Monitoring Technology for Semi-Arid Rangelands: The MARAS System

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Introduction

Long-term land monitoring technology is needed to track slow changes in arid lands and evaluate biodiversity, biological invasions, local extinctions and physical or chemical soil variations including carbon storage. Consistent data sets are lacking because researchers and government agencies use multiple techniques to evaluate the same variables. The MARAS monitoring system (acronym for Monitoring Arid and Semiarid Lands) is a set of standardized techniques that enable different research teams collaborate across wide geographical areas using a common open data-base (Oliva et al. 2011), and this ground data has been combined with remotely sensed information (Gaitán et al. 2013). The effort was partly financed with Gobal Environmental Funds and consists of a network of permanent sites that monitor Ecological Units in a 800.000 km-2 area in Argentina and Chile, that are now in 5-year reassessment process. The objective of this paper was to analyze data obtained in the first assessment in order to estimate errors at two scales: Site subsample variability was analyzed to determine expected errors of the means for the main variables using the fixed sampling effort that is prescribed in the MARAS manuals. At regional scale, between-monitor variability was analyzed in order to determine the minimum number of monitors that deliver an estimate the regional mean within an acceptable error. This analysis shows an estimate of precision of the evaluations and the power to evaluate changes in the future.

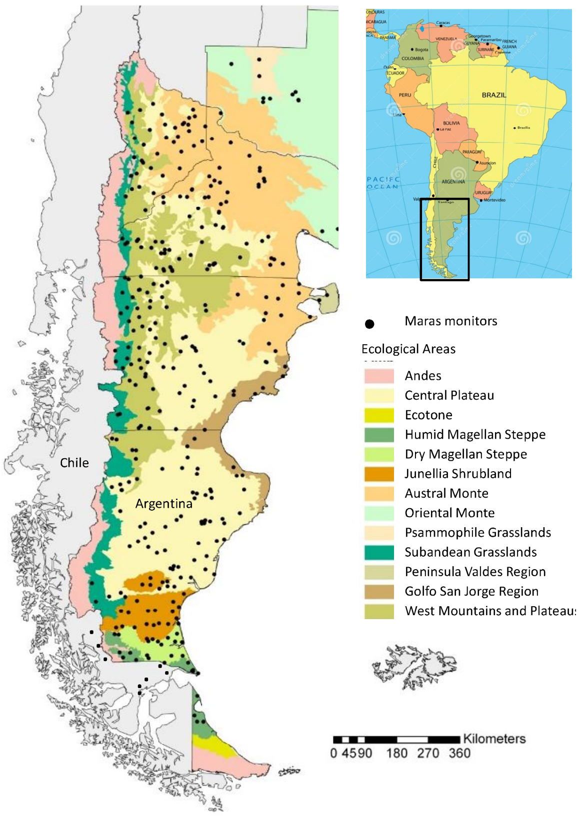

Figure 1. Location of the MARAS sites (black dots) and Ecological Areas of Patagonian region (December 2015).

Materials and Methods

Three hundred and fifty (350) ground-based monitors were set up between 2008 and 2014 in Patagonia, southern Argentina and Chile. Vegetation ranged from shrublands to grasslands and semi-deserts and has been classified in 13 Ecological Areas (Figure 1). Soil cover was sampled with two 50 m transects with a total of 500 points. 50-m long Canfield interception lines were used to recognize >5cm interpatches (areas that loose resources) and >10 cm patches (resource sink areas). Eleven LFA (Landscape Function Analysis) indicators were recorded in 10 bare soil patches and combined to asses: Soil stability, Infiltration and Nutrient cycling. Composite soil samples of patch and interpatch soils were obtained at 0-10 cm depth ant tested for Organic Matter, N, texture, pH and conductivity. Information was stored in a unified database that is accessible through web browsers. Error associated to site observation was estimated by evaluation of variability in 10 subsamples of 50 points in line intercept, variation between 50 interpatches and 10 LFA observations per site. Minimum number of transects required to sample an EA with an error of 5% was estimated using Koltrik and Higgins (2001):

$$n = \frac{(Z_{\alpha/2}\sigma)^2}{(E)^2}$$

Where:
n = number of transects needed. / $Z_{\alpha/2}$ = False-change Type I error rate 0.5 with a probability= 1.96 / σ = Standard deviation of the plots / E = Error in absolute terms.

Results and Discussion

At a plot scale the 500 intercept points provided estimations of vegetation cover within 4.4% absolute cover error. 50 patch-interpatch Canfield lines provided interpatch length estimations within a 6 cm error. 10 LFA Stability index observations provided estimations within 4% in a site. At a regional scale, the minimum number of monitors needed to estimate cover within 5%, richness within 2sp, Interpatch length within 20 cm and Land Function Indexes within 5% varies widely in different Ecological Areas (Table 1).

Table 1. Minimum sample estimation (n° of monitors) in order to estimate four variables (cover, richness, length of interpatches and stability) in the main Ecological Areas of Patagonia.

Ecological Aera	Total area (km^2x 1000)	Monitors installed	Minimum sample (N° monitors/region)			
			Vegetation cover	Species richness	Interpatch length	LFA Stability index
Mean error			5%	2 sp	20 cm	5%
Central District	2066	124	35	42	94	16
Humid Magellan Steppe	79	15	7	16	69	29
Dry Magellan Steppe	90	14	12	13	19	11
Junellia Shrubland	218	24	9	36	12	8
Austral Monte shrubland	1584	56	41	40	19	28
Subandean grasslands	384	24	33	104	54	18
Golfo San Jorge region	202	11	37	23	32	14
West Plateaus and Mountains	952	70	41	48	36	19
Total	5575	338	215	322	335	143

Conclusions and Implications

The sampling effort in each monitor (500 points, 50 m canfield lines and 10 LFA readings) provided site means for the main variables within 5% error. The number of monitors installed by December 2015 provided estimations for cover, diversity, patch size and land function indexes within acceptable errors (Table 1), but more monitors are needed in particularly variable regions such as Subandean Grasslands and Golfo San Jorge Region. Use of standarized methods and precise re-location of the transects will provide evaluations of change with a precision that has not been previously possible and may guide policy-making in view of climate change and natural catastrophes affecting these unique ecosystems.

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The Rangeland Vegetation Simulator: A User-Driven System for Quantifying Production, Succession, Disturbance and Fuels in Non-Forest Environments

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Introduction

Rangeland landscapes occupy roughly 662 million acres in the coterminous U.S. (Reeves and Mitchell 2011) and their vegetation responds quickly to climate and management, with high relative growth rates and inter-annual variability. Current national decision support systems in the U.S. such as the Interagency Fuels Treatment Decision Support System (IFT-DSS) require spatially explicit information describing production, fuels, grazing capacity and successional trajectory. However, no single system presently offers this information. In addition, issues of increasing national attention, such as preservation of lekking birds (e.g. greater sagegrouse (*Centrocercus urophasianus*), and greater prairie chicken (*Tympanuchus cupido*)), has prompted new management guidelines such as stubble height standards, but ecological tools for predicting this type of management outcome on rangelands are quite limited in their ability to predict these variables. Therefore a system is needed that quantifies these vegetation and fuel characteristics in sufficient detail to permit estimations of annual production, treatment success, grazing capacity, and fire behavior and effects. This situation inspired our project to develop a comprehensive program for simulating succession, productivity, and fuels in non-forest environments. This system is called the Rangeland Vegetation Simulator (RVS).

Materials and Methods

The RVS is a multithreaded, portable program written in C#. It also operates in a spatially explicit mode using a series of Python scripts through ArcGIS 10.X. A minimum of six inputs is required for simulating forage and fuels with the RVS (Table 1). The geospatial location is especially critical since it enables sampling of either the Biophysical Settings (BPS) geospatial data product (Rollins 2009) and their associated successional models, or state – transition models from Ecological Sites (Caudle et al. 2013) Growth and production of herbaceous species is governed by the site for which the simulation is being conducted, annual precipitation, and Normalized Difference Vegetation Index (NDVI) (Table 1). Growth and production of shrubs is controlled by allometric relationships and the site on which the shrubs are found. In a similar manner, quantifying fuel loadings of various fuel size classes is also accomplished using allometric equations for shrubs. For example, using height, cover, and species information, the loading of 0.64, 0.64 - 2.54, 2.54 - 7.62 and 7.62 - 20.32 cm. fuel size classes can be estimated using these equations. The RVS offers 46 allometric equations for quantifying and mapping biomass, production and fuels across the landscape. These fuel and production estimates are also influenced by management treatments including mechanical thinning, wildfire and herbivory. The RVS permits user-designed shrub overstory reduction as a treatment option and offers simulation of wildfire effects on shrub mortality and accompanying herbaceous response. Likewise the RVS simulates the effects of herbivory by both grazers and intermediate species (e.g. cattle vs. goats) on standing crop, stubble height, successional trajectory, shrub stature and associated fuel bed components.