Isotopic Heterogeneity and Nutritional Ecology of Whitebark Pine Nuts in the Northern Rockies (USA)

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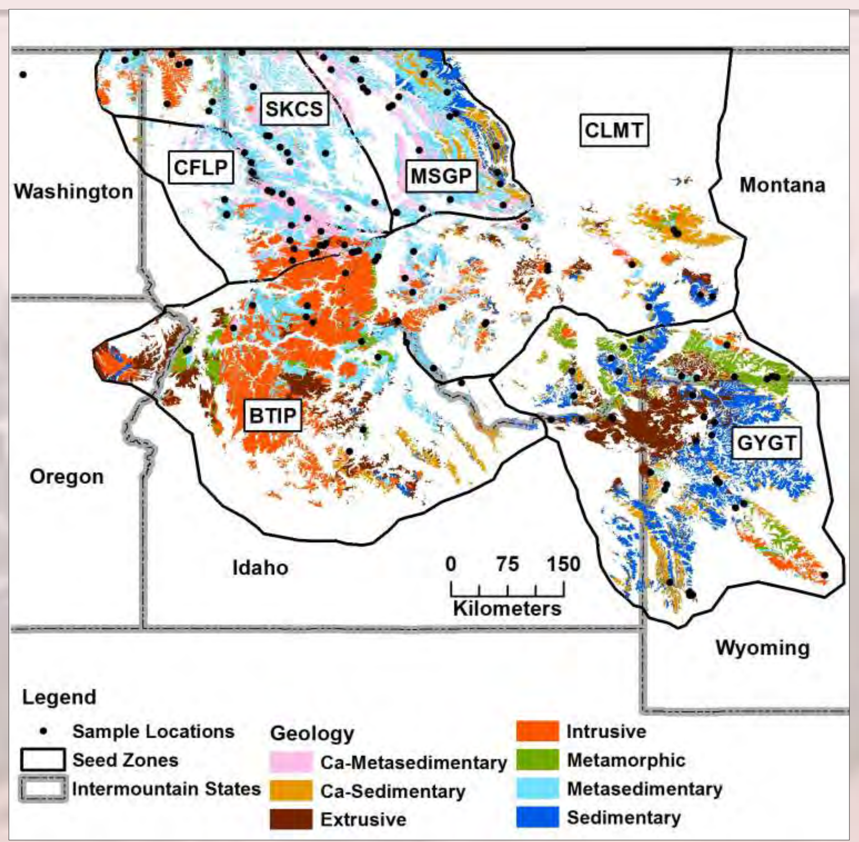

Fig. 1. Whitebark pine sample locations and soil parent material by seed zones (Bitterroot-Idaho Plateau (BTIP), Clark Fork-Lolo Pass (CFLP), Central Montana (CLMT), Greater Yellowstone-Grand Teton (GYGT), Missions-Glacier Park (MSGP), and Selkirk-Cabinets (SKCS) .

Introduction

The overall health and persistence of whitebark pine (*Pinus albicaulis*) is of international concern due to white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), altered fire regimes, and climate change (Keane et al., 2012). A geographically broad seed inventory has been amassed for developing blister rust resistant seedlings (Mahalovich et al., 2006) and quantifying assimilated diet in Yellowstone grizzly bears using stable isotope analysis (Felicetti et al., 2003). This interdisciplinary study highlights seed sources more likely to persist in warmer, drier climates and captures the spatial heterogeneity in one food source used to determine assimilated diet in bears (*Ursus* spp.).

Objectives

1) Characterize the natural abundance of $\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$, and $\Delta^{13}C$, as a proxy for drought tolerance,
2) Evaluate the efficacy of $\delta^{34}S$ as a dietary marker,
3) Characterize the variation in energy, crude fat, and protein content of pine nuts (Mahalovich et al. *in review*)

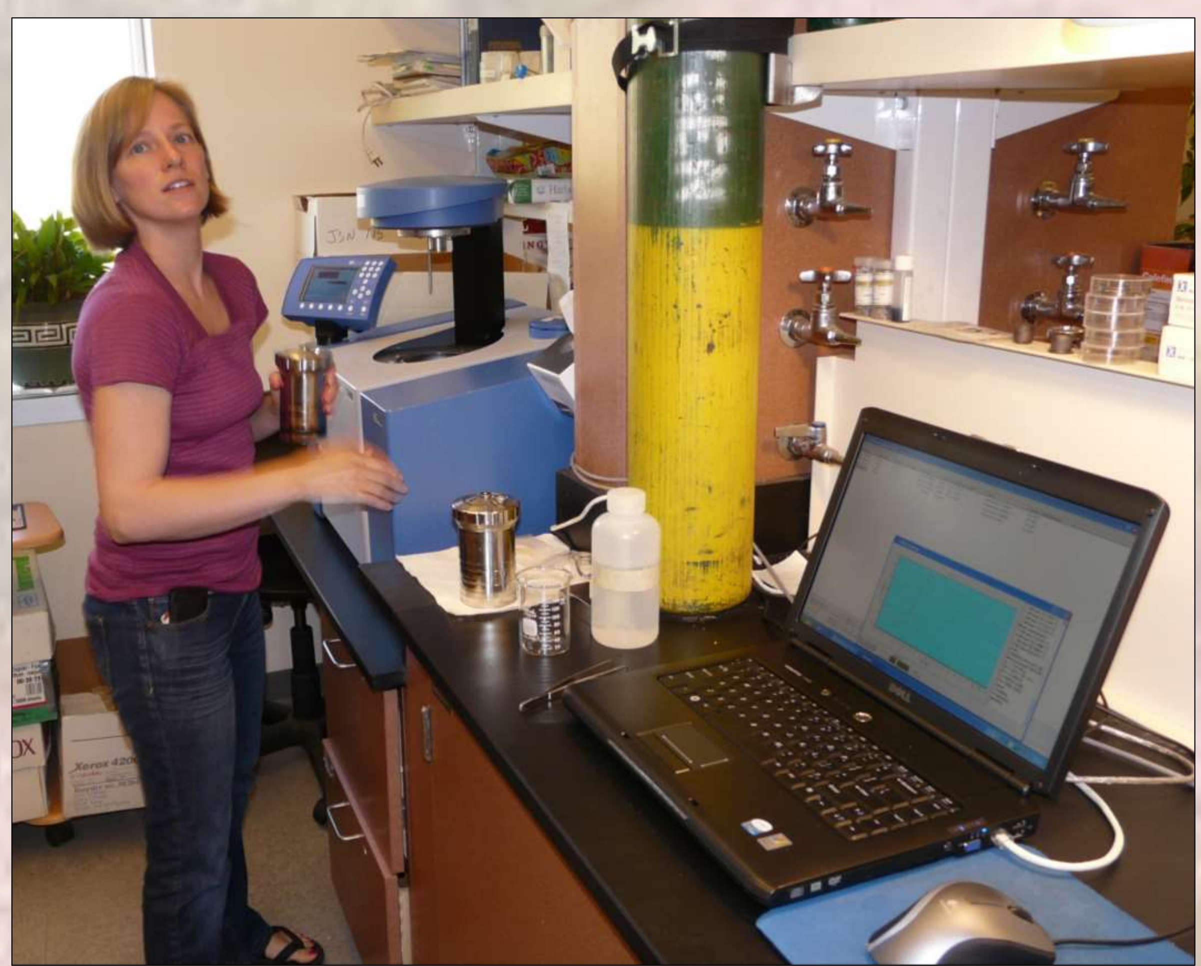

Fig. 2. Parr bomb extraction of sulfur from freeze-dried pine nut tissue.

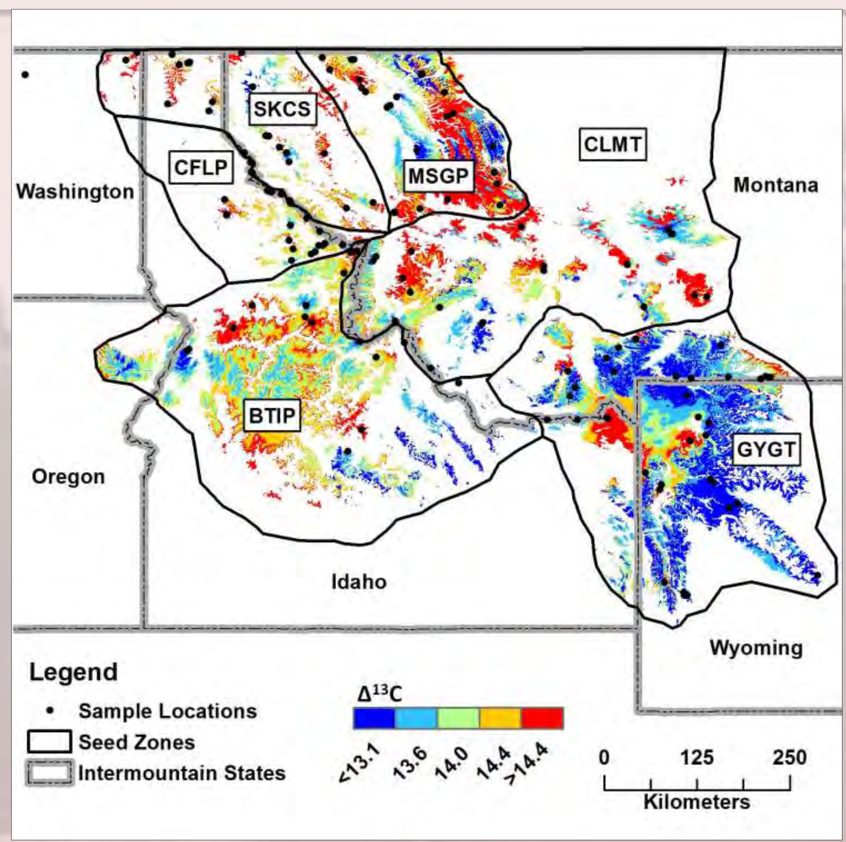

Fig. 3. Predicted drought tolerance (blue tones) in pine nut tissue as measured by carbon-isotope discrimination ($\Delta^{13}C_{lipids\ extracted}$).

Materials and Methods

Selected samples (n=145) and associated soil parent material (Fig. 1) represent the geographic distribution of whitebark pine in the US Northern Rockies. Seed preparation and stable isotope analysis were performed at the Washington State University Wildlife Habitat Nutrition and Stable Isotope Core Labs (Fig. 2). Soils data were obtained from the USGS (USGS, 2005a,b,c) and current-climate data were obtained from the USFS Rocky Mountain Research Station (Rehfeldt et al., 2006). Isotope maps were developed using geostatistical-hybrid regression (Bowen et al., 2009). Unique isotope signatures were based on Duncan's multiple comparison tests and contrasts to other key bear foods.

Results and Discussion

Spatial heterogeneity in all isotopes were broad with moderate geographic and climatic clines (R^2 = 0.25 to 0.60). The most drought tolerant sources were found in the Greater Yellowstone area (Fig.3). Whitebark pine is more drought tolerant compared to other conifers, and paired with rust resistance, this species may be well-positioned for warmer, drier climates. Sulfur isotopes peaked (13.6‰) in Glacier National Park, indicative of sedimentary rather than volcanic source pools (Figs. 1&4). Compared to other dietary foods, whitebark pine retained a unique $\delta^{34}S$ signature (Fig. 5). Future applications to determine the proportion of pine nuts in assimilated bear diets will need to accommodate the spatial heterogeneity, nutrient concentrations and seasonal availability of each food, as well as animal tissue turnover rates. Spatial heterogeneity in energy, crude fat, and protein content were relatively flat climatic clines (R^2 = 0.11 to 0.20). Genetic selection for rust resistance did not adversely impact nutritional quality (Table 1).

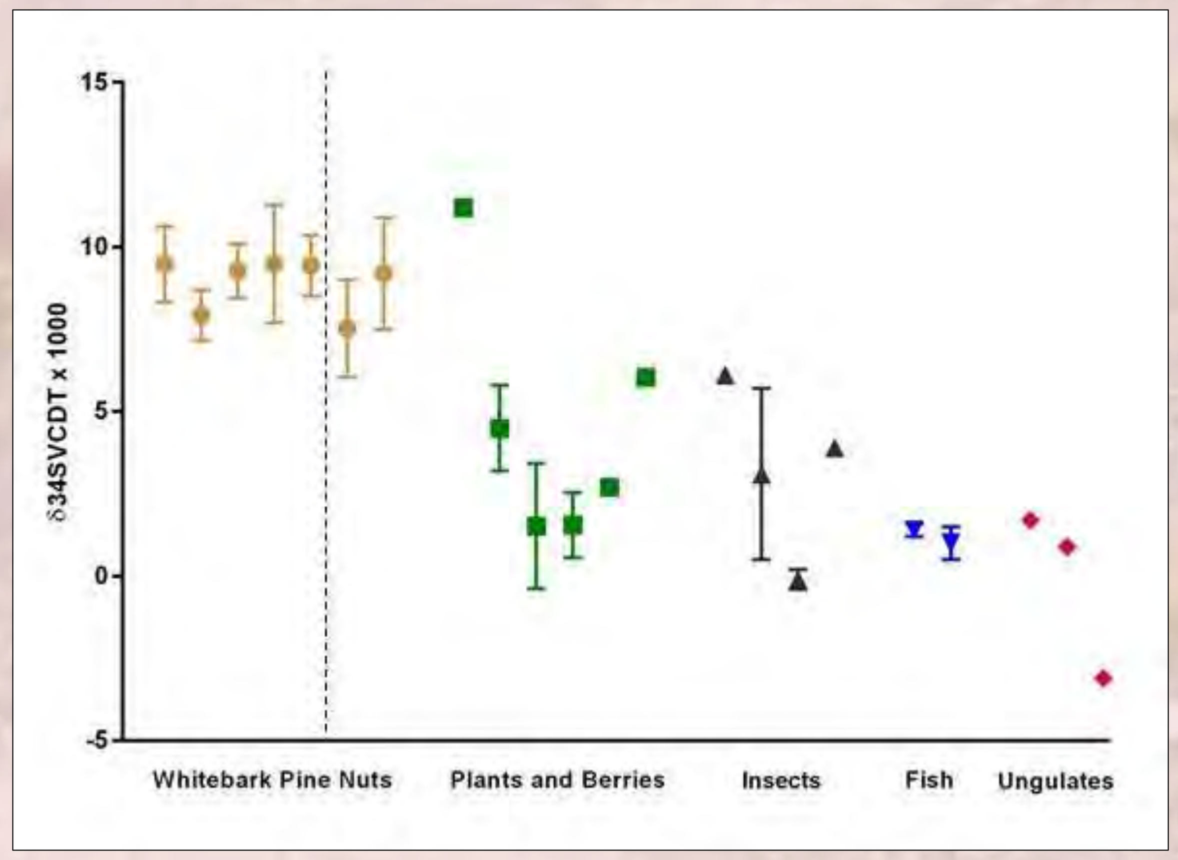

Fig. 5. Comparison of whitebark pine nut $\delta^{34}S$ means and standard deviations (vertical bars) in the Northern Rockies relative to other dietary foods. Bear foods to the right of the dashed line were collected within the Greater Yellowstone Ecosystem. Examples with no standard deviation indicate a sample size of one.

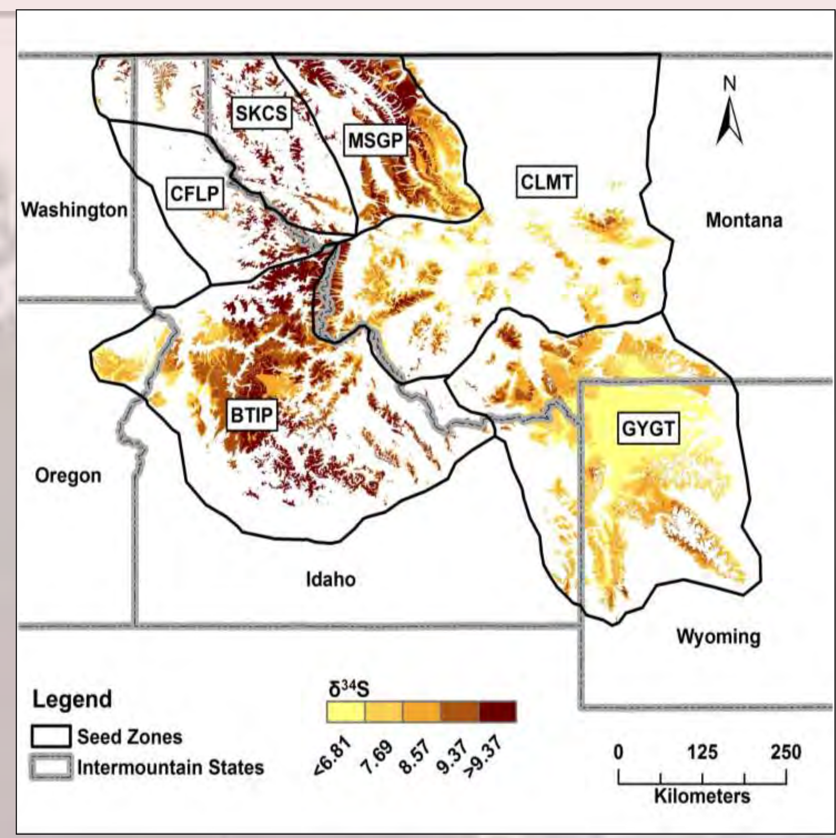

Fig. 4. Predicted whitebark pine nut $\delta^{34}S$ isoscape.

Applications

This study provides baseline data to further investigate the relationships among rust resistance, drought tolerance, and edaphic variation in the Inland West Whitebark Pine Genetic Restoration Program. Stable isotope data from this study will facilitate the determination of wildlife assimilated diets throughout the Northern Rockies.

Table 1. Favorable relationships between rust resistant whitebark pine nuts and associated nutritional ecology attributes. Similar letters are not significantly different at α = 0.05.

Bulked Lots	Energy (cal/g)	Crude Fat (%)	Crude Protein (%)
Resistant	7,355 (8) a	59.2 (1.6) a	19.2 (0.5) a
Susceptible	7,145 (44) b	58.7 (3.2) a	16.9 (0.2) b

Acknowledgements

Funding was provided by the USDA Forest Service, Northern Region, Renewable Resource Management; Intermountain Forest Tree Nutrition Cooperative, University of Idaho; and WSU School of the Environment.

Literature Cited

Bowen, G.J., et al., 2009. Isoscapes to address large-scale earth science challenges. EOS, Transactions American Geophysical Union 90(13), 109-116, doi: 10.1029/2009EO130001.

Felicetti, L.A., et al., 2003. Use of sulfur and nitrogen stable isotopes to determine the importance of whitebark pine nuts to Yellowstone grizzly bears. Canadian Journal of Zoology 81, 763-770, doi: 10.1139/z03-054.

Keane, R.E., et al., 2012. A range-wide restoration strategy for whitebark pine (*Pinus albicaulis*). Gen. Tech. Rep. RMRS-GTR-279. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 108 p.

Mahalovich, M.F., et al., Isotopic heterogeneity in whitebark pine (*Pinus albicaulis* Engelm.) nuts across geographic, edaphic and climatic gradients in the Northern Rockies (USA). Forest Ecology and Management *in review*.

Mahalovich, M.F., et al., 2006. Whitebark pine germination, rust resistance and cold hardiness among seed sources in the Inland Northwest: Planting Strategies for Restoration. In: National Proceedings: Forest and Conservation Nursery Association, 2005 July 18-20, Park City, UT, USA. Proc. RMRS-P-43. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station: 91-101.

Rehfeldt, G.E., et al., 2006. Empirical analyses of plant-climate relationships for the Western United States. International Journal Plant Sciences 167(6), 1123–1150, doi: 1058-5893/2006/16706-0005.

US Geological Survey Open-File Report 2005-1305. 2005a. Preliminary integrated geologic map databases for the United States - Western states http://pubs.usgs.gov/of/2005/1305/. USGS Open-File Report 2005-1351. 2005b. Central states http://pubs.usgs.gov/of/2005/1351/. USGS Open-File Report 2005-1235. 2005c. Northern Rocky Mountains http://pubs.usgs.gov/of/2005/1235/.

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