The Importance of Campos Ecosystem as a World Food Producer and as a Provider of Ecosystem Services

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Abstract
The Campos ecosystem represent one of the largest grassland areas on the world, with great biodiversity in plants and animals. It contributes to improve world food security, based on ruminant livestock production, providing animal protein to feed more than 160.000.000 people. The research agenda for Campos ecosystem demands attention on the productivity and increasing variability phenomena, overgrazing, biodiversity standards and water contamination among other factors. It provides services including genetic resources, carbon storage, control of soil erosion, nutrient recycling, water production with low nutrient concentration and pest control. Overall, there is available technology to improve long-term livestock productivity and preserve current environmental indicators and improve sustainability, contributing to supply increasing world food demand.

Introduction
More than a decade ago, the IGC-IRC agenda held in Hohhot - China 2008 emphasized some emerging issues associated to global warming, the growing population, quality and welfare food, social stability, alternative energy sources, protection of environment and resources among others. The multifunctional use of grasslands introduced a new prospective from potential opportunities provided by grasslands over the world. By 2050, an increase of 34% in world´s population is expected reaching 9.8 billion people. Currently, the dilemma still in to meet the increasing food demand, preserving biodiversity and ecosystems services and minimizing negative environmental effects. The Rio de la Plata Grasslands region (750.000 km^2) in southern South America is one of the largest areas of temperate rangelands over the world. The Pampas and Campos biomes are being affected by the intensification impacts. Despite that, these grasslands feed 42.1 million heads of cattle and 11.9 million heads of sheep, making a significant contribution to global food security.

Impacts, at ecosystem scale, are being leading mainly by agriculture and forestry expansion during the last two decades, because of positive economic inputs. In the southern portion of South America, the area of summer crops (mainly soybean) and "double crops" (wheat-soybean within the same paddock) increased by 62% and 52% respectively (Volante et al. 2015). Most of these changes occurred at the expense of perennial crops (mainly cultivated pastures) and natural habitats (Rearte, 2011). This transformation occurred in 14.2% of the rangelands of the Rio de la Plata (Baeza & Paruelo, 2020). In consequence, livestock production systems are being reoriented, in terms of increase their profitability. In extensive systems, feed resources mainly supported by native grasslands, small improved areas and strategic supplementation. Native grasslands provide an increase in productivity if more refined management practices are applied at global scale. Intensive systems combined introduced pastures, in rotation with crops, use of crops residues, cover crops, hay or silage, mainly to finishing animals. Associated synergies contribute to speed up from calf-cow to finishing processes.

Forage productivity and variability
The Campos region is situated between 24^0 S to 35^0 S, covering approximately 500.000 km^2 of north east of Argentina, south of Brazil and the whole of Uruguay. Considering transitional areas and the Pampas region area is extended to approximately 750.000 km^2 (Soriano, 1991; Pallares et al., 2005). It is one of the largest grazing lands in the world for livestock production. The climate is humid subtropical to temperate, with four defined seasons. Rainfall ranged from 1200 to 1600 mm approximately, with a gradient in temperature from north to south (Oyarzabal et al., 2019). These grasslands are bordered by deciduous xerophytic forest to the west, and deciduous tropical and subtropical humid forests to the north (Overbeck et al., 2007; Andrade et al., 2018; Oyarzabal et al., 2018). Grasslands co-dominated by C3 and C4 species are the most abundant physiognomic type, combined with shrublands and forests (Boldrini, 1997; Overbeck et al., 2007; Perelman et al., 2001, 2017; Oyarzabal et al., 2018; Lezama et al., 2019). Winter is the period with lowest herbage growth rates (5-10 kg/ha/day of DM), contributing with around 10% of annual biomass produced (Bermudez & Ayala, 2005, Baeza et al. 2010). In some conditions, the promotion of C_3 grasses is an alternative to improve pasture growth and seasonal distribution (Bendersky & Pizzio, 2013).

Biomass production has a wide-ranging because of soil conditions, fertility, water accumulation, vegetation types and gazing management. As a reference, annual productivity of native grasslands in the basaltic is 2.9 ± 0.8, 4.5 ± 1.0, 3.8 ± 1.0 to 8.1 ± 0.5 t DM/ha/yr in shallow, black and two deep soils respectively over 15 years (Berretta, 2005; Rodriguez Palma & Rodriguez, 2017). On the granitic areas in the easter region of Uruguay productivity is 1.4 ± 0.6, 1.1 ± 0.5 and 3.7 ± 1.0 t DM/ha/yr in hill areas, poor fertile of medium fertile soils on rolling areas respectively for a series between 8 to 12 years of monitoring (Mas et al., 1997; Bermúdez & Ayala, 2005). In easter region of Argentina, annual productivity

of native grasslands in three different vegetation types is 3.7 ± 0.8, 4.8 ± 0.7 and 6.3 ± 1.3 t DM/ha/yr in `flechillar`, `pajonal` and `pastos cortos` respectively (Bendersky et al., 2017a). In Uruguay, productivity of native grasslands varies from 2.5 to 5.0 t DM/ha/yr, with extreme values of 1.5 to 6.5 t DM/ha/yr under extreme drought or rainy conditions (Ayala et al., 2011). However, by correcting fertility through the addition of phosphorus and nitrogen, PPNA values of 10 t/ha/yr can be achieved (Bendersky et al., 2017b). The variability in herbage production between and within years affect pasture management and animal performance in terms of liveweight gains to reproductive performance of herd in extensive systems, demanding adjustments in stocking rate (Cardozo et. al, 2015), strategic use of improved pastures or supplementary feed (Modernell et al., 2016). For those areas of Uruguay dominated by native grasslands, the PSN was around 760 MJ.ha-1.yr-1 or, in meat equivalents, 77 kg.ha-1.yr-1. This represents a forage-to-meat conversion efficiency of 1.17% (Gutierrez et al. 2020). The control of grazing control, generating adequate sward structures, allows to increase animal productivity, soil quality and water infiltration (Nabinger et al., 2011).

Livestock production

The Campos region support 11.9 and 42.1 million heads of sheep and cattle respectively (Table 1). The high proportion of sheep stock (55%) is settled in Uruguay and the cattle stock (43%) in Argentina. Meat and wool produced is exported in a high proportion to different countries.

Table 1. Cattle and sheep stock in the Campos region.

	Argentina[1]	Brasil[2]	Uruguay[3]	Total
Sheep (heads)	2.136.902	3.187.776	6.562.000	11.886.678
Cattle (heads)	18.113.945	12.561.431	11.411.000	42.086.376

Source: [1]MAGP-SENASA, 2019; [2]Socioeconomic Atlas, 2018; [3]DIEA, 2020

The slaughter rate of animals in Uruguayan herd is 19 and 13% for cattle and sheep respectively (DIEA, 2020). Based on local indicators, outputs from Campos region are being situated on 4.1 and 0.95 million ton of meat of cattle and sheep respectively. Meat consumption rates vary largely among countries, but estimations of consumption rates are 30 kg/habitant of meat including cattle and sheep together (OCDE, 2017). Potentially, the region can provide meat to feed 168.333.333 million people. The 60-70% of produced meat is exported, contributing to feed more than 108.000.000 million people living outside region.

Biodiversity and Ecosystem Services (ES) supply

The region shows a population of 3000 vascular plants, 450 grasses and 150 legumes with forage value, 385 species of birds and 90 terrestrial mammals (Berretta, 2001; Bilenca & Miñarro, 2004; Pallares et al., 2005; Boldrini, 2007). The great diversity of species allows to be a center of origin of germplasm. From the prospective of herbage production, native grasses and legumes are adapted to intensive and frequent grazing and to variations in climate conditions and the occurrence of extreme phenomena (drought -wet, cold-hot, poor fertility-high fertility). There are opportunities for the domestication of native species as well as the use of existing genetic variability for the development of new cultivars of those species of forage value. To understand the potential of native genetic resources from feed source, ornamental, aromatic, nutraceutic or cultural use demands actions of prospection, characterization and conservation (Ayala et al., 2011), especially in areas under risk by the agriculture pressure. Based on biodiversity analysis that integrate species richness (plants, animals) together with soil and water status at paddock scale Blumetto et al. (2019) built an integrity ecosystem index (2017), a tool to evaluate the sustainability of productive systems operating on Campos ecosystem according to economic, social and environmental dimensions. Paruelo et al. (2016) presented a synoptic index on the supply of regulating and supporting ES based on remotely sensed data. The Index was tested to evaluate the level of degradation of grasslands areas (Staiano et al. 2020). State and Transition Models were generated for the main grasslands' communities and geomorphological regions of Uruguay (Altesor et al. 2019, 2020). The Basaltic Cuesta region, in the North-central part of the country presented the best-preserved grasslands.

Outputs from Campos region

The intensification process on livestock production is expected in the next decades based on the increase in world population and food demand, affecting the ecosystem services supply from Campos biome and the conservation status (Paruelo et al. 2016; Modernell et al., 2016; Tiscornia et al., 2019; Baeza & Paruelo, 2018; Texeira et al. 2019; Rivero et al., 2021).

Intensification alternatives to increase meat production and maintain/improve ecosystems services supply must consider:

1. Effects on biomass production: productivity, overgrazing, floristic composition
2. Effects on livestock production: growth rate, reproductive processes, feed conversion efficiency
3. Effects on renewable resources: soil health, water requirements and quality
4. Effects on environment: erosion, nutrients cycle, greenhouse gas emissions, carbon stock, climate change
5. Effects on population: lifestyle, heritage, consumer preferences, human health

Series of topics related with intensification are in the research agenda of different institutes and universities on the region Campos. The "Grupo Campos" is an organization (see www.grupo-campos.org) with actors involved in research, teaching

and transfer actions to promote sustainable livestock production systems. Regularly, meetings allow to see the focus of these group of institutions.

In table 2 there is a list of communications presented in Proceedings of Grupo Campos during 2017 and 2019, 67 and 54 respectively. The 14% of total reports refers to emerging topics as nutrients cycle and gas emissions. Clearly, topics like biomass production, pasture management and utilization and plant ecology and physiology represent the focus (52%). The design and study of production systems and animal performance signify 25% of the list of reports.

A network of approximately 15 universities, 3 research institutes and 3 extension services units still active in the region.

Table 2. Research communications on "Grupo Campos Proceedings" between 2017 and 2019.

Year	Genetic resources	Productivity Quality	Management Utilization	Ecology Physiology	Diseases Weeds	Nutrients cycle	Gas emissions	Production systems	Animal performance
2017	-	17	3	10	4	11	1	12	9
2019	6	13	6	14	1	4	1	5	4

Source: Grupo Campos (www.grupo-campos.org)

Conclusions

The biome Campos and Pampas in the south of South America have the potential to play an important role in food security for world human population. There is knowledge available to improve productive inputs, intensifying the pastures-based system based on process technologies. There is a regional network including universities, research institutes and extension services to adapt and develop technologies for future scenarios. At the same time, agriculture and forestry are competing for available grassland scenario for livestock but providing synergies as sub-products to feed livestock or conditions to reduce negative effects of climate and improve animal performance. This region offers a series of ecosystems services, being necessary mitigate emissions, in a changing climate scenario, but maintaining or improving carbon stock inventory. To improve the feed conversion efficiency is critical in terms of improve resources efficiency and reduce contamination.

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