Influence of vascular plants and biocrusts on the spatial structure of gypsum communities of the Chihuahuan Desert, New Mexico

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GYPWORLD
A GLOBAL INICIATIVE TO UNDERSTAND GYPSUM ECOSYSTEM ECOLOGY

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Gypsum plant communities

Near Carrizozo / Oscuro, NM, USA

Seven Rivers Hills , NM, USA

Belchite, Zaragoza, Spain

Steppe-like scrublands
Species-rich communities

PATCHES OF VASCULAR PLANTS

GYPSOPHYTES
Gypsum soil specialists
Only found in gypsum soils

GYPSOVAGS
Non-specialists
Also found in other substrates

OPEN PATCHES
Biocrusts

bacteria, cyanobacteria, fungus,
eukaryotic algae, bryophytes and lichens

Biotic interactions

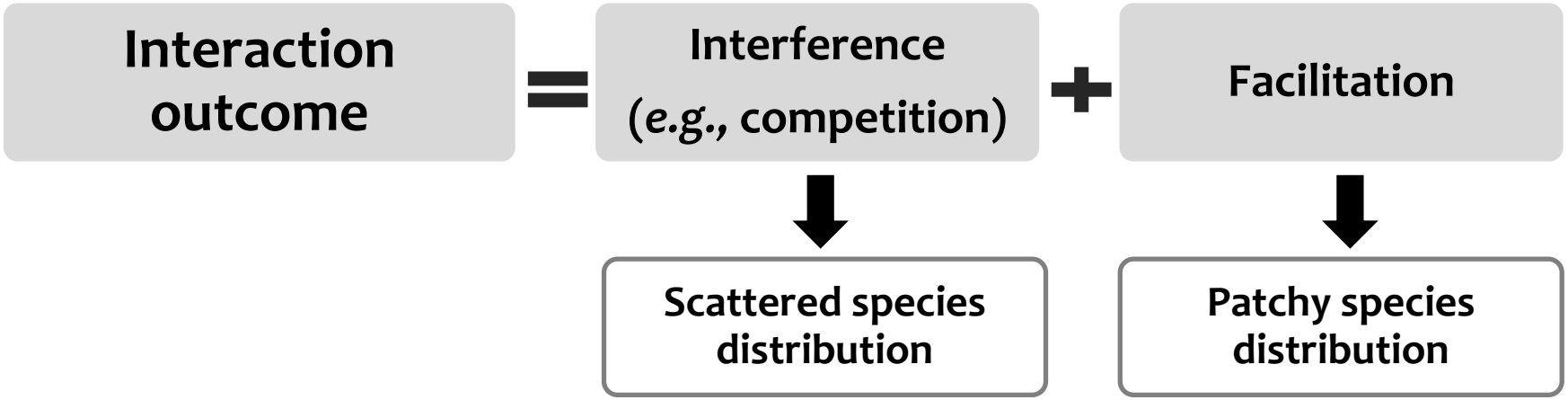
Play key roles in ecosystem functioning

- Maintaining biodiversity, productivity and resilience in the community
- Structuring diversity in the community

Spatial pattern of the community

↓

Valuable information about net biotic interactions



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Spatial pattern of the community

Valuable information about net biotic interactions

Interaction outcome = **Interference (*e.g.*, competition)** + **Facilitation**

Arid and semi-arid environments *e.g.*, gypsum outcrops ?

Scattered species distribution

Patchy species distribution

Objective of the study

Background:

In gypsum plant communities of NE Spain we found that, in general, gypsophytes had a positive role in structuring diversity by facilitating the establishment of other species.

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To do a comparative study to acquire a global knowledge on the structure of gypsum plant communities.

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Aim of our study in the Chihuahuan Desert:

To do a comparative study to acquire a global knowledge on the structure of gypsum plant communities.

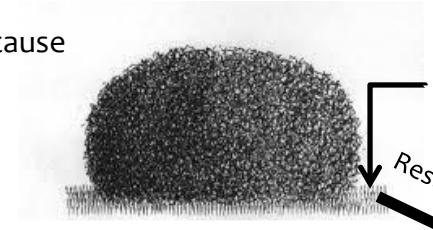
Specifically, to study:

- The role that gypsophytes (compared to gypsovags) play in spatially structuring plant diversity.
- The spatial relationships occurring between biocrusts and vascular plants.

What did we expect?

Plant - plant spatial relationships:

Gypsophytes
can establish in bare soil because they are well adapted (pioneer plants)



They facilitate the establishment of less adapted species

Results in

High species richness in the local vicinity

Act as

Ecosystem engineers:
Micro-environment amelioration

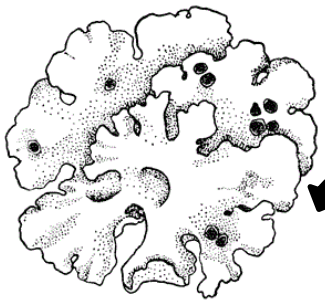
Patchy distribution

=

Diversity islands
+
Open patches

Biocrust - plant spatial relationships:

Biocrusts
grow in open patches and have an important role in soil stabilization, nitrogen and carbon fixation, nutrients availability and water retention



Facilitate the establishment of vascular plants

Mitigate the severe deficiency of essential nutrients and water in bare soil

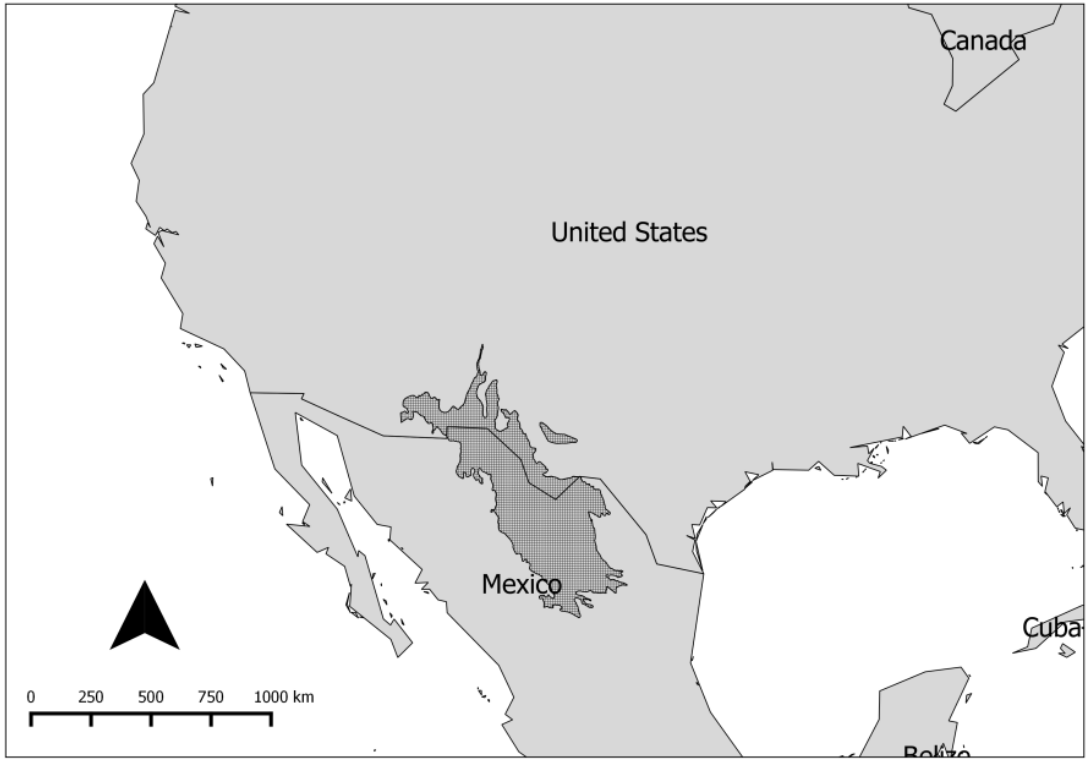
Positive spatial associations between biocrusts and vascular plants

Study area

THE CHIHUAHUAN DESERT

Location

- Mainly in North Mexico
- Southwest of the USA (TX, NM, AZ)



Source: Jornada Experimental Range, NMSU (https://jornada.nmsu.edu/data-catalogs/spatial)

Lithology

- Mainly limestones
- Discontinuously distributed gypsum outcrops

Climate

- Average temperature of 24 °C
- Average annual rainfall 235 mm (150-400 mm)

↳ Mainly in summer → Monsoon (thunderstorms + strong showers)

July 2017 - Next to NMSU, Las Cruces, NM, USA

Study area

GYPSUM OUTCROPS OF THE CHIHUAHUAN DESERT

Vegetation

- Predominantly gypsophytes
- Patchy distributed scrubland - grassland:
  - Shrubs *(e.g., Rhus trilobata, Poliomintha incana)*
  - *Dwarf shrubs (e.g., Nerysirenia linearifolia, Oenothera hartwegii)*
  - *Perennial grasses (e.g., Bouteloua breviseta, Schizachyrium scoparium)*

Dell City, TX, USA

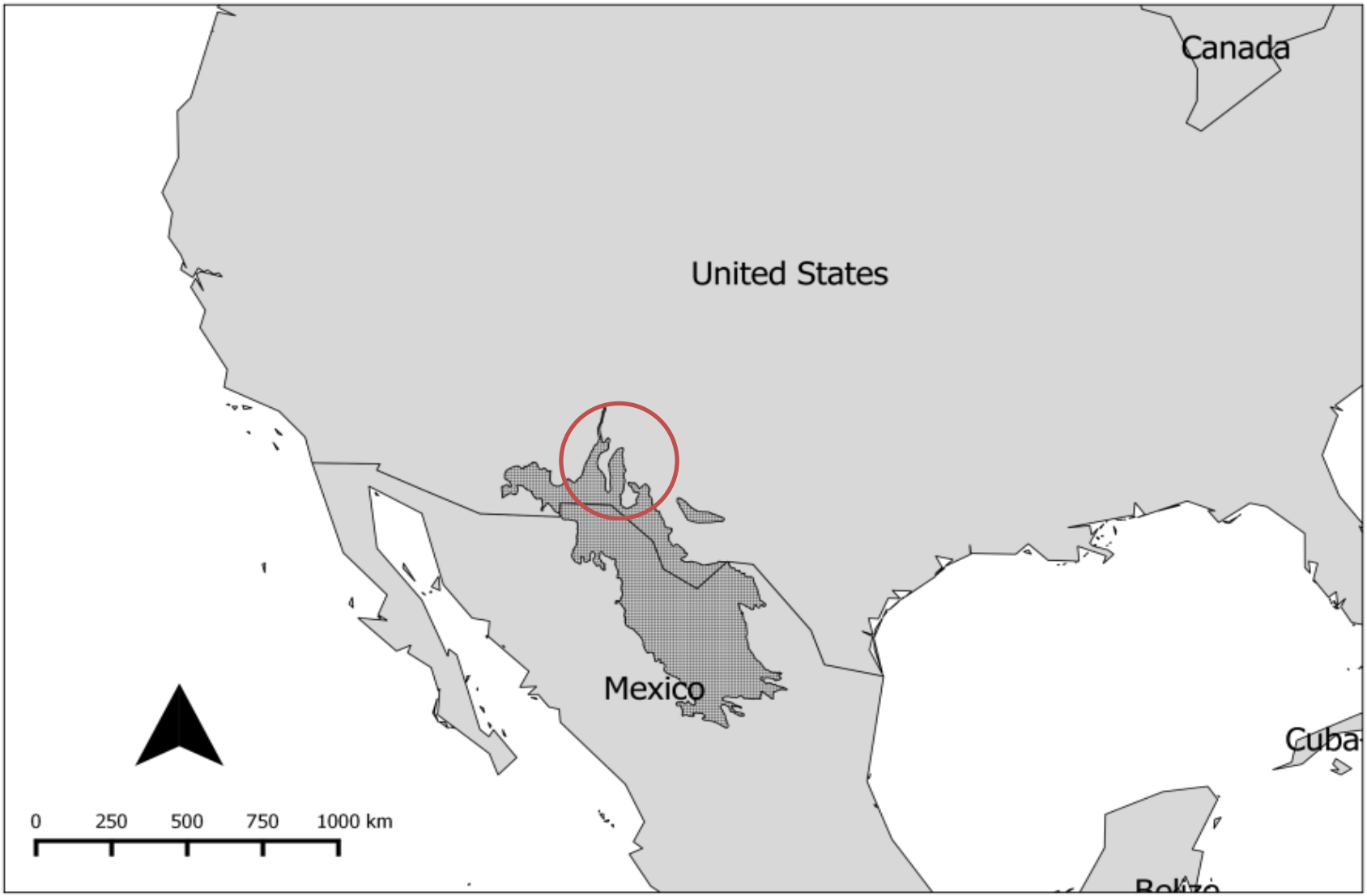
Rhus trilobata

Nerysirenia linearifolia

Bouteloua breviseta

Study area

NORTHERN CHIHUAHUAN DESERT (NEW MEXICO, USA)



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Study area

To record the spatial variability of gypsum ecosystems in New Mexico:

- **Site 1:** *White Sands National Monument* (next to Alamogordo).
- **Site 2:** next to Roswell.
- **Site 3:** *Yeso Hills* (next to Carlsbad).

Site 1: White Sands

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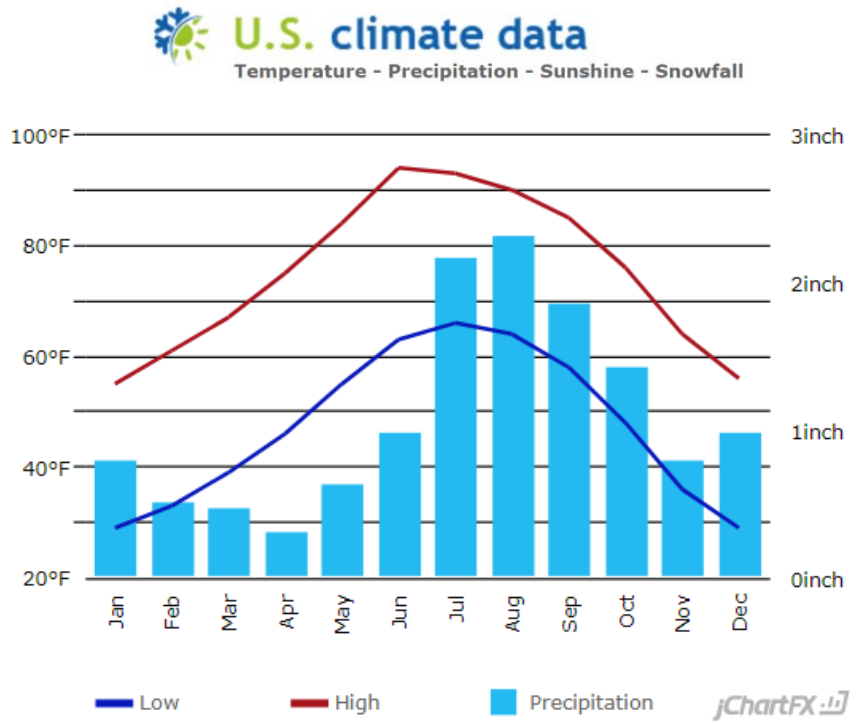
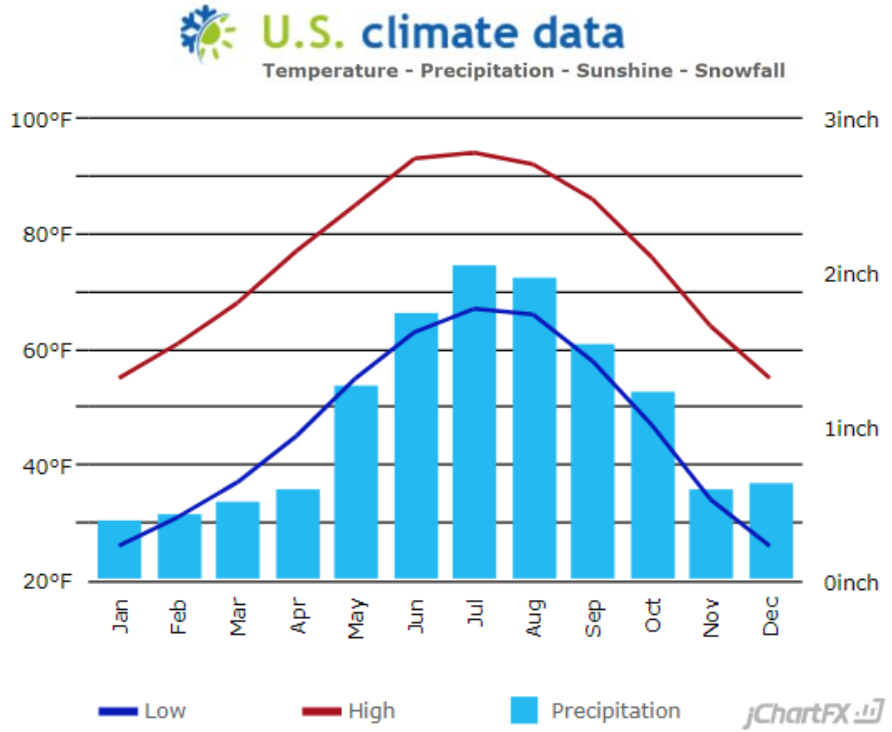


- Sandy gypsum (dunes, playas…)
- Altitude: 1,214 m a.s.l.
- Average temperature: 16.17 °C
- Average annual rainfall: 335.8 mm

Site 2: Roswell

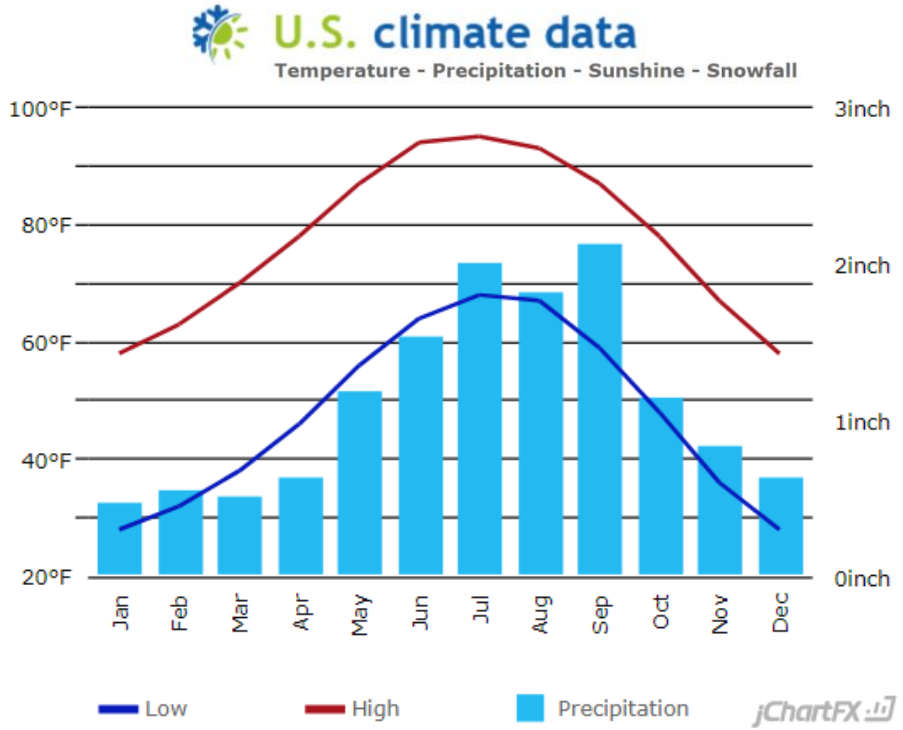
Site 2: Roswell



- Red gypsum rocky hills; shallow soil
- Altitude: 1,140 m a.s.l.
- Average temperature: 16.05 °C
- Average annual rainfall: 327.9 mm

Site 3: Yeso Hills

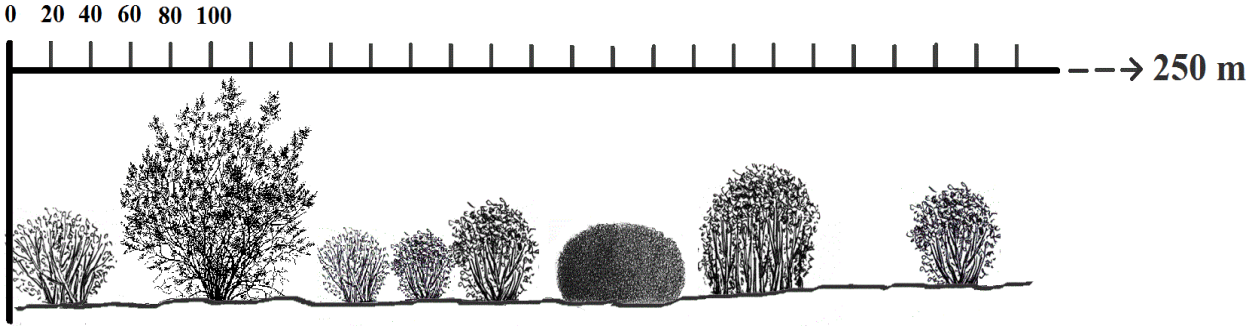
Site 3: Yeso Hills



- Gypsum rocky hills; shallow soil
- Altitude: 1,130 m a.s.l.
- Average temperature: 16.8 °C
- Average annual rainfall: 341.1 mm

Field sampling

- Six 250 m line-point intercept transects per study site (6 x 250 m = 1500m)



- Every vascular plant and biocrust were recorded each 20 cm → 7500 contacts

  - **Vascular plants** → species level

  - **Biocrusts**→ functional groups:

    - Light algal crust
    - Dark algal crust
    - Fungal crust
    - Incipient crust
    - Lichens (genus level)

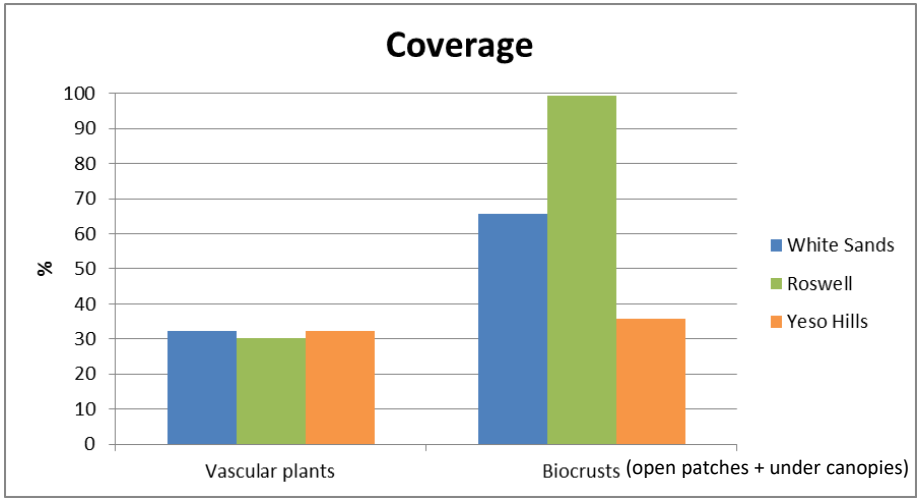
Atriplex canescens

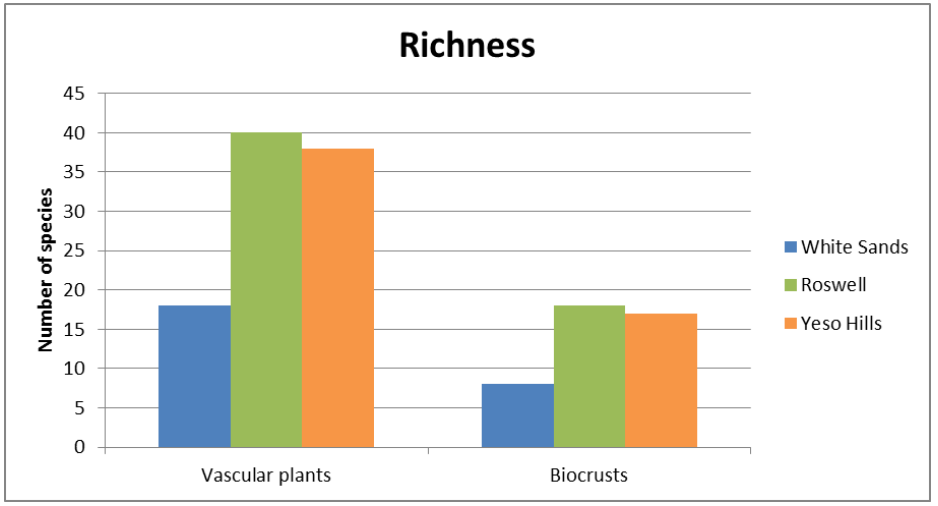
Nama carnosa

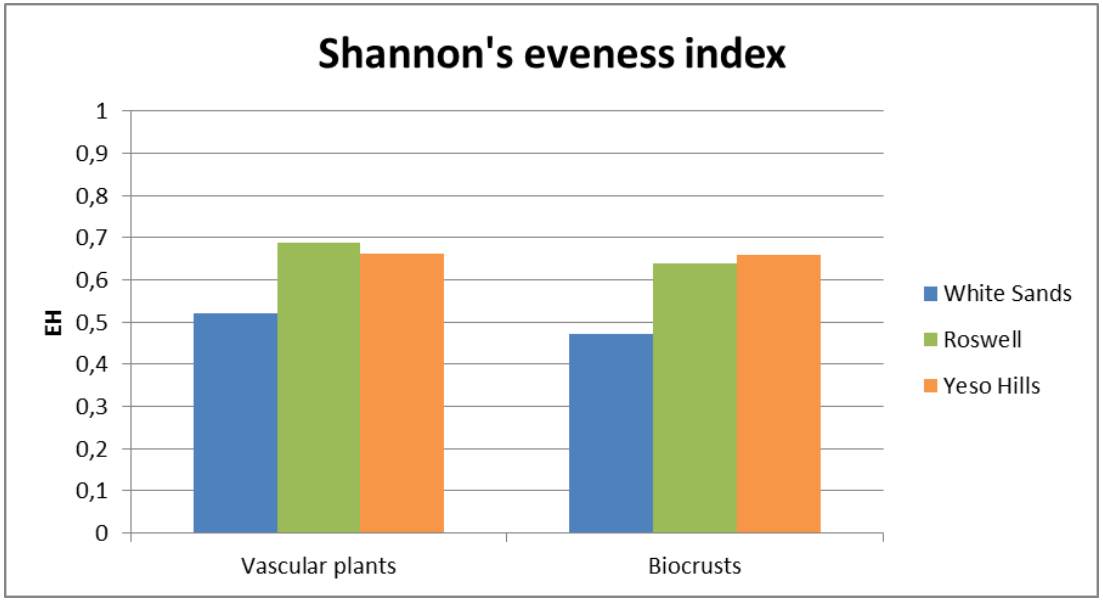
Light algal crust (filaments)

Diploschistes diacapsis

Community composition



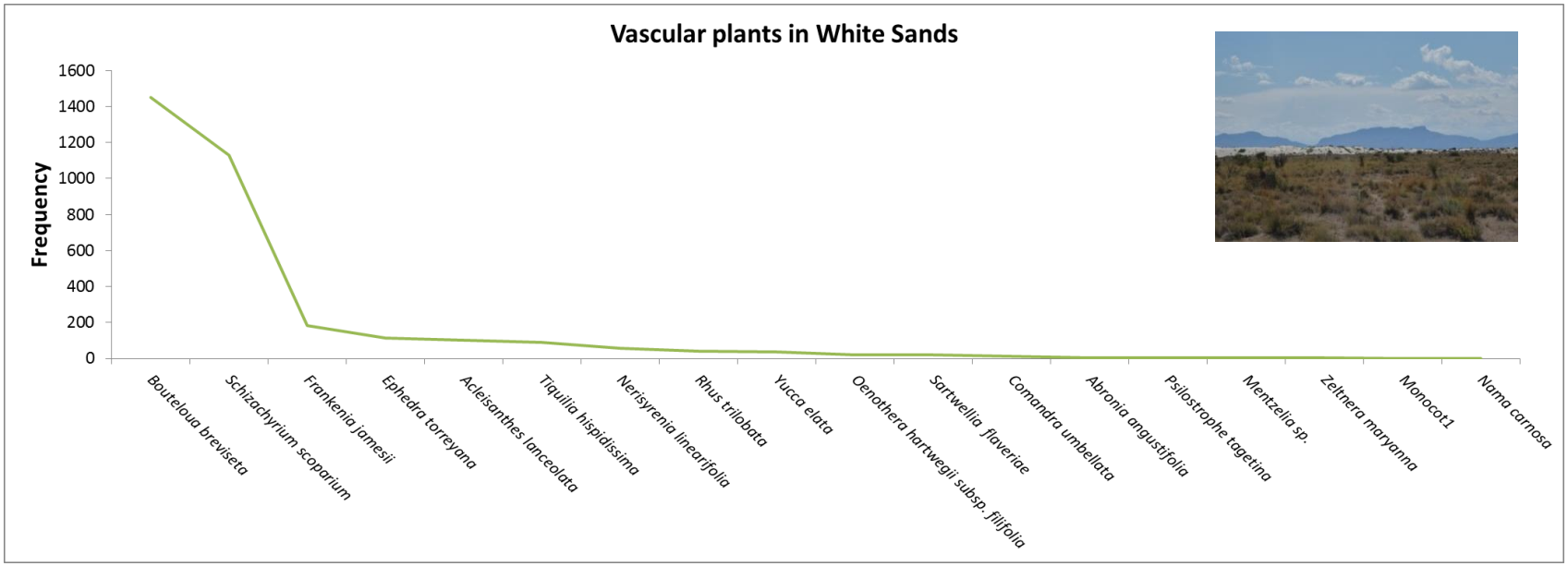


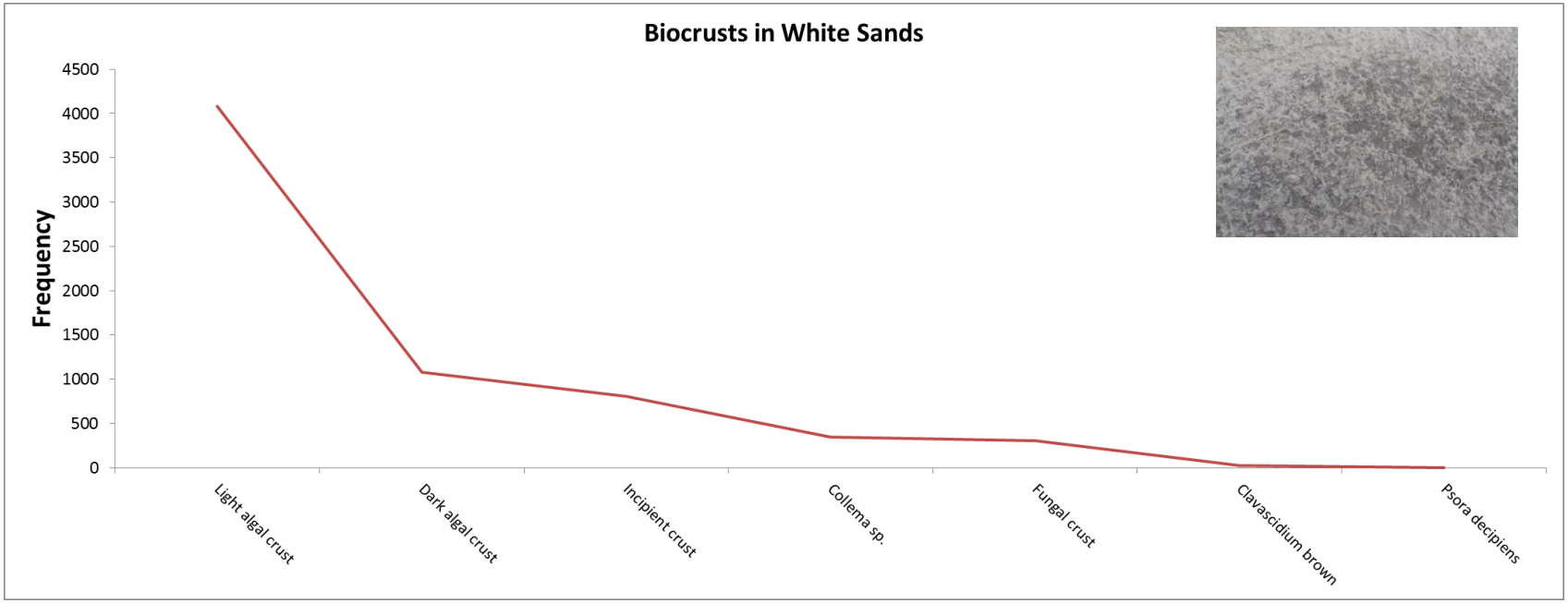


$$E_H = \frac{Shannon\ index}{\ln(Richness)}$$

$E_H \sim 0$ → more diversity
$E_H \sim 1$ → less diversity (sp = freq)

Community composition





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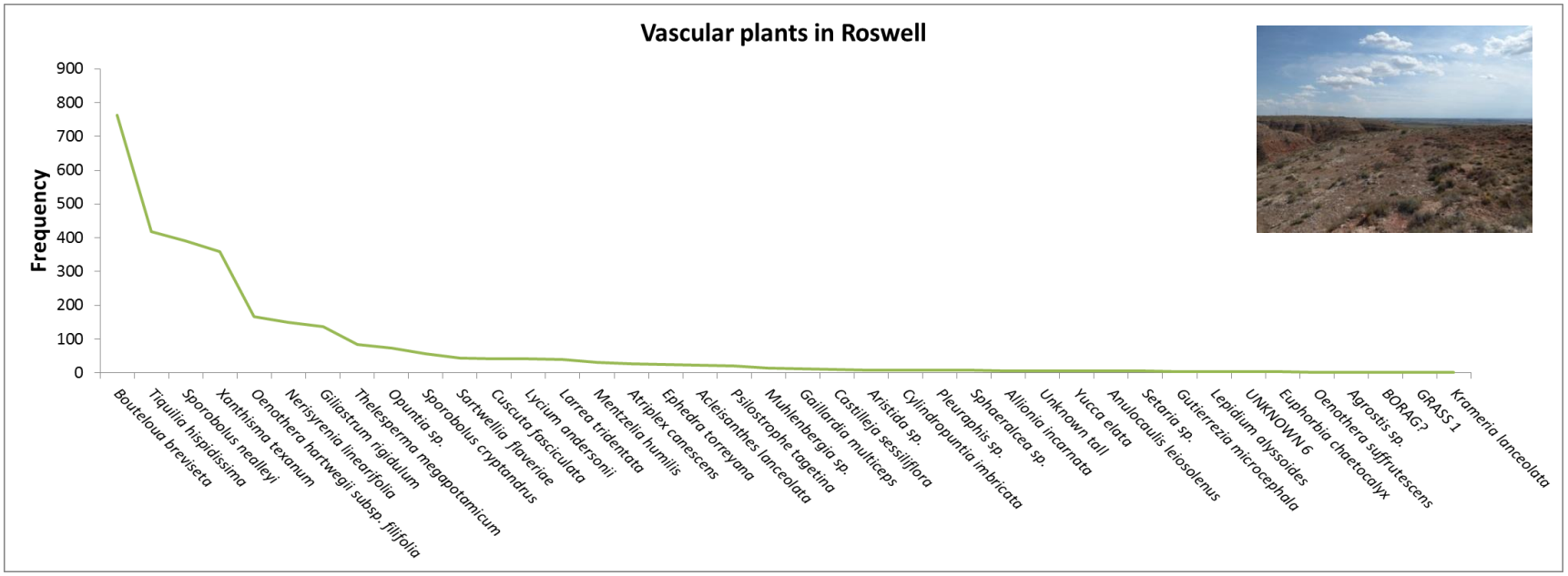

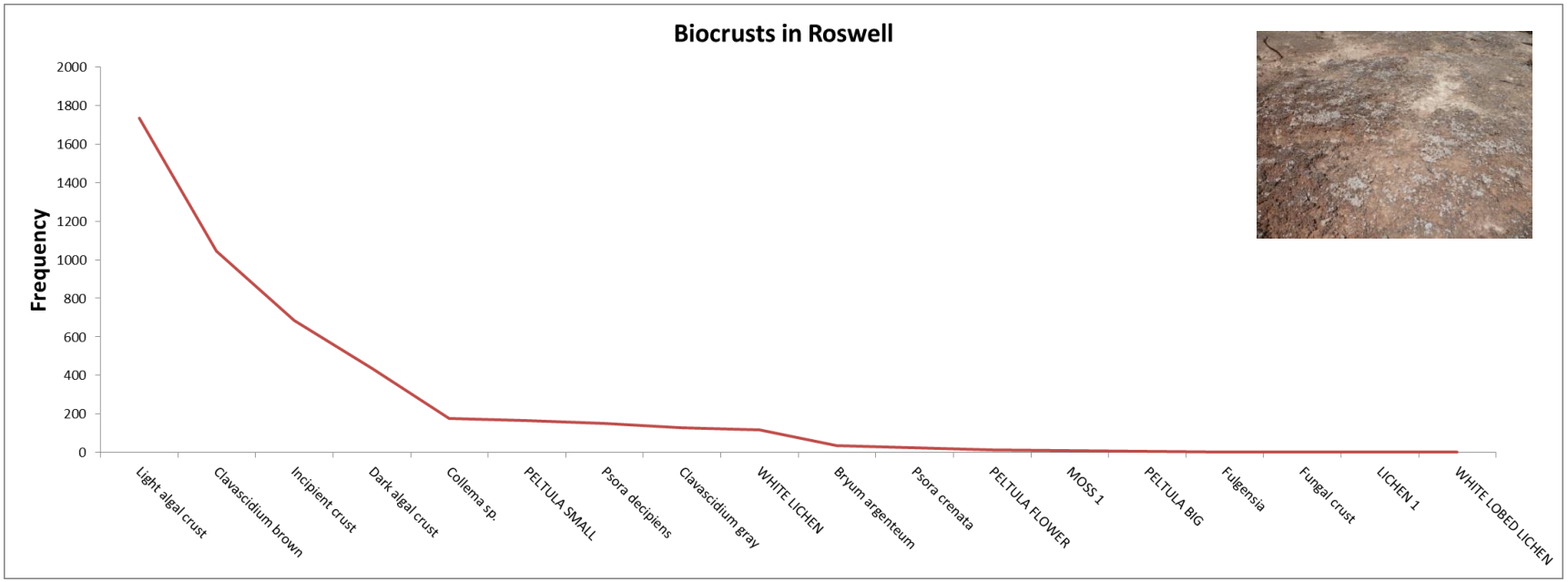

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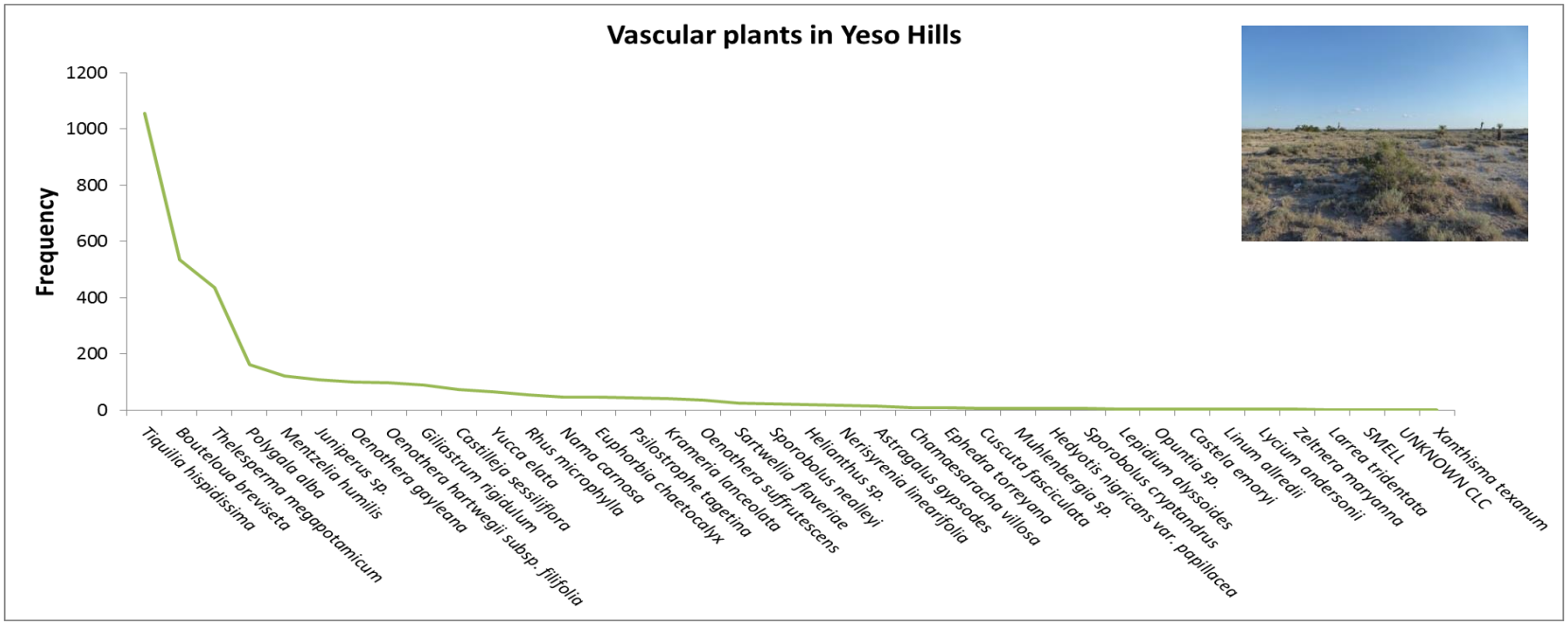

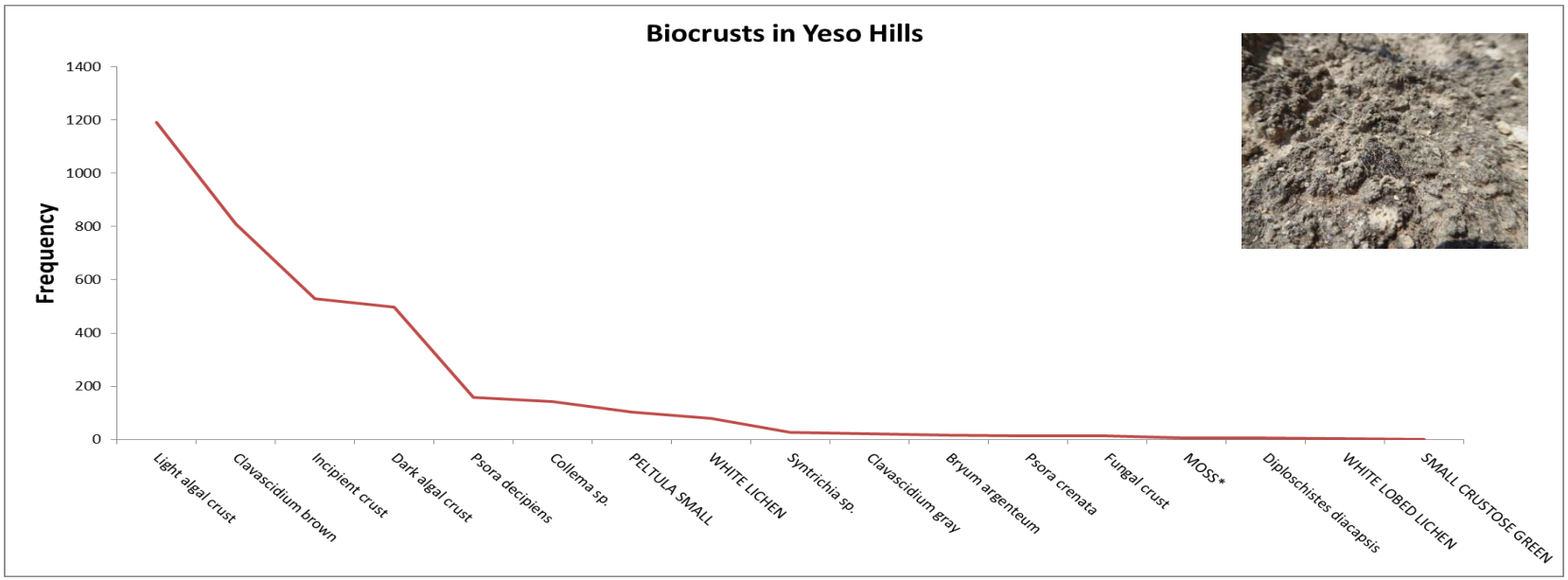

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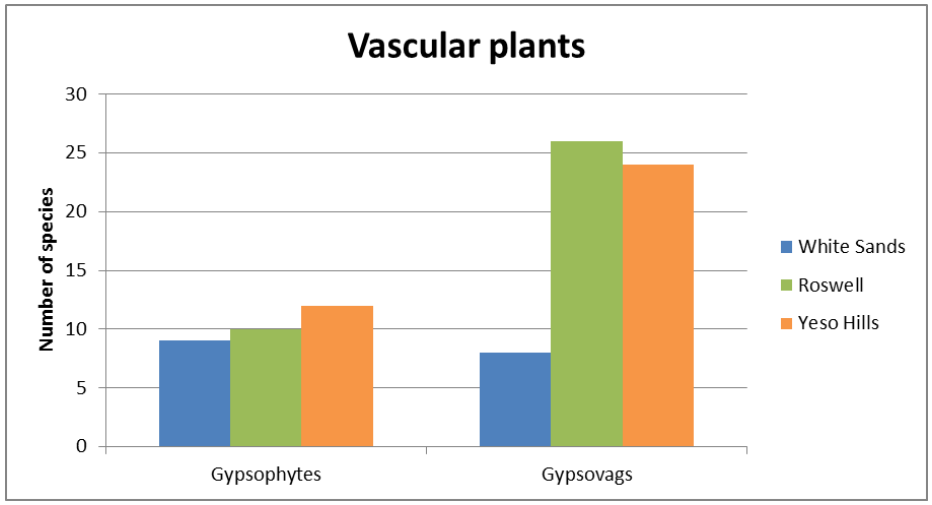
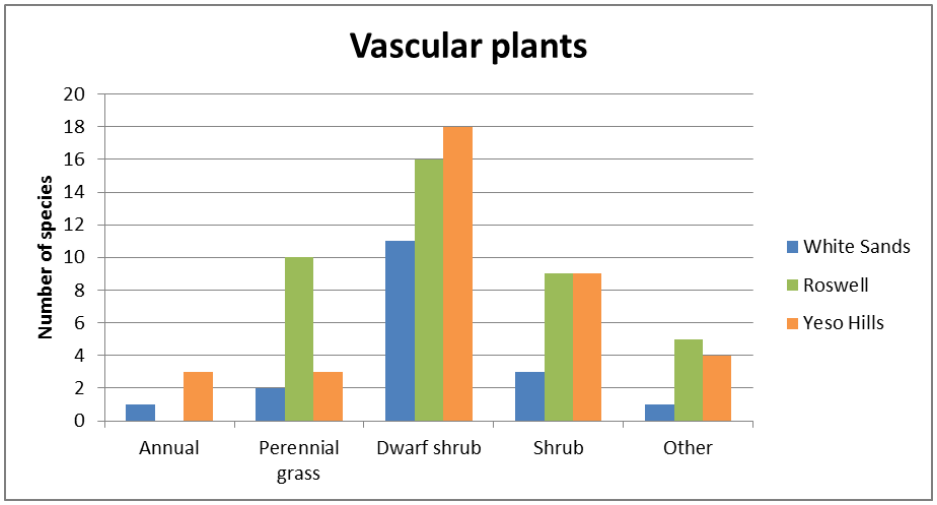
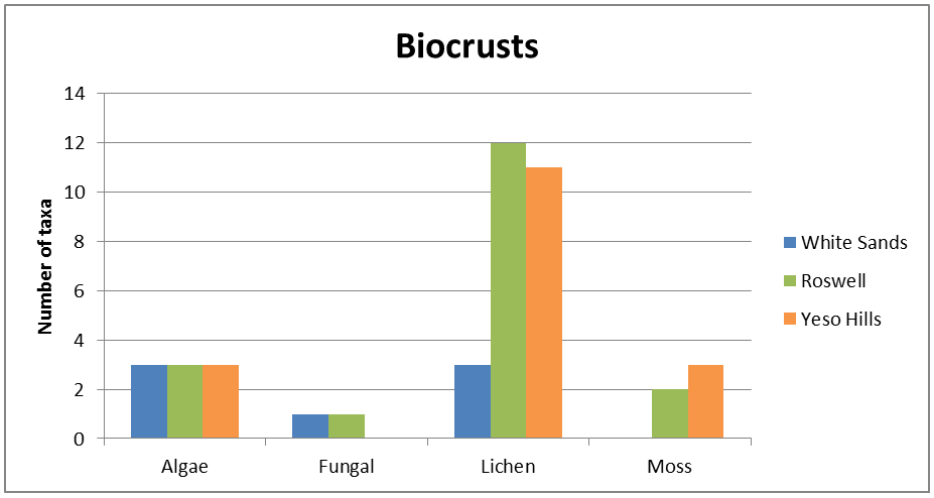




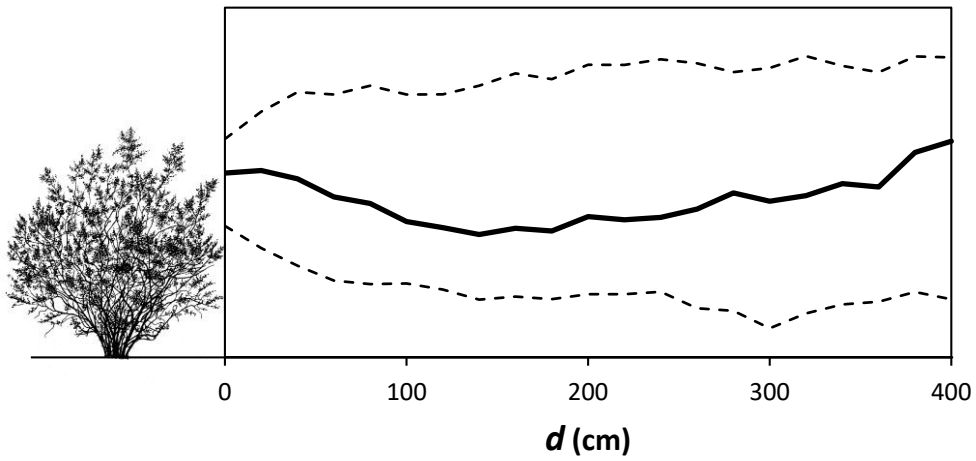


Spatial structure of the community

Individual Species Area Relationships

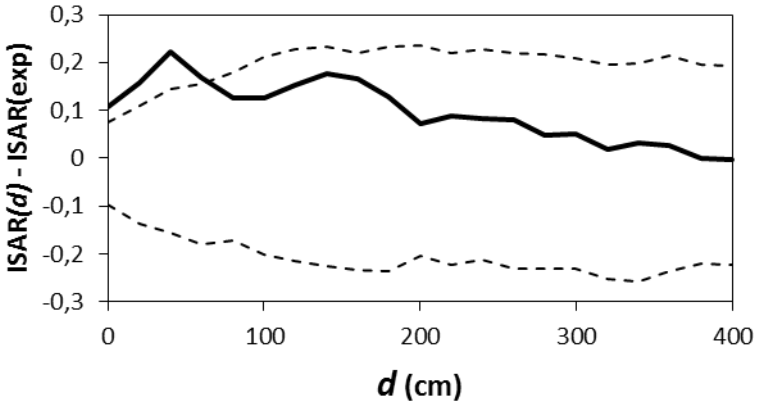
$$\mathrm{ISAR}_{(d)} = \sum_{j=1}^{S} [1 - P_{t,j}(0, d)]$$

Probability that species *j* was present within distance *d* of individuals of target species *t*.



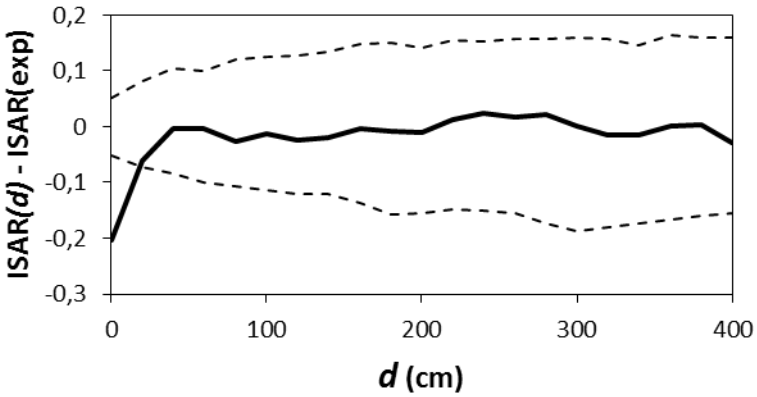
- Number of different species present within a distance *d* from all of the individuals of the target species *t* along the transect
- Maximal distance *d*= 4 m
- Only for species with **≥ 30** individuals along the transect
- *Monte Carlo* null model simulations (expected ISAR)
- ISAR – ISAR (exp)

From spatial structure to biotic interactions



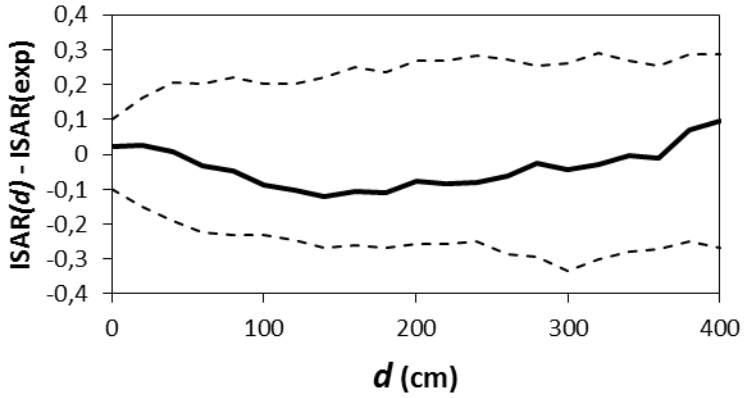
Diversity accumulators

Positive interactions



Diversity repellers

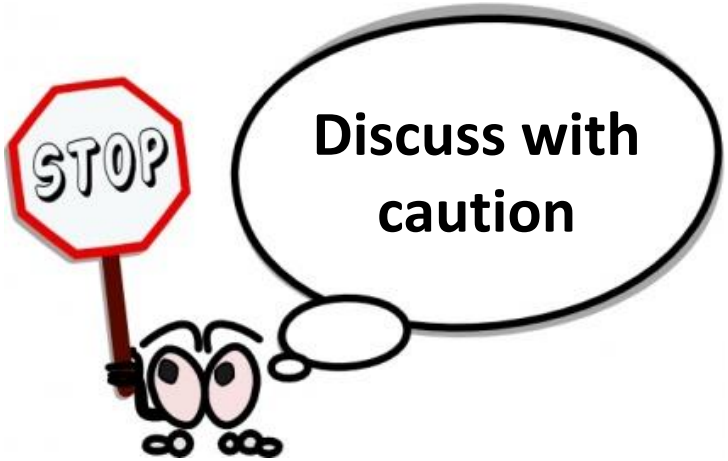
Negative interactions



Neutrals

Neutral net interactions

To take into account

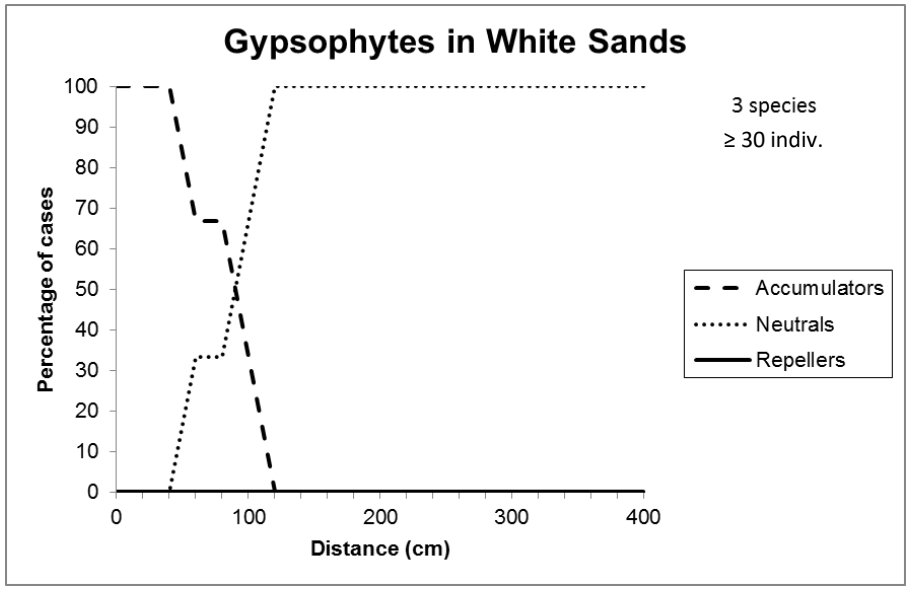


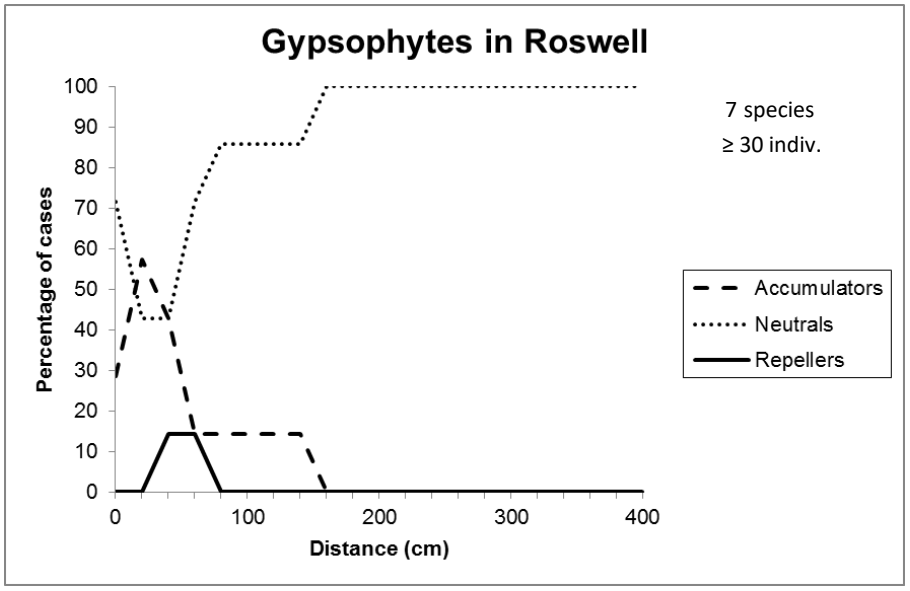
ISAR gives information about spatial associations and not about what are the causes of these associations.

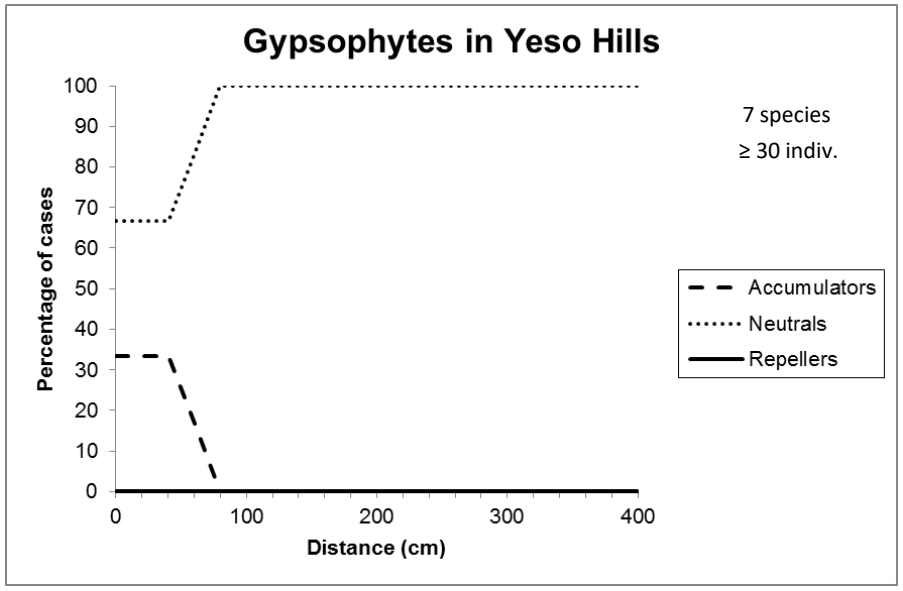
- What are diversity accumulators: facilitator or facilitated plants?

- We need further research on the underlying mechanisms involved in diversity accumulation and repulsion.

Results: plant-plant spatial relationships







Acleisanthes lanceolata

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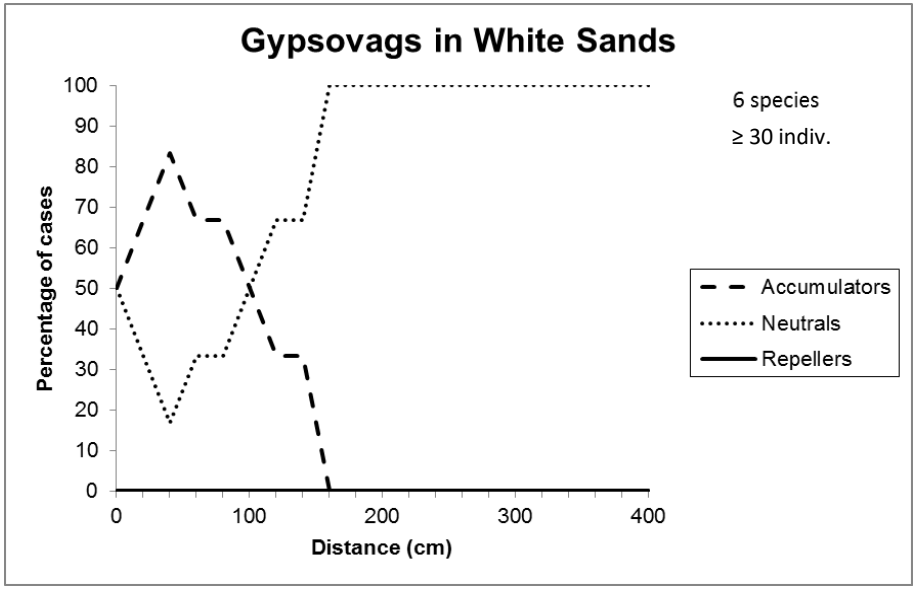
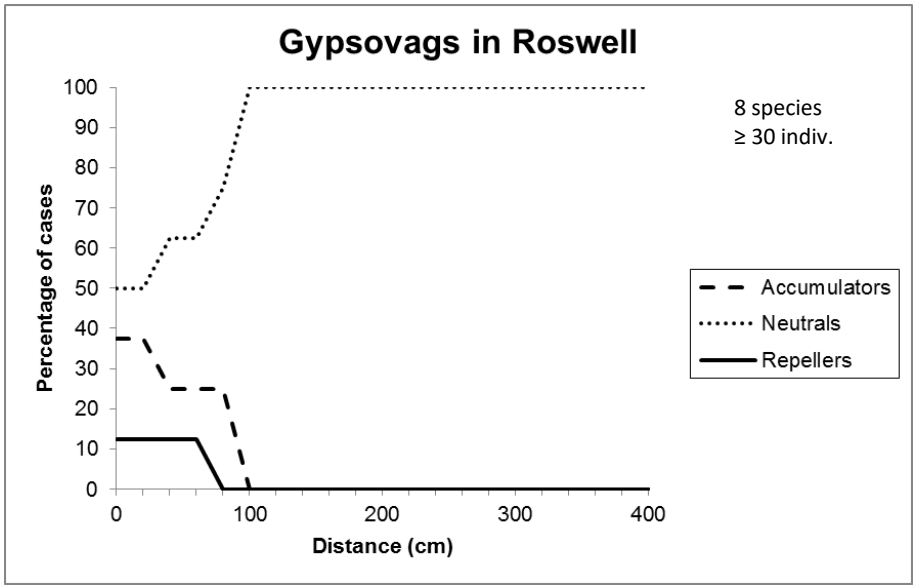
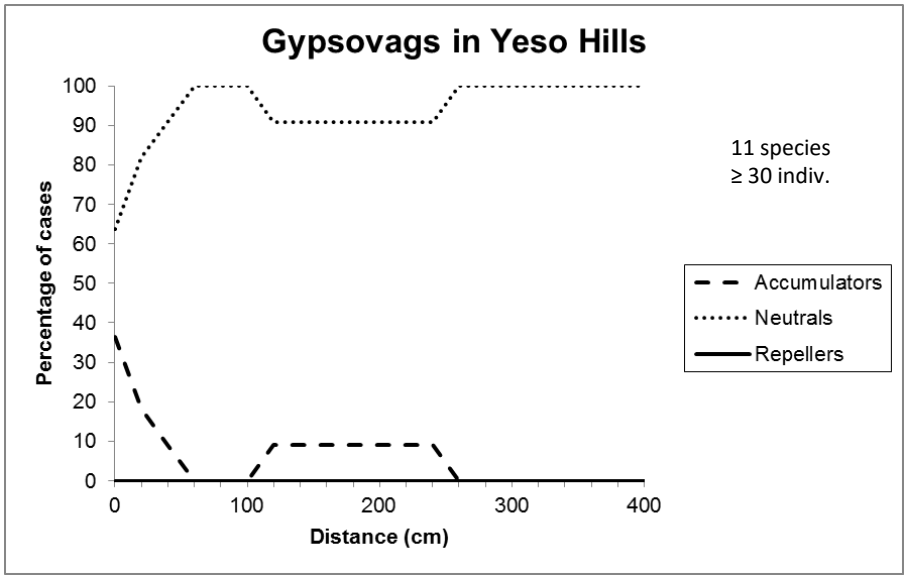
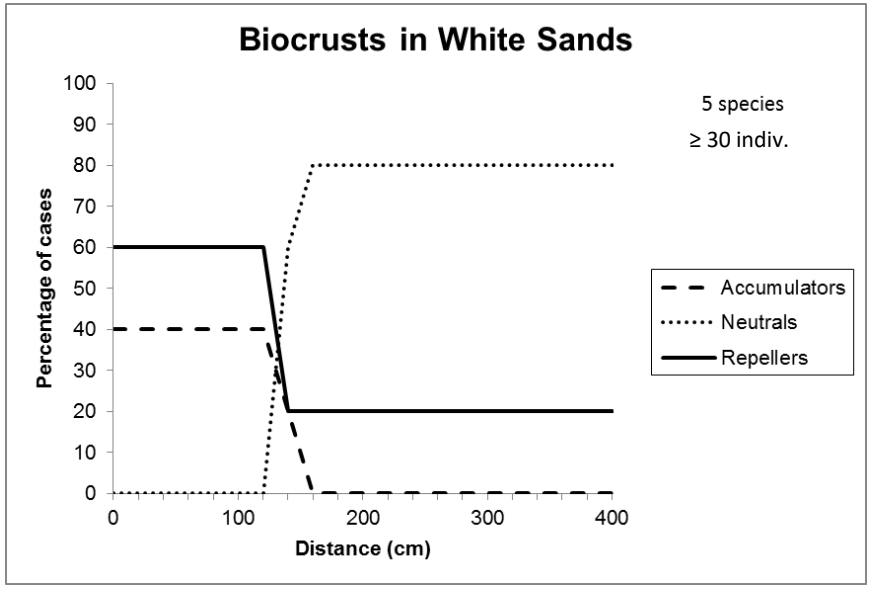


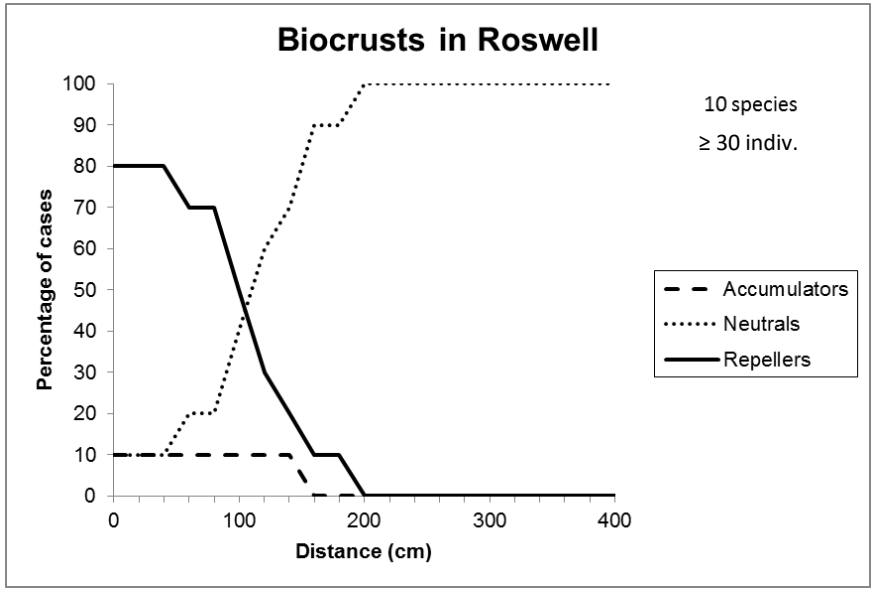


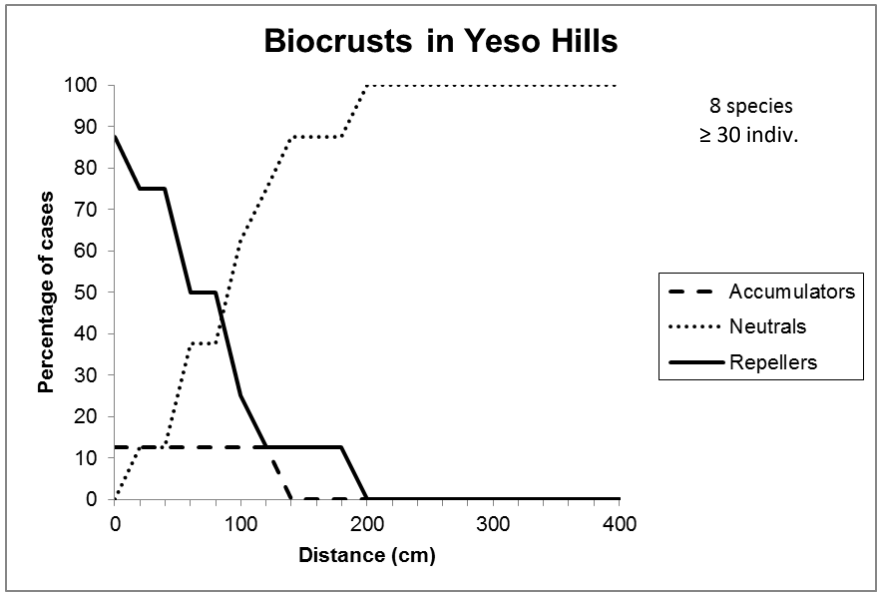


Larrea tridentata

Results: biocrust-plant spatial relationships







Psora decipiens

Summary of the results

Target plants' behaviour at 100 cm distant

	White Sands	Roswell	Yeso Hills	NE Spain
Gypsophytes	Diversity accumulators	Diversity accumulators-neutrals	Neutrals	Diversity accumulators
Gypsovags	Diversity accumulators	Neutrals	Neutrals	Diversity repellers
Biocrusts	Diversity repellers	Diversity repellers	Diversity repellers	No information

Discussion

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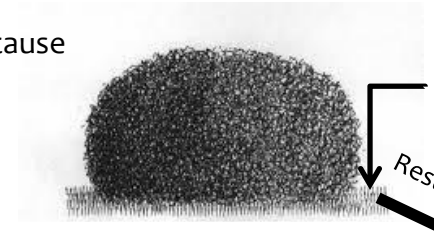

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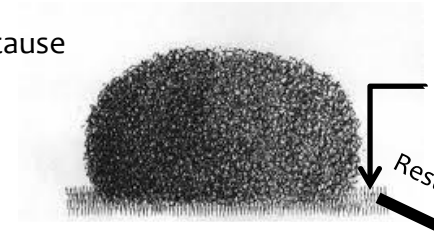

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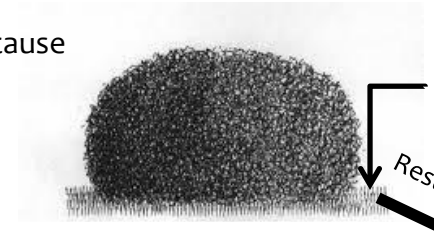

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White Sands > Roswell > Yeso Hills

BUT GYPSOVAGS TOO

White Sands

BRAINSTORMING

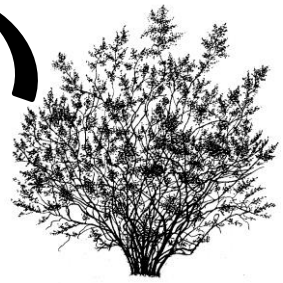
- Rather a species-specific effect than a life strategy trait.
- Depends on abiotic conditions:
  - Stress Gradient Hypothesis → the more stressful conditions, the more facilitation.
    - Mediterranean climate VS Moonsoon; more stressful?
    - White Sands is the site with the most stressful conditions → sandy gypsum.
- Plants in Chihuahuan's gypsum outcrops are very specialized →Ancient outcrops.
  - The more specialist you are, the less competitive you are (plants benefit from you).
- We need more replicates per study site and more in depth studies.
- We need further research on the underlying mechanisms involved

Discussion

Biocrust - plant spatial relationships:

Biocrusts
grow in open patches and have an important role in soil stabilization, nitrogen and carbon fixation, nutrients availability and water retention

Facilitate the establishment of vascular plants



Mitigate the severe deficiency of essential nutrients and water in bare soil

Positive spatial associations between biocrusts and vascular plants

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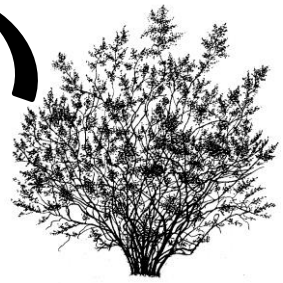

Mitigate the severe deficiency of essential nutrients and water in bare soil

Positive spatial associations between biocrusts and vascular plants

Diversity repellers

BRAINSTORMING

- Biocrusts do not facilitate plant establishment.
  - Assessment at establishment stage → seedlings survey.
- They only appear in open patches, where there is no niche overlapping.
- We need further research on the underlying mechanisms involved → water retention, nutrients availability…
- Interesting to perform a more in detail sampling (zoom in) to evaluate biocrust-biocrust spatial relationships.

BRAINSTORMING

- Biocrusts do not facilitate plant establishment.
  - Assessment at establishment stage → seedlings survey.
- They only appear in open patches, where there is no niche overlapping.
- We need further research on the underlying mechanisms involved → water retention, nutrients availability…
- Interesting to perform a more in detail sampling (zoom in) to evaluate biocrust-biocrust spatial relationships.

HOMEWORK FOR GYPWORLD PROJECT?

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