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Effects of dandelion reproduction

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Abstract:

This paper mainly explored the seed propagation efficiency of dandelions in different environments and the impact of dandelions on specific environments as a species that easily spreads seeds. It also calculated the seed wind propagation distance as a solution.

We incorporated global climate model factors into the first model to explain the factors influencing dandelion dispersal and the ideal range for dandelion seed dispersal in subtropical and temperate environments. Secondly, we used factor analysis to explore whether dandelion is an invasive plant. Expert scoring was used to evaluate whether a species is an invasive plant. In addition, we included two common invasive plants, alfalfa, and American sedge, in the same model and measured them with the same confidence level to conclude. As a result of the above studies, we found that dandelion spreads differently in tropical, subtropical, and temperate zones and is not a serious invasive species. Finally, based on the above conclusions, a suggestion for reasonable cultivation of dandelion was proposed.

Keywords: dandelion propagation, global climate model, factor analysis.

1. Introduction

1.1 Background information

Dandelion is a plant native to Eurasia. And in all aspects of life, we can see traces of dandelions. In this question, we need to determine whether the dandelion is a nuisance invasive species because of its dispersal and role in the invasion. Or it‘s a good, socially useful species.

1.2 Question Restatement

Dandelions‘ seeds have several media to help them finish the next generation since when they attach to a pappus, winds or animals can easily take them away. So, we want to estimate the spread of dandelion throughout 1,2,3,6 and 12 months by using the mathematical model. Moreover, Dandelions have been misunderstood as an invasive species because they have a high speed of spread and a lot of incredible approaches to thrive anywhere. Thus, our purpose is to determine the impact factors of invasive species, including their traits and the degree to which they may cause them.

1.3 Our work

In this paper, we first build a model to analyze the spread of dandelion under certain natural conditions. By placing dandelions in cities under different climatic conditions, we analyzed them separately to explore how climate factors affected the growth and spread of dandelions. In the second question, we explore the factors that influence our judgment of whether dandelion is beneficial or harmful and build an evaluation model to determine whether dandelion is an invasive species. In addition, we selected two other invasive plants for validation. Finally, we tested and analyzed the sensitivity of the model.

1.4 Model overview

In the first model, we calculated several different climatic factors that affect dandelion transport, such as precipitation, temperature, wind speed, and atmospheric carbon concentration, depending on the city. These values can be used to measure whether a city can spread dandelions and how efficiently it spreads them. The model is based on the wind travel distance of the seed. In the second model, we use the commercial weight and analytic hierarchy process to evaluate the model through expert scores.

2. General Assumptions and Justifications

For one, dandelions are only affected by precipitation, temperature, wind speed, and the concentration of carbon in the atmosphere. In this process, the propagation of dandelion is in line with the ideal conditions; that is, no external factors interfere with the spread of dandelion. Second, in the second model, we also presuppose some factors that make dandelion an invasive species. Finally, it is assumed that the process of expert discussion scoring is rigorous.

3. Notation

Table 1 Variables Table

Symbol	Definition
D	Distance of dissemination
K	Kaman constant (usually 0.40)
μ	Horizontal wind speed
F	Seed sinking, drop rate
W	Vertical wind speed
Z	Seed settlement height
And d	the kinetic zero-value shift
Z0	Values for plants identified as invasive species
R	Values for plants identified as invasive species
X	The weight of each indicator
Ri	the assignment of each index corresponding to X
P	The probability that the plant is judged to be an invasive species

4. Model Preparation

4.1 Model preparation and model building for Model1

In the first model, we calculated the propagation distance of dandelion seeds under windy conditions using a wind-propagating model, which only considered the average precipitation, average temperature, average wind speed, and average atmospheric carbon concentration for different months. We‘ve chosen some relevant metrics, such as friction and seed trade rates. These variables can better reflect how seeds reproduce in the atmosphere.

Tropical (Cairo), temperate (Shanghai), and cold (London) in January, February, March, and December, 2022:

Table 2 Rainfall concentration among cities

City/month	In January	In February	In March	In June	In December
Tropical(Cairo)	0	0	0	0	0
Temperate zone (shanghai)	50	69	80	150	50
Cold Belt(London)	50	40	40	40	50

Unit: mm mm

Tropical (Cairo), temperate (Shanghai), cold (London) monthly average in January, February, March, and December 2022: Temperature value:

Table 3 Temperature concentration among cities

City/month	In January	In February	In March	In June	In December
Tropical(Cairo)	18	19	22	32	20
Temperate zone (shanghai)	6	7	10	24	8
Cold Belt(London)	6	6	8	17	7

Unit: degrees Celsius °C

Tropical (Cairo), temperate (Shanghai), cold (London) monthly average in January, February, March, and December 2022: Monthly wind speed value:

Table 4 Wind speed concentration among cities

City/month	In January	In February	In March	In June	In December
Tropical(Cairo)	3	3	3	3	3

Temperate zone (shanghai)	3		3	3	3
Cold Belt(London)	3	3	3	3	7

Unit: m / s m / s

Tropical (Cairo), temperate (Shanghai), cold (London), in January, February, March, December, 2022:

Table 5 Atmospheric carbon concentration among cities

City/month	In January	In February	In March	In June	In December
Tropical(Cairo)	416.6	416.6	416.3	416.1	416.8
Temperate zone (shanghai)	417.2	417.2	417.0	416.7	417.7
Cold Belt(London)	420.2	419.9	420.0	419.5	420.6

Unit: ppm per million

4.2 Mathematical Modeling Realization of Model 1

The WINDISPER-L Lagrangian wind speed profile seed wind propagation calculates model 1 The seed wind propagation distance:

$$D = \frac{\mu_*}{k(F-W)}\left[(z-d)ln\left(\frac{z-d}{e\bullet z_0}\right)+z_0\right] \quad (1)$$

Where D is the propagation distance, the friction rate:

$$\mu_* = \frac{k\times u}{ln\left(\frac{z-d}{z_0}\right)} \quad (2)$$

k is the Karman's constant (usually treated as 0.40), is the horizontal wind speed, F is the seed settlement rate, w is the vertical wind speed, and z is the seed settlement height, zero displacement:

$$d = 0.63h \quad (3)$$

Air friction coefficient (h is the height of the plant):

$$z_0 = 0.13h \quad (4)$$

The instantaneous vertical wind speed

$$W = \bar{W} + 1.25\mu_* \times \in_t \quad (5)$$

Where $\in_t$ is a random variable following the standard normal distribution, W is the average value of vertical wind speed (usually treated as 0 and variable (t)is randomly generated by inverse transformation Monte Carlo, and based on this value, the random vertical wind speed W is calculated, and then w substitutes into the seed dispersal distance formula, and analyses the distance of different seeds carried by the wind. Finally, Monte Carlo is simulated more than 1,000 times by taking advantage of MATLAB.

4.3 Model preparation and model building for Model 2

We use factor analysis and analytic hierarchy processes to explore whether dandelion is invasive or beneficial to humans. Subjective data are also introduced into models to study what conditions are needed to see if plants become invasive or beneficial species for humans. After we came up with a theory about the dandelion itself, we also brought this model into the model of other plants, and we found that the universality of this model we established is good. It can also play a role in other relevant scenes.

Table 6 selected symbols

Affectoi index	Secondary indicators	Secondary indicators	Secondary indicators
Plants characteristics	rate of growth	fecundity	adaptability
Degree of environmental	Local plant effects	Overall environmental	The degree of human benefit
propagation velocity	Average monthly transmission rate	Maximum coverage area	
Ecosystem resistance	Ecosystem diversity	Ecosystem resilience	

By scoring the plant with an expert system, we quantified the comprehensive evaluation of various indicators according to the entropy weight method and principal component analysis method. Finally, we obtained the definition of whether dandelion is called a pest in the environment.

In addition, we introduced the remaining two plants. We scored the plant according to the collected information and the expert system to determine whether it was beneficial or harmful to the environment.

5. Model 1: Model of seed wind spreading model

5.1 Model Coding Realization

Appendix A

5.2 Model Result

We introduce the data produced by the NorESM1-M (RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5 represent atmospheric radiation intensities of 2.6, 4.5, 6.0, and 8.5 W-m-2, respectively) when the climate changes over times. Regarding RCP8.5, different environmental variables will cause different concentrations of carbon dioxide in the atmosphere, which can directly affect the development of Dandelions. When we analyze the influence of climate change on seed dispersal distances, we first put daily wind speed in different months of the year, not only in the standard climate but also in changed climate in the future, into the model for calculating the separated distance of seed wind, and seed settling rate, settling height, friction rate, air friction coefficient, zero displacement parameters. Then, the vertical wind speed generated randomly by the Monte Carlo substitute is put into the model. Next, the dispersal distance of the seed in standard climate conditions and future changed climatic conditions, respectively, will be calculated. Finally, the daily dispersal distance on average is calculated, and the difference between the calculated result of the standard climate condition and that of the future changed climatic condition is compared. With all the data above, we can demonstrate how climate change influences the wind dispersal distance of dandelion seeds.

So, based on this method, we could acquire the final result of the model:

Table 7 monthly predicted spreading distance

City/month	1	2	3	6	12
Tropical(Cairo)	0.26	0.51	0.82	1.78	4.01
Temperate zone(Shanghai)	0.24	0.46	0.75	1.57	3.45
Cold Belt (London)	0.21	0.42	0.60	1.32	2.78

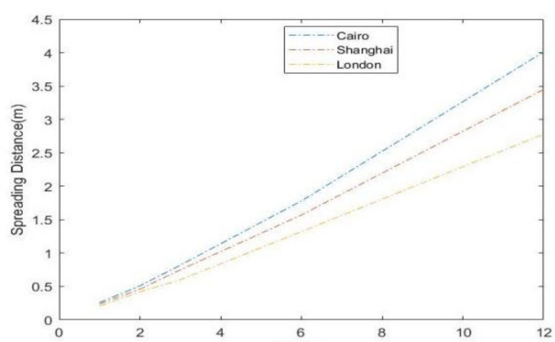

Fig 5.1 Monthly predicted spreading distance

When we bring our relevant data into the model and perform different calculations and iterations on it, we will find that in different cities and different months, the radius of the dandelion spread will be different, proving our conclusion. That is, wind speed, temperature, and climate will have some effect on the dispersal of dandelions, and we have managed to predict how large this effect will be over a year and how many consequences it will have.

6. Model 2

6.1 Model Coding Realization

Appendix B

6.2 Model Calculating Realization

6.2 Model Calculating Realization Using factor analysis and the reading of documents to determine how to assess the damage level of the ecosystem caused by the species. As a result of the long-term evolution of species, species are becoming more and more diverse. At the end of the 20th century, more than 1 million species became extinct worldwide because human activities were detrimental to their survival. United Nations Environment Program predicts that one-fourth of species will face the risk in the first 20-30 years of the 21st century, and more than half of plants and animals will disappear worldwide. After habitat destruction, invasive species are the second most significant factor in decreasing diversity. The species that can successfully usually have innate competitive advantages. As long as they can grow somewhere without any restrictions, they will dramatically generate and develop, or even excrete, materials that can constrain elbow out the local species and become the single dominant community, which will end up losing diversity in the invaded territory. By using an expert system to access the plant, we based on entropy weighting and main components to analyze and figure out whether the dandelions can be defined as invasive species. In addition, we introduce two other plants and score them based on the data and an expert system, which can judge whether they negatively or positively impact the environment.

Table 8 selected symbols for model 2

dandelion	Secondary indicators	Secondary indicators	Secondary indicators
Plant Characteristics	The growth rate of 9	Reproductive capacity of 9	Adaptability 10
Degree of environmental hazards	Native plant impact 3	Overall environmental impact 3	Degree of human benefit6
propagation velocity	Mean monthly transmission rate of 8	Maximum coverage area of 7	
Ecosystem resistance	Ecosystem diversity 9	Ecosystem resilience, 10	

In the following table, the individual indicators of plants are scored (0-10) according to the data, where 0 is the minimum and 10 is the maximum. Dandelion is a perennial herb belonging to the family Asteraceae. Here are some botanical features of dandelion: 1. Morphological feature: roots slightly conical, curved. The length is around 4-10 cm, and the surface is tan and crinkled [1] [4]. Leaves are obovate-lanceolate, oblanceolate, or counterbalance. The length is around 4- 20 cm, 1-5 cm wide, and the petiole and main veins are usually reddish-purple. The petiole and main veins are often reddish purple [7].

2. Habitat environment and habits: dandelions have a strong ability to adapt the growing conditions, and they can develop anywhere, including hillsides, meadows, roadsides, fields, and river banks. The most significant feature dandelions have is their high resistance to adversity[6], which can live in extremely hot and cold, and their seed does not have a dormant period, so they can be sown at any time[6].

3. The medical value: the entire herb of dandelion can be used as medicine. They have the ability to clear heat and detoxify, dispersing knots and diuretics.

4. Reproductive ability: Dandelions have dramatic reproductive ability since they have diverse ways to reproduce, including seed propagation, root grafting, and propagation in greenhouses [1]. Generally, dandelions prefer to reproduce by seed propagation since their seed has no dormant period; mature seeds can be sowed anytime, anywhere [1].

5. Degree of environmental hazard: although the dandelions are not harmful to the environment, they are treated as weeds in the fields and lawns, which will stress the development of other plants in the same areas.

6.3 Extension Model to Alfalfa and American Papyrus

Alfalfa is a perennial herb of the bean family. It is an insect-borne cross-pollinating plant that prefers a warm and semi-arid climate and strongly tolerates cold. The root system of alfalfa goes deep into the soil and has strong drought resistance, but the summer high temperature is detrimental to its growth. It is not resistant to strong acid and strong alkali soil [2].

Table 9 selected symbols for Alfalfa

Alfalfa	Secondary indicators	Secondary indicators	Secondary indicators
Plant Characteristics	The growth rate of 6	Reproduction ability 6	Adaptability 6
Degree of environmental hazards	Native plant impact on 2	Overall environmental impact 2	Degree of human benefit 7
propagation velocity	Average monthly transmission rate of 7	Maximum coverage area of 7	
Ecosystem resistance	Ecosystem diversity 7	Ecosystem resilience 8	

Syracuse: According to the survey results, the growth rate of sedges is generally fast, especially under suitable temperature, humidity, and light conditions. Saldge plants usually have strong growth and reproductive ability, rap-

idly expanding and covering the land.
In general, sedges' growth rate is influenced by various factors, including temperature, light, soil moisture, nutrient supply, etc. Under suitable growth conditions, sedges can grow rapidly and expand their range. As a perennial herb, American sedge plays an important ecological service in the wetland ecosystem. They help with water purification and improve water quality by absorbing nutrients and filtering pollutants from water. In addition, Papyrus provides a habitat and food source for wetland organisms, which is important for protecting the diversity of aquatic animals and plants.

Table 10 selected symbols for American Pupyrus

American papyrus	Secondary indicators	Secondary indicators	Secondary indicators
Plant Characteristics	The growth rate of 5	Reproduction ability 5	Adaptability 6
Degree of environmental hazards	Native plant impact on 2	Overall environmental impact 2	Human fit, benefit 8
propagation velocity	Mean monthly trans-mission rate of 5	Maximum coverage area of 5	
Ecosystem resistance	Ecosystem diversity 7	Ecosystem resilience 7	

We sought to develop a mathematical formula to assess whether a certain plant is an invasive species. The working principle of this formula is to score the secondary indexes of various influence factors of plants first and then take the scores of each index into the formula to calculate the final result. The larger the result, the higher the plant is an invasive species.

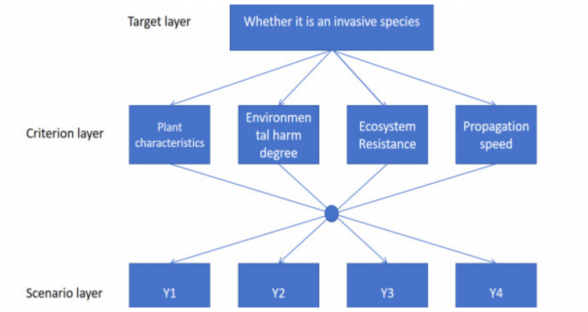

Fig6.1 Model structure explanation

When comparing the importance of the ith element to the j th element relative to a factor in the previous layer, the quantified relative weight a is used to describe it. Let you have a total of n elements.
Participation in the comparison:

$A=\left(a_{ij}\right)(n\times n)$ (6)

The value of a_ir in the pairwise comparison matrix can be assigned by using the Satty proposal according to the following scale: J_A Values are taken between 1 and 9 and are reciprocal.

J_A = 1, element i has the same importance as element j to the previous level factor;

J_A = 3, element i is slightly more important than element j;

J_A = 5, element i is more important than element j;

J_A = 7, element i is much more important than element j;

J_A = 9, element i is more important than element j;

J_A = 2n, n = 1,2,3,4, the importance of elements i and j is between a = 2n + 1 and a = 2n + 1

$$a_{ij}=\frac{1}{n},n=1,2,3\ldots 9 \tag{7}$$

if and only if $a_{ij}=n$

Characteristics of the

$$a_{ij}>0,a_{ij}=\frac{1}{a_{ij}} \tag{8}$$

(Note: When i = j, a = 1) pairwise comparison matrix: Theoretically, if A is A consistent pairwise comparison matrix, there should be:

$$a_{ij}a_{ik}=a_{ij},1\leqslant i,j,k\leqslant n \tag{9}$$

However, it is impossible to satisfy the above many equations when constructing a pairwise comparison matrix. Therefore, the regression requires a certain consistency of the pairwise comparison matrix.
The analysis shows that for the pairwise comparison matrix, the eigenvalue with the largest absolute value is equal to the dimension of the matrix. The consistency requirement of the pairwise comparison matrix is transformed into the requirement that the eigenvalue with the largest absolute value does not differ much from the dimension of the matrix. The steps to test the consistency of the pairwise comparison matrix A are as follows:
The index CI that measures the degree of inconsistency of A pairwise comparison matrix A (n > 1order square):

$$CI = \frac{\lambda_{max}(A) - n}{n-1} \quad (10)$$

We then assigned the indicators of the invasive species environmental impact assessment specification (Technical specifications for assessment of environmental risk of alien invasive species).

Table 11 assigned indicator

	Secondary indicators	Secondary indicators	Secondary indicators
Plant Characteristics	The growth rate was 12%	11%	Adaptability of 9%
Degree of environmental hazards	Native plants were affected by 11%	Overall environmental impact was 11%	Human benefit degree is 5%
propagation velocity	The average monthly transmission rate is 10 %	Maximum overlay, cover area of 8%	
Ecosystem resistance	Ecosystem diversity is 10%	Ecosystem resilience is 13%	

According to the logical relationship and mathematical relationship between the framework of the index system and the index, the following mathematical model for calculating the comprehensive value of risk is established:

$$\sum_{n=1}^{10}(x \times R_i) \times \frac{1}{10} \quad (11)$$

X = weight%, and R_i =the score of each indicator

This formula calculates the probability of three plants as invasive species: Dandelion: P = 0.503; Alfalfa: P = 0.674; American sedge: P = 0.643.

The above formula adopts the method of empowerment and average, which effectively summarizes the indicators of all influence factors. Each index is based on whether the plant is an invasive species and refers to much scientific and expert literature to get as convincing weight as possible. This facilitates the scientific and effective assessment of species invasiveness. Due to the complexity of the evaluation, all indicator systems involve alien species in different categories, so multiple parameters are provided. The disadvantage of the formula is that it is not considered in special circumstances, such as extreme weather conditions or natural disasters.

7. Sensitivity Analysis

In the above table, we can find that the secondary indexes for judging plants are all measured under certain conditions; that is, the certainty is greater. However, some secondary indexes of plants will change with some uncontrollable factors, resulting in deviations in the final value. The plant‘s growth environment largely determines its growth characteristics, which will change the parameters in the above table. After investigation, we summarized some parameters that are more affected by environment and region: „growth rate," „reproductive capacity," and „average monthly spread speed."

Consider dandelion: 1. Growth rate 9 2. Reproductive capacity 9 3. Monthly average transmission speed 8.

We selected five numbers for each parameter to study to prove the model‘s reliability.

1. Growth capacity: 7,8,9,10,11 2. Reproductive capacity: 7,8,9,10,11 3. Monthly average transmission speed: 6,7,8,9,10.

You can get it by plugging it into the formula P (dandelion) min = 0.477; P max = 0.548 P (alfalfa) min = 0.615; P max = 0.703 P (American sedge) min = 0.601; P max = 0.666.

This experiment analyzed the probability of plants being considered invasive in different environments. Still, there may be other relationships, such as elevation or the effect of human activities on the same plant characteristics.

8. Model Evaluation

Strengthens: The advantage of our model is that it creatively uses the mathematical formula of wind travel distance to solve and predict the spread of dandelion under different conditions and at different times. On the other hand, we have adopted global climate models for different climate changes to express our predictions for different variables in a general way, and this prediction method has achieved good results. Finally, in our assessment of how to solve the dandelion problem, our factor selection was scientific because we read a lot of literature. And in the expert score, we got a reasonable score.

Weaknesses: First, we only consider a limited number of factors when considering seed spread and do not consider all the conditions in the real case, so the prediction we get is only in an ideal range. Secondly, the range of factors selected by our factor analysis model is still insufficient. However, limited by what we could find, we did what we could, making our model relatively reliable and convincing.

9. Conclusion

This paper successfully predicted how far dandelion could travel in different months through the dandelion propagation model. Secondly, we find that under different environmental conditions. For example, precipitation, temperature, wind speed, and atmospheric carbon concentration can affect the model's values. Secondly, in our factor analysis and empowerment model, to determine whether dandelions and other plants are invasive species and whether they are beneficial or harmful to humans, our factor analysis model successfully separates different species. And the answers are reasonable and reliable. In our model, we judge by establishing primary and secondary indicators, respectively. As a decision-maker, I know this species is not an invasive species. We judged dandelion, alfalfa, and American sedge and found that dandelion benefits man. At the same time, due to their greater environmental harm, the other two plants did not play a positive role in human society, in the same situation as the facts. Our model successfully classified them as invasive species. This also proves the reliability of our model from another aspect. In addition, our model refers to a large amount of scientific literature and expert literature. These factors together promote the research of our paper. The two plants we have chosen are particularly harmful to the abovementioned areas.

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