LAI-2000 Plant Canopy Analyzer

Q. *How can it correctly measure leaf area if the sensor can't see all the leaves, or if the leaves overlap?*

A. Leaf area is not calculated by viewing all the leaves. Rather, it is calculated from how much radiation is extinguished as it passes through the canopy. Random leaf positioning is assumed, implying a certain amount of leaf overlap. In fact, if a particular canopy had leaves positioned so that no leaf overlap were present, it would cause an error in the LAI-2000's computed result, because radiation is extinguished faster than the ideal in this case.

Q. *How big a plot is necessary?*

A. A rough rule of thumb is that plot radius (distance from the sensor location) should be 3 times the plot height. However, in dense canopies less distance may be required, because the sensor may not be able to see that far through the canopy.

Q. *What if a plot isn't that big?*

A. View caps can be used to prevent the sensor from seeing in a particular direction, allowing readings to be made near the edge of a plot, and reducing the total plot size necessary. Another remedy for small plots is to do the analysis neglecting the outer ring. The LAI-2000 software does not support this, but it can be done using the C2000 program.

Q. *How short can a canopy be and still get good measurements?*

A. There are several considerations when determining if a canopy is too small. First, does the presence of the sensor disturb the canopy? (Are new gaps created when the sensor is pushed in?) Second, the LAI-2000 assumes the foliage elements are small compared to the area of view of each ring. In general, the distance from the optical sensor to the nearest foliage at an angle of 30° should be at least 4 times the leaf width.

Q. *Will the LAI-2000 work in coniferous forests?*

A. Recent work by Gower and Norman (1990) indicates that the LAI-2000 can be successfully used in forest settings. In conifer stands, they found that the LAI-2000 underestimated LAI by 35-40%, apparently due to the fact that the instrument is sensing projected area of shoots, rather than needles. They further found that a correction factor, which is based solely on shoot morphology and can be independently measured, appears to adequately compensate for this. Their suggested technique is to determine the ratio of projected shoot area to total needle area for the particular species being measured, and then multiply the LAI-2000's results by this ratio.

Q. *Can the LAI-2000 differentiate between species - weeds and corn, for example?*

A. No. It only responds to objects (foliage, etc.) that block the transmission of radiation.

Q. *Will the LAI-2000 detect insect defoliation?*

A. Yes, but measurements should be made in the exact same places each time to remove spatial variability from the results.

Q. *Can I measure a single plant?*

A. Yes, assuming that the plant is isolated enough and that the leaves are small enough.

Q. *At the location where my research is conducted, it is almost never cloudy. Can I still take accurate measurements with the LAI-2000?*

A. Sunlit foliage will cause the LAI-2000 to underestimate LAI. To make measurements under these conditions, two techniques should be used. First, a view cap should be used to mask the portion of the sky that contains the sun. Second, the canopy should be shaded as much as possible within the sensor's field of view. Measurements could be taken at dawn or dusk when the sun is near the horizon which minimizes the sunlit leaf area seen by the sensor. When the sun is low in the sky, it is much easier to shade the canopy.

Q. *I have a line quantum sensor that I was going to use to measure LAI. What advantages does the LAI-2000 offer?*

A. Measurements with the LAI-2000 will be much quicker than with a line quantum sensor. A typical measurement with the LAI-2000 takes less that one minute for a short canopy. The line sensor technique relies on direct solar radiation and necessitates waiting for the sun angle to change in order to determine canopy interceptance at several angles. Or, if you assume an extinction coefficient (leaf angle distribution), a line quantum sensor can be used at one angle. The LAI-2000 looks at 5 angles simultaneously for each measurement.

The sample size when using the line sensor technique is limited, since the sensor only samples the portion of the canopy that lies between the sun and the sensor. With its fisheye field-of-view, the LAI-2000 can see 360° (with no view cap).

Lastly, the LAI-2000 calculates LAI immediately after the measurement, allowing on-site inspection and verification of the data.

(over)

Q. *Can I measure canopy PAR absorption with the LAI-2000?*

A. Not directly. The LAI-2000 is designed to measure foliage structure, which is only one of several factors determining absorption. Also, the spectral range of the sensor does not correspond to the PAR region, so it should not be used as a PAR sensor. The diffuse non-interceptance value (DIFN) calculated by the LAI-2000 is a direct estimate of how much diffuse sky radiation gets through the canopy, and (1 - DIFN) would be the absorbed sky radiation; but all this assumes that the foliage does not scatter radiation. Also, this neglects what happens to direct beam radiation, which is a function of solar position. The direct beam absorption could be inferred, perhaps, from the mean gap fraction measurements at the five zenith angles based on diffuse radiation, but this would still neglect the contribution of scattered radiation.

Another approach is to model canopy absorption based on the canopy structure (as measured with the LAI-2000), the foliage reflectance and transmittance, the reflectance of the ground, and measurements of incident total PAR and the fraction thereof that is direct beam.

Q. *What is Mean Tip Angle (MTA) good for?*

A. Gap fraction data at different angles potentially hold two types of information: amount of leaf area and leaf orientation distribution. See Perry et al (1988) for a discussion of how much information can be reliably extracted from gap fraction data. The LAI-2000 calculates MTA as a measure of how the leaves are oriented.

Q. *I've never heard of this "indirect" way to measure LAI. Has the model and the LAI-2000 be thoroughly tested?*

A. Actually, the only thing that is new in the LAI-2000 is the technique used to obtain the gap fraction. Methods of inverting gap fraction data to get canopy structure have been used for many years.

During the development of the LAI-2000, there were a number of verification studies, as described in recent work by Welles and Norman (1990) and in an application note available from LI-COR. Verification work started in summer 1988 and has continued on since then. A wide variety of canopies were used in the verification research, ranging in size from forests to prairie grass. The LAI-2000 data was compared to data from other indirect measurement techniques (fisheye photograph analysis, etc.), and to data from canopies which were harvested (100%) and measured with an electronic area meter.

Q. *Is the C2000 program necessary? What does it do?*

A. The program is not necessary to calculate LAI or MTA. C2000 is useful, because it duplicates and extends many of the calculations and output functions of the control unit. The C2000 program requires input data in the form of LAI-2000 files (one or more) that have been stored as DOS text files. The 1000-90 Communication Software (included with the LAI-2000) can transfer the data from the LAI-2000 to DOS text files.

Q. *How does the LAI-2000 method compare with other indirect methods?*

A. Other gap fraction methods of determining canopy structure include point quadrats (Warren Wilson and Reeve 1959), high-contrast fisheye photography (Anderson 1970, Bonhomme and Chartier 1972), traversing a light sensor beneath a canopy (Norman et al 1979, Lang et al 1985, Perry et al 1988), and using a linear light sensor (Walker et al 1988). The LAI-2000 method is closest to fisheye photography. The LAI-2000 has the advantage over photography of immediate on-site analysis, but the disadvantage of not having a picture (permanent record) on which to do a number of other types of analyses. The point quadrat technique is only suited to small canopies. The remaining techniques involve using the sun as a canopy probe. The obvious disadvantages are two: the sun must be out, and one must wait for the sun to move to get data at various angles. The LAI-2000 gets all the angle data at once, and does not require the sun to be out. (In fact, it is best if the sun is *not* out). On the other hand, the LAI-2000 requires an above canopy reference reading, whereas techniques that use the sun do not.

LAI can be deduced from measurements of light attenuation at only one solar angle, using an integrating radiometer (Pierce and Running 1988). However, canopy extinction (that is, leaf angle distribution) must be assumed beforehand, and is not deduced from the measurement. An above canopy reference reading is also required.

Q. *Can I use a LAI-2050 Optical Sensor with a general purpose data logger?*

A. No. The complexity of the LAI-2050, and the unique data reduction software make it very difficult, if not impossible.

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