The European Ecotron of Montpellier: experimental platforms to study ecosystem and biodiversity response to climate change

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ECOTRON

cnrs

AnaEE
Analysis and Experimentation on Ecosystems

MUSE
MONTPELLIER UNIVERSITY OF EXCELLENCE

EGU
European Geoscience Union
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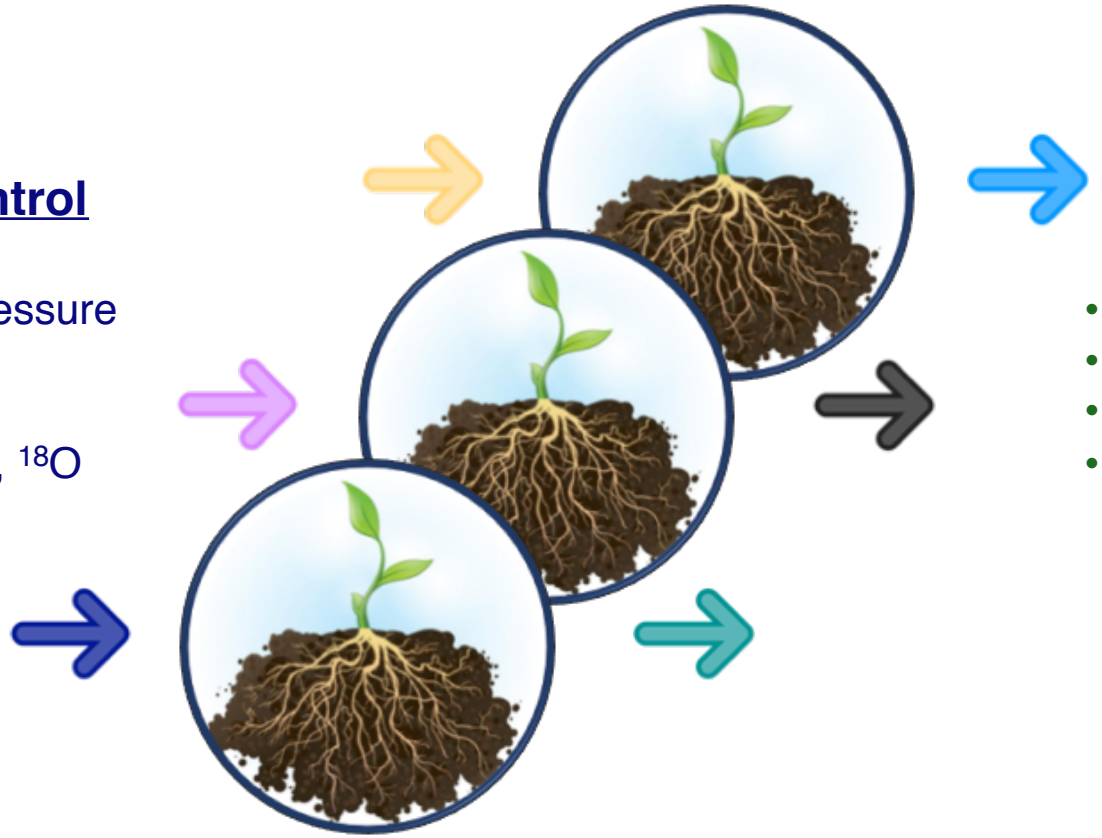
What is an Ecotron?

- An **experimental facility** containing a **set of replicated experimental units** where ecosystems are confined in enclosures allowing to **realistically simulate above- and belowground environmental conditions** while simultaneously and **automatically measuring various ecosystem processes** (fluxes of energy, water and gases), thus providing **continuous information on ecosystem functioning**.

Environmental control

- Soil and air T, H_2O, air pressure
- Soil matrix potential
- Atmospheric CO_2;
- Isotopic labelling ^{13}C, ^{15}N, ^{18}O



Ecosystem processes

- Evapotranspiration
- Ecosystem CO_2 fluxes: NEE, GPP, R_{eco}
- Greenhouse trace gases: N_2O, CH_4
- Isotopic and fractionation measurement

The European Ecotron of Montpellier

- The European Ecotron of Montpellier is a CNRS service unit open to the **national and international community** (www.ecotron.cnrs.fr).

- Three experimental platforms :

Macrocosms

12 units - 40 m^3 each

Experimental surface: 2 to 5 m^2

Mesocosms

18 units - 4 m^3 each

Experimental surface: 0.4 to 1 m^2

Microcosms

13 units - 2 m^3 each

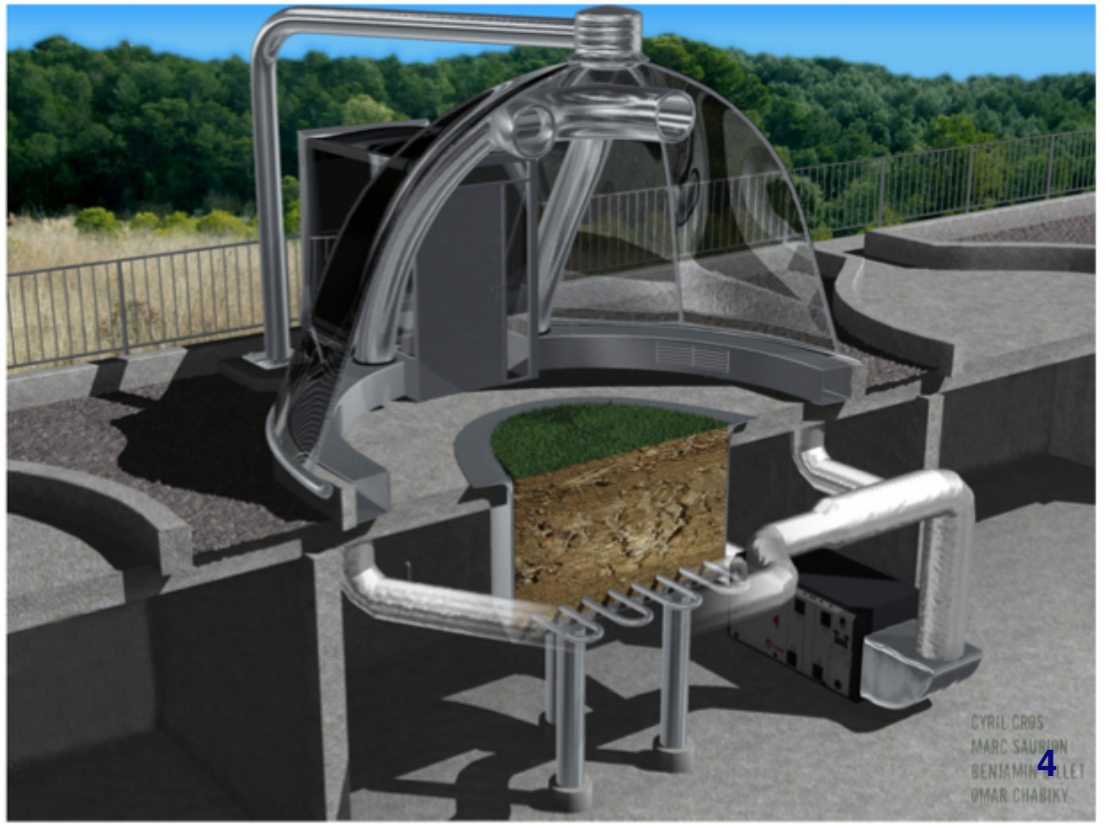
Experimental surface: 1 m^2

- The **uniqueness** of the Montpellier's Ecotron lies on its ability to **continuously measure**, in each unit, **net gas exchange** that occurs in between the ecosystem and the atmosphere.
  - **Biogeochemical fluxes** (CO_2, N_2O, NH_3, O_2 et CH_4)
  - **Stable isotopes** (^{12}C, ^{13}C, ^{14}N, ^{15}N, ^{16}O, ^{17}O, ^{18}O, ^{1}H, ^{2}H)

The Macrocosms platform in numbers

- The largest platform, designed for **realistic experiments conditions** using open-flow, mass-balance systems for the measurements of carbon, water and trace gas fluxes.

  - **12** independent units - **3 m** high
  - Air temperature: **-10 °C** to **+50 °C** (within ± 10 °C from outside temperature)
  - Air relative humidity: **30** - **85 %**
  - Homogeneous precipitation and irrigation (rotary nozzle, sprinklers, drip irrigation or water table)
  - Natural (FEP film) or artificial lighting
  - CO_2 atmospheric concentration : **ambient – 1000 ppm**
  - Continuous measurements of GHG (**CO_2**, **N_2O**, **CH_4**) and evapotranspiration
  - Soil setup (max): **5 m²**, **2 m** depth, **14 tons**
  - Continuous **soil temperature** and **moisture** measurement
  - Soil **temperature gradient control**
  - Soil **matrix potential control**

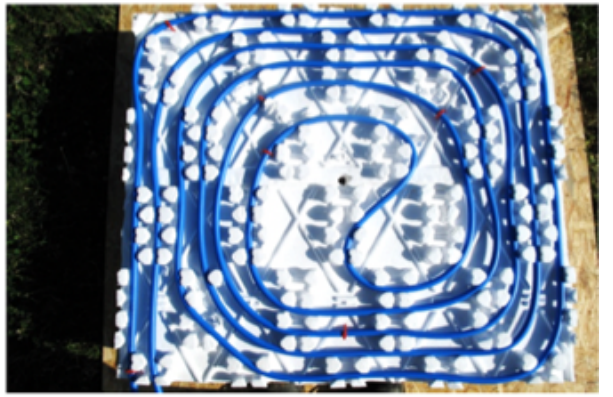


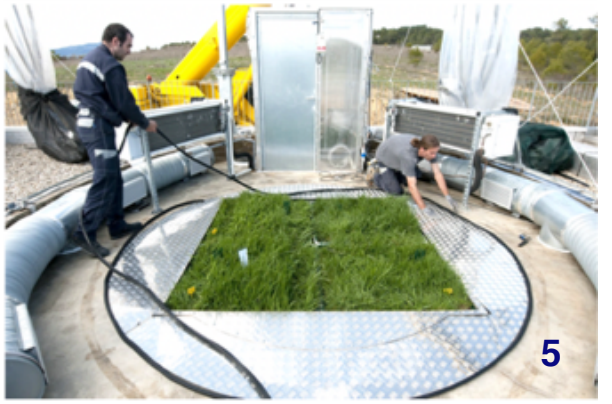
The Macrocosms platform: experimenting grassland in future climate

- **Objective**: Analyse the impact of elevated CO_2 and extreme climatic events expected by 2050 on a C3 grassland by measuring continuously CO_2 and H_2O fluxes.

- Experimental setup
  - **12** experimental units
  - **Average climatic conditions** for the 2050s as projected by the downscaled ARPEGEv4 climate model
  - **Intact soil monoliths** sampled in the French Massif Central (4 m^2 – 0.6 m depth)

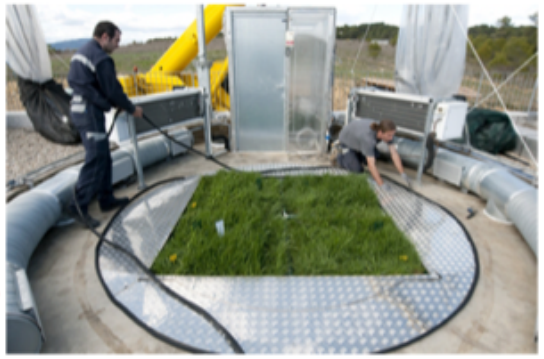
- Two factorial crossed design:
  - **Extreme Climatic Events** (Control vs ECE)
  - **Elevated CO_2** (aCO_2 = 390 vs eCO_2 = 520 ppm)

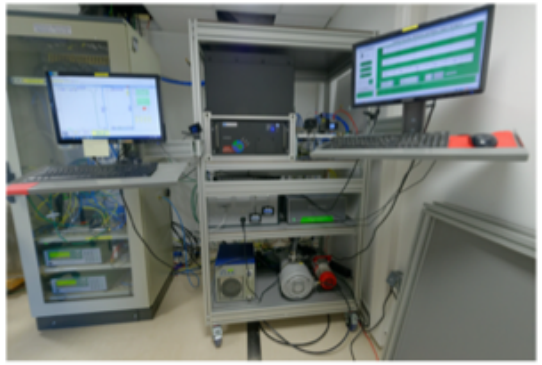




The Macrocosms platform: experimenting grassland in future climate

❑ Timeline





June 2009

Soil intact monoliths excavation in French Massif Central

September 2009

End of soil recovery and transport to Montpellier

March 2011

Start eCO_2 treatment in 6 macrocosms

November 2011

End of the experimentation

April 2010

Insertion of soil monoliths and acclimation to climate projections for the original location of the grassland for the 2050s from the ARPEGEv4

June 25 to August 31, 2011

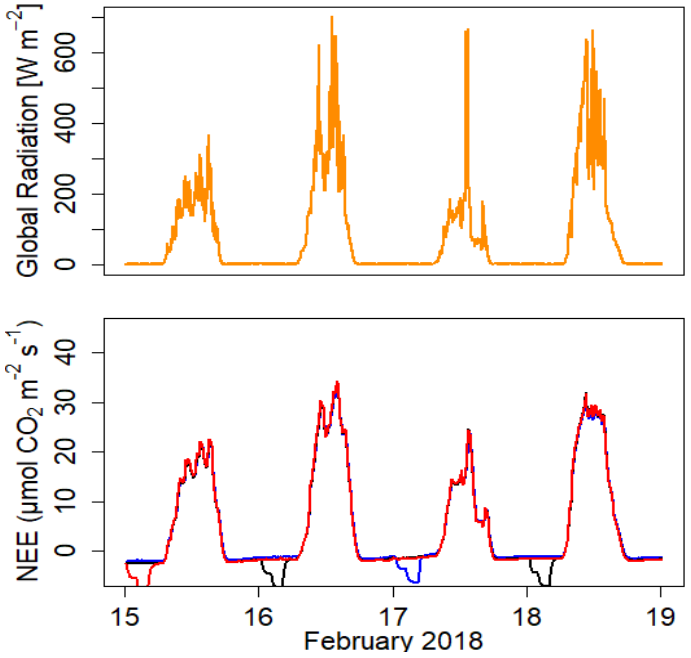
ECE = combined drought and heat waves (applied to three randomly selected macrocosms of the six at each CO_2 concentration).

The Macrocosms platform: experimenting grassland in future climate

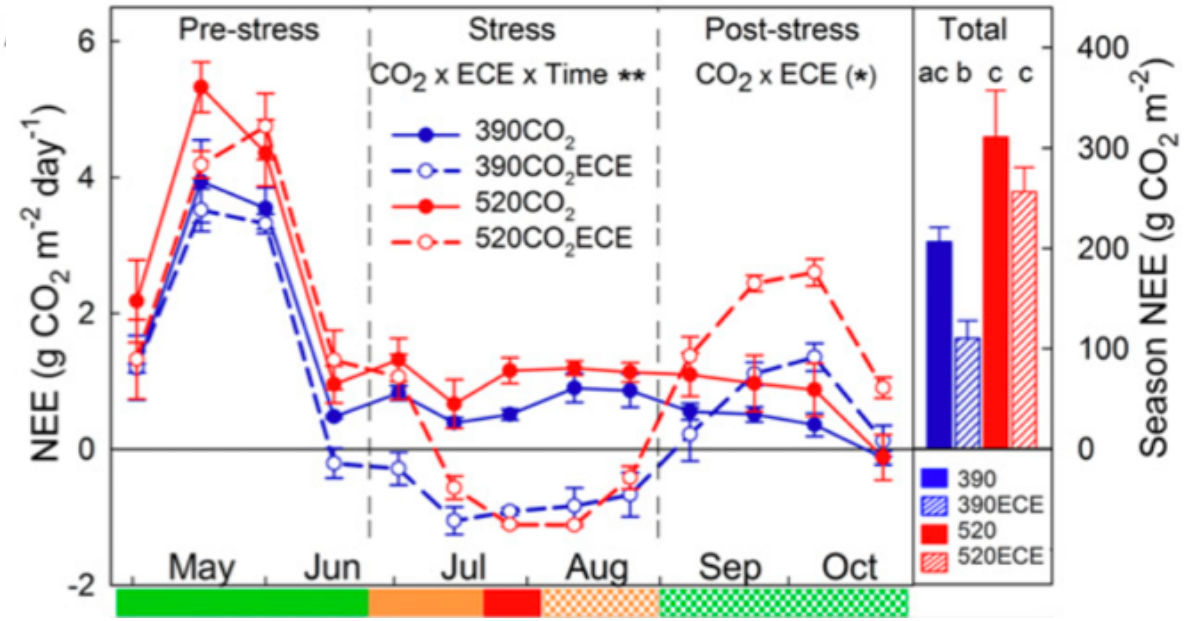
- PNAS

Elevated CO_2 maintains grassland net carbon uptake under a future heat and drought extreme

Jacques Roy[a,1,2], Catherine Picon-Cochard[b,1], Angela Augusti[b,c], Marie-Lise Benot[b,d], Lionel Thiery[b], Olivier Darsonville[b], Damien Landais[a], Clément Piel[a], Marc Defossez[a], Sébastien Devidal[a], Christophe Escape[a], Olivier Ravel[a], Nathalie Fromin[e], Florence Volaire[e,f], Alexandru Milcu[a,e], Michael Bahn[g], and Jean-François Soussana[b]



→ Daily **N**et **E**cosystem **E**xchange and radiation over 5 days

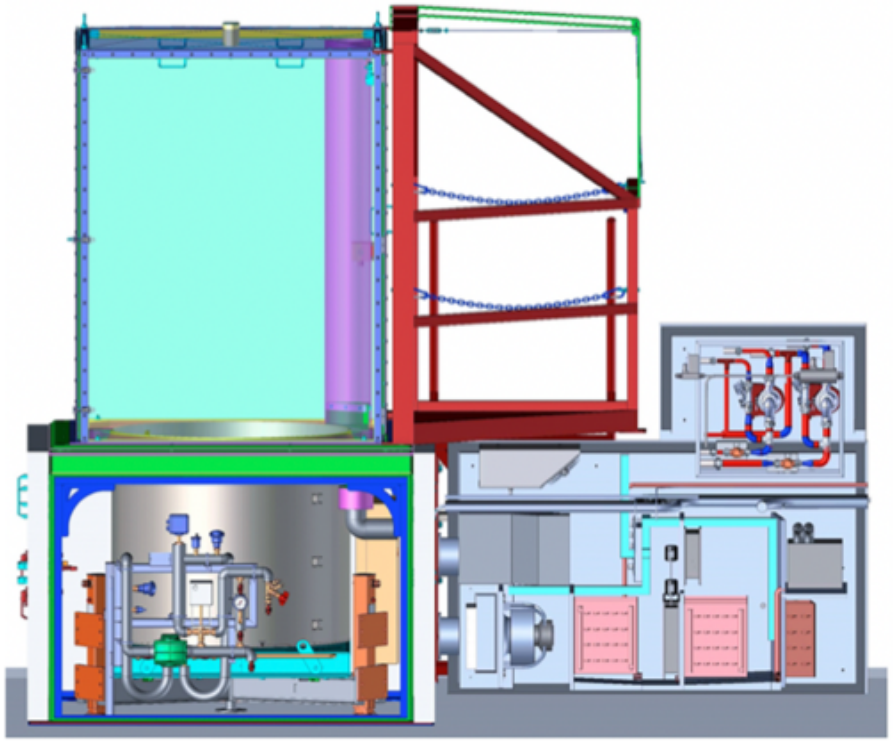


→ Weak eCO_2xECE interaction during ECE episode (Jul-Aug) whereas strong interaction during the recovery (Sep-Oct).

Importance to account for interactions between **drivers of global change**, their **seasonality effects** and **poststress recovery** processes

The Mesocosms platform in numbers

- **Similar specifications** as the Macrocosms platform with **several advantages**:
  - Higher number of units (**18**) for better replication or treatment combination
  - **2** m high
  - CO_2 atmospheric concentration : **10 – 1000 ppm** (adapted for preindustrial experiments) and continuous **^{13}C** labelling
  - Higher sensitivity of gas fluxes measurements
  - Soil setup (max): **1 m²**, **0.4** to **1 m** depth



The Mesocosms platform: experimenting biodiversity X drought

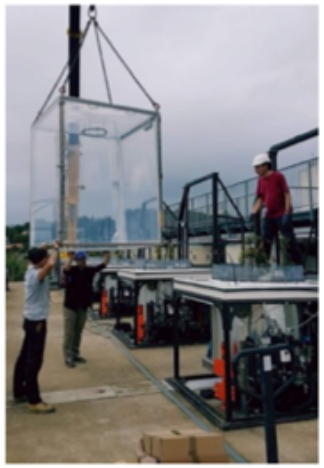
- **Objective**: Analyse the impact of detritivore functional diversity, drought and their interaction on a regenerating Mediterranean forest ecosystem

- Experimental setup:
  - **16 units** with **CO_2 fluxes** and **H_2O mass balance** continuous measurements
  - **mediterranean climate** (mimic the mean of 20 years reccords in a natural Mediterranean forest)
  - **8 two years old trees**: *Arbutus unedo, Quercus ilex, Quercus pubescens, Acer monspessulanum*

- Two factorial crossed design:
  - **Decomposer Functional Diversity** (low FD vs high FD) : mix functional/taxonomic group
  - **Drought effect** (Control vs Drought)

The Mesocosms platform: experimenting biodiversity X drought

❑ Timeline



Fevrier 2018

Soil sampling and lysimeter preparation

August 2019

Start of the drought

June 2020

End of the ecosystem **recovery** – new drought

September 2020

End of the drought

December 2018

Ecosystems insertion in the platform

Soil detritivores addition

October 2019

End of the drought

June 2020

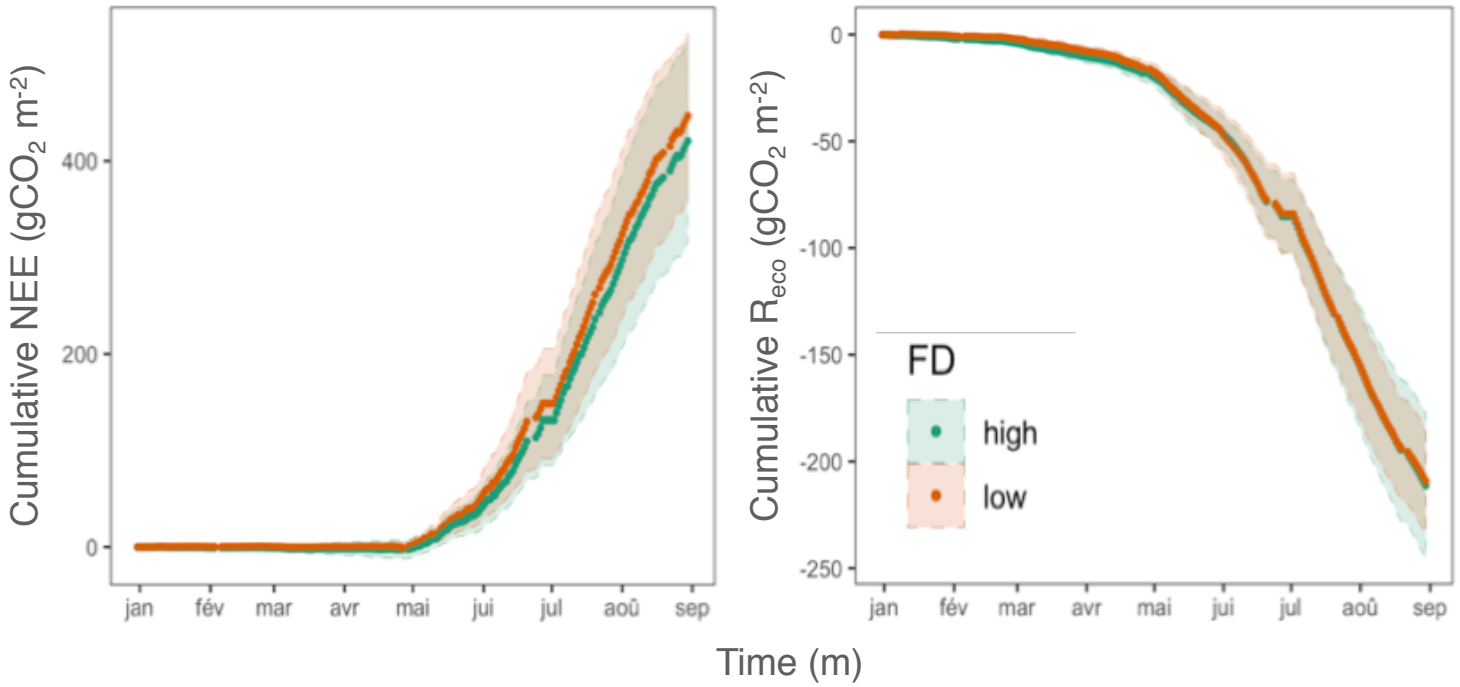
Start of the drought

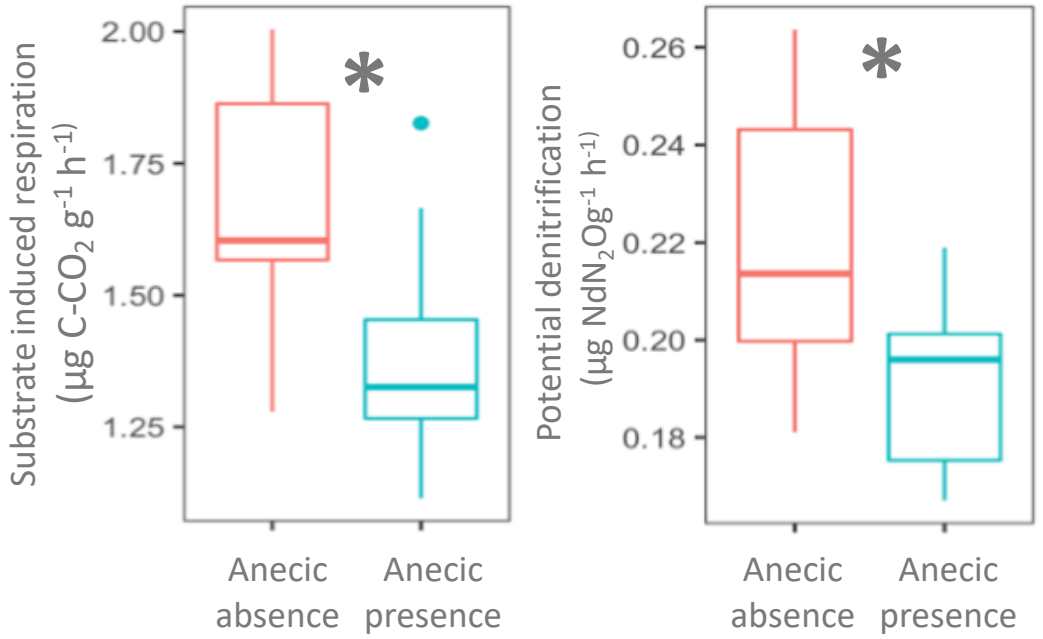
2020

Ecosystem **recovery**

The Mesocosms platform: experimenting biodiversity X drought

❑ **Preliminary results** (*Barantal et al., TEBIS conference*)





→ No effect of **detritivore functional diversity** on **CO_2 gas exchange** continuously measured

→ Effect of the presence of **anecic earthworms** observed by measuring **soil community response**

Selected publications

- Kathryn Barry, Liesje Mommer, Jasper van Ruijven, Christian Wirth, Alexandra Wright, et al.. The Future of Complementarity: Disentangling Causes from Consequences. Trends in Ecology and Evolution (2019)
- Esther Guillot, Philippe Hinsinger, Lydie Dufour, Jacques Roy, Isabelle Bertrand. With or without trees: Resistance and resilience of soil microbial communities to drought and heat stress in a Mediterranean agroforestry system. Soil Biology and Biochemistry (2019)
- Christiane Roscher, Stefan Karlowsky, Alexandru Milcu, Arthur Gessler, Dörte Bachmann, et al.. Functional composition has stronger impact than species richness on carbon gain and allocation in experimental grasslands. PLoS ONE (2019)
- Marcus Guderle, Dörte Bachmann, Alexandru Milcu, Annette Gockele, Marcel Bechmann, et al.. Dynamic niche partitioning in root water uptake facilitates efficient water use in more diverse grassland plant communities. Functional Ecology (2018)
- Alexandru Milcu, Ruben Puga-Freitas, Aaron Ellison, Manuel Blouin, Stefan Scheu, et al.. Genotypic variability enhances the reproducibility of an ecological study. Nature Ecology & Evolution (2018)
- Anne Alexandre, Amarelle Landais, Christine Vallet-Coulomb, Clément Piel, Sebastien Devidal, et al.. The triple oxygen isotope composition of phytoliths as a proxy of continental atmospheric humidity: insights from climate chamber and climate transect calibrations. Biogeosciences (2018)
- Víctor Resco de Dios, Jacques Roy, Juan Pedro Ferrio, Josu Alday, Damien Landais, et al.. Processes driving nocturnal transpiration and implications for estimating land evapotranspiration. Scientific Reports (2015)

Take-home message

- The **European Ecotron of Montpellier**:
  - is **open to national and international** consortium of researchers
  - propose a set of highly instrumented **controlled environment chambers** specialised in ecosystem-level **real-time measurements** of matter and energy fluxes.

- Year-around **open call for projects** with **project submission on the website** (http://www.ecotron.cnrs.fr)

- **Three experimental platforms** to study ecosystem processes from small (Microcosms) to larger (Mesocosms and Macrocosms) scales

- An **analytical platform** (IsoFlux) devoted to the measurement of **biogeochemical fluxes** and **stables isotopes:**
  - coupled to an experimental platform = **online measurements**
  - gas samples through flasks or exetainers = **independent measurements**

Thank you for your interest

You can **visit us** www **http://www.ecotron.cnrs.fr**

and **follow us** **@EcotronCNRS**