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Remotely-Sensing Chemical Diversity and Function of Native Plants Across Sagebrush-Steppe Landscapes

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Abstract

Plant chemical diversity provides ecosystem services by supporting wildlife diversity and offering sources for novel medicines. Current mapping of phytochemicals can be expensive, time-intensive and provides only a snapshot of available diversity. To overcome this, I will use handheld and airborne instruments collecting near infrared spectra and hyperspectral imagery to remotely sense chemical diversity within plants and ecosystems. I hypothesize that greater plant chemical diversity will be correlated with greater habitat use by wildlife and greater bioactivity of plant extracts. This research provides a powerful tool to map chemical diversity, target wildlife conservation and direct the discovery of novel medicines.

Name

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REMOTELY-SENSING CHEMICAL DIVERSITY AND FUNCTION OF NATIVE PLANTS ACROSS SAGEBRUSH-STEPPE LANDSCAPES

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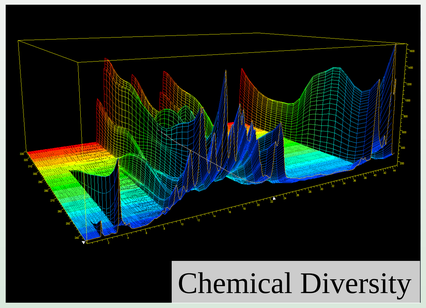


Why does plant chemical diversity matter?

Plant chemicals provide ecosystem services and values:

- Influence wildlife biodiversity and health
- Promote food security
  - Diverse agricultural plots are more resilient to disease[1]
- Are sources for medicinal, agricultural, and technological advances[2]
  - Examples: Opium, Taxol, pesticides, biofuel

The sagebrush-steppe is an ideal ecosystem for chemical diversity arising from plant-herbivore interactions

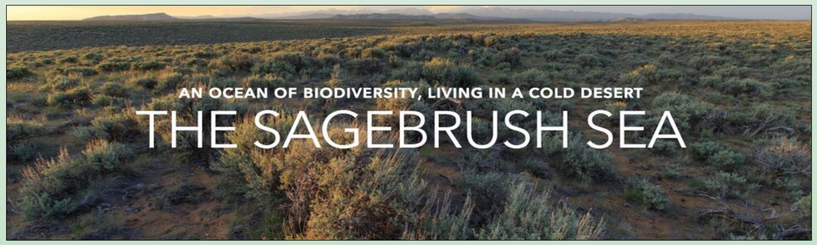
Remote sensing is the key

Detecting, monitoring, and mapping plant diversity is expensive, time intensive and does not capture functional traits

Solution: Remote sensing using spectroscopy (e.g., near infrared spectroscopy (NIRS), hyperspectral) provides rapid quantitative measurements of plant traits without contact

- Spectroscopy produces unique fingerprints based on organic bonds that predict geophysical quantities and chemical traits of plants
- Publicly-made spectral data is low resolution and large-scale
- Spectrometers on handheld devices and attached to unmanned aerial systems (UASs) provide higher resolution and finer-scale data (Fig 1)

Fig 1. Examples of spectrometers on handheld devices (left) and attached to unmanned aerial systems (middle, right).



Research Questions

1. *Species Diversity:* Can spectroscopy differentiate plant species in the sagebrush-steppe ecosystem at increasing spatial scales?
2. *Chemical Diversity:* Can spectroscopy predict known functional phytochemical differences among plants at increasing spatial scales?

Methods

1. *Species Diversity:* Use handheld NIRS and hyperspectral sensors from UASs to determine species of sagebrush from images of single shrubs (Fig 2) & patches of plants (Fig 3).
2. *Chemical Diversity:* Use handheld NIRS and lab-performed chemistry to predict chemical diversity from leaves, whole plants, and patches (Fig 4).
3. *Mapping:* Build taxonomic / chemical diversity maps and indices from spectral data overlaid onto spatial data (Fig 5).

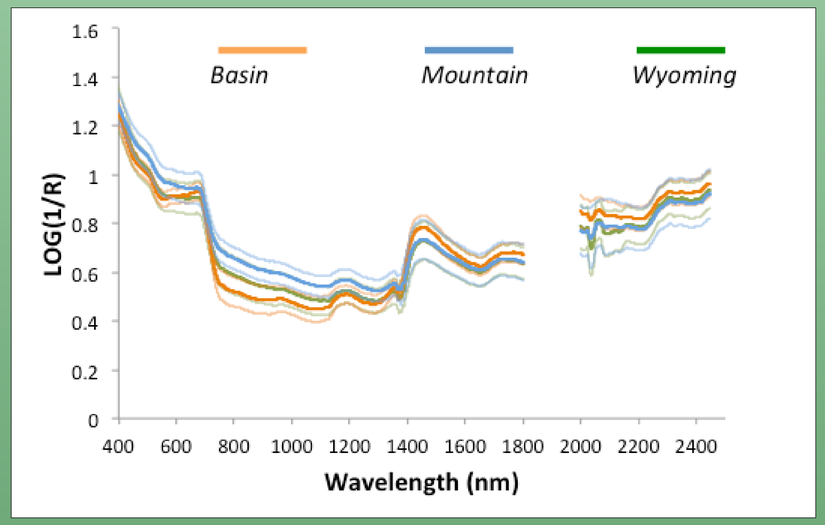


Fig 2. NIR spectra of field scans of Basin (*A. t. tridentata*), Mountain (*A. t. vaseyana*), and Wyoming big (*A. t. wyomingensis*) sagebrush.

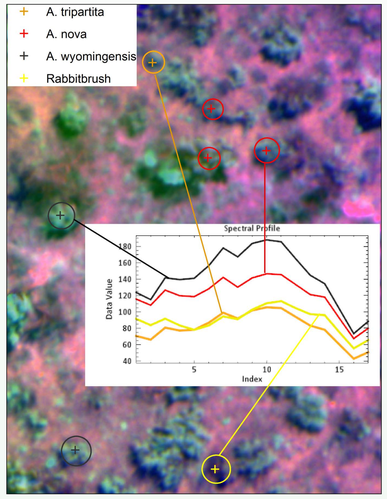


Fig 3. At the patch scale, hyperspectral imagery collected from a UAS[3] can differentiate plant species.

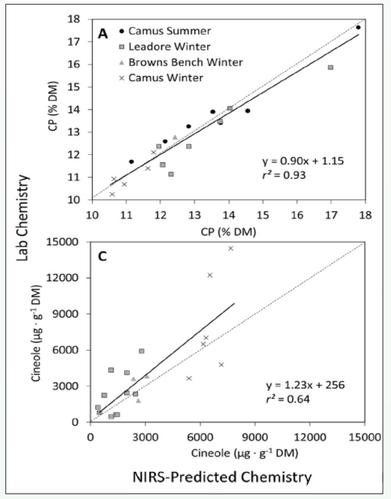


Fig 4. At the leaf scale, NIRS can predict phytochemicals of sagebrush quantified in the lab[4].

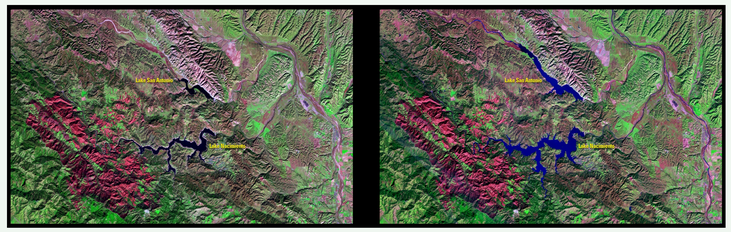


Fig 5. Example maps of landscape diversity changing over time[5].

Remote sensing offers multiple advantages

- Relatively cheap, rapid, precise method to map plant diversity that provides information on functional traits
- Spectrally-obtained diversity data 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

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