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Identification of beef production farms in the Pampas and Campos area that stand out in economic and environmental performance

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ABSTRACT

Worldwide, native grasslands are being converted to non-native pastures and cropland. This process threatens local grassland biomes as well as the livelihoods of farm families that utilize these grasslands.

In the Río de la Plata grasslands region meat production and multispecies native grasslands have coexisted for more than 400 years. Low levels of meat productivity and farm income, however, trigger replacement of native grasslands by crops and leys and threaten the survival of local beef farming systems. We studied the economic and environmental performance of beef farming in the region based on interviews and field measurements on 280 case study farms with the following aims: (a) to identify the multi-functional economic and environmental performance of beef farms across the Rio de la Plata grasslands biome; (b) to identify farms with 'outstanding' multi-functional performance; (c) to compare performance levels with those found in other regions; and (d) to discuss the implications of the outstanding farms for the development of new systems of meat production. The representativeness of the case study farms was ascertained by comparing them with a farm typology constructed from survey data of 15,448 beef farms situated predominantly on native grasslands in Argentina, Brazil and Uruguay. We identified seven farm types on the basis of farm size, labour, farm specialization, land use and stocking rate.

We identified positive deviant farms based on Pareto-ranking and compared these with a classification based on threshold values provided by experts. Out of the 280 farms, 41 were ranked as Pareto-optimal, i.e. outperformed other farms in one or more indicators without being outperformed in other indicators. Out of these, 5 were positive deviants, achieving on average 192 kg LW ha^{-1} yr^{-1} of livestock productivity and 201 US$ ha^{-1} $year^{-1}$ farm income, having most favourable values for fossil energy consumption, phosphorus balance, carbon footprint and having over 95% of their land under native grassland as a proxy for biodiversity conservation value. Four of these farms belonged to farm types that together represented 55% of the population, suggesting scope for widescale improvement.

Compared to the values reported for the OECD countries the beef farming systems of the Río de la Plata grasslands region consume less energy and positive deviant farms demonstrated approximately average livestock productivity and carbon footprint. Increasing livestock productivity in the Rio de la Plata grasslands region resulted in a stronger decline of the carbon footprint without compromising the current negligible levels of fossil fuel energy use. Further elucidation of management practices that lead to positive deviant performance will require modelling of the interaction of pasture and herd dynamics at farm level and is needed to support targeted policy support for sustainable natural grassland-based beef production in the region.

1. Introduction

The global increase in animal protein consumption (FAO, 2006; Godfray et al., 2010) has resulted in intensification of livestock production (Naylor et al., 2005; Steinfeld and Gerber, 2010). Worldwide, native grasslands are being converted to non-native pastures and

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cropland, which threatens local grassland biomes (Newbold et al., 2016) as well as the livelihoods of farm families that utilize these grasslands (Ellis and Ramankutty, 2008; Hoekstra et al., 2005). At the same time, concerns have been raised about the impact of livestock production on climate change, deforestation, biodiversity loss, water contamination and fossil energy depletion (de Vries and de Boer, 2010; Gerber et al., 2013; Herrero et al., 2015, 2009; Steinfeld et al., 2010). Meat production systems that make use of the local plant species diversity of native grasslands and value chains that provide financial rewards for biodiversity-supporting farm practices constitute a way to halt the decline of native grasslands and the ecosystem services that they provide (Power, 2010).

The *Río de la Plata grasslands* cover an area of 700,000 km^2 (28°–38° S; 47°–67° W) in south-east South America (Argentina, Brazil and Uruguay) where meat production and native grasslands have co-existed for more than 400 years (Soriano, 1992; Viglizzo et al., 2001). These grasslands are a hotspot of biodiversity, including 3000–4000 different plant species (Bilenca and Miñarro, 2004; Overbeck et al., 2007), and provide societal benefits such as climate regulation, biodiversity conservation, water purification and regulation, soil erosion control, and low-input, grazing-based meat production. Low livestock productivity and farm income threaten the survival of these local beef farming systems, and render the area vulnerable to replacement of native grasslands by crops and leys[1] (Baeza et al., 2010; Modernel et al., 2016; de Oliveira et al., 2017; Pimenta et al., 2016; Vega et al., 2009).

The assessment of economic and environmental performance of the current farming systems of the *Río de la Plata grasslands* region has been addressed in different studies through the construction and evaluation of stylised model-based farms (Pashaei et al., 2016; Picasso et al., 2014). There is, however, no previous study that evaluated economic and environmental farm performance based on actual farms that are representative across the three countries that compose the *Río de la Plata grasslands* region. Such biome-wide information about economic and environmental farm performance would help to direct policies, and economic or legal support mechanisms for beef farming systems that combine food production with provision of other ecosystem services.

To date, many impact assessment studies on beef farming tend to label grassland-based beef production as 'unsustainable' due to their large carbon footprint (Capper, 2012; de Vries et al., 2015; Modernel et al., 2013; Pelletier et al., 2010; Von Bernard et al., 2007). Publications from the region propose various management changes to decrease greenhouse gas emissions and thus reduce the carbon footprint (Dick et al., 2015a; Picasso et al., 2014; Ruviaro et al., 2016). These proposals involve altering native grasslands by adding species or fertilizers, substituting native grasslands by leys, or by providing supplements to cattle. While reducing the carbon footprint, at the same time trade-offs appear with other sustainability indicators such as biodiversity conservation, energy consumption from fossil fuels, pesticide risk and nutrient balances (Modernel et al., 2016, 2013; Picasso et al., 2014). This focus on carbon footprint as the major indicator to assess sustainability of livestock production has dominated the international debate (Garnett, 2009; Schwarzer et al., 2012), and it should be enriched by a multi-functional perspective.

Few studies have addressed multi-functionality of grassland-based beef farming systems by assessing the various ecosystem services that these systems provide simultaneously (Duru et al., 2015; Power, 2010; Werling et al., 2014), or quantified the trade-offs that may exist between economic, environmental and social benefits (Herrero et al., 2009; Hoffmann, 2011). From a landscape ecology perspective, several authors have pointed out the need to address bundles of ecosystem services associated with particular land use systems and to identify implicit interactions and trade-offs (e.g. Bennett et al., 2009; Raudsepp-Hearne et al., 2010). This study aims to contribute to the empirical basis of multifunctionality of agriculture and the provision of bundles of ecosystem services by studying the case of beef cattle farms in the *Rio de la Plata grasslands* region of south east Southern America.

In a region, a large diversity of farming systems and management practices generally co-exist. Policy development aimed at greater productivity with minimum environmental impact can benefit from this diversity by identifying promising, yet rare options and by effectively addressing least desirable systems (Andersen et al., 2007; Kuivanen et al., 2016). A combination of farm typologies to reveal diversity and agro-environmental performance assessment has been shown to provide useful information for developing and targeting policies and supporting research and development (Andersen et al., 2007; Haileslassie et al., 2016; Landais, 1998; Righi et al., 2011; Tittonell, 2014a; Tittonell et al., 2010). Farm typologies have been developed to reveal relevant farm diversity, usually based on structural farm attributes (Tittonell et al., 2005). While typologies result in clusters of farms with similar structural attributes, these do not necessarily give insight in farm functioning as would be needed for addressing multifunctionality (Cortez-Arriola et al., 2015; Kuivanen et al., 2016; Pacini et al., 2013). Thus, other methods are needed to identify relevant variation in farm populations. In this paper, which aims to contribute to systems of beef production with greater economic-environmental benefits than the current systems, we will use methods to identify farms that stand out from the population of farms in terms of their economic-environmental performance. Our paper has four main goals: (a) to identify the multifunctional economic and environmental performance of beef farms across the *Rio de la Plata grasslands* biome; (b) to identify farms with 'outstanding' multi-functional performance; (c) to compare performance levels with those found in other regions; and (d) to discuss the implications of the outstanding farms for the development of new systems of meat production.

2. Materials and methods

We conducted a detailed survey of 280 beef farms in the three countries that harbour the *Rio de la Plata grasslands* biome (Argentina, Brazil and Uruguay), and assessed their economic and environmental performance. We identified farms with performance levels that made them stand out from the population of sample farms. In order to evaluate if these farms resemble the farming systems of the region, the sample farms were compared to a typology built from a database of 15,448 farms of the region (Fig. 1).

2.1. Study areas and case study farms

Seven study areas were selected: two locations in Argentina (*Entre Ríos* and *Mercedes*), two eco-regions in Uruguay (*Eastern Sierras* and *Basalt*) and three municipalities in the south of the Brazilian state of Río Grande do Sul (*Santana do Livramento*, *Dom Pedrito* and *Bagé*). The selection of the study areas was driven by two criteria: beef farming is the main agricultural activity and land use is predominantly native grassland (Table 1, Fig. 2).

Local experts including agricultural extension agents, technical advisors, researchers and farmers were approached to name farms and farmers that they considered representative of the beef farming systems in each study area. In selecting the farms, the experts were asked to consider the regional diversity in farm size, dominant soil types, livestock and crop management, and farmer participation in professional networks. This resulted in 24 beef farms in Brazil, 33 in Argentina and 223 in Uruguay (including 208 farms participating in a project of the Ministry of Agriculture and Universidad de la República of Uruguay).

The farmers were approached for a structured interview. In 2015, structured interviews were held with the 280 farm heads (men in 230 cases). The interviews focused on collecting data for the period July 2014 to June 2015 on farm structure (land area, land use, herd

[1] Ley: Temporary pastureland/grassland that is integrated in a crop rotation (Allen et al., 2011).