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Not Just Archaeology: Stable Isotopes and the Multifaceted GRSLE Dataset

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The GRSLE Project records more than just traditional archaeology. By documenting lithics, faunal remains, historic debris, modern traces, and ecological materials, GRSLE creates an integrated dataset that allows us to ask new questions about how landscapes were used in the past. This project explores one such avenue through a basic experiment in stable isotope analysis. An elk antler collected during 2025 fieldwork will be analyzed for carbon and nitrogen isotope values, which can provide insight into the seasonal diet and trophic status of the elk during antler formation. While preliminary, this case highlights how GRSLE's multifaceted data structure facilitates diverse forms of experimentation. By linking biogeochemical signals with artifacts and ecological traces, we can expand interpretations of hunting, animal ecology, and human–environment interaction. This study demonstrates how even small-scale projects can contribute to and benefit from the cumulative, context-rich framework developed by GRSLE.

I. Introduction

The GRSLE Project records lithics, faunal remains, historic debris, modern traces, and ecological materials to create an integrated view of past landscapes. This integrative dataset enables researchers to pose new questions about the interactions between humans, animals, and their environment.

This study uses a single elk antler shed as a pilot test of stable isotope analysis to explore how biogeochemical data can complement archaeological and ecological interpretations within GRSLE.

Research Question:
What can $\delta^{13}C$ and $\delta^{15}N$ values in an elk antler reveal about the animal's diet and seasonal landscape use?

Hypotheses:
H_0: The elk consumed primarily C_3 vegetation during antler formation.
H_1: The elk did not consume primarily C_3 vegetation (i.e., $\delta^{13}C$ values fall outside the C_3 range).

Figure 1. Daniel Dalmas[c] carrying an elk antler shed collected in the Shoshone National Forest, Wyoming.

II. Methods

Field Sampling:
- Elk antler shed collected during 2025 GRSLE fieldwork at Pickett Creek, Shoshone National Forest, Wyoming.
- The main beam was divided into ten equal sections to examine isotopic variation through growth.
- At each section, approximately 1 mg of powder was drilled using a Dremel rotary tool and sealed in tin boats.

Isotopic Analysis:
- Conducted at the Iowa State University EaSEL Stable Isotope Laboratory, Department of Earth, Atmosphere, and Climate.
- Analyses performed using a Thermo Delta V mass spectrometer in continuous-flow mode with a Thermo Flash TCEA elemental analyzer.
- Reference standards: USGS-62, USGS-42, and Acetanilide.
- Calibration: Regression-based scale correction to VPDB ($\delta^{13}C$) and Air ($\delta^{15}N$).Uncertainty: ±0.15‰ (combined analytical and correction).
- Preservation: No collagen extraction performed; C:N = 2.94 indicates excellent preservation.

Statistical Analysis
- One-sample t-test: compared mean $\delta^{13}C$ to C_3 baseline (−22.0‰).
- Linear regressions: tested for variation in $\delta^{13}C$ and $\delta^{15}N$ across beam sections (1–10).
- Monte Carlo simulation: 20,000 iterations adding ±0.15‰ measurement uncertainty to propagate lab error and reassess significance.
- Significance level: $\alpha = 0.05$.

Figure 2. Laboratory sampling procedure for stable isotope analysis.

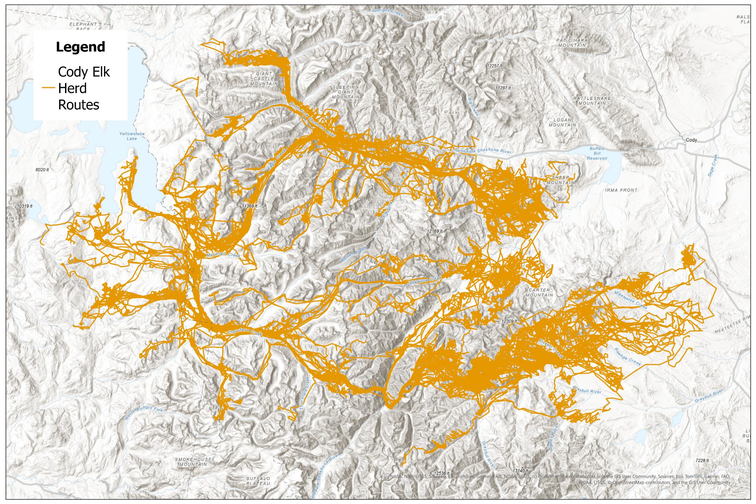

Figure 3. Migration Corridors of the Cody Elk Herd, northwest Wyoming

III. Results

The elk antler samples show isotopic values consistent with a C_3 vegetation diet and a low trophic level, typical of regional elk ecology.

Mean $\delta^{13}C$ (−22.1‰) and $\delta^{15}N$ (+1.7‰) values fall well within expected ranges for herbivores feeding on C_3 plants, and the C:N ratio (2.94) indicates good preservation.

Small directional changes were observed along the beam, with a slightly higher $\delta^{13}C$ and lower $\delta^{15}N$ toward the tip; however, these shifts fall within the ±0.15‰ analytical uncertainty of the mass spectrometer.

Statistical testing confirms no significant variation, meaning the isotope values are functionally the same across the beam, reflecting a stable diet and environment during antler growth.

Table 1. Summary of isotopic values for the Pickett Creek elk antler.

Parameter	Mean ± SD	Range	Interpretation
δ13C (VPDB)	−22.1 ± 0.05‰	−22.17 to −22.04	Consistent with C3 plant diet
δ15N (Air)	+1.7 ± 0.1‰	+1.64 to +1.86	Typical herbivore trophic level
C:N Ratio	2.94	2.92–2.96	Excellent collagen preservation

Table 2. Summary of statistical results for $\delta^{13}C$ and $\delta^{15}N$ values along the antler beam.

Test	Observed	After ±0.15‰ Uncertainty	Interpretation
t-test (δ13C vs −22.0‰)	t(9)=−0.90, p=0.39	p=0.51; 4% significant in 20k runs	No difference — supports H0 (C3 diet)
δ13C Regression	+0.03‰/section, p=0.0009	95% CI: −0.003–+0.063; 31% significant	Isotope values functionally the same across beam
δ15N Regression	−0.02‰/section, p=0.049	95% CI: −0.056–+0.009; 15% significant	Isotope values functionally the same across beam

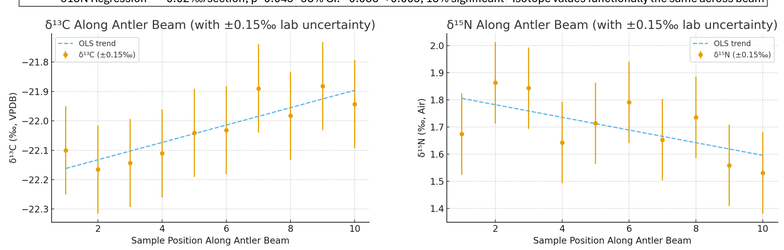

Figure 4. $\delta^{13}C$ and $\delta^{15}N$ values along the elk antler beam with ±0.15‰ analytical uncertainty.

IV. Discussion

Isotopic results from the Pickett Creek elk antler support a consistent C_3-based diet and a stable trophic position during the period of antler growth. The lack of significant $\delta^{13}C$ or $\delta^{15}N$ variation along the beam indicates that the animal likely remained within a single ecological zone and fed on similar plant communities throughout the growing season.

These findings suggest limited seasonal or spatial shifts in feeding behavior, aligning with modern observations of elk occupying high-elevation forest and meadow habitats in the Shoshone region during summer. The stability in isotopic composition implies that dietary resources were reliable and that the elk's range use was localized rather than migratory during antler formation.

Figure 5. Willow shrubs near the Pickett Creek antler find location. Willows are C_3 plants commonly browsed by elk, consistent with the $\delta^{13}C$ values indicating a C_3-based diet during antler growth.

V. Conclusion

Stable isotope results from the Pickett Creek elk antler provide strong support for the null hypothesis that the animal fed primarily on C_3 vegetation during antler formation.

Both $\delta^{13}C$ and $\delta^{15}N$ values remain functionally identical along the beam, confirming a stable diet and habitat through the growth period. The isotopic uniformity suggests the elk occupied a consistent high-elevation or forest-edge environment, with no evidence of dietary or ecological shifts.

These results demonstrate how even small-scale isotopic analyses can yield meaningful ecological insights when placed within the broader GRSLE framework. By combining biogeochemical data with archaeological and environmental observations, GRSLE enhances our ability to interpret animal ecology, landscape use, and human–environment interactions over time.

Figure 6. Elk skeletal remains from the Pickett Creek area, contributing to GRSLE's integrated record of faunal and ecological data.

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