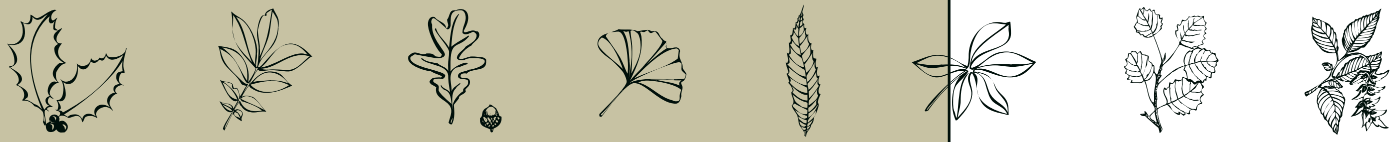

CanopyNews

Calculation of LAI and Interception of Short Canopies

FIRST GROWTH was designed to measure the green cover of short, sparse plant canopies. The camera measures the fraction of its field of view that is green. If the camera views a vegetated surface from a position normal to the surface, then the fraction it measures is the green cover, *c*. With certain assumptions, this value can also be used to estimate the leaf area index, *L*, and the fractional light interception for a plant canopy. For short, sparse canopies, this approach is one of the few indirect methods available.

Continued on page 2

Quantify Effects of Riparian Vegetation Removal on Stream Energy Balance

WHEN THE VEGETATION along a stream bank is removed, the solar load on the stream increases. This results in increased stream water temperature. Elevated stream temperatures degrade freshwater habitats, shifting species composition, and often endangering some of the species that live in the stream. An increasing awareness of this problem has led to the creation of riparian strips to shade streams when timber is harvested or prescribed burns are undertaken. The challenge is to know how much shade is needed, and how large to make the strips.

Continued on page 4

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2004

We are committed to product improvement, keeping pace with new research trends and technology development. For example the original ceptometers was designed for measuring sunflecks. The PAR measurement function of our first ceptometers was added just before its release.

In the second version, the LAI measurement capabilities were added and the original sunfleck feature was discontinued (see page 7 for more.)

Please contact us about your canopy application.

Regards,

Bryan T. Wacker
Decagon Product Manager

Short Canopies (continued from cover)

The fraction of incident light transmitted through a canopy can be calculated from

$$\tau = exp\ (-KL_e) \qquad (1)$$

where K is the extinction coefficient for the canopy and L_e is the effective leaf area index. The extinction coefficient depends on the angle distribution of leaves in the canopy and on the angle with which the light intercepts the canopy. We refer here to the effective leaf area index. This is the leaf area index of randomly distributed leaves that would have the same transmission value as observed. If the leaves in the canopy are actually randomly distributed in space, then the actual leaf area index and the effective leaf area index are the same. If the leaves are clumped, then the actual leaf area is larger than L_e. This effect will be quantified later.

The probability of light getting through the canopy is the same, whether the light is coming from the sun to the soil or the soil to the camera lens, so, we can use a First Growth picture of a canopy to get transmission:

$$\tau_n = 1 - c \qquad (2)$$

where c is the fractional green cover registered by First Growth. The subscript n on τ is to indicate that this the transmission at normal incidence. From this value of τ_n and eq. 1, we can compute effective leaf area index if we know a value for K:

$$L_e = -In(\tau_n)/K_n \qquad (3)$$

It is also possible to compute the canopy transmission for incident light at other angles, and the daily interception of light from this measurement. The details of these calculations can be found in the AccuPAR user manual (available online at www.decagon.com/manuals/LPman.pdf), and will not be repeated here.

Finding K_n and measuring Non-Uniform Canopies

The canopy extinction coefficient is determined by the angle distribution of leaves in the canopy and the incidence angle of the radiation. Additional equations and information on calculating K_n and measuring non-uniform canopies see this article in its entirety at: http://www.decagon.com/appnotes/FGLAI.pdf

Framing Issues

To get accurate measurements of ground cover and LAI, it is important to have a representative field of view in the picture. In a row crop, for example, the picture should extend from half way between one set of rows to half way between the next. The idea is that the whole field could be made up of multiples of the area photographed. If this does not give sufficient resolution, a smaller area containing the row can be photographed, and the cover in that area multiplied by the ratio of the width of the area photographed to the distance between rows.

Conclusion

The First Growth can be used effectively to determine LAI of sparse canopies. For short canopies, this is one of a very few non-destructive methods available for measuring LAI and light interception. The method is relatively insensitive to canopy structure. Straightforward corrections are available for clumping effects. ■

COMPARISON OF THREE LEAF AREA INDEX METERS IN A CORN CANOPY

W. W. WILHELM, K. RUWE, AND M. R. SCHLEMMER

Measurement of leaf area index (LAI) is critical to understanding many aspects of crop development, growth, and management. Availability of portable meters to estimate LAI non-destructively has greatly increased our ability to determine this parameter during the cropping season. However, with several devices on the market, each with an independent set of protocols for gathering accurate estimates of LAI, it is necessary for scientists to have comparisons of these meters under field conditions before selecting one for purchase and use. The objective of our study was to compare the LAI estimates by three meters (AccuPAR, LAI-2000, and SunScan) to LAI measured by destructive sampling. Leaf area index of two corn (*Zea mays L.*) hybrids, grown on a Pachic Haplustoll, was measured at the R2 stage by the four methods before and after successive thinning of plant stands. Destructively sampled LAI ranged from 4.95 to 1.25 for the initial stand to the most severe thinning. Hybrids did not differ in LAI. All meters underestimated LAI compared with destructive sampling. When all data from all rings of the LAI-2000 meter were included in the calculations, LAI-2000 estimates of LAI differed from those of the other two meters. However, when data from Ring 5 was removed from the calculations, estimates of LAI for the LAI-2000 improved and were indistinguishable from the other meters. The relationship between LAI estimated destructively and by each of the meters was described by a unique linear equation for each hybrid. Results of this study, and experience with use of the meters, suggest that users should consider protocols for operating each meter before deciding which device best suits their application. ■

Abstract: Published in Crop Sci. 40:1179-1183 (2000).

▲This is an abstract. If you would like a free reprint of the entire paper, please call Decagon 800-755-2761.

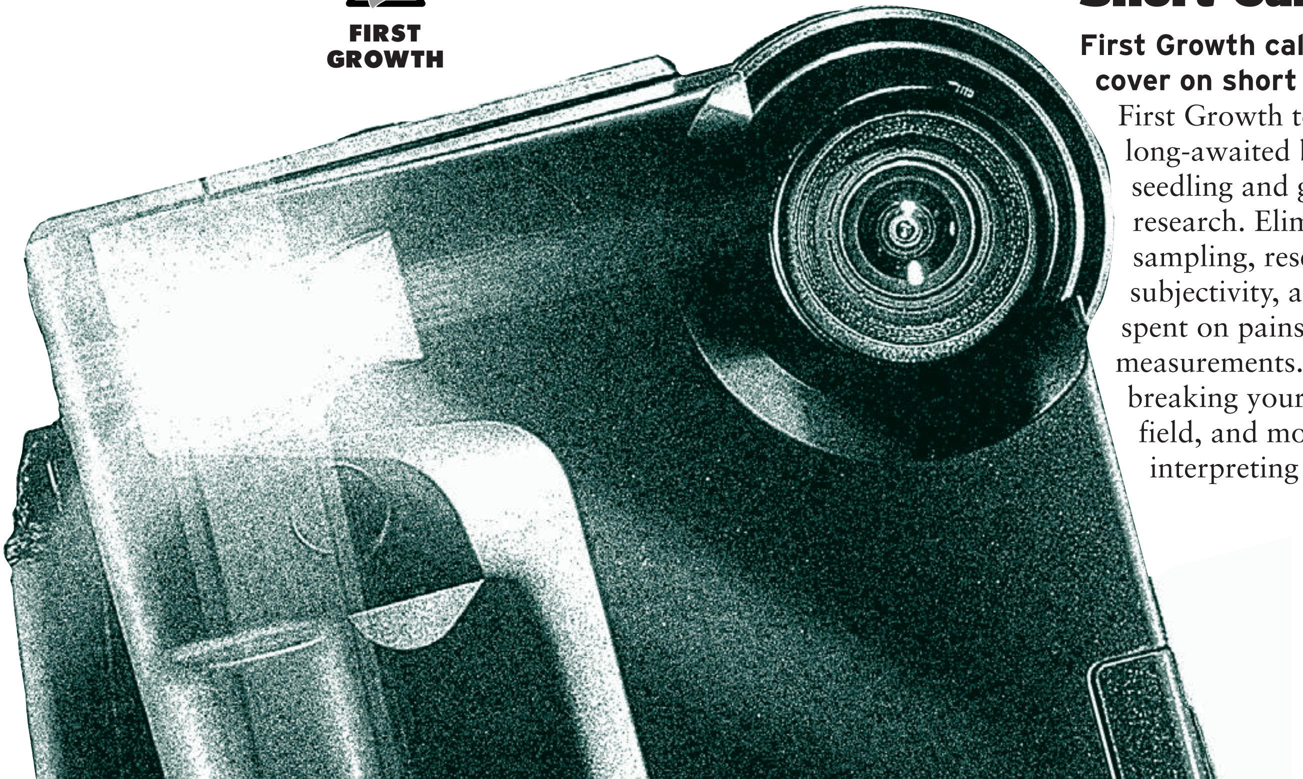
Short Canopies

First Growth calculates percent cover on short canopies.

First Growth technology is a long-awaited breakthrough for seedling and ground cover research. Eliminate destructive sampling, researcher subjectivity, and reduce time spent on painstaking measurements. Spend less time breaking your back in the field, and more time interpreting results. ■

FIRST GROWTH

▼*There is no need to measure emerging leaflets destructively. The First Growth's color segmentation algorithm detects cover directly.*



Quantify Effects of Riparian Vegetation Removal

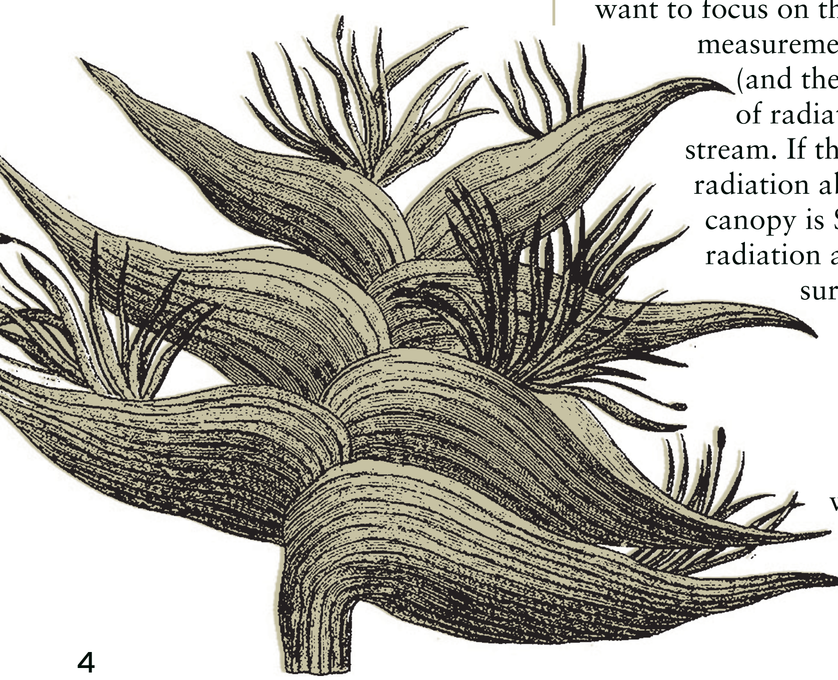
continued from cover

BOTH EMPIRICAL and physically based models are available for designing the strips. The physically-based models use an energy balance for a section of the stream. The energy balance considers all inputs and losses of heat for the stream. The change in temperature is the difference between inputs and losses divided by the heat capacity of the water. The inputs are solar and thermal radiation. Losses are thermal radiation and latent heat. Sensible heat can be either an input or a loss, depending on whether air temperature is above or below stream temperature. Inputs to the stream from ground water can also be inputs or losses, depending on their temperature relative to the stream temperature. Of these, the variable most susceptible to manipulation is the solar radiation, through changing the amount of shade. Manipulating solar radiation also changes the thermal radiation balance. Incoming thermal radiation from vegetation is greater than incoming radiation from the sky. Thus, increasing cover decreases solar input, but increases thermal input. Since the change in solar radiation is the larger of the two, decreasing solar input reduces stream heating, even though it also increases incoming thermal radiation.

Our purpose here is not to present the model. A number of model sources, which give additional information, are cited below. We want to focus on the measurement of solar (and thermal) inputs of radiation to the stream. If the total solar radiation above the canopy is S_o , then the radiation at the stream surface is

$$S = t\,S_o \tag{1}$$

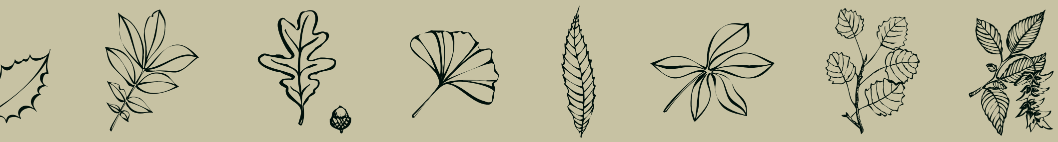
where t is the canopy transmission coefficient.

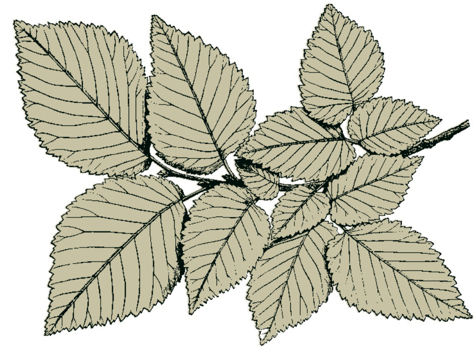


The value of t depends on the leaf area index of the canopy above the stream, the angle of the radiation incident on the canopy, the angle distribution of leaves in the canopy, and spatial distribution of canopy elements. Harvesting or burning the canopy along a stream bank reduces the leaf area index and changes the spatial distribution of canopy elements. If we can measure the effect of management on t, we will have quantified the main effect of management on stream temperature.

The AccuPAR model LP80 makes a direct measurement of t. It does this by taking a ratio of radiation measured under the canopy to radiation incident on the top of the canopy. The LP80 is particularly well suited to this type of measurement because it measures light at 80 locations with a single button-click. Light under plant canopies has high spatial variability, so many measurements are required for acceptable accuracy. Several button presses, with the probe in different locations, gives a good estimate of below canopy radiation.

Two questions now arise. First, the measurement of t is at a particular location and time. How does this measurement relate to the energy balance over entire





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on Stream Energy Balance

days and months? The second relates to PAR vs. total solar radiation. Since PAR is attenuated more strongly than total radiation by plant canopies, can one be determined from the other?

Taking the second question first, Campbell and van Evert (1994) related values of intercepted solar and PAR radiation. Figure 1 shows a similar relationship to theirs, but in terms of transmitted solar radiation and PAR. Note that at total transmission or total interception the two are equal. At 50% transmission of PAR, the transmitted solar is around 60%. At 10% transmission of PAR the transmission of solar is around 20%. The ratio of transmitted solar to transmitted PAR can be computed from

$$\frac{\tau_s}{\tau_p} = exp\ [-((\sqrt{a_s} - \sqrt{a_p})KL)] \qquad (2)$$

where a is the absorptivity of the extinction coefficient of the canopy, and L is the canopy leaf area index. Typical values for a_s and a_p are 0.5 and 0.8. These are the values used for Fig. 1. Using either Fig. 1 or eq. 2 it is easy to convert PAR transmission from the LP80 to total solar transmission.

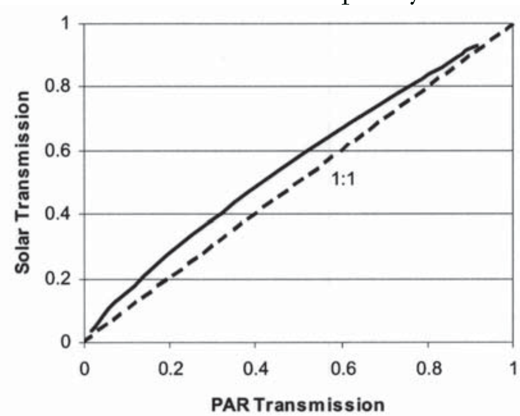
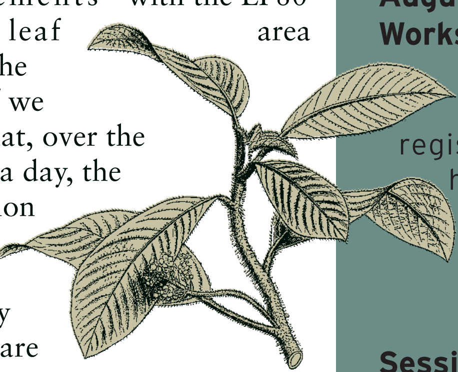


Figure 1. Solar transmission for a plant canopy as a function of PAR transmission. The dashed line is 1 to 1.

We turn now to the question of how a transmission measurement at a single time and location relates to the values needed for computing the energy balance of a stream. One could make repeated measurements throughout the course of a day and average the values. This would be a lot of work. An easier way would be to compute the daily value from measurements at a single time of day. Two possible situations need to be considered. First is one for fairly small streams, such that the shading of the stream is about the same as the shading of areas around the stream. In other words, the canopy in the vicinity of the stream can be assumed to be randomly distributed in space. Measurements with the LP80 give the leaf area index of the canopy. If we assume that, over the course of a day, the transmission of solar and diffuse sky radiation are



continued on page 7

Hands on Seminar

Decagon is offering lecture and practicum sessions on Soil Moisture Measurement Methods.

Be able to select appropriate measurement methods for a given soil moisture measurement application, and know how to install, calibrate, read, and maintain a variety of soils moisture sensors.

Agronomy Society of America 2004
Seattle, Washington
October 31 to November 4
Workshop date: October 30

ASA online registration: http://www.decagon.com/instruments/shortcourse_ASA.html

Ecological Society of America 2004
Portland, Oregon
August 1 to 6
Workshop date: July 31

ESA online registration: http://www.decagon.com/instruments/shortcourse_ESA.html

Session limited to 30 participants.

NEW LP80 Ceptometer

Customer Feedback

"Thanks for letting us check this [Accupar LP80] out! The simplicity of use is much like the Sunfleck that works so well in design for us in our research (Sadly- [Sunfleck] is wearing out)."

Thanks!
Samuel G. Metcalf
UCDavis Pomology
Walnuts and Almonds

OVER THE LAST 15 years that Decagon has produced ceptometers we have heard some interesting stories. They have been run over (when left in a parking lot), washed away (when left outside logging data in a gully), and stolen (when left curbside and the user re-entered the building). While the new LP80 cannot safeguard against these maladies, it does have several improved features to make it easier to use:

A slimmer profiled enclosure makes it easier to hold, and the internal circuitry boasts a larger memory, lower power consumption for longer battery life and a exterior PAR sensor is now standard equipment with each LP80.

Never send your Accupar in for recalibration—the new Accupar LP80 allows you to calibrate the instrument using the included external PAR sensor. ■

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Stream Energy Balance

(continued from page 5)

similar, then the daily solar input to the stream is the diffuse transmission coefficient for the canopy multiplied by the solar radiation incident on the canopy. The diffuse transmission coefficient can be calculated from

$$\tau_d = exp\ (-K_d\ L\sqrt{a_s}) \tag{3}$$

where K_d is the diffuse transmission coefficient for the canopy. The value of K_d varies with LAI and leaf angle distribution, but a value typical of stream heating conditions is 0.85 (Campbell and Norman, 1998). Thus, the value of L obtained from the LP80 is used, along with known values of extinction coefficient and leaf absorptivity to find the diffuse transmission coefficient. This is used with measured or modeled solar radiation values to get solar input to the stream. Logging or burning decreases L and thus increases the solar input.

The second situation is one where the stream width disrupts the canopy to the point where a random distribution of canopy elements can't be assumed. This is a challenging situation for modeling or measurement. An add-on to a GIS is available for doing some of these calculations (Rich et al., 1995). Measurements could also be made over the course of a clear day at representative spots across and along the stream. A weighted average of these, weighted by the sine of the solar elevation angle, gives the diffuse transmission coefficient. This, again, is used with solar radiation measurements or estimates to get solar input to the stream.

Conclusion

When vegetation is removed from stream banks, the increased input of solar energy to the water can cause significant stream warming. Leaving buffer strips along stream banks can mitigate this effect. AccuPAR LP80 measurements can be used to quantify the changes that have occurred through management, and can provide inputs to models of stream temperature. ■

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Rich, P. M., W. A. Hetrick, S. C. Saving. 1995. Modeling topographic influences on solar radiation: a manual for the SOLARFLUX model. Los Alamos National Laboratory Manual LA-12989-M

http://www.ce.washington.edu/~lamarche/STRposter/agu.html

History of the naming of the Ceptometer.

EARLY in 1986 Decagon hired an engineer from China named Xing Chen. Xing left a successful instruments business in China to come to work for Decagon in the USA. While in China he developed an instrument that counted the number of sunflecks along a transect using light sensors placed every centimeter along a meterstick. This idea was developed from Xing watching plant scientists counting the number of sunflecks on a meter stick under a plant canopy.

As the new instrument was developed, it was first designed to measure sunflecks, the number of sensors in sun versus shade. The idea to measure PAR came as an afterthought.

As Decagon was finishing development of the instrument, a member of our board of directors, Paul Campbell (current president of Campbell Scientific) insisted this new product have a better name, instead of canopy meter. He coined the term "ceptometer". Which is derived from the fact the instrument measures light interception.

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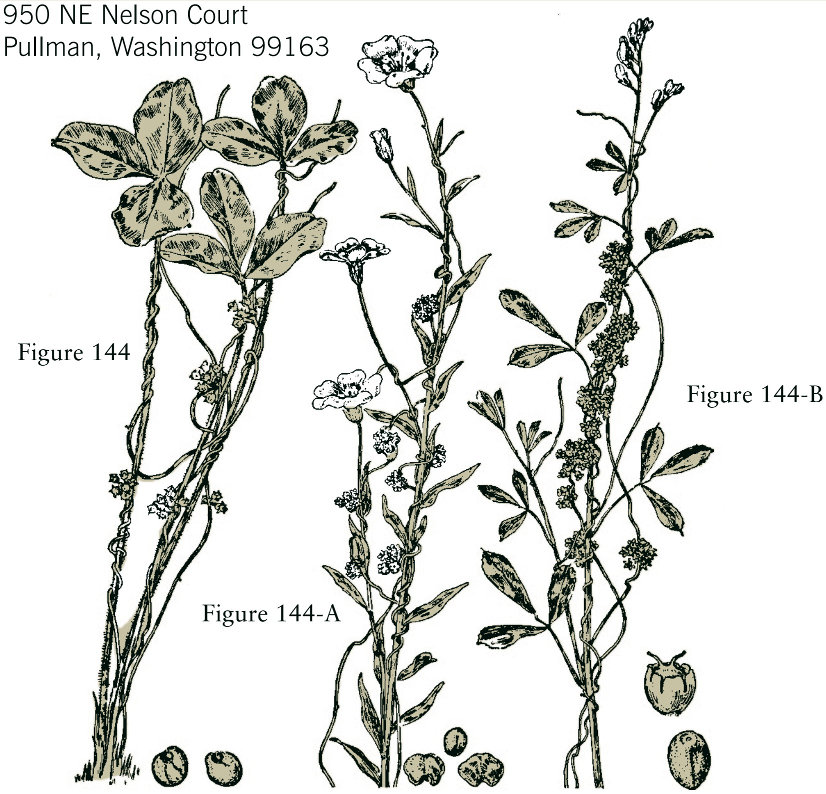

Fig. 144. Field Dodder *(Cuscuta arvensis)*.
Fig. 144-A Flax Dodder *(Cuscuta Epilinum)*.
Fig 144-B Lesser Clover Dodder, Thyma Dodder *(Cuscuta Epithymum)*.

▶ Generally, painted-grid style sensors cannot tolerate puddling, which causes corrosion, plating (shorts), and battery drain. The new Decagon Leaf Wetness Sensor will be forgiving of dew or rain puddling and also impervious to the digestive acid in bird dung which etches painted sensors. It's built for the real world.

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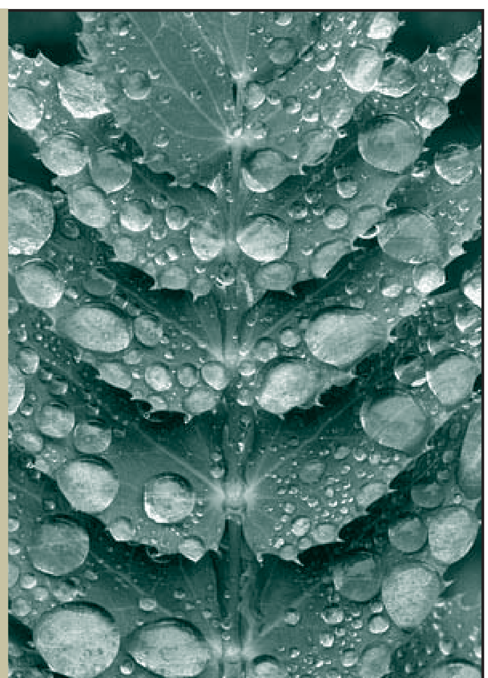

■ No need to paint. ■ Easily suspends in the plant canopy. ■ Thermodynamic properties mimic a real leaf. ■ Plug-and-play with Decagon loggers. Programmable with CSI dataloggers.

Leaf Wetness Sensor

New Ultra-thin leaf wetness sensor.

THE 0.5mm thin fiberglass sensor will use dielectric technique instead of resistance. The dielectric technique allows the sensor exceptional sensitivity to changes in surface wetness.