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What makes a perennial a perennial? A meta-analysis of allocation patterns and functional traits in congeneric annual and perennial plant

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Currently, a large fraction of food, fiber, and feed is provided by annual crops - in particular annual grains. A shift from annual to perennial crops has been advocated to move towards a more sustainable agriculture. While providing lower yields than annuals, perennial crops are often assumed to reduce soil erosion, promote soil health, and be able to achieve higher water and nitrogen use efficiency, primarily through higher allocation below ground. Nevertheless, quantifications of these benefits are still scarce and often inconclusive, as well as mostly limited to first-year perennials. Here we consider congeneric annual and perennial species pairs, for which measured productivity, resource allocation, and resource use efficiency are available in the literature, in search for a signature of life-history (i.e. annuality vs. perenniality) on plant allocation, traits, and agronomic performances. A new database of allocation strategies and functional traits of these congeneric species is developed, covering more than 25 genera of agronomical and ecological relevance, including wild and domesticated species, as well as new hybrids, grown under a variety of conditions. Some general patterns emerge. Perennials have lower biomass allocation to reproductive structures (as expected), and generally higher root-to-shoot biomass ratio, potentially promoting soil C accumulation. Patterns in nitrogen tissue concentration and resource use efficiencies are less clear, due to the limited available data. Our analyses highlight a paucity of comprehensive studies, hampering our understanding of the long-term implications of a shift to perennial crops for ecosystem hydrologic and biogeochemical cycles.