

## Theoretical Research and Prospect of Alien Plant Invasion

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### Abstract

**Invasive alien plants often cause great harm to local biodiversity, ecological environment, economy and human health. In order to better prevent, control and manage invasive plants and effectively carry out ecological regulation, we urgently need to know the invasive patterns of alien plants, including distribution, diffusion and harm, etc. At present, China has been invaded by 270 exotic plants, and the research on the invasion pattern mainly focuses on the composition and distribution of these species. China is a large country with great heterogeneity of environment and climate, and invasive plants are also diversified. Under such circumstances, the invasion pattern may be determined by multiple factors. China's sustained economic development is likely to promote more biological invasions, so studying invasion patterns is very important for ecological security.**

### Keywords

**Exotic plants; Ecological regulation; Biodiversity; Invasion mode; The ecological environment.**

### 1. Introduction

Alien species are those species, subspecies or genotypes that can appear and survive outside their natural range of distribution. Invasive species refers to the species that expand from the original distribution area to the natural evolution area, grow and reproduce in new habitats and establish stable populations, and their transmission is often affected by human action. Most alien species do not thrive in new habitats and eventually invade. However, some of the invasive species are often out of control and have explosive growth, which eventually brings obvious negative impacts on local ecology, economy and society.

Biological invasion can change the structure and function of an invasive ecosystem, and is currently the second factor in the decline of biodiversity in addition to habitat loss, thus constituting an important part of global change. In addition, invasive alien species often cause serious damage to local economies. For example, in the United States, about 4,500 exotic plant and animal species have established free-living colonies, of which at least 675 (15 percent) have caused serious damage. Annual economic losses in the United States due to the impact of invasive species are estimated at \$137 billion.

### 2. Effects and harms of plant invasion

Invasive species include animals, plants, and microorganisms, often with plants being the largest number. For example, among the more than 400 alien organisms invading Our country, 270 species are plants, and the diversity of plants and their corresponding habitats makes the invasion pattern, influence degree and way also show diversity.

### 2.1 Impacts of plant invasion on ecosystem element inventory and cycle

Plant invasions can often alter the inventory and cycle rates of important ecosystem elements such as C and N. For example, in subtropical savanna areas, the invasion of woody plants into the savanna results in an increase in ecosystem C reserves. Another study suggests that changes in C reserves due to biological invasion in these areas depend on rainfall - invasion increases in dry areas and decreases in wet ones. This change is caused in part by the difference of physiological and ecological indexes between the invasive plants and native plants. The invasion of nitrogen-fixing plants often leads to the increase of soil N content. For example I have multiplied the (Myricafaya) after the invasion of Hawaii can organisms in the soil available N content, thus intervention on the volcanic ash soil parent material development and succession of the ecosystem process, some non nitrogen-fixing plants will use the increased nitrogen promote the growth of biomass, and provide more energy for the nitrogen-fixing microbes, thus improve the ecosystem of ammonia reserves. The comprehensive analysis shows that, although the consequences of different plant invasions vary greatly, in general, plant invasions can often increase the reserves of C and N in the soil and promote the circulation rate of elements, which in turn creates conditions for new plant invasions.

### 2.2 The impact of plant invasion on hydrology

There were differences in transpiration rate, morphology, photosynthetic rate and photosynthetic biomass, root depth and other indexes between the invasive plants and native plants, which may lead to changes in the hydrological cycle characteristics of the ecosystem after invasion.

For example, studies have shown that willows invading southwest North America increase the total evapotranspiration of soil water by 300-460mm per year. On annual grasslands in western North America, yellow cornflower invasion increases summer water use by 105 to 120mm. In these cases, more water loss is likely related to the physiological and ecological characteristics of the invasive plants: willows have larger leaf areas, and yellow cornflowers have a vigorous growing season in the summer.

In other cases, the use of invasive plants can also reduce community water in California, for example, foreign annual grass compete replace the local has a deep root of herbaceous plants and other foreign annual grasses transpiration period is relatively short, these physiological mechanism to reduce the plants on soil moisture absorption. These results indicate that invasive plants can alter ecosystem processes by influencing community structure.

### 2.3 Effects of plant invasion on fire

Invasive plants may change the frequency and intensity of fire. The frequency of fire tends to increase when grasses invade communities previously dominated by woody plants. While the invaders can increase the amount of fuel by increasing productivity, the invading plants will increase the depth of the fire. Some shrubs and trees can increase the time, temperature, and extent of a fire when they invade wet grassland, savanna, or fire-prone scrub. In the Western United States, for example, the invasion over the past century of annual grasses into desert thickets has greatly increased the frequency of fire, which in turn has helped transform desert thickets into grasslands. In Hawaii's seasonally dry shrubs and woodlands, grass invasion increased the frequency of fire by more than three times, which in turn had a significant impact on biodiversity.

These results suggest that invasive plants can strongly alter community structure by altering ecosystem processes such as disturbance patterns.

### 2.4 Impact of plant invasion on biodiversity

Some invasive plants tend to outcompete almost all other plants by being highly competitive and have significant effects on other trophic levels. The invasion of Norwegian trees has been observed to reduce the abundance of saplings under the forest. In the Czech Republic, the invasion of *Heracleum mantegazzianum* has also contributed to the loss of biodiversity in the local ecosystem. In China, the invasion of the east coast ecosystems of *C. interflora* can replace all other plants and harm many animal components. For example, although the invasion of *C. interflora* did not change the diversity

of arthropod community, the total number of arthropods and the community structure were seriously changed. On a small scale, although many studies have found that invasive plants reduce the biodiversity of native communities, invasive plants generally do not cause local extinctions of native plants, and on larger scales (e.g., landscape scales) plant invasions usually increase biodiversity. In addition, exotic plants generally invade in places where the environment is disturbed and native biodiversity has been reduced. Some research has shown that invasive plants are more a traveler rather than a cause of the change of the environment, it is combined with interference of human activities on the ecosystem, common prompted the local biodiversity is reduced, but also have some research has shown that if a plant invasion caused the increase of the habitat heterogeneity, local biodiversity will increase accordingly.

### **3. Theory of plant invasion**

In recent decades, due to the enhancement of international trade and human interference, the number and degree of biological invasion have also increased correspondingly. Due to the great harm and impact of biological invasion, ecologists pay more and more attention to the research in this field. Current theoretical advances focus on two aspects: the study of individual species, and the comparison of multiple species. The former can reveal the invasion mechanism, invasion consequences and possible distribution area of a particular species in depth, but these studies mainly focus on a few invasive plants with great harm. The latter reveals the invasive ability, distribution range and harmfulness factors (both biological and non-biological) of each species through comparison among species.

#### **3.1 Hypothesis of loss of natural enemies**

Since Elton's 1958 Hypothesis, the Enemy Release Hypothesis, which continues to be a hot topic of research today, suggests that invasive species can escape the control of natural enemies in the original ecosystem when they arrive in new areas and thus reproduce rapidly. There is a lot of evidence in experimental observation to support this hypothesis, but there are also quite a few studies holding opposite results. The possible reasons for this contradiction include: the number of species that feed on plants decreases, but the degree of feeding does not necessarily decrease; The functions of the natural enemies of the broad and the compulsive eaters are different; Because different plants have different strategies, the effects of loss of natural enemies on the invasion ability of different plants are also different.

Recent studies have shown that when invasive plants arrive in new areas, they may either be resistant to herbivores because they carry new chemicals, or they may be more vulnerable to herbivores because of a lack of signalling mechanisms. At the same time, the loss of some natural enemies also shows a time effect, and the native insects may adapt quickly and feed on the invasive plants, thus inhibiting their growth. In general, the hypothesis of loss of natural enemies is still a hot research topic at present, and has led to some related researches, such as the hypothesis of stronger competitiveness of evolution, the study and practice of biological control, etc. These studies, like the natural predator loss hypothesis itself, have yielded both positive and negative evidence. With further study, the theory will be able to have a deeper understanding.

#### **3.2 Hypothesis of new weapons**

This hypothesis, a kind of plant invasion to a new place, after the release of allelochemicals could strongly inhibit the growth of native plants, plant and its country of origin is already on the allelochemicals adaptation mechanism, high contrast and low the hazards of invasive plants found that high hazard often can produce local plant chemicals do not have.

Allelopathy, on the other hand, may vary greatly with time and space. For example, over time, native plants may develop adaptive mechanisms for these allelopathic substances. For some plants, at least under certain environmental conditions, allelopathy does not play a large role in invasive ability.

### 3.3 Growth feedback mechanism

Plants in growth will also effect on soil environment and modification, the modified habitat may promote or inhibit the growth of plants, invasion plants often also can increase the soil nutrient content and mineralization rate, and this change is beneficial to the growth of their own, and endangered plants are easy to accumulate inhibit the growth of pathogenic bacteria, itself for some invasive plants, feedback may be bad for their growth, such as flower rice grass can improve sludge height, reduce moisture content and bad for their growth.

### 3.4 Rapid evolution of invasive plants

Many characteristics of invasive plants can lead to adaptive evolution in the new environment where they are introduced. Such as the evolution of greater competitiveness, plasticity, adaptive interference ability and so on. There are both positive and negative evidences on this hypothesis. Now it is generally believed that invasive plants have the ability of rapid evolution, and the direction, mechanism and regularity of their evolution are still the research hotspots at present.

### 3.5 Genetic relationship with native plants

The relationship between exotic plants and native species may affect the invasion ability. A study of exotic plants in New Zealand found that exotic plants close to native plants were more likely to be naturalized. In contrast, other studies have shown that exotic plants that are far more closely related to native plants are highly invasive. Although other studies have shown no necessary link between the two, the reasons for these observed differences may include: 1) Different spatial scales of study and different conclusions. Due to the competition and rejection effect, it is difficult to coexist in adjacent species. At large scales, relative species are favorable for adaptation due to similar habitat requirements. 2) From invasion to naturalization, it is likely to be advantageous to be closely related to native plants; But for the naturalized invasion ability is very strong, often is with the native plant relatives distant foreign plants. In a word, the relationship with native plants has both positive and negative effects on the invasion ability, depending on the specific species, the spatial scale of the study, the invasion period, the specific habitat characteristics and other factors.

### 3.6 Interference promotion hypothesis of plant invasion

Foreign plants generally invade in places with severe human activity interference, which is often accompanied by the lack of resources. Interference promotes plant invasion in two aspects: the competitiveness of native plants in disturbed habitats declines; Invasive plants have or evolve to adapt to disturbance. Invasive plants do not have a competitive advantage under all conditions, but often show strong competitiveness only when the disturbance or soil fertility is high. For some leguminous invasive plants, they are more competitive in low-fertility soils, and other studies have shown that although low-fertility soil invasive plants are less competitive, they can still compete with native plants during long-term adaptation.

### 3.7 New biological interactions

The essence of plant invasion is that plants come into a new environment and face a new set of organisms and environments. Under this new selection pressure, new interactions between invasive plants and various native organisms and environments are generated, and the original interactions between invasive plants and various organisms and environments should be broken, while new interactions should be formed.

In new interactions and relationships, various biological and environmental factors are likely to promote or inhibit plant growth, and there may be interactions between them. If these factors and their interactions promote the growth of the invasive plants relative to the similar factors in the origin of the invasive plants, the competitiveness of the invasive plants will also be improved. Conversely, if these factors and their interactions inhibit the growth of the invasive plants relative to their native counterparts, the competitiveness of the invasive plants is reduced.

### 3.8 Comparative study of multiple species

The comparative study of multiple species can reveal the invasive ability, distribution range and harmfulness factors of species. Invasive plants in the classification of the scale of distribution is not random, and more focused on gramineae, compositae, leguminosae, cruciferae, what kind of plant invasion ability is a hotspot in the research of the comparative more species, invasion ability of plant growth and tend to be faster, small seed quality, adapt to high resource habitat and anti-interference characteristics.

Many studies have shown that the number of invasive plants in a region is related to the economic development of the region. For the distribution range of an invasive plant, the influencing factors may include introduction time, seed size, life cycle and so on.

Although multi-species comparative studies are devoted to finding out what species are vulnerable to invasion, it is difficult to generalize from the perspective of species because of the diversity of plants and their adaptability to the environment. Recent studies have shown that a combination of factors explains the invasion. In South Africa, for example, the combination of speciation, environmental characteristics and human exploitation determines the pattern of invasion of exotic plants. The mechanism of plant invasion may also be a combination of resource utilization, loss of natural enemies and soil fertility.

## 4. The situation of invasive plants in China

With the development of international trade and economy in recent decades, the number of invasive plants in China is increasing rapidly. Statistics show that China has 270 kinds of exotic invasive plants, and these invaders have caused great harm and loss to China's ecological environment, biodiversity, agriculture and human health. Despite the extent of the plant invasion, given China's vast environmental diversity, size and rapid economic development, many new plant invasions are expected in the future.

China's 270 invasive plants account for 0.9 percent of the country's total plant population, a relatively low proportion compared to other countries and regions. In California, for example, there are 70 serious invader species, accounting for 1.6% of the total plant population. Although China has a long history of introducing foreign plants, it is only in recent times that a large number of foreign plants were introduced. For example, the Canadian goldenrod was introduced to China in 1935, but in Europe it was already introduced in the 17th century. More than half of the invasive plants in China are annuals, while the proportion of woody plants is very small. In other parts of the world, shrubs and woody plants account for a greater proportion of invasive plants, possibly because woody plants take longer to naturalize than in China, where they have been introduced for less time. In fact, the introduction of woody plants in China is not rare, and they may become a focus of naturalization in the future. The sources of invasive plants in China are the largest in Central and South America, followed by Eurasia, North America and Africa. About half of the plants (mainly perennials, including a small number of annuals) have been artificially introduced as useful plants, mainly for ornamental, forage or feed, medicinal, vegetable, turfgrass, and environmental protection. The rest are mainly brought in by human activities unintentionally, including import and export trade, ballast water, food, passenger carry and so on. Some are spread from neighboring countries, such as ragweed from Russia into the northeast of our country. The invasive plants in China are mainly distributed in provinces with great human disturbance and good natural environment.

## 5. Look

China is a large country with a great climate and environmental diversity, and the corresponding invasive plants are also diverse. In this case, it is likely that a variety of factors play a role in the damage size and distribution pattern of invasive plants in China. Due to the serious harm of invasive species in China, and there will be more invasive plants in the future, it is urgent to provide theoretical basis for macro management and prevention of invasive plants through comparative study of multiple



species. In order to better understand the invasion pattern of exotic plants in China, further research is still needed in the following directions.

Why are China's most dangerous invasive plants perennial, from the Americas and asexual? In other parts of the world, high-impact invasive plants have a variety of characteristics, including sexual reproduction, trees and shrubs. The possible reason is that, in general, the genetic diversity of invasive plants in China is low, which is not conducive to sexual invaders. For cloned plants, low genetic diversity can also help fix a particularly superior genotype.

Are there any differences in the characteristics of other species between high-impact and low-impact invaders? For example, are annuals introduced intentionally and unintentionally, and perennial clones with high and low influence the same in terms of seed size, leaf area per unit mass?

For invasive plants from Eurasia, do they have a low genetic diversity, are they specially unsuitable for invasion, or do they lack some competitive factors (loss of natural enemies, allelopathy, etc.) that make them less influential on the whole?

Which exotic plants will become invasive species in China? This requires collating data on all foreign plants, all naturalized plants, and all invasive plants in China, the first two of which are not available at present.

At present, although there are some studies on Chinese invasive plants, they mainly focus on the observation of their composition and components, and consider them as a whole, and lack of detailed and mechanism research. When further research is carried out in the future, we hope to examine the characteristics of an alien plant species to predict whether it will become an invasive species and, if so, where it will appear. How fast is the diffusion rate? How bad is it? What are the intrusion mechanisms and effects? Answering these questions will significantly improve our ability to prevent and control future plant invasions.

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