Hydrogen isotopes in *n*-alkanes of tree leaves and needles: experimental studies with ecophysiological, ecosystem, climate, and dust-related applications

Intellectual merit. Stable isotopes serve as tracers and integrators of both environmental and physiological signals within plant materials. Cuticular leaf-wax *normal*-alkanes have attracted recent interest as a biomarker for paleo-climate reconstruction as they are easily identified in sediments and robust to alteration. However, the isotope applications of *n*-alkanes to modern ecological systems are virtually unexplored. The initial hypothesis is that H isotopes ($\delta^2H_{n\text{-alkane}}$) of *n*-alkanes record plant source water isotopes. If supported, δ^2H analyses of *n*-alkanes will serve as a powerful tool for biological and ecosystem studies as water source and humidity both can then be reconstructed from leaf isotopes. The critical experimental studies have not been conducted and the fidelity of *n*-alkanes as biomarkers has not been rigorously tested with modern vegetation. Alternative hypotheses are also proposed and will be tested as part of abroad analysis of vegetation in the western USA. While these biomarkers are not yet fully appreciated in ecophysiology and ecosystem science, their use within paleoclimatology without a mechanistic understanding hinders interpretations of ancient $\delta^2H_{n\text{-alkane}}$ values. This study will provide a semi-mechanistic understanding for $\delta^2H_{n\text{-alkane}}$ values across a range of diverse tree/shrub taxa, determining the importance of water source *and* humidity as environmental drivers, in addition to time and spatial integration as potential compounding factors. Trees/shrubs have selected over grasses in the experimental studies, because of their discreet apical meristematic growth. In long-term greenhouse and field studies, source water and humidity will be maintained. Leaf wax and physiological data will be used to test 3 hypotheses on the determinants of $\delta^2H_{n\text{-alkane}}$ values. In addition, this study will examine a fourth hypothesis on the fidelity of the $\delta^2H_{n\text{-alkane}}$ signal between source (plants) and long-term repository (soil/sediments). Lastly, this study will examine the spatial application of herbarium voucher materials to develop a western USA "isoscape" of water sources used by Douglas fir. Using GCMS and IRMS techniques, this study will analyze 36 perennial tree and shrub species from six different ecological systems in Oregon and Utah, spanning the natural humidity range. Risk analyses and initial data demonstrate that proposed measurements can be accomplished. The 4 hypotheses of this study are organized with consideration(s) of the path(s) forward if one or more of the hypotheses are accepted or rejected.

Broader impacts. The proposed research is directed at broad issues relevant to BIO and GEO directorates, although the Emerging Topics in Biogeochemical Cycles call is over. One of the broader impacts of this study is to forge new interdisciplinary linkages that advance both fields. The ecological applications of $\delta^2H_{n\text{-alkane}}$ values are extensive, including trophic-level, ecosystem metabolism, and ecosystem connectivity studies. If history serves as an example, postdoctoral training in this interdisciplinary effort with the biology-geology group at the University of Utah will have broad, long-term impacts on generating new scientists more capable of bridging the common interests of these two disciplines. The research results will be incorporated into lecture and lab portions of our annual international stable isotope ecology course. These courses already attract a multidisciplinary spectrum of graduate students and postdocs from geographically distributed institutions. Students will learn the techniques as part of the SIRFER class experience. Over the past 15 years, our classes have always comprised a gender-balanced participant pool with a large contingent of underrepresented groups. We expect these diversity efforts to continue. Results of this study will be widely disseminated by students returning to their respective universities. The postdoc will be mentored in both research and teaching and will gain teaching experience participating in these classes in years 2/3. The results of this study will be incorporated into site-specific and isoscape-scale web-based modules at stableisotopes.net. Here the broader impacts of the research will allow users to explore isotope landscape-scale patterns, including determining source regions for dust-borne particles that contain leaf waxes.