Measuring Leaf Area Index

Video Transcript

Leaf area index is a great way for farmers, plant scientists, and ecologists to track the health and growth of plants over time. Leaf area index, or LAI, is one-sided leaf surface area divided by the ground area.

[00:17]
The gap fraction method is the most practical way to measure leaf area without damaging the plants. Gap fraction indicates how much of the sky is visible from beneath a plant canopy. If you can see more sky, the gap fraction is bigger. If you see less sky, the gap fraction is smaller. The amount of foliage can be calculated from the gap fraction, if we assume the leaves are positioned randomly within the canopy. Let's see how this works.

[00:48]
How many leaves does it take to block your view of the sky? That depends on how they are arranged. If they don't overlap, it takes relatively few leaves to block your view. At the other extreme, if those same leaves are stacked on top of each other, not much of your view is blocked. A useful assumption is that the leaves are positioned randomly, which puts us between these extremes, with some leaf overlap. When leaves are randomly arranged, there is a simple exponential relationship between leaf area index and gap fraction. This means we can compute leaf area index *from* gap fraction.

[1:27]
If we measure the gap fraction at several angles of view, it turns out we can also deduce something about the leaves' orientation. Are they laying flat, vertical, or something in between?

[1:41]
If all the leaves in a canopy are vertical, your view of the sky is barely blocked looking straight up. But if you look more toward the horizon, your view is mostly blocked.

[1:51]
With the same leaves laying flat, on the other hand, you can see more sky looking toward the horizon. When you look straight up, your view is mostly blocked.

[2:01]
As you can see, gap fraction information - especially as a function of view angle - is quite powerful for indirectly estimating canopy architecture.

[2:11]
How can we measure gap fraction? One method is photography. A high-contrast fisheye photograph taken from below lets you compute gap fraction as a function of the view angle. Digital processing can automate this, but two potential limitations are resolution, especially for small leaves in tall canopies, and differentiating bright, sunlit leaves from the sky background.

Another method for determining gap fraction uses multiple measurements of direct sunlight at different sun angles over time. Gap fraction for each sun angle is determined by how much of the sun is blocked.

[2:50]
LI-COR's LAI-2200C Plant Canopy Analyzer doesn't require multiple sun angles. It uses a fisheye lens to project a nearly hemispheric image of the canopy and sky onto a ringed detector. This lets you quickly get gap fraction at 5 different angles by comparing two readings: one above the canopy, with one below the canopy. A single above-canopy reading can serve as a reference for a number of below-canopy readings, allowing the LAI-2200C to quickly measure leaf area index and foliage orientation over a large area without waiting for the sun to move.

[3:30]
The LAI-2200C comes with view restricting 'caps' to limit the view in small plots, or to block the operator from being viewed. Also, some of the outer view rings can be masked, restricting the diameter of the cone-shaped area viewed by the light sensor.

[3:48]
Some canopies don't conform to the assumption of random leaf location. A widely spaced row crop is a good example. A single below-canopy measurement can't represent the entire field. But if you take a several measurements along two or more diagonal transects with a narrow-view cap attached, the LAI-2200C can account for the non-randomness in the canopy.

[4:13]
Simple gap fraction methods also generally assume leaves are perfectly black: that they block all sunlight. In reality, some sunlight passes through or bounces off leaves. This can cause large errors, especially when sunlit leaves are in view. The LAI-2200C deals with this issue in two ways. First, it uses a blue filter that improves the contrast between leaves and sky. Also, a post-processing correction is provided in the support software. This correction is based on a powerful, published light scattering model. It uses measurements of sky conditions and foliage properties made with the LAI-2200C.

[4:55]
Reliance on actual measurements pays off with better results. Multiple studies have proven the accuracy of the LAI-2200C, with results that compare favorably to destructive sampling methods.

[5:10]
What questions could *you* answer with the LI-COR's plant canopy analyzer? Contact us with your ideas and questions.

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