Dynamic assessment of forest assets based on ecosystem system

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Abstract. Forests are crucial to mitigation efforts, especially for carbon sequestration, as climate change poses a growing global threat. Based on the Forestry for Carbon Sequestration problem, this paper established a model to estimate Carbon Sequestration. And about forest management plan, a series of value indicators are established. Finally, amount of carbon dioxide can be sequestered by forests and their products over time and the results of the forest man-agement plan model are given.

Keywords: Carbon Sequestration, Forest assets, Forest Management, Decision Model.

1. Introduction

In the context of global climate change, forest carbon sequestration has become an important issue and problem for today's society and government. This article will develop a carbon sequestration model for forests and their products and define a forest management plan. Analyze various ways of forest value, consider carbon sequestration and social needs, determine decision-making models, and indicate the scope of management plans.

In terms of problem 1, We established a carbon sequestration model based on three basic data of trees: height, diameter and weights. First, the weight is classified and discussed, and then different formulas are applied. In addition, we use neural network model to find the relationship between tree height and tree diameter. For forest products, we treat them as short-lived trees rather than developing another model for them, which helps simplify and generalize the model. As for problem 2, The study found that the forest should not be cut down when the marginal direct value of forest is less than the indirect value of maintaining the forest under the condition of constant market risk. Therefore, we should first establish a value evaluation model. The model mainly includes direct value and indirect value, among which the direct value includes woodland asset and forest asset. Indirect values include soil stability, soil and water conservation, carbon sequestration and biodiversity. Based on this, we use k-means model to make decisions.

2. The Quantity of Carbon Sequestration

2.1. Carbon Sequestration Model

The rate of carbon sequestration depends on the growth characteristics of the tree species,the conditions for growth where the tree is planted, and the density of the tree's wood. It is greatest in the younger stages of tree growth, between 20 to 50 years.1 Further complicating the issue is the fact that the products of trees are diverse, resulting in harder measure of these. Nevertheless, we can roughly estimate the amount of CO2 sequestered in each tree, and if we divide by the tree's age, get a yearly sequestration rate. This is the process:

1. Determine the total (green) weight of the tree.
2. Determine the dry weight of the tree.
3. Determine the weight of carbon in the tree.
4. Determine the weight of carbon dioxide sequestered in the tree
5. Determine the weight of CO2 sequestered in the tree per year

Algorithm 1: Carbon Sequestration Calculation

Input: D // Diameter at breast height measured at 1.3 meters above the ground
H // Height to the base of crown W //
Above-ground weight of the tree in pounds
Output: C // Carbon Sequestration
Process:
If trees with D < 11:
W = 0.25D2H
else:
W = 0.15D2H
Then
Multiply the above-ground weight of the tree by 120%;
Multiply the weight of the tree by 72.5%;
Multiply the dry weight of the tree by 50%;
Multiply the weight of carbon in the tree by 3.6663;
Divide the weight of carbon dioxide sequestered in the tree by the age of the tree.
End

Data. The data we used came from EARTHDATA. The dataset provides tree stocks, tree height, DBH, and estimated crown measurements from 30 plots collected around the world in September 2010.The study area was in primary forest, primary forest affected by selective impact reduction (PFL) from 1999 to 2003, and secondary forest with different ages and dis-turbance history. Centered on the GLAS(Earth Science Laser Altimeter System) lidar instru-ment footprint, the image is selected along two sensor acquisition tracks that span a wide range of vertical structures and aboveground biomass. Among the 50 × 50 m plots, 8 were old-growth forests, 8 were PFL old-growth forests from 1999 to 2003, and 14 were secondary forests with different ages and disturbance history. The figure shows the distribution and car-bon sequestration of forests.

Figure 1. Carbon sequestration in the world

2.2. Relationship between height and diameter

Model.

In the previous section, tree diameters at tree height and DBH were used to calculate tree volume, estimate aboveground carbon storage, and model variables for tree growth and yield.

Unfortunately, measuring tree height in the field is difficult and error is easy to observe. Tree heights and diameters have traditionally been formalized using their regression relationships , or stochastic differential equations. But as we show below, linear regression model can't deal with the relationship and goodness of fit isn't satisfied.

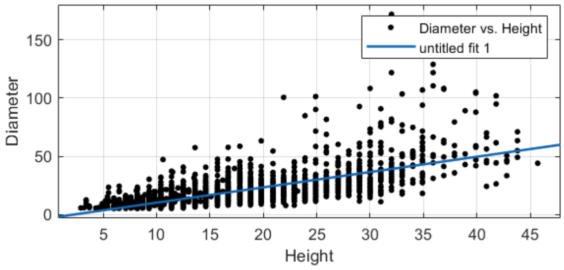


Figure 2. Linear regression result

By introducing additional stand variables and random parameters, height-diameter regression equations were established for local (stand) level and generalized (ecological area) level [6,7]. Application of stand level models on a larger scale may lead to a bias in the prediction, as the established height-diameter equation is related to growth conditions and stand characteristics. The deviation of tree height prediction will affect the accuracy of estimation of stand volume and aboveground carbon storage. To reliably predict tree height, European forest statisticians have applied different techniques, such as generalized height-diameter model variables that include additional stands [8].A generalized height equation evaluates the contribution of stand attributes, such as stand density per hectare, bottom area per hectare, quadratic mean diameter, etc., in the height diameter model [9,10].The addition of stand variables improves the predic-tive ability of the chosen height-diameter equation, but this method requires additional sam-pling work and reduces its practical application. The second technique used to introduce the STAND attribute for the height-diameter equation uses a distributed random variable with specific effects of each stand defined by a normal standard, known as the random effect [7], which allows the model to adapt to diverse growing environments. Here are the results of other model fitting:

Table 1. Results of other model fitting

Name of Equation	Form of Equation	Source
Richards	$H = 1.3 + a(1 - \exp(-bDBH))^c$	[9]
Logistic	$H= 1.3 + a/(1 + b\exp(-cDBH))$	[22]
Gompertz	$H = 1.3 + a\exp(-b\exp(-cDBH))$	[23]
Korf	$H = 1.3 + a\exp(-bDBH^{(-c)})$	[24]
Mitscherlich	$H = 1.3 + a(1-\exp(-bDBH))$	[25]
Schumacher	$H = 1.3 + a\exp(-b/DBH)$	[26]

In this paper, we use neural network model in machine learning to deal with the relation-ship. Neural network model is suitable to study the internal law of mutual influence is not clear. It is reasonable to use neural network model to fit the model.

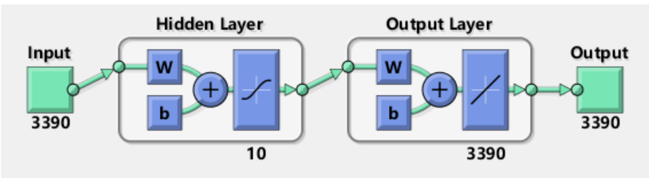


Figure 3. BPNN construction

The main idea of BPNN is to divide the learning process into two phases which are signal forward propagation and error back propagation. In the forward propagation stage, the input information is transmitted from the input layer to the output layer through the hidden layer, and then generates an output signal at the output layer. In the process of signal forward transmission, the weight of the network is fixed and each state of neural just affects next layer. If desired output is not obtained at the output layer, instead, a roll-in error signal occurs through back propagation, in which, error signals that fail to meet the accuracy requirements start from the output layer, propagate layer by layer in kind of ways, and the error appor-tioned to all the cells in each layer, according to the error signal dynamic adjustment to the connection weight of each unit layer. Through the cycle of forward propagation and back ad-justment, nervous weights adjust in many times, which stops when the error of the output signal meets the accuracy requirement.

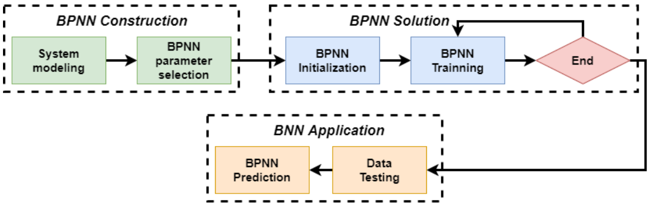


Figure 4. BPNN flowchart

We assume that network input vector is $X=(x_1,x_2,...,x_n)$, output vector is $Y=(y_1,y_2,...,y_n)$, and expected output is $TY=(ty_1,ty_2,...,ty_n)$. TY data is divided into two types: 0 indicates normal data and 1 indicates abnormal data. Given neurons of the hidden layer or output layer has input $I_j=\sum_i w_{ij}O_i+\theta_j$, where w_{ij} is the connection from neurons i to j; input of neurons i is transfer function $O_i=\frac{1}{1+e^{-I_j}}$; θ_j is bias of neurons. For the kth sample in the training set, its error function is $E=\frac{1}{2n}\sum_{j=1}^{n}(ty_{kj}-y_{kj})^2$,and the minimum value of error function is also obtained by gradient descent method that is $\triangle w_{ij}=-\eta\frac{\partial E}{\partial w_{ij}}$,where eta is learning rate and greater than 0.

Algorithm 1: The process of

Input: $D=\{(x_i,y_i)\}$ // Training set

η // Learning rate

Output: BPNN

Assign initial values for connection weights and thresholds of neurons

Repeat:

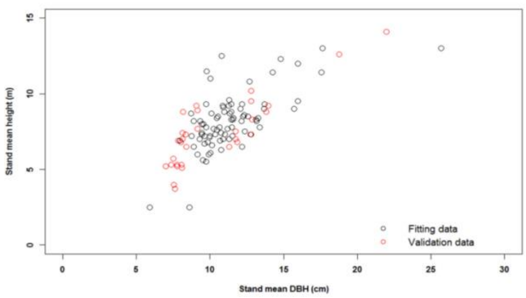
output is calculated according to the data of the c

ıeural network output and label value is calculatec

ıt of each parameter is calculated according to the

ate according to descent gradient;

Until: iteration ends;



(a) Scatter

Data	Variable	Min	Max	Mean	Std
Fitting data set	DBH (cm)	5.9	25.7	11.5	3.0
	Height (m)	2.5	13.0	8.3	1.9
Validation data set	DBH (cm)	7.0	22.0	10.4	3.4
	Height (m)	3.7	14.1	7.5	2.2

(b) Data

Figure 5. Data processing

We calculate the average height (later) height) and the average DBH (hereinafter referred to as DBH) for the purpose of easy fitting, especially for neural network accessories. We ran-domly divided the sample plots into two parts: one for the training model (80 plots, also de-fined as a fitting dataset) and one for model testing (32 plots, also defined as a validation da-taset) using the applied K-fold cross-validation method. The statistics of the summary fitting data set and validation data set are shown in Table 1 and the DBH height is shown in the scat-ter tree.

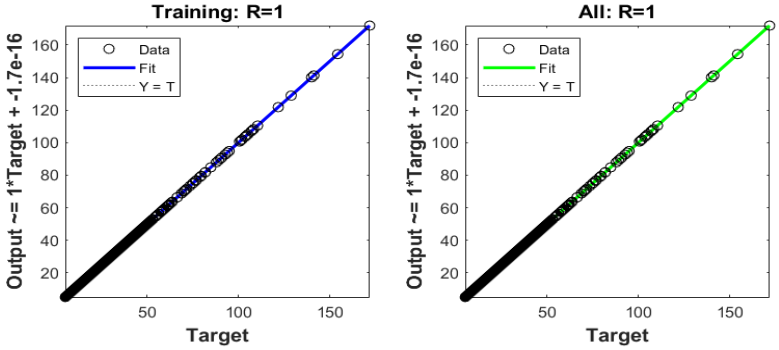


Figure 6. BPNN results

3. Prepare Your Paper Before Styling

To fairly evaluate the price of forest resources, we must build a forest asset value evalua-tion system and use appropriate methods to estimate. According to the price, value category and evaluation index of forest resources, the composition factors and variation range of the price of forest resources are studied.

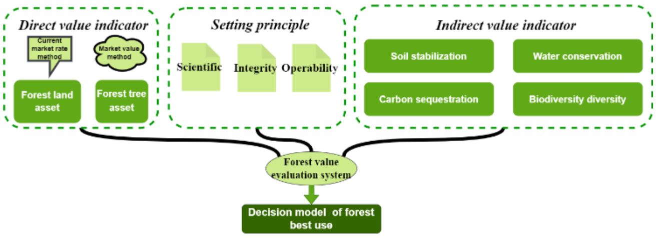


Figure 7. Value evaluation flowchart

3.1. Setting principle

Scientific principle.

Scientific means that in the construction of the evaluation system, the selection of indi-cators should not only be scientific and reasonable, but also meet the requirements of the asset evaluation method and forest resource asset evaluation criteria.

Moreover, the design of the system itself should conform to the value composition of forest resource assets, and be scientific and compliant, so as to make sense.

Only by implementing the scientific indexes and system can we ensure the scientific and accurate evaluation results of forest resource assets.

Integrity principle.

Integrity sex refers to the design to adopt the method of system index system, which must pay attention to the corresponding relationship of each index and the assessment system is not blindly pursue indicators with and ignoring the whole internal logic and integrity, and want to combine the forest resources assessment, the requirements of the relevant technical specifications to appropriate adjustment of indicators, to meet the needs of the evaluation sys-tem as a whole and clear, Logically and systematically reflect the value of forest resource as-sets.

Representativeness principle.

Representativeness refers to the selection of evaluation indicators, which should best re-flect the characteristics of forest resource assets. The connotation of forest resources is rich, the asset value is complex, the content is complex, and the contribution of each index to envi-ronmental purification value is greatly different, so the selection of evaluation index should highlight the key and consider the general, and coordinate with the system.

Operability principle.

Operability is considered reference data availability, and the research present situation of the subject matter to choose evaluation index, not only to meet to be concise, clear, accurate and convenient access requirements, should also consider the ease of operation and economy, effective, feasible, so that the exact and reasonable calculation of forest resources assets of converting and value.

3.2. Indicators selection

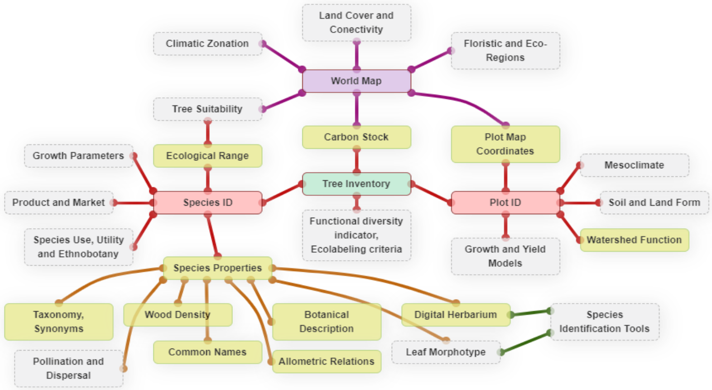


Figure 8. Basic aspects of frost value

We first found the basic aspects of forest value measurement from the United Nations, but there are several problems. First of all, too many aspects are considered, which leads to the time cost of data search and the operation cost of the system is too large. Therefore, we chose to tailor a few aspects to make the model easy to understand, but also have the signifi-cance of further promotion.

Thus, we refers to the forest asset list of Jiulianshan National Forest Park in China. Ad-here to the combination of physical quantity and value quantity, first material after value, first inventory and then flow of the compilation path. Divide forests into woodlands and trees, and create general ledger accounts and detailed accounts of forest resources based on the im-portance principle.

Direct value indicator.

The market value method is used to estimate the forest resources, and the value of forest land is estimated by referring to the market price of the same or similar forest land.

Its calculation formula is as follows:

$$B_m = K_1 \cdot K_2 \cdot G \cdot S$$

Forest resource value mainly refers to the value of all kinds of living trees except young trees in the nature reserve. The market value method is adopted to calculate the forest stock volume and average yield rate of various forest types in the nature reserve by multiplying the market price. The specific formula is as follows:

$$E_u = M \cdot v \cdot r \cdot P_m$$

Where, Eu is the average comprehensive utilization value of forest resources, M is the aver-age stock of forest resources, V is the average net growth rate of forest resources, R is the av-erage timber yield, and PM is the sales price of living wood in the international market. The value of providing forest by-products can be estimated using the market value method, which is the product of yield and price per unit of agricultural product.

To sum up, the direct forest value is:

$$M = B_m + E_u$$

3.3. Indirect value indicator.

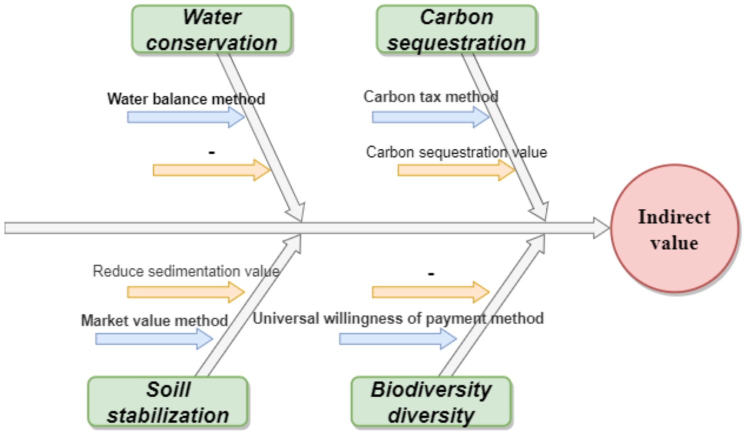


Figure 9. Indriect value

The benefits of water conservation can be obtained by subtracting the evapotranspiration from the precipitation in the study area, and then calculating the value of forest regulated water volume by using the price of reservoir controlled water per square meter. The specific formula is as follows:

$$V_1 = W \cdot P = (R - E) \cdot P_w$$

Where: $V1$ represents the value of forest water conservation, W represents the number of water conservation (M3 ° Y ° R-1), R represents the average rainfall (mm Y ° R-1), E represents the average evapotranspiration (mm ° Y ° R-1), and PW represents the unit storage cost (0.67 yuan /m3).

(1) Reducing soil erosion value

The opportunity cost method is used to calculate the total amount of erosion when the forest soil is weakened, and the annual income of forest land can be considered as the opportunity cost. The specific formula is as follows:

$$C_1 = \frac{Ac}{0.6 \times 10000 \times \rho} \cdot G$$

$$A_c = S(M_0 - M_i)$$

where $C1$ is to reduce land erosion price;AC is the coefficient of reducing soil erosion;

G is the average annual gross profit price of forestry; for determining the content of soil weight. S is the area number of various vegetation types;$M0$ is the erosion coefficient withoutforestland; Mi is the erosion coefficient of forest land. According to the growth rate of plants and animals and the reduction of soil erosivity, the average thickness of 0.5m is taken and the cost of soil loss can be reduced by using opportunity cost method.

(2) Maintain soil fertility value

The conservation soil fertility value required by forests refers to the value of forest erosion and the loss of nitrogen, phosphorus, potassium and organic matter from the soil. Using the market value method, the losses of N, P and K in soil can be expressed as the market value of the same amount of fertilizer. The specific formula is as follows:

$$C_2 = Ac(\frac{Nk_1}{R_1} + \frac{Pk_1}{R_2} + \frac{Kk_2}{R_3})$$

where $C2$ The price of material loss caused by maintaining a certain fertility in the process of using soil; N, P and K are the average action values of N, P and K in different soils.

$k1$ is the value of DPA; $k2$ is the value of KCL; $R1$ and $R2$ are the nitrogen and phosphorus contents of DPA fertilizer; $R3$ is the potassium content of KCL fertilizer.

(3) Reduction of sedimentation value

The price of reducing sedimentation is equal to the cost of increasing reservoir capacity.The specific formula is as follows:

$$C_3 = \theta \cdot \frac{Ac}{\rho} \cdot C$$

where $C3$ is to reduce the price of soil deposition; is the sedimentation coefficient; C is the cost of reservoir construction. To sum up, the soil conservation value is:

$$V_2 = C_1 + C_2 + C_3$$

The forest absorbs a lot of the carbon dioxide produced and the trees spew a lot of fresh oxygen into the trees. Trees can churn out at least one ton of dry gas a year, absorbing 1.63 CO2 and spitting out 1.20 O2.

$$C_4 = 1.63Yc \times \sum_{i=1}^{n} P_i \times S_i$$

where $C4$ represents the annual average forest economic benefit (yuan/year) of forest carbon sequestration, PI is the annual average primary forest productivity (T ° hM-2 ° A-1) of forest natural ecosystem of Category I, SI geographical distribution area (Hm2) of forest natural ecosystem of Category I, Yc is the cost of fixed CO2 (yuan/ton).

$$C_5 = 1.63Y_0 \times \sum_{i=1}^{n} P_i \times S_i$$

where $C5$ represents the annual average forest economic income of carbon sequestration of all kinds of forests (yuan/year), and Y0 represents the cost of industrial oxygen production (yuan/ton).

$$V_3 = C_4 + C_5$$

To sum up, the value of forest carbon sequestration and oxygen release is V3 = C4 +C5

According to the number of protected animals recorded in Jiuliangshan Nature Reserve, we can get that the WPPV of Jiulianshan biodiversity protection is V5.To sum up, indirect forest value is:

$$N = V_1 + V_2 + V_3 + V_4 + V_5$$

Therefore, the total economic value of the protected area

$$M + N$$

3.4. K-means clustering decision

The idea of k-means clustering algorithm: n cases are assigned to one of K classes, where K is a number defined in advance. Its goal is to minimize the differences within each class and maximize the differences between classes. The K-means clustering algorithm is mainly divided into three steps:

(1) The first step is to find the clustering center for the points to be clustered

(2) The second step is to calculate the distance from each point to the cluster center and cluster each point to the nearest cluster

(3) The third step is to calculate the average coordinate value of all points in each cluster and take this average value as the new cluster center

(4) Repeat (2) and (3) until the clustering center no longer moves in a large range or the clustering times meet the requirements.

Because the sample quantity is less, we have adopted the K-means clustering method, it can overcome the shortcomings of a small amount of sample clustering accuracy, not the al-gorithm itself has the function of optimization iteration, in has been obtained on the cluster-ing of iterative correction again pruning determine the clustering of part of the sample, and for some small sample can reduce the overall clustering time complexity. Therefore, the deci-sion-making model based on this is highly efficient.

4. Application of our model

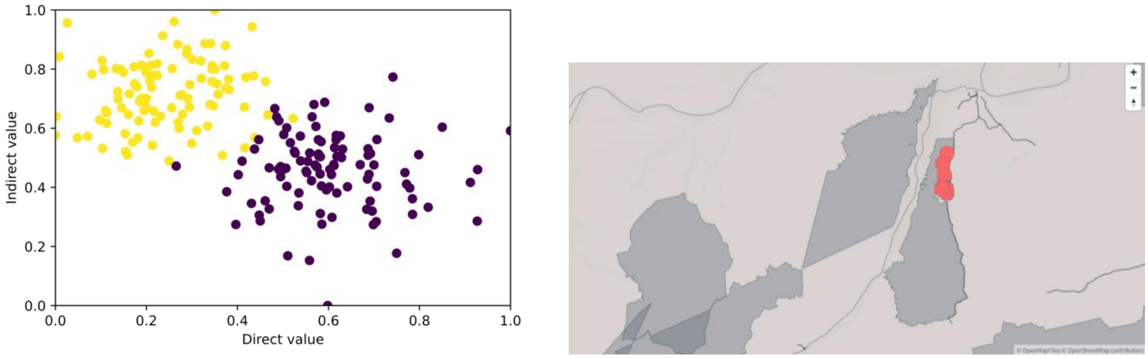
We selected three kinds of forests for model application, Vochysiaceae, Violaceae and Urticaceae. Using the carbon sequestration model, the quantities of Carbon Dioxide sequestrations are

586513.7674, 304961.0482, 70860.1838 pounds thus over 100 years. Urticaceae has the largest amount of carbon sequestration, mainly due to its large area. Therefore, from the perspective of the evaluation of carbon fixation, Vochysiaceae is the largest, with 19550.45892 pounds.

Table 2. Example of forest information

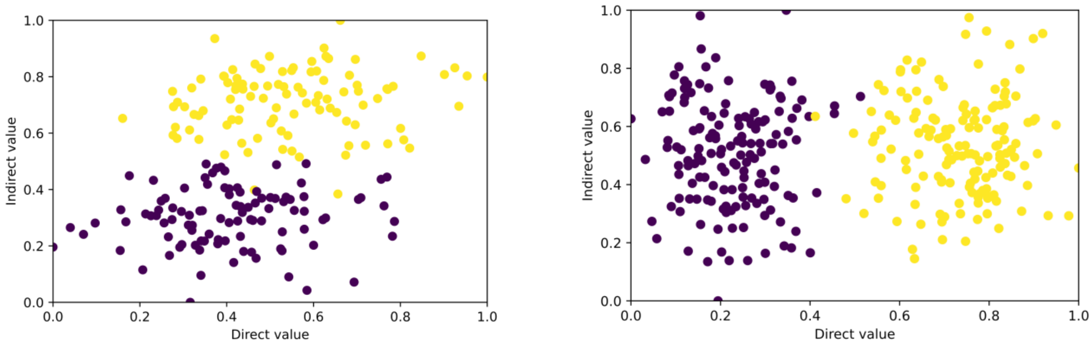
	Family	Longitude	Latitude	Diameter	Height	Carbon sequestered
1	Vochysiaceae	54.9682	3.02017	26.1	24.9	4057.783544
2	Violaceae	54.9527	3.13301	19.8	12.5	1172.327381
3	Urticaceae	54.9531	3.13091	14.5	13.6	684.0430389

Meanwhile, we applied the K-means decision model. The results of direct value and indirect value of three kinds of forest are obtained. The model results show that, the direct value was greater than the indirect value, so this part of the forest should be cut down in Violaceae. In stark contrast, the direct value was less than the indirect value, so this part of the forest should be cut down in Vochysiaceae and Urticaceae.



(a) K-means (b) Uncut forests

Figure 10. Model results



(a) Vochysiaceae (b) Urticaceae

Figure 11. Indirect and direct value

Considering 10 years longer than current practices in the forest, we believe that the discount rate will be greater in the future, so we **plant new Violaceae while harvesting Violaceae**, to get the indirect value ten years from now.

5. Conclusion

Recently, climate change has become more and more drastic. To reduce the effects of climate change, we need to take a number of measures to reduce the amount of greenhouse gases in the atmosphere. More importantly, we need to build a complete ecosystem to in-crease the amount of carbon dioxide we sequester from the atmosphere. This process is also known as carbon sequestration. Thus, forests are integral to any climate change mitigation effort.

In this project, we first collect data by EARTH. After that, carbon sequestration model and carbon sequestration model were established, in which three data were mainly used, height, diameter and weighs. Then we put forward a series of evaluation indexes in order to establish a correct forest value evaluation system. Forest Land Asset and Forest Tree Asset. Indirect values include Soil Stabilization, Water Conservation, Carbon Sequestration and Bi-odiversity. Then, we establish the K-means decision model, which is used to compare the marginal benefit of direct value and indirect value of forest. Finally, we applied the two mod-els to three forests to calculate the amount of carbon sequestration and propose a forest managment plan.

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