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Presenter Information

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Soil water movement in a watershed in the Chilean Patagonia.

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Key words: Patagonian rangelands; water flow; wetlands meadows.

Abstract

Magallanes region, located southern Chile, contains about 1.9 million sheep heads, in about 5 million hectares of rangelands. However, forage production is concentrated in small wetlands meadows called locally "Vegas" that only represent about 300.000 hectares. Those ecosystems that sustain patagonian ranches, produce 20 times more forage biomass than the surrounding natural rangelands. Patagonian vegas have concave topography with a hydrophyte (wet) center, and mesic slopes and xeric highlands of *Festuca gracillima*. Although the moisture content is controled by topography, there is scarce information about the movement of water through this concave topography. Also, the spatial variability of the soil between the Xeric to the Hydrophyte parts must be taking in account. It is essential to evaluate the movement of water inside the soil, to define agronomic managements to promote the storage and conduction of water. The study was conducted in a watershed dominated by vegas at the Kampenaike Experimental Station in Magallanes region, in Chilean Patagonia (-52,7 ° Lat.; -70.97° Long). Soil was monitored by instruments in five pits, two at East and West of Xeric side; two at East and West of mesic side; and the last at the middle of the vega. Soil moisture sensors ($n = 2$) and water tension ($n = 1$) were placed in three soil horizons (5, 30 and 80 cm deep). A weather station was set up in the middle of the vega. Differences in the physical properties that govern the storage and conduction of water between all the sectors were founded. The differences were due to the great spatial variability of the type of soil, because the topography and the genesis.

Introduction

The southern Patagonia of Chile comprises the Magallanes region, which is located in the southwestern part of the continent from 48 ° 36 'to 56 ° 30' south latitude and between meridians 66 ° 25 'and 75 ° 40' west longitude (CIREN, 2010). One of the most important economic sector is livestock production, which is supported exclusively by rangeland grazing. The sheep production would not be possible without the wetlands meadows or "vegas". Vegas are capable of producing up to 20-30 times more forage biomass than the neighboring arid and semiarid places dominated by rangelands (Irrisarri et al., 2012). Vegas area represent 7% of the rangelands (SAG, 2004a, SAG, 2004b, SAG, 2004c). These ecosystems are defined as a hygrophytic azonal community of herbaceous tussock grasses, which vary according to the availability of water and salinity of the area. They are developed in depressions of flat-concave relief that cover large pieces of land with an impervious subsoil layer under a permanent or temporary hydromorphic condition (Bran et al., 1998, Valle et al., 2015). Sáez (1994) define "vegas" as sectors that have a temporary or permanent accumulation of water throughout the year. This condition is due to a discontinuity of their soil horizons in the profile, causing an erratic water movement through the pores, producing temporary or permanent waterlogging. All these definitions point out a special and unique water dynamic in the Patagonian landscape. This particular characteristic to accumulate and conduct water becomes even more relevant, when is considered that they are in a geographical position characterized by arid and semi-arid climates (Ciari, 2009). Low rainfall levels that varies from west to east from 1000 mm annually (Schneider et al., 2003) to 233 mm (Pérez et al., 1993), even with 150 mm in the northeast area (Collantes and Faggi, 1999). Vegas also provide a large amount of ecosystem services, such as biogeochemical and water regulation, habitat and food source for native fauna and migratory birds (Collantes et al., 2009) and a significant source of soil organic carbon (de la Balze et al, 2004).

As wetlands are undergoing constant degradation due to overgrazing (Perotti et al., 2005), further studies are becoming essential, to assure they continue providing fresh water and forage for animal production.

This paper aims to analyze the parameters that make up the water balance of a micro-watershed composed of wetlands and rangelands. Also, analyze the relationship between the water dynamics between the saturated and unsaturated zone of vegas, in order to provide a starting point for further understand the Patagonian wetlands dynamic.

Methods and Study Site

The study was carried out at a micro-watershed made up of wetlands and highlands. This vega belong to National Research of Agriculture Institute (INIA) at Kampenaike experimental station (52 ° 41'28.69 "S; 71 ° 1'30.72" W) and approximately 50 m.a.s.l, 60 km northeast of the Punta Arenas city, Magallanes region.

Figure 1. Position of soil water dynamics measurement stations (black points), Well (red point) and automatic meteorological station (green point).

The watershed is located in a transition zone between the mountain range and the steppe zone. The predominant climate is Cold Steppe (Bsk). The average annual rainfall fluctuates between 400-300 mm / year and the vegetation is conformed by communities of *Chilotrichium diffusum-Festuca gracillima.*

In order to determinate de soil water dynamic, sensors of temperature, volumetric water content and electric conductivity were located at 5, 30, 80 cm depth in every measurement point (C1, C3, C4, C5 and C7, Figure 1). In each depth were used two (n=2) sensors. At the same depth were stablished the soil water potential sensor. In the first horizon (5 cm) were stablished two sensors (n=2) and in the other two horizons only one (n=1). All the sensors measured every 5 minutes and storage the information in the datalogger (Em50 Decagon Devices). In addition, a well was built to measure groundwater level, in the saturated zone. Finally, an automatic meteorological station (AWS) was installed to monitoring climatic variables.The evapotranspiration (ETo) was calculated with the FAO Penman-Monteith ecuation (Allen et al., 2006), using the data from the weather station. Data are presented since June 2019 to June 2020.

Results

At 5 cm, an increase in the volumetric content of water was observed, at precipitation events at the five toposequential levels. These precipitation peaks occur throughout the year, but the water content responds differently to precipitation along this (Figure 2). C1 and C7, the higher points of both slopes, presented a minimum water content of 8.8 and 9.5%, and a maximum of 46.9% and 49.9%, respectively. C1 does not become saturated during the monitoring and C7 saturates for two days when it reaches maximum water content, after a rainfall of 6.7 mm. C1 drained faster after heavy rains, reaching previously the field capacity (FC, 2.5 pF). Both points remain close to FC since May to October 2019, except during the absence of abundant rainfalls in July. C7 dries out first and reaches wilting point (WP, 4.2 pF) in October, while C1 does so in November. C1 and C7 were maintained in the WP until March 2020, reaching high levels of stress in the soil, with stresses of up to 5.6 pF in C1, and 5.2 pF in C7 (Figure 3) with fluctuations where they reach higher levels of water content in the soil after rainfall > 12 mm. However, the soil dries out quickly after the rains due to high evapotranspiration. In March, the evapotranspiration begins to descend and therefore the water content increases. In the middle part of both slopes (C3 and C5), the water content dynamics behaves differently. These

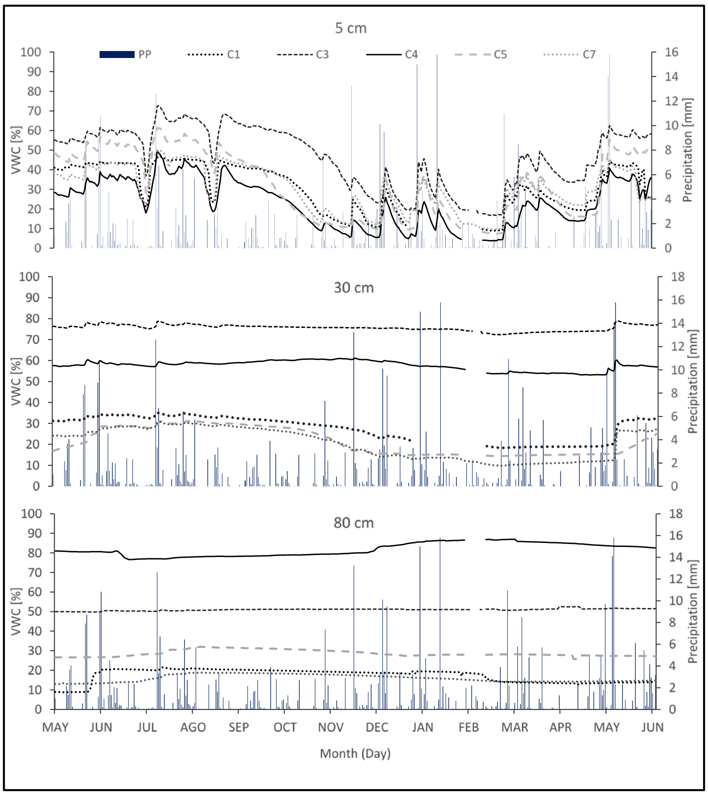

Figure 2. Variation of daily precipitation (PP) and volumetric water content (VWC) in C1, C3, C4, C5 and C7, at depths of 5, 30 and 80 cm between June 2019 and June 2020.

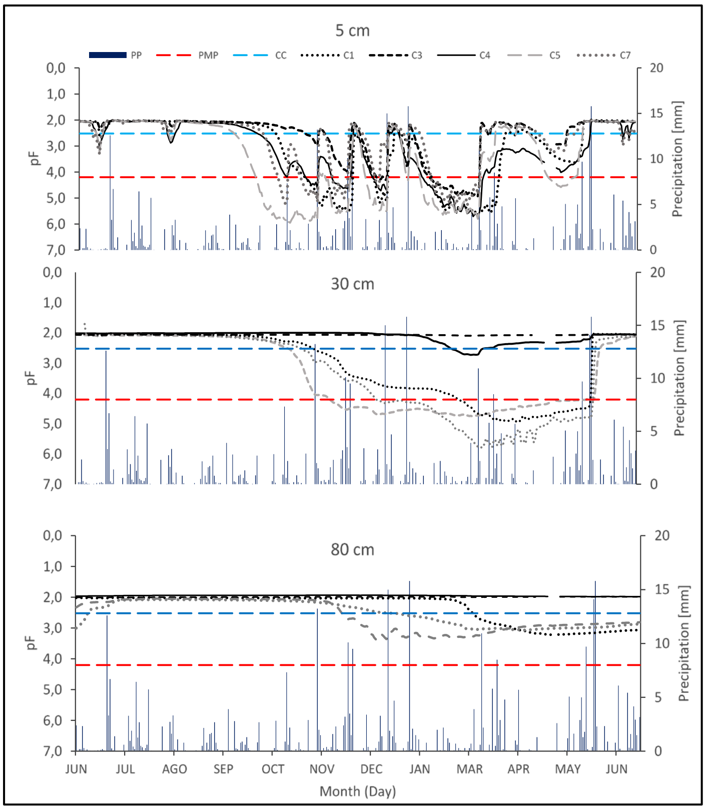

Figure 3. Variation of daily precipitation (PP) and matric potential (pF) in the soil in C1, C3, C4, C5 and C7, at depths 5, 30 and 80 cm since June 2019 to June 2020. Dotted blue line represents field capacity (FC, 2.5 pF) and dotted red line represents wilting point (WP, 4.2 pF).

points presented a maximum value of 72 and 61.4% in July and a minimum of 15 and 7.3% in February and March, respectively. C3 maintains the percentages of highest water content throughout the year, remaining close to the FC between May and November. This point is the last to reach the WP in January and reaches a maximum stress of 4.9 pF in March. C5 on the other hand, remains close to FC from May to September and is the first point to reach the WP in October (Figure 3), reaching a maximum stress of 5.4 pF in the month of March, when evapotranspiration exceeds the daily rainfall. C3 does not become saturated during the monitoring time, while C5 remains partially saturated for at least four days after a 3.3 and 6.7 mm in a row in July.

According to the water balance estimated from the difference between rainfall and potential evapotranspiration, there was a water deficit during nine months, the annual balance being -467 mm. This deficit was accentuated during February (Figure 4), when monthly precipitation is 8.8 mm and evapotranspiration potential exceeds 100 mm, due to higher wind speed, radiation and temperature during the summer. However, the balance is positive during June and July 2019 (13.4 and 6.1 mm, respectively), and between May and June 2020 (38.9 and 3.9 mm, respectively), when ETo reaches its lowest values (Figure 4). In addition, it is observed that from June, when the balance is positive, the water table ascends continuously until August 2019, when it reaches a maximum altitude of 49.4 m.a.s.l (45 cm deep from the ground surface), even when the balance monthly water is negative. Starting this month, the water table begins to drop from sustained form until April 2020, reaching a minimum altitude of 48.4 m.a.s.l (144 cm depth).

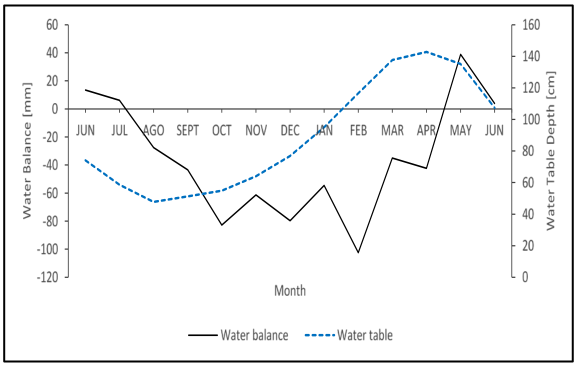

Figure 4. Water balance (June 2019 - June 2020) determined by the difference between the rainfall and potential monthly evapotranspiration (Penman-Monteith), and altitude of the water table (NF).

Conclusions

There are differences in the physical properties that govern the storage and conduction of water between all the sectors evaluated. This is due to the great spatial variability of the type of soil product of the topography and the genesis of these soils that in this case, was due to glaciers dynamics.

Through the above analysis, it is concluded that the soil in the wetland is playing a fundamental role in water storage, especially in depth. In addition, the water table is capable of supporting the existing vegetation through the capillary rise of water.

Acknowledgements

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