Biodiversity and functioning of arid ecosystems of Tunisia

Part I

Plant species richness and ecosystem functioning

-Considerable research has gone into teasing out the linkages between biodiversity, functioning and services. One of the main motivations for this research is the rapid decline in the number of species and populations as a result of human activities and climate change.

-As the understanding of the biodiversity-ecosystem functioning relationship progresses, conservation and management will more and more benefit.

Because of their broad geographical distribution (32 000 km2 in the Mediterranean) and their strong and long-term links with human activities, *Stipa tenacissima* steppes constitute an excellent model ecosystem to expand our knowledge of ecosystem dynamics in arid and semi arid lands. In addition, the wide variety of conditions characterizing *S. tenacissima* steppes make this ecosystem particularly suitable to test the theoretical background of restoration ecology, and explore new approaches for the restoration of semi-arid and arid areas.

METHOD

In this study, we evaluated the effect of perennial vascular plants (species richness) and a range of key abiotic factors (climate, slope, elevation, and soil texture) on multifunctionality of 10 arid steppes dominated by Stipa tenacissima L. in Tunisia.

At each site, we surveyed plots 30 m × 30 m and assessed ecosystem functions related to the cycling and storage of carbon, nitrogen and phosphorus. The multifunctionality index M for each plot was the average Z-score for all functions measured within the plot.

Study area:

Table: Main characteristics of the experimental sites

Site Name	UTM coordinates	Soil type	texture	Mean annual temperature (ºC)	Mean annual Precipitation (mm)	Species richness	Diversity (bits)
Bouhedma	34°29′ 39″N 9°38′49″E	Lithosols	Sandy Loam	18.2	177	11	0,337
Chaambi	35°10′ 03″N 8°40′ 25″E	Calcic Cambisols	Sandy Loam	15.6	355	7	0,54
Matmata	33°31′ 17″N 9°58′ 27″E	Lithosols	Sandy Loam	18.7	221	6	0,613
Sbeitla	35°09′ 36″N 9°06′ 59″E	Haplic Xerosols	Sandy Loam	17.1	274	9	0,378
Sidi Bouzid	34°57′ 23″N 9°43′ 04″E	Lithosols	Sandy Loam	17.4	233	4	0,337
Tataouine	32°59′ 00″N 10°29′54″E	Lithosols	Loamy Sand	20	141	6	0,385
El Gonna	34°41′66″N 10°30′22″E	Haplic Xerosols	Sandy Loam	18.3	191	18	0,4
Gabès	33° 45.56″N 10° 01.69″E	Gipsy Yermosols	Sandy Loam	19.5	171	18	0,547
Haffouz	35° 38′01″N 09° 41′ 27″E	Calcic Cambisols	Sandy Loam	17.6	314	9	0,843
Jbel Halfa	35° 58′ 91″N 10° 29′ 88″E	Lithosols	Sandy Loam	17.8	310	10	0,412

Table: Values of different parameters evaluated

Site	Elevation (m)	Latitude	Longitude	Slope(°)	Sand content(%)	PCA_C1	PCA_C2	PCA_C3	PCA_C4	Species richness	Multifunctio -nality index	Carbon cycling index	Nitrogen cycling index	Phosphorus cycling index
Bouhedma	**172**	**34,494**	**9,647**	**4,0**	**62,087**	**-1,24214**	**1,22519**	**-0,31578**	**0,15095**	**10**	**-0,62**	**-0,71**	**-0,52**	**-0,66**
Chaambi	**934**	**35,168**	**8,674**	**5,0**	**56,713**	**-0,65334**	**0,47179**	**1,03050**	**0,15464**	**9**	**-0,09**	**-0,04**	**0,09**	**-0,76**
Matmata	**473**	**33,522**	**9,974**	**22,0**	**65,873**	**-1,18915**	**1,39090**	**-0,55257**	**0,23754**	**10**	**-0,64**	**-0,47**	**-0,61**	**-1,22**
Sbeitla	**598**	**35,160**	**9,117**	**4,0**	**59,808**	**-1,00833**	**0,78138**	**0,57632**	**0,27330**	**8**	**-0,29**	**-0,12**	**-0,24**	**-0,95**
Sidi Bouzid	**447**	**34,956**	**9,718**	**18,0**	**58,930**	**-1,04502**	**1,01276**	**0,07808**	**0,06514**	**4**	**-0,21**	**-0,28**	**-0,06**	**-0,44**
Tataouine	**235**	**32,983**	**10,499**	**1,0**	**81,167**	**-1,46442**	**1,45030**	**-0,86584**	**0,65941**	**6**	**-0,86**	**-0,73**	**-0,84**	**-1,29**
El Gonna	**104**	**34,685**	**10,506**	**3,0**	**59,196**	**-0,81023**	**1,03247**	**-0,64904**	**0,70067**	**18**	**0,19**	**-0,29**	**0,79**	**-0,18**
Gabès	**94**	**33,759**	**10,028**	**1,5**	**69,144**	**-1,14277**	**1,27712**	**-0,84330**	**0,73727**	**18**	**-0,23**	**-0,45**	**-0,05**	**-0,08**
Haffouz	**288**	**35,634**	**9,688**	**2,0**	**74,515**	**-0,81990**	**0,82661**	**0,46647**	**0,12683**	**11**	**0,09**	**0,44**	**-0,16**	**-0,22**
Jbel Halfa	**221**	**32,979**	**10,498**	**1,5**	**54,756**	**-1,48051**	**1,47738**	**-0,84406**	**0,64833**	**9**	**1,00**	**1,11**	**1,16**	**0,17**

Table. Pearson correlation between abitioc and biotic factors

	Elevation	Latitude	Longitude	Slope	Sand content	Species richness	Multifunctio-nality index	Carbon cycling index	Nitrogen cycling index	Phosphorus cycling index
Elevation	**1**									
Latitude	**0,414**	**1**								
Longitude	**-0,826****	**-0,695***	**1**							
Slope	**0,324**	**0,013**	**-0,118**	**1**						
Sand content	**-0,341**	**-0,222**	**0,307**	**-0,189**	**1**					
Species richness	**-0,482**	**0,001**	**0,271**	**-0,351**	**-0,002**	**1**				
Multifunctionality index	**-0,101**	**0,022**	**0,183**	**-0,301**	**-0,546**	**0,215**	**1**			
Carbon cycling index	**0,074**	**0,036**	**0,045**	**-0,242**	**-0,377**	**-0,054**	**0,907****	**1**		
Nitrogen cycling index	**-0,15**	**-0,016**	**0,251**	**-0,279**	**-0,648***	**0,352**	**0,943****	**0,727***	**1**	
Phosphorus cycling index	**-0,439**	**0,094**	**0,267**	**-0,368**	**-0,361**	**0,477**	**0,825****	**0,626**	**0,805****	**1**

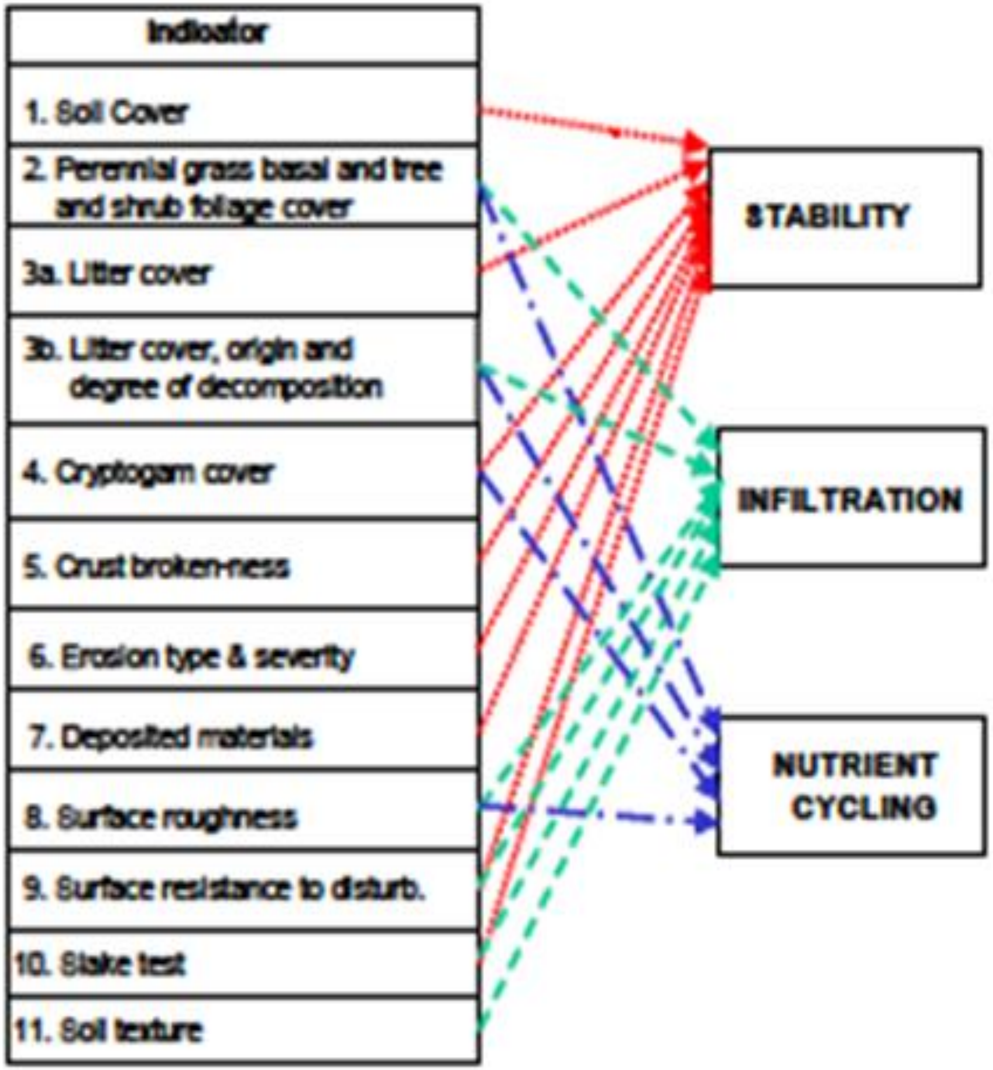
- The number of perennial plant species was significantly and positively related to ecosystem multifunctionality (R=0,215)

- The consistent effects of species richness on multifunctionality over and above those of climate and of abiotic factors highlight the importance of plant biodiversity as a driver of multifunctionality in drylands (Maestre et al, 2012).

Part II.
The landscape function analysis (LFA) a useful method to assess the functional status of arid ecosystems

- The landscape function analysis (LFA), methodology developed in Australian rangelands by Tongway (1995) and Tongway and Hindley (1995, 2004), uses soil surface indicators to assess the status of a given ecosystem in terms of functionality.

- The output of LFA is given by three indices (stability, infiltration, and nutrient cycling) that summarize different facets of the functionality of the ecosystem



Relationship between field indicators and LFA indices (tongway & hindley, 2004).

*The stability index provides information about the ability of the soil to withstand erosive forces, and to recover after disturbance.

*The infiltration index shows how the soil partitions rainfall into plant-available water, and runoff water that is lost from the system.

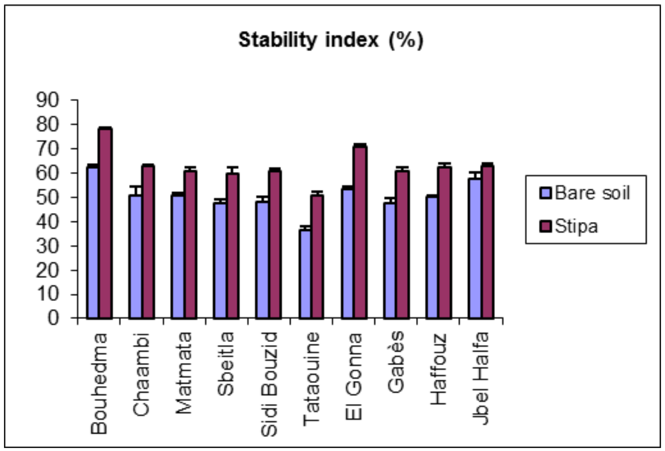
*The nutrient cycling index provides information about how efficiently organic matter is cycled back into the soil.

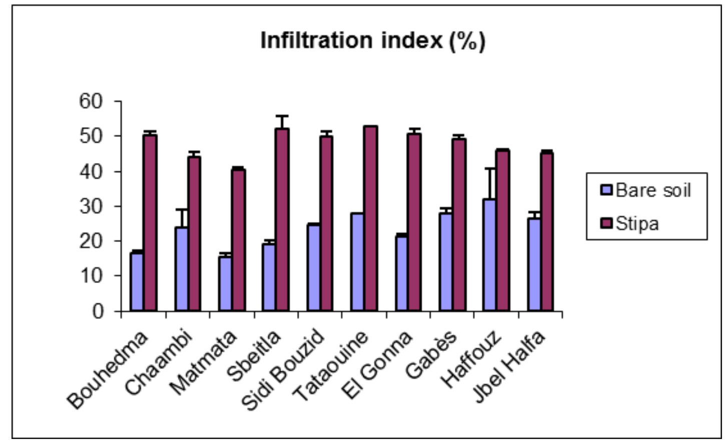
METHOD

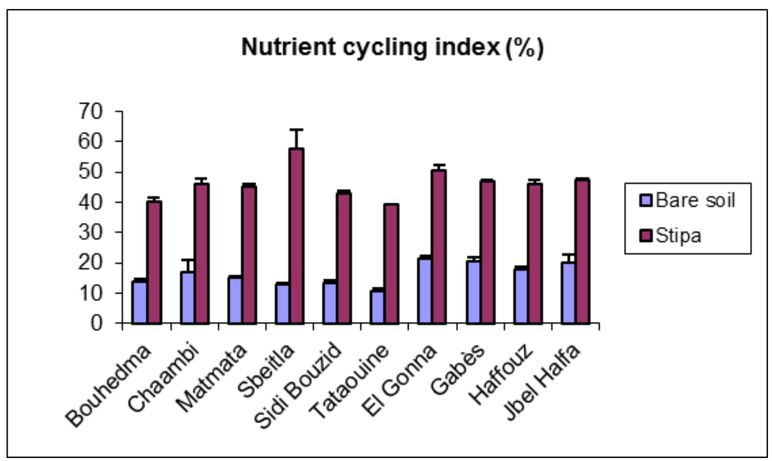
Within each site, we randomly located five (50 cm *50 cm) sampling points in open areas and under the canopy of S. tenacissima tussocks. In each sampling point, 11 soil surface indicators were visually assessed

These indicators were further combined to obtain the three LFA indices (stability, infiltration and nutrient cycling) with a Microsoft1 Excel template developed by David Tongway (downloaded from http:// www.cse.csiro.au/research/efa/).

RESULTS







Summary of the landscape function analysis indices obtained in the microsites evaluated bare soil and stipa (n=5 per microsite).

-The LFA indices were higher in the Tussock microsite than in bare soil. There was a strong microsite effect but its magnitude differed between the study areas.

-The experimental sites differed in their functional status; these differences underlines that these ecosystems are heterogeneous in terms of resource control and possess patches.

Indeed, in ecosystems with a high functional status, soil, water and nutrients are strongly conserved. By contrast, ecosystems with a low functional status tend to lose existing material resources.

Implications for ecosystem restoration:

-The evaluation of ecosystem function provides a useful framework for the initial assessment of ecosystem status and the subsequent selection of repair measures (Tongway & Ludwig, 1996) and can be used to optimize the restoration of degraded arid and semiarid areas.

-The output from the LFA methodology can be used to decide which areas are in more need of restoration and which ecosystem functions should be recovered first (Maestre & Puche, 2009).

 In steppes showing clear symptoms of impaired functionality, restoration actions should focus on repairing soil stability, infiltration, and nutrient cycling. This can be achieved by the creation of new patches using dead branches (Ludwig & Tongway 1996; Tongway & Ludwig 1996).

 In steppes with better functional status, restoration actions should focus on the introduction of late-successional shrubs as a way to improve ecosystem functions and to increase ecosystem resilience against disturbances (Maestre & Cortina 2004).


THANK YOU
FOR YOUR
ATTENTION