The linkage of above and belowground structural diversity within a shrub invaded Chihuahuan Desert landscape

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Background

- There are different dimensions of diversity, both above and belowground, that each play a crucial role in ecosystem processes.
- Structural diversity – the volume and arrangement of vegetation within the ecosystem – has been shown to have a close relationship with ecosystem function, because the physical arrangement of vegetation influences the location of resources and habitat[1].
- The spatial patterns and linkage of above and belowground structural diversity is not all well characterized.
- Dryland landscapes that are invaded by shrubs have a characteristic pattern of patchy plant spacing, that may result in predicable relationships between above and belowground structural diversity.

Objective

Our goal was to use remote sensing to quantify spatial patterns in above and belowground structural diversity and their linkages across a shrub invaded landscape in the northern Chihuahuan Desert.

Methods

Aboveground structural diversity of shrub vegetation was measured with unoccupied aerial vehicle (UAV) lidar at a honey mesquite dominated site at the Jornada Experimental Range (Las Cruces, NM) in the northern Chihuahuan Desert.

Fig. 1. Chihuahuan Desert invaded by shrubs.

Fig. 2. GPR.

The structural diversity of coarse lateral roots was measured within the UAV footprint with Ground Penetrating Radar (GPR). A total of 29 root cores (15 cm diameter x 30 cm depth) were taken to generate a linear model to predict root biomass following the method of Butnor et al. (2003) and Zhou et al. (2022) to predict root biomass across a series of 19 – 10 m GPR transects for estimating structural diversity of roots.

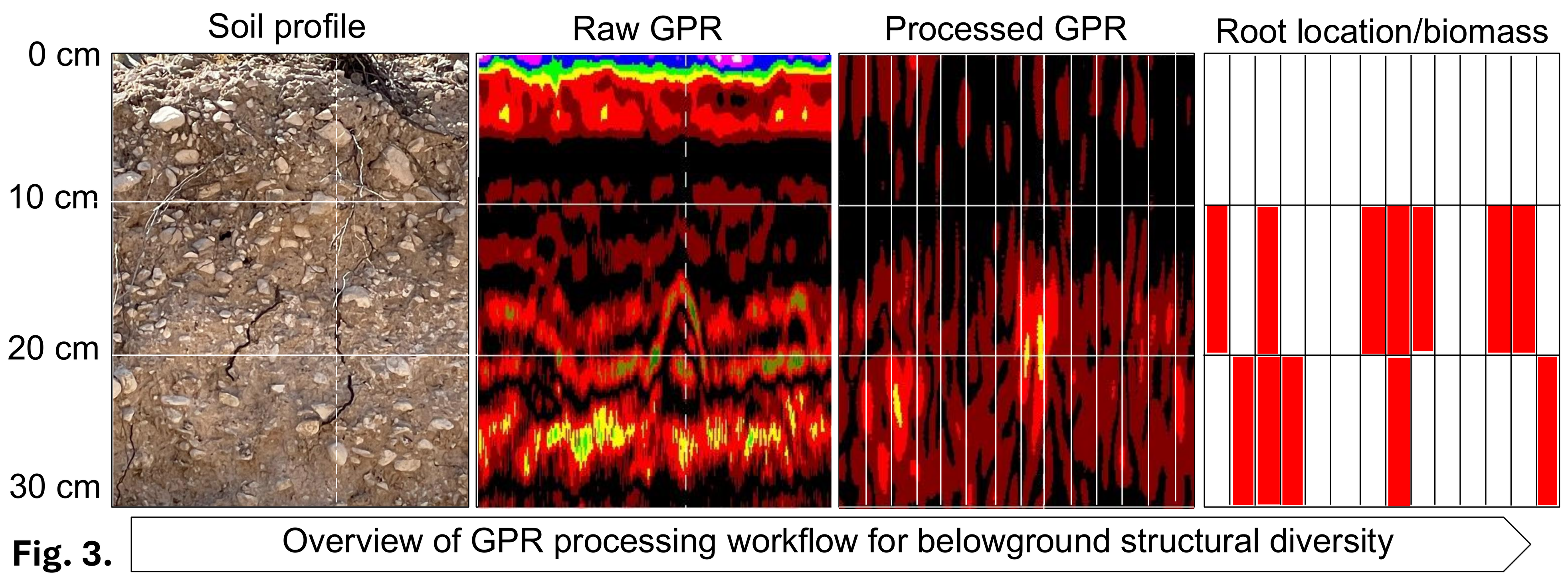

Fig. 3. Overview of steps for processing GPR soil profiles to obtain a 2D matrix of root location and estimated biomass of lateral coarse roots. The biomass estimates are obtained from a linear regression model developed for each site from soil cores and GPR data.

Results

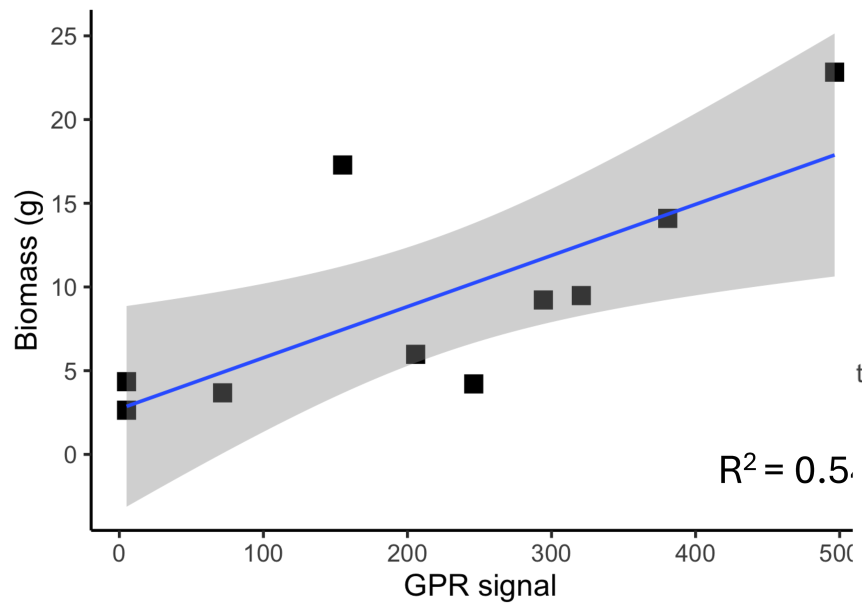

Figure 4. Linear regression model for estimating coarse root biomass from GPR root signals.

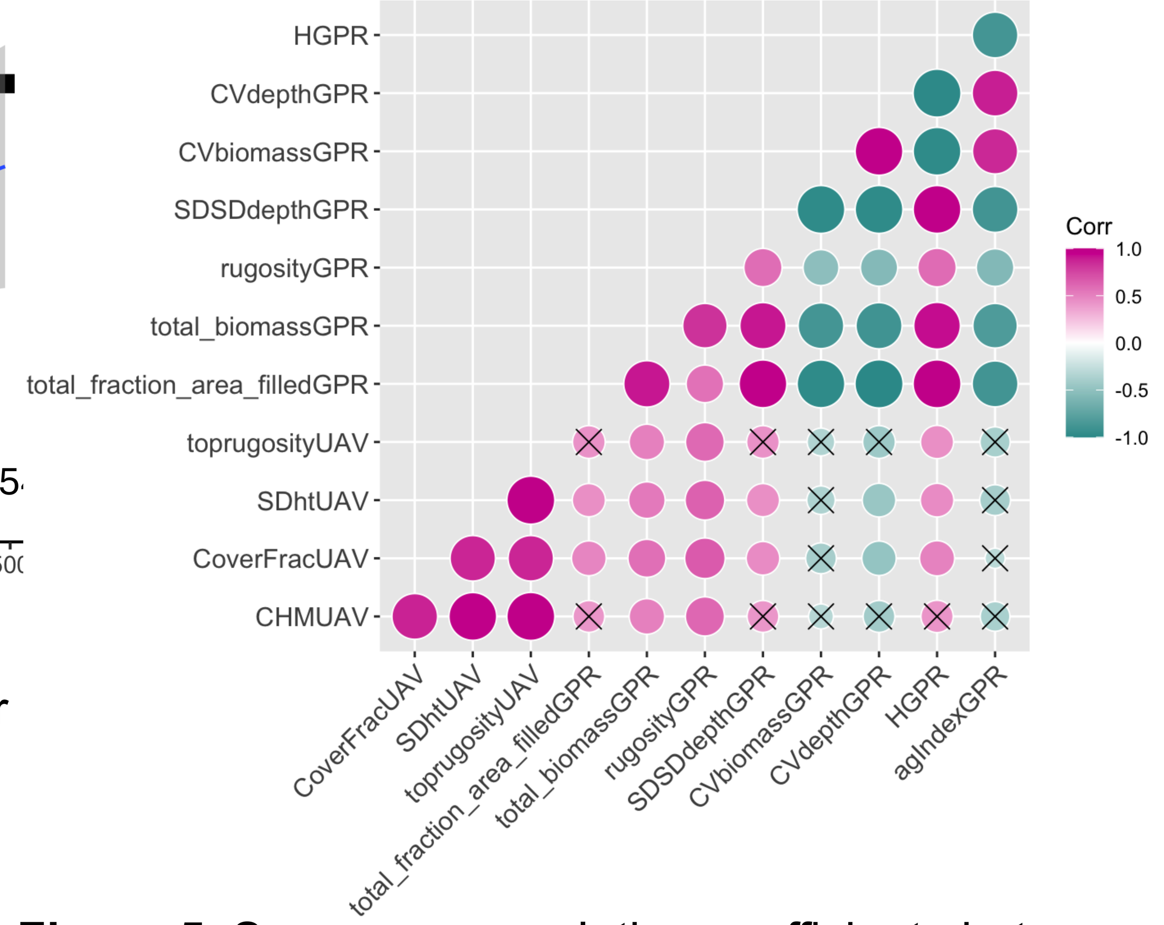

Figure 5. Spearman correlation coefficients between above and belowground structural diversity metrics.

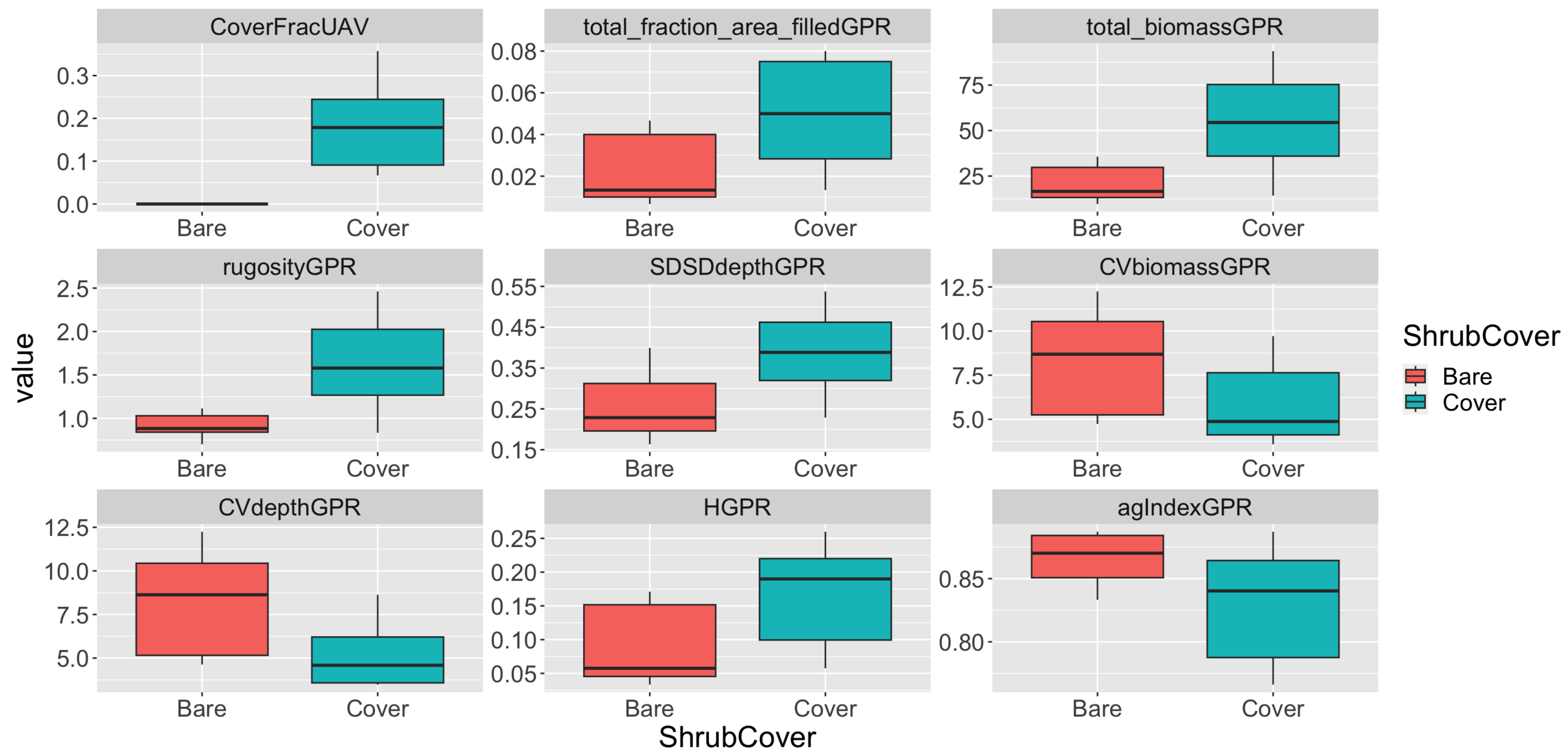

Figure 6. Box plots of cover and no cover belowground structural diversity in areas in bare ground and covered by shrubs. Wilcox sign-rank test: all significantly different except agindex and Cvbiomass.

Summary

- We were able to remotely sense and collocate above (shoot) and belowground (root) structural diversity in a dryland landscape using available remote sensing tools with GPR and UAV lidar.
- Several above and belowground metrics of structural diversity were correlated in this shrub invaded landscape of the northern Chihuahuan Desert.
- Remote sensing of above and belowground structural diversity could provide a basis for future monitoring tools of dryland structure and function in response to global change threats such as shrub encroachment.
- Ongoing work is looking at the linkage of above and belowground structural diversity with microbial community composition and function as the next step to understand their linkage with soil ecosystem function.

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References:
1. LaRue et al. 2023. Frontiers in Ecology and the Environment. 21: 4-13
2. Butnor et al. 2003. Soil Science Society of America Journal 67: 1607-1615.
3. Zhou et al. 2022. Nature 603: 445-449.