Use of Remote Sensing for Monitoring Rangeland Vegetation Changes Following Herbicide Treatment

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Problem Statement

- Encroachment of woody plants into grasslands is a critical social-ecological issue in drylands around the world, including the southwestern United States, where honey mesquite (*Prosopis glandulosa*) is a major encroacher (Adam et al., 2017; Mohamed et al., 2011; Rango et al., 2000). They are known to alter the grazing lands and affect the livestock production (Pejchar & Mooney, 2009).
- The social-ecological consequences of woody plant encroachment, control and management of woody plants has been a major concern for land managers.
- Several strategies have been used to control the encroachment including herbicide treatment (Hamilton & Ueckert, 2004). However, currently there is a lack of information about the effectiveness of the treatment.
- High spatial and spectral resolution imagery need to be used to test the effectiveness of different mapping methods.
- The utility of Multiple Endmember Spectral Mixture Analysis (MESMA) for mapping cover changes of response to herbicide treatment need to be identified.

Dataset

- Sentinel-2 Multispectral Instrument satellite imagery acquired over the study area before (June 6, 2019) and after (July 7, 2022) the herbicide treatment.
- Field spectral reflectance data of green and senescing mesquite, other plants, and soil collected using an ASD FieldSpec 4 Hi-Res Spectroradiometer.
- Spectral library used by Converse et al. (2021)
- Fractional cover data estimated along three transects per plots (total 40 plots).

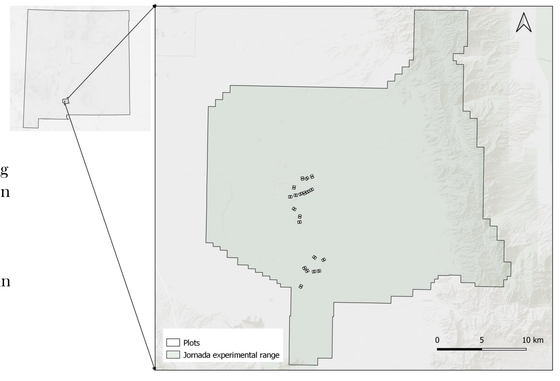

Fig. 1: Study area map showing the 20 paired control/ treatmen plots of honey mesquite *(Prosopis glandulosa)* encroached rangeland on the Jornada Experimental Range in southern New Mexico, USA

Objectives

- Testing the utility of MESMA for mapping fractional cover changes of photosynthetic vegetation (woody plants), non-photosynthetic vegetation, and soil in response to herbicide treatment

Methods

- Created and refined endmembers and MESMA processing using Visualization and Image Processing for Environmental Research (VIPER) Tools 2.1, an open source extension to ENVI 5.6.
- Our spectral library contains 778 spectra from the fieldwork and Converse et al. (2021). We used the whole spectral library and ran MESMA using 2-3-4 endmember models. We retained the endmembers which contributed at least 0.01% of the total fraction cover. In total 178 spectra were retained and we named the library as 'reduced library'
- We applied MESMA on Sentinel data at 10 and 20 m spatial resolution and with reduced spectral library, EMC, IES, and InCOB, three different endmember selection strategies (Converse et al 2021).
- Zonal statistics were used to extract the percentage of fractional covers per plots.
- We assessed the accuracy of the fractional cover maps in terms of R^2 values using transect data provided by Molly Reichenborn.

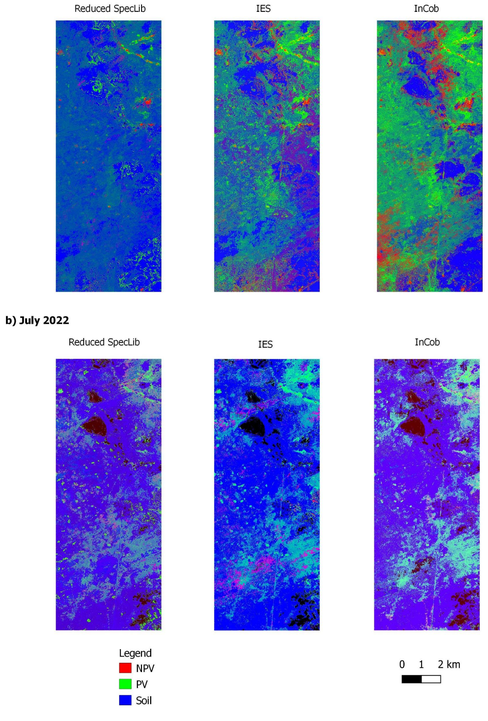

Fig. 2: MESMA classified images as NPV, PV, and Soil for before and after herbicide treatment.

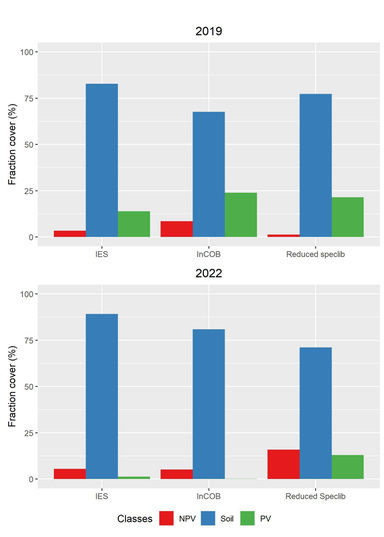

Fig. 3: Average percentages of fraction covers of the 40 plots from the derived 3 endmember models for both 2019 (on top) and 2022 (below)

Results and Discussion

- The resultant spectra from EMC, IES, InCOB, and 'reduced spectral library' are 8, 37, 41, and 178 respectively.
- 10-m resolution imagery produced better results than 20-m for both pre and post treatment.
- EMC produced 40% of unclassified pixels for both 10 and 20m spatial resolution imagery, while IES, InCOB and 'reduced spectral library had less than 2% unclassified pixels. Hence, we did not consider EMC for the final output.
- IES and InCOB picked more photosynthetic vegetation than the reduced spectral library. PV fractional cover percentages were reduced significantly from pre to post treatment phase (**Fig. 2**).
- NPV fraction is also reduced from pre to post treatment phase. It can be argued that a lot of the non-photosynthetic vegetation was confused with the soil class, especially in the post-treatment imagery.
- Agreement between the MESMA fraction and transact varies between the classes with NPV showing highest agreement and soil showing lowest agreement (**Fig. 4**)

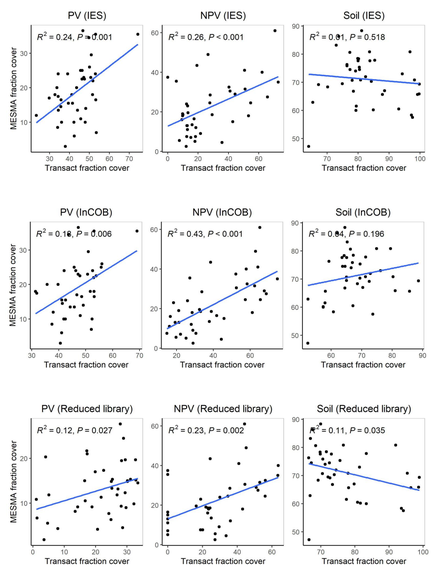

Fig. 4: MESMA derived fractional cover with IES, InCOB and reduced library are plotted against the transact fraction cover while showing the R^2 value

Conclusion and Recommendations

- Phenological mismatch between collected spectra and Converse et al data could be the reason behind low accuracies
- Additional work is needed to refine the spectral library to be used in the unmixing process.

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