Accreditation to supervise research <input type="checkbox"/> yes <input checked="" type="checkbox"/> no If yes, date diploma received:</p> <p>Employer: Ministère de l'Agriculture</p> <p>Doctoral school affiliation: VAAME</p> <p>Rate of thesis supervision in the present project (%): 30%</p> <p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 60%</p> <p>Number of current thesis supervisions/co-supervisions: 2</p>
<p><b>Private partner (if CIFRE funding, private funding...)</b></p> <p>Surname, first name:</p> <p>Position:</p> <p>Employer:</p> <p>Rate of thesis supervision in the present project (%):</p> <p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):</p> <p>Number of current thesis supervisions/co-supervisions:</p>
<p><b>International partner (if Cotutelle thesis)</b></p> <p>Surname, first name:</p> <p>Position:</p>

Employer:

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

**Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)**

*Please provide the following information for each PhD students supervised*

Surname, first name: Mballo Souleymane

Date of PhD beginning and PhD defence: 01/10/2018-31/01/2022

Thesis supervision: Pierre-Emmanuel Bournet

Professional status and location: High school physics teacher, Paris region + entrepreneur (automotive sector)

Contract profile (post-doc, fixed-term, permanent): nc

List of publications from the thesis work:

- Mballo S., Herpin S., Demotes-Mainard S., Bournet P.E. (2021) Impact of well-watered trees on the microclimate inside a canyon street scale model in outdoor environment, Urban Climate, Vol 37, 27p., <https://doi.org/10.1016/j.uclim.2021.1>
- Herpin S., Mballo S., Thierry J., Lemesle D., Brialix L., Rodriguez F., Demotes-Mainard S., Bournet P.E. (2022) Benefits of well-watered trees on street microclimate: what is the influence of meteorological conditions? 35th annual AIC (Association internationale de Climatologie) conference, Toulouse, July 6-9. 6p.
- Demotes-Mainard S., Boukouya A., Mballo S., Dubuc B., Ledroit L., Lebras L., Lemesle D., Bournet P.E., Herpin S. (2022) Impacts of the urban environment on well-watered tree architectural development and tree climate services. IHC2022, Angers, France, August 14-20, Acta Horticulturae, 1374, 189-196 DOI: 10.17660/ActaHortic.2023.1374.24
- Herpin S., Thierry J., Mballo S., Cannavo P., Rodriguez F., Demotes-Mainard S., Bournet P.E. (2023). A new scaled outdoor facility to study street tree climate benefits, with controlled water availability 11th International Conference on Urban Climate ICUC 2023 28 August 1st September, Sydney, Australia, 2p.

Surname, first name: Thierry Julien

Date of PhD beginning and PhD defence: 01/03/2021-29/02/2024

Thesis supervision: Pierre-Emmanuel Bournet

Professional status and location: IRSTV researcher, Nantes

Contract profile (post-doc, fixed-term, permanent): fixed-term

List of publications from the thesis work:

- Thierry J., Herpin S., Levi R., Canonne D. Demotes-Mainard S. Cannavo P., Rodriguez F., Bournet P.E. (2024) Impact of a water restriction on the summer climatic benefits of trees inside an outdoor canyon street scale model, Building and environment, accepted.
- Herpin S., Thierry J., Mballo S., Cannavo P., Rodriguez F., Demotes-Mainard S., Bournet P.E. (2023). A new scaled outdoor facility to study street tree climate benefits, with controlled water availability 11th International Conference on Urban Climate ICUC 2023 28 August 1st September, Sydney, Australia, 2p.

- Thierry J., Herpin S., Rodriguez F., Renard M., Gantois M., Bournet P.E. (2023) An insitu experiment in Paris to monitor street trees physiological response and climatic benefits during heatwaves and drought spells. 11th International Conference on Urban Climate ICUC 2023 28 August 1st September, Sydney, Australia, 2p.
- Thierry J., Herpin S., Maturana L., Demotes-Mainard S., Rodriguez F., Cannavo P., Bournet P.E. (2022) Impact of a moderate water stress on the climatic services provided by street trees: an experimental study inside an outdoor canyon street scale model. 35<sup>th</sup> annual AIC (Association internationale de Climatologie) conference, Toulouse, July 6-9. 6p.
- Herpin S., Mballo S., Thierry J., Lemesle D., Brialex L., Rodriguez F., Demotes-Mainard S., Bournet P.E. (2022) Benefits of well-watered trees on street microclimate: what is the influence of meteorological conditions? 35th annual AIC (Association internationale de Climatologie) conference, Toulouse, July 6-9. 6p.
- Thierry J., Herpin S., Rodriguez F., Renard M., Gantois M., Bournet P.E. (2022) Climatic benefits of street trees on the microclimate and thermal comfort: an in-situ experiment in Paris, IHC2022, Angers, France, August 14-20, Acta Horticulturae, 1374, 197-204 DOI: 10.17660/ActaHortic.2023.1374.25

#### Five main recent publications of the supervisors on thesis subject:

- Bournet P.E., Rojano F. (2022) Advances of Computational Fluid Dynamics (CFD) applications in agricultural building modelling: research, applications and challenges, *Computers and Electronics in Agriculture*, 201(5):107277. <https://doi.org/10.1016/j.compag.2022.107277>.
- Demotes-Mainard, S., S. Herpin, A. Boukouya, S. Mballo, B. Dubuc, Ledroit L., Le Lebras C., Lemesle D., Bournet P.E. (2023) Impacts of the urban environment on well-watered tree architectural development and tree climate services. *Acta Horticulturae*, 1374, pp.189-196. <10.17660/ActaHortic.2023.1374.24>. <hal-04283218>
- Fatnassi H., Bournet P.E., Boulard T., Roy J.C., Molina-Aiz F.D., Zaaboul R. (2023) Use of Computational Fluid Dynamic tools to model the coupling of plant canopy activity and climate in greenhouses and closed plant growth systems: a review., *Biosystems Engineering*, 230: 388-408. <https://doi.org/10.1016/j.biosystemseng.2023.04.016>
- Mballo, S., Herpin, S., Manteau, M., Demotes-Mainard, S., & Bournet, P. E. (2021). Impact of well-watered trees on the microclimate inside a canyon street scale model in outdoor environment. *Urban Climate*, 37, 100844. <https://doi.org/10.1016/j.uclim.2021.100844>.
- Thierry J., Herpin S., Rodriguez F., Renard M., Gantois M., Bournet P.E. (2022) Climatic benefits of street trees on the microclimate and thermal comfort: an in-situ experiment in Paris, IHC2022, Angers, France, August 14-20, Acta Horticulturae, 10.17660/ActaHortic.2023.1374.25

## THESIS FUNDING

Origin(s) of the thesis funding: Angers Loire Métropole
Gross monthly salary: 2460 €
Thesis funding state: Partly acquired (co-funding) : financing of the thesis environment
Funding beginning date/duration of the thesis funding: 01/10/2024

Date: April 5<sup>th</sup> 2024

Name, signature of unit director: Patrice Cannavo



Name, signature of team director: Patrice Cannavo



Name, signature of thesis project director: Pierre-Emmanuel Bournet



**All sections must be filled in. Once completed, please save the proposal form in PDF format using the following naming: Supervisor Name\_Unit\_Subject Acronym\_EN.pdf Please also send a Word version to make it easier to change the layout if necessary.**

**Documents to be send to: [ed-vaame@doctorat-paysdelaloire.fr](mailto:ed-vaame@doctorat-paysdelaloire.fr)**