

The importance of grazing land in post-colonial land-use in Argentina

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June 30th, 2022

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Summary

Humans have been transforming the natural environment for as long as they have walked on this planet; from hunter gatherers to the rise of urban industrial societies. But it is still highly uncertain when did human land-use transformation practices began and how was its trajectory over time. Therefore there is a need to quantify past anthropogenic land cover transformations to better understand the impact that humans have had on the planet and the global climate system. For the American continent the introduction of cattle in the Columbian Exchange had an impact on land-cover by transforming entire ecosystems into grazing lands; having environmental and societal repercussions in the continent.

Having said that, for the following research a literature review based on historical records of land-use and cattle numbers will be carried out in Argentina in order to better understand the historical land-use trajectory of grazing land in post-colonial times (1942-2018). Also it will be analyzed how grazing land ecosystems expanded across the three regions of the country (north, center and south) and what where the drivers of change that influenced this expansion. Adding to that; as this research will work with historical land-use data, the quantitative information found will be compared with the HYDE database.

Introduction

General background

Land-use is one of the main anthropogenic threats that humanity is facing now (Hasan et al., 2020). As the human population increases so do activities that are highly dependent on land-use. Mining, urbanization, industrial operations and agriculture, are just a few examples of intensive land-use activities that have reshaped the Earth's natural cover and while decreasing its biodiversity. Today, land-use is known to be one of the main drivers of global environmental change (Etter et al. 2008).

Given that the planet is an interconnected system, ecosystem disruptions made on a local or regional scale have strong repercussions worldwide (Dong et al., 2019). For example, deforestation in the northern temperate regions leads to an increase in the regional surface albedo effect, which as a result, cools down the deforested region (Brovkin et al., 2004). Another example is the massive deforestation rates that is observed today in tropical regions which has resulted in an increase of the surface temperature and a reduction of precipitation rates in the deforested area (Brovkin et al., 2004). These given examples related to land transformation practices and many more have had a strong effect on global climate change (Dong et al., 2019). But land transformation practices are not something recent, they began to occur a long time ago (Etter et al., 2008).

Humans have been modifying natural landscapes for as long as they have walked on this planet; from hunter gatherers times to the emergence of agricultural societies (Ellis et al., 2020). Ellis et al., (2021) mentions that 12,000 years ago about three quarters of the earth's land surface was already inhabited by human civilizations. There is now archeological evidence that indicates that 10,000 years ago human societies were already practicing land transformation techniques, such as land burning, seeds propagation, domestication and other practices (Ellis et al., 2021). This means that most of the areas that are considered now "wild", "intact" or "natural" have had a long history behind of being intervened. In addition to this, Ellis et al., (2021) also mentions that even the current global biodiversity patterns that are observed today are strongly associated with land-use patterns that were carried out by human civilizations in the past.

Historical land-use in Latin America and the Columbian Exchange

But not all regions and continents have had the same land-use trajectory over time. Around the 14th and 15th centuries, the intensity of land-use in Latin America differed between regions as some areas were more suitable for human settlements and crop development than others. For example, in the Amazon basin humans lived dispersed in small groups along the river, while in the northern part of America and in the Andes region there were civilizations (e.g. Mayans, Incas or the Aztecs) that had relatively advanced and intensive agricultural systems (Klein Goldewijk, Dekker, et al., 2017). Klein Goldewijk, Dekker, et al., (2017) states that due to this it is likely that climatic and other environmental variables influenced the interactions humans had with land-use practices. If it focuses solely on Latin America and its relationship with land-use by the 14th and 15th century, besides croplands and human settlements pastures were

presumed to be non-existent as there were no cattle nor sheep nor pigs in the region. This changed dramatically after the Columbian exchange (Klein Goldewijk, Dekker, et al., 2017).

The Columbian exchange is the exchange of food, ideas, diseases and populations between the New World and the Old World after Christopher Columbus arrived to the American continent in 1492 CE (Nunn & Qian, 2010). When the European settlers arrived to Latin America as the only grazing animals in the region were Llamas and Alpacas pasture extension were too little therefore it was presumed to be non-existent (Klein Goldewijk, Dekker, et al., 2017). This changed after the introduction of cattle and other livestock animals. When cattle arrived to the American continent (~1493 CE), they adapted quite well to the diverse ecosystems of the region, and eventually they made human expansion in America possible. Cattle transformed inhospitable areas into pastures with old-world grasses that benefited the European colonization in Latin America. By the mid-18th century, cattle had arrived to the southern grasslands of South America and altered the ecology in the region by replacing native grasses with European plants, which had an impact on the flora and fauna interactions of the Pampas species (Ficek, 2019). In Colombia, for example, cattle was presumed to be a main driver of land-cover change; especially in the Andean and tropical dry forests. By 2000 the main land-use in Colombia shifted from cropland to grazing land (Etter et al., 2008).

Knowledge gap and the introduction of the HYDE database

But research related to historical land-use is still in its infancy and it needs to be explored further, especially as land-use plays an important role in the climate system (Klein Goldewijk, Dekker, et al., 2017). Different studies and databases have developed to reduce historical land-use uncertainties and one of these is the HYDE database. The HYDE, acronym for the History Database of the Global Environment, is an update database that researches the change of the human population and land-use over the past 12,000 years. HYDE covers different categories of land-use relation to study human influence over environment, some examples of these categories are cropland, population and grazing land or pastures (Klein Goldewijk et al., 2011).

Scientific and societal relevance of the study

Cattle have received special attention when it comes to grazing land cover, as this group of animals has spread throughout the world with their feeding pattern called "grazing" which has had repercussions over the ecosystems (Li & Jiang, 2021). Grazing has decreased plant diversity and altered plant composition, thus eliminating ecosystem biomass. Besides grazing behavior, cattle could affect natural niches through dung deposition, trampling and species interaction as it competes for space with other wildlife populations. In general, cattle have effects over carbon sequestration, plant productivity and soil hydrology (Li & Jiang, 2021).

Li & Jiang (2021) mention that the impact that cattle have on the ecosystem is dependent on many things, such as the intensity of grazing pressure or the evolutionary history of grazing. Therefore, as cattle are a group of interest because of the current impact they have today, it is important to understand the relationships that the human population has had with them over the years.

Focusing on the societal and environmental relevance of this study, according to Ficek (2019), from the late 15th century cattle were animals that are responsible of both environmental and societal problems that Latin America has until now. For example, cattle

were originally private property and led to the accumulation of wealth and property for some social groups, leaving others behind (Ficek, 2019). Also, cattle were introduced by the Spanish conquistadors into native and pristine environments, and not long after they indirectly supported extractive activities and the reach of private capital and market relations in the new world (Ficek, 2019).

Today, large-scale cattle ranching for the modern meat industry has been made possible by the clearing of tropical forests, resulting in large emissions of methane and other greenhouse gasses (Ficek, 2019). Winkler et al., (2021) argue that many environmental and social problems we face today, such as climate change, biodiversity loss and food security are strongly dependent on how humanity interacts with land cover, so successfully addressing these issues requires attention to land-use change.

Aim of the study

The aim of this research is to reduce uncertainties in the historical use of grazing land and cattle numbers in Argentina between the years 1492 and 1960. It was chosen Argentina as this country is now known to be a major exporter of meat and still has important provinces for raising cattle. Therefore it is important to investigate deeper how this on growing demand of meat has had repercussions on the environment. Also, it is assumed that it will be more feasible to find empirical information in this country than in other South American countries. The period 1492-1960 was chosen because FAO (acronym for Food and Agriculture Organization) contains more detailed information from the year 1960 onwards.

The central research question (CQ) of this research is:

- **CQ:** How has the use of pasture expanded in Argentina after colonization?

The sub-questions (SQ) that address this central research question are:

- **SQ1:** How has pasture expansion varied across the northern, central and southern region of Argentina?
- **SQ2:** How have the cattle numbers changed since colonial times (1492-1960)
- **SQ3:** What have been the drivers of change for grazing land?

Methods

Study area

As Figure 1 shows, the study area for this research is Argentina. Argentina is a country located in Latin America and it hosts a high variety of biomes; from the highest mountains in the American continent to subtropical zones (The Nature Conservancy, 2022).

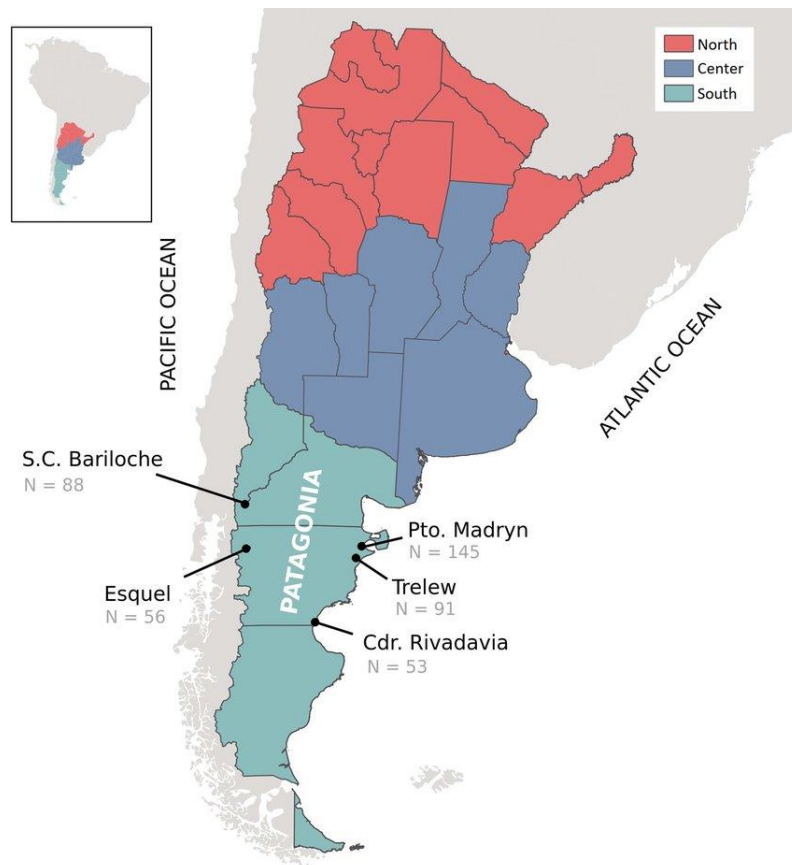


Figure 1. Argentina (Source: Parolin et al., (2019))

Argentina also faces some social and environmental tensions; according to Castro et al., (2016) these tensions have been building up over the past five centuries and they have given rise to a long series of economic problems and social injustice in the region. Argentina also faces now environmental threats related to over use of land like deforestation or the expansion of large scale agriculture; specially for cattle and soy production (The Nature Conservancy, 2022). Argentina is a country with high rates of inequality where social change is highly dependent on natural resources. De Castro et al., (2016) argues that nature and society relationships are both a challenge and an opportunity in the continent for a more inclusive and sustainable development. Therefore Argentina is a good example for studying the relationship human population have had with the expansion of grazing land over the last 500 years.

Data mining

The type of research that will be used to address both the central question (CQ) and the sub-questions (SQ) will be a literature review. For this research, the existing literature on land-use will be examined from different areas of Argentina. To find more precise information, both quantitative and qualitative mainly it will be looked into Spanish historical resources, using the following keywords: “ganado”, “vacuno”, “cabezas”, “colonia”, “haciendas”, “Ganado mayor”, “latinoamérica”, “estancias”, Argentina, “censo nacional”. The searching platforms that will be used will be Scopus, Google Scholar and the online library at Utrecht University, The Netherlands. Once the areas with the most relevant quantitative information are identified, they will be analyzed accordingly to the central question (CQ) and sub questions (SQ).

It's important to point out that this study will have a general and regional approach. Figure 1 shows the regional breakdown of Argentina. The northern region will include the following provinces: Jujuy, Salta, Formosa, Chaco, Tucuman, Catamarca, Santiago del Estero, San Juan, La Rioja, Corrientes and Misiones. The central region will include: Buenos Aires, Santa Fe, Entre Ríos, Córdoba, La Pampa, San Luis and Mendoza. And finally the southern region will include Neuquen, Rio Negro, Chubut, Santa Cruz and Tierra del Fuego.

To address CQ, SQ1 and SQ2 in terms of cattle expansion and its influence on pastures, a special attention will be paid to historical information on pasture and cattle numbers. For the CQ, the main focus will be on pasture extension in hectares and, once a year with detailed information in this regard is found, it will be interpolated over the period of 1500-1962 time span. Therefore, for this study it is not expected to find the exact number of hectares of the full pasture expansion trajectory since 1500, but rather a year as a reference that could help us predict the trajectory of pasture. Also, pasture expansion from 2018 will also be looked into as it is expected that these values will give a better idea of the full pasture expansion over time in Argentina. For the purposes of this study, it is assumed that there was no pasture in 1500.

For SQ1, the pasture data found for the CQ will be divided by regions and provinces to see if there is a difference in patterns and to analyze how socio ecological factors could have consequences on that distribution. For SQ2, two things will be studied: cattle numbers and cattle density, as the latter will give us a clearer idea about the cattle and land-use that each region and province had. For the value of cattle density, the area of the region (which will be where cattle was distributed) will be divided by the reported number of cattle in that same region. For this part of the research it is important that the relevant literature specifies cattle over livestock, as livestock includes other farm animals such pigs, sheeps or goats, for this study our main focus is cattle. With the data obtained it will be further analyzed whether there is a relationship with these values with those of CQ and SQ1.

The historical quantitative information found for CQ, SQ1 and SQ2 will be placed in an Excel sheet and Excel documents to better organize the data and have a backup of the information.

The historical data obtained from CQ and SQ1 will be compared with the HYDE database, which uses historical population numbers to create an algorithm and allocate and categorize historical land-use. As the HYDE database has a different approach than the current study for allocating historical land-use, it is of interest to compare and analyze both approaches.

For SQ3, based on a study by Godde et al. (2018), the 4 drivers of change shown in Figure 2 regarding pasture expansion should be examined. Therefore, qualitative information found in the literature regarding these 4 drivers of change will be noted in order to get a better understanding of what impulse pasture expansion in colonial times.

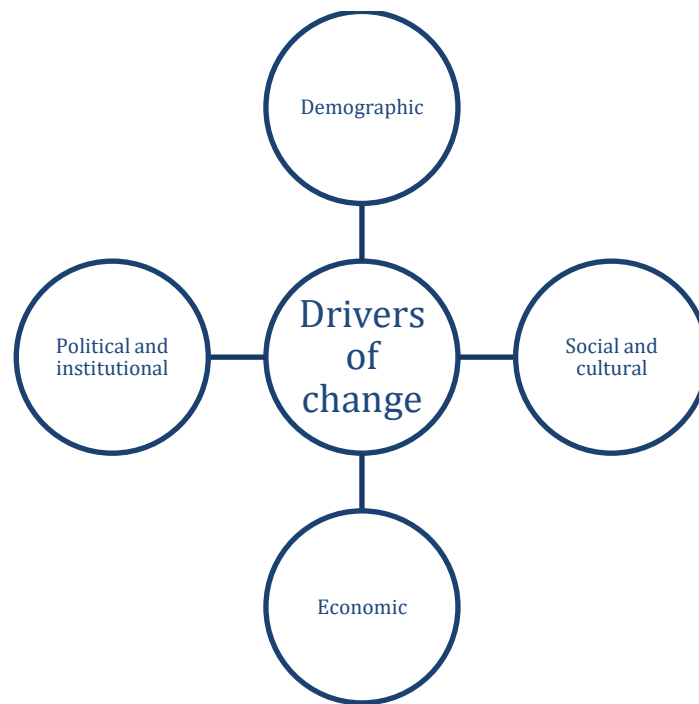


Figure 2. Drivers of change

Results

To answer the central research question (CQ) ‘*How has the use of pasture expanded in Argentina after colonization?*’ A historical record from 1908 that contained detailed information about pasture extension in every province was found. This study also classified pastures into three groups: spontaneous pastures, alfalfa, and other cultivated pastures. As this study focuses in general in pastures for the 1908 record these three categories were summed up and the values obtained were interpolated between the period of 1500-1908. For the periods 1908-1962 and 1962-2018, pasture extension numbers reported by FAO from the years 1962 and 2018 were used as reference. For the period 1908-1962 it was assumed that the percentage that pasture in each province and region occupied, remained constant as pasture expansion grew. For the period 1962-2018, the FAO reference obtained for 2018 was used as a benchmark to obtain pasture extent from each province with the values from the Argentine agricultural national census carried out in 2018. Afterwards the values of pasture area from the period 1962-2018 were interpolated.

In Figure 3 it can be observed the expansion of pasture area in Argentina, where the dark blue color represents the years where the historical records were found and the lighter blue the interpolated values. Based on the interpolated periods, Figure 3 shows how pasture expansion peaked in 1962 with close to 42% of the total area of the country. By 2018 pasture area diminished to 39% of the total area of the country. For more detailed information on the data obtained for general historical pasture expansion from 1500 to 2018, see table A1 (Appendix A).

Expansion of pasture area in Argentina (1500 - 2018), relative to the total land area

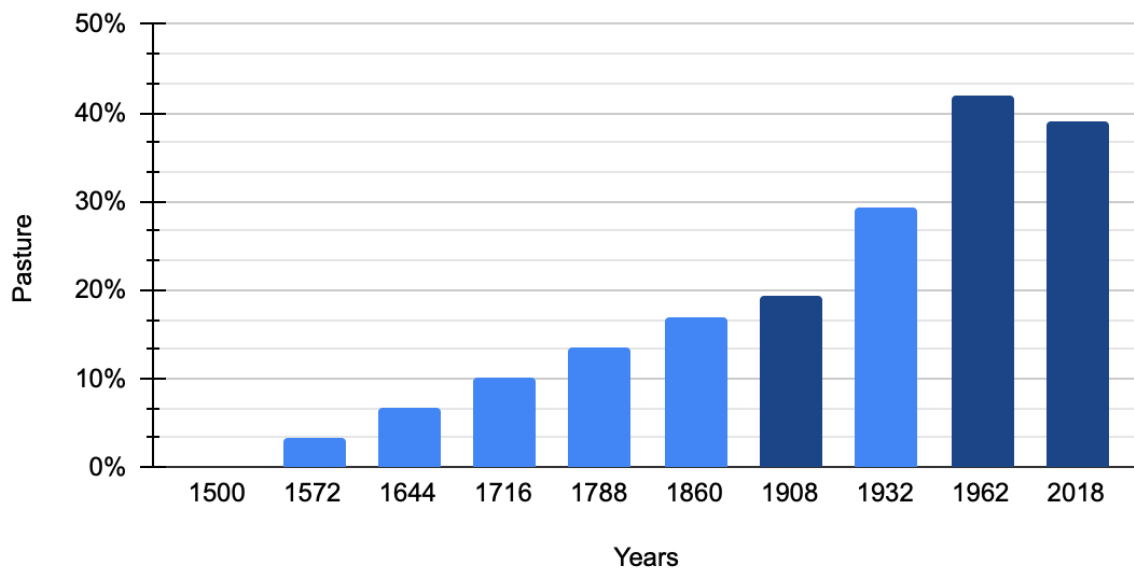


Figure 3. Pasture expansion in Argentina (1500-2018). (Source: *Agropecuario*, (1909); *Instituto Nacional de Estadísticas y Censos*, (2018); *FAO*, (2022))

Based on the results obtained above, historical pasture expansion was divided in provinces and regions to answer sub-question 1 (SQ1) ‘How has pasture expansion varied in different regions?’ The following graph shows the results obtained.

Expansion of pasture area by regions in Argentina (1500-2018), relative to the total land area

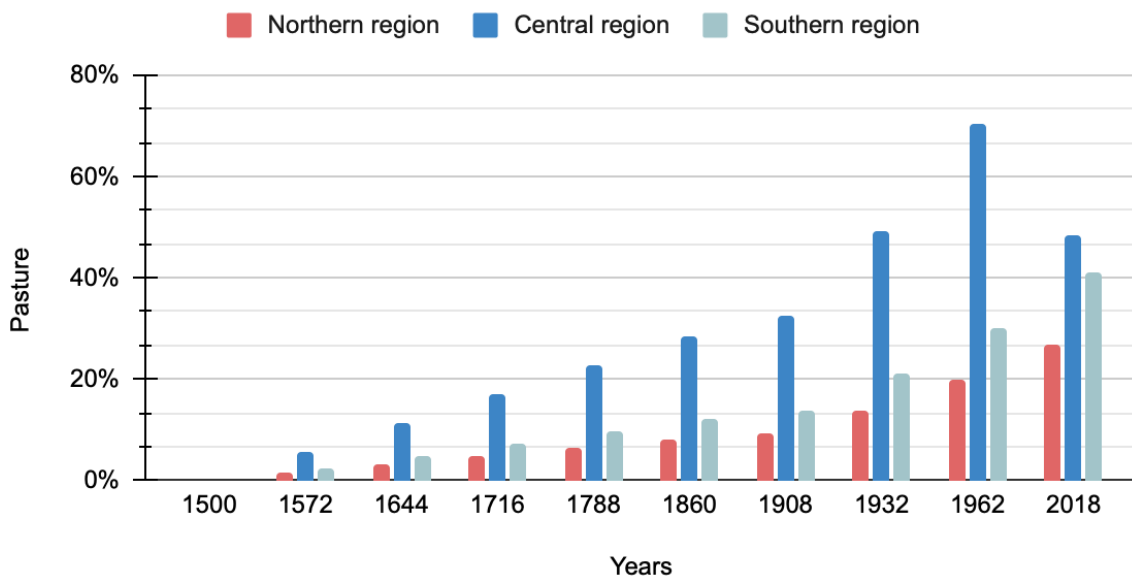


Figure 4. Pasture expansion by regions in Argentina (1500-2018). (Source: *Agropecuario*, (1909); *Instituto Nacional de Estadísticas y Censos*, (2018); *FAO*, (2022))

For the northern region of the country, as shown in Figure 4, it appears that pasture continues to have a gradual expansion, up until 2018 pasture came to occupy 26,8% of the region's land area. For the central region of the country it can be seen clearly that by 1962 the region experienced a peak regarding pasture expansion occupying 70,20% of the region's land area, where after that pasture area has slowly decreased. By 2018, pastures in the central region occupied 48,32% of the region's area. The southern region trajectory seems to have a similar pattern as the northern region; it can be observed that the region has experienced a slight increase of pasture area and up until 2018, pasture accounted for 41,19% of the region's land area. For more detailed information on the data obtained for the regional historical pasture expansion from 1500 to 2018, see table B1, B2 and B3 (Appendix B).

For the comparison between the HYDE database and the data from the current research (CR), the total number of hectares relative to the total land area were compared for the period 1500-2018. As it is shown in Figure 5, in both studies pastures expansion in 1500 is relatively zero and it peaks in 1962. Also it can be seen that as the values of the CR were interpolated, they show a linear and constant increase between the years 1500 and 1908, whereas HYDE has a different approach; values for pasture expansion remains relatively low until mid 1800 where they began to grow exponentially.

Comparison of pasture expansion in Argentina (1500-2018) between HYDE and Current Research

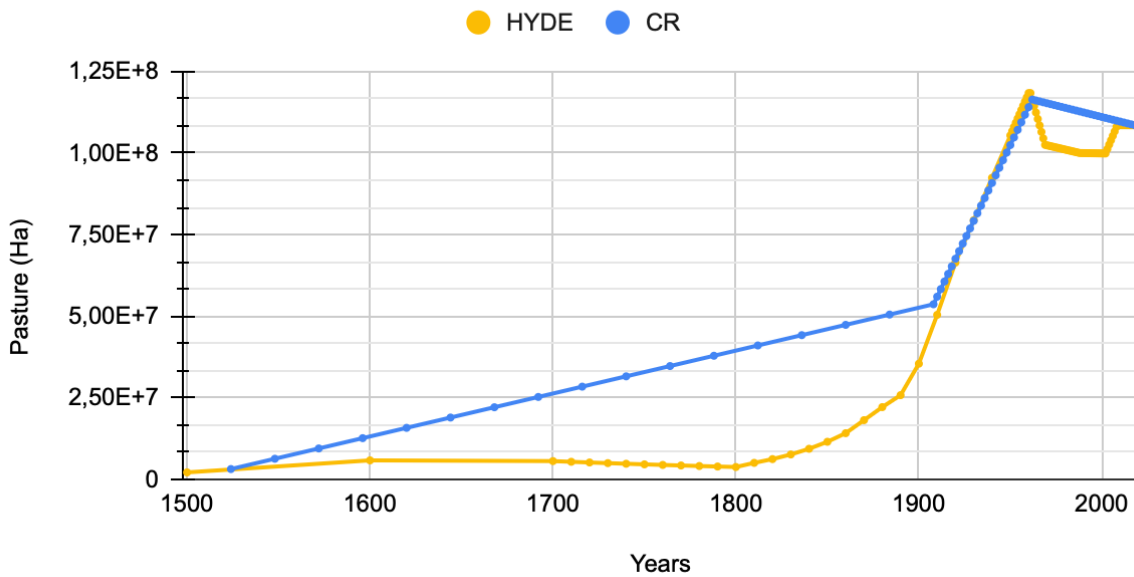


Figure 5. Comparison of pasture expansion in Argentina (1500-2018) between two different approaches; the current research (CR) and HYDE. (Source: *Agropecuario, (1909); Instituto Nacional de Estadísticas y Censos, (2018); FAO, (2022), HYDE*)

Regional comparison of pasture expansion in Argentina (1500-2018) between HYDE and Current Research

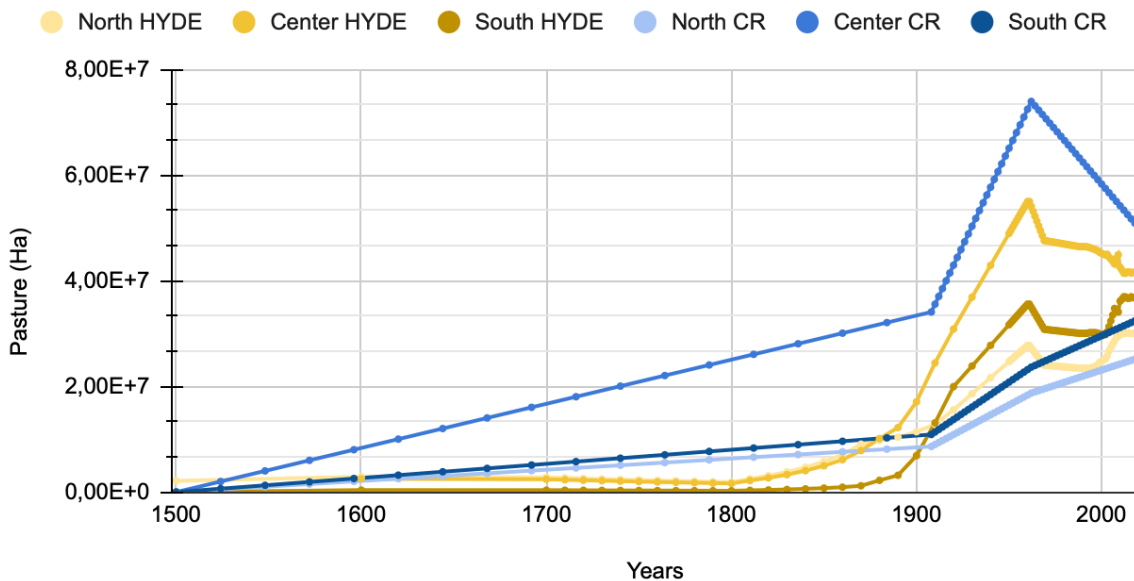


Figure 6. Regional comparison of pasture expansion in Argentina (1500-2018) between two different approaches; the current research (CR) and HYDE. (Source: *Agropecuario, (1909); Instituto Nacional de Estadísticas y Censos, (2018); FAO, (2022), HYDE*)

Figure 6 shows that for both approaches, although the values in the benchmark years for the CR and HYDE do not match, Figure 6 shows that for both databases the central region indeed has been the most land-use intervened from Argentina; followed by the southern region and finally by the northern region. For more detailed information on the data for the general and regional comparison of the CR and HYDE in Argentina (1500-2018), see table C1 and C2 (Appendix C).

To answer sub-question 2 (SQ2), ‘How have the cattle numbers changed since colonial times (1492-1960)?’ Historical information from the Argentinian national agricultural census was used. These national censuses were conducted in the years: 1888, 1895, 1908, 1914, 1922, 1930, 1947, 1952, 1960, 1962 and 2018. Also, the national census specifically specified cattle numbers rather than generalizing livestock per se.

Total number of cattle in Argentina (1500-2018)

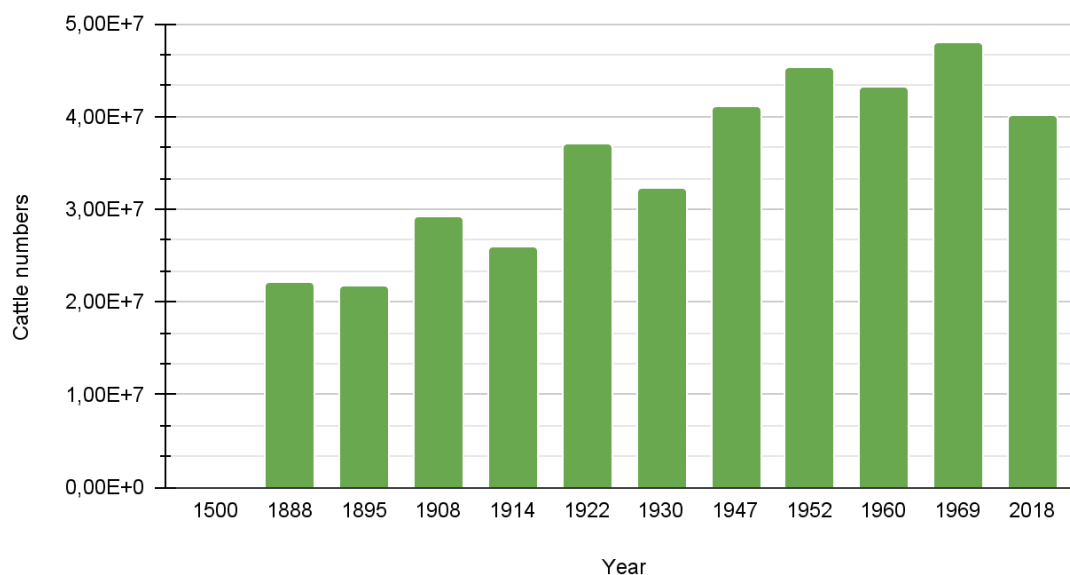


Figure 7. Number of cattle over the years in Argentina (1500-2018). (Source: Nacional, (1932); Censos, (1953); Censos (Argentina), (1970); Instituto Nacional de Estadísticas y Censos, (2018))

As shown in Figure 7 it is assumed that in the year 1500 there were no cattle in Argentina, unfortunately detailed cattle numbers were only found as of the year 1888. By 1888 there were already approximately 22 million cattle heads in Argentina and this number doubled in less than a hundred years. The total number of cattle in Argentina peaked at 48 million and in 2018 the last national census of Argentina revealed that the country had about 40 million cattle. For more detailed information on the numbers of cattle from 1500 to 2018, in each region of Argentina see Table 1D, 2D, 3D (Appendix D).

Average cattle density by region in Argentina (1888-2018). Note: Y- axis is logarithmic

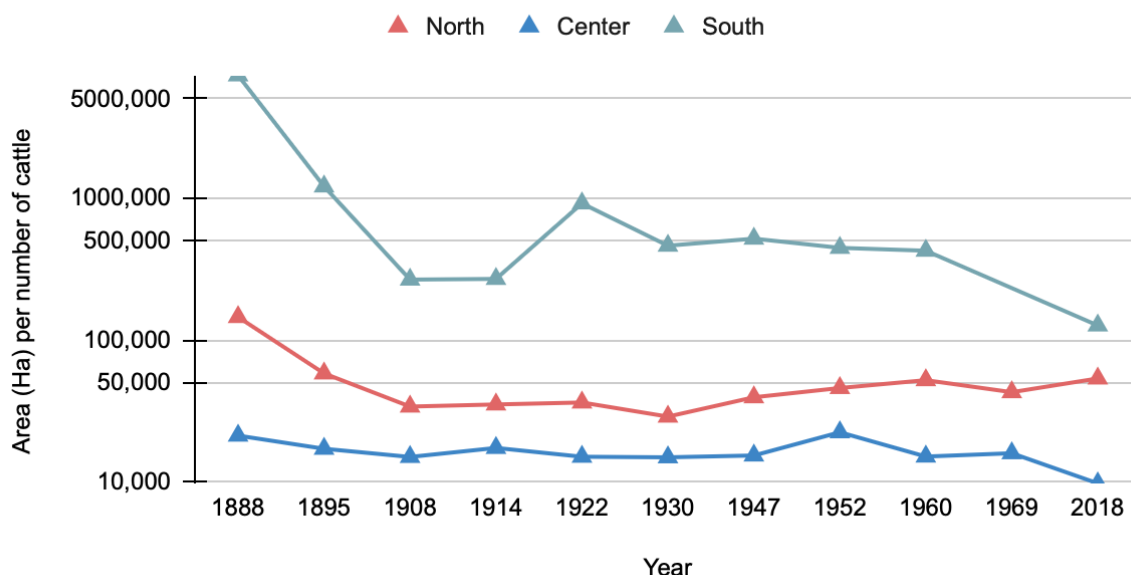


Figure 8. Average cattle density by region (1888-2018). (Source: *Nacional*, (1932); *Censos*, (1953); *Censos (Argentina)*, (1970); *Instituto Nacional de Estadísticas y Censos*, (2018))

Once the average cattle density of each region was taken, it was put into a logarithmic graph, as can be seen in Figure 8. It was chosen as a logarithmic scale as the density values for the northern and central region were relatively very small to be seen in a non-logarithmic scale graph. It is clear to see that the region where it had the lowest density, by means less area available per number of cows was the central region followed by the northern region and as last the southern region. In this graph we can also observe that the southern region as the years goes by the density (area/cattle) tends to decrease. For further information related to cattle density see Table 4D, 5D, 6D (Appendix D).

Having presented the results produced for CQ, SQ1 and SQ2 it is important to note that assumptions were made for the quantitative information for Argentina. For example, from 1888 to 1943 Argentina had an extra province called “Los Andes” which in 1943 was divided in three parts and given to Salta, Catamarca and Jujuy. For purposes of this study the area and the information of the province of “Los Andes” was divided equally to Salta, Catamarca and Jujuy. It is also assumed that by the year 1500 there were no pastures or cattle in the region and as mainly data from 1888 was obtained for the expansion of pasture the scale of the regression up to the year 1500 was made based on 1908 data.

More detailed numerical data related to CQ, SQ1 and SQ2 can be found in appendix section.

To answer sub question 3 (SQ3) ‘*What have been the drivers of change for grazing land?*’ The following information was found for each identified driver of change. But first it is important to note that the factors of change in relation to the expansion of cattle ranching in Argentina emerged at local and regional scales, and also differed greatly between towns or regions (Godde et al., 2018).

Drivers of land-use change

Demographic

According to Godde et al., (2018) population growth is a driver of change when it comes to cattle expansion, as it contributes to an increase in demands for cattle products resulting in an expansion and further intensification in grazing systems.

After the arrival of the Spanish conquistadors, Argentina experienced slow population growth, accompanied by demographic stress due to the fertility rates of the indigenous communities as their population declined, but at the same time an increase in European immigrants which intensified by 1950. The expansion of cattle ranching driven by population growth in Argentina was not only influenced by Argentina's own population growth, but also by population growth in Europe. As the human population grew so did the demand for meat and cattle products, also the dietary change towards a more meat-intensive diet began to increase, accessibility to meat products was easier and by 1950 Argentina was a major exporter of beef, especially the province of Buenos Aires (Waisman, 1986).

Social and cultural

Godde et al., (2018) states that some of the cultural and social drivers of pasture expansion are highly dependent on the farmer himself as he aims to provide more for his family when it comes to land-use as this can lead to expansion and intensification.

The social and cultural drivers of cattle expansion in the Americas were triggered by the arrival of European settlers. According to Ficek (2019), cattle literally replaced indigenous societies, as well as their culture and tradition; for example, savannas and places that indigenous societies used as farmland were subsequently occupied by cattle. The new rural society that emerged and dominated in the 20th century revolved around cattle, where the peasants who raised them but at the same time this was based on the domination of indigenous peoples and land. This social and cultural driver of change in land-use introduced by the Spanish colonists in the New World also had social impacts on society that can still be felt today (Ficek, 2019).

Economic

Some economic drivers of change for the expansion of cattle ranching in Argentina were identified, some of which according to Godde et al., (2018) can be part of income, land opportunity, land costs and labor costs.

For the case of Argentina by the 1800s one of the main agricultural activities was the breeding and export of cattle and as the international demand for cattle grew this led to greater exploitation of the cattle industry which consequently allowed the growth of its economy. By the 1900s, Argentina's economic production indicators were similar to other developed nations, which also led to rapid and extensive land cover changes throughout the country (Ramankutty & Coomes, 2016). With these growth trends, the indigenous people felt pressured to learn and adopt cattle management and breeding techniques in order to be part of the current economic market that Argentina had (Martinez et al., 2020). Ficek, (2019) states that the modern cattle industry that was carried out to generate profits for Argentine and overseas elite societies triggered a capitalist expansion in the country.

Political and institutional

Political institutions are often responsible for encouraging farmers to expand or intensify their farming techniques to increase productivity. Land privatization, for example, is known to aggravate social inequalities and have negative effects on the environment. For example, the reduction of cattle mobility in a given area is known to have intensified land-use, leading to degradation of land and water availability and, in general, negatively affecting the ecosystem (Godde et al., 2018). Ficek, (2019) argues that through this privatization system the links between livestock and capitalism in general in Latin America are profound as livestock was the first private property and in its form allows the accumulation of wealth for some people while leaving other groups behind.

Discussion and conclusion

Based on the results obtained on the CQ it can be observed that Argentina had a steady pasture expansion up until 1962 where it peaked and then slightly decreased until 2018. Godde et al., (2018) says that although a global trend of declining grazing systems areas has been observed this is also due that grazing systems have intensified, which could be the case with the slight decline of pasture area in Argentina between (1962-2018).

The regional difference of pasture expansion area and cattle density observed on figure 4 and 8 can be due to the diverse ecological regions that determine the stocking rates, breeding choices and management styles of cattle in Argentina; although cattle is raised all along the country the extent that each region raises livestock differs (Arelovich et al., 2011). Also, in figure 4 and figure 8 it can be observed that the central region has had overall a stronger intervention from the cattle sector in comparison with the other two regions. This could be due to the central region of Argentina holds the Pampeana region which are South American lowlands formed with natural grasslands which is ideal for cattle raising (Arelovich et al., 2011). Figure 4 shows that by 1716 almost 20% of the central region was already converted into pastures, which according to historical records in 1778 just Buenos Aires only had close to a million of cattle heads and other grazing animals (Garavaglia & Gelman, 2002). This gives a little more confidence with the results presented. Figure 4 and 8 also show that the southern region which is known as the “Patagonian region”, have been increasing and intensifying grazing systems and cattle numbers. According to Arelovich et al., (2011) the Patagonian region used to be known as sheep country, but over the course of the years and adaptation through genetic diversity that criollo cattle have had, cattle have had the opportunity to adapt and thrive in this area (Martinez et al., 2020).

Based on figures 5 and 6 it can be seen that there are differences of pasture expansion area between HYDE and current research (CR), this may be due to that the current research interpolated the numerical data found in historical records as if pasture expansion had remain constant overtime and HYDE uses historical records based on population per capita numbers. As of 1908, where the CR uses it as a benchmark, it can be seen that HYDE shows a lower pasture expansion for continental Argentina and the central region. According to Kaplan et al., (2017) HYDE database appears to underestimate landscape openness during preindustrial times when its compared to pollen-based reconstructions of Holocene cover.

HYDE and CR follow different approaches to quantify historical land-use, the regional comparison for pasture expansion follows a similar trend so it helps to have a higher degree of certainty with the results presented (Figure 6).

It has been presented that different drivers have influenced pasture expansion in the region. According to Arelovich et al., (2011) cattle in Argentina is now at days related to its cultural, social and economic history of the country that promoted inequality along regions but also that brought Buenos Aires (Argentina's capital) to rise in the international market by the late 18th, and with it a reorientation of its economic, political and intellectual life.

Understanding historical land-use change is very important to mitigate the consequences of human-environment interactions. Humanity relies heavily on the environment as a means of support, provision, regulation, and cultural services, and changes in land-use diminish these ecosystem services (Hasan et al., 2020).). But there is also a responsibility in the type of relationship we develop with the environment. Ellis et al., (2021) states that the current environmental crisis is the result of humanity's long standing appropriation and colonization of biodiverse landscapes with the environment and part of successfully addressing current environmental problems is to recognize a deep cultural connection found in humanity with nature (Ellis et al., 2021).

Although assumptions were made during the research, the study presented expects to fill some historical gaps regarding land-use on post-colonial Argentina. Also it is recommended further quantitative research from different areas to have a better idea of land use trajectory on post-colonial Argentina to fill historical land-use gaps and help assess the historical evolution of land-use in Latin America.

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Appendix
Appendix A

Table A1. Expansion of pasture area (in hectares) in post-colonial Argentina (1500-2018).

Year	Pasture (Ha)	Year	Pasture (Ha)	Year	Pasture (Ha)	Year	Pasture (Ha)
1500	0	1914	60621842	1954	107081140	1994	111874143
1524	3156056	1916	62944807	1956	109404105	1996	111592964
1548	6312111	1918	65267772	1958	111727070	1998	111311786
1572	9468167	1920	67590737	1960	114050035	2000	111030607
1596	12624223	1922	69913701	1962	116373000	2002	110749429
1620	15780278	1924	72236666	1964	116091821	2004	110468250
1644	18936334	1926	74559631	1966	115810643	2006	110187071
1668	22092390	1928	76882596	1968	115529464	2008	109905893
1692	25248446	1930	79205561	1970	115248286	2010	109624714
1716	28404501	1932	81528526	1972	114967107	2012	109343536
1740	31560557	1934	83851491	1974	114685929	2014	109062357
1764	34716613	1936	86174456	1976	114404750	2016	108781179
1788	37872668	1938	88497421	1978	114123571	2018	108500000
1812	41028724	1940	90820386	1980	113842393		
1836	44184780	1942	93143351	1982	113561214		
1860	47340835	1944	95466316	1984	113280036		
1884	50496891	1946	97789281	1986	112998857		
1908	53652947	1948	100112246	1988	112717679		
1910	55975912	1950	102435210	1990	112436500		
1912	58298877	1952	104758175	1992	112155321		

Note: The values of pasture in bold represent the numbers found in the historical records and FAO database.

Appendix B

Table B1. Expansion of pasture area (in hectares) in the northern region of Argentina (1500-2018).

	Jujuy (Ha)	Salta (Ha)	Formosa (Ha)	Chaco (Ha)	Tucuman (Ha)	Catamarca (Ha)	Santiago del Estero (Ha)	San Juan (Ha)	La Rioja (Ha)	Corrientes (Ha)	Misiones (Ha)
1500	0	0	0	0	0	0	0	0	0	0	0
1524	11680,52941	28967,1765	49780,1176	31018,4706	30260,4118	17111,8235	131365,059	6411,17647	13195,5882	179292,765	9238,29412
1548	23361,05882	57934,3529	99560,2353	62036,9412	60520,8235	34223,6471	262730,118	12822,3529	26391,1765	358585,529	18476,5882
1572	35041,58824	86901,5294	149340,353	93055,4118	90781,2353	51335,4706	394095,176	19233,5294	39586,7647	537878,294	27714,8824
1596	46722,11765	115868,706	199120,471	124073,882	121041,647	68447,2941	525460,235	25644,7059	52782,3529	717171,059	36953,1765
1620	58402,64706	144835,882	248900,588	155092,353	151302,059	85559,1176	656825,294	32055,8824	65977,9412	896463,824	46191,4706
1644	70083,17647	173803,059	298680,706	186110,824	181562,471	102670,941	788190,353	38467,0588	79173,5294	1075756,59	55429,7647
1668	81763,70588	202770,235	348460,824	217129,294	211822,882	119782,765	919555,412	44878,2353	92369,1176	1255049,35	64668,0588
1692	93444,23529	231737,412	398240,941	248147,765	242083,294	136894,588	1050920,47	51289,4118	105564,706	1434342,12	73906,3529
1716	105124,7647	260704,588	448021,059	279166,235	272343,706	154006,412	1182285,53	57700,5882	118760,294	1613634,88	83144,6471
1740	116805,2941	289671,765	497801,176	310184,706	302604,118	171118,235	1313650,59	64111,7647	131955,882	1792927,65	92382,9412
1764	128485,8235	318638,941	547581,294	341203,176	332864,529	188230,059	1445015,65	70522,9412	145151,471	1972220,41	101621,235
1788	140166,3529	347606,118	597361,412	372221,647	363124,941	205341,882	1576380,71	76934,1176	158347,059	2151513,18	110859,529
1812	151846,8824	376573,294	647141,529	403240,118	393385,353	222453,706	1707745,76	83345,2941	171542,647	2330805,94	120097,824
1836	163527,4118	405540,471	696921,647	434258,588	423645,765	239565,529	1839110,82	89756,4706	184738,235	2510098,71	129336,118
1860	175207,9412	434507,647	746701,765	465277,059	453906,176	256677,353	1970475,88	96167,6471	197933,824	2689391,47	138574,412
1884	186888,4706	463474,824	796481,882	496295,529	484166,588	273789,176	2101840,94	102578,824	211129,412	2868684,24	147812,706
1908	198569	492442	846262	527314	514427	290901	2233206	108990	224325	3047977	157051
1910	207166,2691	513762,832	882901,869	550144,655	536699,698	303495,887	2329895,18	113708,845	234037,404	3179942,61	163850,7
1912	215763,5382	535083,665	919541,738	572975,31	558972,396	316090,775	2426584,35	118427,69	243749,808	3311908,21	170650,401
1914	224360,8072	556404,497	956181,607	595805,965	581245,094	328685,662	2523273,53	123146,535	253462,213	3443873,82	177450,101
1916	232958,0763	577725,33	992821,476	618636,62	603517,791	341280,549	2619962,7	127865,38	263174,617	3575839,42	184249,802
1918	241555,3454	599046,162	1029461,34	641467,275	625790,489	353875,436	2716651,88	132584,226	272887,021	3707805,03	191049,502

1920	250152,6145	620366,995	1066101,21	664297,93	648063,187	366470,324	2813341,05	137303,071	282599,425	3839770,64	197849,202
1922	258749,8836	641687,827	1102741,08	687128,586	670335,885	379065,211	2910030,23	142021,916	292311,829	3971736,24	204648,903
1924	267347,1527	663008,66	1139380,95	709959,241	692608,583	391660,098	3006719,4	146740,761	302024,233	4103701,85	211448,603
1926	275944,4217	684329,492	1176020,82	732789,896	714881,281	404254,986	3103408,58	151459,606	311736,638	4235667,45	218248,304
1928	284541,6908	705650,325	1212660,69	755620,551	737153,979	416849,873	3200097,76	156178,451	321449,042	4367633,06	225048,004
1930	293138,9599	726971,157	1249300,56	778451,206	759426,676	429444,76	3296786,93	160897,296	331161,446	4499598,67	231847,704
1932	301736,229	748291,99	1285940,43	801281,861	781699,374	442039,647	3393476,11	165616,141	340873,85	4631564,27	238647,405
1934	310333,4981	769612,822	1322580,3	824112,516	803972,072	454634,535	3490165,28	170334,987	350586,254	4763529,88	245447,105
1936	318930,7671	790933,654	1359220,16	846943,171	826244,77	467229,422	3586854,46	175053,832	360298,659	4895495,48	252246,805
1938	327528,0362	812254,487	1395860,03	869773,826	848517,468	479824,309	3683543,63	179772,677	370011,063	5027461,09	259046,506
1940	336125,3053	833575,319	1432499,9	892604,481	870790,166	492419,197	3780232,81	184491,522	379723,467	5159426,7	265846,206
1942	344722,5744	854896,152	1469139,77	915435,136	893062,864	505014,084	3876921,98	189210,367	389435,871	5291392,3	272645,907
1944	353319,8435	876216,984	1505779,64	938265,791	915335,562	517608,971	3973611,16	193929,212	399148,275	5423357,91	279445,607
1946	361917,1125	897537,817	1542419,51	961096,447	937608,259	530203,858	4070300,34	198648,057	408860,68	5555323,51	286245,307
1948	370514,3816	918858,649	1579059,38	983927,102	959880,957	542798,746	4166989,51	203366,902	418573,084	5687289,12	293045,008
1950	379111,6507	940179,482	1615699,25	1006757,76	982153,655	555393,633	4263678,69	208085,748	428285,488	5819254,73	299844,708
1952	387708,9198	961500,314	1652339,12	1029588,41	1004426,35	567988,52	4360367,86	212804,593	437997,892	5951220,33	306644,409
1954	396306,1889	982821,147	1688978,98	1052419,07	1026699,05	580583,408	4457057,04	217523,438	447710,296	6083185,94	313444,109
1956	404903,458	1004141,98	1725618,85	1075249,72	1048971,75	593178,295	4553746,21	222242,283	457422,7	6215151,54	320243,809
1958	413500,727	1025462,81	1762258,72	1098080,38	1071244,45	605773,182	4650435,39	226961,128	467135,105	6347117,15	327043,51
1960	422097,9961	1046783,64	1798898,59	1120911,03	1093517,14	618368,069	4747124,56	231679,973	476847,509	6479082,76	333843,21
1962	430695,2652	1068104,48	1835538,46	1143741,69	1115789,84	630962,957	4843813,74	236398,818	486559,913	6611048,36	340642,911
1964	453649,8781	1139768,4	1880991,21	1247576,02	1102379,99	637922,832	4824528,32	247979,963	534186,099	6528722,41	375125,845
1966	476604,4909	1211432,32	1926443,96	1351410,36	1088970,14	644882,708	4805242,91	259561,108	581812,285	6446396,45	409608,78
1968	499559,1038	1283096,24	1971896,71	1455244,69	1075560,29	651842,583	4785957,49	271142,252	629438,471	6364070,49	444091,714
1970	522513,7167	1354760,16	2017349,47	1559079,03	1062150,44	658802,459	4766672,08	282723,397	677064,657	6281744,54	478574,649
1972	545468,3296	1426424,09	2062802,22	1662913,37	1048740,59	665762,334	4747386,67	294304,542	724690,843	6199418,58	513057,583
1974	568422,9424	1498088,01	2108254,97	1766747,7	1035330,74	672722,21	4728101,25	305885,686	772317,029	6117092,63	547540,518
1976	591377,5553	1569751,93	2153707,72	1870582,04	1021920,88	679682,085	4708815,84	317466,831	819943,215	6034766,67	582023,453
1978	614332,1682	1641415,85	2199160,47	1974416,37	1008511,03	686641,961	4689530,42	329047,976	867569,401	5952440,71	616506,387

1980	637286,7811	1713079,77	2244613,22	2078250,71	995101,182	693601,836	4670245,01	340629,12	915195,587	5870114,76	650989,322
1982	660241,3939	1784743,7	2290065,97	2182085,04	981691,331	700561,712	4650959,59	352210,265	962821,773	5787788,8	685472,256
1984	683196,0068	1856407,62	2335518,72	2285919,38	968281,48	707521,587	4631674,18	363791,41	1010447,96	5705462,85	719955,191
1986	706150,6197	1928071,54	2380971,48	2389753,72	954871,629	714481,463	4612388,76	375372,554	1058074,15	5623136,89	754438,126
1988	729105,2326	1999735,46	2426424,23	2493588,05	941461,778	721441,338	4593103,35	386953,699	1105700,33	5540810,93	788921,06
1990	752059,8454	2071399,38	2471876,98	2597422,39	928051,927	728401,214	4573817,93	398534,844	1153326,52	5458484,98	823403,995
1992	775014,4583	2143063,31	2517329,73	2701256,72	914642,075	735361,089	4554532,52	410115,988	1200952,7	5376159,02	857886,929
1994	797969,0712	2214727,23	2562782,48	2805091,06	901232,224	742320,965	4535247,1	421697,133	1248578,89	5293833,07	892369,864
1996	820923,684	2286391,15	2608235,23	2908925,39	887822,373	749280,84	4515961,69	433278,278	1296205,08	5211507,11	926852,798
1998	843878,2969	2358055,07	2653687,98	3012759,73	874412,522	756240,716	4496676,27	444859,422	1343831,26	5129181,15	961335,733
2000	866832,9098	2429718,99	2699140,73	3116594,07	861002,671	763200,591	4477390,86	456440,567	1391457,45	5046855,2	995818,668
2002	889787,5227	2501382,91	2744593,49	3220428,4	847592,82	770160,467	4458105,44	468021,712	1439083,63	4964529,24	1030301,6
2004	912742,1355	2573046,84	2790046,24	3324262,74	834182,969	777120,342	4438820,03	479602,857	1486709,82	4882203,29	1064784,54
2006	935696,7484	2644710,76	2835498,99	3428097,07	820773,118	784080,218	4419534,61	491184,001	1534336,01	4799877,33	1099267,47
2008	958651,3613	2716374,68	2880951,74	3531931,41	807363,266	791040,093	4400249,2	502765,146	1581962,19	4717551,37	1133750,41
2010	981605,9742	2788038,6	2926404,49	3635765,74	793953,415	797999,969	4380963,78	514346,291	1629588,38	4635225,42	1168233,34
2012	1004560,587	2859702,52	2971857,24	3739600,08	780543,564	804959,844	4361678,37	525927,435	1677214,56	4552899,46	1202716,28
2014	1027515,2	2931366,45	3017309,99	3843434,41	767133,713	811919,72	4342392,95	537508,58	1724840,75	4470573,5	1237199,21
2016	1050469,813	3003030,37	3062762,74	3947268,75	753723,862	818879,595	4323107,54	549089,725	1772466,94	4388247,55	1271682,14
2018	1073424,426	3074694,29	3108215,5	4051103,09	740314,011	825839,471	4303822,12	560670,869	1820093,12	4305921,59	1306165,08

Note: The values of pasture in bold represent the numbers found in the historical records and FAO database.

Table B2. Expansion of pasture area (in hectares) in the central region of Argentina (1500-2018).

	Buenos Aires (Ha)	Santa Fe (Ha)	Entre Rios (Ha)	Cordoba (Ha)	La Pampa (Ha)	San Luis (Ha)	Mendoza (Ha)
1500	0	0	0	0	0	0	0
1524	777699,2353	219723,765	162977,176	378097,824	229343,412	199069,294	39071,2353
1548	1555398,471	439447,529	325954,353	756195,647	458686,824	398138,588	78142,4706
1572	2333097,706	659171,294	488931,529	1134293,47	688030,235	597207,882	117213,706
1596	3110796,941	878895,059	651908,706	1512391,29	917373,647	796277,176	156284,941
1620	3888496,176	1098618,82	814885,882	1890489,12	1146717,06	995346,471	195356,176
1644	4666195,412	1318342,59	977863,059	2268586,94	1376060,47	1194415,76	234427,412
1668	5443894,647	1538066,35	1140840,24	2646684,76	1605403,88	1393485,06	273498,647
1692	6221593,882	1757790,12	1303817,41	3024782,59	1834747,29	1592554,35	312569,882
1716	6999293,118	1977513,88	1466794,59	3402880,41	2064090,71	1791623,65	351641,118
1740	7776992,353	2197237,65	1629771,76	3780978,24	2293434,12	1990692,94	390712,353
1764	8554691,588	2416961,41	1792748,94	4159076,06	2522777,53	2189762,24	429783,588
1788	9332390,824	2636685,18	1955726,12	4537173,88	2752120,94	2388831,53	468854,824
1812	10110090,06	2856408,94	2118703,29	4915271,71	2981464,35	2587900,82	507926,059
1836	10887789,29	3076132,71	2281680,47	5293369,53	3210807,76	2786970,12	546997,294
1860	11665488,53	3295856,47	2444657,65	5671467,35	3440151,18	2986039,41	586068,529
1884	12443187,76	3515580,24	2607634,82	6049565,18	3669494,59	3185108,71	625139,765
1908	13220887	3735304	2770612	6427663	3898838	3384178	664211
1910	13793300,23	3897028,2	2890568,78	6705955,93	4067642,59	3530699,81	692968,765
1912	14365713,46	4058752,41	3010525,55	6984248,86	4236447,19	3677221,62	721726,531
1914	14938126,7	4220476,61	3130482,33	7262541,78	4405251,78	3823743,42	750484,296
1916	15510539,93	4382200,82	3250439,1	7540834,71	4574056,38	3970265,23	779242,061
1918	16082953,16	4543925,02	3370395,88	7819127,64	4742860,97	4116787,04	807999,826

1920	16655366,39	4705649,23	3490352,65	8097420,57	4911665,56	4263308,85	836757,592
1922	17227779,62	4867373,43	3610309,43	8375713,49	5080470,16	4409830,66	865515,357
1924	17800192,85	5029097,64	3730266,2	8654006,42	5249274,75	4556352,46	894273,122
1926	18372606,09	5190821,84	3850222,98	8932299,35	5418079,34	4702874,27	923030,888
1928	18945019,32	5352546,05	3970179,75	9210592,28	5586883,94	4849396,08	951788,653
1930	19517432,55	5514270,25	4090136,53	9488885,21	5755688,53	4995917,89	980546,418
1932	20089845,78	5675994,46	4210093,3	9767178,13	5924493,13	5142439,7	1009304,18
1934	20662259,01	5837718,66	4330050,08	10045471,1	6093297,72	5288961,5	1038061,95
1936	21234672,25	5999442,86	4450006,85	10323764	6262102,31	5435483,31	1066819,71
1938	21807085,48	6161167,07	4569963,63	10602056,9	6430906,91	5582005,12	1095577,48
1940	22379498,71	6322891,27	4689920,4	10880349,8	6599711,5	5728526,93	1124335,24
1942	22951911,94	6484615,48	4809877,18	11158642,8	6768516,1	5875048,74	1153093,01
1944	23524325,17	6646339,68	4929833,95	11436935,7	6937320,69	6021570,54	1181850,78
1946	24096738,41	6808063,89	5049790,73	11715228,6	7106125,28	6168092,35	1210608,54
1948	24669151,64	6969788,09	5169747,5	11993521,6	7274929,88	6314614,16	1239366,31
1950	25241564,87	7131512,3	5289704,28	12271814,5	7443734,47	6461135,97	1268124,07
1952	25813978,1	7293236,5	5409661,05	12550107,4	7612539,06	6607657,78	1296881,84
1954	26386391,33	7454960,71	5529617,83	12828400,3	7781343,66	6754179,58	1325639,6
1956	26958804,56	7616684,91	5649574,6	13106693,3	7950148,25	6900701,39	1354397,37
1958	27531217,8	7778409,12	5769531,38	13384986,2	8118952,85	7047223,2	1383155,13
1960	28103631,03	7940133,32	5889488,15	13663279,1	8287757,44	7193745,01	1411912,9
1962	28676044,26	8101857,53	6009444,93	13941572,1	8456562,03	7340266,82	1440670,66
1964	28242608,61	8049766,33	5925062,14	13736794,2	8426196,6	7223480,24	1539103,82
1966	27809172,95	7997675,14	5840679,34	13532016,4	8395831,17	7106693,66	1637536,98
1968	27375737,3	7945583,94	5756296,55	13327238,6	8365465,75	6989907,08	1735970,13
1970	26942301,64	7893492,75	5671913,76	13122460,8	8335100,32	6873120,5	1834403,29
1972	26508865,99	7841401,56	5587530,96	12917683	8304734,89	6756333,92	1932836,45
1974	26075430,33	7789310,36	5503148,17	12712905,2	8274369,46	6639547,35	2031269,6
1976	25641994,68	7737219,17	5418765,38	12508127,4	8244004,03	6522760,77	2129702,76
1978	25208559,03	7685127,98	5334382,58	12303349,6	8213638,6	6405974,19	2228135,91

1980	24775123,37	7633036,78	5249999,79	12098571,8	8183273,17	6289187,61	2326569,07
1982	24341687,72	7580945,59	5165617	11893794	8152907,74	6172401,03	2425002,23
1984	23908252,06	7528854,4	5081234,21	11689016,2	8122542,31	6055614,45	2523435,38
1986	23474816,41	7476763,2	4996851,41	11484238,4	8092176,88	5938827,88	2621868,54
1988	23041380,75	7424672,01	4912468,62	11279460,6	8061811,45	5822041,3	2720301,7
1990	22607945,1	7372580,82	4828085,83	11074682,8	8031446,02	5705254,72	2818734,85
1992	22174509,45	7320489,62	4743703,03	10869905	8001080,6	5588468,14	2917168,01
1994	21741073,79	7268398,43	4659320,24	10665127,2	7970715,17	5471681,56	3015601,17
1996	21307638,14	7216307,24	4574937,45	10460349,4	7940349,74	5354894,98	3114034,32
1998	20874202,48	7164216,04	4490554,65	10255571,6	7909984,31	5238108,41	3212467,48
2000	20440766,83	7112124,85	4406171,86	10050793,8	7879618,88	5121321,83	3310900,64
2002	20007331,17	7060033,65	4321789,07	9846016,03	7849253,45	5004535,25	3409333,79
2004	19573895,52	7007942,46	4237406,27	9641238,23	7818888,02	4887748,67	3507766,95
2006	19140459,87	6955851,27	4153023,48	9436460,43	7788522,59	4770962,09	3606200,11
2008	18707024,21	6903760,07	4068640,69	9231682,63	7758157,16	4654175,51	3704633,26
2010	18273588,56	6851668,88	3984257,9	9026904,83	7727791,73	4537388,94	3803066,42
2012	17840152,9	6799577,69	3899875,1	8822127,03	7697426,3	4420602,36	3901499,58
2014	17406717,25	6747486,49	3815492,31	8617349,23	7667060,87	4303815,78	3999932,73
2016	16973281,59	6695395,3	3731109,52	8412571,43	7636695,45	4187029,2	4098365,89
2018	16539845,94	6643304,11	3646726,72	8207793,63	7606330,02	4070242,62	4196799,05

Note: The values of pasture in bold represent the numbers found in the historical records and FAO database.

Table 3B. Expansion of pasture area (in hectares) in the southern region of Argentina (1500-2018).

	Neuquen (Ha)	Rio negro (Ha)	Chubut (Ha)	Santa Cruz (Ha)	Tierra del fuego (Ha)
1500	0	0	0	0	0
1524	86529,76471	258190,647	84178,8235	131828,235	81024,88235
1548	173059,5294	516381,294	168357,647	263656,471	162049,7647
1572	259589,2941	774571,941	252536,471	395484,706	243074,6471
1596	346119,0588	1032762,59	336715,294	527312,941	324099,5294
1620	432648,8235	1290953,24	420894,118	659141,176	405124,4118
1644	519178,5882	1549143,88	505072,941	790969,412	486149,2941
1668	605708,3529	1807334,53	589251,765	922797,647	567174,1765
1692	692238,1176	2065525,18	673430,588	1054625,88	648199,0588
1716	778767,8824	2323715,82	757609,412	1186454,12	729223,9412
1740	865297,6471	2581906,47	841788,235	1318282,35	810248,8235
1764	951827,4118	2840097,12	925967,059	1450110,59	891273,7059
1788	1038357,176	3098287,76	1010145,88	1581938,82	972298,5882
1812	1124886,941	3356478,41	1094324,71	1713767,06	1053323,471
1836	1211416,706	3614669,06	1178503,53	1845595,29	1134348,353
1860	1297946,471	3872859,71	1262682,35	1977423,53	1215373,235
1884	1384476,235	4131050,35	1346861,18	2109251,76	1296398,118
1908	1471006	4389241	1431040	2241080	1377423
1910	1534694,866	4579278,15	1492998,49	2338110,09	1437060,084
1912	1598383,732	4769315,29	1554956,99	2435140,18	1496697,168
1914	1662072,598	4959352,44	1616915,48	2532170,27	1556334,253
1916	1725761,463	5149389,58	1678873,97	2629200,36	1615971,337
1918	1789450,329	5339426,73	1740832,46	2726230,45	1675608,421
1920	1853139,195	5529463,87	1802790,96	2823260,54	1735245,505
1922	1916828,061	5719501,02	1864749,45	2920290,62	1794882,589

1924	1980516,927	5909538,16	1926707,94	3017320,71	1854519,674
1926	2044205,793	6099575,31	1988666,43	3114350,8	1914156,758
1928	2107894,658	6289612,45	2050624,93	3211380,89	1973793,842
1930	2171583,524	6479649,6	2112583,42	3308410,98	2033430,926
1932	2235272,39	6669686,75	2174541,91	3405441,07	2093068,01
1934	2298961,256	6859723,89	2236500,41	3502471,16	2152705,094
1936	2362650,122	7049761,04	2298458,9	3599501,25	2212342,179
1938	2426338,988	7239798,18	2360417,39	3696531,34	2271979,263
1940	2490027,854	7429835,33	2422375,88	3793561,43	2331616,347
1942	2553716,719	7619872,47	2484334,38	3890591,52	2391253,431
1944	2617405,585	7809909,62	2546292,87	3987621,61	2450890,515
1946	2681094,451	7999946,76	2608251,36	4084651,7	2510527,6
1948	2744783,317	8189983,91	2670209,85	4181681,79	2570164,684
1950	2808472,183	8380021,06	2732168,35	4278711,87	2629801,768
1952	2872161,049	8570058,2	2794126,84	4375741,96	2689438,852
1954	2935849,915	8760095,35	2856085,33	4472772,05	2749075,936
1956	2999538,78	8950132,49	2918043,83	4569802,14	2808713,021
1958	3063227,646	9140169,64	2980002,32	4666832,23	2868350,105
1960	3126916,512	9330206,78	3041960,81	4763862,32	2927987,189
1962	3190605,378	9520243,93	3103919,3	4860892,41	2987624,273
1964	3171010,383	9463247,29	3418189,14	5015772,48	2907759,178
1966	3151415,388	9406250,65	3732458,98	5170652,55	2827894,083
1968	3131820,393	9349254,02	4046728,81	5325532,63	2748028,988
1970	3112225,398	9292257,38	4360998,65	5480412,7	2668163,893
1972	3092630,404	9235260,74	4675268,48	5635292,77	2588298,798
1974	3073035,409	9178264,1	4989538,32	5790172,84	2508433,703
1976	3053440,414	9121267,46	5303808,16	5945052,91	2428568,608
1978	3033845,419	9064270,83	5618077,99	6099932,99	2348703,513
1980	3014250,424	9007274,19	5932347,83	6254813,06	2268838,418
1982	2994655,429	8950277,55	6246617,66	6409693,13	2188973,322

1984	2975060,434	8893280,91	6560887,5	6564573,2	2109108,227
1986	2955465,44	8836284,28	6875157,34	6719453,28	2029243,132
1988	2935870,445	8779287,64	7189427,17	6874333,35	1949378,037
1990	2916275,45	8722291	7503697,01	7029213,42	1869512,942
1992	2896680,455	8665294,36	7817966,84	7184093,49	1789647,847
1994	2877085,46	8608297,73	8132236,68	7338973,56	1709782,752
1996	2857490,465	8551301,09	8446506,52	7493853,64	1629917,657
1998	2837895,47	8494304,45	8760776,35	7648733,71	1550052,562
2000	2818300,476	8437307,81	9075046,19	7803613,78	1470187,467
2002	2798705,481	8380311,18	9389316,02	7958493,85	1390322,372
2004	2779110,486	8323314,54	9703585,86	8113373,93	1310457,277
2006	2759515,491	8266317,9	10017855,7	8268254	1230592,182
2008	2739920,496	8209321,26	10332125,5	8423134,07	1150727,087
2010	2720325,501	8152324,63	10646395,4	8578014,14	1070861,992
2012	2700730,506	8095327,99	10960665,2	8732894,21	990996,8966
2014	2681135,511	8038331,35	11274935	8887774,29	911131,8015
2016	2661540,517	7981334,71	11589204,9	9042654,36	831266,7065
2018	2641945,522	7924338,08	11903474,7	9197534,43	751401,6114

Note: The values of pasture in bold represent the numbers found in the historical records and FAO database.

Appendix C

Table 1C. General comparison of pasture expansion (in hectares) in Argentina (1500-2018) between two different approaches; the current research (CR) and HYDE.

	HYDE (Ha)	CR (Ha)		HYDE (Ha)	CR (Ha)		HYDE (Ha)	CR (Ha)		HYDE (Ha)	CR (Ha)		HYDE (Ha)	CR (Ha)
1500	2134758		1836		44184780	1946		97789281	1976	101566000	114404750	2004	102570000	110468250
1524		3156056	1840	9370146		1948		100112246	1977	101434000		2005	103900000	
1548		6312111	1850	11512466		1950	105372750	102435211	1978	101303000	114123571	2006	105250000	110187071
1572		9468167	1860	14144589	47340836	1951	106671175		1979	101171000		2007	106600000	
1596		12624223	1870	18134089		1952	107969600	104758175	1980	101039000	113842393	2008	108000000	109905893
1600	5819186		1880	22133103		1953	109268025		1981	100908000		2009	108500000	
1620		15780279	1884		50496891	1954	110566450	107081140	1982	100777000	113561214	2010	108500000	109624714
1644		18936334	1890	25797676		1955	111864875		1983	100646000		2011	108500000	
1668		22092390	1900	35446233		1956	113163300	109404105	1984	100514000	113280036	2012	108500000	109343536
1692		25248446	1908		53652947	1957	114461725		1985	100383000		2013	108500000	
1700	5595371		1910	50406557	55975912	1958	115760150	111727070	1986	100251000	112998857	2014	108500000	109062357
1710	5380165		1912		58298877	1959	117058575		1987	100120000		2015	108500000	
1716		28404501	1914		60621842	1960	118357000	114050035	1988	99988000	112717679	2016	108500000	108781179
1720	5173235		1916		62944807	1961	118357000		1989	99980000		2017	108500000	
1730	4974265		1918		65267772	1962	116373000	116373000	1990	99970000	112436500	2018	108500000	108500000
1740	4782947	31560557	1920	66420000	67590737	1963	114389000		1991	99960000				
1750	4598987		1922		69913701	1964	112405000	116091821	1992	99950000	112155321			
1760	4422103		1924		72236666	1965	110422000		1993	99940000				
1764		34716613	1926		74559631	1966	108437000	115810643	1994	99930000	111874143			
1770	4252022		1928		76882596	1967	106454000		1995	99920000				
1780	4088483		1930	79404250	79205561	1968	104470000	115529464	1996	99910000	111592964			
1788		37872668	1932		81528526	1969	102486000		1997	99900000				

1790	3931234		1934		83851491	1970	102355000	115248286	1998	99890000	111311786			
1800	3780032		1936		86174456	1971	102223000		1999	99880000				
1810	5052198		1938		88497421	1972	102092000	114967107	2000	99870000	111030607			
1812		41028724	1940	92388500	90820386	1973	101960000		2001	99860000				
1820	6207295		1942		93143351	1974	101829000	114685929	2002	99848000	110749429			
1830	7626484		1944		95466316	1975	101697000		2003	101200000				

Note: Null values are plotted.

Table 2C. Regional comparison of pasture expansion (in hectares) in Argentina (1500-2018) between two different approaches; the current research (CR) and HYDE.

	North HYDE	Center HYDE	South HYDE	North CR	Center CR	South CR		North HYDE	Center HYDE	South HYDE	North CR	Center CR	South CR
1500	2134758	0	0	0	0	0	1955	26232675	51991530	33640670			
1524				508321	2005982	641752	1956	26537160	52595000	34031140	17620871	69537004	22246230
1548				1016643	4011964	1283505	1957	26841645	53198470	34421610			
1572				1524964	6017946	1925257	1958	27146130	53801940	34812080	17995013	71013476	22718582
1596				2033286	8023928	2567009	1959	27450615	54405410	35202550			
1600	2912920	2523564	382702				1960	27755099	55008880	35593020	18369154	72489947	23190934
1620				2541607	10029910	3208762	1961	27755099	55008880	35593020			
1644				3049928	12035892	3850514	1962	27289845	54086775	34996380	18743296	73966418	23663285
1668				3558250	14041874	4492266	1963	26824591	53164670	34399740			
1692				4066571	16047856	5134019	1964	26359336	52242564	33803100	18972831	73143012	23975978
1700	2800884	2426504	367983				1965	25894316	51320924	33206760			
1710	2693158	2333177	353830				1966	25428827	50398354	32609819	19202366	72319606	24288672
1716				4574893	18053837	5775771	1967	24963807	49476713	32013480			
1720	2589575	2243439	340221				1968	24498553	48554608	31416839	19431900	71496199	24601365
1730	2489976	2157153	327136				1969	24033299	47632502	30820199			
1740	2394208	2074186	314554	5083214	20059819	6417524	1970	24002579	47571617	30780804	19661435	70672793	24914058
1750	2302123	1994409	302455				1971	23971624	47510268	30741108			
1760	2213580	1917701	290822				1972	23940904	47449383	30701713	19890969	69849387	25226751
1764				5591536	22065801	7059276	1973	23909950	47388033	30662017			
1770	2128442	1843943	279637				1974	23879230	47327148	30622622	20120504	69025981	25539444
1780	2046579	1773023	268882				1975	23848275	47265798	30582926			
1788				6099857	24071783	7701028	1976	23817556	47204913	30543531	20350038	68202574	25852138
1790	1967864	1704829	258540				1977	23786601	47143564	30503835			

1800	1892177	1639259	248596				1978	23755881	47082679	30464440	20579573	67379168	26164831
1810	2528987	2190950	332261				1979	23724927	47021329	30424744			
1812				6608178	26077765	8342781	1980	23693972	46959979	30385049	20809107	66555762	26477524
1820	3107196	2691872	408227				1981	23663252	46899094	30345653			
1830	3817602	3307322	501561				1982	23632533	46838209	30306258	21038642	65732355	26790217
1836				7116500	28083747	8984533	1983	23601813	46777324	30266863			
1840	4690430	4063483	616234				1984	23570858	46715974	30227167	21268176	64908949	27102910
1850	5762814	4992527	757125				1985	23540138	46655089	30187772			
1860	7080381	6133981	930228	7624821	30089729	9626285	1986	23509184	46593740	30148077	21497711	64085543	27415603
1870	9077411	7864078	1192600				1987	23478464	46532855	30108681			
1880	9768321	10133705	2231077				1988	23447509	46471505	30068986	21727245	63262136	27728297
1884				8133143	32095711	10268038	1989	23445633	46467787	30066580			
1890	10392657	12217112	3187907				1990	23443288	46463139	30063573	21956780	62438730	28040990
1900	11430525	17103879	6911829				1991	23440943	46458491	30060565			
1908				8641464	34101693	10909790	1992	23438598	46453844	30057558	22186315	61615324	28353683
1910	12830885	24460719	13114953	9015606	35578164	11382142	1993	23455751	46350385	30133864			
1912				9389748	37054636	11854493	1994	23475559	46243520	30210920	22415849	60791918	28666376
1914				9763890	38531107	12326845	1995	23628118	46113486	30178395			
1916				10138032	40007578	12799197	1996	23732276	45983701	30194024	22645384	59968511	28979069
1918				10512174	41484050	13271548	1997	23896946	45828190	30174864			
1920	15575705	30870078	19974217	10886316	42960521	13743900	1998	24137666	45675137	30077197	22874918	59145105	29291763
1922				11260458	44436992	14216252	1999	24567881	45392128	29919991			
1924				11634600	45913463	14688603	2000	24784418	45188840	29896742	23104453	58321699	29604456
1926				12008741	47389935	15160955	2001	25012778	45031836	29815386			
1928				12382883	48866406	15633307	2002	25149117	44909194	29789689	23333987	57498292	29917149
1930	18620553	36904779	23878918	12757025	50342877	16105658	2003	25820850	45024843	30354307			
1932				13131167	51819349	16578010	2004	26730341	44499348	31340311	23563522	56674886	30229842
1934				13505309	53295820	17050362	2005	27389608	44110646	32399746			
1936				13879451	54772291	17522713	2006	28005211	43720197	33524592	23793056	55851480	30542535
1938				14253593	56248763	17995065	2007	28639573	43192303	34768125			

1940	21665402	42939479	27783619	14627735	57725234	18467417	2008	29250518	44302154	34447328	24022591	55028074	30855228
1942				15001877	59201705	18939769	2009	29461615	44935743	34102642			
1944				15376019	60678177	19412120	2010	29783502	42555777	36160720	24252125	54204667	31167922
1946				15750161	62154648	19884472	2011	29931125	42046752	36522123			
1948				16124303	63631119	20356824	2012	30076279	41439924	36983797	24481660	53381261	31480615
1950	24710251	48974180	31688320	16498445	65107590	20829175	2013	30118423	41437098	36944479			
1951	25014736	49577650	32078790				2014	30128538	41678974	36692488	24711194	52557855	31793308
1952	25319220	50181120	32469260	16872587	66584062	21301527	2015	30127993	41676530	36695477			
1953	25623705	50784590	32859730				2016	30048262	41467006	36984733	24940729	51734448	32106001
1954	25928190	51388060	33250200	17246729	68060533	21773879	2017	30032706	41623475	36843820			
							2018	30137337	41618711	36743952	25170264	50911042	32418694

Note: Null values are plotted.

Appendix D

Table 1D. Cattle numbers in the northern region of Argentina (1500-2018)

	1500	1888	1895	1908	1914	1922	1930	1947	1952	1960	1969	2018
Jujuy	0	89855	129355	113319	134335	118526	170973	129949	154424	91354	105674	83430
Salta	0	164944	550599	560299	616391	488943	845578	643313	760398	593889	528151	828162
Formosa	0	14403	41424	233724	379092	526881	984974	1272550	1664496	1058564	1061441	1224504
Chaco	0	17551	83952	265279	455684	596667	1178371			1094260	1314779	1870993
Tucuman	0	198835	426869	403811	358923	336898	469863	280376	284389	234354	239689	81881
Catamarca	0	239834	275515	268460	278082	308147	293076	159345	194644	151400	222610	216930
Santiago del Estero	0	588396	591302	628652	757352	630350	869981	581890	682081	676749	885312	1136199
San Juan	0	54539	69288	81917	63286	58191	69711	59063	38109	30303	38128	27484
La Rioja	0	160197	246750	417353	211729	188064	224440	167057	136594	169359	195847	127377
Corrientes	0	1841455	2893256	4275895	3543395	3793584	3832556	3405385	3774354	2887850	3650808	3082947
Misiones	0	41967	70259	94361	91084	115406	117626	150664	195722	130926	130787	354062

Table 2D. Cattle numbers in the central region of Argentina (1500-2018).

	1500	1888	1895	1908	1914	1922	1930	1947	1952	1960	1969	2018
Buenos Aires	0	8786650	7762295	10356096	9103199	15507530	11649042	17813243	19846604	17517793	18692613	14883528
Santa Fe	0	2328443	2315007	3413446	3179260	4692543	3641804	5576022	6110207	5841097	6302201	4459989
Entre Rios	0	4120068	2784810	3145639	2334372	2820905	2534729	3363145	4281577	3424712	3905364	2866264
Cordoba	0	2110523	1884926	2639480	2540313	4102894	3074697	4719515	4870497	6195679	7213688	3614041
La Pampa	0	469775	530162	464645	561284	1330189	894174	1470700	1181256	1961587	2230415	2556614
San Luis	0	478904	479964	578889	603254	897209	721235	693617	568549	896642	956602	1324833
Mendoza	0	180009	268746	329998	226749	200463	237097	194326	122109	184538	167500	334232

Table 3D. Cattle numbers in the central region of Argentina (1500-2018).

	1500	1888	1895	1908	1914	1922	1930	1947	1952	1960	1969	2018
Neuquen	0		178706	193728	152333	141307	156591	132054	137342			169124
Rio negro	0	77434	82050	279459	90957	100571	110920	123674	124729			507936
Chubut	0		29944	334995	135822	96649	112241	92594	111763			165155
Santa Cruz	0		10551	25329	43521	6502	17982	14115	16571			71368
Tierra del fuego	0	148	796	11851	6346	6431	4194	5592	6580	5000		36030

Table 4D. Cattle density (area/cattle) in the northern region of Argentina (1500-2018).

	1888	1895	1908	1914	1922	1930	1947	1952	1960	1969	2018
Jujuy	59,23	41,14	46,96	39,62	44,90	31,13	40,95	34,46	58,26	50,36	63,79
Salta	94,27	28,24	27,75	25,23	31,80	18,39	24,17	20,45	26,18	29,44	18,78
Formosa	500,35	173,97	30,83	19,01	13,68	7,32	5,66	4,33	6,81	6,79	5,89
Chaco	567,68	118,68	37,56	21,86	16,70	8,46			9,11	7,58	5,33
Tucuman	11,33	5,28	5,58	6,28	6,69	4,79	8,03	7,92	9,61	9,40	27,51
Catamarca	42,78	37,24	38,22	36,90	33,30	35,01	64,39	52,71	67,77	46,09	47,30
Santiago del Estero	23,17	23,06	21,69	18,00	21,63	15,67	23,43	19,99	20,15	15,40	12,00
San Juan	164,38	129,39	109,44	141,66	154,06	128,60	151,79	235,25	295,85	235,13	326,19
La Rioja	55,98	36,34	21,49	42,36	47,69	39,96	53,68	65,65	52,95	45,79	70,41
Corrientes	4,79	3,05	2,06	2,49	2,32	2,30	2,59	2,34	3,05	2,42	2,86
Misiones	71,01	42,42	31,58	32,72	25,82	25,34	19,78	15,23	22,76	22,79	8,42

Table 5D. Cattle density (area/cattle) in the central region of Argentina (1500-2018).

Center	1888	1895	1908	1914	1922	1930	1947	1952	1960	1969	2018
Buenos Aires	3,50	3,96	2,97	3,38	1,98	2,64	1,73	1,55	1,76	1,65	2,07
Santa Fe	5,71	5,75	3,90	4,18	2,83	3,65	2,39	2,18	2,28	2,11	2,98
Entre Rios	1,91	2,83	2,50	3,37	2,79	3,11	2,34	1,84	2,30	2,02	2,75
Cordoba	7,83	8,77	6,26	6,51	4,03	5,38	3,50	3,39	2,67	2,29	4,57
La Pampa	30,53	27,06	30,87	25,56	10,78	16,04	9,75	12,14	7,31	6,43	5,61
San Luis	16,03	15,99	13,26	12,72	8,55	10,64	11,06	13,50	8,56	8,02	5,79
Mendoza	82,68	55,38	45,10	65,64	74,24	62,77	76,59	121,88	80,65	88,85	44,53

Table 6D. Cattle density (area/cattle) in the southern region of Argentina (1500-2018).

Sur	1888	1895	1908	1914	1922	1930	1947	1952	1960	1969	2018
Neuquen		52,64	48,56	61,76	66,58	60,08	71,24	68,50			55,63
Rio negro	262,18	247,43	72,65	223,20	201,86	183,03	164,15	162,76			39,97
Chubut		750,35	67,07	165,43	232,48	200,18	242,66	201,04			136,05
Santa Cruz		2312,04	963,10	560,52	3751,81	1356,60	1728,25	1472,11			341,81
Tierra del fuego	14366,89	2671,23	179,42	335,06	330,63	506,99	380,24	323,15	425,26		59,01