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EXPLORING HYSTERSIS THROUGH LAND CONDITION TRENDS

——A CASE OF CHINA DRYLANDS

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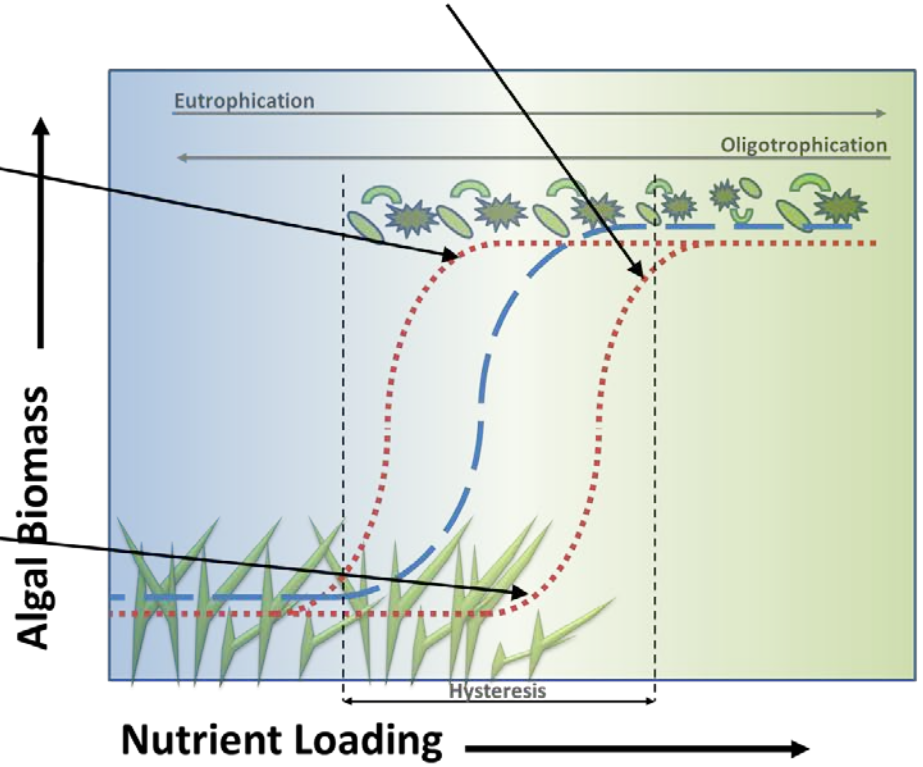
WHAT IS HYSTERESIS

2. At this point, vegetation collapses and the lake "jumps" to the turbid steady-state.

3. Reduction of nutrients after this catastrophic transition does not result in a return of plants until the critical turbidity is reached again. This backward switch happens at a much lower nutrient level than the forward switch

1. An increase of the nutrient level will lead to a gradual and moderate rise in turbidity until the critical turbidity for plant survival is reached



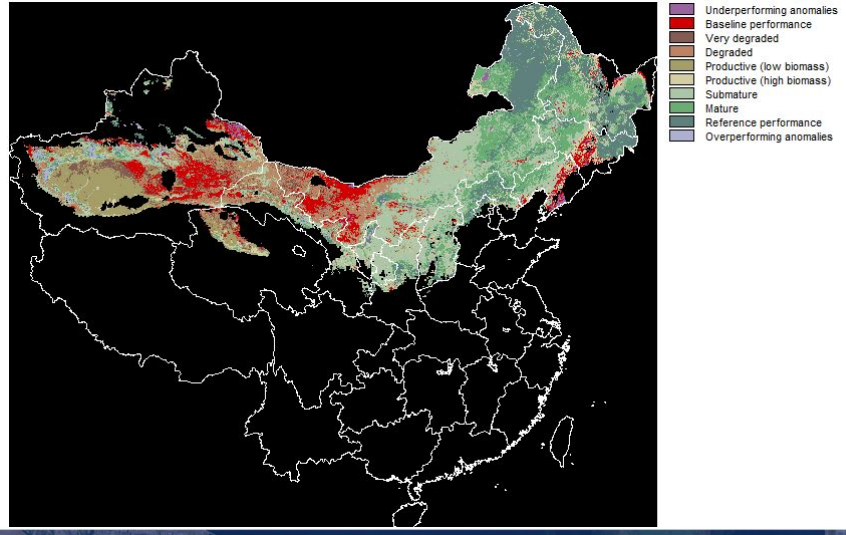
Scheffer, M., Carpenter, S., Foley, J. A., Folke, C., & Walker, B. (2001). Catastrophic shifts in ecosystems. *Nature*, *413*(6856), 591–596.

2dRUE

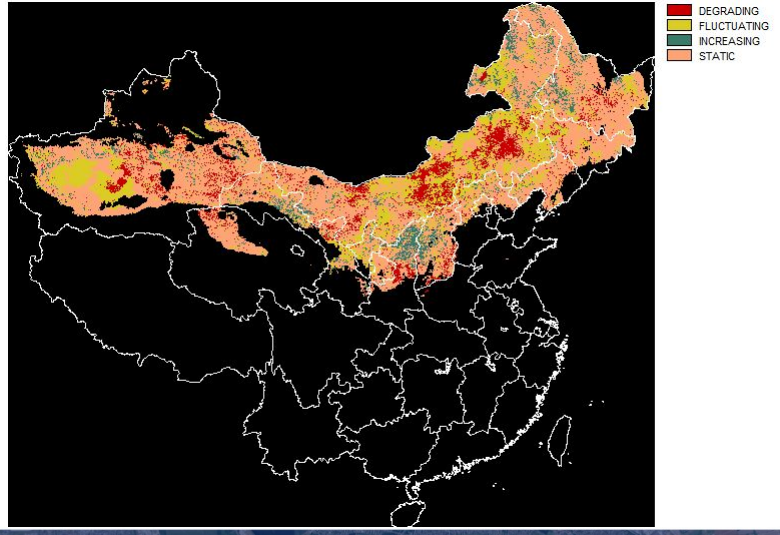
2dRUE is a tool for assessment and monitoring of land condition
Based on the concept of Rain Use Efficiency
Implemented in China drylands

Zhihai, G.; del Barrio, G.; Xiaosong, Li.; Bengyu, W.; Puigdefábregas, J.; Sanjuán, M.E.; Lina, B.; Martínez-Valderrama, J.; Bin, S. 2016. Desertification Assessment and Monitoring based on Remote Sensing. Proceedings of Dragon 3 Final Results & Dragon 4 Kick-Off Symposium. 4–8 July 2016 Wuhan, PR China. Edited by L. Ouwehand. European Space Agency. ISBN 978-92-9221-304-6 ISSN 1609-042X

Map of land condition states



Map of land condition trends



2dRUE SUB-PRODUCTS

Beyond basic indicators, 2dRUE can be exploited to extract alternative useful information to launch interesting analyses.

Multiple stepwise regression was carried out to isolate the effects of time and climate on the green biomass.

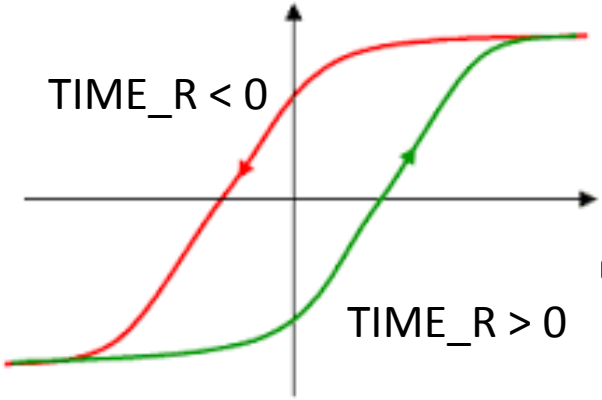
The former can be associated to human impact on a territory.

We call our time coefficient **TIME_R**

It means the expected change of vegetation biomass per unit time, both variables expressed in standard deviation units instead natural units. This is to enable comparisons with other regions.

Positive values means regeneration (TIME_R=3)
Negative values means degradation (TIME_R=1)
Null values means that the pixel remains in the same state (TIME_R=2)

AIM OF THIS WORK



The goal is to test if positive and negative TIME_R coefficients are statistically different.

In this case degradation and regeneration es wil be asymetric and this will support hysteresis.

For such exercises we need a suitable statistical test.

STATISTICAL ANALYSIS

- **U Mann Whitney Test**
- It is the non-parametric alternative test to the independent sample t-test.
- It is used to compare two sample means that come from the same population.
- Used when the data is ordinal or when the assumptions of the t-test are not met.
- Our H_0 is that both groups of values, TIME_R=1 and TIME_R=3, are not statistically different.

SAMPLING

ORIGINAL 2dRUE data. Cover all China drylands (N = 202175)
3234800 km^2

↓

Stratified random sampling (10% of study área). (N = 20028)

↓

Discard TIME_R = 2 data (N = 3442)

↓

Filter according to 3 factors. (N see results)

SAMPLING

Filter according to 3 factors. (N see results)

LAND USE

0. OTHERS
1. FORESTS
2. SHRUBLANDS AND WOODLANDS
3. GRASSLANDS
4. AGRICULTURE
5. DESERTS AND BARE SOILS

ASSESSMENT

1. Underperforming anomalies
2. Baseline performance
3. Very degraded
4. Degraded
5. Productive (low biomass)
6. Productive (high biomass)
7. Submature
8. Mature
9. Reference performance
10. Overperforming anomalies

FAO ARIDITY ZONES

2. Arid (0.05 < Aridity Index<0.20)
3. Semi-arid (0.20 < AI < 0.50)
4. Dry sub-humid

U MANN WHITNEY. CONSIDERATIONS

Significance $p<0.1$

Sum of Ranks. The implementation of the test requires to order the sample, from minor to major values of TIME_R.

To discard the effect of negative and positive values we take ABS(TIME_R)

RESULTS

P-value < 0.1 to be statistically significant

Sample size changes according to the class/category

LAND USE (NT= 3442)	U Mann Whitney		Size sample		Sum of Ranks		
	pvalues	Reject Ho?	n1	n3	Dec (n1)	Inc (n3)	
0. OTHERS	0,1163	NO	72	41	4.367	2.074	-
1. FORESTS	0,9822	NO	166	258	54.853	35.248	-
2. SHRUBLANDS AND WOODLANDS	0,8129	NO	79	59	5.436	4.156	-
3. GRASSLANDS	0	YES	723	417	373.407 > 276.963	→	Dec
4. AGRICULTURE	0,0001	YES	338	295	97.901 < 102.761	→	Inc
5. DESERTS AND BARE SOILS	0,0011	YES	700	294	334.782	159.734	Dec

Half of the categories are statistically significant

The sum of ranks allows specifying which of the two groups is bigger

ASSESSMENT (NT= 3442)	U Mann Whitney		Size sample		Sum of Ranks		
	pvalues	Reject Ho?	n1	n3	Dec (n1)	Inc (n3)	
1. Underperforming anomalies	1	NO	53	10	1.696	320	-
2. Baseline performance	0,1389	NO	241	76	37.288	13.115	-
3. Very degraded	0,007	YES	88	30	5.672	1.349	Dec
4. Degraded	0,2588	NO	253	69	40.086	11.918	-
5. Productive (low biomass)	0,0004	YES	120	49	9.176	5.189	Dec
6. Productive (high biomass)	0,0094	YES	74	110	11.095	5.925	Dec
7. Submature	0	YES	672	432	315.655	294.306	Dec
8. Mature	0,1133	NO	387	279	125.186	96.926	-
9. Reference performance	0,0605	YES	181	283	63.153	44.728	Dec
10. Overperforming anomalies	0,7341	NO	9	26	459	171	-

Half of the categories are statistically significant

FAO (NT= 3442)	U Mann Whitney		Size sample		Sum of Ranks		
	pvalues	Reject Ho?	n1	n3	Dec (n1)	Inc (n3)	
2. Arid	0	YES	1.001	429	677.185	345.980	Dec
3. Semi-arid	0	YES	978	832	824.144	814.811	Dec
4. Dry sub-humid	0,2518	NO	99	103	10.931	9.573	-

2/3 of the categories are statistically significant

INTERPRETATION

- Degradation and regeneration processes live together in the territory.
- Almost all the significant results points out that degradation happens more quickly than regeneration.
- This suggest that reliving human pressure on resources do not guarantee environmental recovery (on a human timescale).
- The only result that gets off this rule is ‘Agriculture’ land use.
- Productivity is favored in this land use with the purpose of harvesting. The rate of aggradation in this case is human-made.
- NEXT CHALLENGE: To fit exponential decrease equations to estimate expected decrease of vegetation over time at meaningful thresholds (e.g. time to halve current biomass).