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Fungal Decomposition of Woody Fibers and Biodiversity Summary

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Abstract

The decomposition of woody fibers by fungi will facilitate the process of carbon cycling, a cycle that is an important component of life on the Earth. It was found that two traits of fungi, hyphal extension rate and moisture tolerance, affect the decomposition of woody fibers. Therefore, the analysis of fungal activities and their interactions is significant for the study of biodiversity. First, we primarily selected the data on nine fungal species from a patch of land in Madison Forest, Wisconsin, USA, as the background for the analytical solution of the full-text problem. To describe the rate of woody fiber decomposition by multiple fungal ac-tivities, we establish the woody fiber decomposition model of fungal communities (WFDM). We take the factors of hyphal extension rate, moisture tolerance and fungal inter-action into account. Under certain environmental conditions at the site, considering interac-tions, we obtain a weight of 0.47 for the effect of hyphal extension rate on woody fiber decomposition rate and 0.71 when interactions are ignored. Next, to describe the interactions between different types of fungi, we establish an index model of interaction intensity between fungal communities based on CUE. In this model, we calculate the value of the interaction intensity index in the short term (10 days) when fungi co-exist and when fungi each exist alone. And the result is that the value of is be-tween . The smaller value represents the stronger interaction intensity. We find that the smallest value of is -0.31333 for group 1 and the largest value of is -0.08 for group 9 among all colonies. What's more, in the long-term trend, due to different competitiveness and changes of environmental conditions, the interaction intensity fluctuates continuously. Further, based on the 'rock-paper-scissors' competition theory, we use the quantita-tive metric of invasion growth rate , to infer the characteristics of the possible species communities. Then, we predict that in different environments (arid, semi-arid, temperate, ar-boreal, tropical rainforest, etc.) the total woody fiber decomposition of the slow-growing fungal communities will exceed that of the faster-growing fungal communities over the same amount of time. Afterwards, we explore the effects of interference competition and intransi-tive competition in terms of species diversity and ecological functions in the context of com-petitive networks. Also, we predict and analyze the importance and role of biodiversity. Not only that, we test the sensitivity of the model, including the effect of changes in the weight of hyphal extension rate on the decomposition rate under interaction, as well as the changes in the value of the interaction intensity index for different ambient temperatures. Finally, we write an article as an introduction to biology for college students.

Keywords

Fungi; Interaction; 'Rock-paper-scissors' competition; Interference competition.

1. Introduction

1.1. Problem Background

As the main organic matter in nature, woody fiber, which plays an important role in the carbon cycle, constitutes 1/3 of the annual plants and 1/2 of the perennials [1]. The decompo-sition of woody fiber is one of the most important processes in the biogeochemical cycle of forest ecosystems. The rate of its decomposition determines the availability of nutrients for plant regeneration, and thus plays an important role in determining the productivity of the ecosystem.

Fungi are one of the key factors that decompose plant material and woody fibers. The wood decomposition rate is related to the hyphal extension rate, the density of the hypha in a given volume, and the moisture tolerance [2]. Fungi play an important role in information transmission, energy flow, and material circulation in the nature. It can also protect biodiver-sity, stabilize ecosystems, and maintain ecological balance [3]. However, the growth of fungi is affected by many factors, such as temperature, carbon, nitrogen, pH, and moisture content [1].

The woody fiber composite is composed of lignin, cellulose and hemicellulose with var-ying concentrations. Wood-rot fungi play a vital role in the biodegradation of lignin. Wood-rot fungi are mostly basidiomycetes and ascomycetes. The woody fibers of different tree species have great differences in chemistry and morphology. This difference also occurs in different types of wood cells, and even at different levels of cell walls. When saprophytic fungi begin to decompose wood, it will produce a series of intercellular degradation, resulting in changes in cell structure. Due to differences in chemistry and morphology, the fungi in-volved in wood decomposition can be divided into three categories, namely white-rot fungi, soft-rot fungi and brown-rot fungi [4].

1.2. Restatement of the Problem

In consideration of the background information and restricted conditions identified in the problem statement, the problems we need to solve are as follows:

Build a mathematical model. This model should describe the decomposition of ground litter and woody fibers by various fungi.

Supplement the model. The model needs to consider the interactions between dif-ferent kinds of fungi with different growth rates and different moisture niche width.

Analyze and describe the model. The impact of fungal decomposition is from two aspects: sensitivity to rapid environmental fluctuations and changes in local weather patterns.

Predict the model. It is necessary to predict the relative advantages and disad-vantages of various species and combinations of species. The predictions under dif-ferent climatic environments should be also considered.

Analyze the importance and role of biodiversity. Think and analyze how the di-versity of fungal communities in an ecosystem affects the overall efficiency of the system in decomposing ground litter, and the importance and role of biodiversity.

1.3. Our Work

First, we develop a model describing the relationship between fungal hyphal extension rate, moisture tolerance, and woody fiber decomposition rate.

Second, we use CUE to calculate an indicator of interaction strength and inferred the strength of inter-species interactions based on the value of this indicator.

Next, we use a metric reflecting the growth rate of invasions to predict the likely long-term species assemblage and analyze its relative strengths and weaknesses based on "rock-paper-scissors" competition theory.

Finally, we predict the importance and role of biodiversity and provide a reference pri-mer on university biology with the role played by fungi in ecosystems as the main topic.

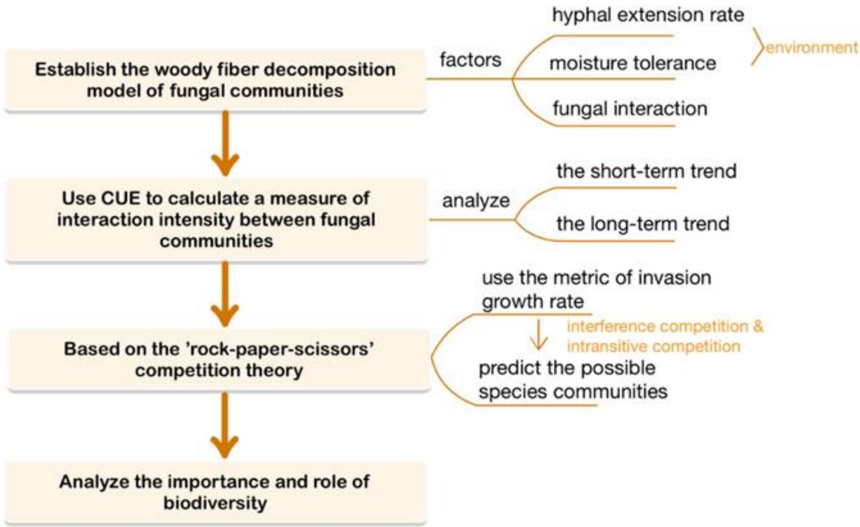

Figure 1: Our approach and work

2. Assumptions and Justifications

For the breakdown of ground litter and woody fibers through fungal activity in the presence of multiple species of fungi, we only consider the decomposition of woody fiber by fungi.

In order to obtain a conclusion of the fungal activity on wood fibers, the rate of decom-position of wood fibers should not be directly influenced by factors other than fungi. And we also do not consider the effect of sudden factors on the decomposition rate of wood fiber in the model.

In building the Woody Fiber Decomposition Model of Fungal Communities, we only study the intermediate stage of decomposition and assumed it to be consistent with the other stages of decomposition.

Woody materials break down through multiple stages, and the fungi that were examined in the research article are most relevant with respect to the decay of woody materials in the middle of their decay cycle. The results may differ for other stages of decay. We only study the intermediate stage of decomposition and assumed it to be consistent with the other stages of decomposition to facilitate model building and solving.

(3) The relationship between the decomposition rate of woody fibers and hyphal exten-sion rate, and the relationship between the decomposition rate of woody fibers and moisture tolerance in the image information given in the question are the correlation of the fungi in our selected region.

(4) Differences in CUE between single fungi and fungi in a community are not constrain by factors other than interaction.

We can better measure the strength of fungal community interaction in terms of CUE when other factors do not have a constraining on the CUE of the single fungi and the fungi in the community. Therefore, when studying the short-term interaction strength, we chose ten days to ensure that the supply of carbon and nitrogen remained in excess. It can minimize the constraining of nutrients on CUE.

(5) The effect of massive invasion of other species on the fungal community is not con-sidered.

In this question, the main study is the interaction between different fungal communities. The invasion of other species can cause problems for the study of interaction strength. We should consider what effect different fungal species will have on population interactions more often .

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3. Notations

The key mathematical notations used in this paper are listed in Table 1.

Table 1: Notations used in this paper

Symbol	Description	Unit
D	The wood decomposition rate	-
E	The hyphal extension rate	mm/day^{-1}
M	Moisture tolerance	-
W	Moisture niche width	Mpa
σ	The weight of hyphal extension rate	-
I	The quantified index of the fungal interaction intensity per group	-

4. Woody Fiber Decomposition Model of Fungal Communities

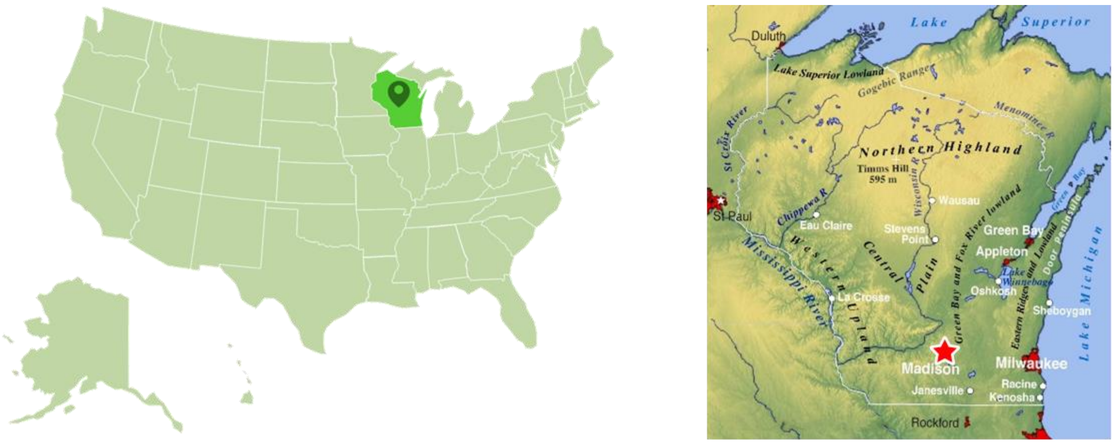
In this chapter, we will establish the woody fiber decomposition model of fungal com-munities (WFDM). In this model, we first consider the effects of two characteristics of a sin-gle fungus, namely hyphal extension rate and moisture tolerance, under certain environmental conditions. And then, we modify the model in consideration of the non-negligible interactions between fungal communities.

4.1. Choice of Region and Species of Fungi

4.1.1. Geographical Environment of The Region

As there are most kinds of fungi living in temperate forests, we choose the temperate mixed forest zone in the north-central part of the US mainland, which is one of the world's most typical temperate forest zones, to study the process of fungi decomposing woody fibers.

Definitely, our study is based on the temperate forest (89°24' W, 43°4' N) in Madison, Wisconsin, USA. South of the upland in Wisconsin is the v-shaped belt of the flat Central Plain covered by hardwood forest.



(a) Location map of Wisconsin in the US (b) Topographic Regions Map of Wisconsin

Figure 2: Location and topographic regions maps of Wisconsin

Location map of Wisconsin in the US: Wisconsin is one of the East North Central states situated in the north-central part of the US mainland.

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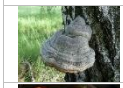
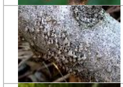
Topographic Regions Map of Wisconsin: Madison is in the south of Wisconsin. https://www.nationsonline.org/oneworld/map/USA/wisconsin_map.htm

4.1.2. Species of Fungi

Based on the research by D. S. Maynard et al [5], We mainly selected 9 wood-rot fungi located in Madison Forest in Wisconsin, USA. Our selection criterion is that the selected fun-gi have overlapping habitats within a certain range to ensure that the interaction between them can be analyzed. The 9 wood-rot fungi all belong to Basidiomycota and Agaricomy-cetes.

The specific information of 9 wood-rot fungi is listed in Table 2:

Table 2: The specific introduction of 9 wood-rot fungi

Picture	Binomial name	Abbreviation	Order	Family	Genus
	Fomes fomentarius	f.fom	Polyporales	Polyporaceae	Fomes
	Laetiporus caribensis	l.carib	Polyporales	Fomitopsidaceae	Laetiporus
	Lentinus crinitus	l.crin	Polyporales	Polyporaceae	Lentinus
	Merulius tremellosus	m.trem	Polyporales	Meruliaceae	Phlebia
	Phlebia acerina	p.rufa.acer	Polyporales	Meruliaceae	Phlebia
	Phlebiopsis flavidoalba	p.flav	Polyporales	Phanerochaetaceae	Phlebiopsis
	Pycnoporus sanguineus	p.sang	Polyporales	Polyporaceae	Pycnoporus
	Porodisculus pendulus	p.pend	Agaricales	Fistulinaceae	Porodisculus
	Schizophyllum commune	s.comm	Agaricales	Schizophyllaceae	Schizophyllum

4.2. Model of Hyphal Extension Rate and Moisture Tolerance Between Fungal Communities

4.2.1. Hyphal Extension Rate and Moisture Tolerance

According to the information in the first picture given by the title, we can find that the hyphal extension rate (mm/day) of various fungi is directly proportional to the wood decom-position rate (% mass loss over 122 days) at three different temperatures (10℃, 16℃, 22℃). Thus, the relationship between the hyphal extension rate and the wood decomposition rate can be expressed as

$$D \propto E \tag{1}$$

where D represents the wood decomposition rate and E represents the hyphal extension rate.

Similarly, according to the information in the second picture given by the title, it can be seen that there is a positive correlation between the moisture tolerance of various fungi and the logarithm of the wood decomposition rate (% mass loss over 122 days). It can be ex-pressed as

$$\ln D = kM + b \tag{2}$$

Namely,

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$$D = e^{kM+b} \tag{3}$$

In this equation, represents moisture tolerance. The definition of moisture tolerance is that the difference between a fungus' competitive ranking and its moisture niche width. Therefore, we select the relative data of competitive ranking and moisture niche width of 9 fungi to calculate the moisture tolerance. After dimensionless moisture niche width data processing, we use the following formula to calculate the moisture tolerance.

$$M = C - \frac{W}{1+[W_{\max}]} \tag{4}$$

In this formula, we define C as competitive ranking and define as moisture niche width. represents the integer value that is no more than the maximum moisture level in which half of a fungal community can maintain its fastest growth rate. The processed data and results of the calculation are shown in Table 3.

Table 3: The processed data and results of the calculation

Name	Hyphal extension rate (mm day^{-1})	Moisture Niche Width (Mpa)	Moisture tolerance (--)
f.fom	4.71	1.19	-0.310252601
l.carib	3.77	1.85	-0.096791422
l.crin	6.38	1.55	-0.205505203
m.trem	9.62	1.24	0.218273644
p.flav	10.8	2.54	0.139727257
p.pend	4.06	1.24	-0.155009445
p.rufa.acer	8.75	1.19	0.405000000
p.sang	4.97	1.71	0.127485832
s.comm	2.57	2.32	-0.180584355

We incorporate the hyphal extension rate and moisture tolerance into the woody fiber decomposition model (WFDM), and assigning a coefficient to the hyphal extension rate. Then, we could obtain the following model (5) about the woody fiber decomposition rate:

$$D = \sigma E + (1-\sigma)e^{kM+b} \tag{5}$$

4.2.2. Interactions between Different Fungi

In fact, there are more than one type of fungi in the same area that have an impact on the rate of woody fiber decomposition. In addition, the interaction between different fungi will also have a non-negligible impact. And the interaction between different fungi is reflected in many aspects. The research by D. S. Maynard et al indicates that fast-growing fungi are more competitive [6]. Hence, we analyze the data related to the hyphal extension rate and competitive ranking of the 9 fungi, and find that there is a relatively obvious linear correlation be-tween the two factors, cf. Figure 3.

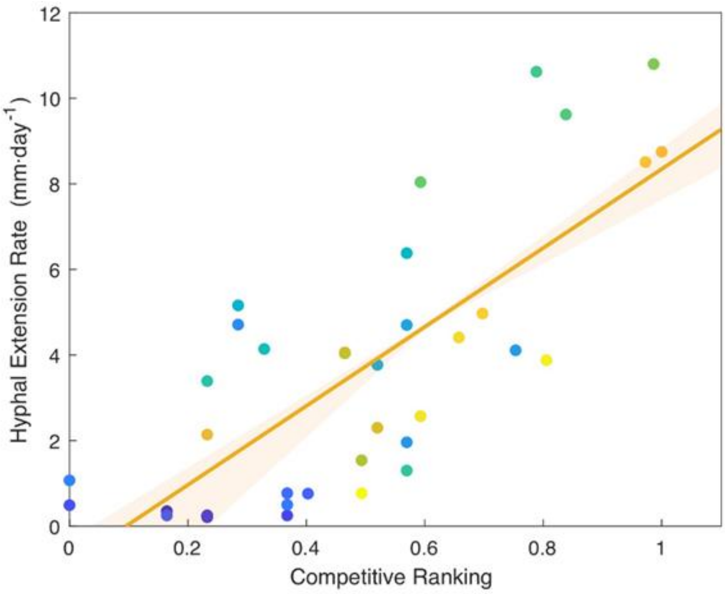


Figure 3: Our approach and work

Thus, we can draw a conclusion from above that when nine species of fungi exist in a certain range at the same time, the fungi with a higher competitive position will retain their original hyphal extension rate in a higher proportion.

What's more, the interactions between the communities have a small impact on its decomposition of woody fibers. We might as well consider this ratio as a competitive ranking denoted by C. Hence, considering the fungal interactions, the woody fiber decomposition model (WFDM) can be modified as

$$D = \sigma CE + (1-\sigma)e^{kM+b} \tag{6}$$

The value range of C is [0,1]. When C=1, it represents the highest competitive ranking, that is, the ideal situation where only a single fungus exists.

4.3. Model Solving and Result Analysis

According to the experimental data obtained by D. S. Maynard et al, the most suitable humidity range for the living environment of these 9 fungi is -1.0 ~ -0.2Mpa, and the most suitable temperature range is 22~32℃. We select the environmental condition in the range as

-0.6Mpa, 22℃ for analysis.

First, the logarithm of the moisture tolerance of these 9 fungi with respect to the rate of woody fiber decomposition was fitted using least squares to obtain a value of of 1.5 and a value of of 2.4, i.e., . Thus, we obtain a fitting diagram of the moisture tolerance of these nine different fungi on the rate of woody fiber decomposition, cf. Figure 4.

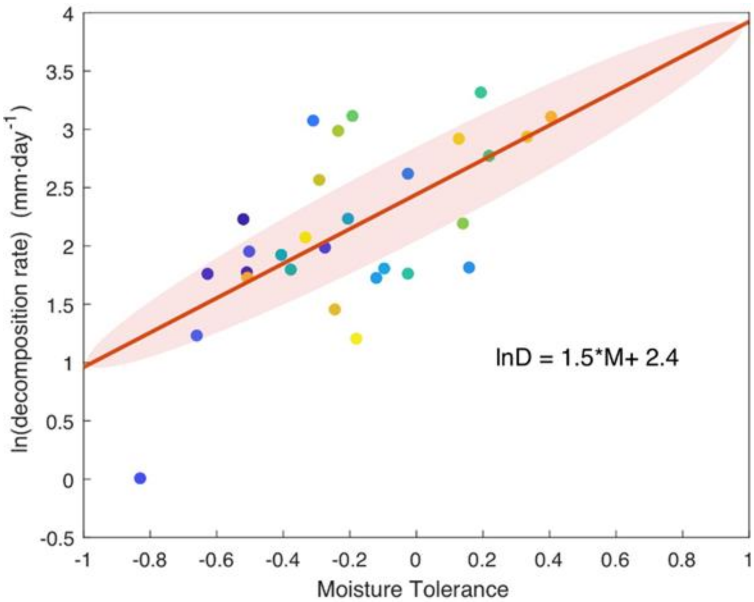
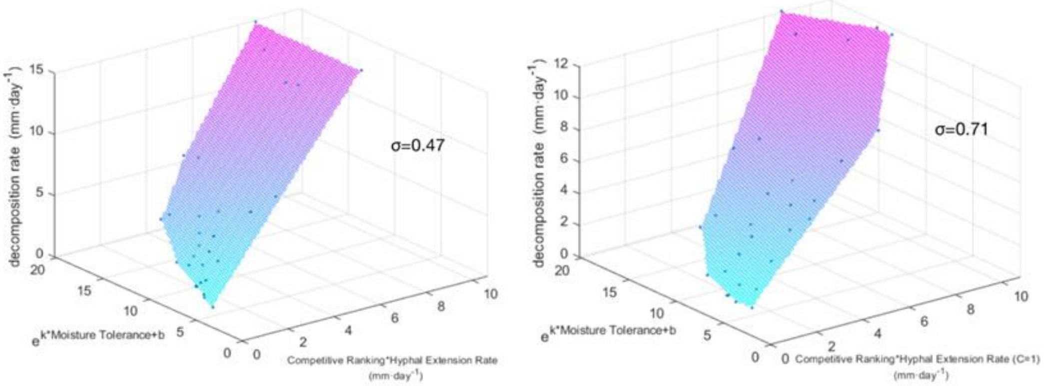


Figure 4: The fitting diagram of the moisture tolerance on the rate of woody fiber decompositio

Similarly, we use the least squares method to fit and finally obtain a value of 0.47 for the parameter , i.e., . To better observe the effect of interactions between fungal communities, we also fitted the case of (i.e., without considering interactions) and obtained the parameter of 0.71, i.e., $\sigma = 0.71$.

As you can see in figure 5, the figure (a) considers the fungal interactions, i.e., when . Instead, the figure (b) shows the result without consideration of the fungal inter-actions, i.e., when . Because is 0.47, which is approximately equal to 0.5, we can draw a conclusion that hyphal extension rate and moisture tolerance of fungal communi-ties are weighted relatively equally. Namely, they both have a significant impact on the rate of woody fiber decomposition.



(a) $\sigma = 0.47$ (b) $\sigma = 0.71$

Figure 5: The relationship of three variables under different parameters

Then, we combine the figure (a) with figure (b) and compare the rates of wood fiber decomposition in the two cases, cf. Figure 6. We find that the weight changes considera-bly when fungal interactions are not considered and that the rate of woody fiber decomposition has decreased. In conclusion, fungal interactions could promote the rate of woody fiber de-composition. Therefore, it’s necessary to take the fungal interactions into consideration.

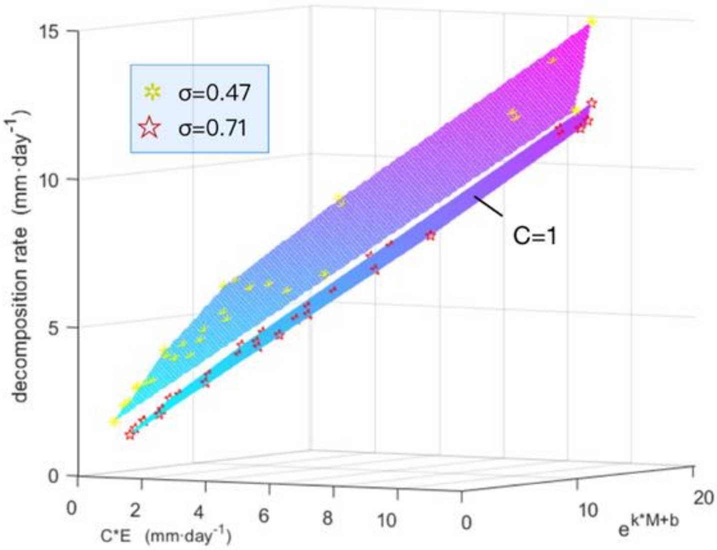


Figure 6: Comparison between the two cases

4.4. Model Testing

To test the applicability of the model, we apply the value of 0.47 derived above to predict the thumb fiber decomposition rate of other fungal communities on this land under the same temperature and humidity conditions. Finally, we obtain the mean value of the ratio of predicted to actual values, i.e. 1.12.

5. Index Model of Interaction Intensity Between Fungal Communities Based on CUE

5.1. Choice of CUE Indicator

Carbon Use Efficiency (CUE) is a quantitative indicator that describes the proportion of the carbon used by organisms to form biomass to the total carbon absorbed. It reflects the carbon assimilation capacity and carbon sequestration potential of organisms. CUE is used to study the carbon flux in the carbon cycle of the ecosystem and the important parameters of the carbon allocation model, which can effectively predict the carbon circulation and carbon feedback between organisms and the surrounding environment [7].

CUE is affected by various non-biological conditions. The research of D. S. Maynard et al has shown that the physiological process of interspecies interaction would also change the value of CUE [5]. The carbon biomass of fungal communities can be strongly affected by species interactions. The formula (7) shows how to calculate CUE.

$$CUE = \frac{N_B}{N_B + N_R} \tag{7}$$

In this formula, represents the net amount of carbon in biomass and repre-sents the total amount of carbon that was either mineralized (i.e. respired).

The following Table 4 shows the data related to carbon and nitrogen of a certain fungal community biomass.

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Table 4: The Parameter Values of a certain group of fungal community

Group	Temp	N level	Total biomass	%C	%N	respiratory carbon
l.carib, p.flav, p.sang	16℃	High	37.7 mg	46.2	6.9	17.5 mg

Additional explanation: N level represents nitrogen content level. High nitrogen content level means. High quality leaf litter and microbial tissue are its typical repre-sentatives. Low nitrogen content level means. It's typically represented by dead branches.

5.2. Establishment of CUE Measurement Index Model

In order to establish an index model based on CUE, we decide to select several types of fungi (here we choose any three) to form a random fungal community. And their interactions are explored under certain environmental conditions (relatively constant temperature and ni-trogen content).

The average of the and values of the three fungi when surviving alone was used to calculate the ideal carbon use efficiency of the colony without considering interspe-cific interactions, which is represented as . In addition, represents actual car-bon use efficiency of the three fungi when living together. Then, we regard the change in the ratio of the two as the indicators of the intensity of interspecies interactions. The formula can be expressed as

$$I = \frac{CUE_2 - CUE_1}{CUE_1} \tag{8}$$

where represents the quantified index of the fungal interaction intensity per group

5.3. Solution of the Indicator and Analysis of the Results

5.3.1. Description of Different Fungal Interactions in the Short Term

We choose the condition of 22℃ and high level of nitrogen content and analyze the in-teraction of 10 different colony combinations in a short time range of 10 days. After calculat-ing, we can obtain the following numerical results, cf. Table 5.

Analyzing the distribution of the index in Table 5, we can find that the values of all range between , which means that the interspecific interactions of fungi generally lead to a decrease in the actual carbon use efficiency (CUE) of the whole community.

Table 5: The results of index I

Group	s1	s2	s3	*I*
1	l.crin	p.flav	p.rufa.acer	-0.31333
2	l.crin	m.trem	p.flav	-0.23667
3	f.fom	p.gilv	p.rufa.acer	-0.09333
4	m.trem	p.pend	p.rufa.acer	-0.14333
5	l.carib	p.rufa.acer	t.chion	-0.21500
6	l.crin	m.trem	t.chion	-0.11667
7	l.crin	p.gilv	p.sang	-0.11000
8	p.gilv	p.rufa.acer	t.chion	-0.17500
9	l.carib	p.pend	p.sang	-0.08000
10	p.gilv	p.pend	t.chion	-0.14500

Lynne Boddy mentioned the concept ‘interference competition’ in his article. Fungi alter their physiology, trait expression and metabolism in order to kill, inhibit and displace their competitors; a set of interactions collectively referred to as ‘interference competition’ [8].

The smaller the value of in Table 5, the more the actual CUE of the colony group negatively deviates from the ideal CUE, i.e., the stronger the interspecific competitive inter-action and the more intense the ‘interference competition’.

For example, the value of group 1 is relatively lower than others, which means there is a strong interaction in the group composed by l.crin, p.flav and p.rufa.acer. And this interaction greatly suppresses the CUE of fungal communities.

For another instance, I.crin is included in both group 1 and group 2, but the value of of the group 1 is lower than that of the group 2, which means fungal community interactions in group 1 are much smaller. Thus, for I.crin, group 2 of the fungal community has less inter-ference competition and is more suitable for its growth and reproduction.

In addition, from the data in Table 5, we can conclude that the fungal community of group 9 has the least interaction effect and is most conducive to the growth of these fungi, which contributes to accelerate the decomposition of organic matter in the forest ecosystem.

5.3.2. Description of Different Fungal Interactions in the Long Term

In the long term, ecological processes such as carbon utilization by fungi correlates strongly with competitive ability or environmental condition [9]. In addition, this strong cor-relation may lead to very different results for fungal interactions compared with those ob-served in the short term above.

According to the ‘GREENHOUSE GAS BULLETIN’ published by WHO in 2018, we can see from the Figure 7 that emissions of three greenhouse gases (CO2, CH4, N2O) have been increasing in recent years, which leads to the changes of various environmental variables such as temperature, precipitation, air quality, etc. Thus, the change of the environment will have a non-negligible impact on the ecological processes and interactions of the fungi.

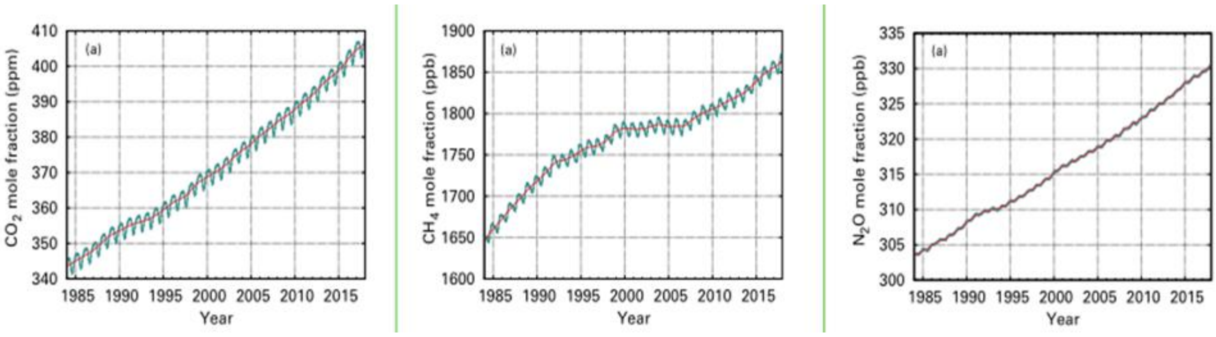

Figure 7: Mole fractions of CO2, CH4, N2O

Resource: https://library.wmo.int/doc_num.php?explnum_id=5455

6. Advantages, Disadvantages and Biodiversity of Combinations of Species

In this chapter, we will explore the effects of interference competition and intransitive competition in terms of species diversity and ecological functions in the context of competi-tive networks. Also, we will analyze the advantages and disadvantages for combinations of species.

6.1. Evaluation of the Advantages and Disadvantages of Different Combinations

6.1.1. Predictions about Combinations of Species Based on ‘Rock–paper–scissors’Competition

Before predicting, we figure out the definition of ‘rock-paper-scissors’ competition first. Some species appear to engage in a game similar to ‘rock-paper-scissors’ in which no species enjoys lasting dominance. The chances of winning are equal regardless of the choices made by the 'game players'. And there is always a clear winner when two species 'play' to-gether. After more species join, the competition becomes more complex, and the success rate of different competitive strategies tends to rise and fall periodically. This may be part of the reason why nature has been able to maintain such a rich biodiversity [10].

According to the article written by Laure Gallien et al, we know that predicting the spe-cies combinations likely to persist cannot rely solely on coexistence theory. The development of coexistence theory almost only focuses on the interactions between two species, usually ignoring more complex and indirect interactions, such as intransitive loops, which can emerge in competition networks.

Next, we choose a metric of invasion growth rate. This metric quantifies the importance of intransitivity for the stability of species coexistence， and integrates intransitivity into tra-ditional coexistence theory. Whereas intransitivity has an important implication for species coexistence, this metric is used to predict species combination likely to persist. Hence, the metric can be expressed as the formula (9).

$$\Delta r_i = \frac{\sum_{j \neq i}^{\mathrm{S}} r_i - r_{i-j}}{\mathrm{S}-1} \tag{9}$$

In the formula (9), r_i represents the invasion growth rate of fungi i invading the whole community. r_{i-j} represents the invasion growth rate of fungi i invading the same community after the removal of fungi j . S represents the number of fungal species contained in this community. Δr_i represents the average of invasion growth rate of fungi i following the extinction of fungi j , which provides a measure of the importance of the in-transitivity to fungi i .

Based on the theory of 'rock-paper-scissors' competition, intransitivity, to some extent, fos-ters dissimilarity by negating hierarchical or asymmetrical competition. Therefore, the species in potentially persistent species combinations are those with different competitive strategies and different characteristics. Hence, in sufficiently complex ecosystems, even though the weakest species may persist in environment where they are surrounded by species that can't displace them [11].

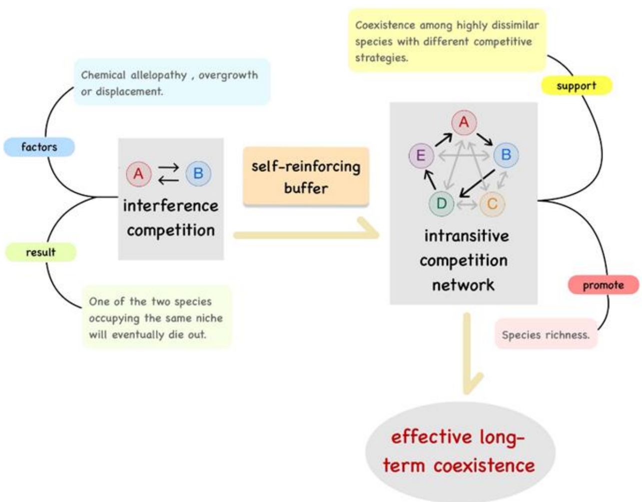

Figure 8: Intransitive competition against interference competition through self-reinforcing buffer to realize effective long-term coexistence

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6.1.2. Prediction of Relative Strengths and Weaknesses of Single Species and Species Combinations

Single species: For a fungus, it isn't subject to interference competition when they exist alone, but the maximum environmental capacity will be reached at an uncontrollable rate in the future, thus developing into a situation where the growth rate is reduced by resource limitations.

Species combinations: For species combinations that are likely to persist, we are going to do prediction in two different ways.

First, the prediction is for communities consisting of fungi with weakly interfering competitive relationships. There is strong intransitive competition among these strains, so that no strain can win overwhelmingly in this 'rock-paper-scissors' competition even in a longer period of time, and there is no tendency of species extinction. At the same time, in order to prevent being replaced by competitors, the strains will produce more biomass to defense and prevent excessive growth of competitors. These will promote the formation of biodiversity.

Second, the other is for fungal communities consisting of fungi with strong interference competition relationships. Because strong interference competition relationship means that the substitution process between two fungi is more likely to occur, long-term development will reduce species combinations richness and affect ecosystem function.

6.1.3. Prediction in Different Environments

In five different environments including arid, semi-arid, temperate, arboreal and tropical rainforest, temperature and humidity are significantly different. From the information in the question, it is clear that slow-growing fungal strains tend to survive and grow better in re-sponse to environmental changes such as humidity and temperature change, while fast-er-growing strains tend not to grow robustly in response to the same changes. For a combination consisting of many fungal strains, it would be reflected macroscopically as a change in the overall rate of woody fiber decomposition in the area.

Therefore, we predict that the total woody fiber decomposition of the slow-growing fungal communities will exceed that of the faster-growing fungal communities in different environments over the same amount of time.

6.2. Evaluation of the Advantages and Disadvantages of Different Combinations

Biodiversity refers to genetic diversity, species diversity and ecosystems. After the above series of model building and solving, we understand the important role of species diversity in environmental change.

Therefore, our team predict the importance and role of biodiversity in the presence of different degrees of variability in the local environment. When there are small changes in the local environment, biodiversity will contribute to the stability of ecosystems. Ecosystem sta-bility also promotes species diversity and genetic diversity. When there is a large degree of change in the local environment, biodiversity can be temporarily compromised. However, after a period of time, there is a high probability that biodiversity will recover. Therefore, the importance of diverse ecosystems is reflected in the important role it plays in maintaining soil fertility, ensuring water quality, regulating climate and so on.

7. Advantages, Disadvantages and Biodiversity of Combinations of Species

7.1. Impact of the Weight σ of Hyphal Extension Rate on the Decomposition Rate D

In the woody fiber decomposition model of Fungal Communities (WFDM), we have considered the weight of the effect of hyphal extension rate on the woody fiber decomposi-tion rate. Now, we fix the environmental temperature as 22°C and the humidity as -0.6Mpa first. Then, we change the value of hyphal extension rate weight to observe the change of woody fiber decomposition rate, cf. Figure 9.

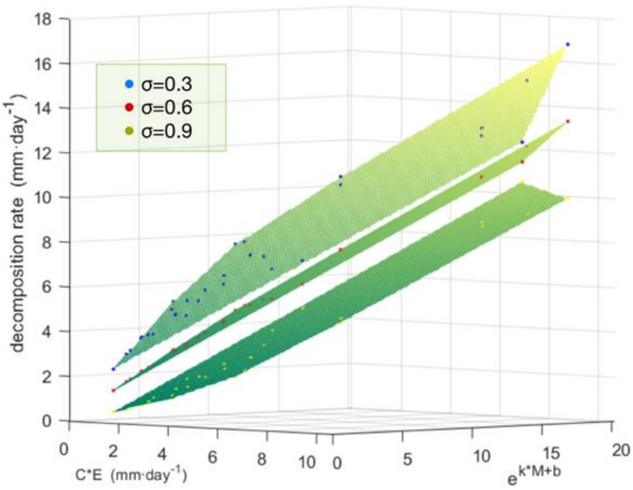

Figure 9: Different decomposition rate under different values of

We can see from the figure 9 that the woody fiber decomposition rate D is decreasing with the increase of . This indicates that under certain temperature and humidity condition, hyphal extension rate causes an effect on the decomposition rate D.

7.2. Impact of Rapid Temperature Fluctuations on the Intensity of Fungal Interactions I

In the index model of interaction intensity between fungal communities based on CUE, we calculate the index on a certain condition of environmental temperature and nitrogen content level. Now, we fix the high level of nitrogen content and change the environmental temperature to observe the change of , cf. Figure 10.

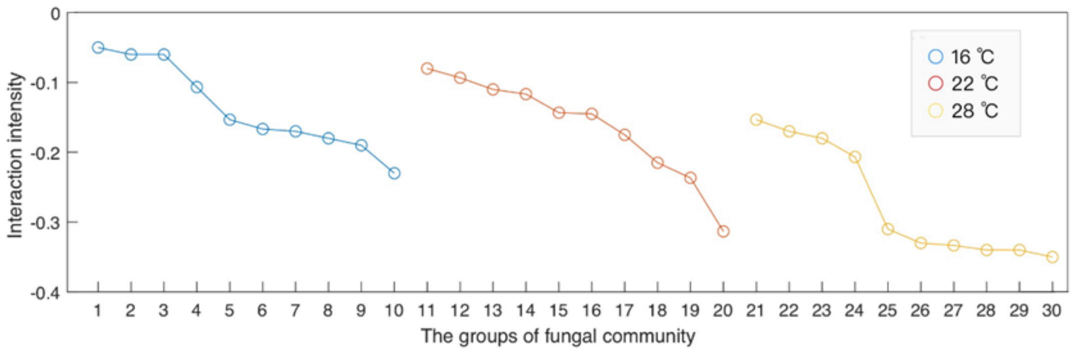

Figure 10: The interaction intensify of groups under different temperatures

At the high nitrogen content level, the higher the temperature, the higher the interaction intensity of most fungal communities. The result indicates that temperature affects the interaction intensity of fungal communities at a certain level of nitrogen content and relatively fixed combinations of fungi.

8. Model Evaluation and Further Discussion

8.1. Strengths

Woody Fiber Decomposition Model of Fungal Communities：

The interaction strength the can be visually measured visually by using the level of competitive position.

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In inter-specific interactions, the weight of hyphal extension rate and moisture tolerance on the rate of woody fiber decomposition can be measured.

Easy to compare the effect of the presence or absence of interactions on the woody fiber decomposition rate

Index Model of Interaction Intensity Between Fungal Communities Based on CUE

The interaction strength between fungal communities can be quantified.

The interaction strength can be converted into microscopic CUE calculations to facilitate the evaluation of interactions in laboratory and other scenarios.

The interaction strength can be converted into microscopic CUE calculations to facilitate the evaluation of interactions in laboratory and other scenarios.

8.2. Weaknesses

Woody Fiber Decomposition Model of Fungal Communities：

It holds only if there is a significant linear relationship between hyphal extension rate and moisture tolerance and woody fiber decomposition rate.

Instead of taking environmental factors directly into account in the model, temperature and humidity are indirectly allowed to influence hyphal extension rate and moisture tolerance, thus affecting the rate of woody fiber decomposition.

Index Model of Interaction Intensity Between Fungal Communities Based on CUE

Interaction intensity evaluations for long-term trends are expensive to observe and not readily observable. In addition, it fluctuates due to significant environmental and seasonal changes. The results of the measurement do not give a good picture of a whole long-term process.

8.3. Further Discussion

For the model of fungal interactions and wood fiber decomposition rate, we can consider the inclusion of abiotic conditions such as environment. The purpose is to make it easier to obtain the data needed for model calculations. Or we can replace the simple linear relation-ship in the model with a functional relationship more in line with the characteristics of fungal woody fibers. It is expected to achieve better results.

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