Assessing ecosystem resilience from their spatial structure

Sonia Kéfi

CeMEB, 13/03/2018

BioDICée Lab

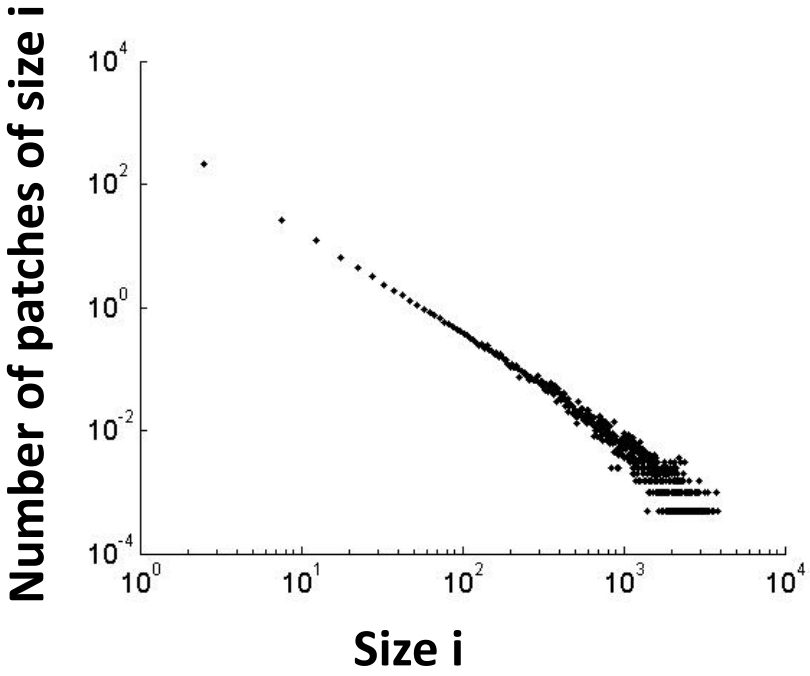
CASCADE
Catastrophic shifts in drylands

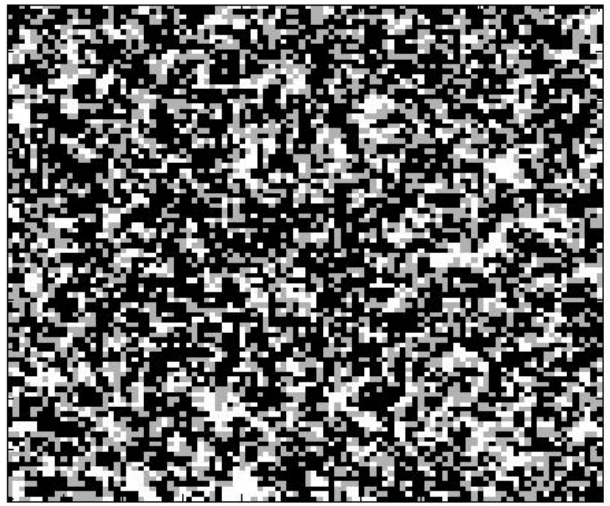
cnrs

isem
Institut des Sciences de l'Evolution-Montpellier

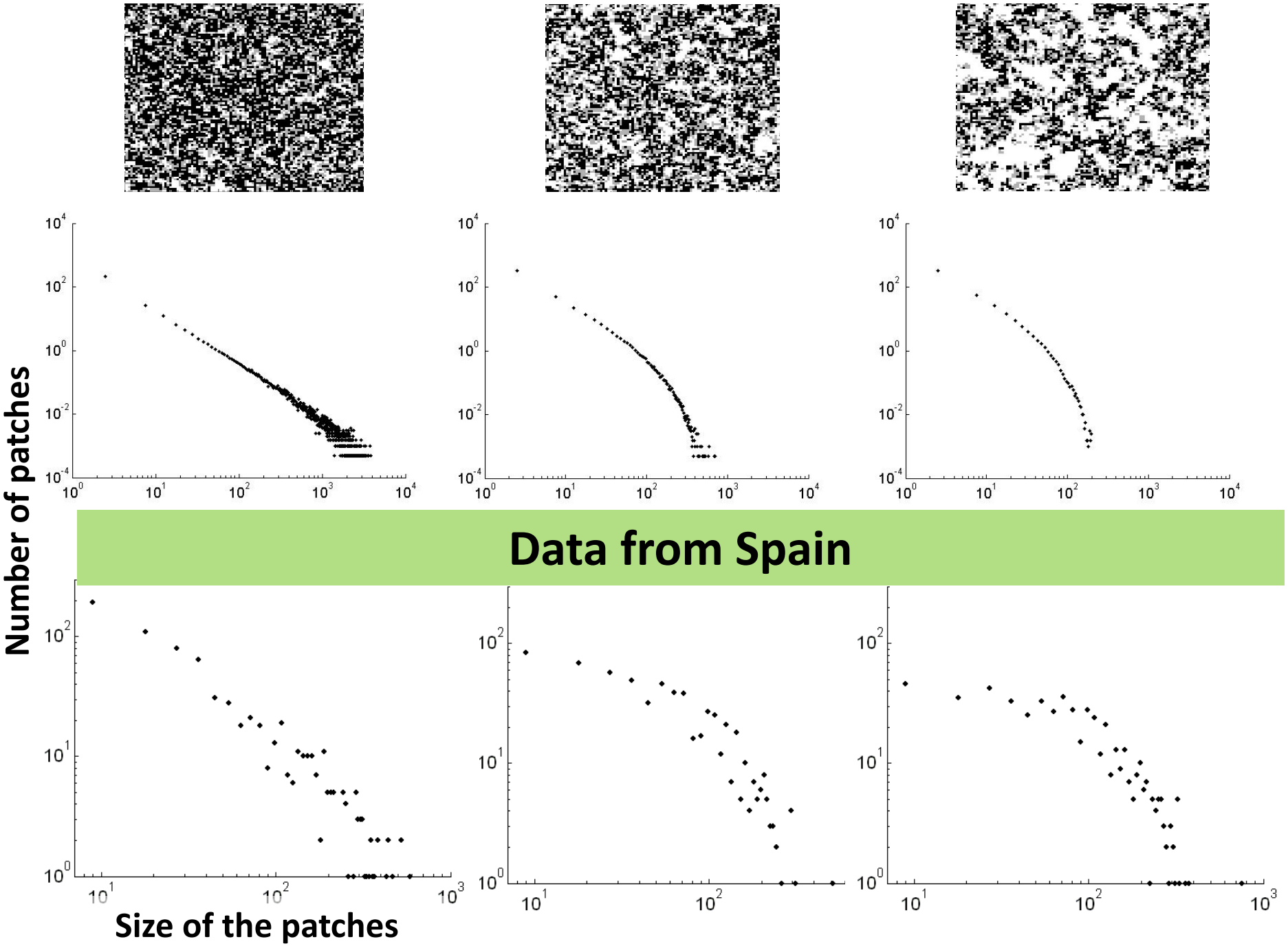
Scale-free patterns

"Patch" = group of adjacent occupied cells





Kéfi et al. 2007

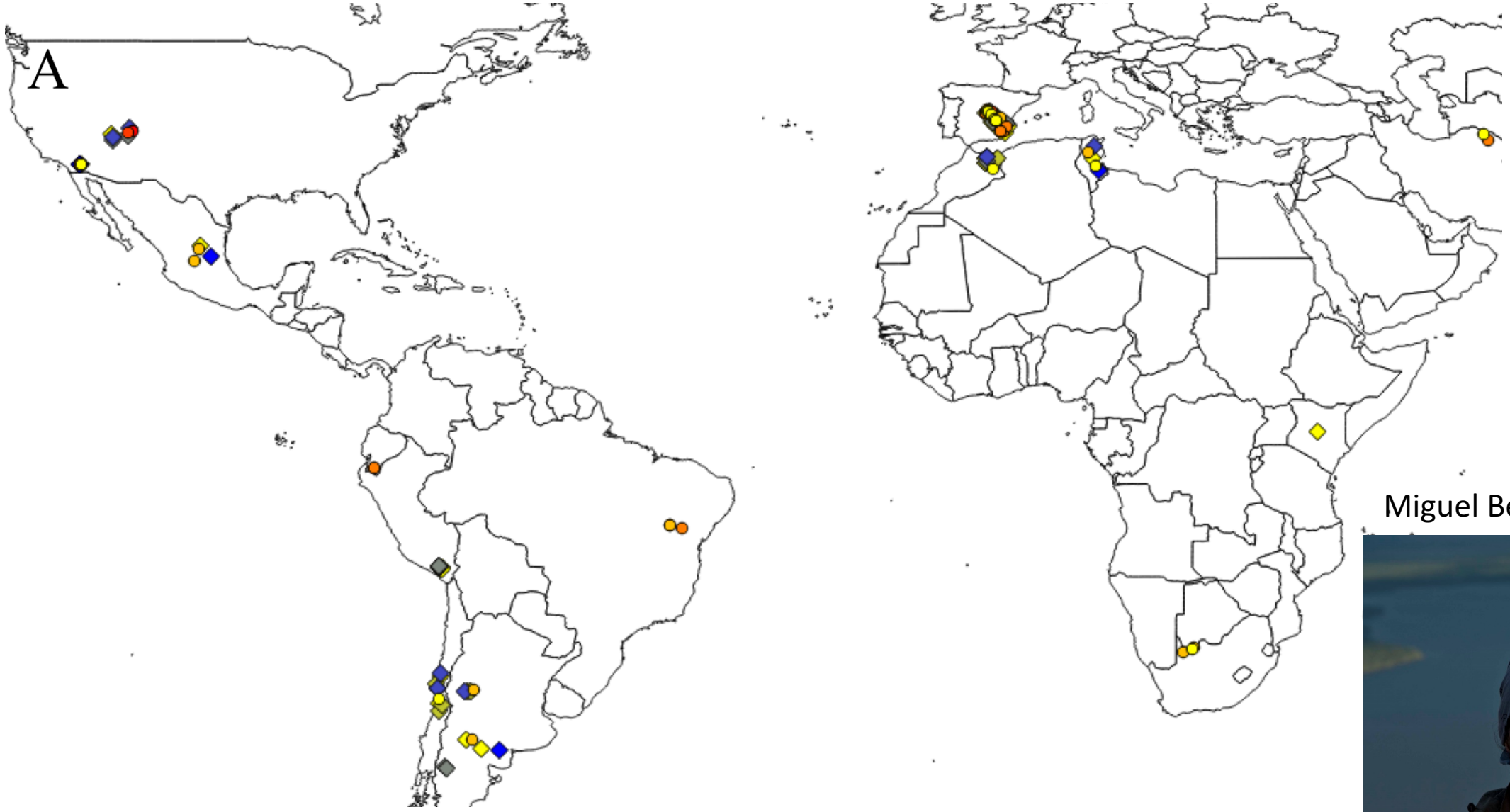


Kéfi et al. 2007

Patch-based indicators may provide a qualitative distance to the desertification point

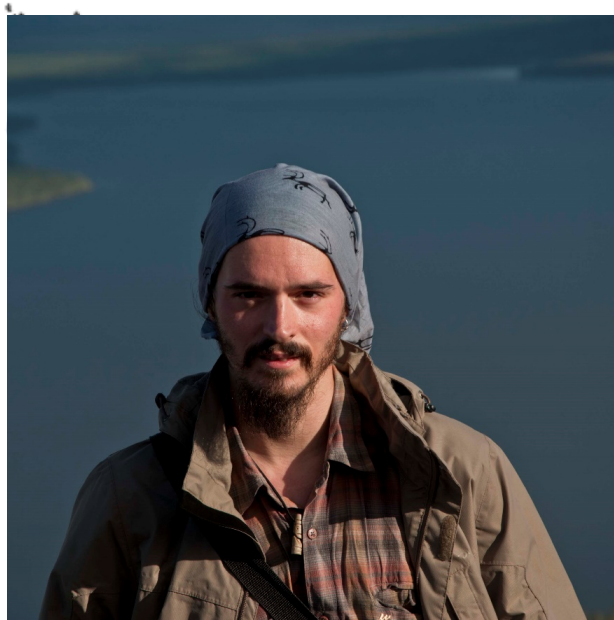
Kéfi et al. 2010, 2011

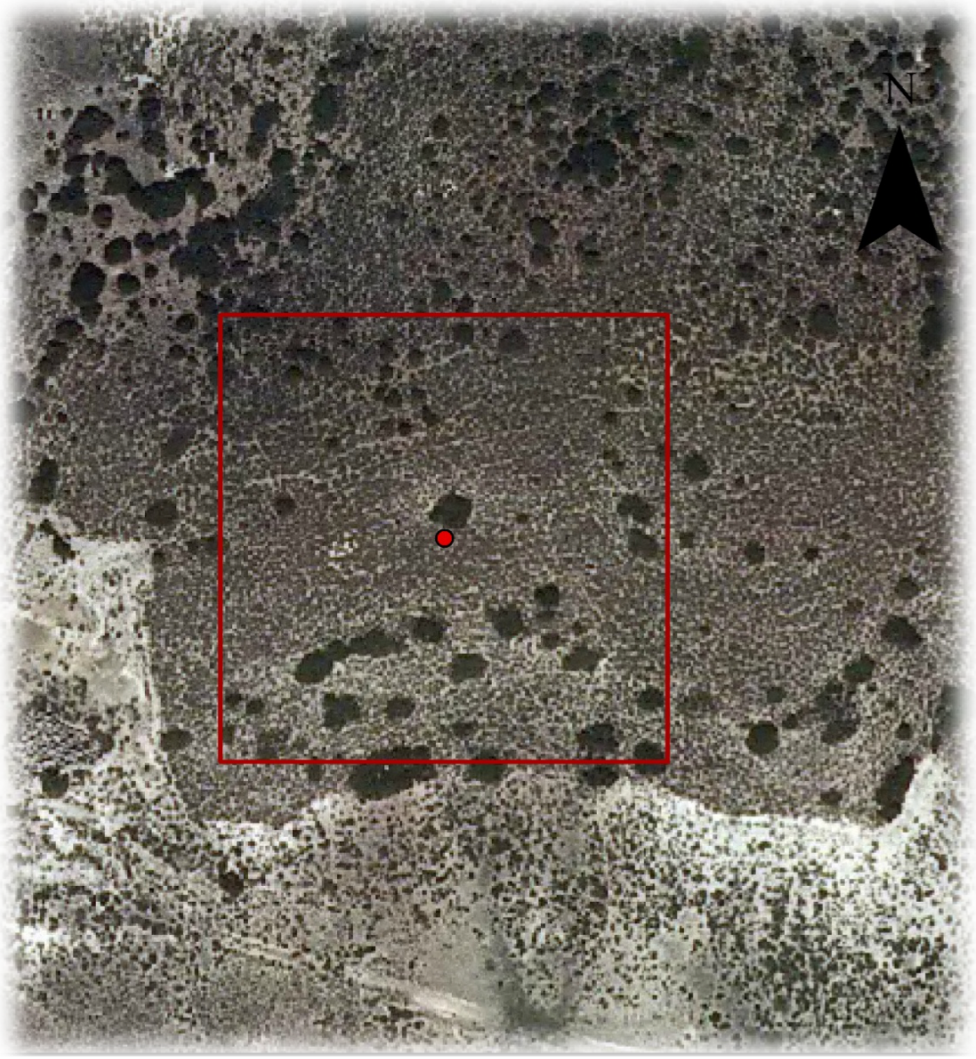
Mapping ecosystem resilience?



115 sites worldwide
(Maestre et al. 2012)

Miguel Berdugo (PhD thesis)





For each site:

→Cover
→Aridity
→Ecosystem functions

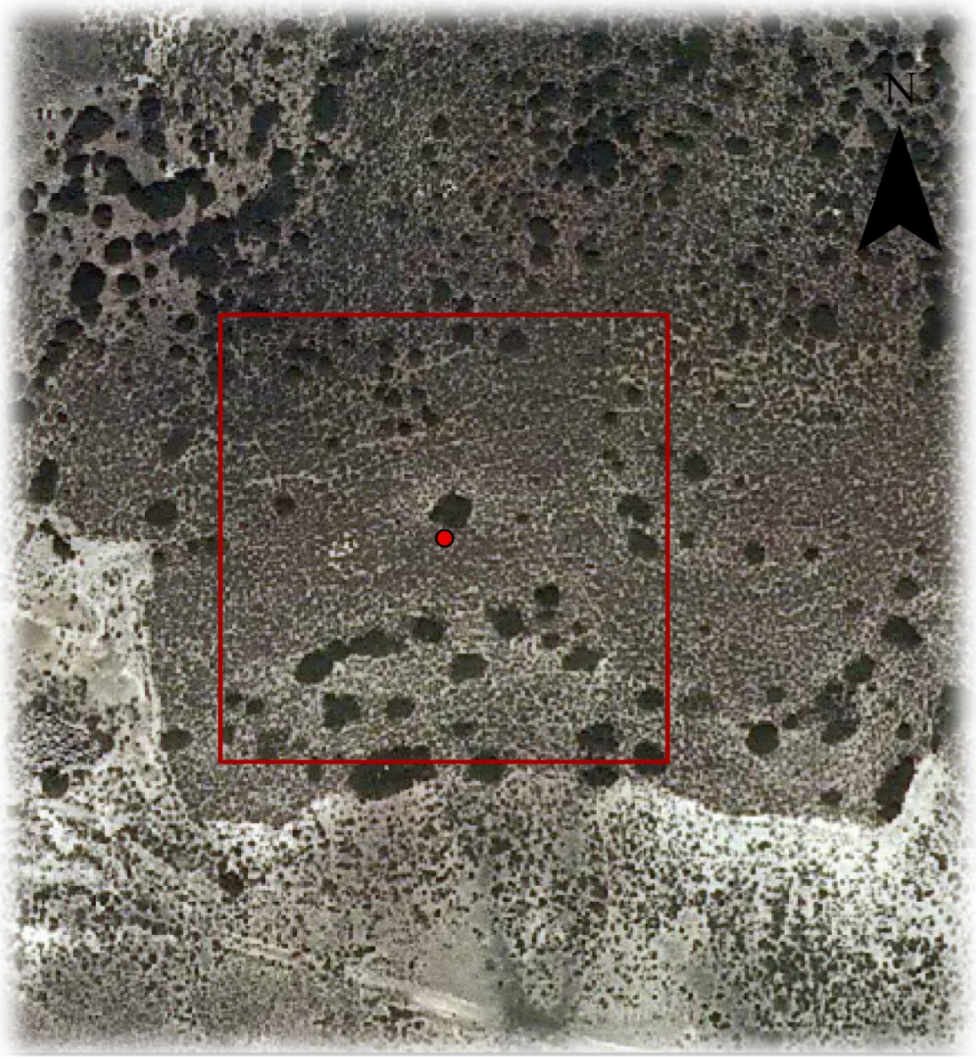
Field data

Berdugo, Kéfi, Soliveres and Maestre, NEE 2017

Ecosystem functions → **Z-score (for each function)** → **Multifunctionality (sum of z-scores)**

NITROGEN CYCLE	Nitrate	Nitrates concentration in the soil
	Amonium	Amonium concentration in the soil
	Nitrogen	Total nitrogen
	PotNtransf	Potential Nitrogen transformation rate
	aa	aminoacids
	Prots	Proteins
CARBON CYCLE	Carbon	Total carbon
	Pentoses	Pentoses
	Hexoses	Hexoses
	Arom	Aromaci compounds
	Phenols	Phenols
	beta	activity of beta glucosidase enzime
PHOSPHOROUS CYCLE	AVP	Available phosphorous
	phos	activity of phosphatase enzime
	P_HCL	Inorganic phosphorous
	TP	Total phosphorous

Maestre et al. 2012



For each site:

→Cover
→Aridity
→Multifunctionality

→3 times 50x50 m plots

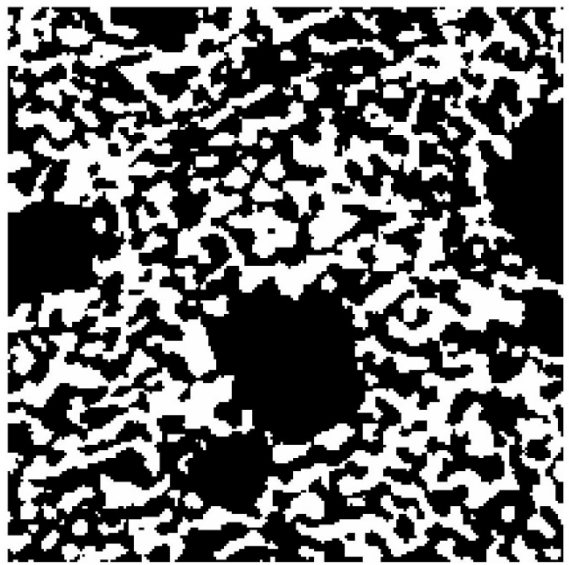
Field data

Aerial image data

Berdugo, Kéfi, Soliveres and Maestre, NEE 2017

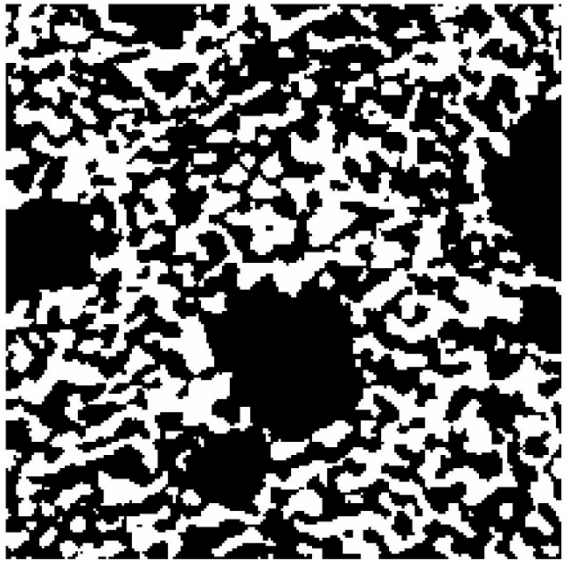
x3

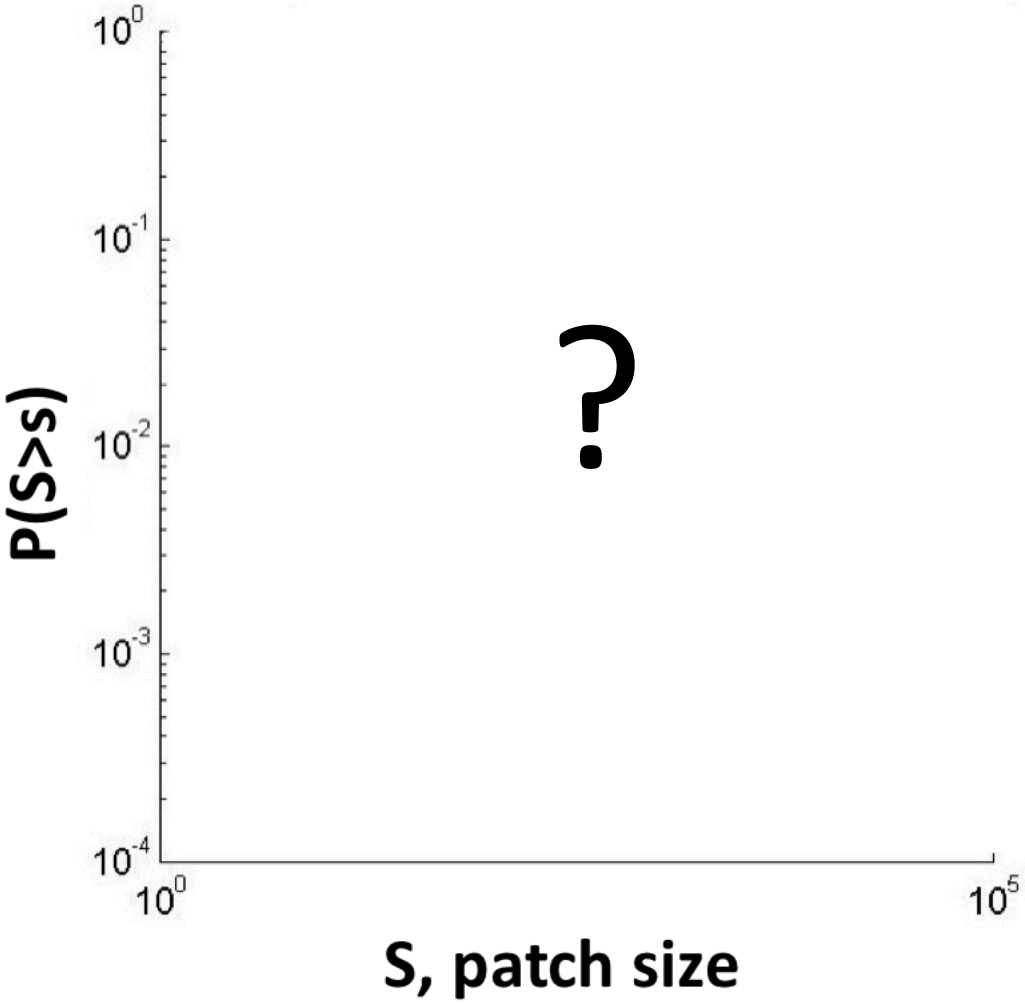
Berdugo, Kéfi, Soliveres and Maestre, NEE 2017



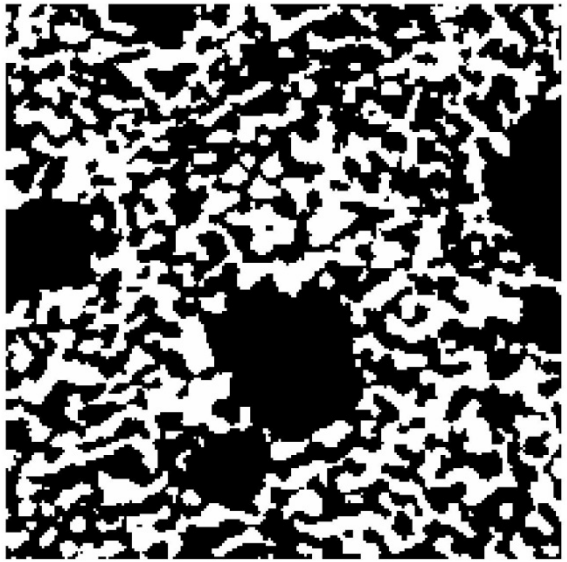
x3

Berdugo, Kéfi, Soliveres and Maestre, NEE 2017





Berdugo, Kéfi, Soliveres and Maestre, NEE 2017



For each site:

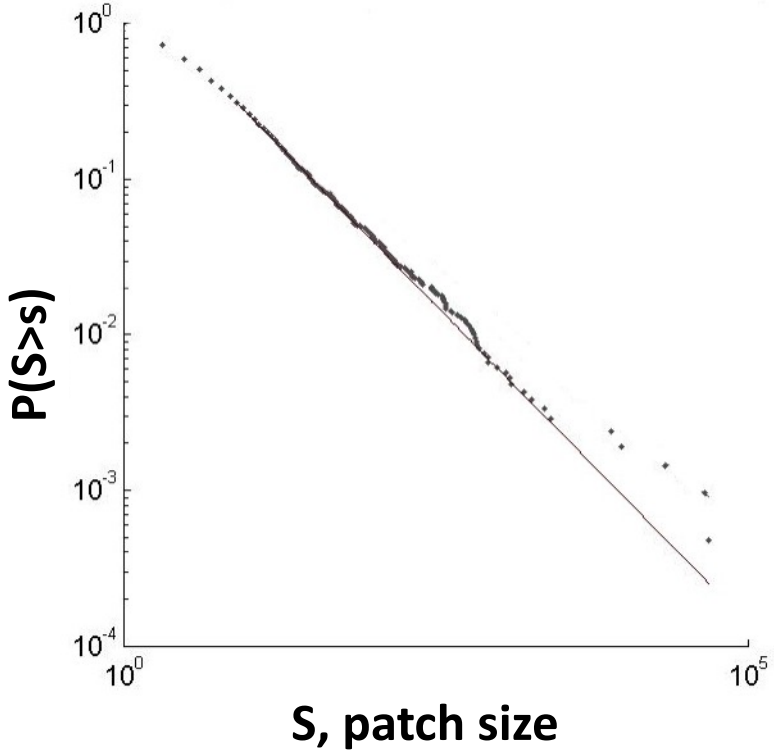
→Cover
→Aridity
→Multifunctionality

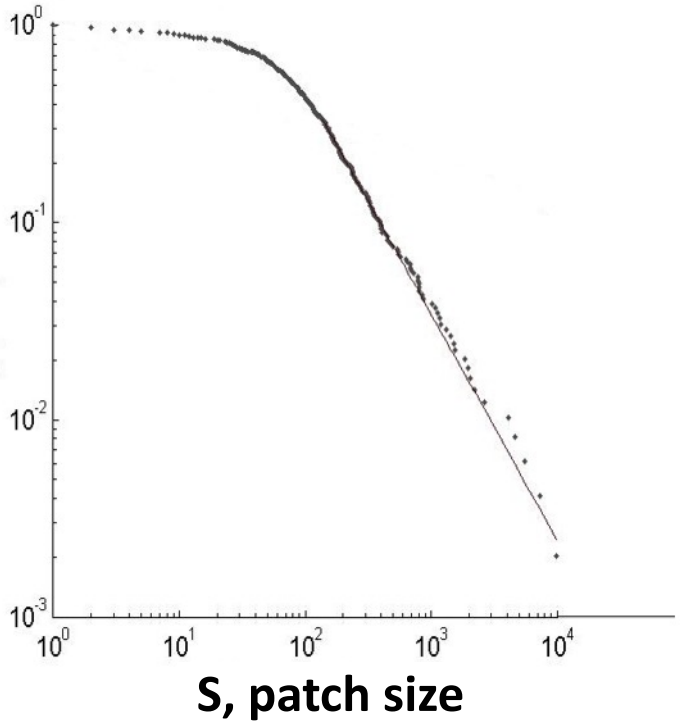
Field data

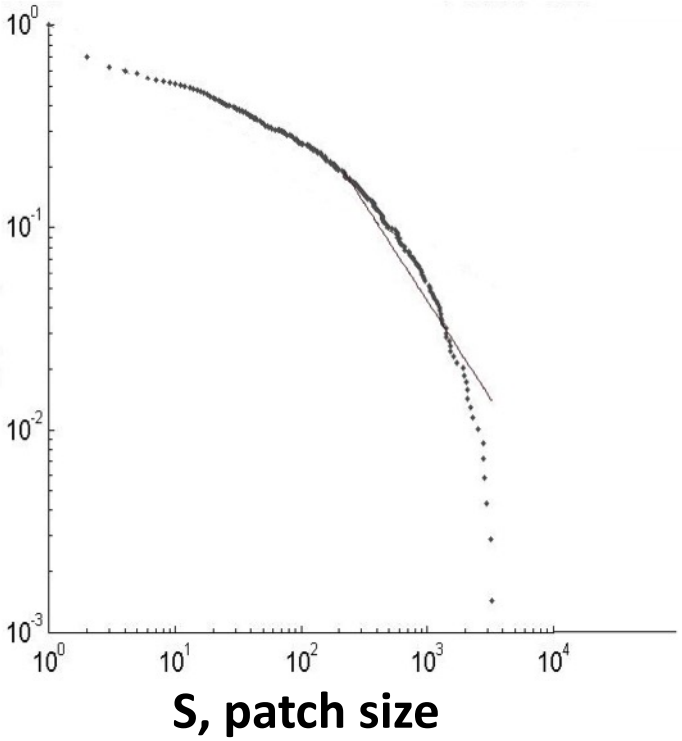
→3 times 50x50 m plots
Patch size distribution

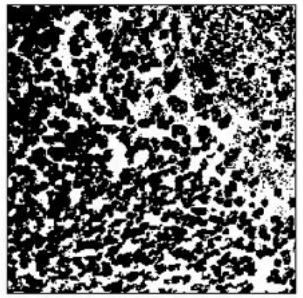
Aerial image data

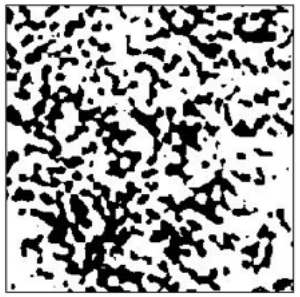
Berdugo, Kéfi, Soliveres and Maestre, NEE 2017

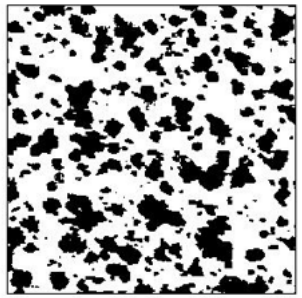












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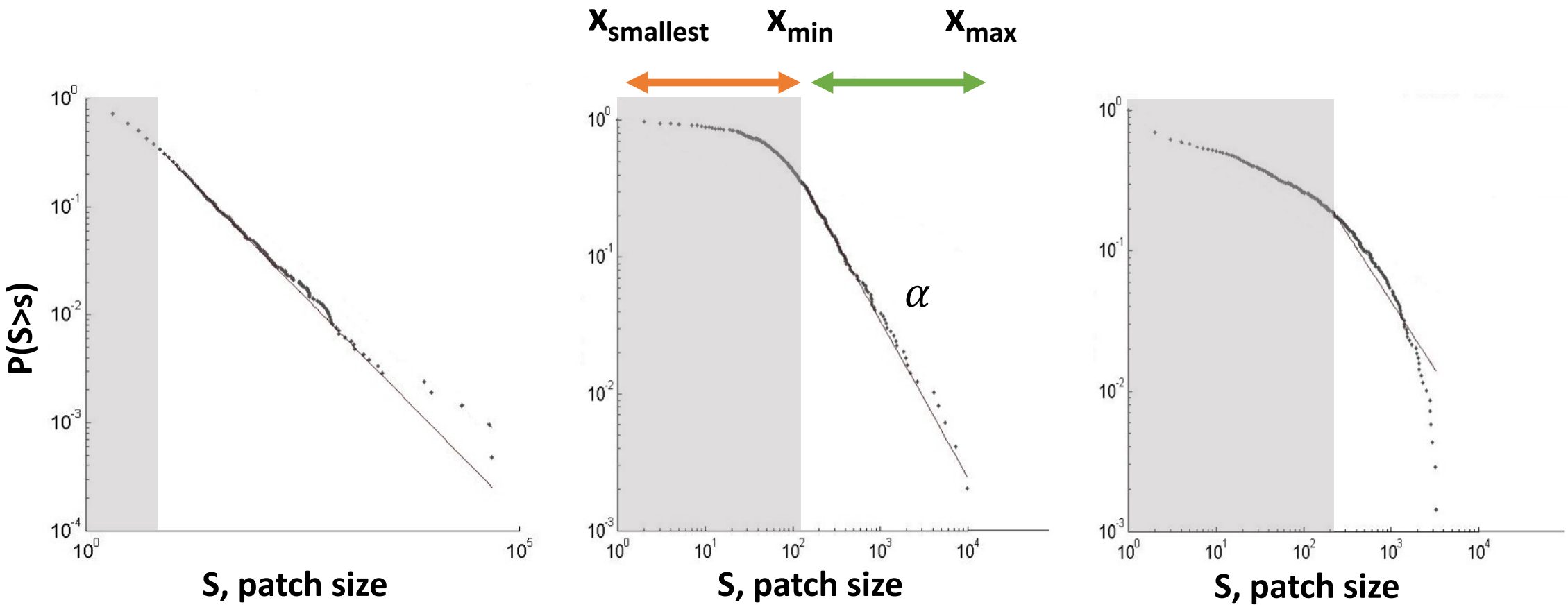


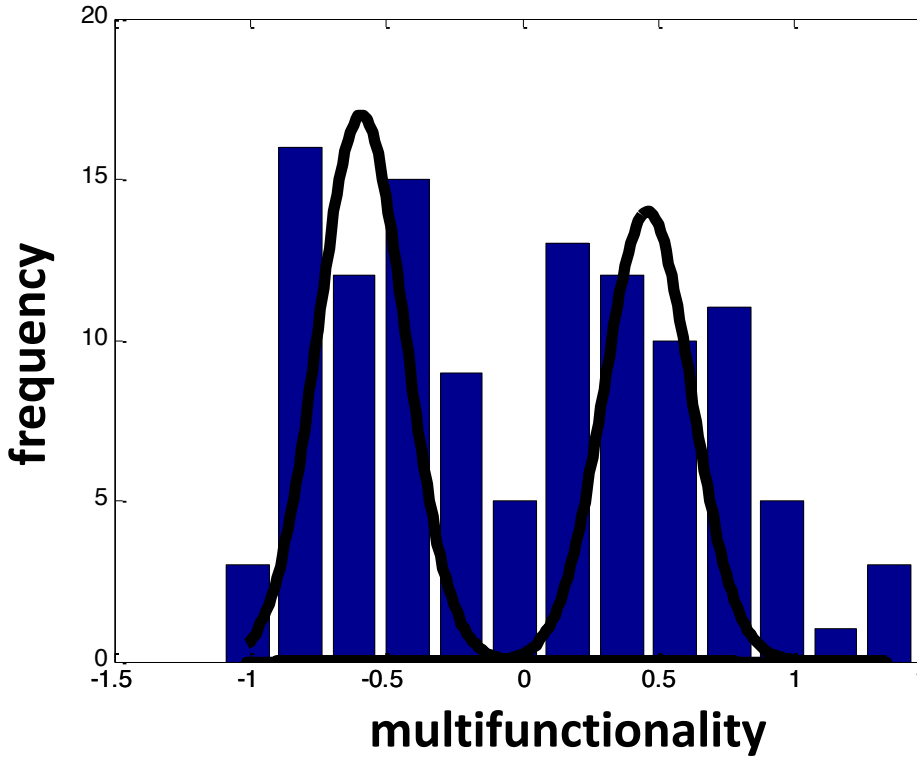
x_{min}=8
α = 1.82

x_{min}=137
α = 2.14

x_{min}=220
α = 1.96

$$PLR = 1 - \frac{(log_{10}[x_{min}] - log_{10}[x_{smallest}])}{(log_{10}[x_{max}] - log_{10}[x_{smallest}])}$$

Link with ecosystem functioning?



Potential:

$$U' = -\frac{\sigma^2}{2}\log\left(PDF\right)$$

Gaussian mixture analysis:
one mode: AIC = 220.8, BIC = 226.3
two modes: AIC = 199.8, BIC = 213.6

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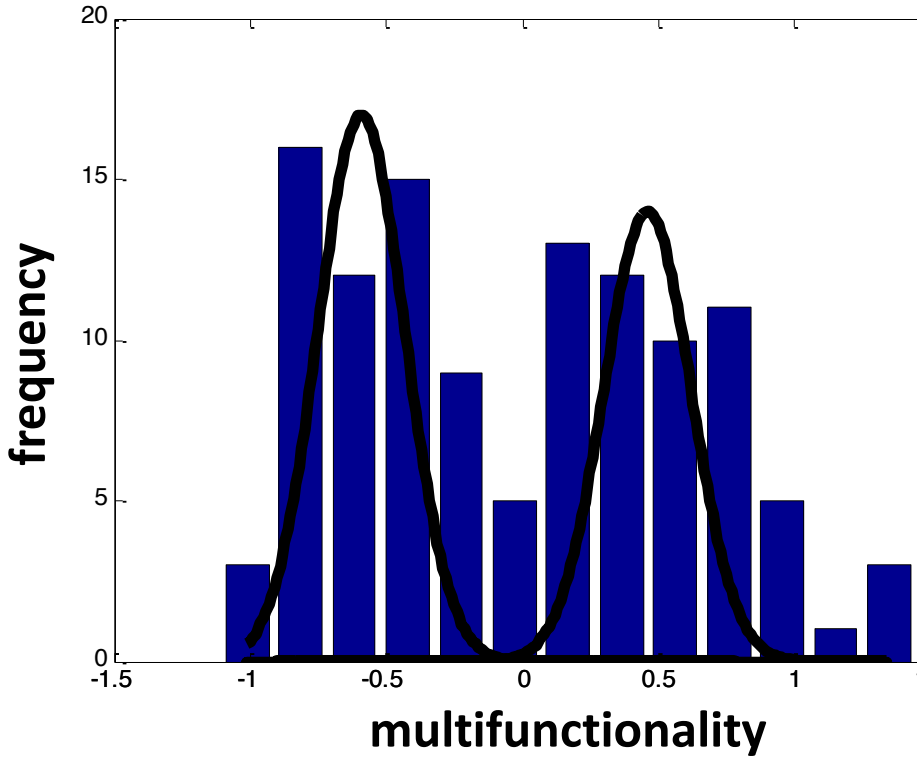

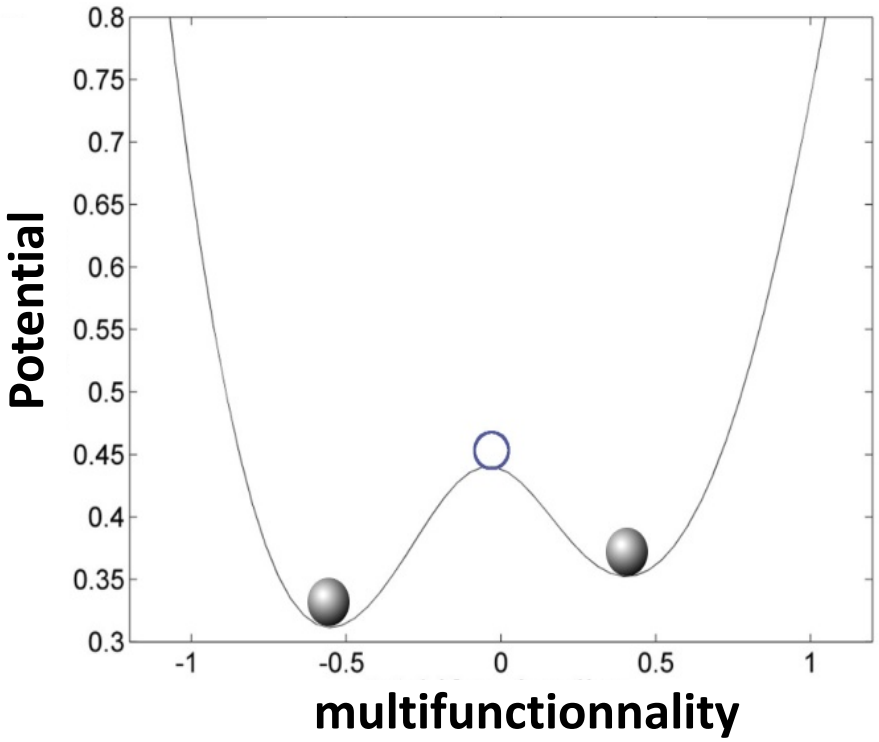

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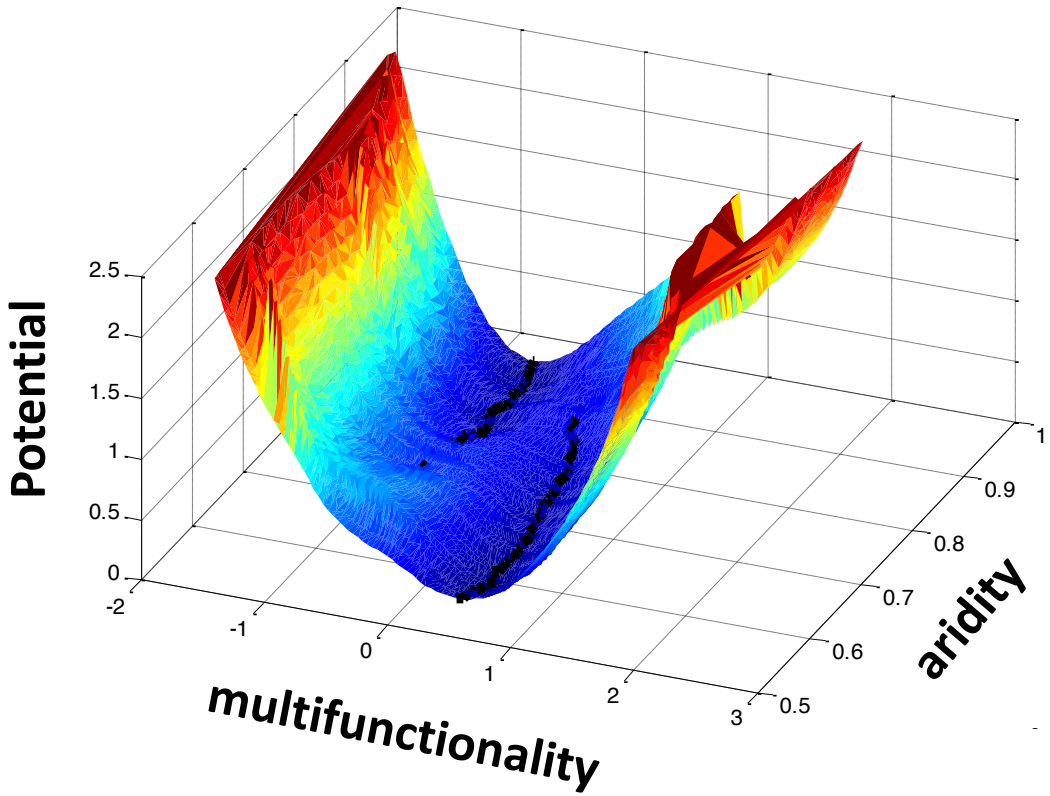
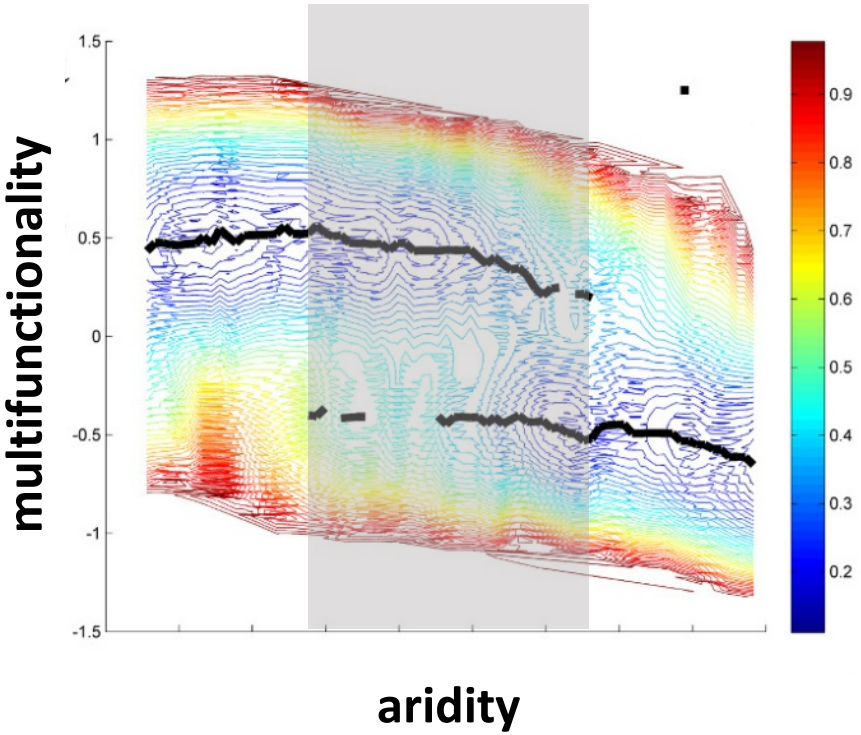




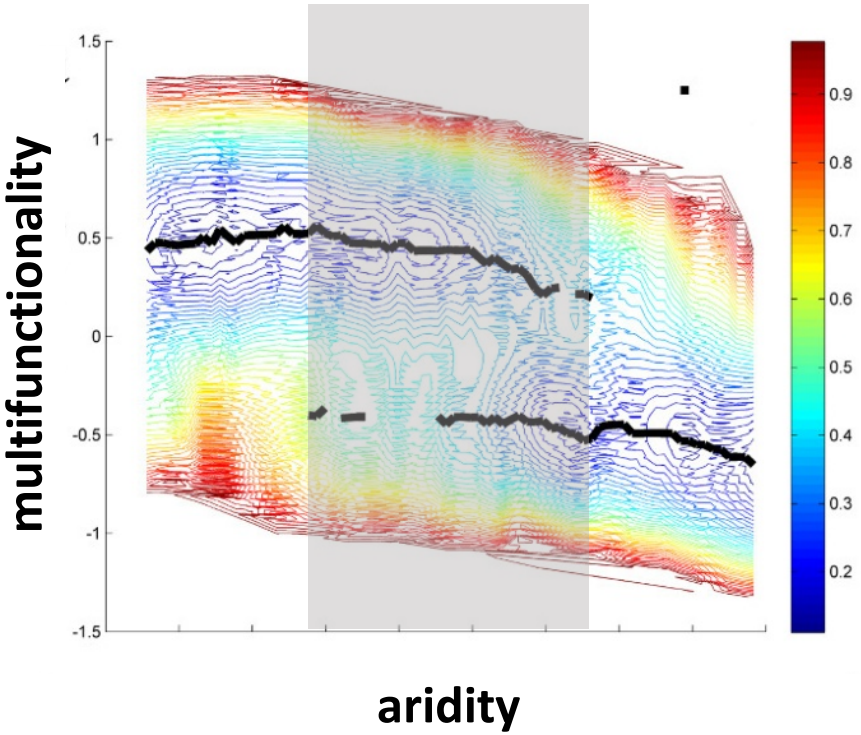
biomodality

Berdugo, Kéfi, Soliveres and Maestre, NEE 2017

Are spatial structure and multifunctionality related?

PL

Deviation from PL



Association MF – PSD:
$\chi^2 = 6.64$, $P = 0.01$

biomodality

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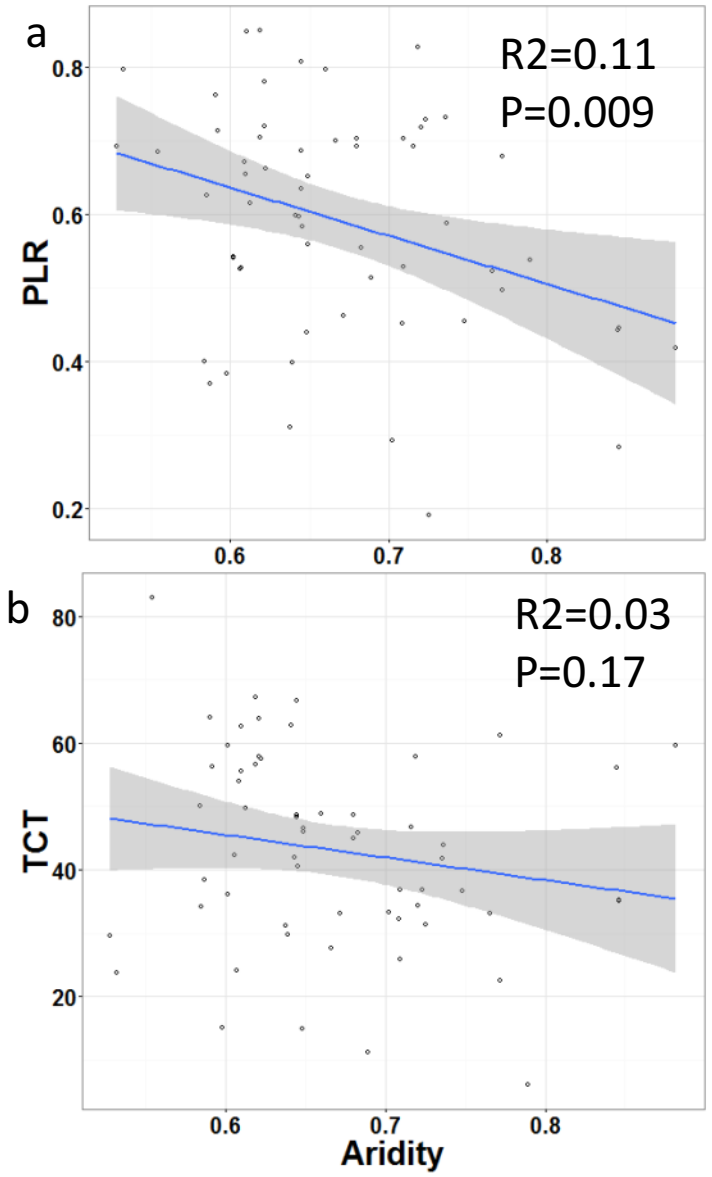
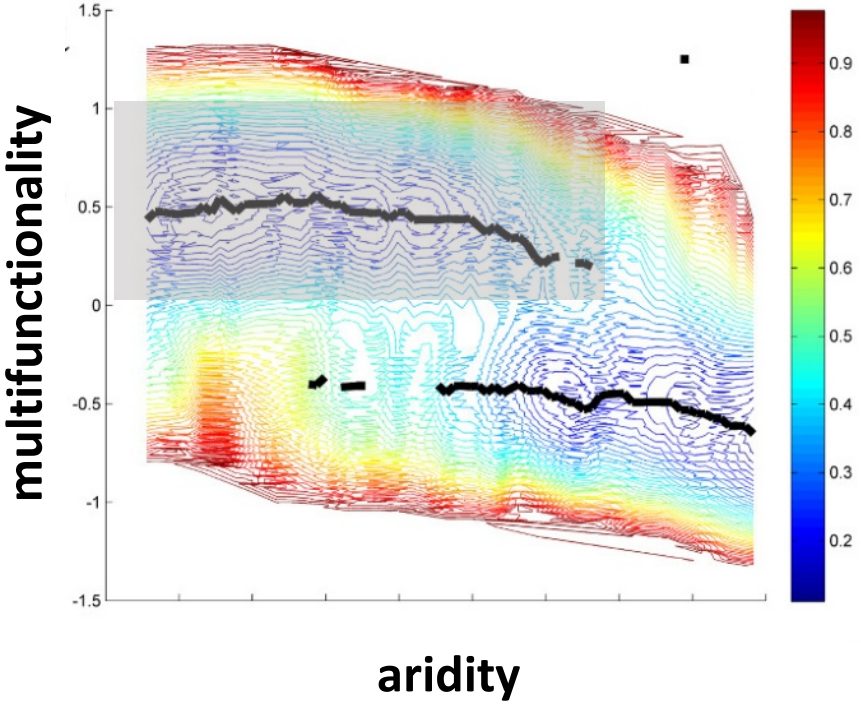


PL →

Deviation from PL →



Association MF – PSD:
$\chi^2 = 6.64$, $P = 0.01$

↔ biomodality

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Degradation drivers?

Conclusion

- Bimodality in multifunctionality: alternative stable states?
  [Degradation drivers + time series]
- Spatial Patterns are related with MF: indicators?
  [But again time series needed for validation and clear stress gradients]

→Promising but more validation needed

- Extrapolation to different spatially structured ecosystems?

Merci

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