

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 Europeans 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 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).

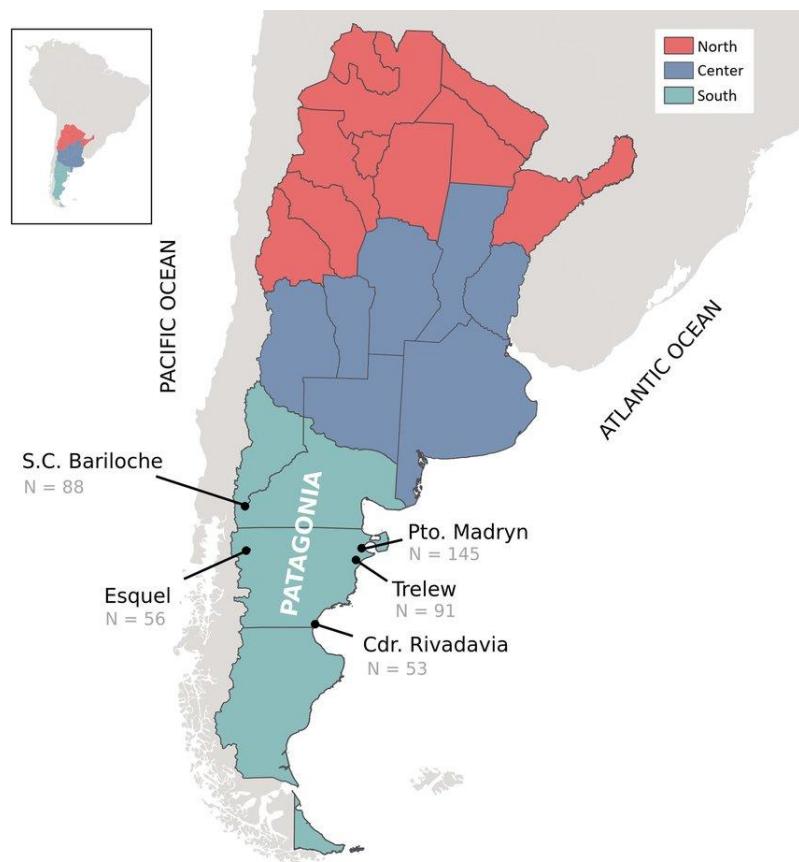


Figure 1. Argentina (*Source: Parolin et al., (2019)*)

Argentina also faces some social and environmental tensions; according to Castro et al., (2016) this 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.

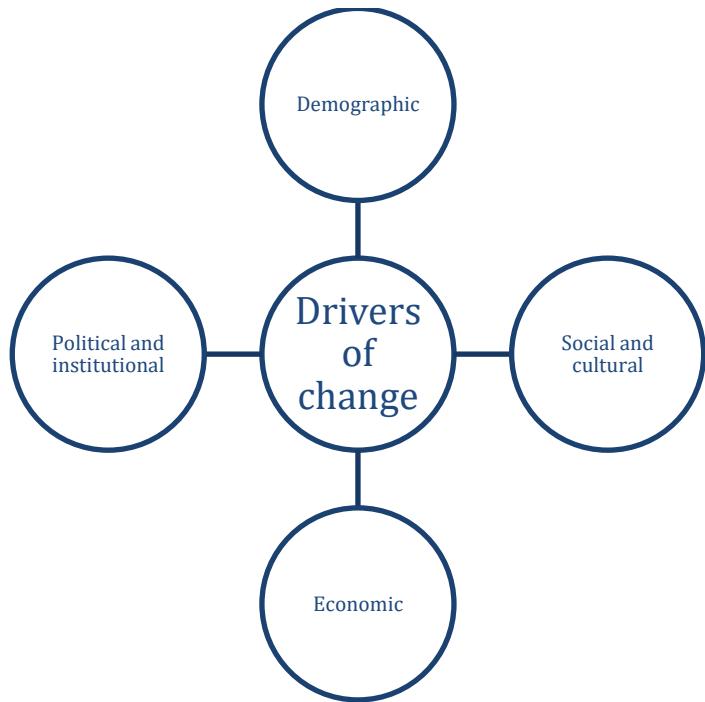


Figure 2. Drivers of change

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 were the historical records where 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

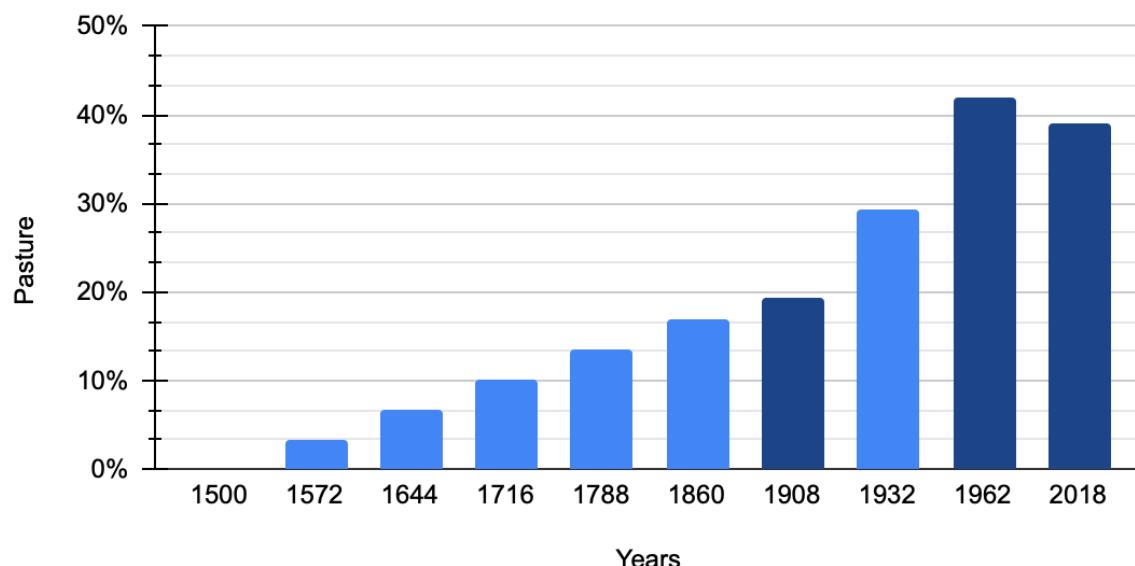


Figure 3. Pasture expansion in Argentina (1500-2018). (*Source: Agropecuario, (1909); Instituto Nacional de Estadísticas y Censos, (2018); FAO, (2022)*)

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

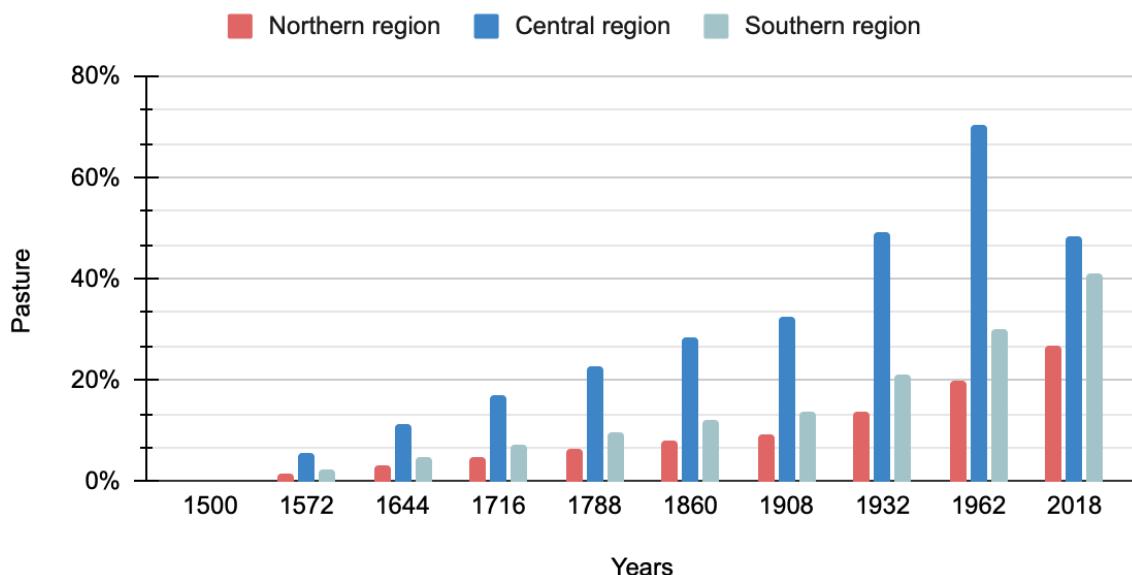


Figure 4. Pasture expansion by regions in Argentina (1500-2018). (*Source: Agropecuario, (1909); Instituto Nacional de Estadísticas y Censos, (2018); FAO, (2022)*)

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

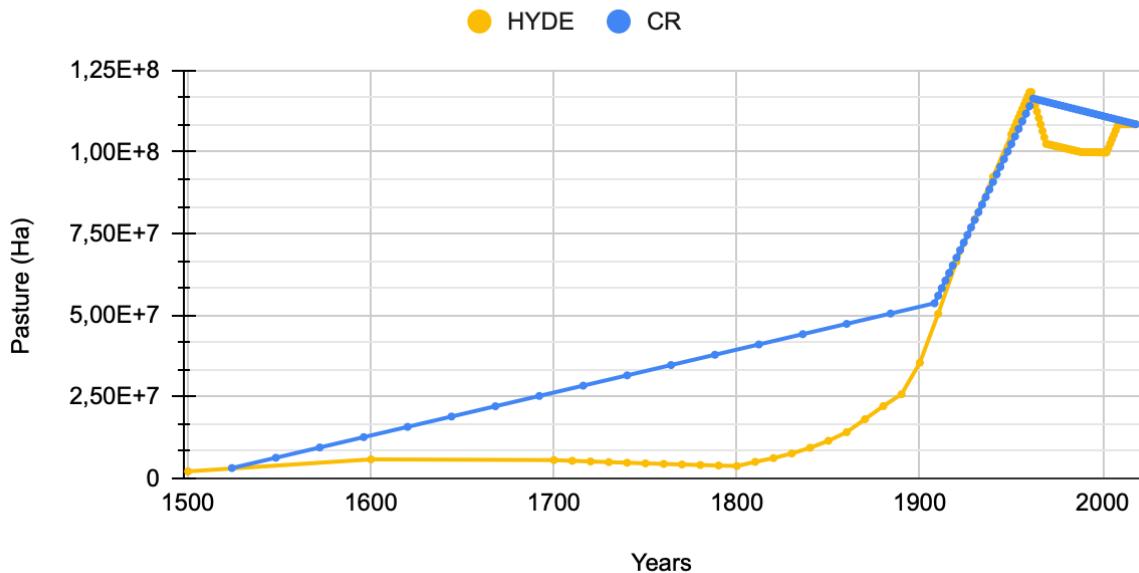


Figure 5. Comparison of pasture expansion in Argentina (1500-2018) between two different approaches; the current research (CR) and HYDE. (Source: *Agropecuario*, (1909); *Instituto Nacional de Estadísticas y Censos*, (2018); FAO, (2022), HYDE)

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

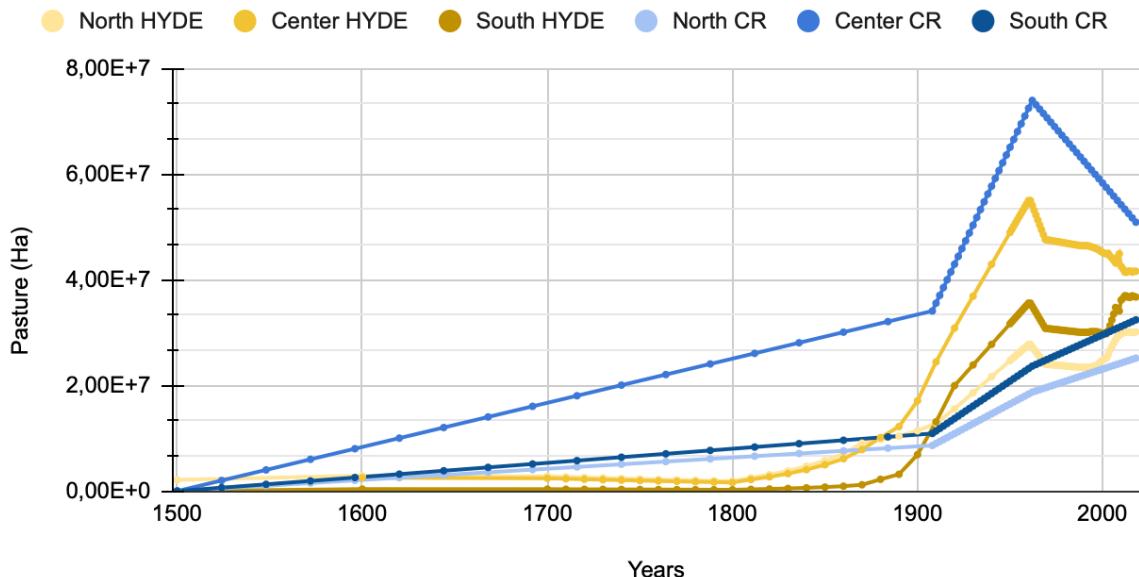


Figure 6. Regional comparison of pasture expansion in Argentina (1500-2018) between two different approaches; the current research (CR) and HYDE. (Source: *Agropecuario*, (1909); *Instituto Nacional de Estadísticas y Censos*, (2018); FAO, (2022), HYDE)

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)

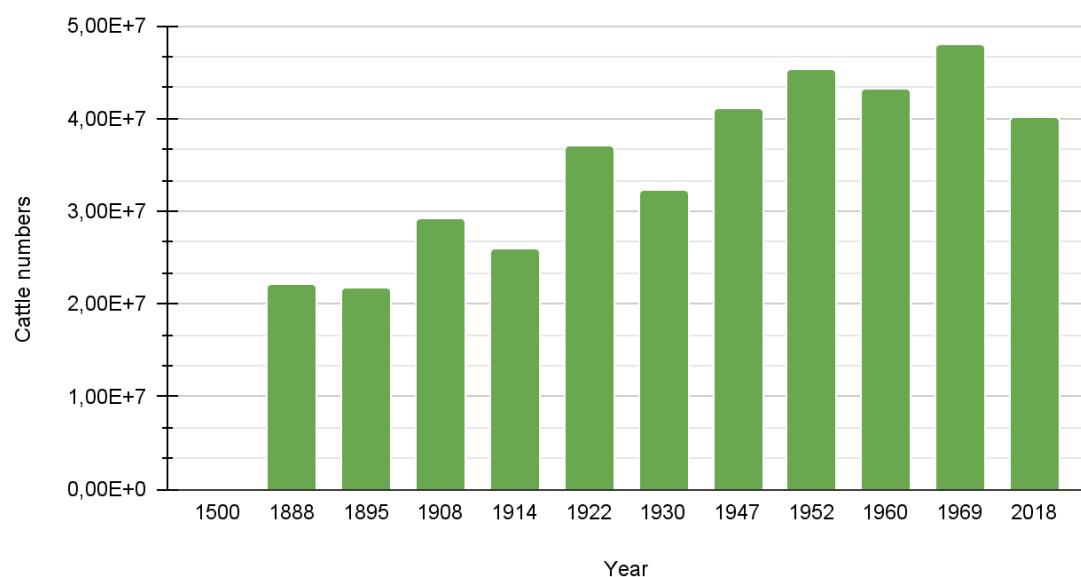


Figure 7. Number of cattle over the years in Argentina (1500-2018). (*Source: Nacional, (1932); Censos, (1953); Censos (Argentina), (1970); Instituto Nacional de Estadísticas y Censos, (2018)*)

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

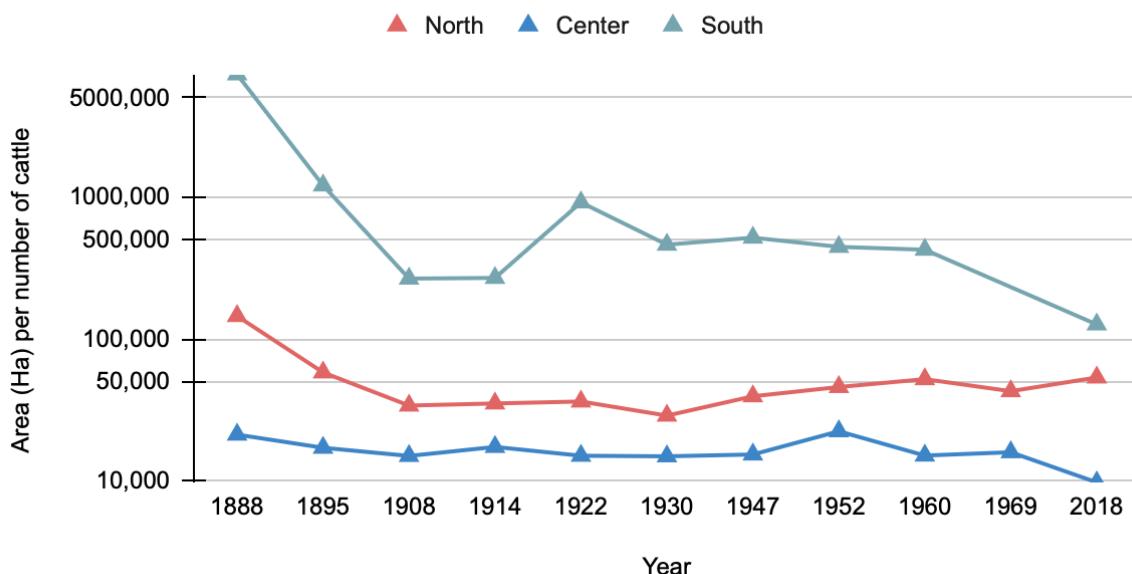


Figure 8. Average cattle density by region (1888-2018). (Source: *Nacional*, (1932); *Censos*, (1953); *Censos (Argentina)*, (1970); *Instituto Nacional de Estadísticas y Censos*, (2018))

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 all., (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.

Cited literature

Agropecuario, A. C. N. del C. (1909). La ganadería y la agricultura en 1908: Censo levantado durante la presidencia del José Figueroa Alcorta. (Rolla et al., 2019)

Arelovich, H., Bravo, R., & Martinez, M. F. (2011). Development, characteristic, and trends for beef cattle production in Argentina. *Animal Frontiers*, 1, 37–45. <https://doi.org/10.2527/af.2011-0021>

Brovkin, V., Sitch, S., Von Bloh, W., Claussen, M., Bauer, E., & Cramer, W. (2004). Role of land cover changes for atmospheric CO₂ increase and climate change during the last 150 years. *Global Change Biology*, 10, 1253–1266. <https://doi.org/10.1111/j.1365-2486.2004.00812.x>

Censos, A. D. N. de E. y. (1953). Censo nacional agropecuario de 1952: Existencia de ganado vacuno, porcino y lanar, resultados provisionales. La Dirección. <https://books.google.nl/books?id=Kn5YAAAAMAAJ>

Censos (Argentina), I. N. de E. y. (1970). Censo nacional agropecuario, 1969: Datos comparativos, 1969-1960. Republica Argentina, Instituto Nacional de Estadística y Censos. <https://books.google.nl/books?id=1XZYAAAAMAAJ>

de Castro, F., Hogenboom, B., & Baud, M. (2016). Introduction: Environment and Society in Contemporary Latin America. In F. de Castro, B. Hogenboom, & M. Baud (Eds.), Environmental Governance in Latin America (pp. 1–25). Palgrave Macmillan UK. https://doi.org/10.1007/978-1-37-50572-9_1

Dong, N., Liu, Z., Luo, M., Fang, C., & Lin, H. (2019). The Effects of Anthropogenic Land Use Changes on Climate in China Driven by Global Socioeconomic and Emission Scenarios. *Earth's Future*, 7, 784–804.

Hasan, S. S., Zhen, L., Miah, M. G., Ahamed, T., & Samie, A. (2020). Impact of land use change on ecosystem services: A review. *Environmental Development*, 34, 100527. <https://doi.org/10.1016/j.envdev.2020.100527>

Ellis, E. C., Beusen, A. H. W., & Goldewijk, K. K. (2020). Anthropogenic Biomes: 10,000 BCE to 2015 CE. *Land*, 9(5). <https://doi.org/10.3390/land9050129>

Ellis, E. C., Gauthier, N., Goldewijk, K. K., Bird, R. B., Boivin, N., Díaz, S., Fuller, D. Q., Gill, J. L., Kaplan, J. O., Kingston, N., Locke, H., McMichael, C. N. H., Ranco, D., Rick, T. C., Shaw, M. R., Stephens, L., Svenning, J.-C., & Watson, J. E. M. (2021). People have shaped most of terrestrial nature for at least 12,000 years. *Proceedings of the National Academy of Sciences*, 118(17), e2023483118. <https://doi.org/10.1073/pnas.2023483118>

Etter, A., McAlpine, C., & Possingham, H. (2008). Historical Patterns and Drivers of Landscape Change in Colombia Since 1500: A Regionalized Spatial Approach. *Annals of the Association of American Geographers*, 98(1), 2–23. <https://doi.org/10.1080/00045600701733911>

FAO. (2022). FAOSTAT. Argentina. Retrieved from Food and Agriculture Organization of the United Nations: <https://www.fao.org/faostat/en/#country/9>

Ficek, R. (2019). Cattle, Capital, Colonization Tracking Creatures of the Anthropocene In and Out of Human Projects. 60, 260–271. <https://doi.org/10.1086/702788>

Garavaglia, J., & Gelman, J. (2002). *Capitalismo agrario en la frontera. Buenos Aires y la región pampeana en el siglo XIX.* Obtenido de Historia Agraria: https://www.historiaagraria.com/FILE/articulos/HA29_garavaglia.pdf

Godde, C. M., Garnett, T., Thornton, P. K., Ash, A. J., & Herrero, M. (2018). Grazing systems expansion and intensification: Drivers, dynamics, and trade-offs. Global Food Security, 16, 93–105. <https://doi.org/10.1016/j.gfs.2017.11.003>

Hasan, S. S., Zhen, L., Miah, M. G., Ahamed, T., & Samie, A. (2020). Impact of land use change on ecosystem services: A review. Environmental Development, 34, 100527. <https://doi.org/10.1016/j.envdev.2020.100527>

Instituto Nacional de Estadísticas y Censos. (2018). Censo Nacional Agropecuario 2018. Resultados preliminares. Agricultura. Retrieved from Censo Agropecuario: <https://www.indec.gob.ar/indec/web/Nivel4-Tema-3-8-87>

Kaplan, J. O., Krumhardt, K. M., Gaillard, M.-J., Sugita, S., Trondman, A.-K., Fyfe, R., Marquer, L., Mazier, F., & Nielsen, A. B. (2017). Constraining the Deforestation History of Europe: Evaluation of Historical Land Use Scenarios with Pollen-Based Land Cover Reconstructions. *Land*, 6(4). <https://doi.org/10.3390/land6040091>

Klein Goldewijk, K., Beusen, A., Drecht, G., & Vos, M. (2011). The HYDE 3.1 spatially explicit database of human-induced global land-use change over the past 12,000 years. *Global Ecology and Biogeography*, 20, 73–86. <https://doi.org/10.1111/j.1466-8238.2010.00587.x>

Klein Goldewijk, K., Dekker, S. C., & van Zanden, J. L. (2017). Per-capita estimations of long-term historical land use and the consequences for global change research. *Journal of Land Use Science*, 12(5), 313–337. <https://doi.org/10.1080/1747423X.2017.1354938>

Li, B. V., & Jiang, B. (2021). Responses of forest structure, functions, and biodiversity to livestock disturbances: A global meta-analysis. *Global Change Biology*, 27, 4745–4757

Martínez, R., Carpinetti, B., Moreno, L., & Solis, R. (2020). El ganado bovino criollo patagónico de Argentina. *Archivos Latinoamericanos de Producción Animal*, 28, 53–68. <https://doi.org/10.53588/alpa283401>

Nacional, A. C. del C. G. (1932). Censo ganadero nacional: Existencia al 1º de julio de 1930. Talleres Gráficos del Ministerio de Agricultura de la Nación. <https://books.google.nl/books?id=FBY0AAAAIAAJ>

Nunn, N., & Qian, N. (2010). The Columbian Exchange: A History of Disease, Food, and Ideas. *Journal of Economic Perspectives*, 24(2), 163–188. <https://doi.org/10.1257/jep.24.2.163>

Ramankutty, N., & Coomes, O. T. (2016). Land-use regime shifts: An analytical framework and agenda for future land-use research. *Ecology and Society*, 21(2). <https://doi.org/10.5751/ES-08370-210201>

Rolla, A. L., Nuñez, M. N., Ramayón, J. J., & Ramayón, M. E. (2019). Impacts of climate change on bovine livestock production in Argentina. *Climatic Change*, 153(3), 439–455. <https://doi.org/10.1007/s10584-019-02399-5>

The Nature Conservancy. (2022). The Nature Conservancy. Obtenido de Latin America: Argentina: <https://www.nature.org/en-us/about-us/where-we-work/latin-america/argentina/>

Waisman, C. H. (1986). Population and Social structure in Argentina. *Latin American Research Review*, 21(2), 256–265. JSTOR.

Winkler, K., Fuchs, R., Rounsevell, M., & Herold, M. (2021). Global land use changes are four times greater than previously estimated. *Nature Communications*, 12(1), 2501. <https://doi.org/10.1038/s41467-021-22702-2>

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 Ríos | 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 |