INTEGRATING MICROBIOLOGICAL QUALITY INDICATORS AND SOIL PROPERTIES THROUGH SCORE FUNCTIONS TO ASSESS LAND USES CHANGES IN COLOMBIAN *ANDISOLS*

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PROBLEM STATEMENT

We need to perform **quantitative assessments of Soil Quality** (SQ) to Identify changes in Soil Properties and Functionality (Hinge, 2019)

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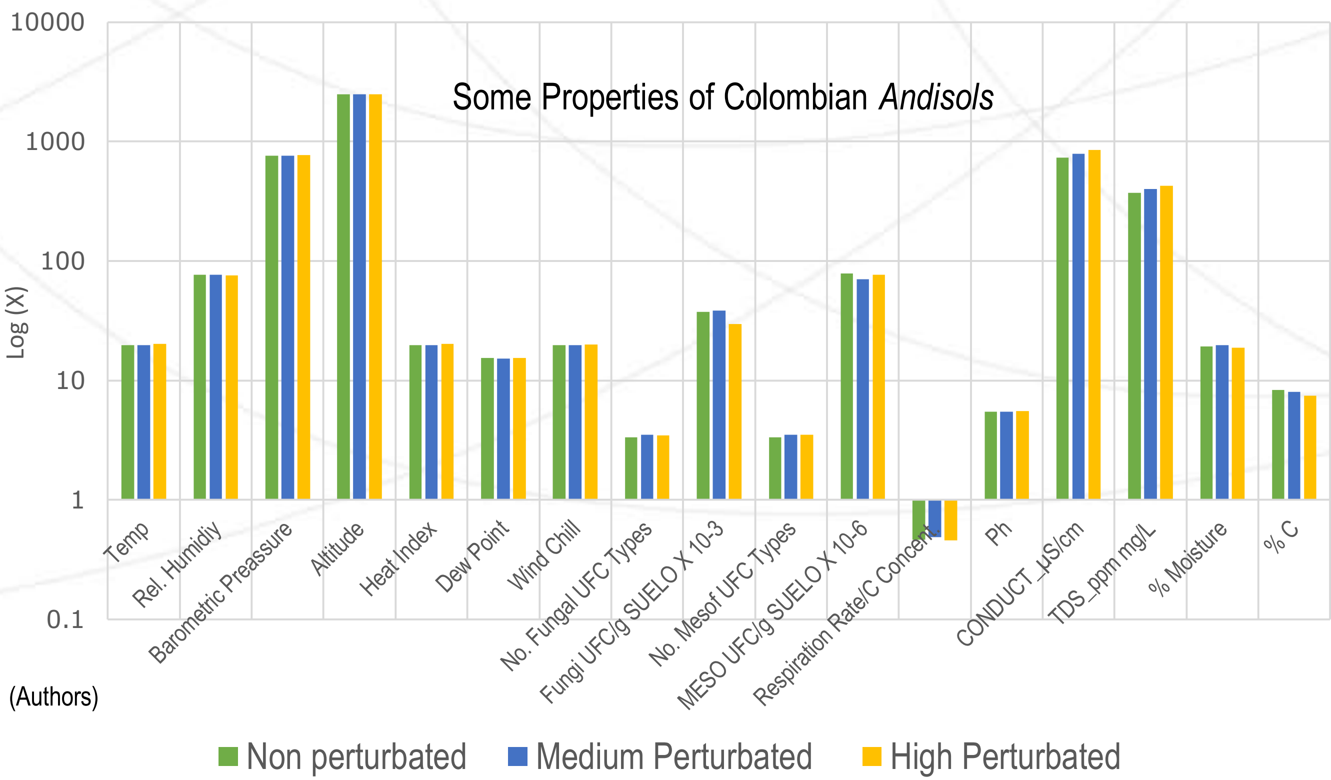


(Authors)

(Forest – Np) (Crops - Agr) (Mining – Mp)

SQ MEASURES NEED INDICATORS WITH:

INTEGRALITY
(Without loss of information)

REPRESENTABILITY
(**Specificity** - Treats – Soil Functions.)

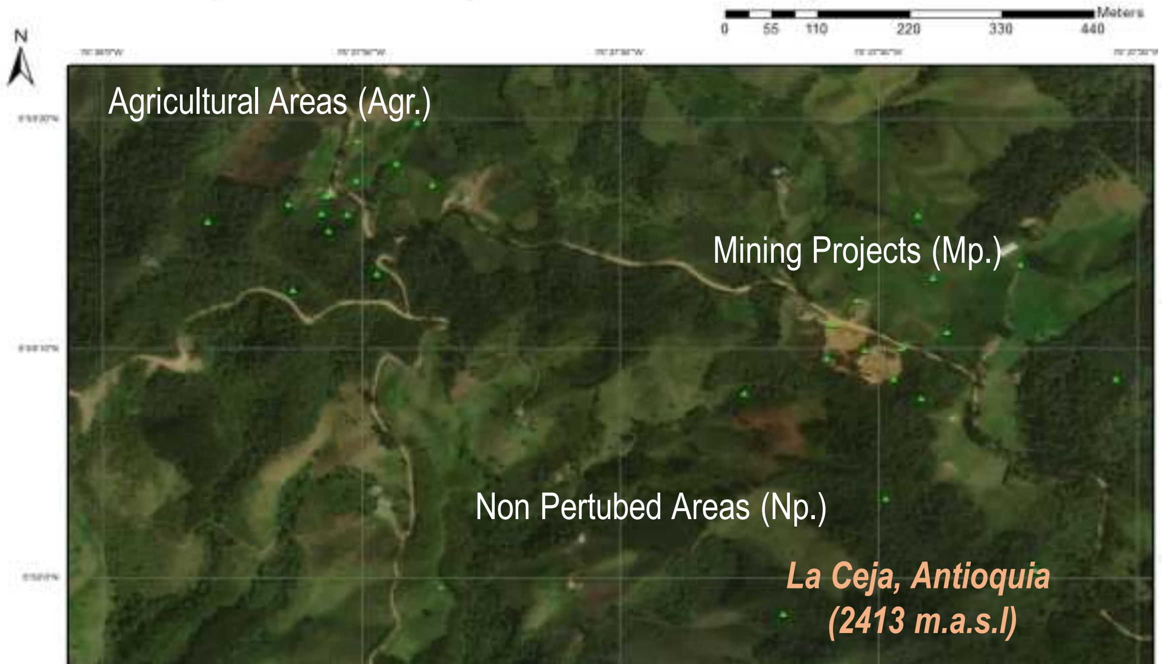
DIFFERENTIATION

EARLY WARNINGS
(A signal of Impacts)

SIMPLE INTERPRETATION

LOW COST
(Analysis – Approach)

MATERIAL AND METHODS



Antioquia, Colombia
La Ceja , El Retiro, Envigado
Land uses: Agr, Mp., Np.
Period: September – October 2018
Sampled Points: 90

AIM: To build a Minimum Data Set (MDS) to measure SQ in Colombian *Andisols* based on **microbial indicator**, soil properties and environmental variables (with low measurement cost).

Why: 14% National Mining Projects are located in Antioquia. ***Andisols*** of Antioquian Andean Area are the **most treated** soils. 1st producer of non metallic minerals.

(DIASAM, 2019)

MATERIAL AND METHODS 2

Treats by Mp. and Agr. Activities

SOM decline

Salinization

Soil Functions Affected

Habitat provision (Loss of Biodiversity)

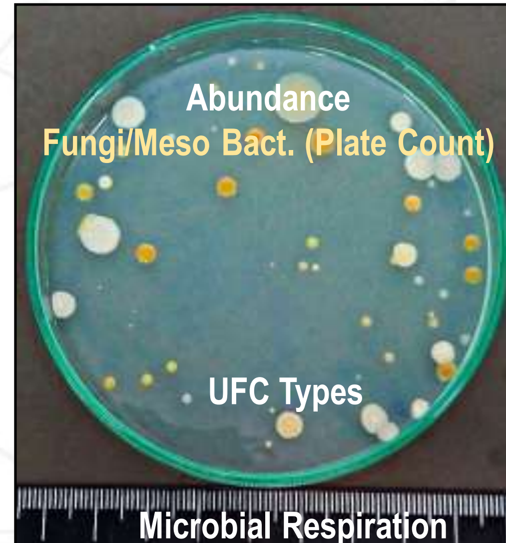
OM cycling (C sequestration/Respiration)

Statistical Analysis

ANOVA/LSD test to Identify Differences between land uses.
Integration of Variables by Geometric Means (GM).
Create a MDS by Factor Analysis and Correlation Factors.
Use Scoring Function to qualify land uses according to MDS (Linear and Non-Lin.).

(Raiesi & Kabiri, 2016)

MICROBIAL INDICATORS



SOIL PROPERTIES

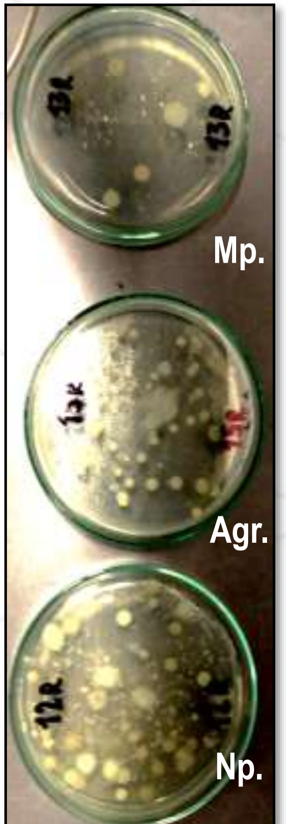
RESULTS AND DISCUSSIONS

1. CAPACITY OF SHOWING IMPACTS/CHANGES IN THE SOIL

Dif. Between each land use

Dif. Between Np. & Perturbed Areas (Agr. & Mp.)

Dif. Between Np. & Higher Perturbed Areas (Mp.)



Fungi Abundance CFU/g Soil x 10-3

Test ANOVA/LSD in a set of soil variables in Colombian Andisols using some GM

VARIABLE	LAND USES								
	Agr. - Mp.			Agr. - Np.			Mp. - Np.		
	Sig.	Dif.	Limit (+/-)	Sig.	Dif.	Limit (+/-)	Sig.	Dif.	Limit (+/-)
Temperature (°C)	X	-2.2340	1.0556	-	0.4158	1.0556	X	2.6498	1.0556
Dew Point (°C)	X	-0.9960	0.7363	-	-0.6448	0.7363	-	0.3512	0.7363
GM Temps. (T, DP, WCh)	X	-0.0768	0.0371	-	0.0042	0.0371	X	0.0809	0.0371
RHA (%)	**X**	**5.0928**	**4.0063**	**X**	**-5.4925**	**4.0063**	**X**	**-10.5853**	**4.0063**
pH	-	-0.1280	0.1378	-	-0.1000	0.1378	-	0.0280	0.1378
Conductivity (µS/cm)	-	-95.6333	108.5890	-	49.7333	108.5890	**X**	**145.3670**	**108.5890**
TDS (ppm)	-	-33.5111	50.8755	-	36.6889	50.8755	**X**	**70.2000**	**50.8755**
Soil Moisture (%)	X	5.2579	2.2919	-	-1.4789	2.2919	X	-6.7368	2.2919
Carbon content (%)	**X**	**2.5317**	**1.1309**	**X**	**-2.4369**	**1.1309**	**X**	**-4.9686**	**1.1309**
GM (Moist, C)	**X**	**0.8232**	**0.2896**	**X**	**-0.3499**	**0.2896**	**X**	**-1.1731**	**0.2896**
Mesof. Abundance (CFU/g Soil)	X	23.8621	15.7730	-	-1.4498	15.7730	X	-25.3118	15.7730
Fungi Abundance (CFU/g Soil)	**X**	**27.0980**	**8.2477**	**X**	**16.3922**	**8.2477**	**X**	**-10.7059**	**8.2477**
GM Microbial Abundances (Fungi/Mesof. Ln)	**X**	**0.2428**	**0.0766**	**X**	**0.0786**	**0.0766**	**X**	**-0.1642**	**0.0766**
No. FCU Types Mesof.	-	-0.3000	0.4866	**X**	**0.8000**	**0.4866**	**X**	**1.1000**	**0.4866**
No. FCU Types Fungi	-	0.0000	0.4604	**X**	**0.7667**	**0.4604**	**X**	**0.7667**	**0.4604**
GM CFU Types (Fungi/Mesof. Ln)	-	-0.0726	0.1445	**X**	**0.1613**	**0.1445**	**X**	**0.2339**	**0.1445**
MRRat/C	**X**	**-0.9143**	**0.3003**	**X**	**0.3847**	**0.3003**	**X**	**1.2991**	**0.3003**

(Authors)

RESULTS AND DISCUSSIONS

Spearman´s Correlation Coefficients

Fertilization/TDS/MI
(Traoré et al. 2007)

	RAH	GM Temp	GM Types Fung./Bact.	GM Abundance Fung./Bact.	MRRat/C	Conductivity	TDS	% Moisture	% C
RAH		0.0001	0.636	0.3061	0.0023	0.04	0.1578	0.0078	0.002
GM Temp	0.0001		0.5594	0.4913	0.0192	0.3443	0.2951	0.0103	0.0076
GM Types Fung./Bact.	0.636	0.5594		0.0124	0.0164	0.8774	0.9039	0.0615	0.0345
GM Abundance Fung./Bact.	0.3061	0.4913	0.0124		0.0065	0.612	0.7507	0.1672	0.0061
MRRat/C	0.0023	0.0192	0.0164	0.0065		0.2874	0.1954	0	0
Conductivity	0.04	0.3443	0.8774	0.612	0.2874		0.0002	0.0895	0.6701
TDS	0.1578	0.2951	0.9039	0.7507	0.1954	0.0002		0.0171	0.6576
% Moisture	0.0078	0.0103	0.0615	0.1672	0	0.0895	0.0171		0.0011
% C	0.002	0.0076	0.0345	0.0061	0	0.6701	0.6576	0.0011	

(Authors)

	Factor 1	Factor 2	Factor 3	Communality	Specific Variance
RAH(%)	0.05143	-0.10029	**0.88705**	0.79956	0.20043
GM Temp.	-0.05526	0.04772	**-0.84359**	0.71698	0.28301
GM Types Fung./Bact.	-0.44932	0.03209	0.15258	0.22620	0.77379
GM Abundance Fung./Bact.	0.73042	-0.19654	-0.14059	0.59191	0.40808
MRRat/C	**-0.86696**	0.10596	-0.21097	0.80735	0.19264
Conductivity(μS/cm)	-0.08549	**0.95965**	-0.08046	0.93471	0.06528
TDS(mg/L)	-0.11754	**0.96944**	-0.08060	0.96014	0.03986
%Moisture	0.70384	0.27847	0.30760	0.66756	0.33243
%C	**0.80971**	-0.16461	0.28574	0.76438	0.23560
Eigenvalue	3.1296	1.8449	1.4943		
Variance (%)	34.773	20.499	16.604		
Cumulative variance (%)	34.773	55.272	71.876		

Vegetal Cover Loss
(Procházka et al. 2011)

FA/CI and Eigenvectors of a set of variables to measure soil functionality in Colombian Andisols

RESULTS AND DISCUSSIONS

SCORING FUNCTION TO MEASURE CHANGES IN SOIL THROUGH MDS VARIABLES

$$A)\quad L_{SF}(Y) = x/x_{max}$$

$$B)\quad NL_{SF}(Y) = \frac{a}{\left(1 + \left(\frac{x}{x_0}\right)^{b}\right)}$$

$$C)\quad SQI = \sum_{i=1}^{n} w_i\, s_i$$

(A) Linear Scoring Function Transformation.
(B) Non linear Scoring Function Transformation.
(C) Additive equation.

(Raiesi & Kabiri, 2016)

$L_{SF}(Y)$ WAS EFFECTIVE TO SHOW CHANGES ON OUR MDS VARIABLES

SQI by Land Uses.
NT, non-transformed variables; (CI) calculated with CI.

(Authors)

ICs increase sensitivity of the SQI to identify changes in soil functionality

(Hussain et al. 1999).

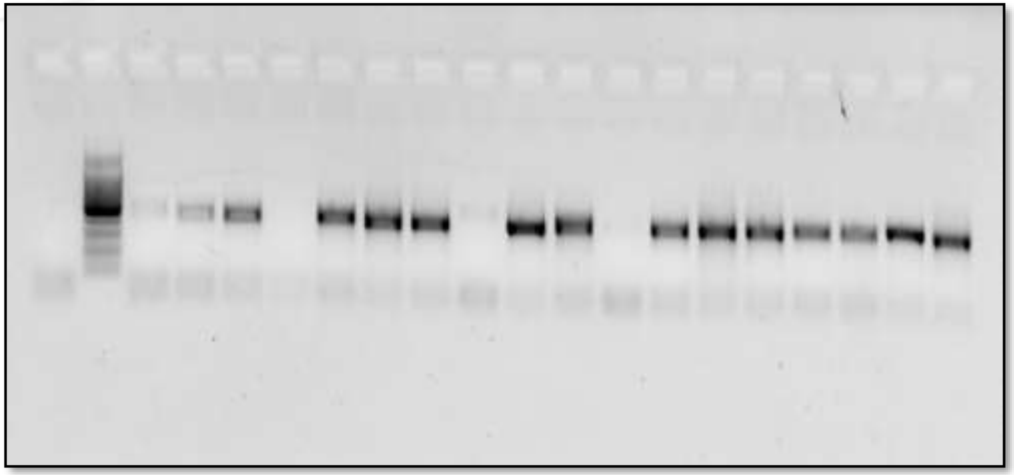
FINAL REMARKS

- **GEOMETRIC MEANS** are a good alternative for including significant variables of **SOIL FUNCTIONALITY** in an SQI.

- **SQI** calculated with IC and non-linear functions are **more sensitive to disturbances**. This sensitivity allows to discriminate between degrees of impact using variables with **low measurement cost.**

- We suggest using robust **indicators of microbial diversity and functionality** (specially on Fungal communities) in **MDS/SQI,** since these indicators are important to discriminate impacts on soil functionality.

- **Further work:** we will integrate three more factors into the SQI: 1) the structure of Fungal communities using Metabarcoding of Fungal nuclear ribosomal ITS2 region with primers fITS7/ITS4; 2) Glomaline concentration from soil samples; 3) Mycorrhizal Diversity from trap cultures.



Grazie Mille

References

Ayala, Helcías, Mauricio Cabrera, Ana Judith Cadena, Carlos Castaño, Sandra Contreras, Luis Carlos Diaz, Lyda Marcela Espiti, and Gonzalo Alfredo Gil. 2019. DIAGNÓSTICO DE LA INFORMACIÓN AMBIENTAL Y SOCIAL RESPECTO A LA ACTIVIDAD MINERA Y LA EXTRACCIÓN ILÍCITA DE MINERALES EN EL PAÍS Elaborado. Bogotá.

Hinge, Gilbert, Rao Y. Surampalli, and Manish Kumar Goyal. 2019. "Effects of Land Use and Soil Management on Soil Quality in India's Northeastern Himalayas." Journal of Environmental Engineering 145(4).

Hussain, I., K. R. Olson, M. M. Wander, and D. L. Karlen. 1999. "Adaptation of Soil Quality Indices and Application to Three Tillage Systems in Southern Illinois." Soil and Tillage Research 50(3–4):237–49.

Procházka, Jan, Jakub Brom, Jakub Šťastný, and Emilie Pecharová. 2011. "The Impact of Vegetation Cover on Temperature and Humidity Properties in the Reclaimed Area of a Brown Coal Dump." International Journal of Mining, Reclamation and Environment 25(4):350–66.

Raiesi, Fayez and Vida Kabiri. 2016. "Identification of Soil Quality Indicators for Assessing the Effect of Different Tillage Practices through a Soil Quality Index in a Semi-Arid Environment." Ecological Indicators 71:198–207.

Traoré, Salifou, Lamourdia Thiombiano, Jeanne Rasolodimby Millogo, and Sita Guinko. 2007. "Carbon and Nitrogen Enhancement in Cambisols and Vertisols by Acacia Spp. in Eastern Burkina Faso: Relation to Soil Respiration and Microbial Biomass." Applied Soil Ecology 35(3):660–69.

Acknowledgments

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