

**Research Article**

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Advances in Soil Water Vegetation Carrying Capacity

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The soil water vegetation carrying capacity is the most important theory for sustainable utilization of soil and water resources and agriculture high-quality development in water-limited areas. The term of soil water vegetation carrying capacity, occurred in 2000, is the ability of soil water resources to support vegetation, especially the soil water resources in the critical periods of plant water relationship regulation, expressed by numbers of population or plant density of indicator plant in a plant community. Soil water resources are water stored in the soil. The indicator plant of soil water vegetation carrying capacity in a plant community is the constructive plant species for nature vegetation or goal species for non-native vegetation. Now, the research of soil water vegetation carrying capacity should be strengthened to estimate the soil water vegetation carrying capacity in different vegetation types, times, especially in the critical periods of plant water relationship regulation, and location. The responsible forecasting of precipitation and soil water vegetation carrying capacity is important for Climatology and agriculture Sciences to make plant grow well and get maximum yield and benefit to achieve sustainable utilization of soil water resources and agriculture high-quality development.

Since 1950, in order to change the environment and develop the economy, China, large-scale afforestation and greening work has been carried out on the loess plateau, China. About ten years later, in the 1960s, the artificial forest and grassland in the semi-humid area of Guanzhong, and the semi-humid Ziwoing forest area in eastern Longdong, Gansu, China in the farmland of the semi-arid area in the eastern part of the Wei River Basin in Shaanxi Province, it was successively discovered that there were underlying dried soil layers, abbreviated as dry layers, which caused soil and vegetation degradation and crop failure and drew the attention of many scholars to this issue. To solve this emerging chaos problem, many related concepts were introduced. Concepts such as load emerged one after another. When the author encountered this issue in 2000, based on years of innovative research, he proposed the concepts of vegetation carrying capacity and soil moisture vegetation carrying capacity, which resonated with everyone and developed into the theory of vegetation carrying capacity and soil moisture vegetation carrying capacity. The proposal of the concept of high-quality development in 2017 greatly promoted the soil water vegetation carrying capacity. In the future, research on the soil water vegetation carrying capacity of different vegetation types in water-scarce areas should be strengthened, especially during the critical period of plant-water relationship regulation of different vegetation types, to serve the sustainable utilization of soil water resources and the high-quality development of agriculture in water-limited regions.

Keywords: Water-limited areas; soil water resources; soil water vegetation carrying capacity; critical periods of plant water relationship regulation; agricultural high-quality development

Introduction

After 1950, China has planted large areas of artificial forests in the perennial artificial forest grasslands of the Loess Plateau and the rain-scarce areas in the north. Due to the excessive load, plant density of plants is more than carrying capacity, plant consume a large amount of soil water resources more than soil water supply. However, the maximum infiltration depth and quantity of soil water replenishment in forest land are limited. So, as plant grow, soil drought has occurred in the forest vegetation ecosystem, which is actually an overloaded, led to soil degradation phenomenon. Soil degradation not only affects the stability of the forest and vegetation ecosystem, but also hinders the continuous and stable exertion of the ecological, economic and social benefits of forest vegetation [1,2]. To solve these problems and achieve sustainable utilization of soil water resources, the issue of vegetation carrying capacity has drawn widespread attention, giving rise to the concept of vegetation carrying capacity and soil moisture vegetation carrying capacity [3-7].

Since 2017, economic and social development in China had entered high-quality development, so, Agriculture development had entered the new stage of Agriculture high-quality development [8-12]. Agriculture high quality development is to take some effective measures and methods to make the land produce the maximum output and services to meet people's yearning for a better life and agricultural production and services. The theoretical foundations of Agriculture high quality development is the resources use limit by plants, vegetation carrying capacity and critical period of plant resources relationship regulation, which includes space resources use limit by plants, space vegetation carrying capacity and the critical period of plant space resources relationship regulation in soil water and nutrient rich regions; soil water resources use limit by plants, soil water vegetation carrying capacity and critical period of plant water relationship regulation in water limited regions, and the soil nutrient resources use limit by plants, soil nutrient vegetation carrying capacity and critical period of plant nutrient relationship regulation in soil nutrient limited regions. The methods of Agriculture high quality development are to select the best species or variety [11,12], determine the suitable initial plant density [11,12], and regulate the plant resources relationship in the process of plant growth to make plant grow well and get the maximum yield and benefits to realize the sustainable use of natural resources and the high-quality development of agriculture [11,12]. In the future, we must strengthen the basic research of agriculture and select the best species or variety, determine the resources use limits by plants, the vegetation carrying capacity and critical period of plant resources relationship regulation. The purpose of the paper is to introduce the process of soil water vegetation carrying capacity, promote the study of soil water vegetation carrying capacity in different vegetation type and different period of plant growth, especially the in the critical period of plant water relation regulation in water-limited regions.

Preparation Stage

The study process of soil water vegetation carrying capacity have gone a long time, these process can be divided into three stages: preparation stage, occurrence of Soil Water Vegetation Carrying Capacity and the need of high-quality development,

which promote the development of Soil Water Vegetation Carrying Capacity. After Verhulst developed a general equation for population growth in 1838, in 1953, Odum asymptotes K value Asymptotes of the logistic equation was Asymptotes linked in carrying capacity (Young, 1998; Price, 1999) [13]. Since 1950, afforestation has been carried out in the Loess Plateau, especially the construction of the "Three North" shelterbelt system, which began in 1978 (Wu and Yang 1998). In the 1960s, the underlying desiccated soil layer was discovered successively in semi-arid farmland such as in the eastern Weibei Plateau of Shaanxi Province, artificial grassland in the sub-humid area of Guanzhong plain and Ziwuling forest area in the sub-humid area of Longdong, the eastern part of Gansu, China. This phenomenon attracted the attention of many scholars [1,2].

In 1968, dozens of scientists, educators, economists and other scholars from around the world met in Rome and founded the Club OF Rome. The goal of its work is to focus on, explore and study the common problems faced by mankind, so that the international community can have a deeper understanding of the plight of mankind, including social, economic and environmental problems, and put forward new attitudes, new policies and new systems that should be adopted to reverse the unfavorable situation. Commissioned by the Club and led by Dennis L Meadows of the Massachusetts Institute of Technology, the group rethought the long-prevailing Western theory of high growth and submitted its 1972 "Limits to Growth" study, which profoundly clarified the importance of the environment and the fundamental link between resources and population.

Occurrence of Soil Water Vegetation Carrying Capacity

In 2000, when Author heard of soil and vegetation degradation and crop failure, he put forward the concept of soil water vegetation carrying capacity in [3] and then defined the concept of vegetation carrying capacity and Soil Water Vegetation Carrying Capacity [3] and establish the model of estimating method of soil Water Vegetation Carrying Capacity [5-7]. With the increase of population and economic and social development, there is an increasing demand for the quantity and variety of forest ecosystem products and services. To meet these kinds of demands, 80% of the original forest all over the world, special in China has become plantation, grass land, crops and orchard. As plant grow, the plant resources relationship changed from resources to non-equilibrium, which will lead to soil and vegetation degradation and crops failure because of plant overload or waste of nature resources because of low load. In order to solve the soil degradation and vegetation decline or waste of nature resources and realize the sustainable utilization of soil water resources and the high quality sustainable development of social economy, a tens of years researches showed that the best way of solving the problems is to apply the theory of nature resources use limit by plants, the theory of vegetation carrying capacity and the critical period of plant resources relation regulation to adjust the plant water relationship to obtain the maximum yield and benefit of vegetation when the existent plant density is more than vegetation carrying capacity to meet the need of people for resources and environment and promote the high quality sustainable development of social economy.

The nature resources use limit by plants, vegetation carrying capacity and the critical period of plant resources relation regulation

include space resources use limit by plants, space vegetation carrying capacity and the critical period of plant space relation regulation in soil water and nutrient regions, soil water resources use limit by plants, soil water vegetation carrying capacity and the critical period of plant water relation regulation in water-limited regions and soil fertility resources use limit by plants, vegetation carrying capacity and the critical period of plant nutrient relation regulation in soil nutrient limited regions. When the quantity of available nature resources is smaller than nature resources use limit by plants, the plant-resources relationship enters the critical period of plant-resources relationship regulation, the ending time

of the critical period of plant-resources relationship regulation is the invalid time of plant-resources relationship regulation. For example, in the semiarid loess hilly region, China, the precipitation, see Figure 1, the ending time of the critical period of plant-resources relationship regulation for red plum apricot is 15 July, see Figure 2 and the end of September for Caragana shrubland because the severe soil and water loss mainly happens in the raining season and soil and water conservation vegetation stop service the end of September in the semiarid loess hilly region, China [11,12,14] (Figures 3 and 4).

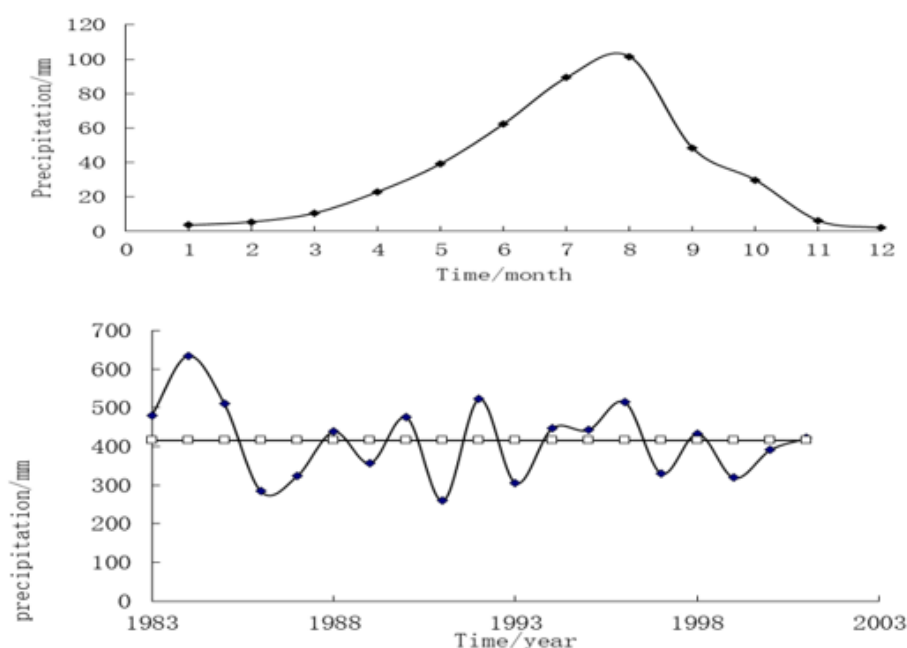


Figure 1: Change of precipitation with time (month,photo above and year,photo below) in semiarid loess hilly region, Guyuan. China.



Figure 2: The flowers (left photo) and fruit (right photo) of red plum apricot in semiarid loess hilly region, Guyuan. China.



Figure 3: Caragana shrubland in semiarid loess hilly region, Guyuan. China.



Figure 4: The above and underground production relation of the Robinia (*Robinia pseudoacacia* L. in semiarid loess hilly region. The maximum infiltration depth (MID) is 290 cm.

Natural resources, such as soil water resources in water-limited regions, is limit. So, the ability of Natural resources to support vegetation is limit, which can be expressed by vegetation carrying capacity. If the plant density is more than the ability of Natural resources to support vegetation, which will cause soil and vegetation degradation. So, we have to regulate the plant water relation in the critical period of plant resources relation regulation by reducing numbers of plant or leaf in plantation, grass and crops in water limited region to carry out sustainable utilization of soil water resources or nature resources and agriculture high-quality development. The soil water vegetation carrying capacity is one of theoretical foundation of plant water relation. Because the adding plant density is more difficulty than reducing plant density in the process of plant growth, so, we should make the initial planting density is equal to or more than vegetation carrying capacity, and

then to regulate the plant water relation by reducing plant density. Authors put forward the soil water and plant density model can be expressed in the following form in 2004 (Guo and Shao 2004):

$$F1 = a - bPD$$

$$F2 = cPD^2 - dPD$$

Here, F1 is the soil water supply in mm. F2 is the soil water consumption in mm. Pd is the plant density. We take the data of plant density, soil water supply and consumption to fit in the caragana shrubland in the semiarid region in 2002, the result showed as following:

$$F_1 = 92.494 - 0.2913PD$$

$$F_2 = 0.0118PD^2 - 0.7575PD + 64.759$$

Here, F_1 is the soil water supply in mm. F_2 is the soil water

consumption in mm. Pd is the plant density. The SWVCC in the Caragana shrubland is 72 shrub per 100m², see Figure 5 [5-7]. The soil water vegetation carrying capacity is the function of vegetation type, time and location [5]. If the existing plant density is more than the vegetation carrying capacity in critical period of plant resources relationship regulation, we has to be regulated to get the maximum yield and service.

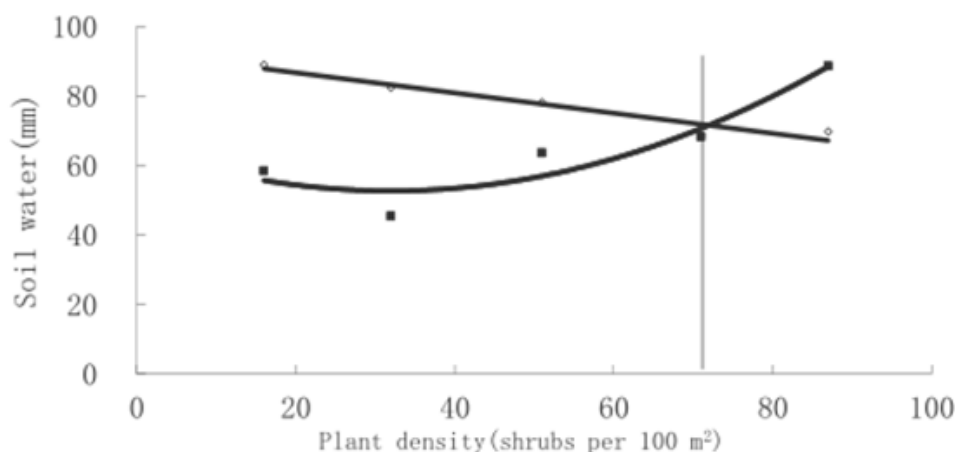


Figure 5: The relationship between plant density and Soil water supply or Soil water consumption. The cross point is the SWVCC.

Forecasting of Vegetation Carrying Capacity

The vegetation carrying capacity include space vegetation carrying capacity in soil water and nutrient rich regions, soil water vegetation carrying capacity in water-limited regions and soil fertility vegetation carrying capacity in soil nutrient limited regions, which is important for sustainable utilization of nature resources and agriculture high-quality development [11,12,14,15]. The soil water vegetation carrying capacity is the function of vegetation type, time and location [11,12,14,15]. The responsible forecasting of precipitation is important for deciding soil water vegetation carrying capacity in water-limited regions , achieving sustainable utilization of nature resources and agriculture high-quality development because it is difficult to make the initially planting density in the sowing or planting equal to soil water vegetation carrying capacity in the critical period of plant water relation regulation in water-limited regions, and we have to regulate the plant water relation regulation and get the maximum yield and benefit to achieve sustainable utilization of soil water resources and agriculture high-quality development. For example, the soil water in water-limited region is the most important indicator influencing plant growth. the critical period of plant water relation regulation is from the starting time, such as soil water resources in the maximum infiltration depth is equal to soil water resources use limit, to the end time, such as fruit mature or stop expanding, or stop use plant service [16-19]. The red plum apricot is 15 July to this time, red plum arirocote fruit stop expanding or matures, caragana stop use

in the end of September because caragana is used for soil and water conservation vegetation and soil water loss is small and not used to conserve soil and water loss after the end of September in the semiarid region. If we forecast the precipitation and estimate the soil water vegetation carrying capacity in advanced in the critical period of plant water relation regulation according to the weather report, we can regulate the plant density. If the present plant density is more than soil water vegetation carrying capacity in the critical period of plant water relation regulation in water-limited regions, we can reduce the plant density and regulate the plant water relation regulation to make preserve plants grow well and get the maximum yield and benefit to achieve sustainable utilization of soil water resources and agriculture high-quality development.

Conclusion

The vegetation carrying capacity include space vegetation carrying capacity in soil water and soil nutrient rich regions, soil water vegetation carrying capacity in water-limited regions and soil fertility vegetation carrying capacity in soil nutrient limited regions, which is important for sustainable utilization of nature resources and agriculture high-quality development. We cannot make the initial planting density is equal to vegetation carrying capacity in planting tree or sowing in the critical period of plant water relation regulation in water-limited regions. If we forecast the precipitation and estimate soil water vegetation carrying capacity in advanced in the critical period of plant water relation regulation in water-limited regions, we can estimate soil water vegetation

carrying capacity in advanced and regulate the plant water relation regulation in the critical period of plant water relation regulation in water-limited regions to make plant grow well and get the maximum yield and benefit to carry out sustainable utilization of soil water resources and agriculture high-quality development.

In the future, we have to forecast the precipitation and estimate soil water vegetation carrying capacity in advanced in the critical period of plant water relation regulation in water-limited regions to regulate the plant water relation regulation to carry out sustainable use of soil water resources and agriculture high-quality production. Because the soil water vegetation carrying capacity is the function of vegetation type, time and location.

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