**Leaf area shows greater positive response to nitrogen addition than leaf quality**

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**Abstract**

Fossil fuel burning and agricultural runoff are increasing rates of nitrogen inputs to terrestrial ecosystems globally. These inputs may act to alter ecosystem processes and services, including plant productivity. Past studies have shown that nitrogen additions can increase plant productivity; however, the physiological mechanisms underlying this response are not well known. It is commonly assumed that added nitrogen will increase leaf nitrogen, stimulating photosynthetic carbon assimilation and, resultingly, biomass accumulation. However, it is possible that increased leaf nitrogen, most of which is in the enzyme Rubisco, may quickly lead to light limitation of photosynthesis. An alternative plant strategy is to use the added soil nitrogen to increase leaf area, increasing whole-plant photosynthesis even without an increase in per-leaf-area photosynthesis. Here, we test these two hypotheses using a globally distributed network of grassland nitrogen addition experiments (Nutrient Network). We find that soil nitrogen addition (10 g m-2 yr-1) had no impact on per-leaf-area nitrogen content, but that most of the variation can be explained by leaf thickness and climate. However, the soil nitrogen addition increased leaf area index (leaf area per ground area) by 41%. Our results indicate that grassland plants use added to nitrogen to build new leaves rather than increasing the quality of their leaves.