# New solution for measuring $g_{sw}$ and $\Phi_{PSII}$ on a single conifer needle


Lingling Yuan, Elizabeth Gordon, and Shannon Loriaux

LI-COR Biosciences, 4421 Superior Street, Lincoln, NE 68504

*shannon.loriaux@licor.com


## Introduction

- Conifer forests occur around the world and contain about a third of the earth's trees (Blinkley and Fisher, 2019). Understanding the underlying physiological responses of conifers to environmental drivers is important for making accurate and reliable predictions of forest productivity in the face of climate change scenarios.
- Two important physiological measurements useful for forest health assessment are the effective quantum efficiency of Photosystem II ($\Phi_{PSII}$) and the rate of electron transport from chlorophyll fluorescence measurements (Genty et al., 1989) and stomatal conductance ($g_{sw}$) assessed by gas exchange (Farquhar and Sharkey, 1982, Lawson and Blatt, 2014).
- Traditionally, multiple conifer needles or branches are measured together to provide enough signal to make accurate and simultaneous measurements of $g_{sw}$ and $\Phi_{PSII}$. In this study, we introduce a new solution for making rapid, accurate $g_{sw}$ and $\Phi_{PSII}$ measurements on a single conifer needle using the LI-600N Porometer/Fluorometer.


**Figure 1:** LI-600N Design. (A) LI-600N clamped on a loblolly pine (*Pinus taeda)* needle. (B) LI-600N flow path design.

## Methods

- Confirmation measurements were first done using narrow broadleaves.
- Survey measurements of $\Phi_{PSII}$ and $g_{sw}$ using the LI-600 were made on single needles of well-watered and water-stressed, greenhouse-grown loblolly pine (*Pinus taeda*) seedlings at growth irradiances of 150-200 µmol m$^{-2}$ s$^{-1}$ PPFD.
- In addition, the LI-6800 was used for traditional measurements of multiple needles as a comparison for survey measurements as well as adding additional eco-physiological insight through light response curves of the pine seedlings.

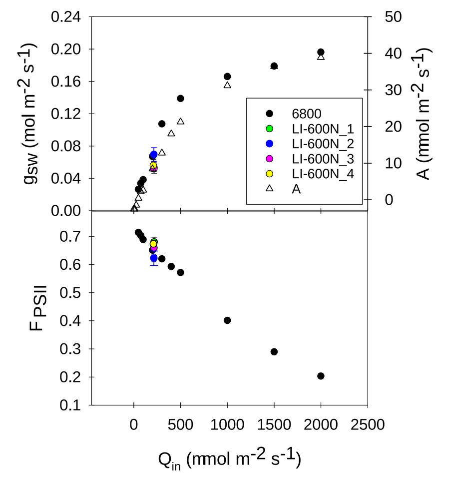


**Figure 2:** Measurements of stomatal conductance ($g_{sw}$) from four LI-600N instruments were compared to LI-6800 using greenhouse-grown narrow grass blades of *Bouteloua dactyloides*. Broadleaves were chosen because the boundary layer conductance ($g_{bl}$) of LI-6800 chambers is well-modeled for broadleaves. Each point is the mean of four (±SE) measurements on different leaves of the same pot.

## Results

### Survey measurements

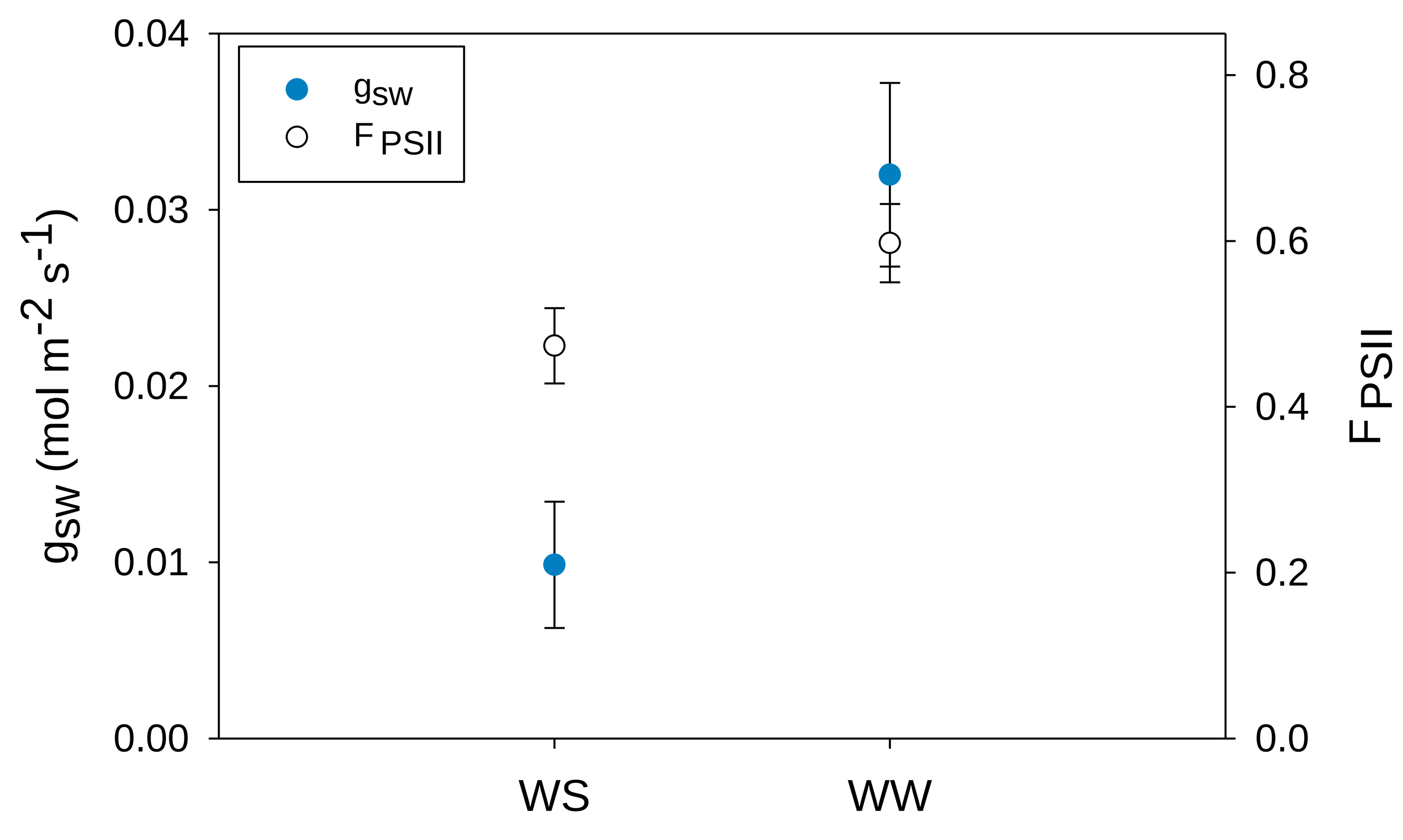


**Figure 3:** LI-600 survey measurements of well-watered (WW) or water-stressed (WS) single pine needles. Each point is the mean (±SE) of four measurements on four different plants.

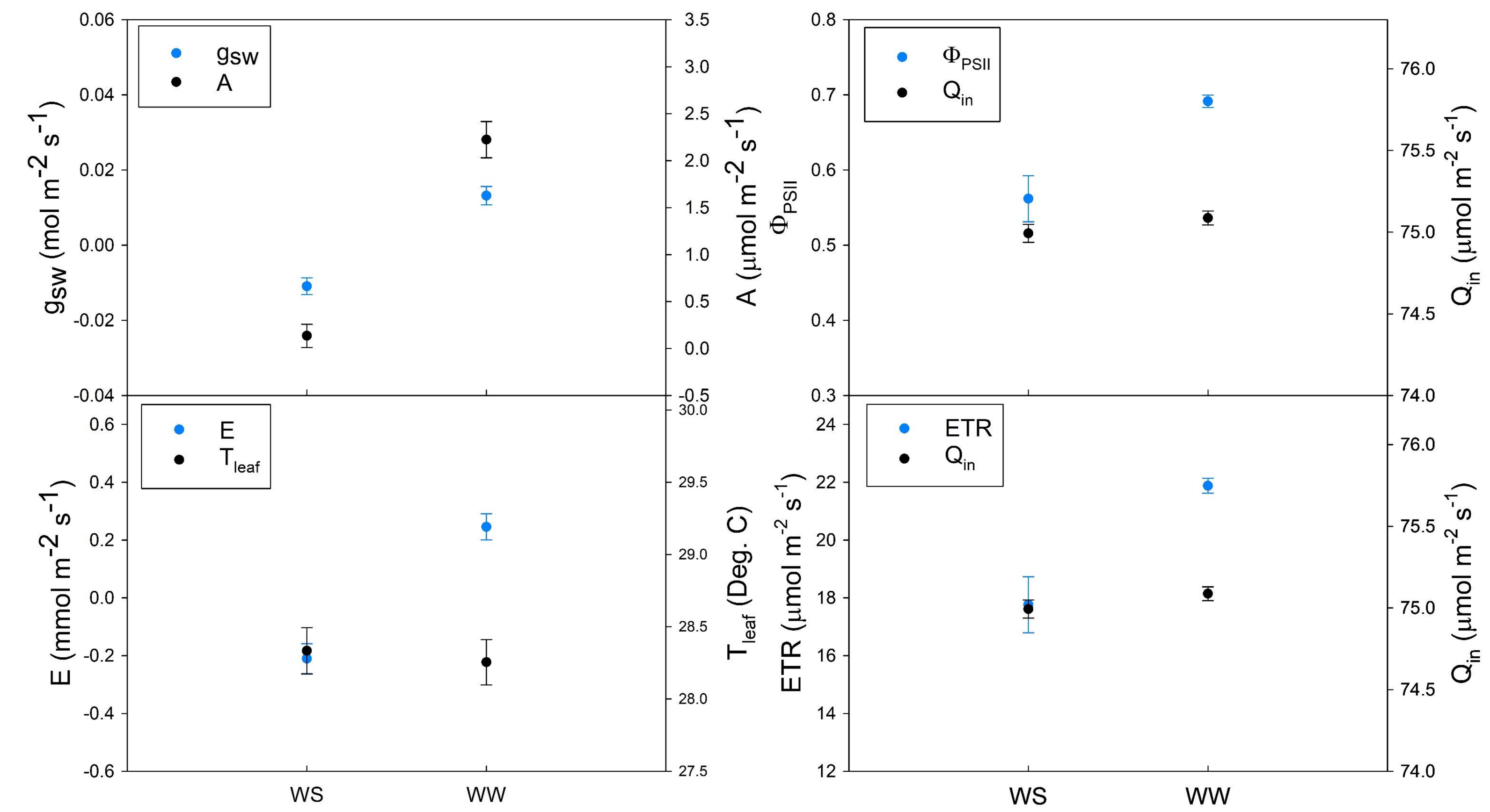


**Figure 4:** Additional survey parameters measured by the LI-6800, pooled by well-watered (WW) and water-stressed (WS) treatment. Each point is the mean (±SE) of six measurements on six different plants.

## Results

### Light response

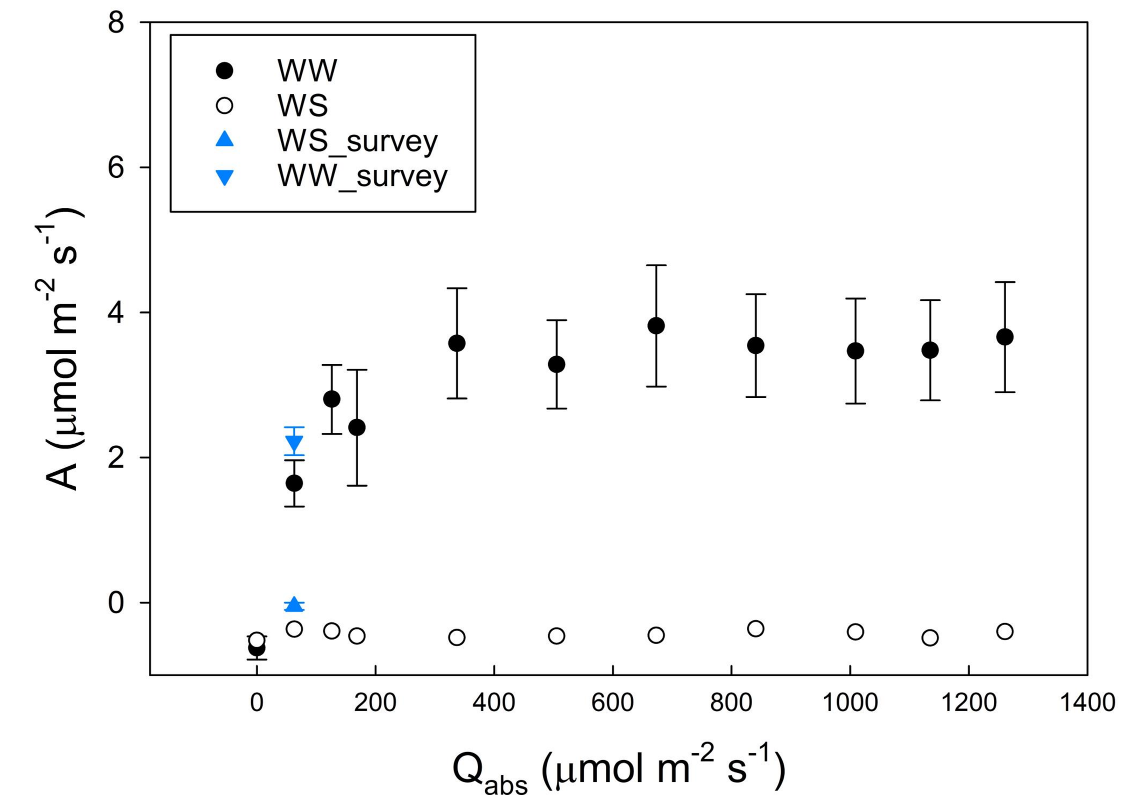


**Figure 5:** Average response curve of four well-watered (WW) pine plants (±SE) compared to water-stressed (WS) plants which exhibited net respiration at all light levels. Average survey measurement data for each treatment is noted by blue symbols.

## Conclusions

- LI-600 survey measurements revealed significant differences in $\Phi_{PSII}$ and $g_{sw}$ between well-watered and water-stressed seedlings. Additional measurements from the LI-6800 revealed that stomatal closure (measured by near-zero $g_{sw}$ values) and lower quantum efficiencies in the water-stressed seedlings led to net respiration at all light levels measured with light curves.
- The design of the LI-600N has been optimized to obtain precise readings from small samples, enabling quick measurements of $g_{sw}$ and $\Phi_{PSII}$ on a single conifer needle or narrow leaf. Its RH sensors have a high signal-to-noise ratio and the small chamber volume is easily influenced by leaf transpiration rates such that low $g_{sw}$ of small samples can be resolved. Additionally, the LI-600N has a smaller chamber surface area, reducing sorption effects and leading to more accurate estimates of sample water vapor mole fractions and consequently more precise $g_{sw}$ calculations. Moreover, each LI-600N is equipped with an infrared thermometer (IRT) that is individually calibrated for measuring leaf temperature, eliminating the need to make good contact with a leaf using a traditional thermocouple. Lastly, the LI-600N fluorometer is designed with a fixed geometry optimized for small leaf areas and offers a high signal-to-noise ratio, further contributing to the system's improved performance.

## References


- Dan Binkley and Richard F. Fisher. 2019. *Ecology and management of forest soils*. John Wiley & Sons.
- Bernard Genty, Jean-Marie Briantais, and Neil R. Baker. 1989. The relationship between the quantum yield of photosynthetic electron transport and quenching of chlorophyll fluorescence. Biochimica et Biophysica Acta 990, 87-92.
- Graham D. Farquhar and Thomas D. Sharkey. 1982. Stomatal Conductance and Photosynthesis. Annu. Rev. Plant Phys. 33:1, 317-345.
- Tracy Lawson and Michael R. Blatt. 2014. Stomatal size, speed, and responsiveness impact on photosynthesis and water use efficiency. Plant Physiol. 164(4):1556-70.



©2023 LI-COR, Inc. Presented at Ecological Society of America 2023. LI-COR is a registered trademark of LI-COR, Inc. All other trademarks belong to their respective owners.


LI-COR®

www.licor.com/env