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The C-household of young broad-leaved and conifer tree species exposed to long-term carbon limitation by shading

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Non-structural carbohydrates (NSC, i.e. free sugars and starch) are regarded as freely available carbon (C) reserves in plants. They are often quantified to estimate a plant's C-balance, assuming that NSC are controlled by the net-balance between photo-assimilation and C-usage (respiration, growth and other sinks). Within a recent field experiment, we investigated the extent, to which C-reserves (NSC) can be formed in young trees against prevailing C-sink demands (growth) under C-limitation. A total of almost 1000 individuals of two-year-old tree saplings from 6 deciduous, broadleaved species and 4 evergreen conifer species were planted on a field side. Half of the trees per species were treated with long-term C-limitation by exposing them to continuous deep shade conditions (5% of natural PPFD) under a permanent shading tent. C gas-exchange, growth and NSC tissue concentrations were analyzed in shaded and unshaded saplings for two consecutive years. Three months after the beginning of the experiment, leaf photosynthesis acclimatized to the low light conditions, with leaves of shaded trees showing significantly higher SLA and lower light saturation and maximum photosynthesis. During the second season of the experiment, most species exhibited very strong reductions in NSC, but much less pronounced reductions in growth. In contrast, other species, with few exceptions, kept NSC concentrations similar to unshaded controls, while growth virtually stopped under deep shade. In conclusion, we found species-specific strategies in the trees' C-household after two years of C-limitation, that fall into two major carbon allocation strategies: 1) "C-spenders", which deplete C reserves in order to keep up significant growth, and 2) "C-savers", which reduce C sink activities to a minimum in order to store substantial amounts of C reserves. Overall, early-successional species tended to follow the first strategy, while late-successional species tended to save higher C reserve pools in trade-off with growth.