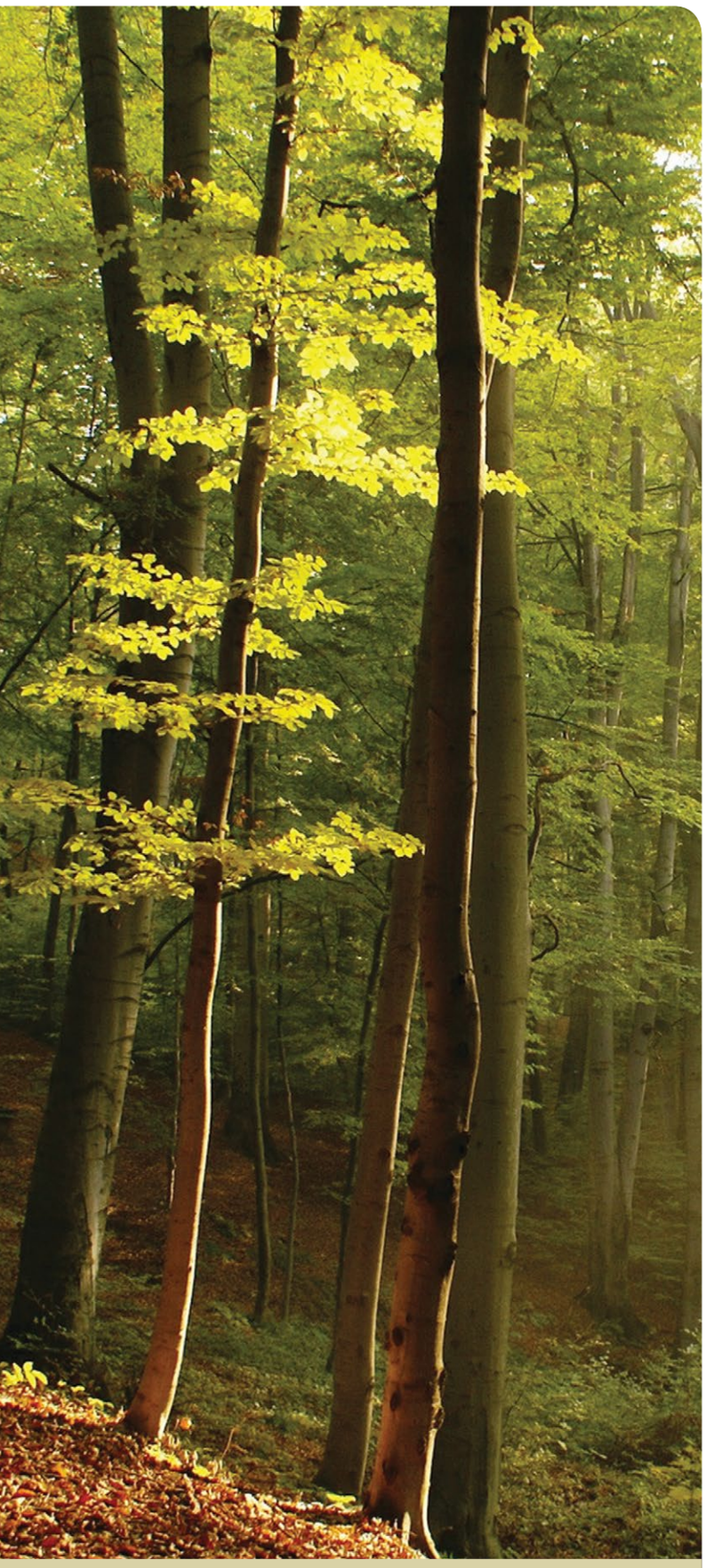
VERSION 3



Environmental Instrumentation

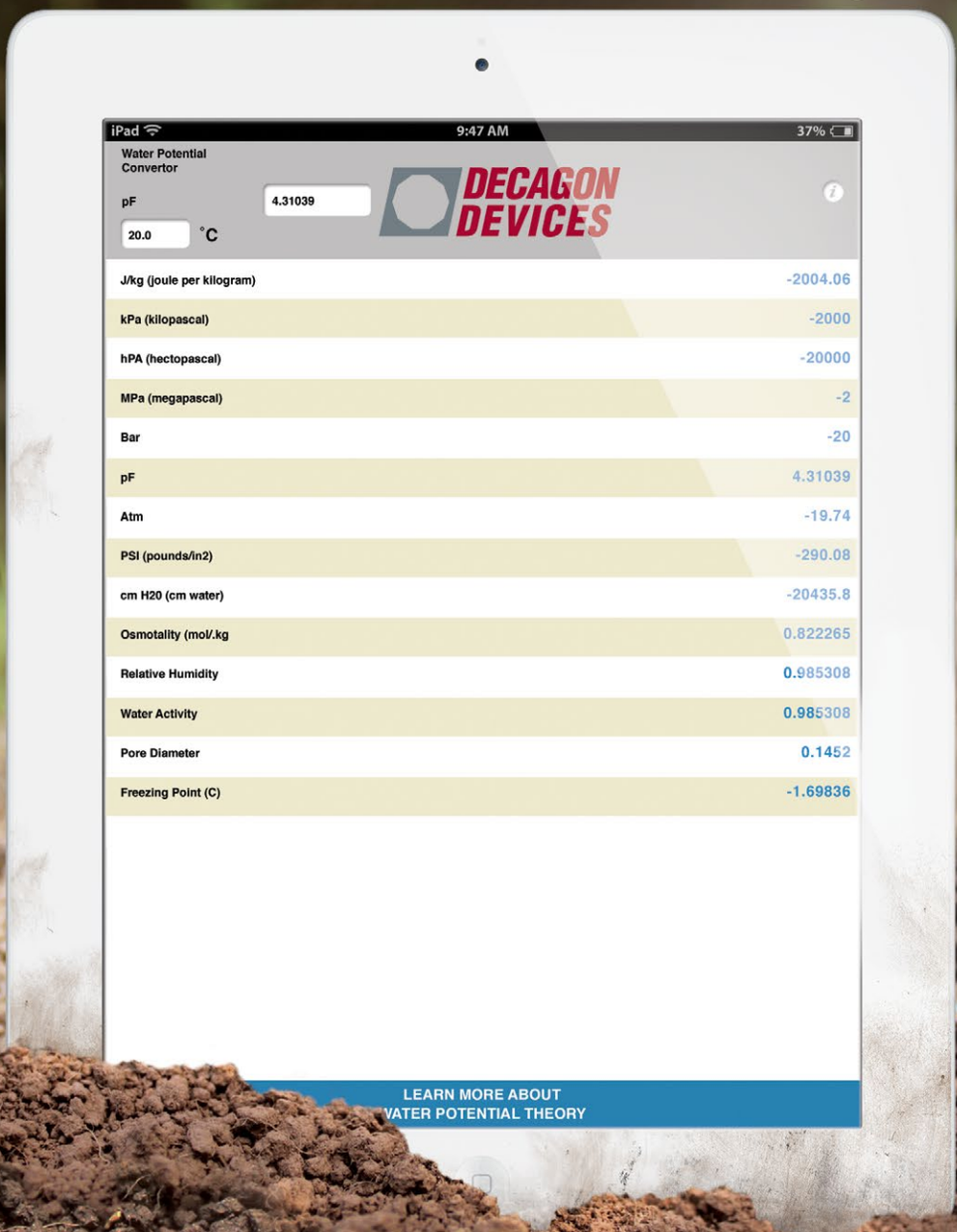
Characterize the environment.

DECAGON DEVICES

we measure the world®

Water Potential Conversions

–On the go.



FREE Decagon Mobile Application now available from the App Store and Google Play. Search for Decagon on either online location.

Google play

Available on the App Store

30 Years
QUALITY INSTRUMENTATION

2013 marks Decagon's 30th anniversary and it has made me think about the progress in monitoring the environment over the last 30 years. I think there are three instrument-related developments that have advanced environmental science:

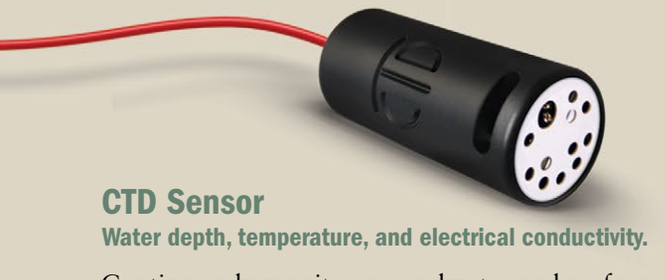
- *Small, low-power data loggers with wireless communication capabilities.*
- *Significant increases in computer processing power and speed.*
- *Dielectric soil moisture sensors (TDR, FDR).*

These developments make it possible to scatter collection nodes across the landscape. Researchers can now gather and analyze staggering amounts of data. Projects like B2 Landscape Evolution Observatory at Biosphere 2 and the Site-Specific Climate Friendly Farming project at Cook Farm are beginning to show us what's possible with these big networks.

What's next? It's impossible to say, of course, but I'm excited to see what new measurements will move the science forward. EC measurements, for example, are still somewhat crude but show promise in refining the way we look at water and nutrient movement in soils.

Bryan Wacker
Vice-President Marketing

New Instrumentation



CTD Sensor

Water depth, temperature, and electrical conductivity.

Continuously monitor groundwater and surface water level changes along with electrical conductivity and temperature.

CTD Specifications

Water Depth
Range: 0 to 3.5 m.
Accuracy: ±0.2 % of span at 20°C.
Resolution: 1 mm.

Electrical Conductivity
Range: 0 to 120 dS/m (mS/cm).
Accuracy: ±0.01 dS/m or ±10%.
Resolution: 0.001 dS/m.

Temperature
Range: -40 to +50°C.*
Accuracy: ±1°C.
Resolution: 0.1°C.

Data Logger Compatibility
Em50/Em50R/Em50G.
Call for compatibility of Data Loggers.

*Operating temperature 0 to 50˚C (Pressure transducer cannot be allowed to freeze while submerged).

GS3 Sensor

New rugged design.

Stainless steel needles and epoxy casing make the GS3 the optimal sensor for long term soil water studies.

GS3 Specifications

Volumetric Water Content
Range: 0–100%.
Accuracy: ±3% in typical soils.
Resolution: 0.002 m3/m3

Electrical Conductivity
Range: 0 to 23 dS/m (bulk).
Accuracy: ±1%
Resolution: 0.001 dS/m

Temperature
Range: -40–80°C.
Accuracy: ±1°C.
Resolution: 0.1°C.

+

DS-2

Measure wind speed and direction.

Details on page 5 “Environmental Sensors.”

SRS (PRI/NDVI)

Monitor the Normalized Difference Vegetation Index or the Photochemical Reflectance Index.

The SRS is designed for long-term autonomous measurement of vegetation indices under field conditions. One of its primary design goals is to reduce the cost of collecting high quality spatially distributed data in quantity over an entire growing season.

SRS Specifications

Calibration: NIST traceable calibration known spectral radiance (W m^{-2} nm^{-1}) or irradiance (W m^{-2} nm^{-1} sr^{-1}).
Foreoptics: (1) Cosine correcting Teflon diffuser, hemispherical field of view (2) Field stop, 20° field of view.
PRI Wavebands: 531±3 and 570±3 nm peak wavelengths, with 10 nm full width half maximum (FWHM) band widths
NDVI Wavebands: 630±5 and 800±5 nm peak wavelengths, with 50 nm and 40 nm full width half maximum (FWHM) band widths.
Cable Length: 5 m standard, custom cable length available upon request.

Operating Temperature Range: 40 to 50°C.
Accuracy: 10% or better for spectral irradiance and radiance values.
Measurement Time: < 300 ms.
Dimensions: 43 x 40 x 27mm.
Power: 3.6 to 15 VDC, 4 mA (reading, 300 ms), 30µA (quiescent).
Connector Type: 3.5 mm (stereo) plug or stripped and tinned lead wires.
Communication: SDI-12 digital sensor.

Drain Gauge G3

Water movement below the root zone.

Use the Drain Gauge G3 to collect, monitor, and analyze water moving below the root zone. The Drain Gauge G3 collects water moving through the vadose zone and sends drainage rate measurements to a surface data logger. The Drain Gauge G3 is built to be buried and stay buried.

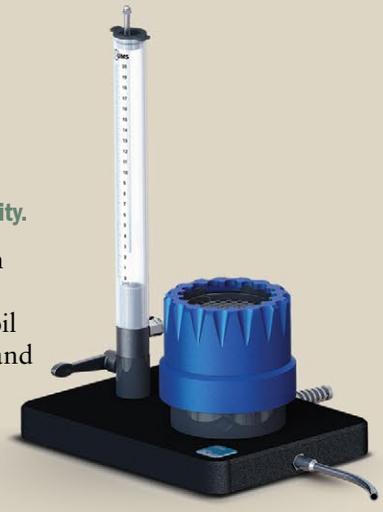
Drain Gauge G3 Specifications

Measurement surface area: 507 cm^2.
Sampling reservoir volume: 3 L.
Accuracy: ±1.4 mm drainage.
Resolution: 0.2 mm drainage.
Suction at intake: 110cm (11 kPa).
Total length: 147 cm.
Divergence control tube (DCT) length: 60 cm.
Measurement time: 150 ms.

KSat

Saturated Hydraulic Conductivity.

Designed for determination of saturated hydraulic conductivity on 250 cm^3 soil samples by constant-head and falling-head experiments.



KSat Specifications

Measurable K_{sat} values (min): 0.1 cm/d (0.004 in/d).
Measurable K_{sat} values (max): 10000 cm/d (3937 in/d).
Hydaulic conductivity (K_s) of the porous plate:
K_s = 20000 cm/d (10000 in/d)

Typical statistical inaccuracy at constant environmental parameters and constant flow resistance of the soils:
approx. 2% (in practice 10%)

Pressure sensor accuracy: 1 Pa (0.01 cm WC or 0.0001 psi).
Sample ring (Also fits with UMS HyProp):
- **Volume:** 250 ml (0.066 gal).
- **Height:** 50 mm (2 in).
- **Inside diameter:** 80 mm (3.15 in).

Vapor Sorption Analyzer

Automated soil water characterize curves.

Generates up to 200 data points (water potential vs. water content) for both adsorption and desorption within 24-48 hours. The VSA works in the dry (-10 to -475 MPa) range. Create automated soil-water characteristic curves and generate all the correlations with clay activity, surface area, and swelling potential.

Hold humidity constant and look at the way soil takes up water into its crystal structure (2:1 clays) and monitor water content change over time.

VSA Specifications

Range: -10 to -475 MPa.
Accuracy: ±1 MPa or ±1%.
Temperature operating range: 15 to 60°C.
Size: W 25.4 x L 38.1 x H 30.5 cm (10x15x12 in.)
Weight: 19 kg.

ES-2

Temperature and electrical conductivity.

The ES-2 allows you to obtain additional EC measurements for salt balance studies and nutriet monitoring. Monitor EC in pipes, tanks or wells.

ES-2 Specifications

Electrical Conductivity
Range: 0 to 120 dS/m (mS/cm).
Accuracy: ±0.01 dS/m or ±10% (whichever is greater).
Resolution: 0.001 dS/m.

Temperature
Range: -40 to +50°C.
Accuracy: ±1°C.
Resolution: 0.1°C.

Data Logger Compatibility
Call for compatibility of Non-Decagon data loggers.

WP4C

Lab water potential measurements.

The WP4C measures water potential by determining the relative humidity of the air above a sample in a closed chamber (an AOAC-approved method, conforms to ASTM 6836).

New features

- **Precise Mode**—verifies full equilibrium before displaying a final reading.
- **Speedy Equilibration**—new hydrophobic teflon impregnated nickel alloy sample chamber coating reduces equilibration time.
- **Finely-Tuned Adjustments**—new algorithms allow precision calibration and ±0.05 MPa (or better) accuracy.
- **Better range and accuracy**—resolves temperatures to a thousandth of a degree to push the functional range to -0.1 MPa.

WPC4 Specifications

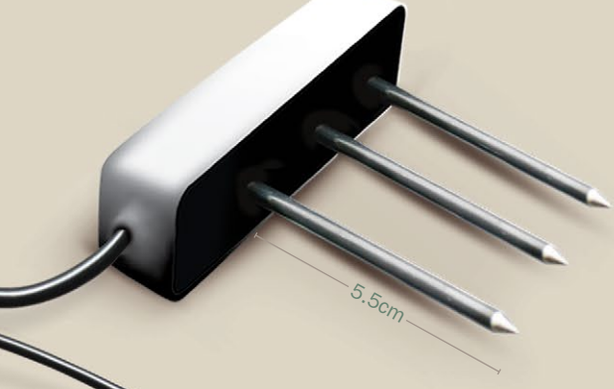
Operating environment: 5 to 43°C (41 to 110°F).
Temperature control: 15 to 40°C ±0.2°C.
Sensors: 1. Infrared temperature 2. Chilled-mirror dew point.
Range: 0 to -300 MPa.
Accuracy: ±0.05 MPa from 0 to -5 MPa, ±1% from -5 to -300 MPa.
Read time: Typically 5 to 10 minutes.
Interface cable: Serial cable (included).
Data communications: RS232 compatible, 8-bit ASCII code, 9600 baud, no parity, 1 stop bit.
Weight: 3.2 kg (5.2 kg shipping weight).
Universal power: 110-220V AC, 50/60 Hz.
Sample dish* capacity: 7 ml recommended (15ml full).
Calibration standard: 0.5 molal KCl (-2.22 MPa).

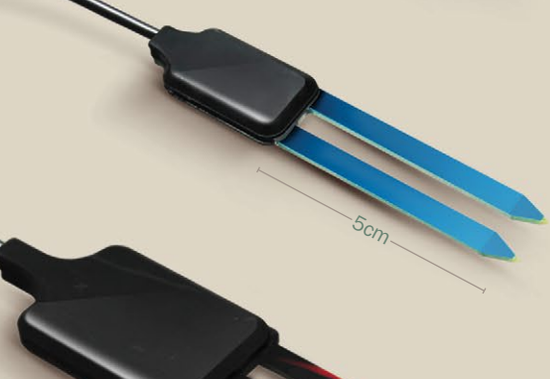
*25 plastic cups and 10 stainless steel cups included.

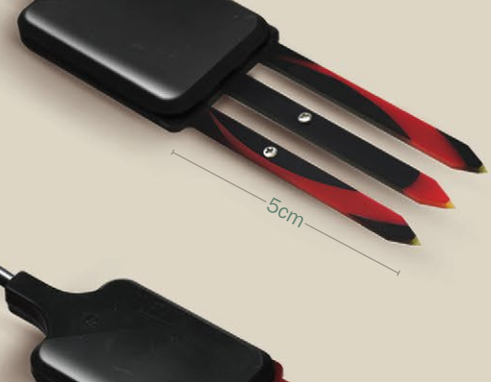
Watch a video on innovative ways the VSA is being used in soils applications.
learn.decagon.com/VSA

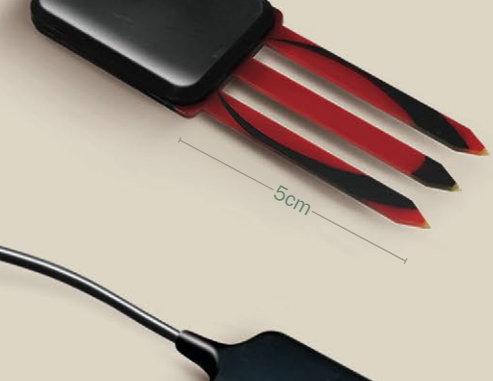
Watch R&D scientist Dr. Doug Cobos discuss the advancements made with the new WP4C.
learn.decagon.com/WP4C

Soil Moisture Networks









Measurement & Benefits	Range	Accuracy
GS3 Volumetric Water Content, Electrical Conductivity, Dielectric Permittivity, Temperature. **Benefits:** Optimized for greenhouse and nursery substrates.	**VWC:** 0–100%. **Apparent dielectric permittivity (ε_a):** 1 (air) to 80. **EC:** 0 to 23 dS/m (bulk). **Temperature:** -40 to 80°C.	**VWC:** ± 3%, typical mineral soils up to 10 dS/m **(ε_a):** ±1 ε_a (unitless) from 1–40 (soil range), ±15% from 40-80. **Electrical Conductivity (EC):** ±10% from 0 to 10 dS/m, user calibration required above 10 dS/m. **Temperature:** ±1°C.
EC-5 Volumetric Water Content. **Benefits:** All purpose, least expensive soil moisture sensor.	**VWC:** 0–100%.	**VWC:** ±3%, typical mineral soils up to 8 dS/m. **VWC Rockwool:** ±3% VWC, 0.5 to 8 dS/m. **VWC Potting soil:** ±3% VWC, 3 to 14 dS/m.
5TE Volumetric Water Content, Electrical Conductivity, Dielectric Permittivity, Temperature. **Benefits:** Manage salts and fertilizers in your soils.	**VWC:** 0–100%. **Apparent dielectric permittivity (ε_a):** 1 (air) to 80. **EC:** 0 to 23 dS/m (bulk). **Temperature**: -40 to 50°C.	**VWC:** ±3%, typical mineral soils up to 8 dS/m. **(ε_a):** ±1 ε_a (unitless) from 1–40 (soil range) ±15% from 40–80. **Bulk EC:** ±10%. **Temperature:** ±1°C.
5TM Volumetric Water Content, Dielectric Permittivity, Temperature. **Benefits:** Include temperature dependencies in your research study. Rugged epoxy body.	**VWC:** 0–100%. **Apparent dielectric permittivity (ε_a):** 1 (air) to 80. **Temperature:** -40 to 50°C.	**VWC:** ±3%, typical mineral soils up to 8 dS/m. **(ε_a):** ±1 ε_a (unitless) from 1–40 (soil range) ±15% from 40–80. **Temperature:** ±1°C.
MPS-2 Soil Matric Potential, Temperature. **Benefits:** Maintenance-free water potential and soil temperature monitoring measurements that do not drift over time.	**Soil water potential (Ψ):** -10 to -500kPa (pF 1.71 to pF 3.71). **Temperature:** -40°C to 50°C.	**Ψ:** ±25% of reading from -5 to -100 kPa* **Temperature:** ±1°C. *Accuracy significantly improved with custom calibration.

Data Management

Em50 Data Loggers

Data loggers use either direct connection, radio, or cellular (GSM Cell Modem) technology to deliver stored data. With the cellular-enabled Em50G you can access and download the data anywhere with internet connection.

Storage: Up to 36,000 scans.
Logging Interval: 5 min. to 24 hrs.
Input ports: 5 channels, any Decagon sensor.


Cellular Transmission


Direct Connection


Radio 900 MHz

ProCheck

Handheld readout for all Decagon sensors.

The ProCheck is an indispensible tool for making portable measurements, or for checking the quality of sensor installations. You can also program SDI-12 addresses of supported sensors, making large-scale installations of SDI-12 systems much quicker. The ProCheck is a must have for any large installation.

DataTrac 3

Understand your data.

DataTrac 3 graphical and database software organizes, graphs, and stores your data. View and edit data in table format, create reports, and transfer information to other DataTrac 3 users.

- Educate and inform your team efficiently.
- Adjust date ranges, add/subtract data from specific sensors, change target bands of your finding.
- Watch data in real-time.
- Add notes to the data stream.
- Automatically collect data from your Em50G/Em50R loggers chronologically.
- Combine data streams and track meaningful indicators.

Download free 30-day trial DataTrac 3 software:
learn.decagon.com/datatrac3

Environmental Sensors

RT-1

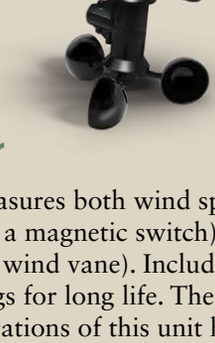
The rugged RT-1 soil temperature sensor is an easy-to-use sensor for measuring the temperature of soil or other materials. The sensor is stainless steel, completely water proof, submersible, and designed for continuous outdoor use.

Resolution: 0.1°C.
Range: -40 to 80°C.
Temperature accuracy: ±1°C.
Type: Thermistor.

ECRN-100

High-resolution rain gauge with two internal tipping spoons.

Resolution: 0.2 mm.
Funnel size 17x14.2 cm.



Cup Anemometer

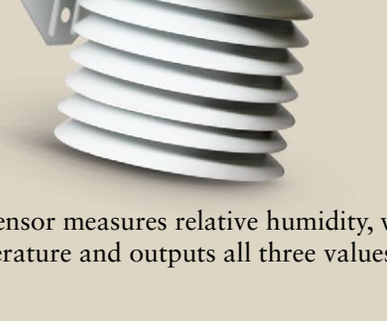
The anemometer measures both wind speed (using windcups and a magnetic switch) and wind direction (with wind vane). Includes sealed stainless steel bearings for long life. The range and accuracy specifications of this unit have been verified in wind-tunnel tests (information available upon request).

Resolution: 1 mph (0.45 ms^{-1}).
Range: 0 to 129 mph.
Accuracy: ±5%.
Direction Resolution: 1°C (0-355°).

Pyranometer or Photosynthetically Active Radiation

Completely water proof, submersible and designed for continuous outdoor use.

Cable length: 3 m.
Range PAR: 0 to 2000 µmol/$m^{-2}s^{-1}$.
Range PYR: 0 to 1750 W m^{-2}.
Dimensions: 24 mm diameter, 29 mm deep.
Accuracy: ±5%.



VP-3

Durable sensor measures relative humidity, vapor pressure, and temperature and outputs all three values as a digital signal.

Probe RH range: 0 to 100% RH.
Temperature range: -40 to 60°C.
Temperature accuracy: ±1°C.
RH accuracy: ±2% from 10–90% RH, ±3% from 0–10% RH, and 90–100% RH. See website for complete accuracy of specs.

New

DS-2

The DS-2 is a two dimensional sonic anemometer that measures wind speed and wind direction. Wind speed and direction are fundamental measurements necessary for a wide range of agricultural, forestry, and micrometeorological research and management applications. The DS-2 has no moving parts, does not require maintenance or recalibration and is capable of making high accuracy measurements, even at low wind speeds.

SC-1 Leaf Porometer

Get high quality data without fans, tubes, or pumps.

Steady state design makes accurate stomatal conductance measurements affordable and practical for everyday research. Use stomatal conductance to evaluate plant water use, quantify water stress, and compare physiological response of different species.

Benefits

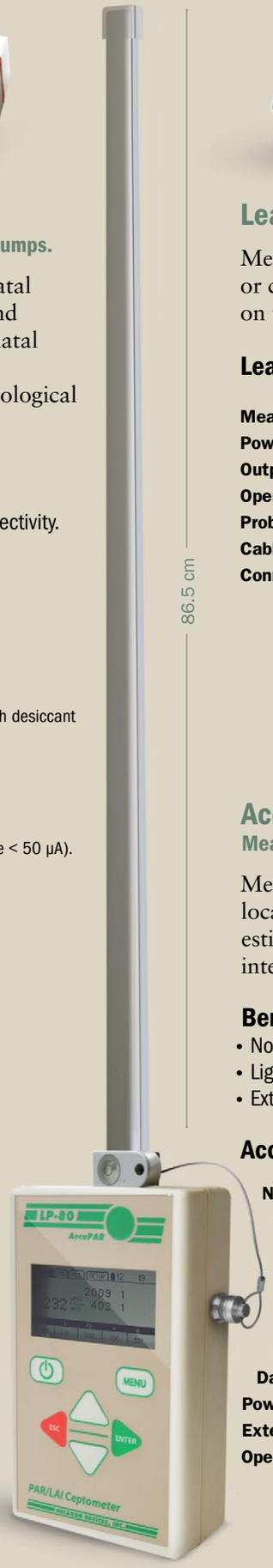
- Automatic sampling mode eliminates user subjectivity.
- No tubes, pumps, or fans.

Leaf Porometer Specifications

Conductance range: 0-1000 mmol/m^{-2} s^{-1}.
Accuracy: ±10%.
Operating environment: 5 to 40°C, 10 to 100% RH with desiccant chamber.
Measurement Units: mmol/$m^{-2}s^{-1}$, m^2s /mol^{-1}, s/m.
Sensor head cable length: 1.2 m (4 ft.).
Measurement time in auto mode: 30 s.
Power: 4 AA alkaline cells, 3 years (AA drain in sleep mode < 50 µA).
Data Storage: 4095 measurements in flash memory.

DS-2 Specifications

Wind speed range: 0 to 30 m/s.
Wind speed resolution: 0.01 m/s.
Wind speed accuracy: 0.30 m/s or < 3%, which ever is greater.
Wind direction range: 0 to 359°.
Wind direction resolution: 1°.
Wind direction accuracy: ± 3°.
Maximum sampling speed: 1 Hz.
Operating temperature range: 40 to +50°C.
Physical dimensions diameter: 100 mm, Overall height: 155 mm.
Cable length: 5 m standard, custom length available upon request.
Outputs: (3) Wind speed, gust speed, wind direction or vector.



Leaf Wetness Sensor

Measure duration of leaf wetness. Requires no painting or calibrations and detects trace amounts of water or ice on the sensor surface.

Leaf Wetness Sensor Specifications

Measurement time: 2 ms.
Power: 2.5 VDC @ 2 mA to 5 VDC @ 7 mA.
Output: 320 - 1000 mV @ 3 V excitation.
Operating environment: -20 to 60°C.
Probe dimensions: 11.2 x 5.8 x 0.075 cm (4.4 x 2.3 x 0.029 in).
Cable length: 5 m standard, or custom length.
Connector type: 3.5 mm plug.

AccuPAR LP-80 Ceptometer

Measure both PAR and LAI.

Measure transmitted PAR and calculate LAI at any location within a plant or forest canopy. Used to estimate biomass production, determine radiation interception.

Benefits

- Non destructive.
- Lightweight and rugged field-ready design.
- External PAR sensor included.

AccuPar LP-80 Specifications

Number of sensors: 80.
Overall length: 102 cm (40.25 in).
PAR range: 0 to >2,500 µmol $m^{-2}s^{-1}$.
Resolution: 1 µmol $m^{-2}s^{-1}$.
Minimum spatial resolution: 1 cm.
Data storage capacity: 1MB RAM, 9000 readings.
Unattended logging interval: User selectable, between 1 and 60 minutes.
Data retrieval: Direct via RS-232 cable.
Power: 4 AAA batteries.
Extension cable option: 7.6 m (25 ft).
Operating environment: 0° to 50°C (32°-122°F), 0 to 100% relative humidity.

Watch a three minute video to see how the SC-1 uses first-principle methods to measure stomatal conductance.
learn.decagon.com/porometer

Watch a two minute video on measuring PAR and LAI with the AccuPar LP-80.
learn.decagon.com/LP80

Hydrology

Remote Ground Water Monitoring

CTD Sensor and Em50G data logger.

The CTD sensor combined with the Em50G data logger are the perfect pair for remote groundwater monitoring. The Em50G can send your water depth, temperature, and electrical conductivity data to your computer up to six times daily by cellular transmission worldwide.

Infiltrometer

Portable Measurement of Hydraulic Conductivity and Infiltration.

Adjustable suction and porous stainless steel contact plate ensures good contact and minimizes surface disturbance for a quick and accurate measurement.

Infiltrometer Specifications

Total length: 32.7 cm.
Suction range: 0.5 to 7 cm of suction.
Water volume for operation: 135 mL.
Diameter of sintered stainless steel disc:
4.5 cm diameter, 3 mm width.

Thermal

KD2 Pro

Thermal conductivity, resistivity, diffusivity and specific heat capacity.

Measure heat transfer in the soil-plant-atmosphere continuum with the KD2 Pro Thermal Properties Analyzer. The KD2 Pro has three interchangeable sensors which measure thermal conductivity, diffusivity and specific heat (heat capacity). Data storage capabilities, an automatic data collection mode, and utility software to download data to your computer.

KD2 Pro Specifications:

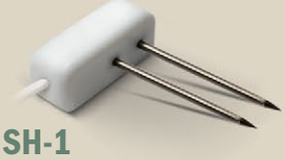
Measurement time: 1 to 10 min.
Data storage: 4095 readings.
Case size: 15.5 x 9.5 x 3.5 cm.
Power: 4 AA Batteries.
Cable: .8 m.

Accuracy*: ±5 to ±10% Conductivity/ Resistivity. ±10% Thermal Diffusivity, ± 10% Specific Heat.
Environment: –50 to 150°C.
Ranges*: K: 0.02 to 4 Wm^{-1} C^{-1}, D: 0.1 to 1.0 mm^2s^{-1}, R: 0.5 to 50 mC W^{-1}, C: 0.5 to 4 MJ m^{-3} C^{-1}.

*Accuracy and measurement range vary with sensor type.

TR-1

10 cm needle length
Thermal conductivity/resistivity of soil or porous materials. ASTM and IEEE compliant.



SH-1

3 cm dual needle length
3 parameters: thermal conductivity, thermal diffusivity, and specific heat.

KS-1

6 cm needle length
Thermal conductivity of liquids.

Optional Sensor

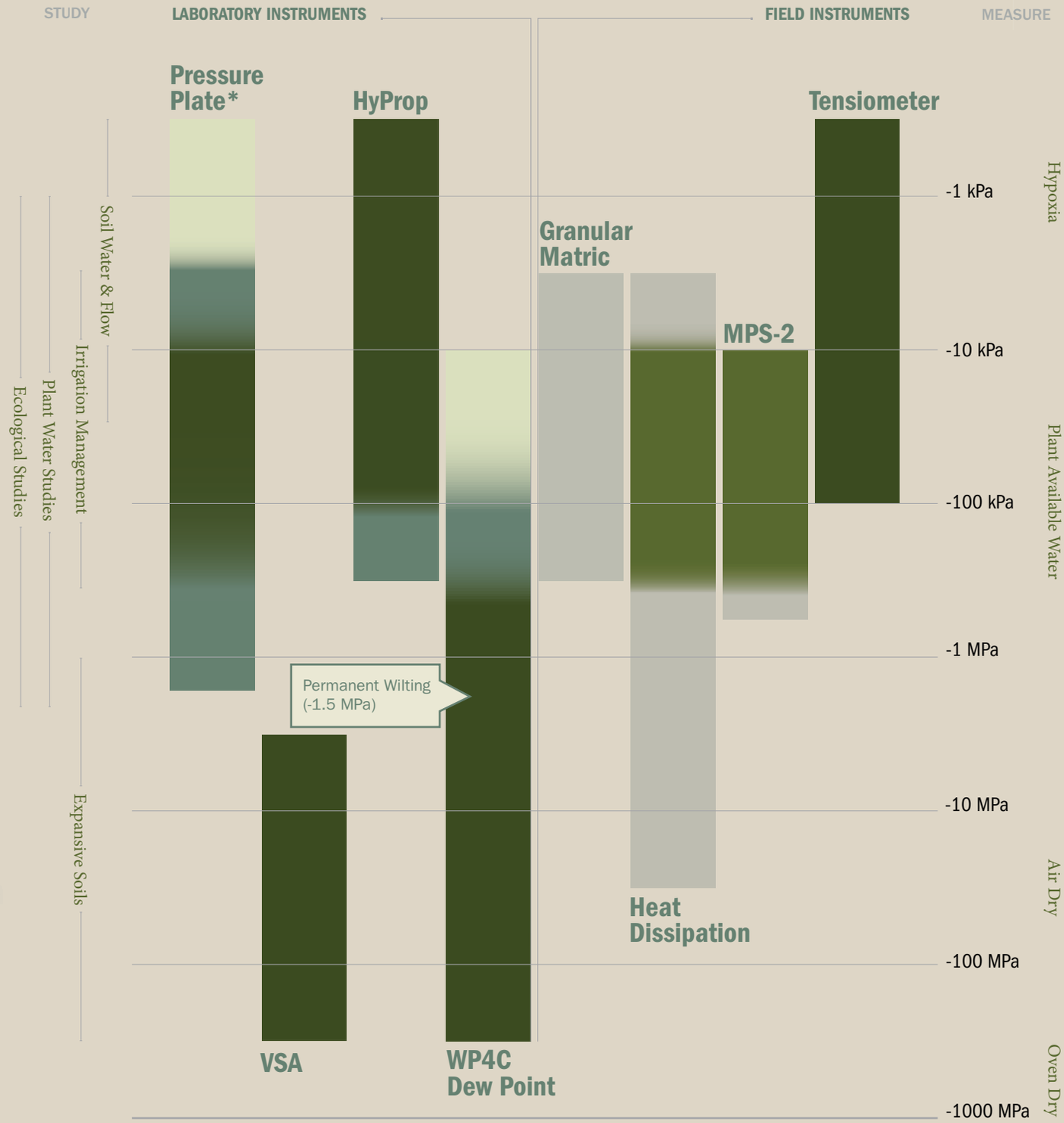
RK-1 (sold separately)

6 cm needle length
Thermal conductivity/resistivity; for use with stone or cement samples. The optional RK-1 sensor kit measures rock, concrete and other materials where drilling a pilot hole is required.

Watch a three and a half minute video about measuring soil thermal conductivity with the KD2 Pro.
learn.decagon.com/KD2pro

Water Potential

Instrument Ranges



- Excellent accuracy
- Good accuracy
- Moderate accuracy
- Responds to change, may not be accurate
- Useful in some applications
- Not recommended or out of range

**Assumes equilibrium time 1-3 months.*

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