A report for:

Regenerative Grazing and its Impact on the Water Cycle in Semi-Arid Environments

by Isidora Molina Pérez de Castro

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Executive Summary

This report delves into the transformative potential of regenerative grazing practices in semi-arid environments, particularly their ability to improve the water cycle, soil health, and ecosystem functionality. Semi-arid regions, characterized by low and irregular rainfall, poor soil quality, and high rates of evaporation, face significant challenges that limit their agricultural productivity. Through field observations, interviews, and secondary data from diverse countries—Mexico, the United States and Chile—this study evaluates the role of regenerative livestock farming as a sustainable solution to these issues. It also includes critical findings on behalf of our GFP visited countries, that are not related to the main topic but have a strong relationship with sustainability.

The findings show that regenerative grazing practices, particularly those based on **Holistic Management**, have the potential to restore degraded soils, enhance water retention, and improve overall land productivity. Holistic Management employs strategic grazing plans that mimic the natural movements of herbivores, creating conditions that promote the recovery and health of plant communities. These practices reduce overgrazing and desertification by aligning grazing periods with the ecological needs of plants, allowing for deeper root systems and increased organic matter in the soil. As a result, soils become more resilient, capable of storing more water, and less prone to erosion.

One of the most significant impacts of regenerative grazing is its ability to address the inefficiencies of the water cycle in semi-arid areas. Research indicates that well-managed pastures can infiltrate and retain significantly more rainwater than conventionally grazed systems. For instance, each 1% increase in soil organic matter allows an additional 182,000 liters of water per hectare to be stored, creating a buffer against erratic rainfall patterns exacerbated by climate change. This improvement in water management is critical for maintaining productivity and reducing environmental vulnerability in these fragile ecosystems.

In addition to environmental benefits, regenerative grazing also offers economic advantages. Data from monitored sites in Chile reveal that producers transitioning to regenerative systems experience greater profitability compared to traditional practices. This is largely attributed to reduced feed costs, improved pasture management, and the enhanced resilience of their systems to external shocks. However, barriers to wider adoption persist. Key challenges include cultural paradigms rooted in traditional grazing methods, limited education on regenerative practices, and the lack of public policies that support these transitions.

The report underscores the need for a comprehensive approach to overcome these obstacles. Education and technical assistance are critical to empowering producers with the knowledge and tools required to implement regenerative practices. Furthermore, public policy must play a role in incentivizing sustainable land management, whether through subsidies, training programs, or market mechanisms that reward environmentally responsible farming practices.

Regenerative livestock farming has the potential to not only address the environmental challenges of semi-arid regions but also to offer a sustainable and profitable model for agricultural producers. By improving water cycle efficiency, fostering biodiversity, and sequestering carbon, this approach aligns with global goals for climate resilience and sustainable development. The report concludes that with adequate support, regenerative grazing can transform semi-arid landscapes into thriving, productive systems, providing benefits that extend from local producers to global environmental health.

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Foreword

The following report is addressed to the entire Nuffield community, so that the learnings obtained from the experience as a fellow can transcend and be shared, with the aim that these can be applied by fellows and Nuveen in their work and deeper research regarding Regenerative Livestock Farming.

The research topic is Regenerative Ranching, or Livestock Farming and its impact on the water cycle in semi-arid environments. The goal of the study is to assess the importance of the impact of livestock and recovery periods in grazing so that rainwater can infiltrate and be retained in soils that were previously managed in a traditional or extensive manner before the implementation of Regenerative Livestock Farming, through interviews, field visits, and secondary data in various semi-arid environments.

I am Isidora Molina Pérez de Castro born and raised in Santiago, Chile. I am 40 years old and joined the Nuffield program in 2022 (2022 Nuffield Scholar). I studied Veterinary Medicine at Universidad Mayor in Santiago, Chile, earning distinction with honors in the publication and presentation of my thesis and degree exam, titled "Economic and Financial Analysis of a Dairy Goat Herd in the Los Lagos Region, Chile." I completed a Diploma in Rural Extension and I am a specialist in the Holistic Management methodology developed by the Savory Institute. I am the Hub Leader of the "Efecto Manada" Hub, a center that has served Chile since 2017.
My company, Efecto Manada (efectomanada.cl), celebrated its 10th anniversary in 2024, providing consulting, courses, and ecological monitoring across Chile, working with various sizes of operations and audiences.

I knew about Nuffield by a Professor named Rafael Larraín from Universidad Católica de Chile, who was contacted by José Manuel Irarrázabal to recommend someone that was involved in the Chilean agricultural ecosystem from more than 10 years and who was able to speak in English fluently. Also, someone who was working in something that is having impact on the Chilean agricultural development, related to sustainability.

About the scholarship and Nuffield:

- "Gratitude for having had the opportunity to encounter so many different scenarios, cultures, and ways of seeing life. "
- "I didn't expect it, but after almost 12 years working in regenerative agriculture, I realized that I had been very focused on that area, thinking it was the only important thing. I discovered that staying connected to the most common ways of farming is crucial; it provides perspective and promotes transitions. "
- "To have hope for my country and its inhabitants. We are facing a drought that has been going on for over 15 years, and the population is leaving their rural activities to move to the city. "
- "Acquiring more tools for myself and my team, which we are already sharing with our community, to maintain food production, ecosystems, and the well-being of people in semi-arid areas."

Acknowledgments

I would like to express my heartfelt gratitude to everyone who has supported me throughout this journey.
To the Nuffield program, for the opportunity to explore, learn, and grow through this unique experience. Special acknowledgements to José Manuel Irarrázabal and Rafael Larraín Prieto for inviting and encouraging me to apply to this amazing grant, to Felipe Sanchez and Dominique Chauveau for helping me in my whole Efecto Manada´s journey. To Martin Davies and Nicolás Infante form Nuveen Natural Capital for funding my scholarship, without them it would have been impossible.

Also, to Jodie Redcliffe, who was always there to answer questions and guide me through the process and, who was with Wayne Redcliffe in our Japan trip always making us feeling more comfortable and making us laugh.

To my family and friends, for their unconditional encouragement and love, always inspiring me to strive for more. To the mentors, colleagues, and farmers who generously shared their knowledge, experiences, and time, enriching my understanding of regenerative agriculture.
As the Chihuahua desert visit to Rancho Las Damas opened my eyes and made me believe that a better present and future is possible, also gave me the opportunity to come back to my country full of hope, and that those semiarid areas are capable to change and thrive again, I give my acknowledgment to Alejandro Carrillo who taught me all he could with an open heart, we still talk a lot and I am still learning from him.

And finally, to all those who believe in the power of change and sustainable practices, thank you for being part of this journey, specially to the Savory Institute. Your passion and commitment continue to motivate me every day.

Objectives

- Describe the characteristics of semi-arid environments and their relationship with livestock farming.
- Describe the most important attributes of regenerative ranching, and relate them to the effects that they have in water cycle.
- Comment on ecosystem processes and observations related to regenerative livestock farming, with a special emphasis on the water cycle, that are going to impact sustainability and production.
- Acknowledge the effects of regenerative livestock farming on the water cycle by observations in places visited during personal trips.
- Share my findings from the places visited during the GFP related to sustainability upon the three pillars: environmental, economic and quality of life.

Introduction

In Chile, regenerative agriculture and livestock farming have yet to achieve significant adoption. According to a survey conducted by Efecto Manada in August 2024, only 80 farms, out of the 120,000 producers registered in the VIII Agricultural Census, implement regenerative livestock farming. These farms cover a total of 253,294 hectares.(INE, 2022)

The study “Barriers to the Adoption of Regenerative Livestock Farming in Chile” (Álamos et al., 2022) identifies the main obstacles as: lack of education, the need to break cultural paradigms, limited knowledge of regenerative systems, and the absence of public policies supporting this transition.

Despite these barriers, the results point to clear benefits. In the fields we have worked on over the past 10 years, cost reductions have been significant, leading to increased profitability. A study conducted by the Faculty of Agronomy at the Pontificia Universidad Católica de Chile on 17 farms transitioning to regenerative livestock farming (from 1 to 3 years) showed that this model is more profitable than traditional systems. This is primarily due to the significant reduction in feed costs achieved through effective pasture management, using holistic grazing planning while eliminating agrochemicals and reestablishment practices.

Studying the effects of regenerative ranching in water cycle and beyond, is crucial because it offers a sustainable solution to pressing challenges in agriculture and livestock farming, particularly in regions like Chile where adoption remains low despite its proven benefits. By examining its impact, we can address key barriers such as the lack of education, cultural paradigms, and limited knowledge of regenerative systems, which have hindered its broader implementation. Furthermore, studying these effects allows policymakers, producers, and stakeholders to better understand the ecological and economic benefits, fostering greater adoption.

Methodology

This report was based on interviews and observations during personal and group trips organized according to the scholarship. A key part of this report is the knowledge and experience gained over more than 12 years as a professional working in Regenerative Ranching. Additionally, secondary information was researched to support the provided data. One of the relevant conceptual information sources is the Savory Institute, which has developed the Holistic Management methodology, offering insights from the perspective of the principles of Regenerative Livestock Farming and ecosystem processes, allowing me to observe nature from various viewpoints.

The countries visited during the personal trips were Mexico, the United States, and Chile, while the trips organized by the GFP included New Zealand, Australia, Indonesia, and Japan.

Semiarid areas or environments: definition and particularities

Arid and semi-arid zones are geographical and ecological units where extreme dryness and reduced or almost absent vegetation coverage prevail. These factors influence all ecosystem processes, and the behavior of different species adapted to live in such conditions.

Rangelands including silvopastoral systems (grasslands, savannas, and woodlands comprised of grasses and woody species) cover 54% of the global terrestrial surface and drylands globally make up 6.1 billion hectares. The world's rangelands co-evolved with enormous herds of grazers over millions of years. Grazing built a treasure of extraordinarily rich soils, thereby creating our most productive farming regions. (Savory Institute. 2022)

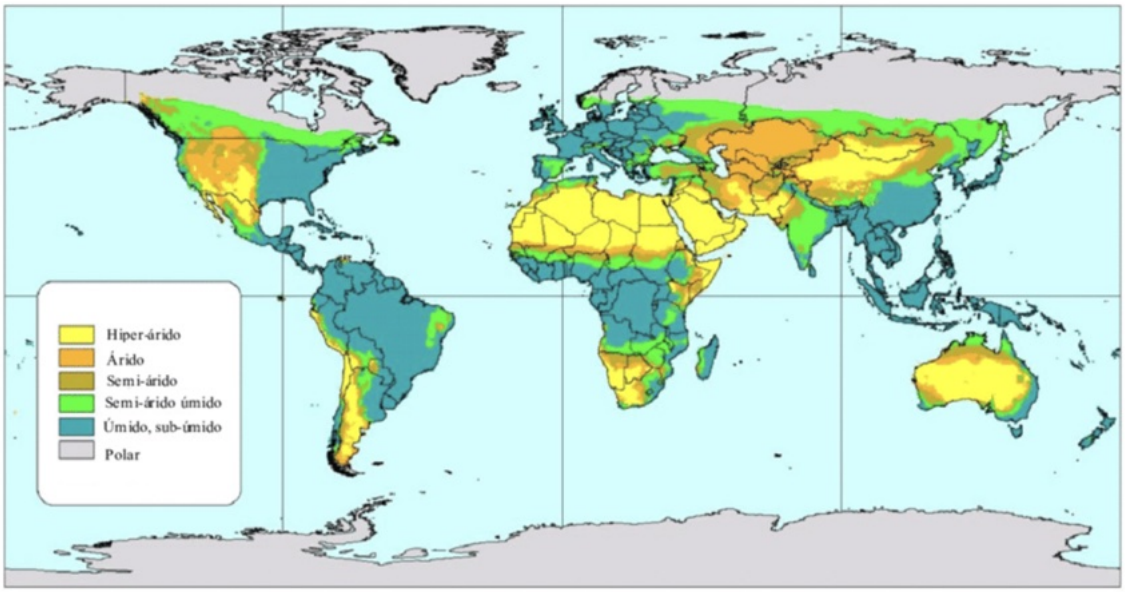


Figure 1: World map of semi-arid regions shown in brown. Source: FAOIIASA (2001).

In Africa, the Sahel stands out, a semi-arid strip extending south of the Sahara Desert. In Asia, there are the steppes of Kazakhstan and semi-arid regions in the interior of China. Australia has

vast semi-arid areas known as the “Outback.” In North America, the Chihuahua Desert spans parts of Mexico and the southwestern United States. South America has the western Chaco and the Coquimbo region in Chile. In Europe, the southeast of Spain features a semi-arid climate, especially in areas like Murcia and Almería.

Semi-arid environments are characterized by having a climate with annual precipitation between 250 and 500 mm, with scarce and irregular rainfall. Being an environment with a seasonal distribution of moisture, on a scale from 1 to 10, where 1 is an arid environment and 10 is completely humid, it is rated at 7.

Temperatures vary widely, with hot days and cool nights, high evaporation rates, leading to water deficits or inefficient water cycles, further exacerbated by the sparse vegetation cover in most territories.

The scarcity of vegetation is likely due to many environments that once had large herbivores in constant movement, like the case of Chihuahua, which transitioned from this natural state to extensive livestock farming with continuous grazing and overgrazing.

Prairie ecosystems prior to European settlement of the Great Plains of North America (same conditions that in Chihuahua desert), were characterized by free-ranging herds of large, migratory herbivores which moved constantly in response to changes in the vegetation due to topography, edaphic effects and variable and patchy precipitation to improve their diet quality and grazing efficiency (Frank et al., 1998). They also moved for a variety of other reasons including social factors, fire, predators, and movements by herders and hunters (Bailey and Provenza, 2008). Therefore, although grazing was intense at any particular site, such concentrated grazing seldom occurred at length and defoliated plants were usually afforded time and growing conditions to recover (Frank et al., 1998). This periodic vegetation defoliation and regrowth created by migratory herbivores contributed to ecosystem stability and the availability of high-quality diet for these herbivores. Now, the most common form of grazing management on rangeland with livestock is continuous year-round stocking. Livestock grazing large paddocks exhibit spatial patterns of repetitive use; heavily using preferred plants, patches and areas while avoiding or lightly using others (Willms et al., 1988), this would lead to overgrazing and over resting of plants that causes degradations and desertification, also a decrease in forage quantity. (Teague et al., 2011)

The vegetation consists of grasslands, low shrubs, and scattered trees, but as observed during the visit to Chihuahua desert, in Mexico, the areas surrounding the ranch show vegetation cover close to 5%, with small plants, small leaves, or wax-covered surfaces as adaptations to water loss.

The soil has moderate to low fertility, with few microorganisms capable of cycling nutrients, in contrast to moisture distribution environments. In these cases, herbivores become essential for cycling minerals, providing microorganisms and moisture from their digestive system, trampling, and urine. These thin soils are also very prone to erosion. Generally, the soils are sandy in texture, with low capacity to retain water. Intensive agricultural practices and overgrazing are mentioned as causes of desertification.

Regenerative Agriculture, grazing and Holistic Management

Agriculture

Regenerative Agriculture (RA) is an agricultural and transdisciplinary approach that integrates local and indigenous knowledge of landscapes, as well as their management, with established scientific knowledge. It combines a range of adoptable principles with context-specific practices, focusing on soil conservation as the initial step to restore soil health, enhance ecosystem functions, and promote improved socioeconomic outcomes". (Jayasinghe et al., 2023)

It has Environmental Outcomes: these definitions focus on practices that restore soil health, enhance carbon capture, combat climate change, and promote biodiversity. They include improving soil quality, minimizing tillage, increasing fertility, enhancing soil health, and mitigating soil threats like erosion and degradation. Additionally, RA addresses water supply and quality improvements and has the potential to mitigate climate change through carbon sequestration and reducing greenhouse gas emissions. (Global Application of Regenerative Agriculture: A Review of Definitions and Assessment Approaches. Sustainability 2023)

Regenerative pasture management can increase carbon capture. The study showed that well-managed grazing can boost the soil's carbon capture rate, contributing to long-term carbon storage. This is a crucial element when discussing the water cycle, as each 1% increase in soil organic matter (SOM) stores an additional 182,000 liters of rainwater per hectare, providing superior buffering for the increasingly erratic rainfall the climate crisis brings. (Kansas State Extension Agronomy, 2012)

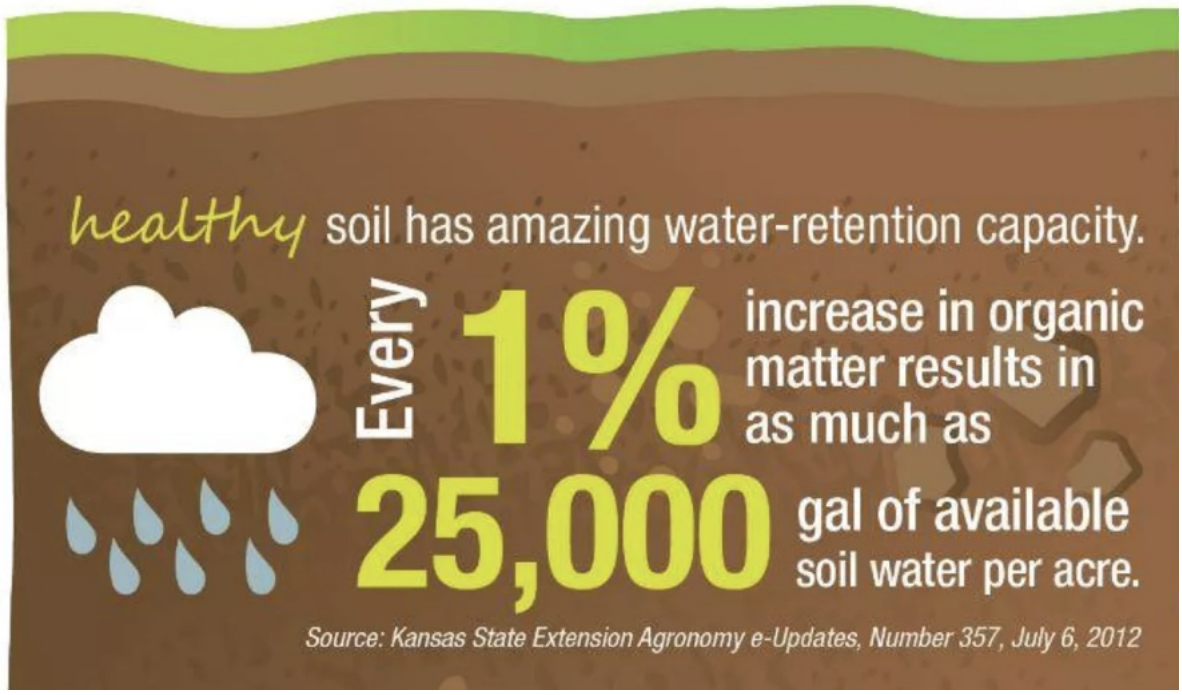


Figure 2: How Organic matter can affect the increase of water retention

Regenerative Agriculture, including Regenerative Ranching has principles, practices (like regenerative rotational grazing), benefits and mechanisms, which are described in the following diagram:

RA Principles	RA Practices	RA Benefits	Microbial Mechanisms

•Minimise soil disturbance
•Keep soils covered
•Keep living roots in soil year round
•Encourage diversity
•Integrate livestock
	• No/minimum tillage
	• Stubble retention
	• Diverse crop rotations
	• Multispecies cover crops
	• Intercropping
	• Composting and use biostimulants
	• Rotational grazing
	• Reduce synthetic inputs
		• Improved soil health through
		  • Increased soil carbon
		  • Improved microbial functions and associated nutrient cycling
		  • Improved soil moisture
		  • Improved resilience to pests and diseases
		• Nutrient rich food
		• Reduced greenhouse gas emissions
			•Liquid carbon pathway
			•Improved uptake of water and minerals
			•Enhanced soil aggregation, plant growth and photosynthesis

Figure 3, Source: Khangura et al., 2023

Ranching

In my professional career as a consultant and educator in regenerative livestock farming, I have learned and observed that regenerative livestock farming or ranching, is one that is capable of sequestering carbon, increasing water infiltration and retention, and enhancing biodiversity. The key tool to make livestock farming regenerative is pasture management planning, or Holistic Grazing Planning, with a Planning Chart, shown in figure 4. Designing a strategic route for the animals across the field allows us to place them in the right place at the right time. This means that, through the knowledge of those who know the land best and our experience, we can determine when pastures begin to regrow after winter and how much time they need to fully recover. In this way, we minimize degradation due to overgrazing by respecting growth and recovery periods.
Having a grazing plan allows for pre-planning tasks and events (shown with colors), reducing uncertainty about them during the season, facilitating decision-making, and better organizing time to dedicate to other tasks.

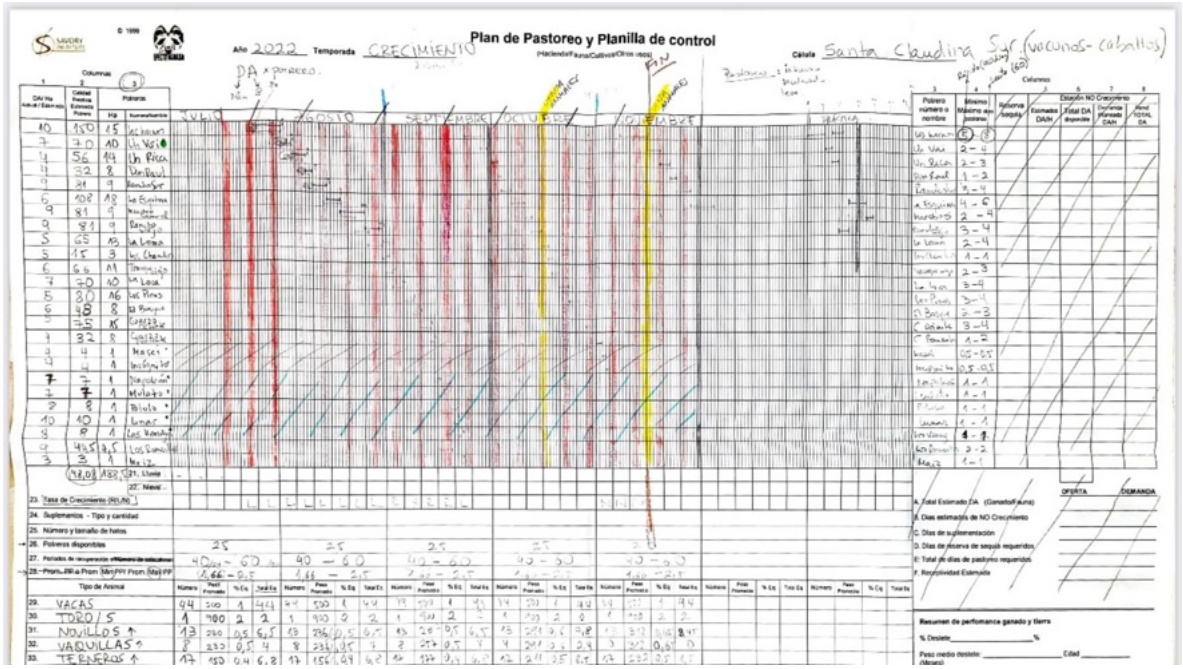


Figure 4: Holistic Grazing Planning and control Chart. Source: Isidora Molina

Determining the time periods the animals will spend in each pasture improves forage utilization without having negative effects on the pastures. The grazing planning process also allows us to establish when events such as breeding, calving, weaning, and sales will occur throughout the year.

I work with Holistic Management, it is a decision-making framework with associated strategic planning processes that result in ecologically regenerative, economically viable and socially sound management of the world's grasslands. It was first developed over 40 years ago by Allan Savory, a Zimbabwean biologist, game ranger, politician, farmer, and rancher, who was searching for ways to save the beautiful savannah and its wildlife in southern Africa.

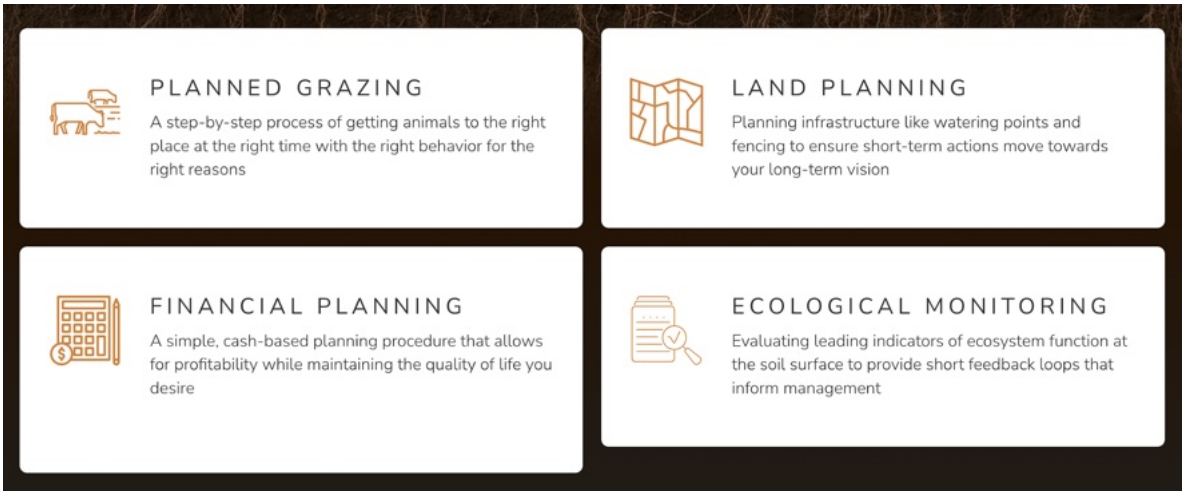


Figure 5. Planning processes of Holistic Management. Source: Savory Institute

Holistic Management teaches people about the relationship between large herds of wild herbivores and the grasslands, and then helps them develop strategies for managing herds of domestic livestock to mimic those wild herds to heal the land. It gives land managers, farmers,

ranchers, environmentalists, policymakers and others the insights and management tools needed to understand nature and work with it, resulting in better, more informed decisions that balance key social, environmental and financial considerations.

Holistic Management is successful because it is cost-effective, highly scalable and nature based. It is sustainable because it increases land productivity, livestock stocking rates and profits for landowners without compromising the long-term viability of the resource base.

It has Four Key Principles (Savory Institute, Savory Hub Handbook 2017)

1. Nature functions in wholes. You can't control or change one thing in one area without having an impact on something else in another area.
2. Regading the humidity distribution, explained as the distribution of it yearround: The same actions can produce completely unique results in different environments, having humidity distribution from seasonal to non-seasonal and short timing humidity.
3. Properly managed livestock can improve land health when properly managed to mimic the behavior of wild herbivores.
4. Time is more important than numbers. Overgrazing of plants is directly related to the amount of time the plants are exposed to the grazing animals and the amount of time that lapses between consecutive grazing events.

Ecosystem processes and my personal experience

Figure 6: Ecosystem processes

The four ecosystem processes work together, and when one becomes more efficient, it will drive the others to become more efficient as well. They are generally found in similar states of efficiency because the factors affecting these processes co-evolve following the application of different tools, such as animal impact and proper recovery periods for key plants.

This is a way of observing how nature is working, viewed from different perspectives. What follows are those perspectives on concrete examples that allow us to evaluate how ecosystem cycles are functioning and the signs we can observe of their efficiency. Although the examples have been used to describe each process individually, the same situation can be used to describe all of them simultaneously.

Now, I will discuss 3 of the 4 ecosystem processes, as the water cycle will be addressed in greater detail later.

1. **Mineral Cycle:** This refers to the ability of the soil-plant relationship to mobilize minerals from the atmosphere to the soil through photosynthesis and the integration of organic matter from vegetation, supported by moisture and microorganisms.

This photo was taken in the Metropolitan Region of Santiago, Chile, in a semi-arid environment with seasonal humidity distribution. It is very common that, in the absence of herbivores, plants, after their growth, fail to integrate and decompose into the soil due to the lack of biological activity in such environments. A very common sign is seeing oxidized plants, gray in color, which stop photosynthesizing and instead release CO2 into the atmosphere. The action of herd animals is strictly necessary

Picture 1: Plant oxidation Source: Isidora Molina, Región Metropolitana.

2. Community dynamics: It is related to changes in biodiversity, transitioning through early stages such as bare soil, followed by annual plants, then the presence of perennial plants, shrubs, trees, and even forests. In semi-arid environments, it is possible to find states with shrubs and trees combined with annual and perennial grasslands when these are well-managed meaning with animals grazing together in constant movement (animal impact – long term recovery periods). In an interview conducted with Joaquín Cadario in March 2023, a participant in the "Action Against Hunger" project in Niger, I was able to observe and learn about the impact of high density animals and long recovery periods.

Niger results:

Pictures 2: Source: Joaquín Cadario, member of Savory Network

Here we can continue observing how the mineral cycle becomes more effective with greater live vegetation cover performing photosynthesis. Now let us add the observations of the transition states: we start with bare soil and progress to biodiverse grasslands with annual and perennial plants and trees. This was achieved by incorporating domestic and wild livestock for 14 consecutive nights and with rest periods as long as one year.

3. Energy Flow: The business of agriculture is to capture the energy of the sun and transform it into food, leather, or wool. The energy flow is the ability to perform photosynthesis. It is very common to see in semi-arid environments, such degradation caused by continuous grazing, where the soils are exposed. In contrast, once again, the tool of high-density grazing with long recovery periods makes it possible to cover the soil and allow the highest possible rate of photosynthesis.

In South Portugal, in a semiarid area near Spain we can see how Cork oak (*Quercus suber)* producers are integrating well managed herding pigs which allows to maintain soil cover. It will increase the efficiency of water infiltratrion, community dynamics and also the energy flow, comparing to the conventional management of orchards that often do not allow weeds and grasses to be part of the system. This picture was taken in April 2022, after the GFP in a Savory Network´s meeting.

Picture 3: Pigs in silvopastures, Source: Isidora Molina, South Portugal

Water Flow in depth

This picture was taken in the Coquimbo Region, a semi-arid area in the central north of Chile, during a visit to goat herding communities. When we asked what the main issue in the región that was was causing a decrease in livestock and desertification, they responded, *"The problem is that it does not rain."*

Picture 4, water erotion, Source Isidora Molina

What can we notice in this photo? If we take a closer look at what an effective water cycle means, it is one that allows water to infiltrate and be retained in the soil, used by plants, and evapotranspiration instead of simply evaporating. Bare, dry soil becomes hydrophobic, allowing erosion with every raindrop that falls, making these soils unable to infiltrate water. We see a large amount of water; the issue, therefore, lies in the soil.

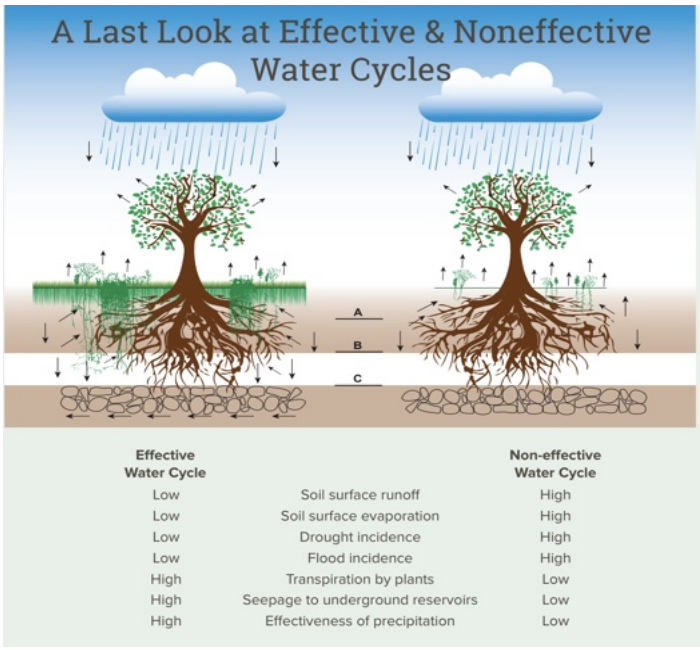


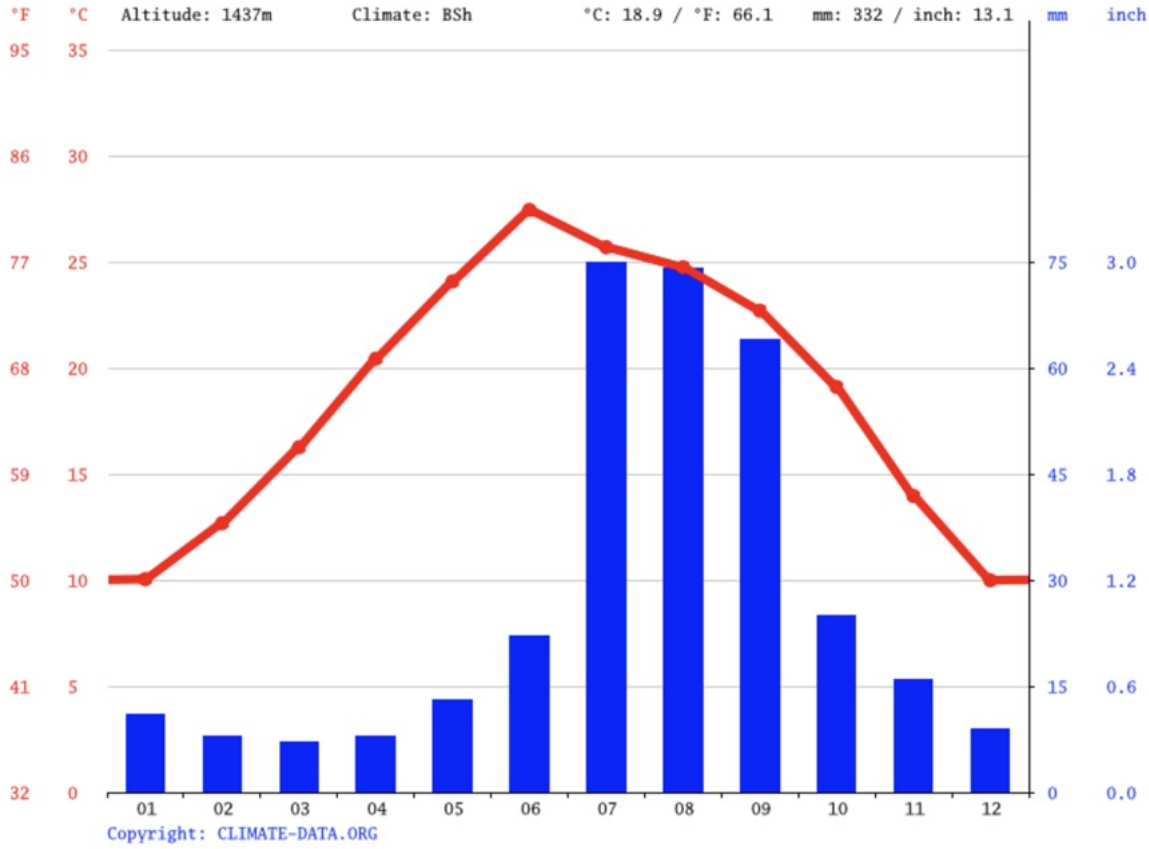
Image 7: Water Cycle effectiveness, Source: Savory Institut

Personally visited countries and findings

Rancho Las Damas de Alejandro Carrillo, Chihuahua Desert, Mexico

Chihuahua's climate (semi-arid), characterized by low annual precipitation (332 mm) and significant temperature variations, presents challenges for agriculture, livestock, and water resource management. The region experiences hot summers and mild winters, making it vulnerable to drought and desertification.
It has a easonal rainfall concentration, where the majority of the rainfall occurs between June and September, with July being the wettest month. This concentrated rainy season implies that effective water harvesting and storage systems are essential to sustain agriculture and livestock during the prolonged dry months.
It also has extended dry periods. The extended dry season from October to May leads to water scarcity, increasing pressure on soil quality and vegetation. This condition necessitates the adoption of drought-resistant crops and adaptive grazing practices to prevent land degradation.

CHIHUAHUA CLIMOGRAPH



Alejandro Carrillo has 10,000 hectares, of which 9,000 are grazed and Holistic Management has been applied for 16 years. He uses between 12 and 14 months of recovery, allowing a complete growth cycle before grazing. One of the strategies used to ensure that the cattle, when entering paddocks that have had over a year of recovery—where plants are dry and have lower nutritional quality—is to provide an additional two months of recovery. This allows a new

growth cycle to occur, producing green plants. In this way, the diet becomes more balanced, enabling the livestock to reach optimal weights suitable for both the producer and the market.

Picture 5: Las Damas, Neigbord´s Ranch (Source: Isidora Molina 2022)

Looking at this photograph, we return to earlier explanations about the water cycle. These are extensive gullies caused by water erosion. While semi-arid environments are known for low precipitation, over time, they have also become characterized by eroded soils with low water infiltration capacity. Such is the case with the land surrounding Rancho Las Damas, where conventional extensive livestock farming with overgrazing is still practiced. This management results in significant water runoff, leading to symptoms of water erosion like those visible here. In the photograph, a remnant of a fence can be seen, which at one point was installed on soil that has now been lost.

Pictures 7: Water infiltration, Source Alejandro Carrillo

In this image, two water infiltration tests are shown. On the left, the results indicate an inefficient water cycle, while on the right, there is evidence of a much more efficient cycle, achieving nine times more water infiltration per hour. This was observed on a ranch that has been practicing regenerative ranching for approximately 15 years. As the saying goes, "We cannot make it rain more, but we can make better use of the rainfall we receive."

Picture 8, Rancho Las Damas, Neigbord´s Ranch. Source, Isidora Molina 2022

Overgrazing is the fact of eating plants that are in the procces of recovery, and overresting is when a plan has not being grazed for more than it´s fenological process, leaving them oxidizing.It is a typical situation of low density and long grazing periods. Here we can see how bare the ground is in an vast area where the cattle is managed in an extensive way, allowing overgrazing and over resting plants that will re incorporate to the soil in a difficult way. There is no animal impact or high stocking rate, that can trample or provide dung and urine, the most important way vegetation can cycle in these areas.

The water cycle will not be efficient as the bare ground is hydrophobic, and runoff will take place here, besides, there are no plants doing photosynthesis, which means that carbon is not being sequestrated and the organic matter, that allows to maintain water in the soil is far lower than in covered ground.

Another impact of bare ground is the difference in soil temperature, as show in the next two pictures, as the lack of vegetation makes evaporation to be greater than in covered ground.

65° C 43,6° C

Pictures 9, Rancho las Damas. Source, Isidora Molina, 2022

Pictures 10, Difference in grasses. Source, Alenandro Carrillo

In the two previous photographs, we can observe the physiological state of the plants at different stages. On the left, the plants appear dry and some are senescent, while on the right, they are in full development, showing reproductive capacity and greater vigor. According to the interviewee and secondary information, this difference can be attributed to two factors related to the water cycle. The first factor is root depth: plants in areas subjected to continuous overgrazing tend to have smaller and shallower roots, whereas those in areas managed with planned grazing develop deeper and more complex root systems, allowing them to access subsurface moisture. The second factor is soil moisture, with better infiltration and water retention capacity in the planned grazing areas, which extends the growing season for the plants.

When I visited, he was managing 700 breeding cows, 15 times the stocking capacity of his neighboring property, during a year in which 250 mm of rain fell. During the drought of 2023 and 2024, when rainfall reached 100 mm and 75 mm respectively, he had to reduce his livestock to 450 heads. During the interview conducted in 2024, to follow up on the events, he mentioned that other neighbors had to reduce their stocking rates, maintaining the following loads:

Ranches	Hectares	Breeding cows	Hectares/cow	Ratio of hectares needed for a cow, comparing with Rancho Las Damas
Rancho Las Damas	9.000	450	20	100%
Ranch 1	20.000	300	66,6	333%
Ranch 2	10.000	180	55,5	275,5%

Ranch 3	8.000	100	80	400%
Ranch 4	35.000	300	116,6	580%

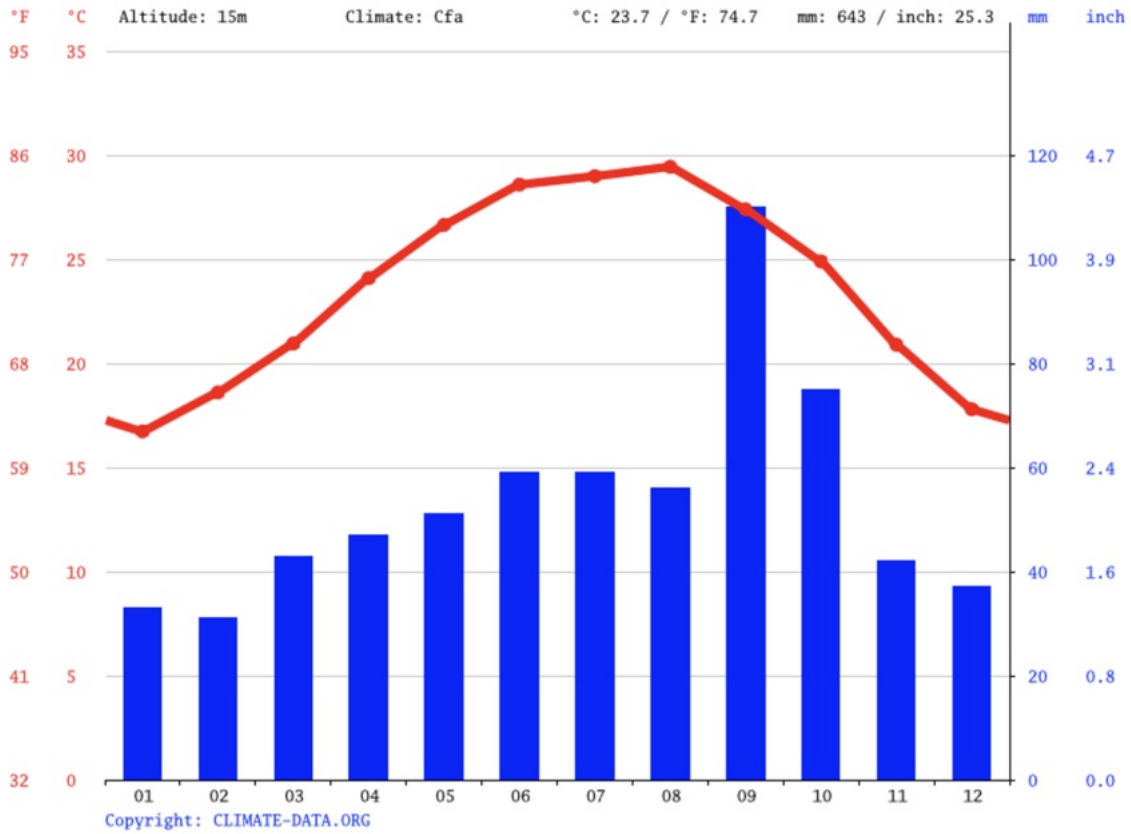
"In Rancho Las Damas, we maintain 450 cows, 300 ewes, and 20 donkeys due to the drought. In 2023, only 75mm of rain fell. A great advantage is that we haven't had to supplement anything and resort to panic sales. The vast majority of ranchers have had to sell their livestock, and what they have left is in the pens "(Alejandro Carrillo, 2024)

Paicines Ranch, Kelly Mulville, San José, California, United States of America

San Benito, California, does not have a strictly semi-arid climate, but it could be classified as a Mediterranean climate with semi-arid characteristics. It has warm, dry summers and mild, rainy winters. The average annual precipitation is moderate (around 400 mm), which is not enough to consider it fully humid, but it is also not dry enough to be considered completely semi-arid.

The region experiences seasonal droughts in the summer due to the scarcity of rainfall, which gives it some semi-arid climate characteristics, especially during the warm season.

SAN BENITO CLIMOGRAPH



Paicines Ranch consists of approximately 3,500 hectares of rangeland, 550 acres of row crop ground, and 25 acres of vineyards, all certified organic. In all 3 areas they are making changes to move towards more perennial systems, more complexity, and more diversity.

Nestled in the heart of San Benito County among the sweeping oak-studded hillsides, Paicines Ranch is habitat for a diversity of wildlife including animals, birds, insects, trees, plants, grasses, springs, rivers, and much more. Their mission is to work with the dynamic natural world at the ranch to regenerate the health of the ecosystem from the soil up while growing delicious, nourishing food for our community.

Picture 11, High canopy vineyard. Source, Isidora Molina, 2022

Kelly Mulville installed a tall canopy vineyard, about 1.7 meters high, so the sheep cannot eat the leaves and grapes, while keeping them year-round in a regenerative planned grazing. Having the sheep during the vineyard growing season is interesting related to the organic matter (they have increased from 1,5% to 2% in 1,5 years) that this extra season can increase because the animals are there, consuming the vegetation that will not cycle as easy as with animals would happen, besides the manure and urine that is providing more humidity and microorganisms into the soil.

They have eliminated tillage, maintaining the soil covered through the whole season, which moderates temperature, evaporation/evapotranspiration, by not allowing bare soil to be present, water erosion does not take place. They also implemented soil biology monitoring, plants studies and got about 40 species of plants, meaning a great biodiversity for the area. Having more biodiversity means different roots structures and different phenological states, giving a more equilibrated diet to the animals and always having some plant species that is doing photosynthesis. All of this means a beneficial cycle. The rain season is only in the winter and early spring. Also giving long recovery periods make roots longer and deeper allowing plant to catch the humidity deeper in the soil.

Picture 12, High canopy vineyards. Source, Isidora Molina

They use an electric fence that allows to move 3,000 sheep with herders that help in the management, using high density and animal impact that allows uneaten plants to be decomposed by letting them get in contact with the soil and having more microorganisms and humidity that comes from urine and dung. The bottom line, as Kelly Mulville says is that we must restore the natural cycles that we already destroyed with conventional agriculture and we have to restore biodiversity, soil health and sequestering carbon by the vegetation into the soil.

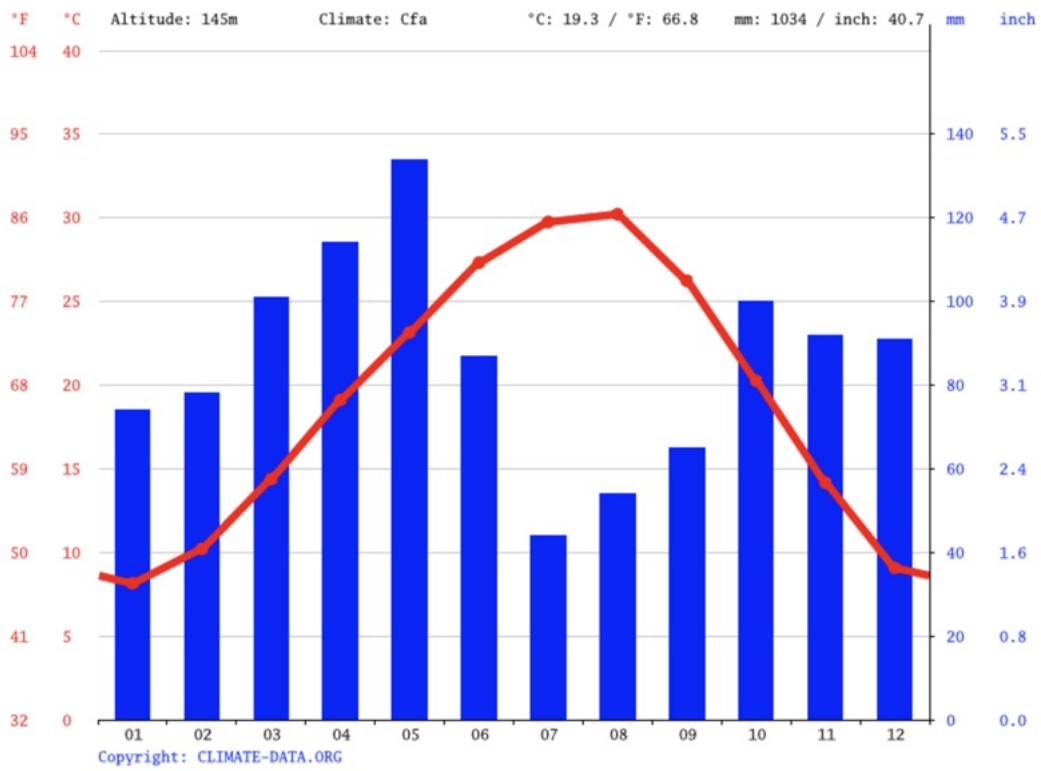
Birdwell and Clark Ranch, Clay Country, Texas, United States of America

Dallas experiences a humid subtropical climate, characterized by hot summers and mild winters. The average annual temperature is 19.3°C (66.8°F), and the annual precipitation is 1,034 mm (40.7 inches).

Rainfall is relatively well-distributed throughout the year, with May being the wettest month, experiencing the highest precipitation. A secondary peak is observed in October and November. The driest months are typically July and August.

The concentration of rainfall in specific months, particularly in May and late autumn, poses risks of flooding. In contrast, the summer months experience lower rainfall and high temperatures, leading to potential drought conditions.

DALLAS CLIMOGRAPH



Birdwell and Clark Ranch is a stocker operation, with 14,200-acre ranch of tall grass prairie, river bottoms and brushy draws. They sell between 8,000 and 9,000 heads of cattle per year. After a severe drought in 2011, they decided to reduce from three herds to maintaining only one herd of between 4,000 and 6,000 heads of cattle with Holistic Grazing Planning (Holistic Management). After 19 years of practicing regenerative livestock farming, they have tripled their livestock carrying capacity compared to their neighbors. They mention that thanks to this change in management, their ranch has been able to survive.

In the fast-growing season, the herd is moved 4 -6 times a day depending on the rate of growth of the forage and the quantity and quality of available forage, this high density allows for high animal impact, and the benefits mentioned before to take place. The average rest or recovery period of any given paddock is a minimum of 50 days and a maximum of 120 days, allowing the roots to be stronger and deeper. The importance of the recovery period and animal impact to the overall improvement in range conditions experienced at the ranch in the past 12 years cannot be emphasized enough.

Picture 13, Movements of animals. Source, Isidora Molina.

Movement of the herd can be done with only one or two people. Managing a big herd is not labor intensive. It does require focused, planned, observant stockmen who are experienced in low stress handling of livestock. Watching the behavior of 4,000 – 5,000 head of cattle move peacefully from one paddock to another never gets old.

Visited countries and findings: GFP

During March 2022, I completed my GFP, which was a very enriching experience in the sense of having encountered realities I had not known before. I had been immersed in Regenerative Grazing for 12 years and had not seen, for a long time, operations with different characteristics. The countries visited were New Zealand, Australia, Japan, and Indonesia**.**

Image 8, Visited countries. Source, Isidora Molina

Japan

What I recognized during the trip to Japan was primarily the innovation, and added value to their products, besides the great impact of the agricultural cooperatives, and the subsidies of the state.

One of the main features of agricultural aggregation in Japan is the existence of agricultural cooperatives, known as JA: Japan Agricultural Cooperatives. These cooperatives group farmers together and provide services such as marketing, supplies purchasing, product processing, and distribution.

The High-Quality Agriculture is focus on quality over quantity, particularly in rice, tea, fruits, vegetables, and meat, especially Wagyu. They also have specialized and luxury agricultural products, such as premium melons, strawberries and grapes, which are sold at high prices due to the exceptional care and quality involved and a high performance in marketing.

In this photo, we were visiting a high-quality strawberry production farm with a unique business model. Instead of selling the strawberries packaged or through retail, the farm offered a “pick-and-eat” experience where customers paid to harvest and eat the strawberries directly on-site. The concept was marketed as “all you can eat in 40 minutes,” allowing the farm to charge at least four times the price compared to stores and supermarkets. This innovative approach not

only created an engaging experience for visitors but also maximized the farm's revenue by focusing on direct consumer interaction.

Picture 9, Strawbery production. Source, Isidora Molina

Japan employs a large number of advanced technologies in agriculture to increase productivity, such as agricultural robots (that were also used in restaurants), crop monitoring sensors, and precision farming. These technologies allow for more efficient and controlled aggregation of products.

My work revolves heavily around planning processes, which is why I was particularly interested in the strategies for scheduling activities, management, and timelines. Here, some methods for carrying out this essential work are presented, highlighting their importance in ensuring the fundamental tasks of industries and businesses are successfully executed.

Image 10, planning methods in Japan. Source, Isidora Molina

And last but not least, the Japanese government plays an active role in agricultural aggregation, providing subsidies and support to farmers to improve productivity, quality, and market competitiveness. This includes assistance with marketing infrastructure, agricultural technology upgrades, and farmer training.

Indonesia

We visited a feedlot in Indonesia that truly impressed me with how they transformed their business. They not only raised animals for meat production but also implemented a circular economy. The animals' feed was made from byproducts of the agricultural industry, utilizing materials that would otherwise have gone to waste.
Furthermore, the entire system seemed designed to maximize efficiency and minimize environmental impact. Waste generated by the animals was used as organic fertilizer for nearby crops, effectively closing the loop between agriculture and livestock farming. This not only reduced costs but also promoted sustainability.
Additionally, this feedlot implemented a strategy that directly benefited small-scale farmers in the surrounding area. They provided breeding females to local farmers, allowing them to manage the rearing stage on their own land.

The feedlot in Indonesia implemented an innovative model that not only focused on fattening livestock but also supported local communities in multiple ways. One key aspect was generating local income, as farmers were given the opportunity to raise calves and, once weaned, sell them

back to the feedlot for fattening. This arrangement provided a reliable source of income, improving the economic stability of the surrounding area.

Additionally, this system redistributed labor by creating employment opportunities for local families, integrating them into the livestock production value chain, and fostering regional economic development and an improvement of quality of life. To further support these efforts, the feedlot offered technical assistance and training, helping farmers enhance their animal husbandry practices.

This not only ensured that the calves met feedlot standards but also boosted overall productivity. The model established a sustainable cycle where resources were maximized, and rural communities actively participated in livestock production. By doing so, it strengthened the social and economic fabric of the region while promoting sustainability and resource.
This collaborative approach not only benefited the feedlot by ensuring a steady supply of animals for fattening but also supported social and economic sustainability in rural areas.

Picture 14, In a visit to a small holder with their cow calf small operation to provide the feedlot. Source, Isidora Molina

New Zealand

Most of the things I saw in New Zealand came from the Nuffield Triennial, where a lot of talks took place. I learnt that this country is well-known for its agricultural and livestock export model, which is a cornerstone of its economy. The country produces far more than its population can consume. For example, over 90% of lamb and dairy products are destined for export, including milk powder, cheese, and butter, with China, Europe, and the United States as key markets.

Also, significant investments have been made to position New Zealand's products as sustainable, natural, and of high quality. Campaigns like "100% Pure New Zealand" not only promote tourism but also reinforce the perception that their products are ethically produced and environmentally friendly.

Much of New Zealand's meat and dairy production comes from extensive grazing systems, which reduce reliance on imported grains or intensive farming methods. This approach is marketed as being less resource-intensive and having lower carbon emissions. The country has also implemented strict animal welfare standards, bolstering international consumer trust. Additionally, they are pioneers in using traceability systems to ensure transparency in their supply chains.

Despite their sustainable image, New Zealand's livestock production has significant environmental impacts. Water contamination from nitrates and methane emissions from ruminants are two of the main challenges the country faces. I am really used to see and read the land through ecosystem processes and signs of erosions, what I saw, in the few land visits was that the land was truly eroded with bare ground and gullies, while they were saying that it was well managed. However, both the government and producers are investing in solutions, such as regenerative practices and public policies. They made a huge emphasis in that.
In this photo you can see the erosion´s signs like gullies.


Picture 15, water erotion. Source, Isidora Molina

New Zealand has also focused on exporting value-added products instead of just raw commodities. Examples include gourmet cheeses, premium meat cuts, and processed goods that yield higher margins in international markets. The country relies on agricultural technology to maintain its competitive edge, using drones, satellite monitoring, virtual fences, and data analysis to improve crop and pasture efficiency.
They have turned its agricultural system into an export-driven model with a strong emphasis on marketing and quality. However, it continues to address significant environmental challenges through innovation and sustainable practices.

Australia

My greatest visit was to a permaculture-based agricultural system. I was truly amazed by how the farm utilized a holistic approach that combined sustainable farming practices with designs that mimicked natural processes. The system focused on ecological diversity, resource efficiency, and resilience to climate conditions. The farm was designed in zones, which optimized resource use and reduced labor. The areas closest to the house were dedicated to frequently used crops, while the more distant zones featured perennial crops, edible forests, and even reforestation efforts.

I also noticed the use of Keyline design, which is a technique for maximizing water retention and optimizing water distribution across the landscape. The land was shaped in a way that allowed the water to flow evenly and be absorbed by the soil, reducing erosion and improving soil fertility. The farm also employed syntropic agriculture, a method that focuses on increasing biodiversity and mimicking natural forest ecosystems. By using syntropic practices (as shown

in the picture), they were able to create a highly productive, resilient system that promotes soil regeneration and reduces the need for external inputs. This approach integrates the principles of agroforestry, crop diversification, and natural regeneration, all while increasing the overall health of the land.

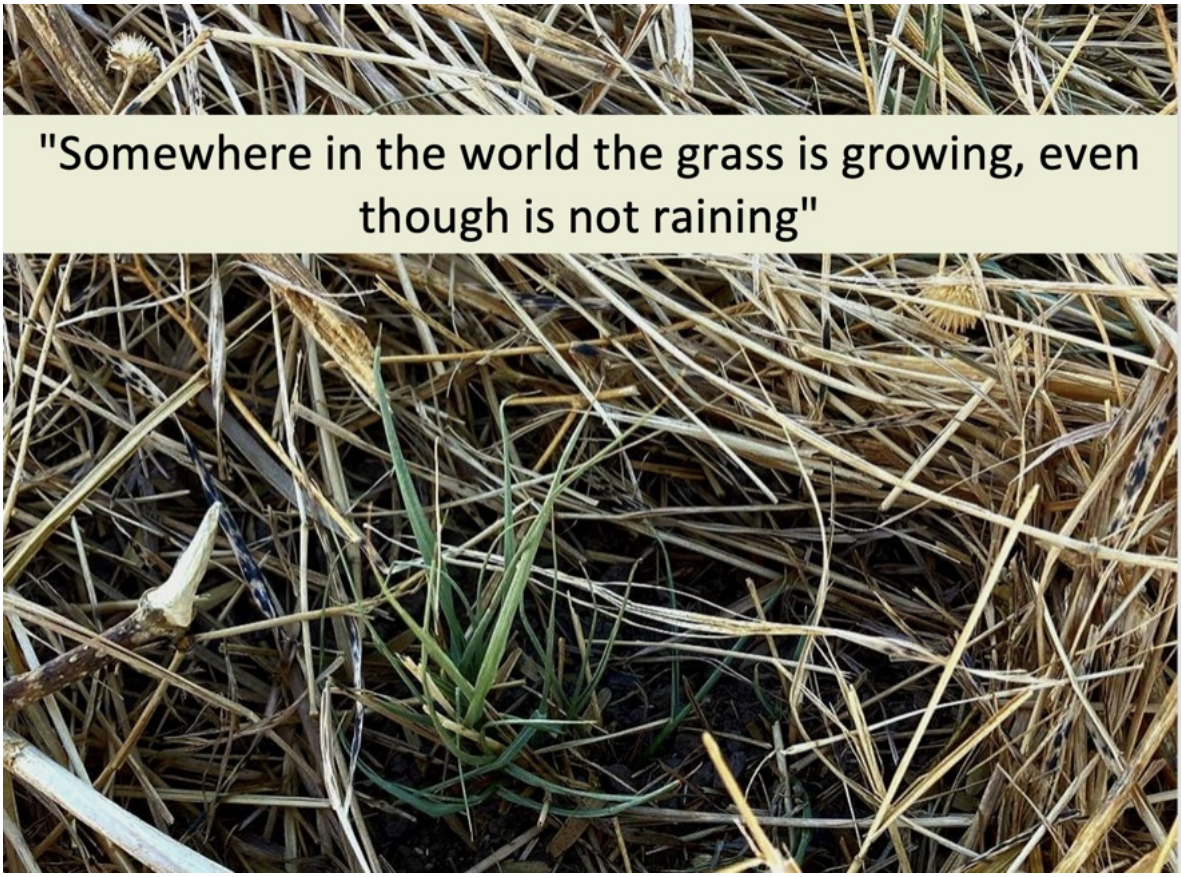
Picture 16, diversity of crops. Source, Isidora Molina

The diversity of crops on the farm was impressive. The farm produced tropical fruits like mangoes, pineapples, papayas, and bananas, along with coffee and medicinal herbs. There was also an agroforestry system in place, with a mix of fruit trees, herbs, and annual crops, creating a natural forest-like environment. I saw how this diversified system generated microclimates that allowed different plant species to thrive.

What really stood out to me was the farm's commitment to biodiversity conservation. They planted native species and created habitats for local wildlife, which not only helped maintain the local ecosystem but also enhanced the farm's resilience. The integration of native plants and animals into the system made it more sustainable and balanced.

The farm's approach also had a strong community focus. Products were sold locally, through farmers' markets, and subscription boxes, and the farm actively promoted education about sustainable farming practices. It was clear that the community played a vital role in the success of the farm.

I felt near my spectrum of knowledge, and I was happy to be there. The system was incredibly resilient to the local climate, with its diverse mix of crops, animals, and sustainable practices. The farm's use of Keyline design and syntropic agriculture demonstrated how agriculture can be integrated with nature to create a self-sufficient, sustainable, and environmentally friendly system. The farm not only served as a model for sustainable agriculture but also demonstrated the importance of community involvement in building a resilient, ecological food system with a well-managed marketing experience.



Picture 17: Chihuahua Dessert, after 8 months of dryness, we can see a perennial plant growing. Credits/Source: Isidora Molina

Conclusions

1. Regenerative Grazing as a Key Driver for Water Cycle Restoration: Regenerative grazing practices have shown significant potential to restore and enhance the water cycle in semi-arid environments. By improving soil structure and increasing organic matter, these practices facilitate better water infiltration and retention. This leads to a reduction in surface runoff and soil erosion, allowing more water to be stored in the soil, which is crucial for maintaining moisture during dry periods. These improvements create more resilient ecosystems capable of withstanding climate variability, particularly in regions prone to drought.

2. Soil Health and Biodiversity as Foundational Elements: Central to the success of regenerative grazing is its positive impact on soil health and biodiversity. Practices like rotational grazing and holistic land management help build soil organic matter, which improves soil structure and fertility. Healthier soils support a greater diversity of plant and microbial life, leading to more robust ecosystems. This increase in biodiversity not only strengthens the natural resilience of the environment but also enhances the productivity of grazing lands by providing nutrient-rich pastures and reducing the need for synthetic fertilizers.

3. Economic Viability and Long-Term Sustainability: Regenerative grazing offers substantial economic advantages for farmers and ranchers. By reducing the dependence on external inputs such as chemical fertilizers and pesticides, operational costs decrease. Additionally, improved soil and pasture health contribute to higher livestock productivity and resilience. These factors result in increased profitability over time, providing farmers with a more sustainable and self-reliant model of production. This economic resilience is particularly valuable in semi-arid regions, where traditional farming practices are vulnerable to environmental stress.

4. Barriers to Adoption and the Need for Education: Despite the clear environmental and economic benefits, the adoption of regenerative grazing remains limited. Key barriers include a lack of access to education and training on regenerative practices, cultural resistance to changing long-standing farming traditions, and limited financial resources for transitioning to new systems. Overcoming these obstacles requires comprehensive education initiatives to raise awareness about the benefits of regenerative grazing and provide practical guidance on its implementation.

5. Role of Policy Support and Community Engagement: Public policies play a critical role in enabling the widespread adoption of regenerative grazing. Government support through incentives, subsidies, and policy frameworks can encourage farmers to transition to sustainable practices. Community engagement is equally important; fostering collaboration among farmers, researchers, and policymakers can accelerate the adoption of regenerative practices. Programs that support farmer-to-farmer knowledge sharing and local demonstration projects can build trust and showcase the tangible benefits of these methods.

6. Global Scalability and Adaptability of Regenerative Grazing: The principles of regenerative grazing are globally applicable. Semi-arid regions around the world face similar challenges related to soil degradation, water scarcity, and biodiversity loss. Regenerative grazing offers a scalable and adaptable solution that can be tailored to diverse environmental and socio-economic contexts. By sharing knowledge and best practices internationally, other regions can replicate efforts to combat climate change and restore ecological balance.
7. Long-Term Environmental and Social Impact: Beyond immediate environmental and economic gains, regenerative grazing has far-reaching social and ecological implications. By restoring degraded lands and improving ecosystem health, these practices contribute to global efforts to combat climate change. Moreover, regenerative practices empower farming communities by fostering independence, resilience, and sustainable livelihoods. This holistic approach not only regenerates the land but also revitalizes rural economies and strengthens social cohesion.

Recommendations

1. Adopt Holistic Grazing Management Practices: Implement holistic planned grazing and planned rest periods for pastures to allow plant recovery and soil regeneration while adjusting grazing intensity based on seasonal growth patterns and pasture health to prevent overgrazing. Use holistic management frameworks to align grazing with ecological conditions, improving soil structure and water retention.

2. Reduce Dependence on External Inputs: Gradually eliminate the use of chemical fertilizers and pesticides, replacing them with natural soil amendments and biological pest control so it is possible to drop the costs. Rely on natural pasture cycles and adaptive livestock management to sustain forage production.

3. Invest in Farmer Education and Capacity Building: Provide ongoing training programs on regenerative grazing, soil health, and water management tailored to semi-arid conditions. Facilitate peer-to-peer learning and field demonstrations to showcase successful regenerative practices. It is really important to collaborate with research institutions to develop region-specific strategies.

4. Engage in Policy Advocacy and Incentive Programs: Advocate for government policies that support regenerative grazing through subsidies, grants, and tax incentives and encourage the development of public-private partnerships to fund infrastructure for water conservation and land restoration through regenerative practices like Holistic Management for ranching.

5. Monitor and Evaluate Grazing Impact: Use tools to track improvements in soil health, biodiversity, and water retention and infiltration. One of the well-known and scientific methodology is the Ecological Outcome Verification, developed by the Savory Institute along Michigan State University and ranchers. Setting clear benchmarks for success and adapt management practices based on ongoing results, will allow more ranchers to transitioned to regenerative ranching with numbers and facts. Maintain detailed records of grazing patterns, pasture conditions, and livestock performance.

6. Promote Community Engagement and Collaboration: Form cooperative networks among local farmers to share resources, knowledge, and market access. Educating consumers about the environmental benefits of regenerative products could create demand for sustainably produced goods while encouraging ranchers to produce added value products. Partner with NGOs and environmental organizations to support large-scale land restoration projects.

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