Investigation of the Relationship Between Drought Adaptability and Plant Community Diversity

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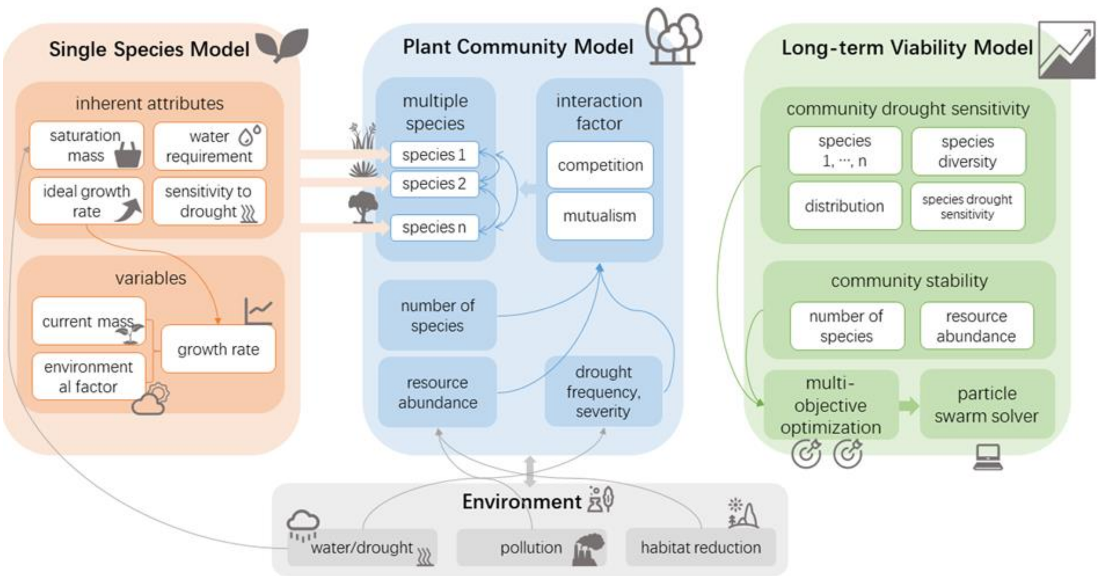
Abstract: Plant communities are quite vulnerable to the increasing frequency and intensity of droughts caused by climate change. The loss of plant communities due to drought can have profound ecological and economic consequences. Observations suggest that greater species diversity within a community enhances a plant's ability to adapt to drought. We propose Plant Community with Drought (PCD) Model. PCD predicts the plant community changes under the influence of drought. The model explores from a single-species changing model to a plant community model. It also investigates the community's long-term viability. Sensitivity analysis is performed on the model. Two main parameters, sensitivity to drought sensitivity and interaction factor between species, are selected both from 0.1 to 1. To observe the change rate of community size, 100 experiments were conducted. The maximum rate of change is less than 10%, which shows the stability and robustness of the model. On the impact of species type, it mainly reflects the attributes of the species.

1. Overall Flowchart



2. Introduction

Exploring the relationship between drought adaptability and plant community diversity, we investigate the impacts of different species compositions and weather cycles on the long-term viability of plant communities. Plant species react differently to stress like drought, which occurs at varying frequencies and severity. Studies suggest that having a greater number of species present can help a plant community better adapt to drought cycles over time. Single-species communities produce generations less adapted to drought than those with four or more species. To investigate the

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relationship between the adaptability of a plant community to drought and the number of plant species present, the following tasks must be performed:

1) A mathematical model that predicts how a plant community changes over time when exposed to different weather cycles is established, including droughts with varying severity and frequency, and taking into account the interactions between different plant species during drought cycles.

2) The impact of the number and types of plant species are explored on the long-term interactions of the plant community and the larger environment, and determine the minimum number of plant species needed for the community to benefit from localized biodiversity [1].

3) An investigation is taken to find how the occurrence of droughts with varying frequency and severity in future weather cycles affects the plant community's adaptability, and whether the number of plant species has the same impact on the overall population when droughts are less frequent.

3. Assumptions

1) The growth area for plant is limited and known. The climate, weather and other environmental conditions in this area are well-proportioned.

2) One or more plants are evenly distributed in the area, with the identical density of the same plant species.

You need to build a mathematical model to predict how a plant community will change over time in a variety of irregular weather cycles, including periods of drought when rainfall should be plentiful. The model should take into account the interactions between different species during the drought cycle.

4. Model 1: Model For a Single Species

According to the two basic assumptions, to study plant changes in a certain area can be interpreted as to study plant changes per unit area. The following discussion is made in terms of unit area. For plants of different species, since the number of plants is not comparable, the growth quality will be used as a comparison index. Only rainfall per unit area and plant mass per unit area are considered below.

4.1. Model Assumption

Water requirements per unit mass are fixed for different plant species;

The growth rate of different plant species is a function of current mass, saturation mass, and it is influenced by both environmental adaptability and plant species' own attributes;

Maximum mass and ideal growth rates are fixed for different plant species.

4.1.1. Definition of Variables

When building a plant growth model, we need to define some variables to describe the growth state of plants and their own attributes, including:

1) time: t, used to represent the growth time of plants, represented by day d.

2) mass of plant: m(t), used to represent the current mass of the plant, expressed in kg.

3) saturation mass： m_max_ideal, used to represent the maximum mass of plant growth, expressed in kg.

4) ideal growth rate: r_ideal, which represents the growth rate of plants under ideal environment, used as a ratio value.

5) water requirement: w is used to represent the daily water required by plants per unit mass in the growth, expressed in kg/kg.

6) sensitivity to drought: sensitivity_drought, (0,1], the larger the size, the more sensitive it is to drought. 1 means that water requirements need to be fully met, and 0 means that you can grow even in complete drought situation.

7) environmental factor: e(t), used to represent the adaptability of plants to environmental

changes, expressed in a value between -1 and 1. The larger the value, the more favorable the environment is for plant growth; e=1, the ideal environment for plant growth; e=-1, the harsh living environment, where plants will die quickly [2].

8) rainfall: rain(t), which represents the rainfall mass per unit area in a day, expressed in kg.

The above variables can be used to describe various factors and parameters needed in plant growth models, so as to better establish and analyze plant growth models.

4.1.2. Formula of the Model

Factor of environmental rainwater:

$e\_rain(t) = \min(1, rain(t) / (w * m))$

Environmental factor:

$e(t) = e\_rain(t)$

In the event of environmental deterioration such as drought, the saturation mass will decrease, which means that the number of plants that can be accommodated by the environment will also decrease. In the worst case, the number decreases to 0, and the population gradually disappears.

$m\_max = \max(0, m\_max\_ideal * e(t))$

Wherein, the actual growth rate r(t) is affected by the ideal growth rate, environmental changes, and population size.

$r(t) = e(t) * r\_ideal * (1 - m(t) / m\_max)$, if $e(t) > sensitivity\_drought$

$r(t) = - r\_ideal$, otherwise

Thus, a model of plant mass change over time can be obtained:

$m(t+1) = m(t) * (1+r(t))$

Wherein, m_max_i is the saturation mass (maximum carrying capacity) of the ith plant species, representing the maximum mass of the species that can be accommodated per unit area of the environment. When m_i(t) approaches m_max_i, plant growth rate will be inhibited, so as to avoid excessive population growth and environmental deterioration.

The model can be used to predict plant growth under different environmental factors and water requirements.

4.2. Model Solutions

4.2.1. Attribute of Plant Species

Different plant species, such as grasses, shrubs, and trees, contain different attributes of their own, including:

- saturation mass m
- ideal growth rate r_{ideal}
- water requirement w
- sensitivity to drought sensitivity_drought

The Table 1 and Figure 1 show different types of plant species. The following are three different plants with varying growth properties.

Table 1 Attributes of different plant species.

	Bahia Grass	Conifer Shrubs	American elm
			
plant species	grasses	shrubs	trees
m	1.41	3.49	2.13
r_{ideal}	0.041	0.064	0.018
w	0.004	0.008	0.014
sensitivity_drought	0.8	0.2	0.5

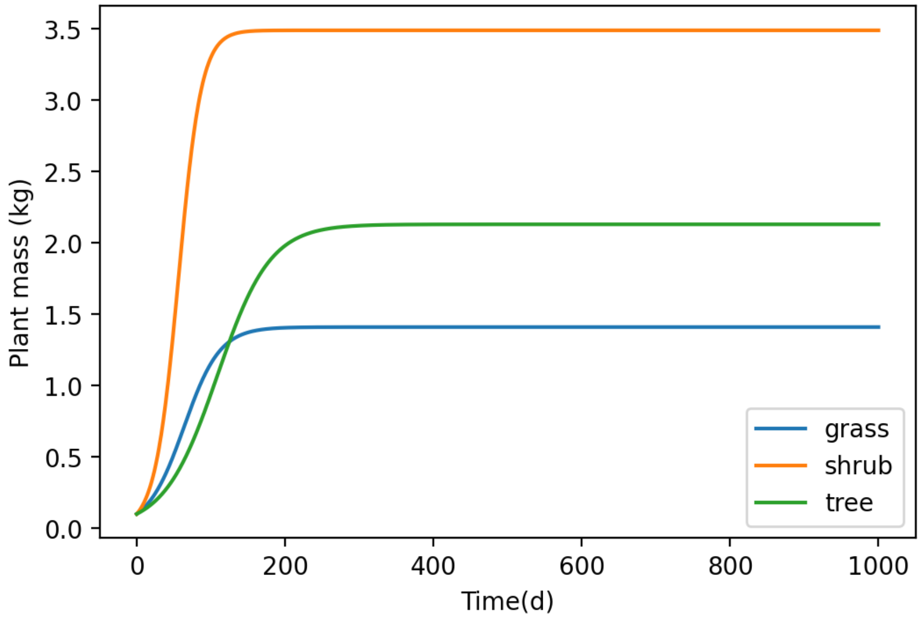

Figure 1 Relationship between rainfall and plant mass over time.

As shown in Figure 2, under ideal environmental conditions, only the growth curves of a single plant species are considered. It can be seen that it basically conforms to the logistics growth curve.

It will increase or decrease regularly as the seasonal climate changes.Trends in mass over time for different plant species.

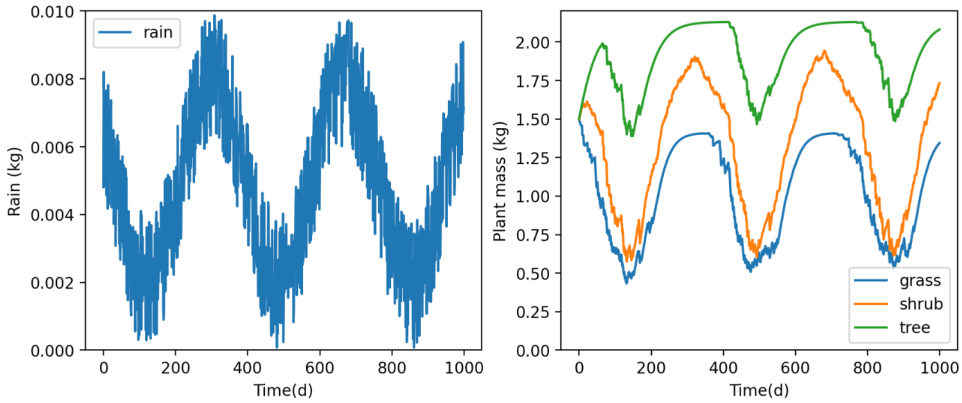

Figure 2 Relationship between rainfall and plant mass over time.

As shown in Figure 3, When d=500, there will be a drought. During periods of drought when there should have been rainfall, individual communities of plant species declined rapidly to something near zero. Grasses, which were most sensitive to drought, declined first and fastest.

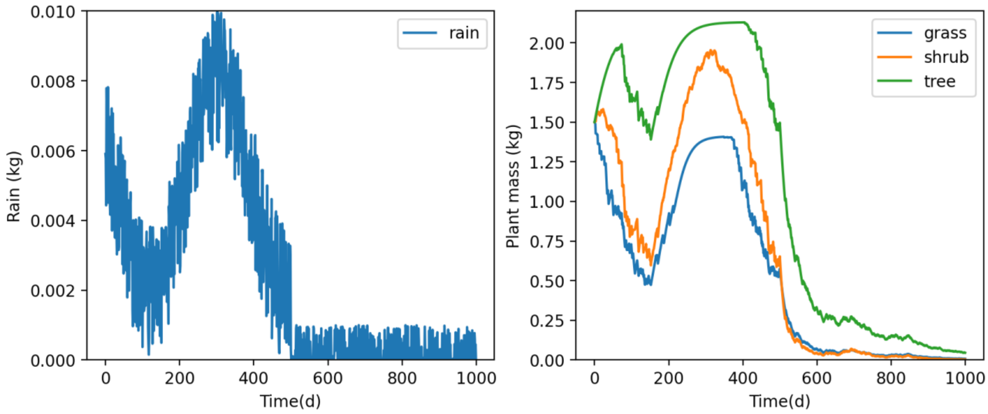

Figure 3 Impact of drought on plant community at d=500.

As shown in Figure 4, under completely irregular rainfall or drought conditions, the size changes of single-species plant communities are more dramatic. Grasses are the most sensitive to the change.

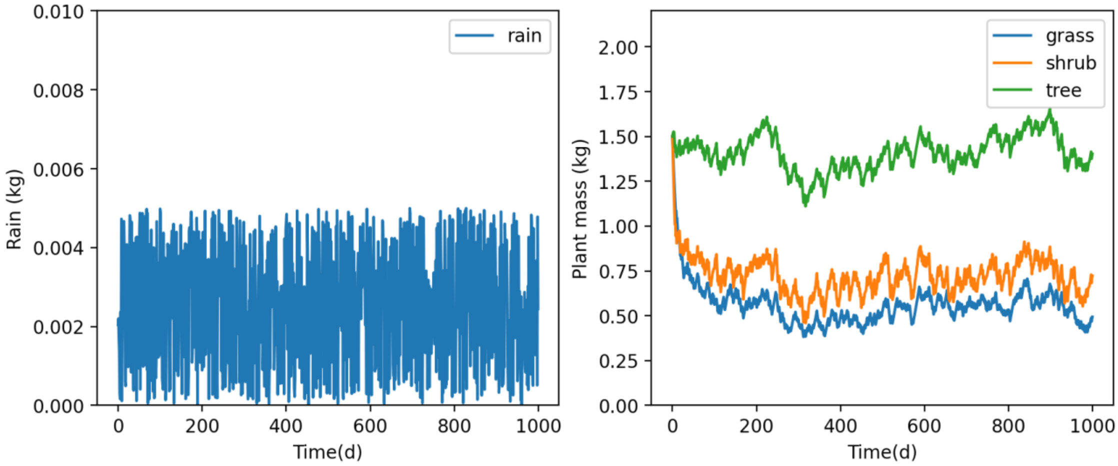

Figure 4 Relationship between rainfall and plant mass over time.

5. Model 2: Model For Plant Community

5.1. Model Assumption

1) Grasses are the most sensitive to the change. There are many different species in the plant community, and their growth states will affect each other;

2) All species in the plant community are affected by environmental factors, including drought and rainfall;

3) Different species have different sensitivity to drought, which will affect their growth and competition in arid environment;

4) The density of species in a community has an effect on their growth and drought adaptability.

5.1.1. Definition of Variables

When modeling drought sensitivity of plant communities, we need to define the following variables:

1) Number of species: n, used to represent the number of different species in the community, represented by the number n;

2) Mass of each species: m_i(t), i=1,2... n, used to represent the current mass of the ith species, expressed in kg;

3) Competition and cooperation between plants: alpha_ij, representing the intensity of interaction between the ith species and the jth species. If alpha_ij>0, it means there is a mutualistic relationship between i and j; if alpha_ij<0, it means there is competition between i and j; alpha_ij=0, it means there is no obvious interaction between the two plants.

5.1.2. Interaction Among Plant Species

In order to describe the interactions and mutualism in plant communities, we can add the following variables and formulas based on Model 1:

Considering the interaction between plants, the growth rate r_i(t) of the ith plant can be redefined as:

(1 - sum(alpha_ij * m_j(t)) / (m_max_i * m_i(t)))

r_i(t)=e_i(t)*r_ideal_i *, if e_i(t) > sensetivity_drought_i

r_i(t) = - r_ideal_i, otherwise

Wherein, m_max_i is the saturation mass (maximum carrying capacity) of the ith plant species, representing the maximum mass of the species that can be accommodated per unit area of the environment. When m_i(t) approaches m_max_i, plant growth rate will be inhibited, so as to avoid excessive population growth and environmental deterioration.

According to the above formula, a model of the change of the number of each species over time can be obtained:

$$m\_i(t+1) = m\_i(t) * (1 + r\_i(t)) \quad (1)$$

5.2. Model Solutions

To visualize the changes in the model of the entire plant community as different species experience drought cycles, it can be shown by plotting the number of each species over time. As can be seen in the Figure 5, after increasing the interaction between species, the process of drought arrival, the size of each species changes more gently, even at peak and valley location. The mass of each species is higher than when growing alone, and the community is better able to withstand drought. Of the three different plants, trees had the best drought resistance and the lowest drought sensitivity, followed by shrubs and grass [3].

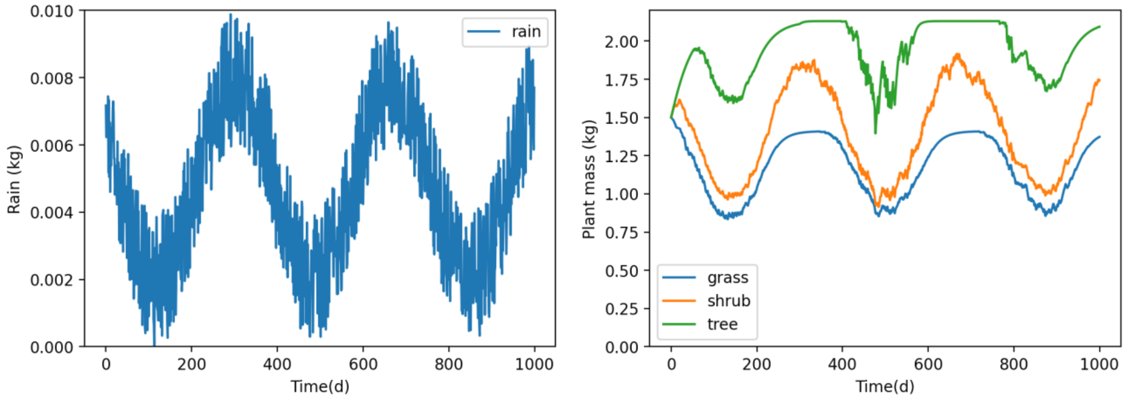

Figure 5 Variation in the number of different plant species during drought circle.

Figure 6 shows that after d>500, drought occurred when rainfall should have been abundant. Taking into account the interactions between different species during the drought cycle, the entire community does not decline directly to near 0, but operates at a moderate level, showing better drought adaptability among multiple species.

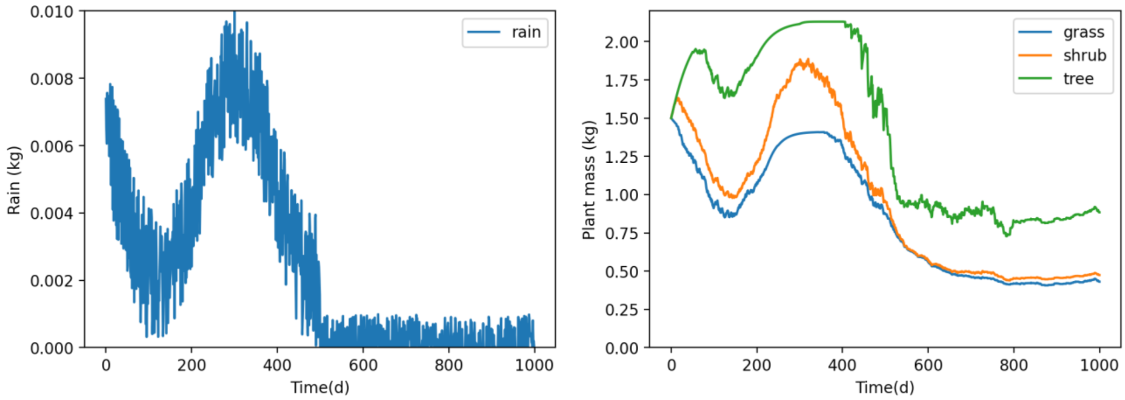

Figure 6 Comparing adaptions of different plant species under drought conditions.

5.2.1. Other Factors: Effects of Pollution and Habitat Loss

Environmental pollution, habitat loss, and other factors affect the saturation mass of each species in a plant community — the maximum mass loss under ideal climate conditions. At the same time, the ideal growth rate is slowed down, thus affecting the growth simulation results of species in the model.

(As a comparison) As shown in Figure 7, Normal conditions:

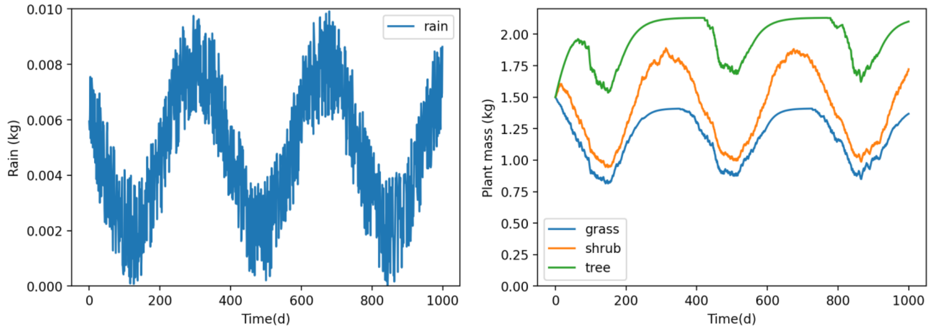

Figure 7 Impact of environmental pollution on saturation mass of plant species.

As shown in Figure 8, under conditions of pollution and habitat reduction, saturation mass decrease and growth rate decline. The crests are gentler and the population size is smaller when there is plenty of rain, harming the long-term development of the population.

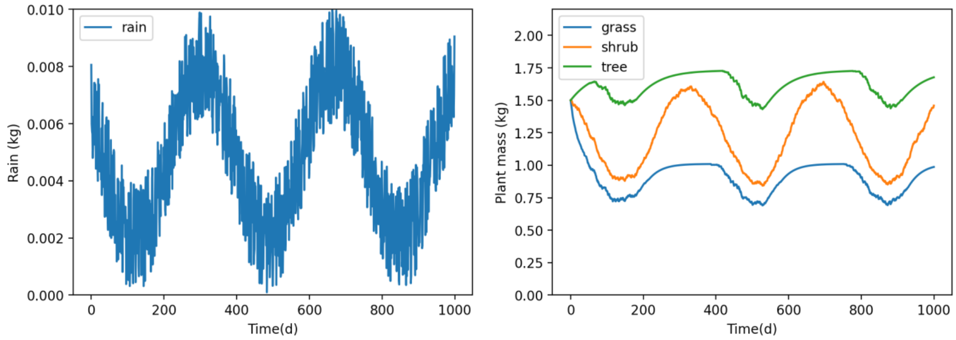

Figure 8 Impact of environmental pollution and habitat reduction on plant species.

5.2.2. The Effect of the Intensity of Drought

(As a comparison) As shown in Figure 9, Moderate drought. Multi-species plant community can maintain a moderate community size.

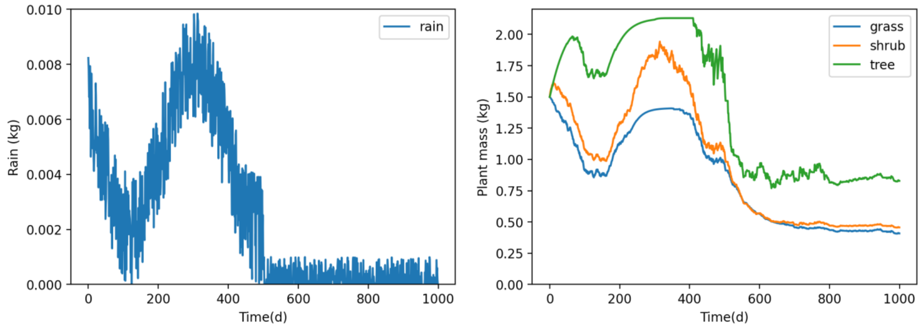

Figure 9 The impact of moderate drought intensity on multi-species plant communities.

As shown in Figure 10, severe drought. Rainfall was almost zero and the community size became very small.

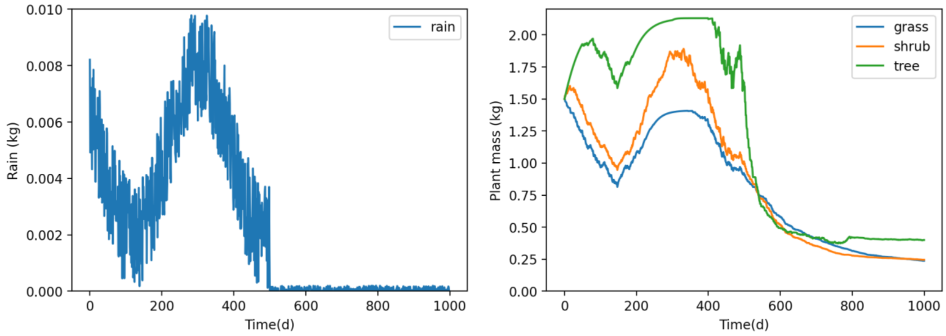

Figure 10 The impact of severe drought intensity on multi-species plant communities.

5.2.3. The Effect of Drought Frequency

(As a comparison) As shown in Figure 11, moderate frequency of drought:

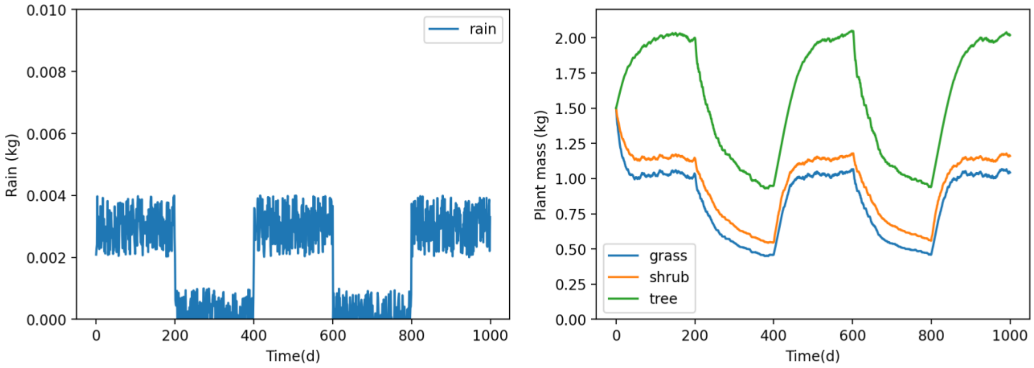

Figure 11 The impact of moderate drought frequency on multi-species plant communities.

As shown in Figure 12, high frequency of drought. When the frequency of drought is too high, the plant has not had time to recover to the ideal growth level, and the long-term development ability of the community is impaired.

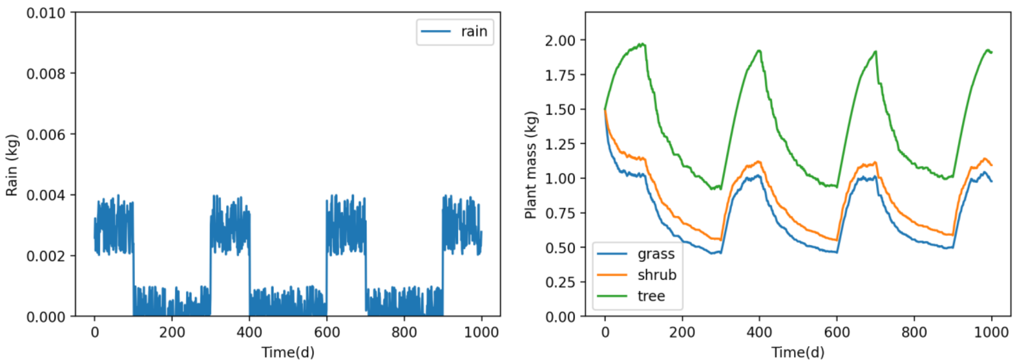

Figure 12 The impact of high drought frequency on multi-species plant communities.

As shown in Figure 13, low frequency of drought. Sufficient time is available to recover to ideal levels.

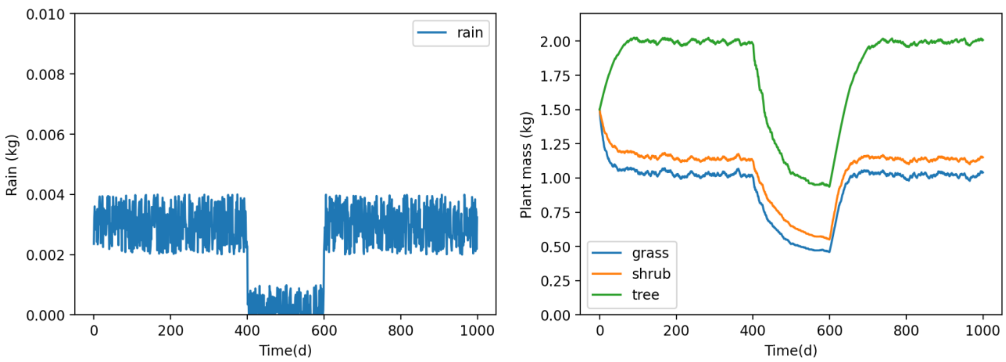

Figure 13 The impact of low drought frequency on multi-species plant communities.

6. Model 3: Long-term Variability Model

6.1. Model Content

6.1.1. Drought Sensitivity of Communities

To describe the drought sensitivity of plant communities, we introduce a new variable s_i to express the drought sensitivity of the i th plant population. The range of this variable is $(0,1]$, wherein $s_i=1$ means that it needs to fully meet the water demand to grow, and $s_i=0$ means that it can still grow under a full drought. We believe that the more sensitive the plant population is to drought, the more vulnerable it is to drought.

To establish the drought sensitivity model of various plant communities, we need to consider the interaction between different species in plant communities. We assume that each species will have a certain impact on environmental factors, which is determined by its population density and drought sensitivity. Specifically, we can use the following formula to describe the drought sensitivity of the community [4]:

$$s(t) = \prod_{i=1}^{n} s_i^{\frac{m_i(t)}{M(t)}} \quad (2)$$

Wherein, n is the number of plant populations, $m_i(t)$ is the population mass of the i th plant population at time t, and $M(t)$ is the sum of the population masses of all plant populations, that is, $M(t)=\sum_{i=1}^{n} m_i(t)$.

The implication of this equation is that the effect of each plant population on the drought sensitivity of the whole community is proportional to its population density and also related to the magnitude of its drought sensitivity. If the drought sensitivity of a plant population is high, then even if the population density of that population is low, it will still have a large effect on the drought sensitivity of the whole community.

The Figure 14 below shows an example of the relationship between drought sensitivity and population mass for the entire plant community. Where the drought sensitivity of each species is the same as defined in Model 1.

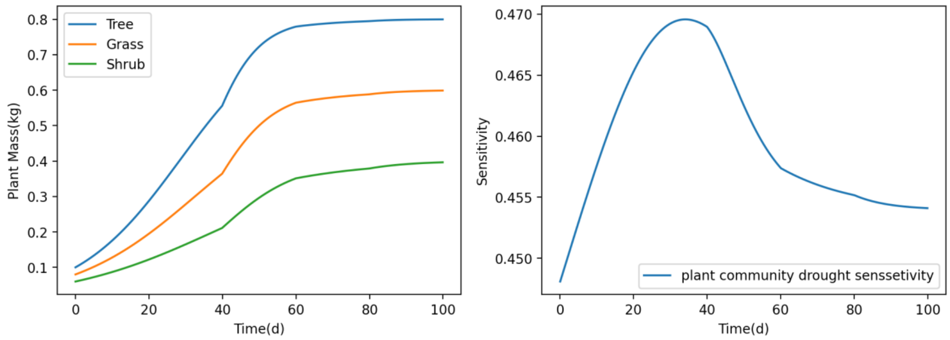

Figure 14 The relationship between drought sensitivity and population mass for the entire plant community.

The number of species and species types have an impact on the drought resilience of plant communities. In general, rich local species diversity and diverse plant species types are beneficial to enhance the drought resilience of plant communities. Next, a model is developed to describe this specific relationship.

Considering introducing a species diversity index to describe the species diversity of plant communities, we choose the Shannon-Weiner index H to represent the species diversity of plant communities, which can be calculated by the following equation [5]:

$$H = -\sum_{i=1}^{n} p_i \ln p_i \quad (3)$$

Wherein, n is the number of plant populations and p_i is the proportion of the ith plant population in the community.

The greater the H index, the more evenly distributed the species in the community, and the higher the diversity of species. If a species occupies an absolute dominant position in the community, the p_i of that species will be very close to 1, while the p_i of other species will be close to 0, resulting in a smaller H index [6]. Therefore, the more evenly distributed the community, the larger its H index and the higher its species diversity.

Next, we combine the concepts of species diversity index and plant drought sensitivity to build the model. Specifically, we can consider the introduction of a correction factor f, which represents the effect of species diversity on the drought resilience of plant communities. The correction factor f can be calculated by the following equation:

$$f = \frac{H}{H_{max}} \quad (4)$$

Wherein, H_{max} is the maximum species diversity index, which is the diversity index when the plant community has the largest number of plant populations.

Then, we can introduce the correction factor f into the plant community drought sensitivity model 2b to obtain the following model 2c:

$$s(t) = f \prod_{i=1}^{n} s_i^{\frac{m_i(t)}{M(t)}} \quad (5)$$

The implication of this model is that a species diversity correction factor f is added to the previous model, which indicates the effect of species diversity on the drought sensitivity of the whole plant community [7].

Overall, it shows that the greater the number of species in the plant community, the more species types, the more evenly distributed the proportions, and the larger the correction factor f, the greater the drought resilience of the plant community.

6.1.2. The Effect of Species Number on Long-term Viability

Model 2d: Minimizing the minimum number of species required to improve the long-viability of plant communities.

We suppose there are n plant populations and each species in the community has a drought sensitivity s_i, which indicates its sensitivity to drought conditions. We can take the drought resilience coefficient of each species as the contribution of that species. Let p_i denote the proportion of the ith species present in the plant community, and the goal is to find a reasonable set of the number of species n in the plant community, with the proportion of each species p_i, to maximize long-term viability [8].

Next, considering how many different species are needed in the plant community to make the entire community benefit from drought resilience, we develop a mathematical model is to describe this problem as an optimization problem.

The optimization objective function is the long-term viability of the entire community. The long-term viability of the community is a complex objective, and we reduce this multi-objective optimization problem to a linear combination of the two main objectives, which are related to community stability and drought resilience. A positive long-term viability indicates that the community benefits from the local diversity of several different species.

As shown in Figure 15, the Community stability stable(n) = a_0*n/(1 + a_1 * n^2) indicates that when the number of species increases from 0, the community stability increases first due to the increase in local biodiversity. However, when the number of species is too large, the limited resources lead to a gradual change in the mutual relationship between species from mutual benefit-oriented to competition-oriented.

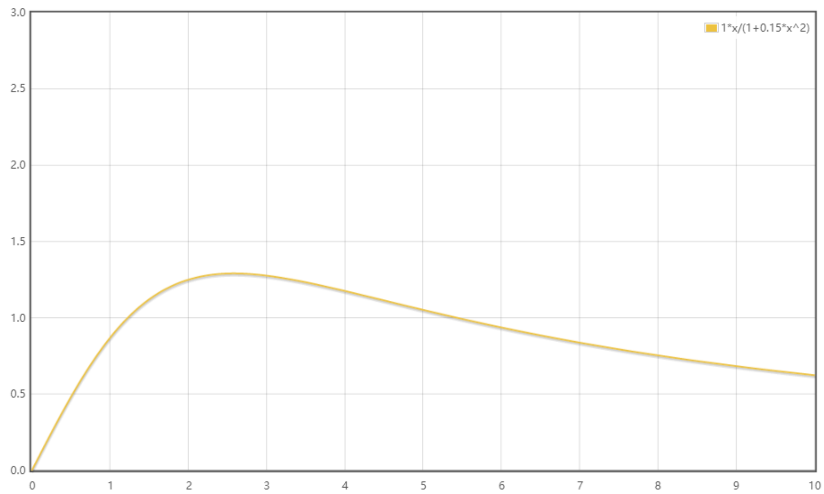

Figure 15 Effect of species quantity on long-term viability.

The drought sensitivity comes from sub-model

$$s(t) = f \prod_{i=1}^{n} s_i^{\frac{m_i(t)}{M(t)}} \quad (6)$$

Objective function: it can be expressed as long-term survivability $\max \gamma_0\, stable(t) - \gamma_1 s(t)$

Optimization variables: number of species n in the plant community, species distribution p_i, i=1,2, ... ,n

Constraint variables are limited growing resources throughout the region, containing water, sunlight, etc.

Constraints:

1) The maximum number of species allowed to occur in the plant community is artificially specified is:

$$n \leq N$$

Wherein, N denotes the maximum number of species allowed to occur in the plant community.

2) The limited nature of growth resources is

$$\sum_{i=1}^{n} m_i K_i \leq K_{max} \quad (7)$$

Wherein, K_i denotes the number of resources required by the ith species during growth, and K_{max} denotes the maximum amount of resources that the plant community can provide.

3) The presence of each species in the community cannot be negative, i.e.:

$$m_i(t) \geq 0, i = 1,2, \ldots, n \quad (8)$$

4) The presence of each species in the community cannot exceed the maximum carrying capacity of the plant community, i.e.:

$$m_i(t) \leq m_{imax}(t), i = 1,2, \ldots, n \quad (9)$$

In summary, the mathematical expression of model 2d is as follows:

\begin{aligned} \min\quad & \gamma_0 \frac{a_0 * n}{1 + a_1 * n^2}
− \gamma_1 f\prod_{i
= 1}^{n} s_i^{\frac{m_i(t)}{M(t)}} \\ \text{s. t. }\quad & n\leq N \\ & \sum_{i
= 1}^{n}m_iK_i\leq K_{max} \\ & m_i(t)\geq 0,\ i
= 1,2,\ldots, n \\ & m_i(t)\leq m_{i max}(t),\ i
= 1,2,\ldots, n \\ & p_i(t) = \frac{m_i(t)}{\sum_j m_j(t)} 0,\ i
= 1,2,\ldots, n \end{aligned}

The above optimization problem is relatively simple given that p_i=p_j.

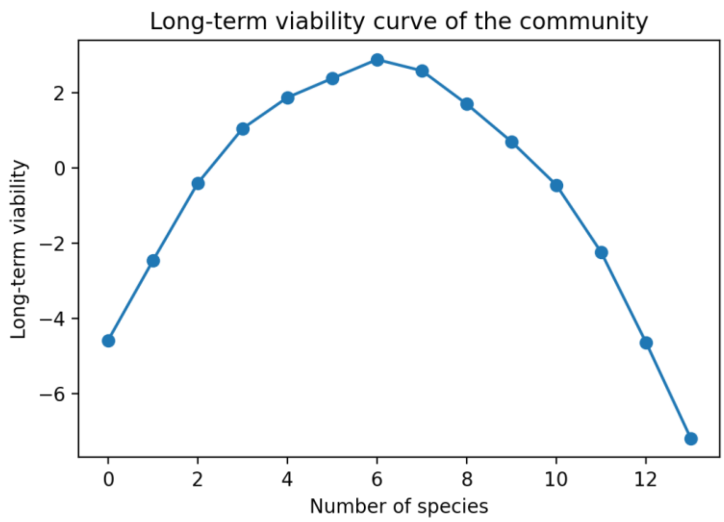

Figure 16 The relationship between optimal long-term viability and species quantity.

At this point, it is easy to see from Figure 16 that to achieve optimal long-term viability, the number of species should be 6. To make the community benefit from the number of species, a minimum of 3 species is needed to make the long-term viability positive. It is important to note that when the number of species continues to increase, the competition between species will be more intense because of too many species, which will cause some of the inferior species to be unable to survive in the community, thus reducing the community stability.

6.1.3. Model Solution

Since n and p_i need to be solved simultaneously, which is a non-convex complex optimization problem, the particle swarm algorithm is used to solve it. Particle swarm algorithm is an optimization algorithm based on population intelligence, which searches for the optimal solution by simulating the motion of particles in the solution space. The particle swarm algorithm has global search capability and fast convergence performance. Its main steps include [9].

1) Initializing the population, including randomly initializing the position and velocity of each individual in the population;

2) Calculating the fitness value for each individual;

3) Updating its individual optimal position and the global optimal position for each individual;

4) Updating the velocity and position of each individual based on the individual and global optimal position;

5) Outputting the optimal solution if the maximum number of iterations is reached or the stopping condition is satisfied, otherwise returning to step 2.

The joint solution for the number of plant species n and the proportion of each species p_i is performed in Figure 17 with the following results:

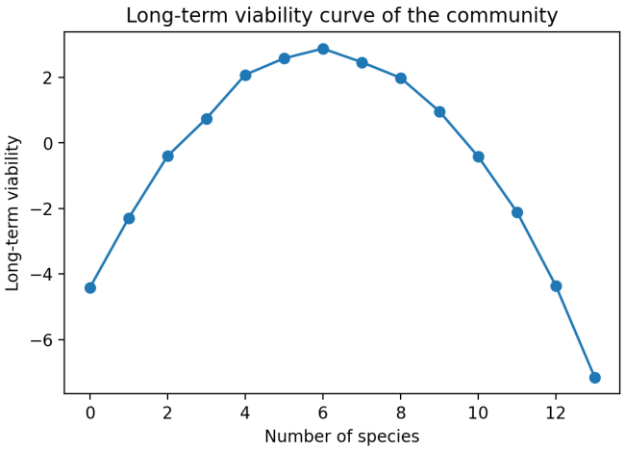

Figure 17 Impact of species quantity on long-term viability curve of the community.

As shown in Table 2 and Figure 18, the corresponding distribution of 6 species of plants.

Table 2 Distribution of six plant species.

	Bermuda Grass	Pine Trees	Red Oak	Zoysiagrass	Juniper Shrubs	Maple Trees
m	1.37	2.78	2.23	2.91	1.49	2.33
r_{ideal}	0.034	0.019	0.027	0.017	0.041	0.038
w	0.004	0.016	0.012	0.023	0.018	0.015
sensetivity_drought	0.77	0.47	0.39	0.85	0.64	0.46

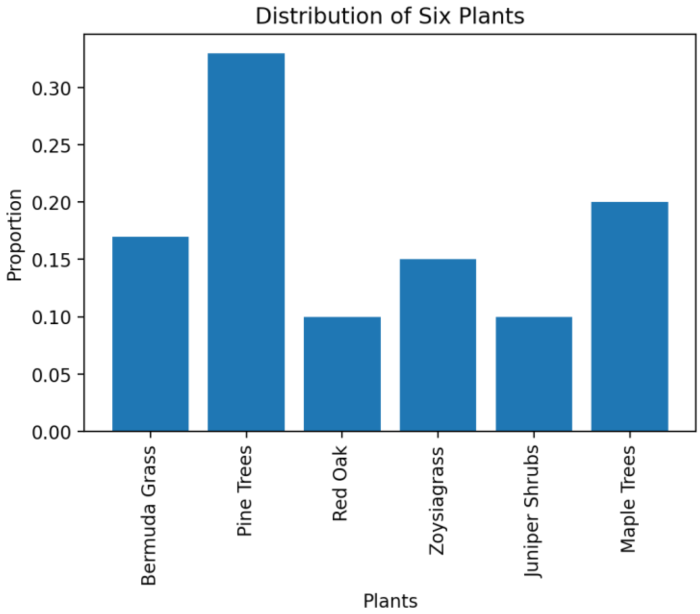

Figure 18 Proportion distribution of six plant species.

6.1.4. The Effect of Species Types

Different species types are modeled with different parameter values. It mainly includes saturation mass m, ideal growth rate r_{ideal}, water demand w, drought sensitivity sensetivity_drought, etc. Additional different plant types will yield different optimal solution results, which are as following the Table 3, Figure 19 and Figure 20.

Table 3 The effect of species types.

	Kentucky Bluegrass	Douglas Fir	White Oak	St. Augustinegrass	Sugar Maple
m	1.51	2.03	2.37	2.13	2.84
r_{ideal}	0.036	0.025	0.037	0.021	0.041
w	0.014	0.011	0.016	0.018	0.018
sensetivity_drought	0.71	0.59	0.63	0.72	0.75

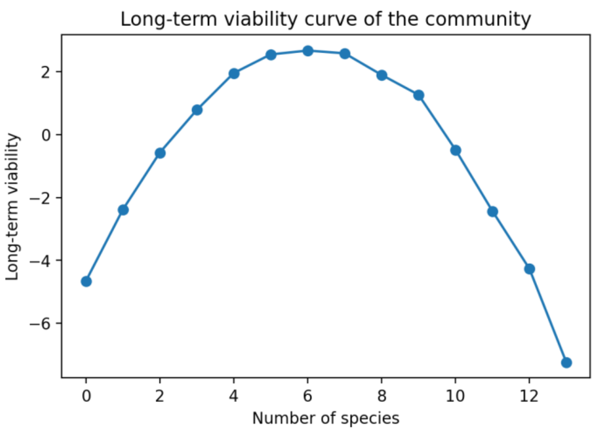

Figure 19 Impact of species quantity on long-term viability curve of the community.

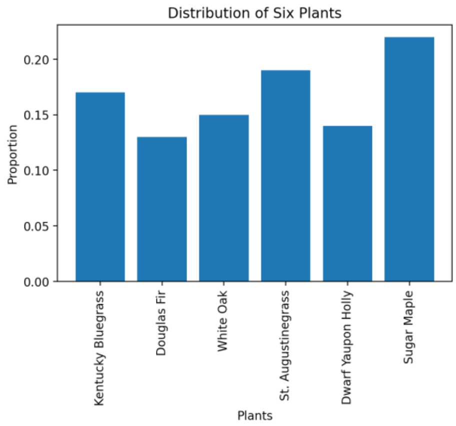

Figure 20 Proportion distribution of different species types.

6.1.5. The Effect of Drought Frequency

In addition, when the drought frequency becomes lower, the community stability is improved, stable(n) = a_0*n/(1 + a_1 * n^2). This is because the rainwater resources are more abundant, the competition of plant communities is reduced, the number of species that can be accommodated is increased, and the overall optimal number of species has changed from 6 to 7. See below Figure 21.

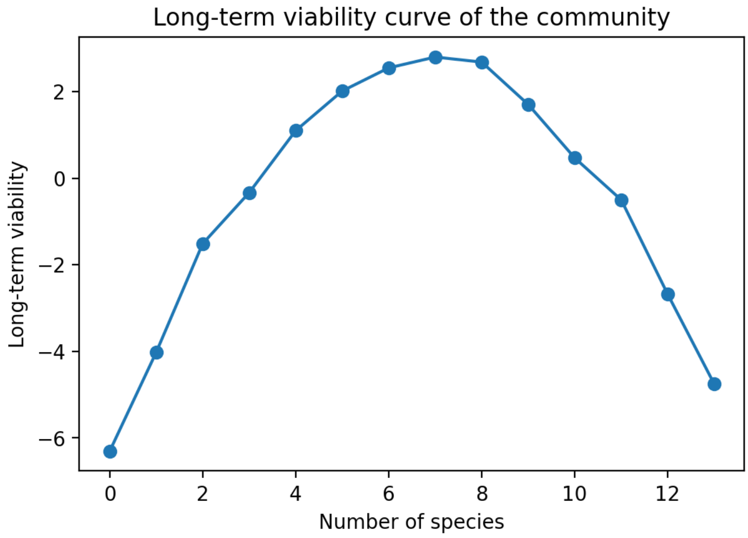

Figure 21 Long-term viability curve of the community

6.2. Model Analysis and Suggestions

Based on the above models, in order to ensure the long-term viability of a plant community, the following solutions can be considered:

1) Protecting and increasing the species diversity of plant communities: planting diverse plants, reducing the use of pesticides and fertilizers, and protecting natural ecosystems are all helpful to protect and increase the species diversity of plant communities. These measures can improve the stability and long-term viability of plant communities by increasing local species diversity. Reducing the impact of a single plant species on the environment and increasing the stability of the ecosystem are conducive to long-term survival.

2) Utilizing water resources fairly: Through rational utilization of water resources, such as reducing water consumption, recycling water resources, water resources protection and other measures, large-scale drought and water shortage caused by human activities can be avoided, and the pressure of plant communities on water resources can be reduced, which will help maintain the sustainability of water resources and promote the long-term survival of plant communities.

3) Improving soil environment: Through reasonable fertilization, vegetation coverage, planting green plants and other measures, the soil environment can be improved, and the soil quality and

fertility can be improved, so as to enhance the saturation mass of various species and increase the plant community, which is beneficial to the growth and development of the plant community.

These solutions also have a significant impact on the environment. For example,

1) Increasing the species diversity of plant communities can promote the stability of the ecosystem and enhance the resilience of the ecosystem, which is conducive to protecting and improving the ecosystem of the big environment. Planting diversified plants can increase the content of organic matter in soil and improve the structure and quality of soil. Adopting sustainable agricultural methods can reduce the use of chemical fertilizers and pesticides, reduce soil pollution and destruction, thus improving soil quality and fertility, which is conducive to agricultural production and improvement of ecological environment.

2) Utilizing water resources fairly can reduce the pressure of water shortage and promote the sustainable utilization of water resources. Diversified plant communities can improve the utilization efficiency of water resources and reduce water waste. Adopting sustainable agricultural methods can reduce the pollution and destruction of water resources and protect the quality and quantity of water resources.

Therefore, the above solutions can not only protect the long-term viability of plant communities, but also have a positive impact on the environment.

6.3. Sensitivity Analysis

Sensitivity analysis can help us understand how sensitive the model output results are to the model parameters and initial conditions. First, we determine the parameters to be subjected to sensitivity analysis: select those parameters that have a significant impact on the model output results. In the model of this paper, the drought sensitivity of species sensetivity_drought, the competition coefficient between species (interaction coefficient) ahpla_{ij} are presented as follow, as shown in Table 4.

Table 4 Drought sensitivity and species interaction coefficients in the model.

ahpla_{ij} \ sensetivity_drought	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.1	-0.094	-0.084	-0.069	-0.04	-0.029	0.017	-0.016	0.0321	-0.011	0.0046
0.2	-0.087	-0.049	-0.04	0.0125	-0.047	-0.026	-0.023	-0.016	0.0595	-0.056
0.3	-0.079	-0.069	-0.059	0.0123	-0.036	-0.006	-0.023	0.0363	-0.049	0.0333
0.4	-0.064	-0.045	-0.049	-0.047	0.0062	0.0207	-0.035	0.0398	-0.028	0.0038
0.5	-0.05	-0.048	-0.044	-0.013	0	0.0363	-0.045	-0.046	-0.017	0.0161
0.6	-0.034	-0.048	0.0607	-0.013	-0.02	0.0238	0.034	0.0272	0.0636	-0.033
0.7	-0.018	-0.053	0.0902	0.0166	0.0464	0.048	0.0684	0.0396	0.0636	-0.056
0.8	0.0413	-0.023	-0.019	-0.017	-0.04	0.0757	0.0391	0.0396	0.0716	0.0181
0.9	-0.034	0.004	0.1028	0.0064	0.0237	0.0736	0.0389	0.0925	0.0925	0.0842
1.0	0.0172	0.04	0.0311	0.0035	0.0064	-0.067	0.0876	0.0576	0.0878	0.1226

Analysis results: According to the results of sensitivity analysis, it can be seen that the model output results are not very sensitive to the model parameters, and the vast majority of the results do not change more than 10% with the variable perturbation of the parameters. With these analysis results, the model has certain accuracy and reliability.

7. Conclusion

In this paper, a single species model is developed to predict the size change of a single species plant community under drought conditions, and it is concluded that grasses are the most sensitive to drought among several different plant species. Shrubs are the most resilient to drought. At the same time, the plant community model proposed in this paper also shows that multiple species are more adaptive to drought than a single species during dry periods when rainfall should be abundant. In order to observe community stability and drought sensitivity, we design a long-term viability model and find that when there are too many species, limited environmental resources will gradually change the relationship between species from mutual benefit to competition. More than 15 common plant species are tested on the model. Results show that the model could effectively predict the change of plant community in irregular weather such as drought. It is verified that multiple species are more beneficial to long-term viability than single species.

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