Climate change alters woody shrub carbon storage and utilization in a moist acidic tundra

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Permafrost warming in the climate sensitive Arctic tundra has been linked to shifts in vegetation, from tussock dominated to tussock/shrub systems. This vegetation shift has the potential to not only impact the abiotic conditions, but also the energy balance and biogeochemical cycling of these systems; as plant assimilation, respiration, C allocation, and rooting depth may differ between plant functional groups. In order to better understand woody shrub responses to these changing conditions, we assessed leaf-level morphological and gas-exchange parameters of dwarf birch and diamond-leaf willow in conjunction with site level abiotic parameters across a simulated winter (snow fence) and summer (open-top chamber) warming experiment at a moist acidic tundra at the Toolik Field Station in Alaska. Additionally, we incubated ephemeral organs (fine root and leaf) while concomitantly analyzing bulk tissue (fine root, coarse root, stem and leaf) for 14C to assess the ages of metabolic and structural carbon. Our results indicate a positive correlation between summer soil thaw depth and leaf surface area indicating hydrological responses of both species. Additionally, leaf area was higher in the summer warming treatment relative to non-summer warming treatment in both the snow addition and the control treatments. Furthermore, we found that diamond-leaf willow exhibits elevated assimilation rates relative to dwarf birch, a pattern maintained when light response curves were constructed at elevated CO₂ (800 ppm). We observed species-specific metabolic (respired 14C-CO₂) and structural (bulk 14C) responses to both summer and winter warming. Both shrubs were more metabolically active (younger respired CO₂ age) in the winter warmed treatment relative to control. In diamond-leaf willow, perennial coarse root tissue exhibited a differential response to warming (older in the summer warmed treatment while younger in winter warmed treatment). While in dwarf birch, perennial tissues are younger in winter warmed and summer warmed areas relative to their respective controls. These responses highlight the forcing imposed by woody vegetation in arctic regions with the potential to increase net primary production in addition to positive feedbacks on winter snow depth, soil temperature, and moisture.