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Population Prediction and Evaluation of Impact Factors of Dandelions

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Abstract:

Seeds are the fundamental source of dandelion life on earth, and their germination process is the first step towards plant growth. The seed germination process involves activating a complex series of biochemical reactions that transform the dandelion seed into an active and viable organism. The germination process is crucial for producing plants and flowers, and dandelions require specific environmental conditions for successful growth. In this article, we will explore the growing process of dandelion seeds, the spread of dandelions during their growth, and the impact factors for invasive species, including dandelions.

In Problem 1, we answer the question from two perspectives. We first predict the population size of dandelions. We predicted the population of dandelions over the course of one, two, three, six, and twelve months in certain various climatic conditions. We first outlined the life cycle of dandelions in five stages: seed, germination, plant, flower, and seed dispersal. We defined three variables related to the dandelion life cycle as Seed (S), Germination (G), and Flowering (F); with two more additional variables, Resources (R) and Temperature (T) in a given environment, we constructed Dandelion Demography Model using the Ordinary Differential Equations (ODEs). The results showed that the number of dandelion populations gradually increased in summer, and with the advent of autumn and winter, the temperature decreased, and the number of dandelions gradually decreased to 0. After that, we set the average temperature for the whole year higher and carried out the sensitivity analysis of the model. The results showed that dandelion populations could increase more in one year and even in autumn and winter as the temperature increased. We then used Gaussian equations in conjunction with the wind to predict the extent of dandelion coverage. The results show that in the absence of wind, the population will spread outward uniformly. Under windy conditions, the population will concentrate more in the direction of the wind, but the population density decreases as the distance from the mother plant increases.

In Problem 2, we continued to study three plant species, including dandelions. We applied the hybrid entropy weight method EWM-TOPSIS model to develop an index-based measurement to determine impact factors for three invasive species: Taraxacum officinale, Amaranthus palmeri, and Alternanthera philoxeroides. EWM is used to calculate the weight of each index and reduce the disadvantages of TOPSIS, which adopts equal weights. The results showed that the influence factors of the three plants were 0.51, 0.69, and 0.71, respectively. After that, we verified the reasonableness of the model by querying the distribution of the plants worldwide.

Keywords: Impact Factors of Dandelions, Differential Equation Model (DEM), EWM, TOPSIS

1 Overview

1.1 Background

Dandelion, scientifically called Taraxacum officinale, is a widespread plant with intricate plant features and a complex relationship with humans. Indigenous to Eurasia and North America, the dandelion is renowned for its composite, luminous yellow blossoms and iconic “puffball” seed head [1].

The dandelion’s life cycle consists of five stages: germination, plant, flower, and seed head. An interesting fact about dandelions is that they reproduce asexually. This means that a dandelion is capable of producing seeds without cross-pollination or any other kinds of pollination. This allows dandelions to reproduce at a relatively rapid rate [2].

Dandelions often encounter classification as invasive species in domestic lawns and cultivated gardens. Because of their fast reproduction rate and adaptive ability to various environmental conditions, they are sometimes characterized as a hindrance for gardeners [3]. Nonetheless, dandelions play an important role as early-season nectar sources for pollinators and in enhancing soil quality [5]. Dandelions have culinary and medicinal uses and applications [5][6]. The plant is a rich source of vitamins A and C and calcium, fiber, manganese, iron, potassium, and protein [5][6].

Presently, dandelions remain the subjects of both acclaim and disdain, fostering discussions and debates within horticulture and ecology.

1.2 Restatement of the Problem

• We are asked to construct a model to predict the spread of dandelions throughout 1, 2, 3, 6, and 12 months with a single dandelion in its "puffball" stage that is adjacent to an open one-hectare plot of land set initially. Because dandelions go through five growing stages — germination, plant, flower, and "puffball" seed head — we should consider each stage's time to determine the rate at which a dandelion produces new seeds. In addition, we should incorporate the effects of various climatic conditions, such as temperate, arid, and tropical climates, on the growth of dandelion. We should also consider the number of seeds that have landed in the one-hectare plot of land from the initially set dandelion so that there is a starting point for future projections.

• We should also formulate a mathematical model to determine an 'impact factor' for invasive species. Our model should integrate multiple variables, including the plant's characteristics, such as its growth rate and reproductive rate, and the nature and extent of the harm it inflicts on its environment, for example, the effects of the plant on air, water, or soil quality. We should test our model by using it to compute an impact factor for dandelions. We should also apply our model to two other plant species considered invasive and identify the region for each to be considered invasive.

1.3 Our Work

In Problem 1, we answer the question from two perspectives. We first predict the population size of dandelions. We predicted the population of dandelions over the course of one, two, three, six, and twelve months in certain various climatic conditions. We first outlined the life cycle of dandelions in five stages: seed, germination, plant, flower, and seed dispersal. We defined three variables related to the dandelion life cycle as Seed (S), Germination (G), and Flowering (F); with two more additional variables, Resources (R) and Temperature (T) in a given environment, we constructed Dandelion Demography Model using the Ordinary Differential Equations (ODEs). We then used Gaussian equations in conjunction with the wind to predict the extent of dandelion coverage.

In Problem 2, we must use a model to comprehensively evaluate whether the selected species are invasive. Here, we will combine the entropy method with TOPSIS for processing. We select the introduction ability, colonization ability, economic harm, and ecological harm as indicators. The first step is to standardize the original data, then calculate the weight of each indicator using the entropy method, and multiply the weight and standardized data together as the original data for TOPSIS. After that, TOPSIS is used to calculate the closeness of each evaluation object to the optimal scheme, Ci (i.e., the comprehensive evaluation index of each sample). Finally, it will be sorted according to Ci and analyzed with the comprehensive evaluation index.

2 Assumptions and Justifications.

Assumption: We assumed the average 180 seed numbers are found on a single dandelion in its "puffball" stage.

Justification: The flowers bloom about eight to 15 weeks after germination at the end of the seedling stage. Individual plants bloom continuously while active but most profusely in May and June. A single flower produces up to 400 seeds but averages 180. Seeds ripen from nine to 12 days after the flowers bloom.

Assumption: The open one-hectare plot of land has a square shape with a side of a hundred meters.

Justification: Since we did not have any information about the shape of the open one-hectare plot,
we assumed that it is close to a typical square region.

Assumption: We assumed there were no natural enemies for the dandelion population during the life cycle. Dandelions only die out of natural causes or infections.

Justification: We considered that dandelions grow in an open environment, and factors of predators and natural disasters are ignored for simplification.

Assumption: We combined both stages of plants and flowers as one separate stage of flowering in the dandelion life cycle for our modeling.

Justification: Stock plants are found in both stages, no matter what stage it is (in the stage or plants or flowers). We considered the number of stock plants and the average number of flowers on each stock plant when we needed to calculate the number of dandelions in the flowering stage.

3 Notation

Symbol	Meaning
T	The growing temperature
S	The number of the seeds
G	The number of germination

F	The number of the flowering
K	Resources available in a given environment
κ	Maximum resources available in a given environment
T_0	The initial temperature
T_{mid}	The middle temperature of the climatic region
T_K	The temperature at a given resource K
ϕ_S	The conversion rate of seeds to germination
ϕ_G	The conversion rate of germination to flowers
r	The growth rate of dandelions during flowering
τ	Time-lag
L_F	The number of stock plants of dandelions
γ_S	The consumption of resources by seeds
γ_G	The consumption of resources by germination
γ_F	The consumption of resources by flowering
γ_K	The average consumption of the above three ones

4 Analysis of The Spread of Dandelions

4.1 Problem Analysis

In Problem 1, the question asked us to predict the spread of dandelion populations. We explored the spread of dandelion boats from two separate perspectives. Firstly, we investigated the population by modeling differential equations with climatic factors (temperature variation, humidity throughout the year) and with consideration of the environmental carrying capacity, after which we considered the range change in the absence of wind separately. Considering that different regions of the globe are windy in various seasons, the range change in windy conditions is further discussed.

4.2 Determination of Variables Based on Dandelion Life Cycle

The dandelion life cycle starts as their seeds are on the ground. The seeds germinate and begin to grow (stage 1). Seedings emerge from the seeds and grow into mature plants (stage 2). The mature plants will develop flowers on them (stage 3). At the same time, flowers produce more seeds (stage 4). Those seeds are scattered by wind (stage 5). Then, the life cycle begins again.

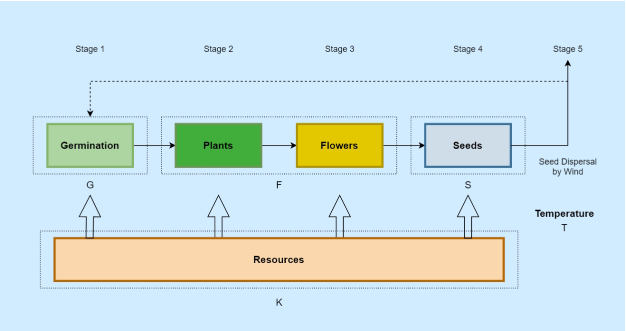


Figure 1. Dandelion Demography is represented in the model.

The five different stages represent the life cycle of dandelions. Temperature (T) and four classes (such as G/ F/ S/ K) appearing in a box with a dashed border are functions of time (t). Their rates of change would be modeled to predict the spread of dandelions over time.

Factors such as resource availability, environmental temperature, and dandelion population can alter the development cycle, as shown in Figure 1.

4.3 Dandelion Demography Model (DDM)

We start to have a mathematical model for the dandelion population dynamics, which are the changes in size and composition of dandelion populations, time, resource availability, and climatic temperatures, by using ordinary differential equations (ODEs).

We constructed a demographic model for dandelion, which includes three parts from the life cycle: seed, Germination, and Flowering.

We constructed a model for the population of dandelions, which included seeds, germination, plants, and flowers. Those were divided into three classes: Seeding S(t), Germination G(t), and Flowering F(t). All of them are functions of time (t).

Let S be the number of seeds. Let f be a measure of resources stored in the open one-hectare plot of land and available for the dandelions to use. We do not distinguish between plants and flowers during flowering in the life cycle of dandelions here. We aimWe aim to keep the model simple so we can perform comprehensive analyses of model demography transparently. We assume the number of flowers is dependent on the number of stock plants of dandelions $\left(L_F\right)$.

Let t be the time in days. Then, we can represent the model illustrated in Figure 1 as FIVE differential equations.

Rate of change of seed numbers:

$$\frac{dS}{dt} = L_F \cdot F \cdot f\left(K,T\right) - \phi_S \cdot S$$

The first term represents the initial total number of seeds L_F, which is the stock plant of dandelions and

$f(K,T)$ is a function of resource availability and temperature. In other words, $f(K,T)$ it measures the amount of resources available for the dandelion population to use in a given environment, and it depends on the temperature in a given environment. Explicitly, we can model $f(K,T)$ it as

$$f(K,T)=\frac{K^2}{K^2+b^2}\left(1-\alpha_a(T-T_0)^2\right)$$

where b α_a and are constant parameters and T_0 is the initial temperature in a given environment. The second term $\phi_S \cdot S$ gives the number of seeds at the time (t), where ϕ_S is the conversion rate of seeds to germination.
Now, the equation (XX) can be written as

$$\frac{dS}{dt}=L_F \cdot F \cdot \left[\frac{K^2}{K^2+b^2}\left(1-\alpha_a(T-T_0)^2\right)\right]-\phi_S \cdot S$$

Rate of change of germination numbers:

$$\frac{dG}{dt}=\phi_S S(t-\tau)-\phi_G G(t)$$

$$\frac{dG}{dt}=\phi_S S_{t-\tau}-\phi_G G$$

where $\phi_S S(t-\tau)$ is the conversion rate of seeds to germination at this time $(t-\tau)$? The term $\phi_G G(t)$ gives the number of flowers at the time (t), where ϕ_G is the conversion rate of germination to flowers.

Rate of change of flowering numbers:

$$\frac{dF}{dt}=\phi_G G(t-\tau)-\frac{dF_K}{dt}$$

$$\frac{dF}{dt}=\phi_G G_{t-\tau}-\frac{dF_K}{dt}$$

Where ϕ_G is the conversion rate of germination to flowers at a time $(t-\tau)$?

We let K represent the resource available for dandelions to use in the given environment, and we let r be a real number representing dandelions' growth rate during flowering. $K(t)$ Represents the availability of resources during flowering, and it is a function of time (t).

Then, by a logistic differential equation, the dandelion growth rate during flowering in the presence of available resources as

$$\frac{dF_K}{dt}=r \cdot F(t) \cdot \left(1-\frac{K(t)}{\kappa}\right)$$

where κ the maximum resources are available in a given environment.

We would rewrite equation (XX) as

$$\frac{dF}{dt}=\phi_G G(t-\tau)-r \cdot F(t) \cdot \left(1-\frac{K(t)}{\kappa}\right)$$

$$\frac{dF}{dt}=\phi_G G(t-\tau)+r \cdot F(t) \cdot \left(\frac{K(t)}{\kappa}-1\right)$$

$$\frac{dF}{dt}=\phi_G G_{t-\tau}+rF\left(\frac{K}{\kappa}-1\right)$$

Rate of change of temperature:

Suppose we charted the average daily temperatures in the given environment over a year. We would expect to find the lowest and highest temperatures. The familiar cycle repeats year after year, and if we were to extend the graph over multiple years, it would resemble a periodic function. Now, the temperature function $T(t)$ can be modeled by a sinusoidal function.

$$T(t)=A_{trig}\sin\left(B_{trig}t\right)+C_{trig}$$

Where $amplitude=\left|A_{trig}\right|$ B_{trig} is it related to a period such that the period $=\frac{2\pi}{B_{trig}}$ C_{trig} represents the vertical shift?

Now, we modeled the temperature function $T(t)$ as follows:

$$T(t)=A\sin(\omega t)+C$$

$$\frac{dT}{dt}=A\omega\cos(\omega t)$$

We set both parameters: $A=20$ $\omega=\frac{2\pi}{365}$ for equation (XX)

$$T(t)=20\sin\left(\frac{2\pi t}{365}\right)+C$$

It begins with the average value of the temperature $(A=20)$ for the above function. Then, the rate of change of temperature concerning time (t) is given by

$$\frac{dT}{dt}=\frac{40\pi}{365}\cos\left(\frac{2\pi t}{365}\right)$$

Rate of change of resource carrying capacity:

$$\frac{dK}{dt}=K_0 T_K-\gamma_S S-\gamma_G G-\gamma_F F$$

For the equation (XX), the first term represents the initial resource available in a given environment. It consists of K_0 a constant parameter with a particular value for a climatic condition (such as temperate, arid, and tropical climates). The second part T_K is a function of temperature. In this case, we modeled T_K with a quadratic function at a range of its function values between 0 and 1.

$$T_K = 1 - \alpha_K \left(T_{mid} - T\right)^2$$

Where α_K is a constant parameter and T_{mid} is the middle temperature of the climatic region.

The consumption of resources by seeds, flowers, and germination is given by $\gamma_S\ \gamma_G\ \gamma_F$, respectively. We would assume that these three parameters are the same for simplicity. We took an average of these three parameters and then the new consumption γ_K so that equation (XX) can be written as

$$\frac{dK}{dt} = K_0 T_K - \gamma_K \left(S + G + F\right)$$

By using a function (XX), the rate of change of resources available was finalized as

$$\frac{dK}{dt} = K_0\left[1 - \alpha_K \left(T_{mid} - T\right)^2\right] - \gamma_K \left(S + G + F\right)$$

So far, we have obtained the model determined by the following set of equations and parameters.

$$\begin{cases} \dfrac{dT}{dt} = A\omega \cos\left(\omega t\right) \\ \dfrac{dS}{dt} = L_F \cdot F \cdot f\left(K, T\right) - \phi \cdot S \\ \dfrac{dG}{dt} = \phi_1 S_{t-\tau} - \phi_2 G \\ \dfrac{dF}{dt} = \phi_3 G_{t-\tau} + rF\left(\dfrac{K}{\kappa} - 1\right) \\ \dfrac{dK}{dt} = K_0 T_K - \gamma_K \left(S + G + F\right) \end{cases}$$

After that, we need to analyze and determine the parameters used in the model.

4.4 Model Results

4.4.1 Predicted Results of Population Size

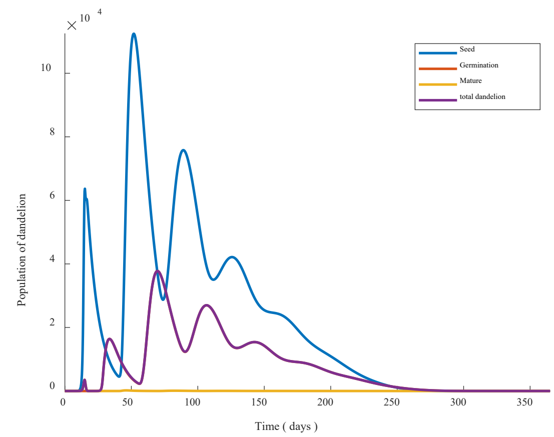
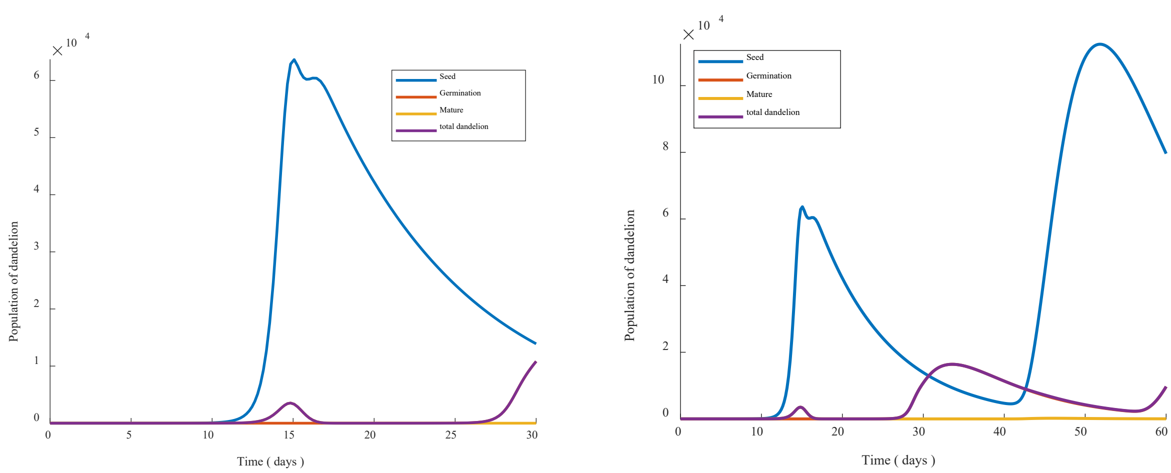


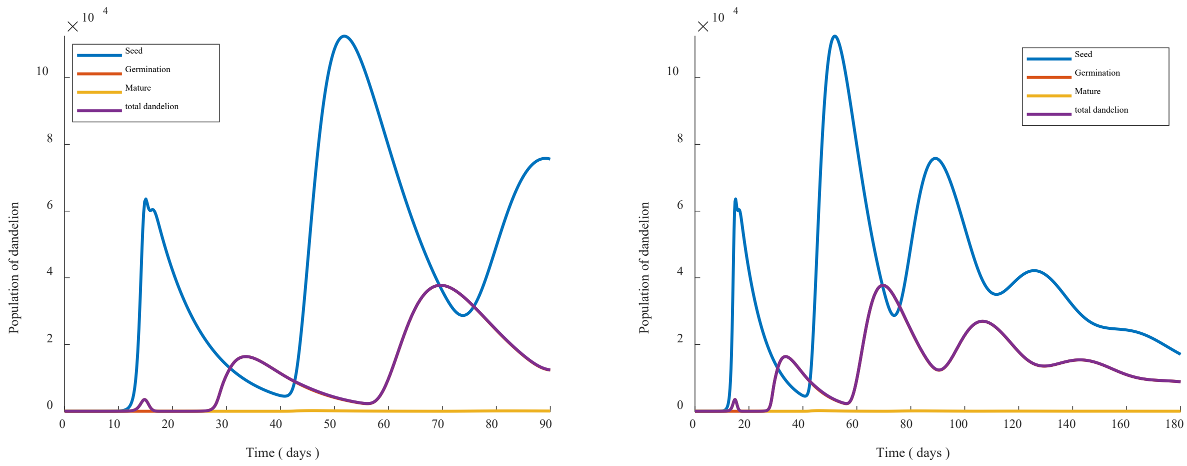
Figure 2. Predicted changes in dandelion populations

As shown in Figure 2, dandelions are low in number in the spring, and their numbers fluctuate as the summer progresses. Their growth reaches suitable temperatures, then gradually decreases as winter approaches and the temperatures become more and more unsuitable.

The predicted results of the dandelion population at months 1, 2, 3, and 6 are shown in Figure 3.



(a) (b)



(c) (d)

Figure 3. Predicted results of dandelion population. (a) 1 month; (b) 2 months; (3) 3 months; (4) 6 months.

4.4.2 Predictions of Dandelion Coverage When There Is No Wind

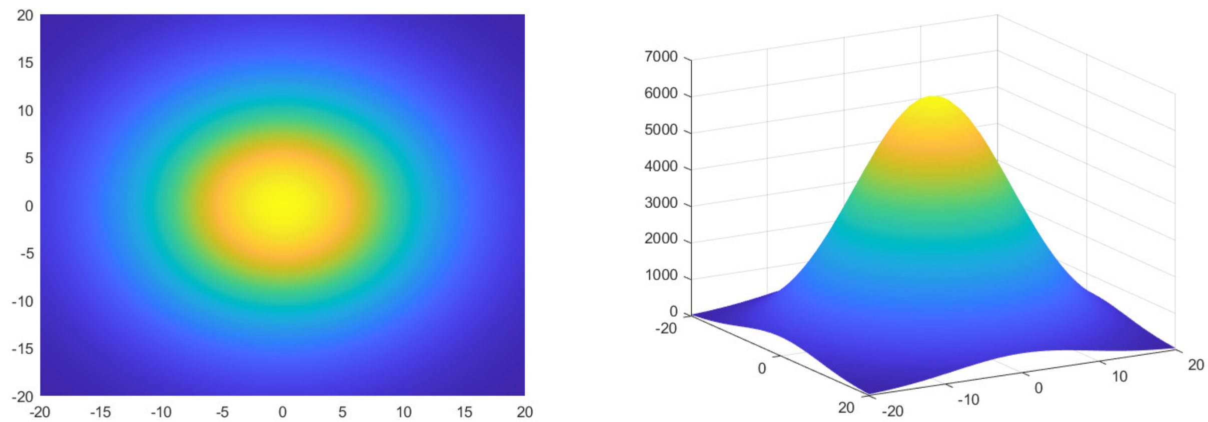
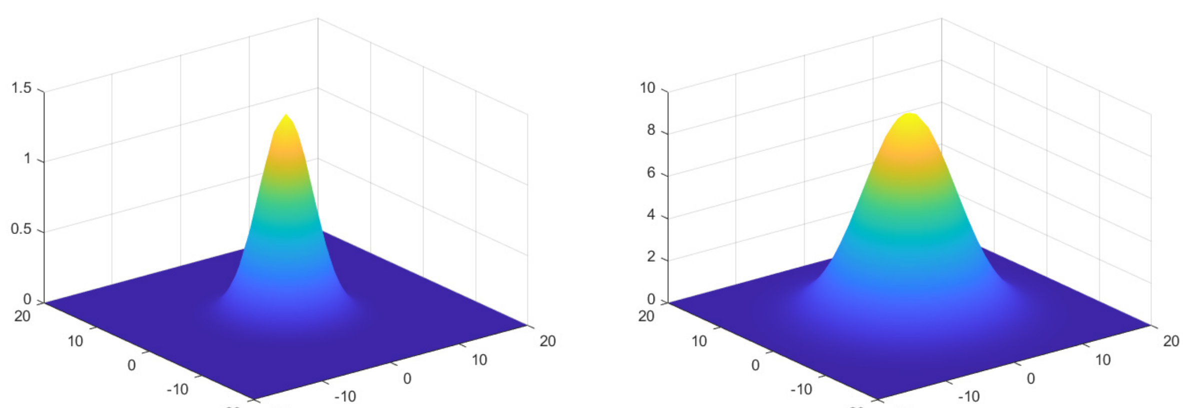
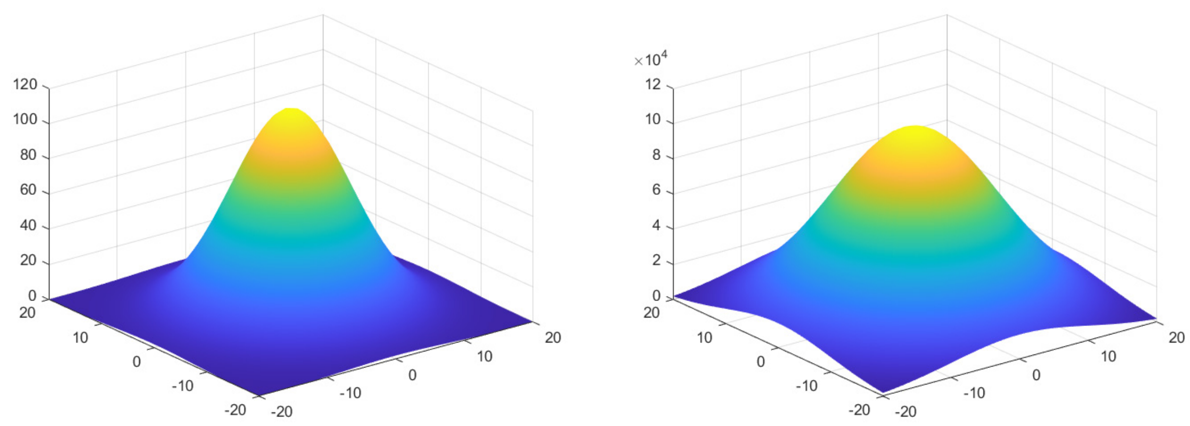


Figure4. Dandelion coverage when there is no wind

In the absence of wind, the diffusion of dandelions satisfies a normal distribution, and the results are shown in Figure 3.



(a) (b)



(c) (d)

Figure 5. Predicted results of dandelion coverage. (a) 1 month; (b) 2 months; (3) 3 months; (4) 6 months.

The predicted results of dandelion coverage at months 1, 2, 3, and 6 are shown in Figure 5.

4.4.3 Predictions of Dandelion Coverage in Windy Conditions

The probability density function of seed dispersal with wind in the windy condition is shown in Figure 6. The slower the wind speed, the more concentrated the seeds are.

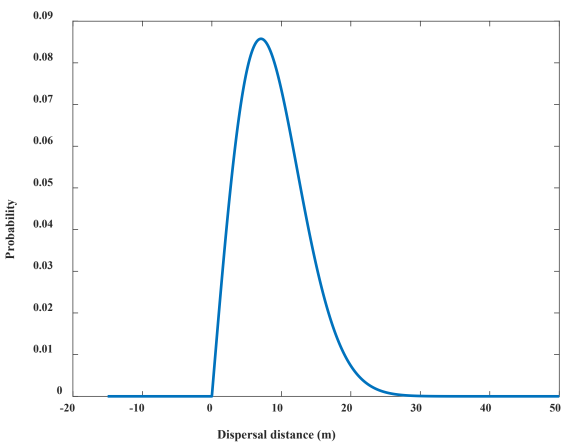


Figure 6 Probability density of seeds dispersing in the wind

Therefore, in windy conditions, the seeds will remain mostly concentrated at the parent plant's attachment, decreasing seed density as the distance from the parent plant increases. And will be mainly distributed in the direction of the wind blowing. The results are shown in Figure 7.

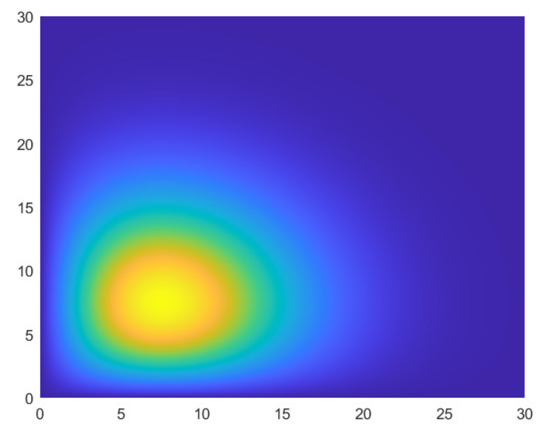


Figure 7. Dandelion Coverage in Windy Conditions

4.5 Sensitivity Analysis

When the temperature changes, i.e., when dandelions are in different climatic zones, their growth and development are significantly affected. Therefore, we performed sensitivity analyses on the average temperature throughout the year, and the results are shown in Figure 8.

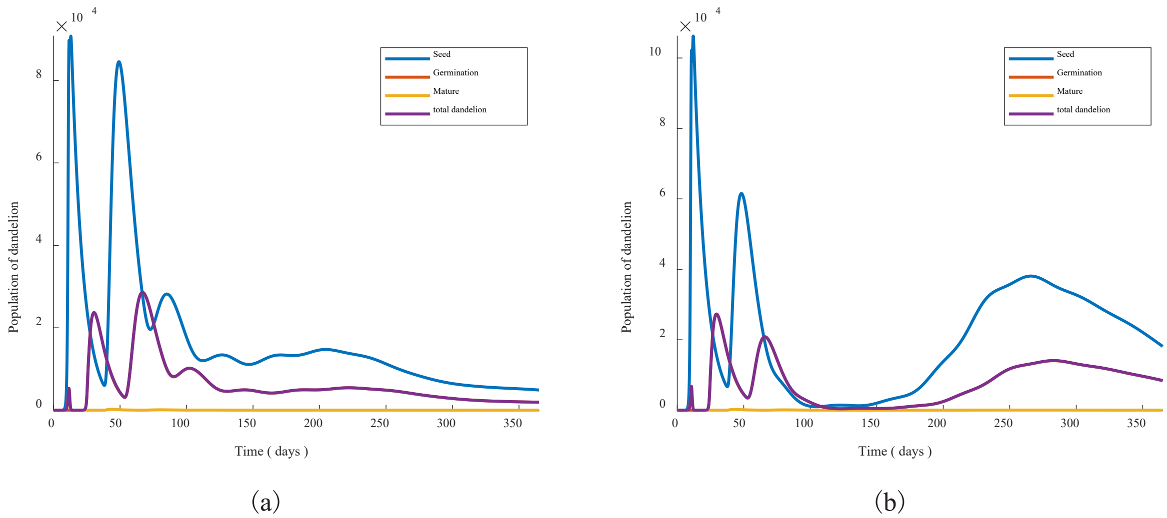


Figure 8. Changes in dandelion populations at different temperatures. (a)20 degree centigrade; (b)25 degree centigrade;

5 Impact Factor of Invasive Species Based on EWM-TOPSIS

TOPSIS is a solution evaluation and analysis method for the existence of the dataset of impact factors, that is, to determine the advantages and disadvantages of each solution in the data based on the existence of data. The central idea is to first determine the optimal ideal value (positive ideal value) and the worst ideal value (negative ideal solution) of each indicator and then find out the weighted Euclidean distance between each program and the positive ideal value and negative ideal value, thus the closeness of each solution to the optimal solution is obtained as the criterion for evaluating the superiority and inferiority of the solutions。

5.1 Problem Analysis

In Problem 2, we are asked to calculate the impact factor of an invasive species. The impact of a species on a local area is not just about how fast it spreads but is related to several factors. We have selected some of the most important factors, such as introduction difficulty, colonization capacity, etc. We selected several indicators to establish a comprehensive evaluation index system, then standardized. We forwarded the data to obtain the evaluation matrix, weighted the matrix using the entropy weighting method, and finally calculated the impact factor of the invasive species using TOPSIS according to the weighted evaluation matrix.

5.2 Indicator System for Evaluating Impact Factors of Invasive Species

Invasive species are species that do not belong to the species composition of a geographic habitat, which are introduced due to human activities and can form self-sustaining communities in new habitats. We established the following evaluation index system to evaluate invasive species' local ecological impacts.

Introduction Difficulty

Inheritance difficulty is used to measure the difficulty of preventing and controlling the invasion of a species before it invades, mainly including the degree of domestic attention, quarantine difficulty, and foreign distribution. The lower the degree of domestic attention, the easier for the species to invade. The higher the quarantine difficulty, the more likely the species will invade, and the wider the foreign distribution, the more likely the species will invade.

Colonization capacity

The colonization ability is used to measure the speed of expansion of the invasive range of a species, which mainly includes reproductive ability, adaptive ability, and suitable area. The greater the reproductive and adaptive capacity, the more serious the invasion is likely to be.

Economic Hazard

Economic hazard is used to measure the degree of economic loss caused to the local community after the invasion of a species, which mainly includes the types of crops affected, the planting area of the affected crops, and the economic value of the affected crops. The greater the economic hazard, the greater the local damage caused by the invasion.

Ecological Hazard

Ecological hazard is a measure of the impact of an invasive species on the local ecological structure, including the difficulty of control and the spread of other harmful organisms.

The complete invasive species evaluation indicator system is shown in Figure.

5.3 The EWM-TOPSIS Model

We would use TOPSIS, one of the most popular multi-criteria decision-making methods (MCDM). Its fundamental role is the establishment of chosen alternatives ranking based on their distance from the ideal and negative-ideal solution. Strictly speaking, we would use the fuzzy version of the TOPSIS method, which is used for decision problems in the conditions of interval data of a fuzzy character. In practice, there are frequently situations where the set of criteria is ambiguous and covers various criteria groups where the ratings have a character of real numbers and interval and fuzzy data.

We covered the analysis of the use of the TOPSIS method by following decisive steps:
step 1 – creation of a decision matrix
step 2 – creation of a normalized decision matrix
step 3 – creation of a weight, normalized decision matrix
step 4 – an indication of the ideal and negative-ideal solution
step 5 – calculation of the distance of each alternative for the ideal and negative-ideal solution
step 6 – calculation of the similarity indicators of particular alternatives for the ideal solution
Step 7 – Create the final alternatives ranking in the decreasing order of the similarity value indicator.
The specific calculations are as follows:

Entropy Weight Method (EWM)

In the Entropy Weight Method (EWM), m indicators and n samples are set in the evaluation, and the measured value of the i th indicator in the j th sample is recorded as x_{ij} The first step is standardizing measured values [16, 17]. The standardized value of the i th index in the j th sample is denoted as p_{ij}, and its calculation method is as follows:

$$p_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} \tag{22}$$

In the EWM, the entropy value Ei of the i th index is defined as [18]

$$E_i = \frac{\sum_{j=1}^{n} p_{ij} \cdot \ln p_{ij}}{\ln n} \tag{23}$$

The evaluation using the EWM is generally set when $p_{ij} = 0$ for the convenience of calculation.

$$\omega_i = \frac{1 - E_i}{\sum_{i=1}^{m} \left(1 - E_i\right)} \tag{24}$$

The range of entropy value Ei is [0, 1]. The larger the Ei is, the greater the differentiation degree of index i is, and more information can be derived. Hence, a higher weight should be given to the index. Therefore, in the EWM, the calculation method of weight is [1, 19]

TOPICS

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution). It is based on the normalization after the original data matrix, finding the optimal solution and the worst in this limited solution scheme (with the optimal vector and the worst vectors, resp.), and then calculating the distance between the evaluation object and the optimal plan and the distance between the evaluation object and the worst plan, as well as obtaining relative proximity of each evaluation object and the optimal scheme, as the basis of the evaluation of advantages and disadvantages.

Specific steps are as follows:

Step 1. There are □ evaluation objects and □ evaluation indexes, and the original data can be written as a matrix □ = $(□_{□□})_{□\times□}$.

$$\omega_i = \frac{1 - E_i}{\sum_{i=1}^{m} \left(1 - E_i\right)} \tag{25}$$

Step 2. Maximum index uniform transformation and minimum index normalization transformation are as follows:
Maximum:

$$Z_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^{2}}} \tag{26}$$

Minimum:

$$Z_{ij} = \frac{\frac{1}{X_{ij}}}{\sqrt{\sum_{i=1}^{n} \left(\frac{1}{X_{ij}^{2}} \right)}} \tag{27}$$

Step 3 (normalized matrix □ = $(□_{□□})_{□\times□}$). The maximum and minimum values of each column constitute the best and the worst vector, expression with $□^{+} = (□_{\max,1}, □_{\max,2}, \ldots, □_{\max,□})$ and $□^{-} = (□_{\min,1}, □_{\min,2}, \ldots, □_{\min,□})$, respectively.

Step 4. The distances between the ith evaluation object and the optimum and the worst scheme are as follows:

$$D_i^{+} = \sqrt{\sum_{1}^{m} \left(Z_{\max j} - Z_{ij} \right)^2}$$

$$D_i^{-} = \sqrt{\sum_{1}^{m} \left(Z_{\min j} - Z_{ij} \right)^2}$$

Step 5. The proximity between the ith evaluation object and the optimal scheme can be represented as C_i.

$$C_i = D_i^{-} \cdot \left(\frac{1}{D_i^{-} + D_i^{+}} \right)$$

5.4 Model Results

We selected three plants, Taraxacum officinale, Amaranthus palmeri, and Alternanthera philoxeroides, and conducted research in the United States. The results are shown in the figure.

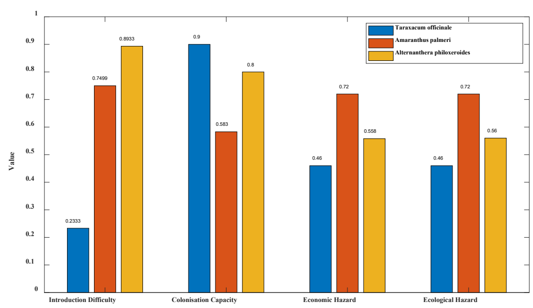


Figure 9. Evaluation of invasive species impact factors

The total impact factors are shown in the table.

Table1.Evaluation of invasive species impact factors

	Taraxacum officinale	Amaranthus palmeri	Alternanthera philoxeroides
Introduction Difficulty	0.23	0.75	0.89
Colonization Capacity	0.9	0.583	0.8
Economic Hazard	0.46	0.72	0.56
Ecological Hazard	0.46	0.72	0.56
Impact Factor	0.51	0.69	0.71

To verify the rationality of the model, we queried the population distribution of Taraxacum officinale and Alternanthera philoxeroides, as shown in the figure. The model calculation results showed that the Colonisation Capacity of Taraxacum officinale was higher than that of Alternanthera philoxeroides, which was also true in the actual distribution. However, Taraxacum officinale had a lower hazard than Alternanthera philoxeroide, resulting in a lower impact factor.

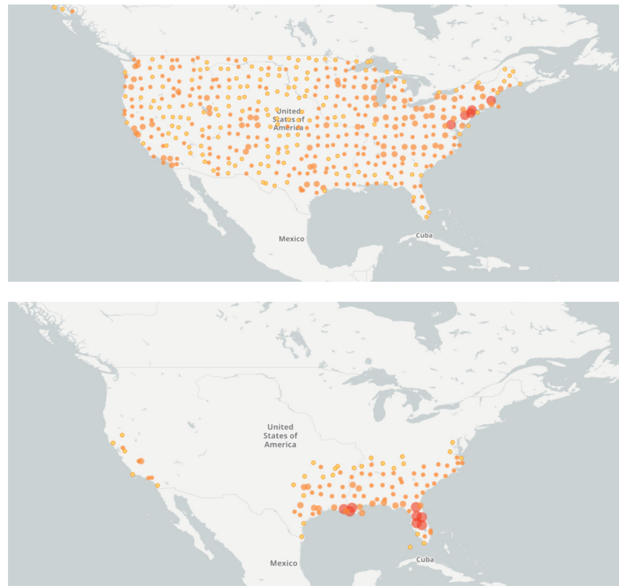


Figure 10.Population distribution of Taraxacum officinale and Alternanthera philoxeroides

6 Strengths and Weaknesses

6.1 Strengths

a) The entropy method can simultaneously consider the impact of multiple attribute factors on the decision-making outcome, providing a more comprehensive and objective evaluation of the decision.

b) Avoiding the subjectivity of data, not requiring objective functions, not needing to pass inspection, and being able to effectively characterize the comprehensive impact of multiple influencing indicators

c) There are no strict restrictions on data distribution, sample size, and number of indicators, making it suitable for both small sample data and large systems with multiple evaluation units and indicators, making it flexible and convenient.

6.2 Weaknesses

a) The analysis results of the entropy method are affected by the number of attributes. If the number of attributes is too large, the calculation will increase, which may cause information redundancy.

b) TOPSIS is uncertain how many indicators should be selected to accurately depict the influence of the indicators.

References

[1] Kershaw Linda, Cotterill Pastsy, and Wilkinson Sarah. Alerta Native Pant Council.

[2] Pinehouse Drive Saskatoon. https://www.rmcormanpark.ca/DocumentCenter/

View/3402/Dandelion
[3] ISU Extension and Outreach. 2150 Beardshear Hall Ames, IA 50011-2031(800)262-3804.
[4]Antia Sanchez. Maine Organic Farmers And Gardeners. 2007.
[5] Alvaro Dock. British local food. https://britishlocalfood.com/dandelion/.
[6] The Guardian. Let dandelions grow. Bees, beetles, and birds need them. 2015

Appendix

Appendix 1

```
clc;clear;close all
lags=[14 7];
K0=500;
T0=25;
N0=3000;
Phi=1/9;
b=15000;
a_min=0.25;
a_max=0.25;
sita=0.75;
ya=1/(35^2);
yc=0.1;
L=140;
K=3000;
f=@(t,x,Z)[
50*pi/365*cos(2*pi*t/365);
L*x(4)*(x(5)^2/(x(5)^2+b^2)*(1-ya*(x(1)-
T0)^2))-Phi*x(2);
Phi*Z(2,1)-0.3*x(3);
0.3*Z(3,1)+x(4)*(x(5)/K-1);
K0*(1-ya*(35-x(1)^2))-yc*(x(2)+x(3)+x(4));
];

tx=dde23(f,lags,[15 0 0 1 K0],[0,365]);
figure
hold on
plot(tx.x,tx.y(2,:),'Linewidth',2)
plot(tx.x,tx.y(3,:),'Linewidth',2)
plot(tx.x,tx.y(4,:),'Linewidth',2)
plot(tx.x,tx.y(3,:)+tx.y(4,:),'Linewidth',2)
legend('Seed,' 'Germination,' 'Mature,' 'total
dandelion,' "FontSize," 10)
label('Time ( days ),' "FontSize," 15)
ylabel('Population of dandelion,' "FontSize,"
15)
```