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Optimal photosynthetic strategies

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Leaf traits collectively offer valuable insight into a plant's photosynthetic strategy under varying environmental conditions. Eco-evolutionary optimality (EEO) theory can be used to predict photosynthetic trait variation, offering insight into the underlying mechanisms beyond what can be gleaned from data alone. EEO has been used to explore mechanisms underlying the variation in individual photosynthetic traits across space and time. Here, I extend this approach to (1) examine global variability in biochemical, stomatal, chemical, and morphological traits that collectively define an optimal photosynthetic strategy and (2) within-site variability in optimal photosynthetic strategies across different ecosystems. The global analysis revealed that the primary axis of variation was defined by differences in C_3 and C_4 plants with C_4 plants displaying greater optimal intrinsic water use efficiency and higher amounts of photosynthetic nitrogen that generally conveyed faster rates of photosynthesis. This reflects the unique, fast-efficient strategy employed by C_4 plants. The secondary axis of variation was defined by a correlation between optimal photosynthetic nitrogen use efficiency and optimal stomatal conductance. This was common across all plant types, with increasing aridity driving lower optimal stomatal conductance and nitrogen use efficiency, following expectations from photosynthetic least-cost theory. At the site-level, I generally found greater within-site than across-site variability in optimal photosynthetic strategy, suggesting a wide range of successful strategies within sites. The major site separator was between C_4 grasslands and C_3-dominated ecosystems, primarily because of greater water use efficiency and photosynthetic nitrogen investment at C_4 sites. The results indicate that EEO theory can reproduce patterns of photosynthetic strategies across global gradients, while also revealing new insights into the clustering of these strategies. These results can be used to better understand photosynthetic trait data and, ultimately, plant physiological functioning.