Nitrogen-use efficiency

To simplify discussion of the $A_{\text{max}}$ realized for a given level of N, it is useful to eliminate the confounding variable LSW and consider the ratio of $A_{\text{max}}$ to N, which we term potential photosynthetic nitrogen-use efficiency (PPNUE). As long as $A_{\text{max}}$ and N are both expressed on the same basis, PPNUE is independent of the measurement basis. We can view PPNUE as an index of potential performance under defined conditions that allows direct comparison among species. PPNUE is not an ecologically complete definition of nitrogen-use efficiency, but it is an important component of a more general, ecological definition, as provided by Rundel (1982) or Vitousek (1982). In addition to photosynthesis or growth per unit of nitrogen in tissue, these more complete definitions account for the critical roles in nitrogen-use efficiency played by leaf duration, nitrogen recovery from leaves, and whole-plant patterns of nitrogen allocation (Field and Mooney, 1986). PPNUE is currently useful for initiating the mechanistic interpretation of nitrogen-use efficiency. Its potential utility for approaching broader questions about nitrogen and growth will be increased as this index is modified to reflect long-term photosynthesis under natural conditions, and as photosynthetic data are combined with other components of nitrogen-use efficiency.

For the VINE survey, the analysis of PPNUE does provide several insights into the $A_{\text{max}}$-N relationship. PPNUE is lowest in the plants of lowest $A_{\text{max}}$, and increases with $A_{\text{max}}$. From values of less than 30 μmol CO$_2$ (mol N)$^{-1}$ s$^{-1}$ for leaves of less than 1 mmol N g$^{-1}$, PPNUE rises to a plateau at around 125 μmol CO$_2$ (mol N)$^{-1}$ s$^{-1}$ for leaves with nitrogen contents above about 2 mmol g$^{-1}$ (Figure 1.5). Reviewing the data of Medina (1981) and others, Grubb (1984) also reached the conclusion that PPNUE is positively related to $A_{\text{max}}$. In the VINE survey, the relationship can be seen more precisely as a staircase of nearly constant PPNUE within major species types (annuals, deciduous shrubs, evergreen sclerophylls) and stepwise increases between them (Table 1.2). Although not in subgroups within the VINE survey, an increase in PPNUE with increasing N per unit weight is suggested by some studies on individual species (e.g., Guimon and Chu 1981).

Several hypotheses may potentially explain the increase in PPNUE with increasing $A_{\text{max}}$. Observing that $A_{\text{max}}$ and leaf longevity tend to be inversely related, Grubb (personal communication) and others have speculated that increased nitrogen-use efficiency is an important strategy for plants with shorter leaf durations.