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Spectral Fingerprints Predict Functional Chemistry of Native Plants Across Sagebrush-Steppe Landscapes

Brecken C. Robb
Boise State University

Jessica Mitchell
University of Montana

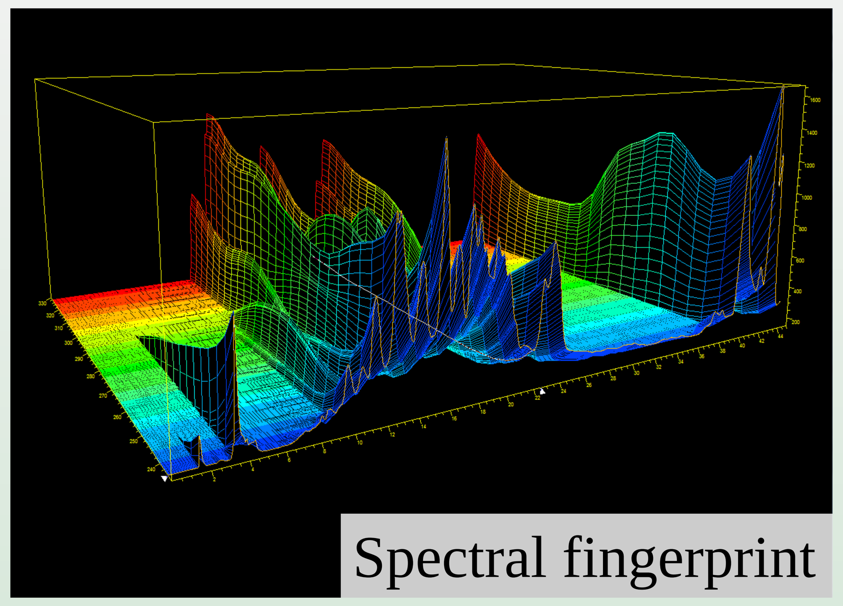
Peter Olsoy
Washington State University

Donna Delparte
Idaho State University

Janet Rachlow
University of Idaho

See next page for additional authors

Name
Brecken C. Robb, Jessica Mitchell, Peter Olsoy, Donna Delparte, Janet Rachlow, Lisa Shipley, Jordan Nobler, Marcella Fremgen, Chelsea Merriman, Lilly Whitehead, Jennifer Sorensen Forbey, and Jack Connellyu



Spectral fingerprint

SPECTRAL FINGERPRINTS PREDICT FUNCTIONAL CHEMISTRY OF NATIVE PLANTS ACROSS SAGEBRUSH-STEPPE LANDSCAPES

Brecken C. Robb[1], Jessica Mitchell[2], Peter Olsoy[3], Donna Delparte[4], Janet Rachlow[5], Lisa Shipley[3], Jordan Nobler[1], Marcella Fremgen[1], Chelsea Merriman[1], Lilly Whitehead[6], Jack Connelly[5], Jennifer Sorensen Forbey[1]

[1]Boise State Univ, [2]Univ of Montana, [3]Washington State Univ, [4]Idaho State Univ, [5]Univ of Idaho, [6]College of Idaho

Sagebrush-steppe

Plant chemicals influence foraging by herbivores

Herbivores make foraging decisions, in part, due to the functional chemical traits found in plants[1,2]

Plant chemistry also provides critical ecosystem services that ensure healthy stable communities by:

- Influencing wildlife biodiversity and fecundity[3]
- Promoting food security[4]
- Providing sources for medicinal, agricultural, and technological advances[5]

How do we monitor these changing chemical traits?

Current monitoring of plant chemistry is expensive, tedious, and does not rapidly capture dynamics over space and time

Solution: Spectroscopy, in the forms of near infrared spectroscopy (NIRS, Fig 1) and hyperspectral imagery, provides rapid quantitative measurements of plant traits without contact

- Spectra produce unique fingerprints based on organic bonds that predict geophysical and chemical quantities and qualities of plants

The sagebrush-steppe is an ideal system to pioneer using spectroscopy to monitor changing plant chemistry

- Sagebrush (*Artemisia* spp) is widely distributed over 43 million hectares of land
- It is under severe threat from fire, invasive plants, and climate change
- It is rich in chemical diversity that influences specialist herbivores

Fig 1. Examples of handheld spectrometers measuring near infrared spectroscopy (NIRS)

Research Question

Can spectroscopy predict known functional chemicals in plants that explain foraging behavior of herbivores at increasing taxonomic, spatial, and temporal scales?

Methods

We developed predictive equations for phytochemical concentrations (nitrogen (Figs 2, 3, 4), coumarins (Fig 5)) using data from handheld NIRS (Fig 1) and wet chemistry.

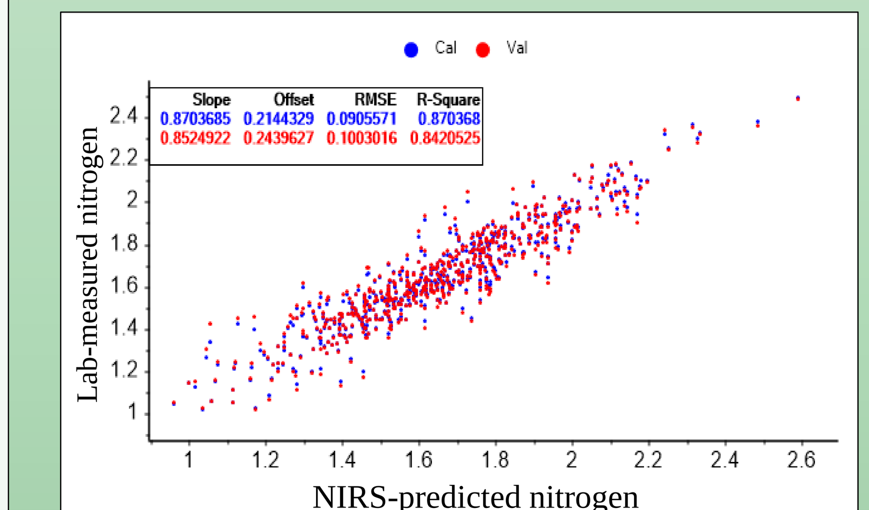


Fig 2 (above). NIRS can predict nitrogen in two species of sagebrush at one study site across two seasons (R^2 = 0.870, RMSE = 0.091).

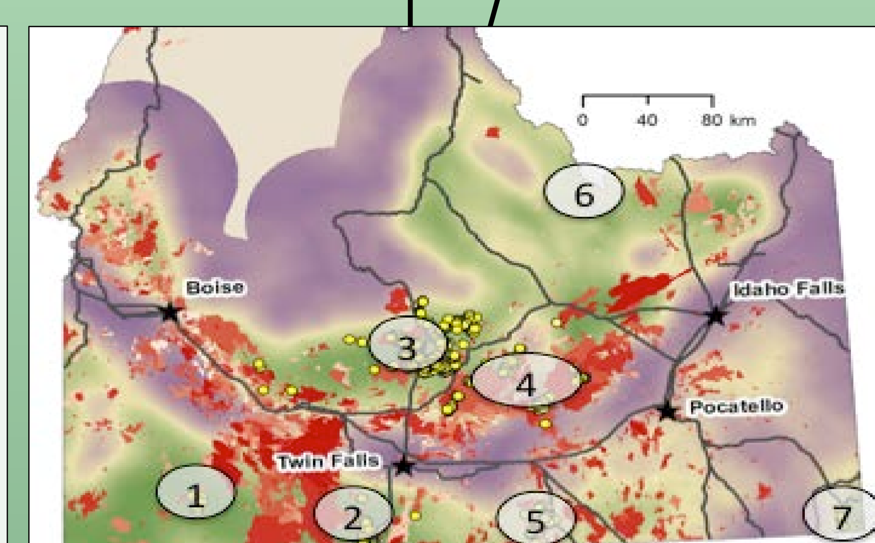
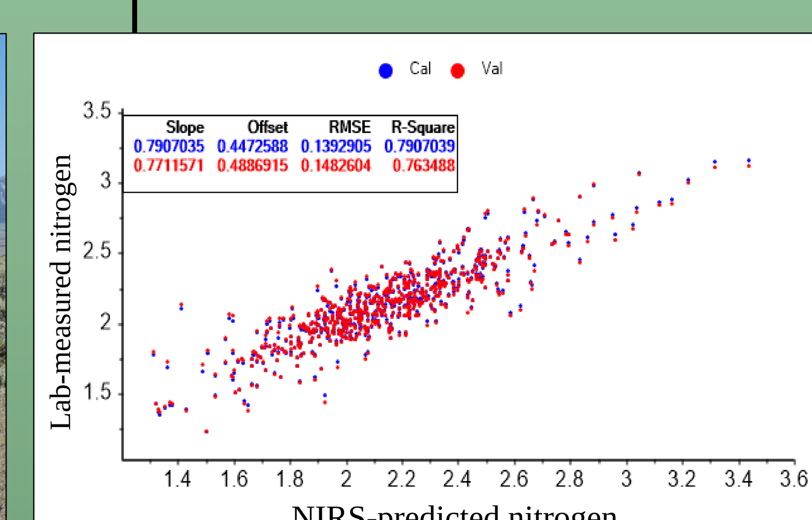


Fig 3 (below). NIRS can predict nitrogen in three species of sagebrush at one study site across two seasons (R^2 = 0.791, RMSE = 0.139).



A global equation can predict nitrogen in sagebrush

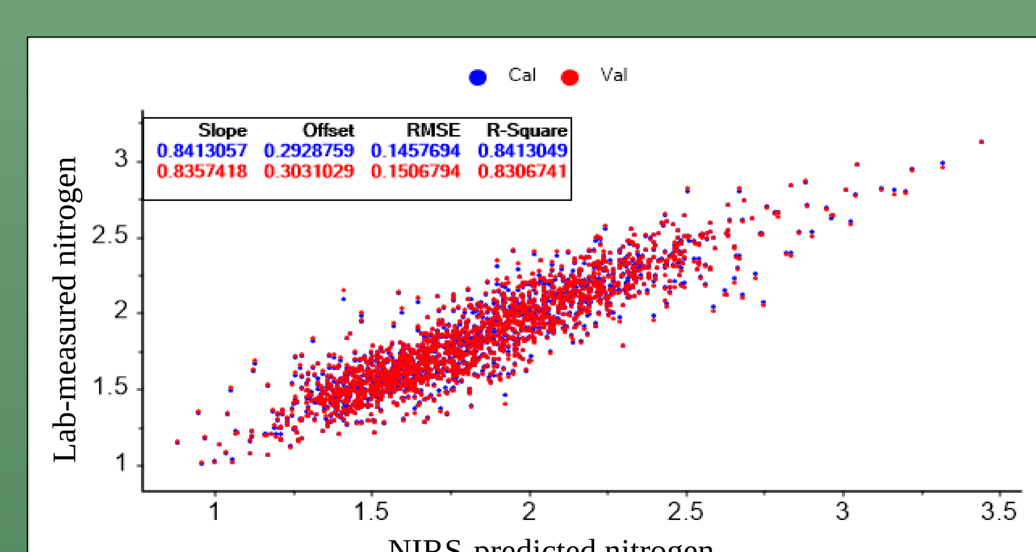
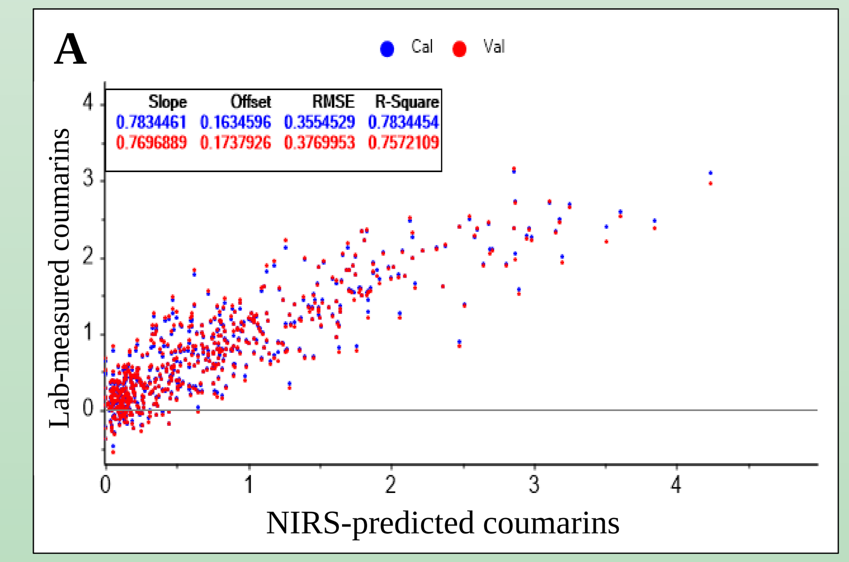


Fig 4. NIRS can predict nitrogen in five species of sagebrush at three study sites (3, 4, 6) across two seasons and multiple years (R^2 = 0.841, RMSE = 0.146).

NIRS can predict phytochemicals that explain diet selection by a specialist avian herbivore



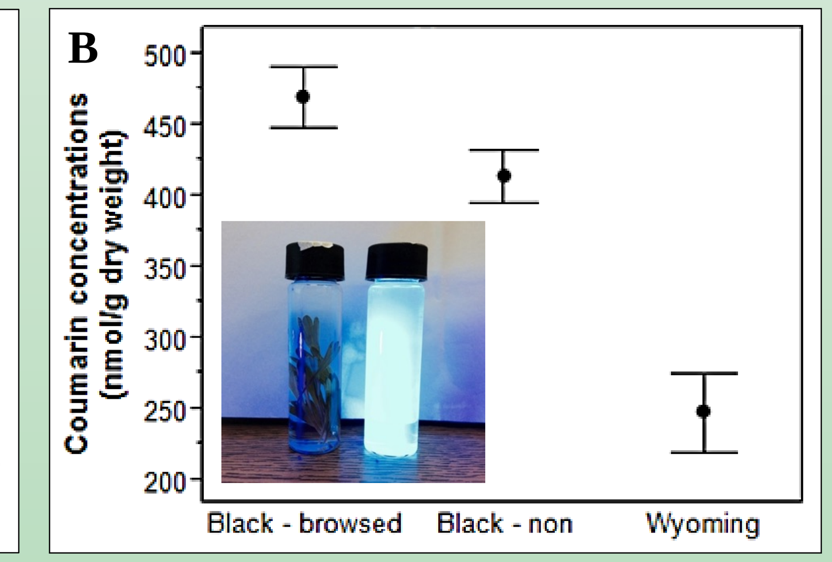


Fig 5. NIRS can predict (A) coumarins in sagebrush (R^2 = 0.783, RMSE = 0.355), which are (B) highest in browsed (*A. nova*) and lowest in non-browsed sagebrush (*A. tridentata wyomingensis*)[2].

Next Steps: Map species distribution and phytochemistry with hyperspectral imagery

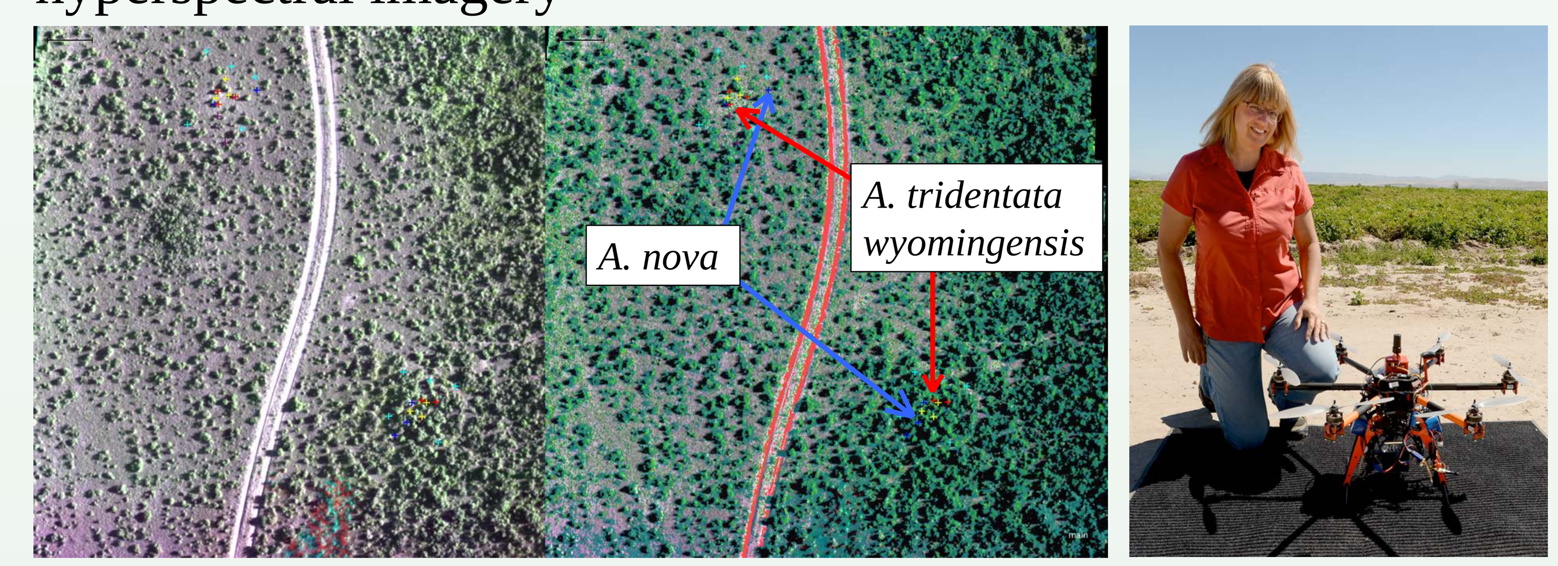


Fig 6. Hyperspectral imagery collected from an UAS[6] can differentiate plant species, with known chemical content (Fig 6B), across landscapes.

Remote sensing offers multiple advantages

- Rapid, precise, non-invasive method to map diversity of plant taxa and functional traits important to herbivores
- Spectrally-obtained taxonomic and chemical diversity can be used to predict herbivore habitat use, monitor plant communities after restoration efforts, and identify hot-spots of chemical diversity for drug discovery

References & Acknowledgements

[1]Ulappa, et al. 2014. Journal of Mammalogy.
[2]Frye, et al. 2013. Ecology.
[3]DeGabriel, et al. 2009. Ecological Society of America.
[4]Abson, et al. 2013. Agriculture & Food Security.
[5]Veeresham. 2012. Advanced Pharmaceutical Tech.
[6]Delparte, et al. 2016. Unpublished data.

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