

addition of radioactive isotopes with a photon counting camera. With the new method it was possible to make continuous recordings and produce time-lap films of the events (see <http://www.blackwell-science.com/products/journals/suppmat/NPH/NPH288/NPH288sm.htm>).

The two main findings were that the translocation of labelled AIB was faster than diffusion and that there was a pulsatile component in the translocation. Translocation more rapid than diffusion has been shown before (Olsson & Gray, 1998), but the observation of a pulsation in the translocation is completely new. The pulsatile component has a period of 11–12 h and there is no obvious explanation. It could hardly have been detected without the continuous recordings. Similar experiments should now be performed for many other fungi to see if such pulsations are a common characteristic (although the authors do report that they have investigated *Serpula lacrymans*, but found no pulsation). A whole range of interesting experiments with *P. velutina* can be envisaged to elucidate the cause of the pulsations, and these might give important insights into the mechanism(s) and regulation of nutrient reallocations in fungi.

The method is a clever combination of standard intensifying screens and photon counting systems combined with image analysis. There is no need for a dedicated and expensive radioactivity β -scanning system. The main improvement to existing methods using β -scanners (Olsson & Gray, 1998; Lindahl *et al.*, 1999) is in spatial resolution, but it also makes it possible to record continuously over a long period. The general method, to use a scintillating screen and a photon counting camera to record the radioactivity in the sample, can potentially be used for any thin biological sample and for all kinds of β -emitting radioactive isotopes which are at least as penetrating as ^{14}C . The only requirement is that the sample is thin and that the light absorption from the biomass is negligible.

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Key words: *Phanerochaete velutina*, amino acid transport, scintillation imaging, nitrogen translocation, mycelia.

Nondestructive chlorophyll assessment

The determination of leaf chlorophyll content is a common procedure for plant scientists. One might think that procedures should evolve that produce more accurate results with more simple protocols and thereby gain wide acceptance – ‘If you build a better mousetrap, the world will beat a path to your door’. Unfortunately, the quest for an improved chlorophyll assessment method is not that simple. Richardson *et al.* (see pp. 185–194 in this issue), report on a comprehensive assessment of two chlorophyll meters and eight algorithmic analyses of reflectance data.

The ‘gold-standard’ for chlorophyll determination remains extraction of the pigments into a solvent such as acetone or dimethyl sulphoxide (DMSO), followed by spectrophotometric analysis. Recently, some ‘chlorophyll meters’ have become commercially available that permit scientists rapidly to monitor the chlorophyll content of leaves with a hand held device measuring absorbance of light from two diodes emitting different wavelengths. However, there has been an even greater interest in being able to discern chlorophyll content in leaves using reflectance – the ability accurately to predict the chlorophyll content of a canopy based on the reflectance spectrum would be valuable in the analysis of remote sensing data. Unfortunately, there have been a plethora of channel ratios and algorithms proposed for determining chlorophyll contents from reflectance data, but little consensus on their relative merits.

In the work of Richardson *et al.*, data were taken from a set of 100 paper birch (*Betula papyrifera*) leaves with chlorophyll contents varying over two orders of magnitude as determined by the spectrophotometric method. The 10 sets of replicated data from each leaf were then subjected to robust statistical analyses to assess the efficacy, as well as the extent and nature of the errors associated with each method.

As might be expected, some of the algorithms for analysis of reflectance data provide a very strong correlation with leaf chlorophyll content, whereas others much poorer correlations and much greater errors. In general, the method having the best correlation with chlorophyll *a* and total chlorophyll was the Normalized Difference Index (Gitelson & Merzlyak, 1994) based on two reflectance channels, 705 nm and 750 nm. The two chlorophyll meters were ranked in the middle of the pack, limited by their use of 650 nm light that is strongly absorbed by chlorophyll, causing increasing error with higher chlorophyll concentrations within the range normally encountered in leaves. The major unresolved aspect from this work is whether the reflectance methods found to be highly correlated with chlorophyll in birch leaves will be equally reliable with leaves from different species with different thickness and anatomical design. This is probably less of a concern for the absorbency-based instruments, but remains to be established for the reflectance-based methods.

Surprised to learn that determining chlorophyll content is more complex than you thought? Imagine my surprise in looking up the 'mousetrap' quote from Ralph Waldo Emerson: 'If a man can write a better book, preach a better sermon, or make a better mouse-trap, than his neighbour, though he build his house in the woods, the world will make a beaten path to his door'.

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- Key words:** chlorophyll measurement, optical methods, absorbency, reflectance, paper birch (*Betula papyrifera*), hand-held meters.

Woody-tissue respiration

The complete accounting of carbon entering and exiting forest ecosystems is a vital task, and Damesin *et al.* have examined the contribution of woody-tissue respiration to this, as reported on pp. 159–172 in this issue. However, scaling up from tree measurements to estimations at the stand level is fraught with difficulties. The sizeable effort put into determining volume and surface area of branches was an important component of the study.

What was noteworthy? First, it was found that branch respiration rate differs from stem respiration rate at all times of the year, with the direction and magnitude of the difference depending on the base for expressing the fluxes. Sprugel (1990) and Maier *et al.* (1998) reported similar findings, but this is the first such report for a deciduous species. Damesin *et al.* show that as a consequence of these differences between stems and branches, the common practice of using measurements of stem respiration to estimate branch respiration leads to underestimates when sapwood volume is the basis for scaling, or overestimates when surface area is the basis.

The second point of note was that branch respiration appears to make about the same contribution to ecosystem respiration as does stem respiration in the beech ecosystem, because of both higher specific rates and the large amount of respiring branch matter. Partly because of the relatively high flux from branches, the above-ground, woody-tissue respiration contributed a large fraction of total ecosystem respiration in the beech ecosystem in comparison to previous reports for coniferous forests (e.g. Ryan *et al.* (1996), Lavigne *et al.* (1997)). The authors found that one third of ecosystem respiration is derived from woody-tissues in their beech forest whereas values of 15% and less are typical in coniferous ecosystems.

Assuming that the present results are typical of deciduous forests, then measurements of woody-tissue respiration are essential in studies having as an objective the complete accounting of C entering and exiting the ecosystem. Increasingly chamber measurements are taken at sites where the eddy covariance method is used to estimate net ecosystem exchange, for the purpose of explaining the observed exchange between ecosystem and atmosphere. Damesin *et al.* have shown that woody-tissue respiration deserves as much attention as other fluxes, such as soil respiration, that branch respiration should be measured in addition to stem respiration, and that allometric relationships established by harvesting a sample of trees at the site should facilitate the scaling of woody tissue respiration.