Ants as Indicators of Land Use and Soil-Based Ecosystem Services in Agroecosystems of the Colombian Llanos

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Introduction:

- Soils are involved in the provision of many ecosystem services that are of great importance for the maintenance of ecosystem functioning and human societies.
- Soils also are considered a large reservoir of biodiversity that contribute to this functioning.
- Ants in particular fulfill key roles in the maintenance of energy and material flow in soils.
- In addition to their fundamental role as ecosystem engineers, ants have been proposed as indicators of soil quality.

Objectives:

- Evaluate the impact of rapidly changing agricultural land use on ant communities in the Llanos region of Colombia
- Identify indicator species for key soil-based ecosystem services

Methods:

- Sampling was conducted in 75 fields along a 150 km transect in Meta Department of Colombia
- Five common agricultural land uses in the region were surveyed on 15 fields per use (Figs. 2a-e):
  1) Annual crops (maize, soy and rice)
  2) Rubber plantations
  3) Oil palm plantations
  4) Improved pastures (based on *Brachiaria* sp.)
  5) Semi-natural savannas

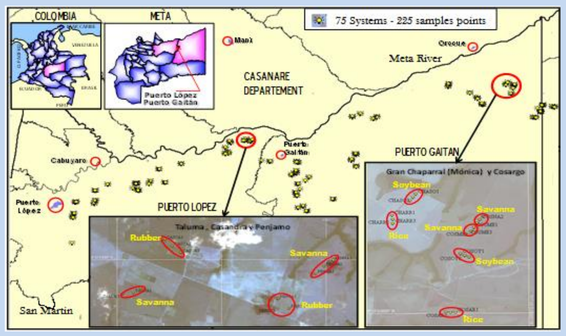

Figure 1. Map of study area

- Five indicators of soil-based ecosystem services were developed (Lavelle et al., 2014):
  1) Chemical fertility (nutrient provision)
  2) Physical properties (water storage and regulation)
  3) Aggregate morphology (maintenance of soil structure)
  4) Biological function (soil macrofauna abundance and diversity)
  5) Climate regulation services (C storage and greenhouse gas emissions)
- Ants were collected by excavation and hand-sorting of soil pits (25 x 25cm x 20 cm deep; Anderson and Ingram 1993)
- Ants were identified to the genus level (or greater resolution) and associated with the ecosystem service indicators using the IndVal method (Dufrêne & Legendre 1997)


Figure 2a: Improved Pasture


Figure 2b: Annual Crops


Figure 2c: Rubber Plantation

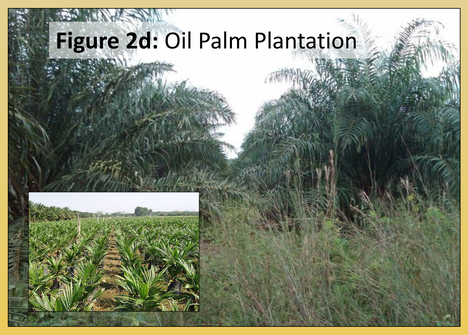
Figure 2d: Oil Palm Plantation


Figure 2e: Semi-natural Savanna

Results:

- In total, 5154 individuals were collected, comprised of 91 ant species and 33 genera.
- Management systems exhibited great differences in ecosystem service provision (Fig. 3) as well as ant abundance and diversity (Fig. 4).

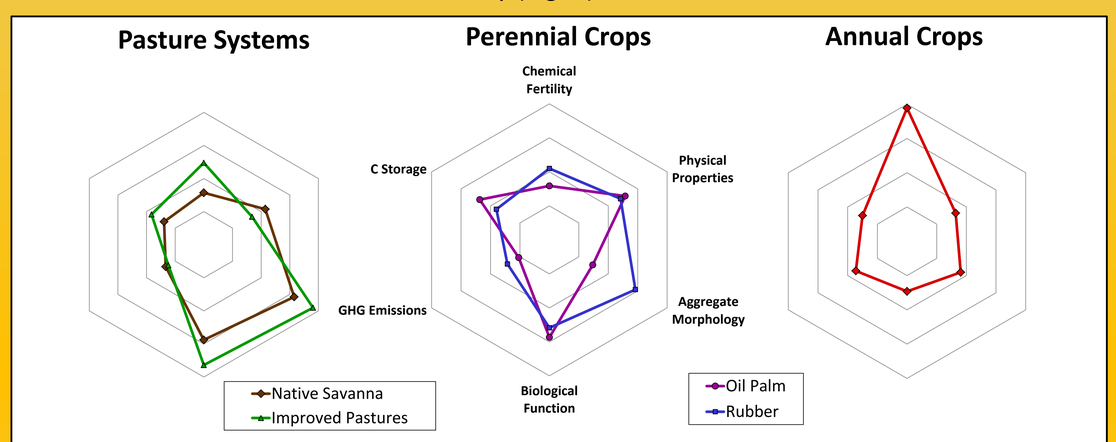

Figure 3. Indicators for soil-based ecosystem services for five dominant land uses in the Llanos region of Colombia (based on data from Lavelle et al., 2014)

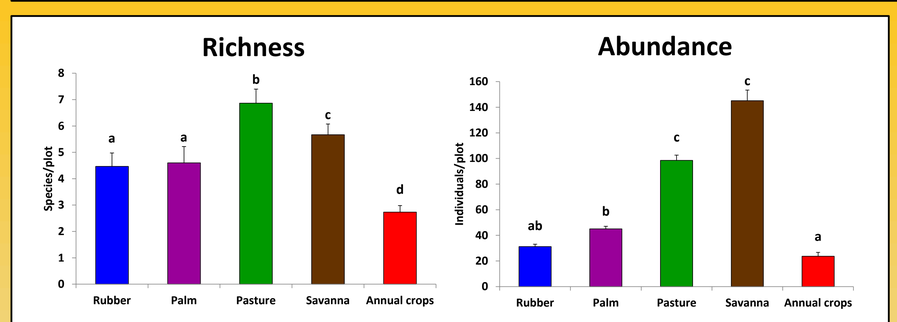

Figure 4. Mean ant species richness and abundance in five land uses in the Llanos region of Colombia.

Table 1. Analysis of indicator species for ecosystem services using the IndVal Method (significance is based on Monte Carlo tests). Values range from zero (no indication) to 100 (perfect indication) , while direction refers to low (-) vs. high (+) quality.

Ecosystem Service Indicator	Species	IndVal value		Monte Carlo Test	Indication Direction
		Observed	Expected		
Biological Function	*Brachymyrmex* sp. 2	22.2	6.8	0.005	+
	Hypoponera sp. 2	15.4	5.0	0.02	+
	Monomorium pharaonis	13.8	5.7	0.03	+
	Pheidole inversa	24.7	11.1	0.01	+
	Pseudomyrmex gracilis	20.7	6.3	0.008	+
Aggregate Morphology	*Acromyrmex sp. 1*	23.0	8.8	0.005	+
	Pheidole inversa	22.7	10.7	0.01	+
	Nylanderia fulva	28.0	15.5	0.017	+
	Solenopsis sp. 1	11.5	5.1	0.05	+
	Pseudomyrmex pallens sp.1	17.6	7.2	0.01	+
Physical Properties	*Hypoponera creola*	27.9	15.7	0.05	-
Nutrient Provision	*Crematogaster nigropilosa*	21.0	13.3	0.07	-
	Ectatomma ruidum	26.0	13.5	0.02	-
	Hypoponera creola	22.3	14.6	0.05	+
	Hypoponera punctaticeps	14.3	4.9	0.03	+
Climate Regulation	*Crematogaster curvispinosa*	44.5	11.8	0.05	+

Results (continued):

- Fifteen ant species were found to be significantly ($P < 0.05$) associated with the five indicators of soil-based ecosystem services, according to the IndVal method.
- These indicators could be implemented by technicians to better understand and manage the provision of ecosystem services from soils in agricultural fields.
- Collection and identification of these ant species is likely to be much faster and less expensive than measuring the associated ecosystem services.

Conclusions:

- Our findings support that land use greatly impacts ant communities, via clear effects on their diversity and abundance.
- Some forms of management and proper combinations of different land uses in the landscape could contribute to biodiversity conservation and ecosystem functions at the regional scale.
- Ants can serve as valuable bioindicators for land use impacts and ecosystem service provision, thus offering a valuable tool to help better manage agricultural landscapes.

Literature Cited:

Anderson, J.P.E. and J.S.I. Ingram (1993) Tropical Soil Biology and Fertility. A handbook of methods. CAB International. Oxon. 44-46.

Dufrêne, M. and P. Legendre (1997) Species assemblages and indicator species: The need for a flexible asymmetrical approach. Ecological Monographs, 67(3): 345-366.

Lavelle, P., N. Rodríguez , O. Arguello, J. Bernal, C. Botero, P. Chaparro, Y. Gómez, A. Gutiérrez, M.P. Hurtado , S. Loaiza, E. Rodríguez , C. Sanabria, E. Velásquez, and S.J. Fonte. (2014) Soil ecosystem services and land use in the rapidly changing Orinoco River Basin of eastern Colombia. *Agriculture, Ecosystems, and Environment*, 185: 106-117.

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