Photosynthesis—nitrogen relationship in wild plants

The most striking example of these species is Prunus ilicifolia, a shrub of the California chaparral. This species is a special case in that its leaves contain cyanogenic glucosides. These nitrogen-containing secondary compounds almost certainly play no direct functional role in determining \( A_{\text{max}} \), and may represent allocation of nitrogen away from compounds functionally related to \( A_{\text{max}} \) and toward defense. We shall assess the possibility that sclerophylls, in general, allocate proportionally less nitrogen to photosynthesis than do nonsclerophylls when we consider nitrogen-use efficiency. Some of the ecological factors controlling the allocation of nitrogen to defensive compounds have been considered by Bryant et al. (1983) and by Gulmon and Mooney (Chapter 20).

Which basis for expressing the \( A_{\text{max}} - N \) relationship is more significant functionally? Compelling arguments can be used to support either expression. Because light capture and \( CO_2 \) exchange with the atmosphere are intrinsically area-based phenomena, the area-based analysis provides a resource-harvesting framework for understanding the \( A_{\text{max}} - N \) relationship. On the other hand, a weight-based analysis yields more information on the economics of nitrogen and carbon allocation. Each expression gives important information, and the sources of the differences between them can contribute to the elucidation of the functional and ecological controls on photosynthetic capacity and leaf nitrogen.

Differences between the weight-based and area-based relationships result largely from variation in LSW (leaf weight/leaf area). In the VINE survey, LSW varies inversely with the weight-based measure of leaf nitrogen (Figure 1.4). The evergreen sclerophylls have the highest LSWs and also the survey’s lowest photosynthetic capacities, either weight-based or area-based. The Death Valley annuals have the highest photosynthetic capacities on both measurement bases and a narrow range of LSW, somewhat above the lowest values. Converting from a weight-based (Figure 1.2) to an area-based (Figure 1.3) \( A_{\text{max}} - N \) relationship requires only multiplying each value for \( A_{\text{max}} \) and \( N \) by the LSW for that leaf. The consequence of the inverse relationship between LSW and \( N \) per unit weight is to increase small values and decrease large values of area-based \( A_{\text{max}} \) and \( N \), relative to the weight-based parameters. Thus, the transformation from a weight-based to an area-based analysis tends to compress the total range of variation in \( A_{\text{max}} \) and \( N \), and to increase the variability among the leaves with the highest LSWs.

The \( A_{\text{max}} - N \) relationship is not fundamentally changed by the choice of measurement basis (as long as \( A_{\text{max}} \) and \( N \) are expressed in the same units), but the choice of units does alter the prominence of various segments of the relationship. On any measurement basis, the data in Figure 1.4 suggest that:

- \( A_{\text{max}} \) and \( N \) are positively correlated.
- For a given range of \( N \), the leaves with the highest \( A_{\text{max}} \) are on the left side of the graph.
- For a given range of \( A_{\text{max}} \), the leaves with the highest \( N \) are on the top side of the graph.

These relationships are consistent with the idea that nitrogen is a limiting resource in photosynthesis, and that the allocation of nitrogen to photosynthesis is positively correlated with the metabolic capacity of the leaf.