LC*pro* **T**

ADC BioScientific Ltd.

The Intelligent Photosynthesis System



User-friendly chamber climate control

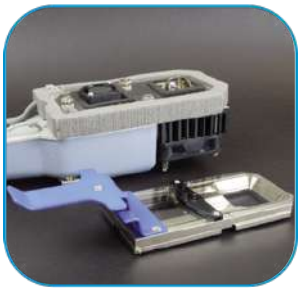
Instant, touch screen data entry

Real-time, colour graphing

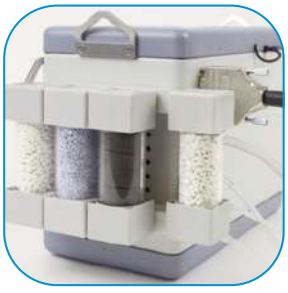
Choice of integrated light units

With colour, touch screen LCD and RGB LED light unit











Hear from users of the established forerunner of the LC*pro* ***T***:

"It is not hard to use the instrument. Indeed, the instrument is easy to work with and the manual is very helpful. "
André Araujo da Paz (Msc.), Science Teacher, Colégio Santa Maria Nova Suíça, Brasil.

"This system is the right solution when time matters; you can get the measurements you want easily and rapidly". *Dr JT Tsialtas, Aristotle University of Thessaloniki.*

Enhanced performance

- Touch screen, colour LCD display
- Instant touch key response
- Advanced graphing functionality and visibility
- Choice of light units; one supplied as standard:
  - Red Green Blue (RGB) LED light unit
  - White LED light unit
- Light unit control integrated into the console
- Enhanced, elevated CO_2 control, expert gas circuitry and dedicated soda lime column
- Automatic screen-dimming function and energy efficient components to save power
- Lightweight, high capacity lithium-ion battery
- GPS to record location and elevation data

Unparalleled Portability

Weighing only 4.1kg

The LC*pro* ***T*** is an exceptionally lightweight, portable system.

A comfortable, adjustable strap is supplied, so that the LC*pro* ***T*** can be easily carried and operated around the waist or on the shoulder.

Featuring our highly accurate, miniaturised infrared gas analyser and surface mount technology.

Full programmability, data display and capture are contained within the compact and rugged console.

16 hour battery life

Powered by a single, small 12V Lithium-ion rechargeable battery. The LC*pro* ***T*** will function continuously up to a maximum of 16 hours, depending on the environmental controls being operated.

Membrane sealed LCD

Designed for prolonged, reliable operation in harsh field conditions, the LC*pro* ***T*** maintains optimal performance even in highly humid and dusty climates. Both the touch screen LCD and the control panel are sealed within a membrane.

GPS

Pinpoint your data

The LC*pro* ***T*** is equipped with a GPS unit that automatically records the exact position of each sampling location.

All measurements taken outside, including latitude, longitude, UTC (Coordinated Universal Time), and GPS altitude, are displayed on screen within 30 seconds of obtaining a signal.

GPS parameters are automatically saved with each data record and then integrated into the data files for viewing in spreadsheet software.



Expert gas exchange performance

0 - 3000 ppm CO_2 range: Supplied as standard. Exceptional IRGA performance is maintained at this maximum CO_2 concentration.

Rapid auto-zero:

The LCpro *T* has an auto-zero cycling time of only 4 seconds, optimised to chamber type (subject to a flow check being performed).

This rapid cycling significantly improves the response times whilst maintaining analyser stability.

Stability of data:

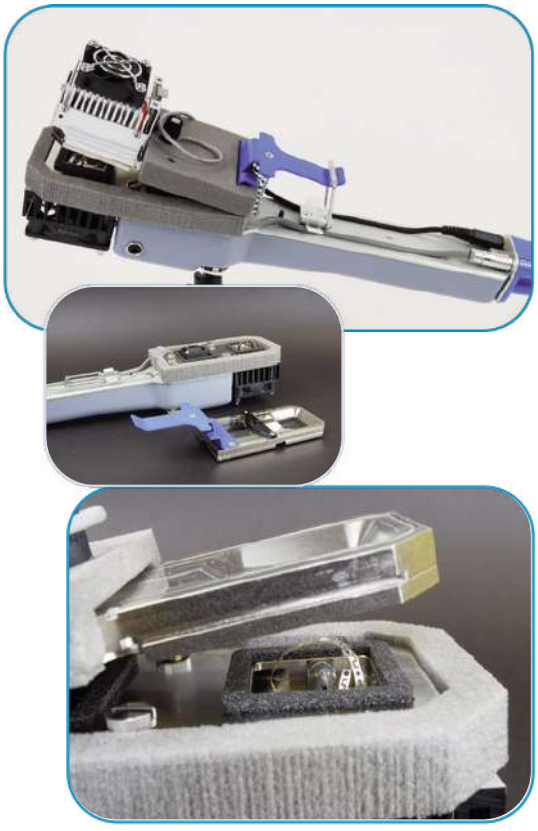
The effect of fluctuations in CO_2 concentrations in ambient air on gas exchange data is kept to a minimum by a refined, gas circuit system.

Long-term field performance:

Long life, durable components and sensors further enhance performance, even in harsh field conditions.

Quality testing:

Each instrument is checked and tested rigorously at each stage of assembly. A final, comprehensive calibraDon is performed by our expert engineers prior to release of a system.



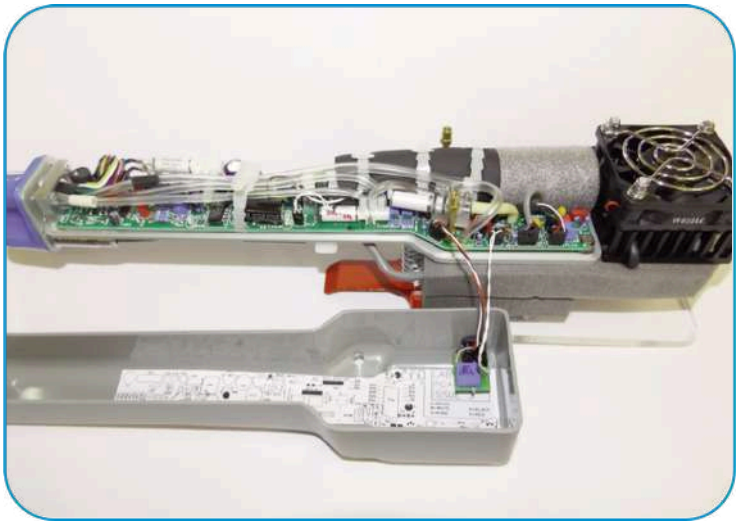
Expert measurement technique

Since 1969, ADC has been a world leader in the design and manufacture of infrared gas analysers (IRGAs). We have consistently advocated the **open mode** of analysis, whereby a constant flow of air and ambient pressure are maintained throughout the sample chamber.

This technique is widely accepted within the plant science community as the most accurate and versatile method for photosynthesis research.

The LC*pro* ***T*** chamber handle (see below) houses our expertly crafted, miniaturised IRGA. Gold-plated by hand, the IRGA provides accurate, fast and stable gas exchange performance.

By housing the IRGA directly within the chamber handle, we minimise any possible response delays in either gas exchange measurements or environmental controls. In addition, this configuration reduces gas 'hang-up' or water vapour 'drop-out', which is known to occur in long lengths of gas tubing.



Reliably stable

The LC*pro* ***T*** IRGA performs an automatic zero within its standard operational cycle, ensuring long-term measurement stability.

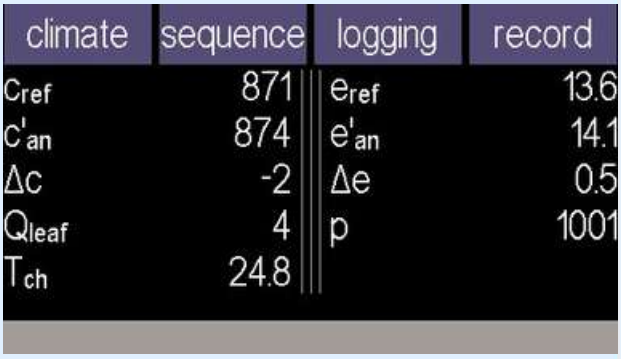
All CO_2 measurements are automatically corrected for Atmospheric pressure, temperature, and the effects of water vapour.
Our novel 'differential in time' IRGA design removes the need to constantly balance dual IRGA systems to prevent the calibration of the two cells drifting apart over time.

Highest quality sensors

To provide full photosynthesis data, the LC*pro* ***T*** plant leaf chamber encloses several environmental sensors. Two highly accurate, laser-trimmed humidity sensors provide exceptionally reliable transpiration data. High-calibre sensors also measure Photosynthetically Active Radiation (PAR) and chamber temperature.

The LC*pro* ***T*** offers a choice of accurate leaf temperature determination methods. An innovative, self-positioning thermistor is provided as standard in many chambers. Alternatively, a manual placement sensor can be employed, or the proven Energy Balance Equation can be used with any chamber.

Chamber Climate Control



The LC*pro* ***T*** provides complete and automatic climate control within each chamber type. All climate facilities are controlled through the LCpro T console. Each of the four parameters (H_2O, CO_2, PAR, and temperature) can be set to a constant level or controlled at multiple concentrations in sequence. Any combination of parameters can be controlled simultaneously.

The LC*pro* ***T*** climate control facilities use power-efficient components to maximise the internal battery life.

Rapid, intuitive experimental programming, whether by climate or sequential control, is achieved through selections made on the LC*pro* ***T*** software using the touchscreen.

H_2O control



Individual or sequential control of H_2O between 0 - 75 mbar, is achieved using self-indicating, conditioning chemicals housed within dedicated, removable columns.

Humidifying the chamber air is advantageous in experimental conditions that cause the chamber air to become excessively dry. Restoring and controlling the ambient humidity of chamber air can prevent influence on the transpiration activity of a sample.

Drying the air inside the chamber can be helpful when working with moist soil, for example, to prevent condensation occurring inside the soil respiration chamber.

CO_2 control



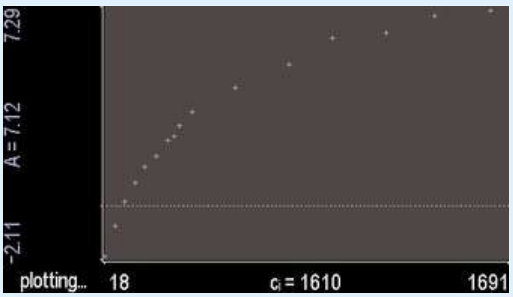
The LC*pro* ***T*** elevated CO_2 supply system enables the advancement of crop resilience research in the face of global climate change. This system is internally housed and protected from any potential environmental or physical damage.

A 4 g, pure CO_2 cartridge is used to deliver a stable, elevated supply for up to 32 hours of continuous operation. This supply is combined with air stripped of CO_2 to maintain the leaf chamber CO_2 concentration at any desired level between 0 and 3,000 ppm.

Automatic 'A/Ci curves' may be easily performed by programming several sequential control levels with required dwell times and automatic data recording.

The influence of local, elevated CO_2 can be quantified for plant leaves, stems, pods, spikelets, or soils by calculating gas exchange data generated by the LC*pro* ***T.***

Partially used cartridges are safely exhausted via an external vent.



PAR control

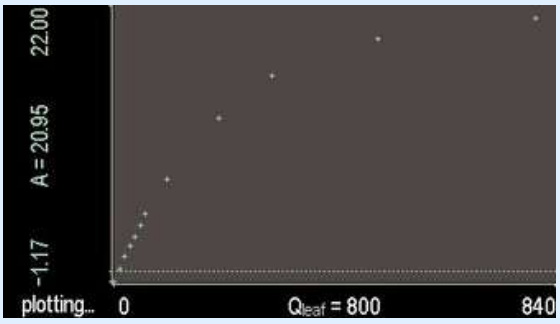
Via a fully integrated, White or adjustable R:G:B light unit.



A mixed Red/Green/Blue LED array provides versatile control of light between 0 and 2,400 µmol m^{-2} s^{-1}. A White LED array provides a maximum intensity of 2,500 µmol m^{-2} s^{-1}.

A micro PAR sensor measures the light emitted from a fitted LED array onto the leaf surface. The light units closely replicate the PAR spectrum evenly throughout the leaf chamber window. Both energy-efficient LED arrays maintain spectral quality over the entire intensity range with minimal heating effect.

The LC*pro* ***T*** can be easily programmed to generate automatic, light response curves (LRCs) using either unit. To ensure the optimal light control on the broadest possible number of plant species, each type of LC*pro* ***T*** chamber head (Broad, Narrow and Conifer) is supplied with a dedicated LED unit; with the choice of either RGB or White for Broad and Narrow heads.



Multiple options for setting PAR:

When using the white light unit: Total PAR can be set with the chamber climate control menu.

When using the RGB light unit, total PAR can be set directly from the same menu, or the relative % of Red, Green and Blue light can be set to achieve a total PAR comprising a desired ratio of RGB.

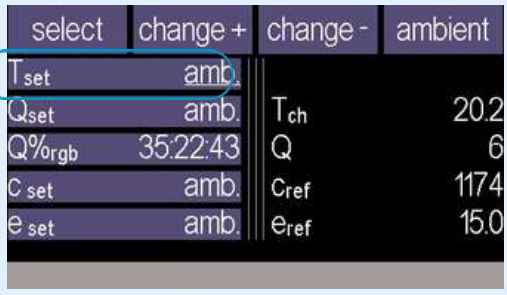
Temperature control



The LC*pro* ***T*** advanced, compact, Peltier heat transfer system provides the most dynamic temperature control range available.

The temperature inside all standard leaf chambers (Broad, Narrow, Conifer) can be automatically regulated +15 °C and -10 °C above and below ambient, or set to track ambient air temperature.

The LC*pro* ***T*** temperature control is both responsive and stable.



Simple, time-saving programming



ADC BioScientific are proud of our long-standing ability to design the easiest to use gas exchange devices.

The LC*pro* ***T*** enables *even more* intuitive, rapid menu navigation, parameter editing and sequence programming.

Unlimited data storage

The LC*pro* ***T*** features unlimited data storage. All experimental protocols, photosynthesis data and calculations are stored on Secure Digital (SD) cards. Separate cards can be allocated to specific experiments or individual users.

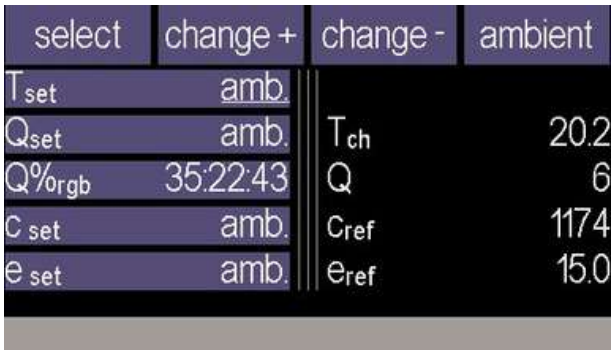
Data recording can be initiated both automatically and manually. Automatic data recording can be programmed to take place as part of an experimental sequence, such as during the generation of an A/Ci curve. Alternatively, manual recordings can be made either via the keypad or the button on the chamber handle.

Stored data can be viewed directly on the console LCD. Data can be downloaded directly from SD card or via USB output.

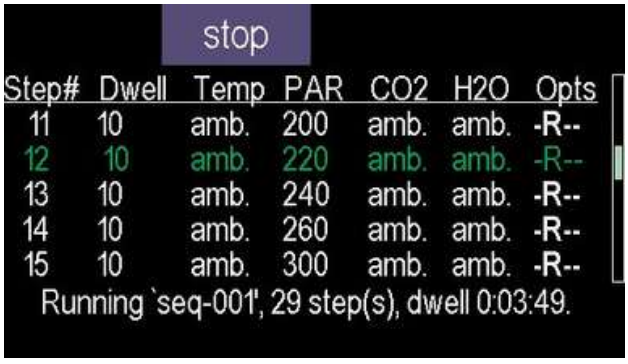
Instant, touch key response

Two selection options are provided on each menu screen:
1. Swipe across the screen with one finger to reveal the next menu page, then rftouch the parameter to be changed.

2. Select parameters in turn by pressing the key labelled ‘select ’.



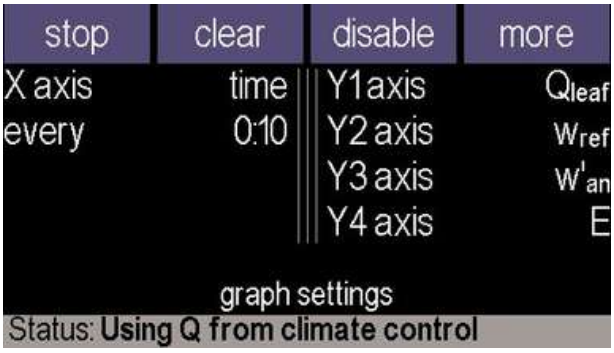
Experienced researchers and novice users can quickly and easily program sophisticated gas exchange experiments. Sequential changes in multiple parameters or factors are made by setting a ‘sequence file’:



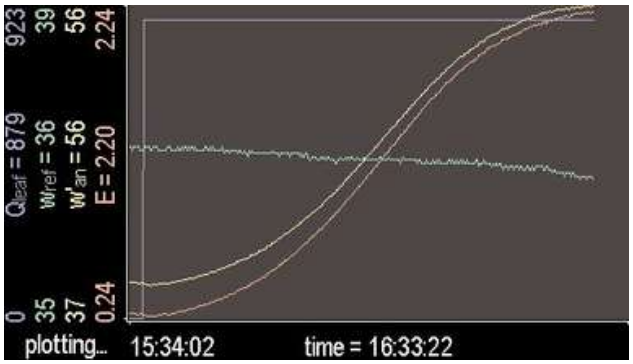
Colour, graphic display

Recorded, experimental data are easily plotted on a graph in real-time, with automatic scaling for presentation clarity.

Parameters may be plotted against time or record number. As many as four parameters may be plotted against each other, In distinct colours, providing a greater depth of data analysis.



The resulting plots of multiple parameters can include: Light Response Curves (LRCs) of photosynthetic rate, A (µmol m^{-2} sec^{-1}) against effective irradiance (Q) and also curves generated by A against intercellular CO_2 concentration (Ci).



Interchangeable chambers

The LC*pro* ***T*** is available with interchangeable chambers for the broadest range of experimental applications. These chambers can be easily and quickly exchanged by hand in any location. Upon fitting, each chamber has an automatic configuration, selected from the LC*pro* ***T*** menu via the touch LCD.

Boundary layer resistances and concentration gradients are minimised in all chambers. Carefully chosen materials ensure that there is minimal interaction with CO_2 or water vapour. All chamber windows are hard-coated to reduce scratching.



Broad Leaf Chamber

Our most widely used chamber, suitable for the most significant number of plant species, features both a self-positioning leaf temperature sensor and a manual placement temperature sensor.
The chamber window area is 6.25 cm^2.

Narrow Leaf Chamber

Designed especially for long grasses and narrow leaves less than 1cm in width.

Featuring a self-positioning leaf temperature sensor and a manual placement sensor.
The chamber window area is 5.8 cm^2.





Conifer Leaf Chamber

Transparent, cylindrical design suitable for pine needles and conifers, also ideal for small fruits and composites of very small leaves. The dedicated light unit provides even irradiance throughout the chamber. An approximate cylinder of 69 mm in length and 47 mm in diameter.

Small Leaf Chamber

This chamber has a unique flexible arm to allow easy, non-destructive positioning onto a leaf, even when the leaf is close to the soil surface. Chamber window diameter is 16.5 mm,
The window area is 2.16 cm^2.





Soil / Small Plant Chamber

Transparent 1-litre chamber with detachable collar (area 97.5 cm^2) for determining Net Carbon Exchange Rate over the soil. This chamber can also be configured for measuring photosynthesis on turf or whole plants up to 55 mm tall. Opaque chamber version also available.

NEW

Stem /Pod / Spikelet Chamber

Designed for the measurement of photosynthesis and transpiration in non-leaf plant parts such as stems, pods, or spikelets. The central acrylic tube bore is 22 mm, and the working length is 100 mm. The PAR LED is controllable from the LC*pro/i* consoles up to 1,500 µmol m^{-2} sec^{-1} .
Cooling and heating: at least +/-10 degrees from ambient and CO2 control (LC*pro T*) control 0 - 3,000 ppm.

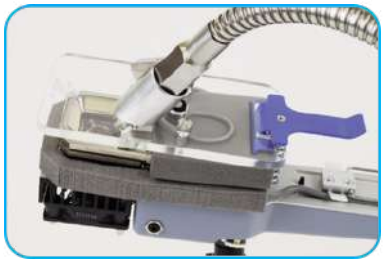




Versatile Chamber

Two-part chamber with multiple uses. Examples include whole, small plant photosynthesis, Antarctic microalgal gas exchange (Davey, M.P., Cambridge University, UK), and soil respiration measurement. Plants can be grown in the sealed pot, or the lower collar can be embedded into soil. Adapters are available for direct connection to 4” or 6” pipe. For whole-plant measurement, a suitable medium must be used to exclude the influence of soil respiration.

Fluorometer Adapter



A fibre-optic cable adapter to enable the use of the LC*pro* ***T*** with chlorophyll fluorometers.

Broad and Narrow leaf chambers are compatible with the OS5p+ and OS1p Portable Fluorometers, supplied by ADC. Fluorescence data can be recorded simultaneously with gas exchange data using the fluorometer and the LCpro *T*. The resulting data files can be combined within spreadsheet software.

For the investigation of plant, soil and atmospheric interactions, ADC BioScientific Ltd expertly produce a wide range of portable, user-friendly and cost-effective devices, from photosynthesis to soil respiration systems. We are committed to enabling carbon cycle research worldwide through quality instrumentation and local technical support.

ADC BioScientific Ltd also supplies: Leaf Area Meters, Chlorophyll Content Meters, Advanced Fluorometers, Automated Soil CO_2 Exchange Systems, Portable Soil Respiration Systems and Field Gas Analysers.

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LCpro *T* Technical Specification

Measurement range and technique:

CO_2: 0-3000 ppm, 1 ppm resolution
Infrared gas analysis; differential open system, auto zero, automatic atmospheric pressure compensation

H_2O: 0-75 mbar, 0.1 mbar resolution
Two laser-trimmed, fast-response water vapour sensors

PAR:0-3000 µmol $m^{-2}sec^{-1}$
Silicon photocell

Chamber Temperature : -5 °C to 50 °C
Precision thermistor
+/- 0.2 °C accuracy

Direct Leaf Temperature: -5°C to 50°C Self positioning microchip thermistor/energy balance/manually positioned thermistor

Flow rate to leaf chamber: 100 to 500 ml min^{-1}

Automatic Environmental Control:

Programming: Internal LC***pro*** *T* menu-driven software.
Automatic and independent control of environmental conditions within the leaf chamber. For automatic response curves, sequential control levels and dwell times may be set.

CO_2: Up to 2000ppm CO_2, by integral elevated CO_2 supply system

H_2O: Above and below ambient (dependent on ambient conditions), by on-board self-indicating conditioning chemicals

Temperature: Micro-peltier element.
All chambers automatically regulated +15 °C, -10 °C from ambient.

PAR:Up to 2400 µmol $m^{-2}sec^{-1}$mixed RGB LED array, or up to 2,500 µmol $m^{-2}sec^{-1}$ by White LED array.

Warm up time: 5 minutes @ 20 °C

Display: Colour WQVGA touch-sensitive LCD

Recorded Data: Removable SD cards. Compatible with cards up to 32 GB in size.

Battery: 7.5 Ah 12 V Lithium-ion battery
Up to 16 hours between charges

Battery Charger: Universal input voltage, fixed output

Electrical Outputs: Mini-B
USB connection: Functions as a mass storage device

RS232 output: 9 Pin "D" type
User-selectable rates of up to 230400 baud for computer or printer connection

Operating temperature range: 5 °C to 45 °C

Dimensions H X W X D:
Console: 230 x 110 x 170 mm
Plant Leaf Chamber: 300 x 80 x 75 mm

Weight:
Console: 4.1 kg
Plant Leaf Chamber: 0.8kg

ADC BioScientific Ltd. retain the right to change any specification as part of their continual product development

Selected Publications

1. D'Addazio, Veronica, Monica Maria Pereira Tognella, Adriano Alves Fernandes, Antelmo Ralph Falqueto, Marcelo Barcellos da Rosa, Ivoney GonDjo, and Marcelo Antônio de Oliveira. 2023. 'Impact of Metal Accumulation on Photosynthetic Pigments, Carbon Assimilation, and Oxidative Metabolism in Mangroves Affected by the Fundão Dam Tailings Plume'. *Coasts 2023, Vol. 3, Pages 125-144* 3 (2): 125–44. hHps://doi.org/10.3390/COASTS3020008

2. Fajardo-Cantos, E. Peña-Molina, A. Díaz-Montero, J. González-Romero, D. Moya, M. E. Lucas-Borja, and J. De Las Heras. 2023. 'Short-Term Macrochloa Tenacissima Response Understory Pinus Halepensis Mill Forest after Early Prescribed Burns in a Semi-Arid Landscape'. *Science of The Total Environment* 902 (December): 166268. https://doi.org/10.1016/J.SCITOTENV.2023.166268

3. Gray, Andrew, Monika Krolikowski, Peter Fretwell, Peter Convey, Lloyd S. Peck, Monika Mendelova, Alison G. Smith, and Matthew P. Davey. 2020. 'Remote Sensing Reveals Antarctic Green Snow Algae as Important Terrestrial Carbon Sink'. *Nature Communications* 11 (1). https://doi.org/10.1038/s41467-020-16018-w

4. Grisafi, Francesca, and Sergio Tombesi. 2023. 'Temperature AcclimaDon of Leaf Dark RespiraDon in Corylus Avellana: The Role of RelaDve Growth Rate'. *Tree Physiology* 43 (9): 1562–70. hHps://doi.org/10.1093/TREEPHYS/TPAD069

5. Kowalska, Aneta, Bal Ram Singh, and Anna Grobelak. 2022. 'Carbon Footprint for Post-Mining Soils: The Dynamic of Net CO_2 Fluxes and SOC Sequestration at Different Soil Remediation Stages under Reforestation'. *Energies 2022, Vol. 15, Page 9452* 15 (24): 9452. https://doi.org/10.3390/EN15249452

6. Leitão, Susana T., Mara Lisa Alves, Priscila Pereira, Aziza Zerrouk, Bruno Godinho, Ana Barradas, and Maria Carlota Vaz Patto. 2021. 'Towards a Trait-Based Approach to Potentiate Yield under Drought in Legume-Rich Annual Forage Mixtures'. *Plants* 10 (9): 1763. https://doi.org/10.3390/plants10091763

7. Liu, Lei, Hui Li, Na Li, Shuxin Li, Junhong Guo, and Xiangnan Li. 2022. 'Parental Salt Priming Improves the Low Temperature Tolerance in Wheat Offspring via ModulaDng the Seed Proteome'. *Plant Science* 324 (November): 111428. https://doi.org/10.1016/J.PLANTSCI.2022.111428

Online Resources

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