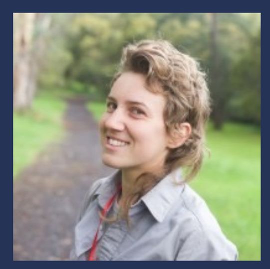

Patterns of Plant Biodiversity along Elevation in the Organ Mountains, NM

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Introduction

Arid Sky Islands– such as the Organ Mountains of southern NM – are model systems for understanding the impacts of climate change on biological communities[1]. The Organ Mountains' harsh elevation gradient (1,189 – 2,738 m) enables real-time interpretation of species' responds to changes because elevation serves as a proxy for moisture, weather, and climate(Fig. 1). Understanding these processes is critical for ecosystem management, nevertheless, very little is known about individual species response to climate change in New Mexico and arid regions globally[3]. In this study, we leverage 178 years of biodiversity data in the context of the Organs' unique physical geography to understand the relationship between weather, climate, and plant species distribution, abundance, and biodiversity.

Objectives

1) To synthesize biodiversity occurrence data from 1848 – 2021 in the Organ Mountains
2) Analyze relationship between species richness, abundance, diversity, and landscape position (e.g., elevation, slope, aspect)

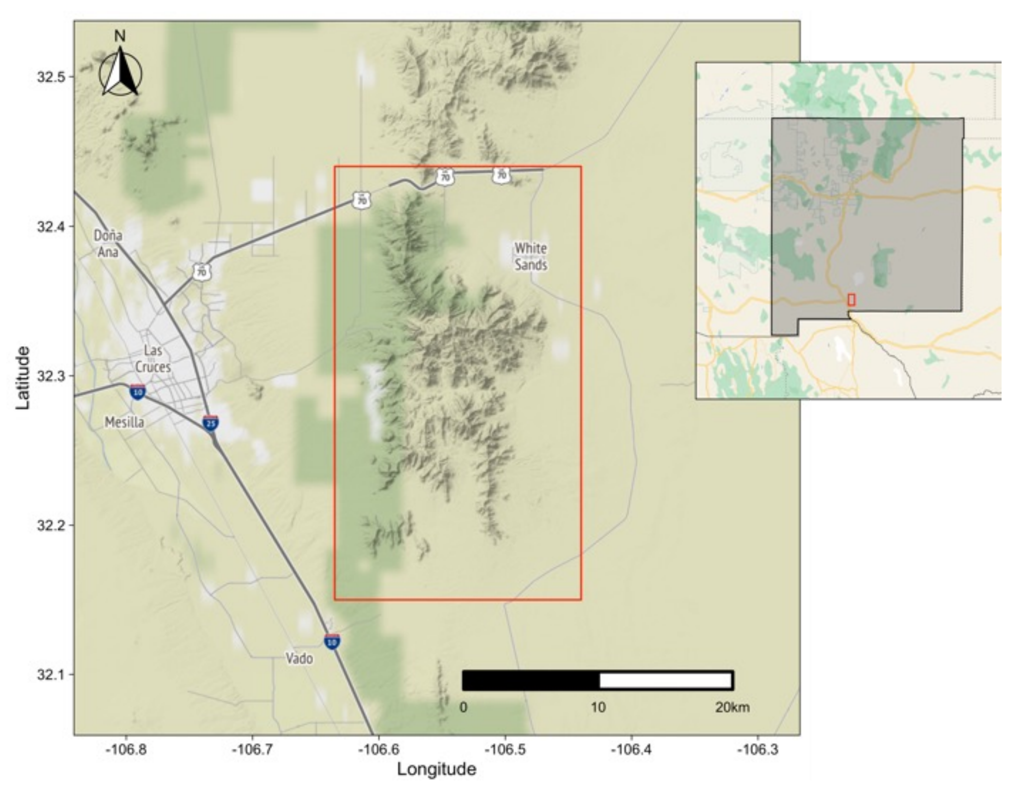


Figure 1. Terrain map of the Organ Mountains and inset of the study site within New Mexico. Sources: OpenStreetMap, Stamen Map, Google 2020.

Compilation of Biodiversity Data

We reviewed historical references from 1890 – 2020 from the NMSU Branson Library Archives and Special Collections, Google Scholar, and agency monitoring data. Additionally, we harmonized occurrence data from four biodiversity repositories – which each query up to 199 institutions – and two herbaria. We determined the temporal scope of our historical review to start in 1848 with the first specimen collections made in the Organs marking the introduction of western science and taxonomy to the region (Fig. 2).

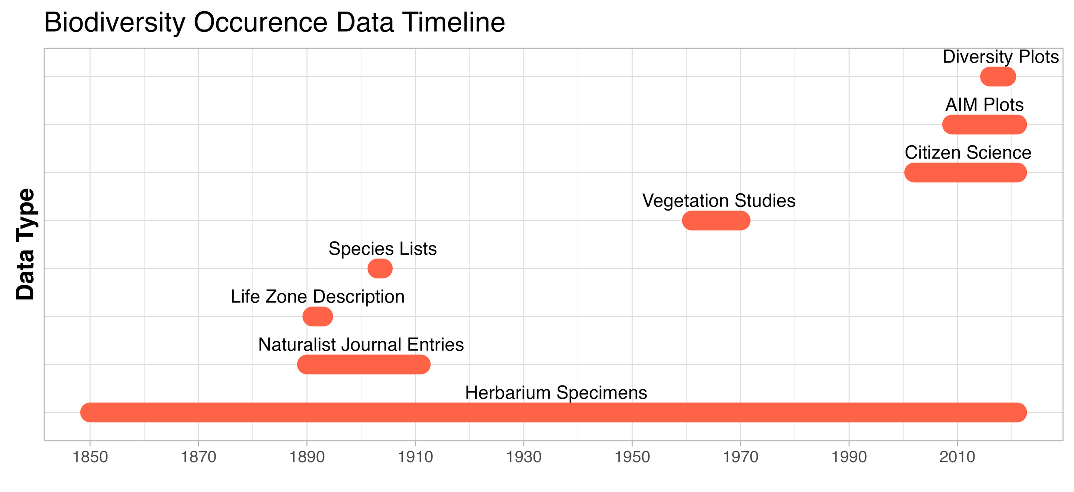


Figure 2. Timeline of biodiversity data types from historical review that were processed into occurrence data.

Harmonizing Species Occurrence Data

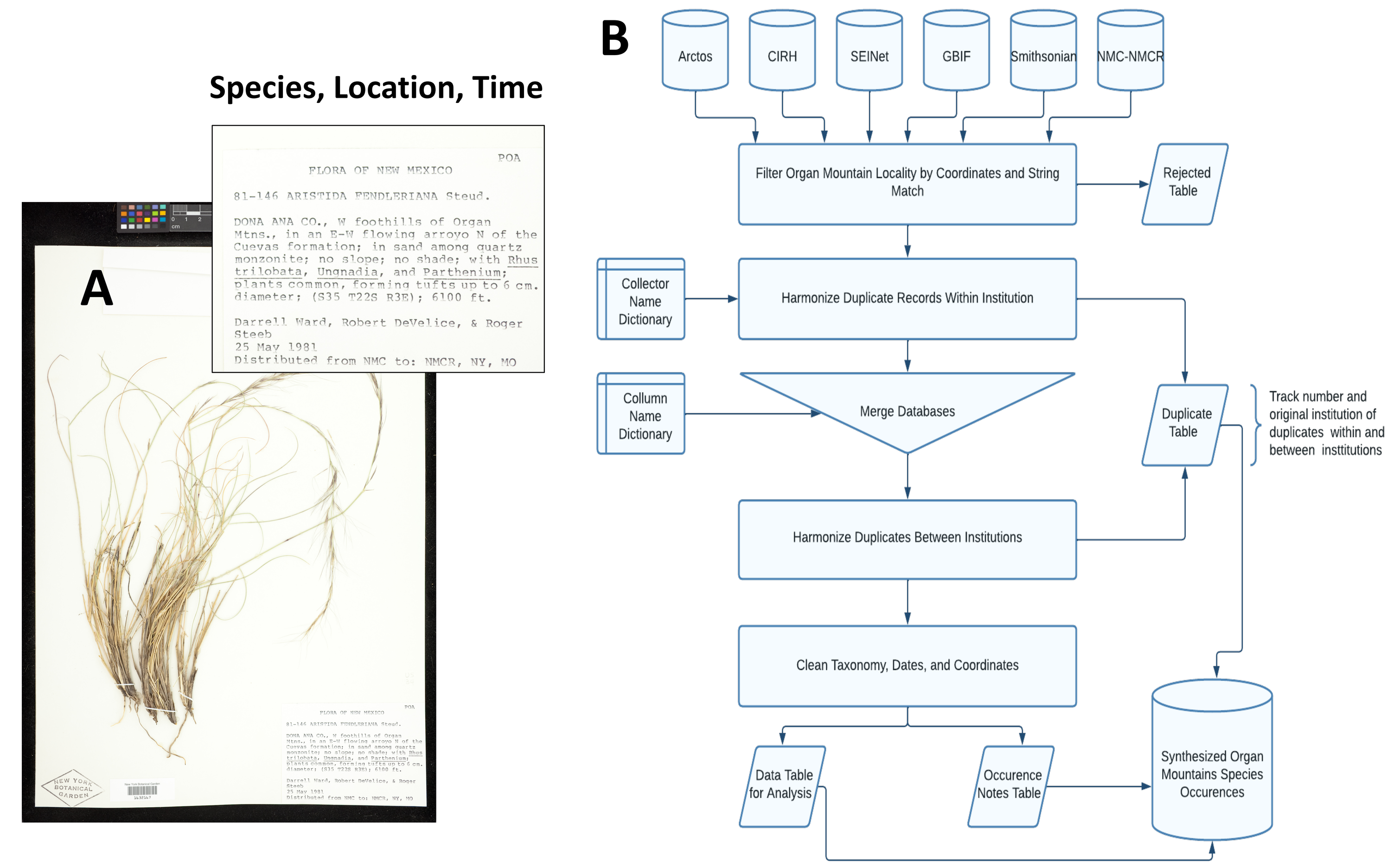
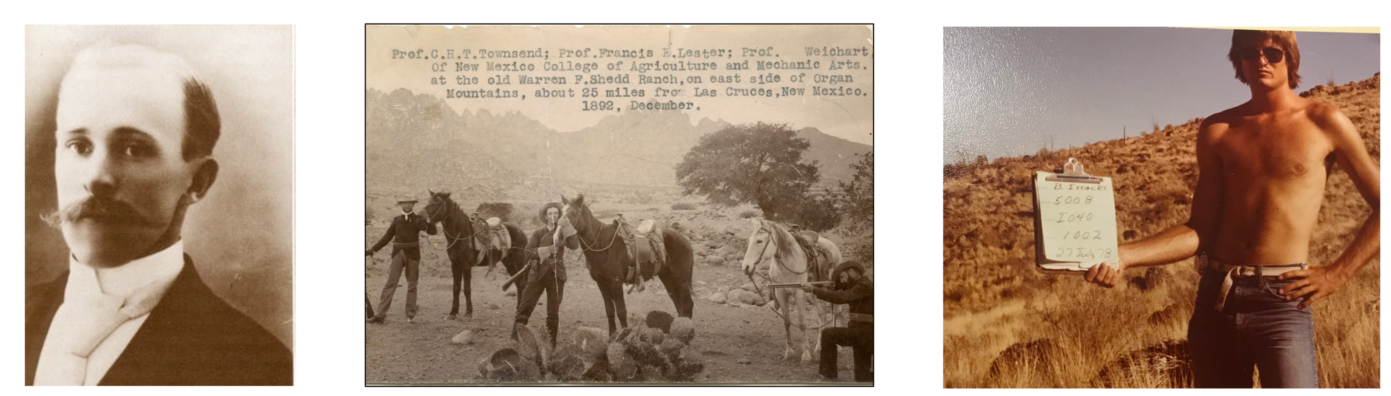


Figure 3. Diagram of data harmonizing process. A) Image of a specimen from the organ Mountains demonstrating how specimen collections represent species occurrence data documenting the time location and identity of a sample. B) Diagram of workflow for processing occurrence data from multiple institutions. Biodiversity Repositories queried were Arctos, Consortia of Regional Intermountain herbaria, SEINet, and Global Biodiversity Information Facility. Smithsonian and New Mexico State University (NMC-NMCR) herbaria were also incorporated.

Historical Biodiversity Literature



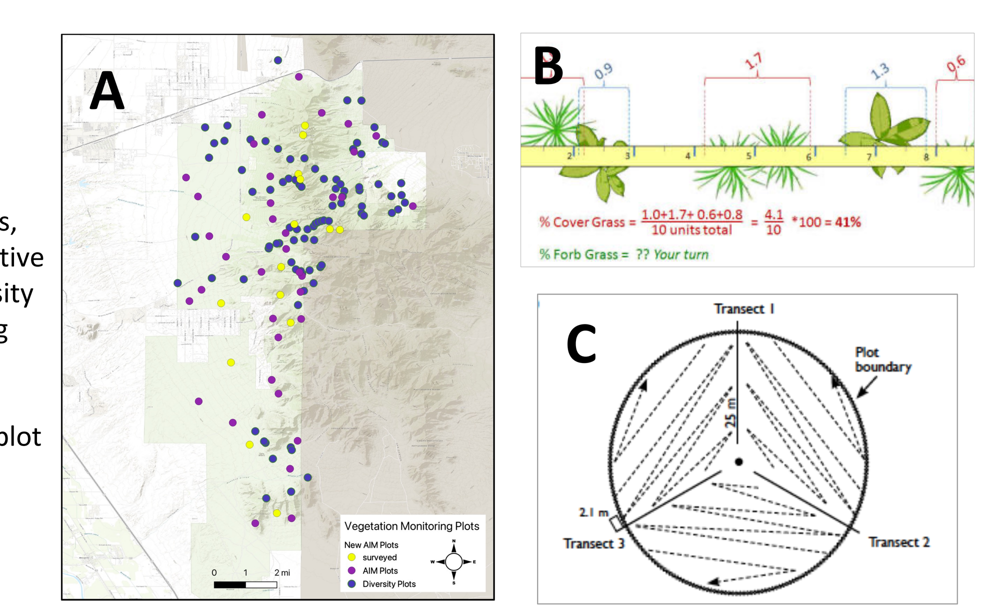
Time Period	Order	Family	Genus	Species	Infraspecific Epithet
1848 - 1920	39	99	374	861	186
1921 - 1960	34	77	247	450	97
1961 - 2000	47	125	446	1011	158
2001 - 2021	37	90	329	566	72
Total	**157**	**391**	**1396**	**2888**	**513**

Figure 3. Table of plant species occurrence records by time period and taxonomic rank showing increases in our understanding of biodiversity over time.

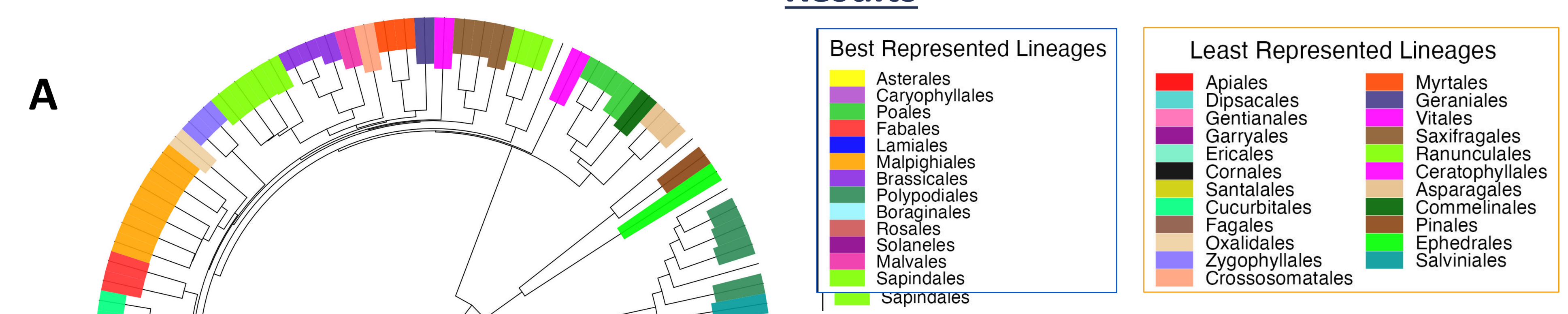
Ecological Monitoring Data

We included ecological monitoring data from the Bureau of Land Management Assessment (BLM) Inventory and Monitoring program and collected additional plots in high elevation areas (Fig. 4).

Figure 4. Elements contributed to this project by the Assessment Inventory Monitoring methods – species richness, ecosystem structure, and species' relative abundance. **A.** Map of AIM and Diversity plots in the Organ Mountains including additional plots from this project (in yellow). **B.** Illustration of a transect measuring canopy gap. **C.** Diagram of plot layout.



Results



B

Order	Sp. Richness	Order	Sp. Richness	Order	Sp. Richness
Asterales	14.90%	Ranunculales	1.70%	Geraniales	0.40%
Caryophyllales	12.90%	Asparagales	1.10%	Grimmiales	0.40%
Poales	12.70%	Cornales	1.10%	Ephedrales	0.30%
Fabales	7.30%	Hypnales	1%	Marchantiales	0.30%
Lamiales	6.40%	Pottiales	1%	Porellales	0.30%
Malpighiales	4.50%	Fagales	0.90%	Funariales	0.20%
Brassicales	4.10%	Pinales	0.90%	Orthotrichales	0.20%
Boraginales	3.40%	Apiales	0.70%	Oxalidales	0.20%
Polypodiales	2.90%	Saxifragales	0.70%	Vitales	0.20%
Solanales	2.80%	Bryales	0.60%	Ceratophyllales	0.10%
Malvales	2.30%	Dipsacales	0.60%	Crossosomatales	0.10%
Rosales	2.30%	Santalales	0.60%	Dicranales	0.10%
Sapindales	2.20%	Selaginellales	0.60%	Fissidentales	0.10%
Gentianales	1.90%	Zygophyllales	0.60%	Garryales	0.10%
Myrtales	1.80%	Commelinales	0.50%	Jungermanniales	0.10%
Ericales	1.70%	Cucurbitales	0.40%	Leucodontales	0.10%

Figure 5. Plant Community phylogenetics of Angiosperms and gymnosperms in the Organ Mountains (right panel). A. List of best (blue box) and least (orange box) represented lineages in the Organs. B. List of species richness per order.

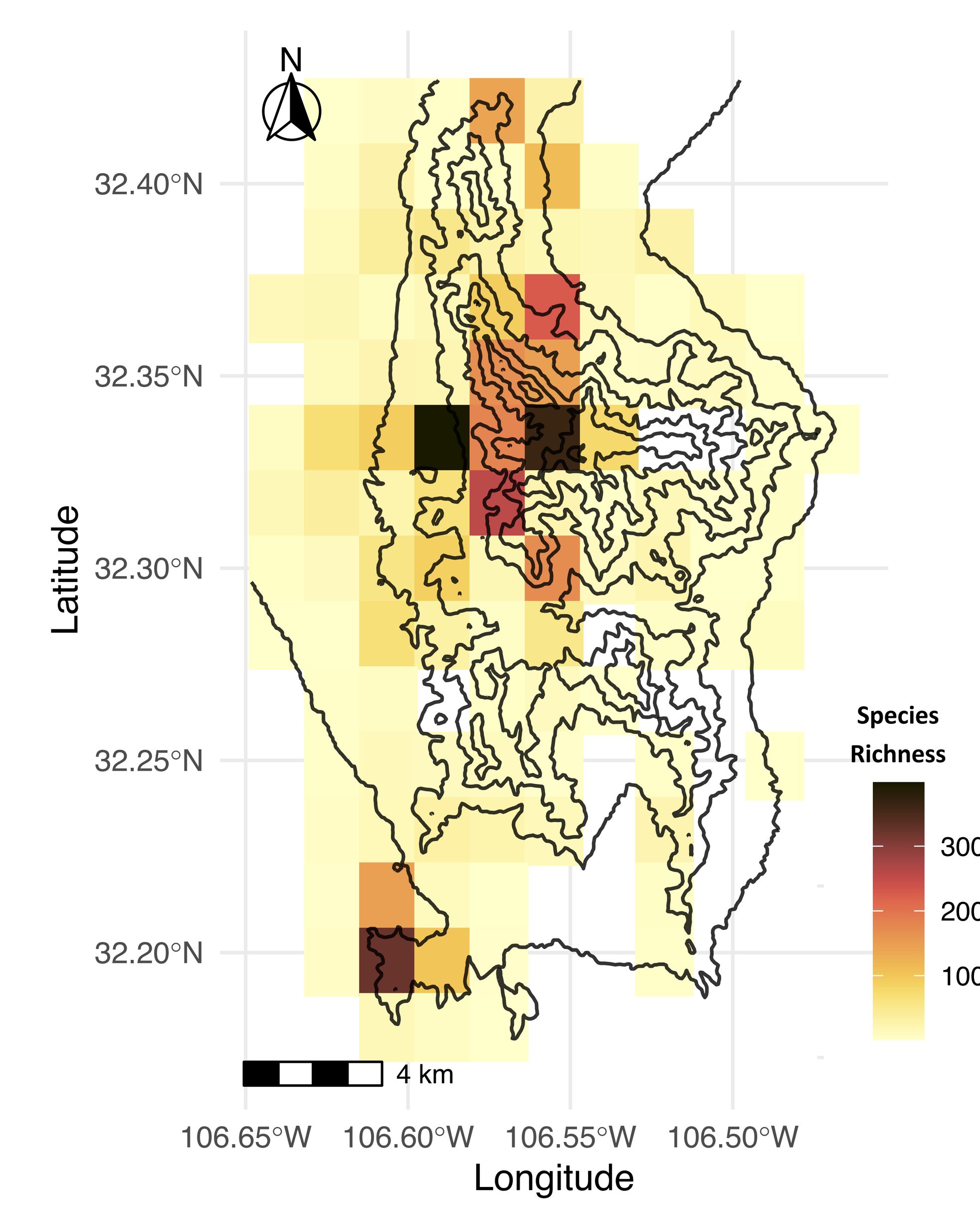


Figure 6. Heat map of the Organ Mountains showing the relationship between elevation and species observed richness. High values for species richness may be biased by sampling effort.

Elevation (m)	Richness	Shannon	Simpson	Inv.Simpson	n
1300	686	6.33	0.0017	583.632	2602
1400	2005	7.04	0.0012	816.048	26743
1500	2119	6.62	0.0021	482.899	69591
1600	1613	6.93	0.0013	767.887	13683
1700	2314	7.32	0.0008	1189.743	20802
1800	2182	6.83	0.002	497.822	27092
1900	1270	6.83	0.0012	820.497	6786
2000	406	5.55	0.0056	177.783	1316
2100	450	5.84	0.0029	340.292	1296
2200	211	4.42	0.0182	55.076	1033
2300	190	4.88	0.0091	110.242	412
2400	952	5.93	0.005	200.786	5956
2500	60	3.98	0.0105	95.357	90
2600	112	4.62	0.0057	176.029	190
2700	19	2.91	0.0095	105	21
Total	**14589**	**86.03**	**0.0768**	**6419.093**	**177613**

Figure 7. Table of biodiversity metrics Species Richness, Shannon, Simpson, and Inverse Simpson index as well as the number of overall occurrence records for each 100m elevation band.

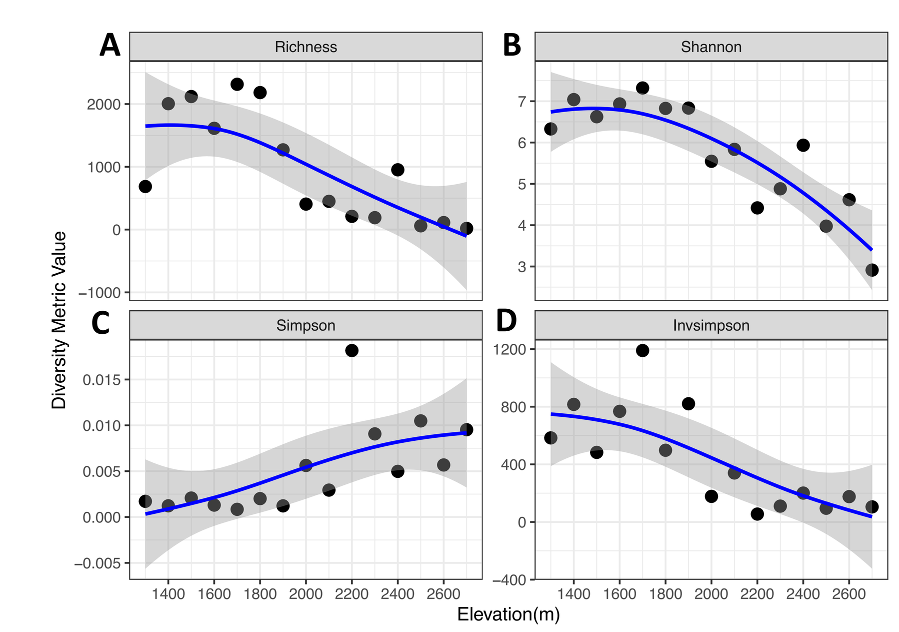


Figure 8. Linear regression of biodiversity metrics with respect to elevation. A Total species observed per sample. B Shannon's diversity index showing the highest species diversity between 1400m – 1800m. C Simpson index demonstrating that plant community evenness increases with elevation. D Inverse Simpson index showing same pattern with actual counts.

Conclusions and Future Directions

Synthesis of biodiversity data through time is an essential step towards understanding species response to land use and climate change. With more exploration of these data, we aim to detect changes in abundance of climate generalist and climate-sensitive species along elevation.

Implications

- Identify fast-adapting species for restoration, translocation, and targeted demographic studies
- Identified local extirpations, new invasions, sensitive taxa, and threatened populations
- Protection of ecological, socio-ecological, and tourism-related resources
- Supply models for plant community response to climate change in arid systems
- Provide proof of concept for a long-term ecological monitoring of the Organ Mountains

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