Ecosystem Integrity Index: A New Tool for Ecosystem Services Evaluation in Livestock Production Systems

Oscar Blumetto *, Andrés Castagna, Gerónimo Cardozo, Andrea Ruggia, Santiago Scarlato, Guadalupe Tiscornia, Felipe García and Verónica Aguerre*

National Institute of Agriculture Research (INIA), Uruguay
* Corresponding author email: oblumetto@inia.org.uy

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Introduction

Animal production systems based on rangeland are very complex being its management closely related to the functioning of the ecosystem in which it is supported. For assessing the environmental impact of livestock management many variables need to be considered, making difficult and expensive to obtain a comprehensive overview of the ecosystem state and evolution. Therefore a qualitative and quantitative assessment tool was developed in order to evaluate the integrity of the ecosystem under productive use that may be applied in a simple and practical process. The aim of this study was to evaluate the performance of the index in real production systems that were part of a participatory research project.

Materials and Methods

A three years co-innovation project was carried out in seven livestock farms based on rangelands, located in the east zone of Uruguay. The main goal was to improve the productive results while, maintaining environmental status and contributing to social development (Aguerre *et al*, 2015).

In this framework, Ecosystem Integrity Index (EII) was applied as a 10 points scale index (from 0 to 5, 0.5 step) that includes four dimensions: vegetation structure, species presence, soil erosion evidence and state of streams including water, riparian zone and vegetation, assessing the status of the ecosystem relative to a natural (low intervention) condition. The develop of the EII had three phases: a) design of the structure and evaluation protocol, b) discussion with interdisciplinary panel of specialists and c) application in different situation. Values were determined for each paddock of the farm and a general value was calculated by prorating the area contribution of each paddock as showed in the equation 1.

(Eq1)
$$EII = \sum_{n=1}^{n} \frac{(St_i + Sp_i + So_i + \ Rz_i\ )\mathrm{PA}i}{4FA}$$

Where, St_i=score value of vegetation structure for paddock i, Sp_i=score value of species presence for paddock i, So_i=score value of soil for paddock i, Rz_i=score value of riparian zone for paddock i, PA_i= area of paddock i and FA= farm total area

Each farm was evaluated at the beginning of diagnostic process and was re-evaluated three years later. In addition to this, beef production was estimated for the three years before starting the project by using farmer's data and measured during the project implementation. Also biomass production, grassland structure and diversity, soil organic carbon, and birds assemblage were evaluated (Blumetto et al, 2014). In order to validate EII, Pearson correlation coefficients between EEI and other variables were obtained.

Results and Discussion

The environmental quality measured throw the EII stayed without substantial changes while productive results (beef kg /hectare/year) increased comparing the average of the three years before starting the project with the average of the three years of the project implementation (see table 1).

This could indicate that low input technology applied can be an adequate option for the sustainability of this production system.

Table 1. Values of Ecosystem Integrity Index and beef production for the seven study cases.

Farm	A	B	C	D	E	F	G
EII (2012)	3.3	3.0	3.8	3.9	3.7	3.6	3.4
EII (2015)	3.5	3.2	3.7	3.9	4.0	3.7	3.6
EII difference	0.2	0.2	-0.2	-0.1	0.2	0.1	0.2
BP b 2012	78	80	30	63	59	101	127
BP 2012-2015	126	83	71	83	84	119	181
BP difference	48	3	41	20	25	18	54

EII (2012): Ecosystem Integrity Index obtained at the start of project; EII (2015): Ecosystem Integrity Index obtained at the end of project; BP b 2012: Beef production Kg/ha estimated average three years before project; BP b 2012: Beef production Kg/ha measured average for the three years of the project

In order to validate the EII as an evaluation tool for the functionality of the ecosystem, correlation with other variable were studied (table 2).

Table 2. Pearson Correlation Coefficient between Ecosystem Integrity Index and other variables.

Variable	Shannon Birds	Richness Birds	Shannon Grass	Richness Grass	C Org 0-3 cm depth	C Org 3-6 cm depth	Sward height (cm)	Biomass (kgDM/ha)	Stocking rate (LU/ha)
Pearson EII	0.77	0.81	0.82	0.76	0.74	0.57	0.07	0.12	-0.65
p	$1.8E^{-09}$	0.03	0.05	0.02	$1.7E^{-03}$	0.03	0.79	0.64	0.12

EII had positive correlation with species richness and diversity of grasses and birds. Both variables do not integrate directly the index, although some appreciations of herbaceous communities are included. Three of the index dimensions can be associated with bird diversity: vegetal diversity, vegetation structure and riparian zone status, which could explain this strong correlation. EII values had also positive correlation with organic carbon content of the soil in both 0 to 3 cm and 3 to 6 cm depth. Organic matter of the soil is considered strongly associated to productivity and soil health, and important support for many ecosystem services.

No correlation was found for average sward height and aerial biomass, which means the index result independent of characteristics that can change in very short time and are associated to management decisions. Although not significant, a tendency of negative correlation was found with stocking rate, which high values are widely associated to rangeland degradation (Angerer *et al*, 2016).

Conclusion

A practical and low cost tool (Ecosystem Integrity Index) have been developed and shown to be useful for evaluating several aspect of the ecosystem functionality. Additionally, EEI provides numeric values that can be useful for comparing different farm or paddock level, and also can be mapped in order to help to farmers in management decisions.

References

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