



## **Transformation of tacit knowledge into recommendations for ranchers through rural extension in Uruguay.**

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### **Abstract**

Grasslands cover more than half of the Uruguayan territory. The Instituto Plan Agropecuario (IPA), a national extension agency, is implementing a project to systematize and promote good grassland management practices (2021-2025). The project considers the knowledge that ranchers have (tacit knowledge) and thanks to which they have been able to successfully develop in a changing and unpredictable environment. This initiative uses an open innovation framework through 26 "living laboratories" installed in different parts of the country. Through a monitoring and evaluation system, 28 key grassland management practices have been identified, which are classified into five macro-variables, which interact with each other and with the broader context. The macro variables are: infrastructure, strategic productive areas (EPA), grazing management, livestock management, and monitoring system. The rancher is responsible for decision-making. Due to limited cognitive abilities, incomplete information, and the complexity of the context, ranchers often adopt a "satisficing" approach rather than "maximizing" when making decisions. To conclude, a conceptual model was developed that describes the main macro variables related to good grassland management practices. Monitoring these macro-variables would allow ranchers to establish their current situation and co-design a route of action together with ranchers and extension technicians. Paddockging is highlighted in the case of infrastructure, the proportion of improved area in the strategic production areas (EPAs), the proportion of the ranch over 5 cm (PRO5) in the case of grazing management, strategic supplementation for livestock management and the importance of having a monitoring system. The work balance reveals that there are agents who have two hours a day to "think" about the management of macro-variables and there are others who, due to the dedication required by routine work, do not have this possibility. Extension has an important role in promoting learning, through integrating and sharing different types of knowledge, and reflective processes and group strategies.

### **Introduction**

Grasslands currently occupy 55 percent of the national territory (MapBiomass Uruguay, 2024), constituting the main feed source for livestock in Uruguay. There is scientific evidence of the importance of grasslands management in determining good economic, productive and environmental results (Torres et al. 2024).

Recognizing that ranchers have an important capital in accumulated tacit knowledge, which is valuable, little known and little understood, the Instituto Plan Agropecuario is implementing a project called "Grassland Management", which aims to rescue this knowledge, systematize it and make it explicit to the rest of the national livestock industry.

## Methods

Twenty-six ranches (cattle and sheep) located throughout the country were selected. The sampling was done by convenience, choosing ranchers who managed grasslands in a way that allowed them to obtain outstanding results.

Under a theoretical framework of open innovation and adaptive management (Holling 1978), each ranch was taken as a “living laboratory” (Higgins et al., 2011) and monitoring was initiated that covered productive, economic, environmental and social aspects (fiscal years 2021/22, 2022/23, 2023/24).

The variables monitored and their frequency were: sward height of each paddock (seasonally), weight of cattle (seasonally), weight of sheep (seasonally estimated); from this information an index was used to estimate a forage balance, Food Plate Index (Duarte et al. 2021). Net primary production area (NAPP) was also estimated. All this information was recorded in a platform called iPasto (Lombardo et al 2021).

Information was collected to estimate meat production, economic results and environmental performance indicators. A typology of ranchers was made, through semi-structured questionnaire, since it combines open-ended questions with a general consultation scheme, allowing flexibility to go deeper according to the answers given by the interviewee to characterize the manager's vision of the aspects that affect grassland management, and the work balance was calculated (Dieguez et al., 2009). The environmental livestock tool (EMAG) (Becoña, 2020), the index of ecosystem integrity (IEI) (Blumetto, 2021) and environmental performance indicators included in the livestock environmental footprint (Paruelo et al., 2023) were applied.

This information was managed in 150 dialogue workshops - biannual frequency - with ranchers neighbouring each laboratory. They were evaluated with a focus on learning.

The database was analysed through descriptive statistics, performing linear regressions and multivariate analysis, using the statistical package Infostat/L version 2017.

## Results

The farms analysed were dedicated to cattle ranching, with an average area of 1,295 hectares, ranging from 60 to 5,500 hectares. Regarding production systems, 40% of the farms focused on breeding, 24% operated a complete cycle, while the rest were divided among incomplete cycle (12%), backgrounding (12%), and finishing (12%). The average improved pasture area was 23%, with some farms heavily relying on improvements; 11 of them had over 90% grasslands, and three operated entirely on improved pastures.

Grazing methods varied across the farms. While 24% implemented rotational grazing, 28% combined continuous grazing with rest periods and rotational modules. Another 19% practiced continuous grazing with paddock rest, whereas 7% maintained continuous grazing without rest. Sheep were present in more than half of the farms (52%), with an average sheep-to-cattle ratio (S/C) of 1.21. Meat production levels averaged 114 kg/ha, fluctuating between 70 and 248 kg/ha, while capital income (CI) stood at 92 USD/ha, with values ranging from 28 to 171 USD/ha. The economic input/output ratio was 0.6, with a variability between 0.4 and 0.8.

Net aboveground primary production (NAPP) for the 2021/22 season aligned with the historical average recorded between 2000 and 2024. However, in 2022/23, NAPP was 9% lower, whereas in 2023/24, it exceeded the average by 18%.

A survey conducted during the study identified 28 good practices related to grassland management. These were grouped into five key macro-variables: infrastructure, strategic productive areas (SPAs), grazing management, livestock management, and monitoring systems. Infrastructure included watering points, paddock subdivisions, shade, roads, handling facilities, and the strategic use of attractions based on vegetation heterogeneity. Strategic productive areas (SPAs) incorporated modules designed for high forage production

(MHFP) (Pereira Machín, 2017) and those for preventing forage crises (MFCP) (Pereira Machín et al., 2018), which functioned as deferred forage reserves. Grazing management extended beyond specific methods and instead considered morphogenic factors essential for maintaining plant function under grazing pressure. Livestock management encompassed breeding strategies, ewe management, genetics suited to field conditions, and the strategic use of supplementation to enhance grassland efficiency. Lastly, monitoring systems served as tools to track activities closely, allowing for informed decision-making and proactive adaptation.

At the core of this conceptual model is the decision-making agent, which could be a rancher, a company board, a rural manager, or a family unit overseeing the system.

Data from the monitoring process highlighted important aspects of grassland management. The balance of work showed that while some managers dedicated at least two hours per day to analysing macro-variable management, others were entirely absorbed in routine tasks, limiting their ability to plan strategically. The variation in paddocking and infrastructure played a significant role in explaining fluctuations in meat production. Differences in the improved pasture area were closely linked to the stocking rate, the proportion of the ranch with pastures exceeding 5 cm (PRO5), and overall meat production levels. The proportion of the ranch with pastures above 5 cm was also strongly correlated with stocking rate and meat production.

Strategic supplementation was implemented only in specific cases, and its impact on economic performance was evident only in years of good pasture availability. The proportion of native grassland contributed positively to environmental performance indicators. However, although increasing improved pasture areas resulted in higher sward heights, excessive reliance on pasture improvement came with trade-offs, as it led to higher greenhouse gas emissions due to increased input usage.

## Discussion

Grassland management can neither be seen in isolation nor fixed. It is necessary to have a systemic view that considers its changes in the temporal dimension. For the discussion of the results, we will use an analogy with the evolutionary approach developed by Charles Darwin (1859). The interesting thing about Darwin was that he managed to explain the phenomenon of why evolution occurs (Vorzimmer, 1969).

The theory of evolution is based on three pillars: variability, natural selection and heredity (Mayr, 2002). For evolution to operate, there must be variation. In the case of grassland management, if we weight each macro variable as the producer in each of them can be bad, good or excellent; there are 243 possible combinations, where some give very good results, and the worst determine that the companies are out of the game.

In the case of grassland management, the selection is given by the context, and the companies that “learn” survive. Such learning positions them better for future events, because it is based on a better understanding of their ranch and contextual factors. We call this “sustainable adoption”.

In the case of the “selected” ones, for them to endure, there must be a mechanism that transmits these characteristics (*i.e.*, the self-replication of DNA in the theory of evolution), here through what we call “cultural transmission” (Cavalli-Sforza et al 1981), which can occur vertically from parents to children or horizontally among ranchers.

Extension must devote efforts to achieve learning and encourage cultural transmission, to “prevent” natural selection from operating wildly.

The producer manages the different macro-variables through a “filter” that is constituted among other things by his purposes, his age, education, production system, and the external context. It is necessary to dedicate time to “think” this management and for that the organization of the work and its planning is important. Decisions are always made with insufficient information, which is why it is said that it is a process with limited rationality, where the result is satisfaction (Simon, 1957). Optimization implies considering the 5 macro variables and it is more realistic to think that the agent prioritizes one or some of them.

One of the key benefits of the conceptual model is its ability to provide guidance through monitoring, helping to assess the current situation and determine the most appropriate decisions for each macro-variable. This process enables self-referencing, which, when combined with a forward-looking vision, establishes a clear course of action.

In this context, infrastructure plays a crucial role, as highlighted by ranchers. Its proper implementation facilitates improved forage management by optimizing grazing distribution and access to key resources. Strategic productive areas are reflected in the extent of improved pastures and their influence on grass height, meat production, and the proportion of the ranch with pastures above five centimetres. These areas also support high concentrations of cattle while maintaining good performance, which indirectly contributes to the regeneration and relief of natural grasslands.

Regarding grazing management, the PRO5 variable emerges as a critical determinant of meat production. Its reference values exceed those traditionally used, suggesting a shift towards more effective and productive management strategies.

Livestock management, which involves both cattle and sheep, along with adapted genetics and strategic supplementation, plays a crucial role as it interacts with all other aspects of the system.

Having a monitoring system is essential for making proactive decisions, allowing for adaptation and course correction when necessary. Without a monitoring system, self-referencing becomes impossible.

### **Conclusions**

A conceptual model was elaborated that describes in a systemic way the main macro variables that make up good grassland management practices. It can be used as a tool for self-evaluation in its different macro variables so that, through monitoring, decisions can be made in advance to improve management. Paddock management is highlighted in the case of infrastructure, the proportion of improved area in the EPAs, PRO5 in the case of grazing management, strategic supplementation for livestock management and the importance of having a monitoring system.

In the case of the improved area, these must be implemented efficiently, taking care of the use of inputs. The role of the grassland as a determinant of good environmental performance indicators is evident, providing the systems with resilience and resistance.

The persistence of the ranches in the long term is based on adapting to the changes of the context (learning in ascending scale), within the framework of the designed route of action. To this end, it is necessary to promote: i) reflective processes (critical thinking) that necessarily require time and ii) group strategies that promote cooperation. The organization of work in a simple way and delegation collaborate, to the extent that it generates time for reflection.

Extension has an important role in fostering learning, through integrating and sharing different types of knowledge, and reflective processes and group strategies.

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