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To cite this article: Ruiqiang Ni *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **791** 012194

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Study on wind damage grade model for eucalyptus plantation in Guangxi, China

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Abstract. Wind damage is one of the dominant natural disasters that have the greatest impact on the growth of plantations. However, little attention has been paid to the wind damage grade model. Based on eucalyptus plantations from national forest inventory data and field investigations in Guangxi, ten significant factors that are susceptible to wind damage were selected to perform multiple linear regression analysis on wind damage grade model. Through assessing the level of wind damage based on forest characteristic and site conditions, we aimed to reduce the loss of economic benefits caused by wind damage. The results showed that the age group of eucalyptus trees, slope, soil thickness, management grade, and total vegetation coverage had significant effects on the wind damage of eucalyptus trees in this area. Therefore, it is necessary to protect the vegetation coverage of forest land and to strengthen the management of forest land to improve the wind resistance of eucalyptus forests in the future.

1. Introduction

The continuous development of the social economy has led to a substantial increase in the demand for wood, which has led to an increasingly prominent contradiction between wood supply and demand. Many countries have highlighted the development of plantation forests to solve this problem [1]. Plantation forests or planted forests are cultivated forest ecosystems established by planting or seeding or both in the process of afforestation and reforestation, primarily for wood biomass production but also for soil and water conservation or wind protection [2]. Their importance is rapidly increasing as countries move to establish sustainable sources of wood fiber to meet the increasing demand for wood pulp and energy [3].

Among the various plantation tree species, due to their high wood value, strong adaptability and high economic benefits, eucalyptus is favored and widely planted in Yunnan, Guangxi, Guangdong and other suitable planting regions in China. Until 2016, the planting area of eucalyptus has reached 3.68 million hectares [4]. However, in the process of planting plantation, the phenomenon of soil fertility decline, economic benefit decline caused by multiple generations of continuous harvesting, as well as susceptibility to damage caused by natural disasters have attracted extensive research by many scholars [5-10]. Eucalyptus is often affected by natural disasters such as forest fires, wind disasters, floods, and the damage to forest growth is immeasurable [11]. In particular, wind damage is one of the dominant natural disasters that have the greatest impact on the growth of plantations.

In recent years, global climate prediction models have shown that wind disasters exhibit an increasing trend in frequency and intensity. Wind can cause damage to trees such as broken branches, bent branches, and uprooted roots. Furthermore, broken trees can cause damage to buildings, casualties, increase cleaning expenses, and cause diseases and insect pests. As a result, directly or indirectly caused wood losses of up to millions of cubic meters. Therefore, it is extremely urgent to conduct a comprehensive



risk assessment of fast-growing and high-yield forests that are vulnerable to wind damage and propose corresponding preventive measures.

Although there are many researches on wind damages to eucalyptus trees in Guangxi, most of them are based on the action principle of wind on plantations, or qualitatively describe wind damage risks. Few researchers reported them in a quantitative way. Therefore, this study selected eucalyptus plantations in Guangxi as the research object and used multiple linear regression to establish a wind damage rating model for eucalyptus plantations. The proposed model can be used as a guideline for farmers' planting directions, so that when eucalyptus is planted, wind damage to trees can be prevented according to natural conditions to ensure the reasonable production of trees.

2. Materials and methods

2.1. Study site:

Based on the 533 standard plots of eucalyptus forests set up in Guangxi national forest inventory in 2015, all the sample plots are 20m×30m in sizes. The plots cover the main site types in the region, and the number of samples and distribution points are sufficiently representative.

2.2. Statistical method:

Ten factor that have an impact on wind damage were selected and standardized, including age group, altitude, aspect, slope position, slope, soil thickness, canopy closure, management level, total vegetation coverage, tree height. The evaluation standard values of wind damage factors and wind damage levels are shown in Table 1.

A multiple linear regression method was used to establish a model between the wind damage level and the 10 most relevant factors (Formula 1). Among them, Y is wind damage grade, $X_1, X_2, X_3 \dots X_k$ are independent variables, $\beta_0, \beta_1, \beta_2, \beta_k$ are parameters, namely regression coefficients; k is the number of explanatory variables; n is the sample size. Wind damage level Y was chosen as the dependent variable and the impact factor (normalized treatment) as the independent variable. Through stepwise regression, the model based on the lowest AIC value is the optimal wind damage level model.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_k X_k (i = 1, 2, \dots, n) \quad (1)$$

According to the ten selected factors affecting wind damage, the grade coefficients of age group, slope position, slope, canopy closure, soil thickness, management grade (Table 2), and total vegetation coverage of eucalyptus according to the grade table, and bring the grade coefficient into the above formula (1), we can get the wind damage grade model of eucalyptus.

Table 1. Impact factors on wind damage for Eucalyptus

Factors	1	2	3	4	5	6	7	8	9
Soil thickness/cm	60-74	75-89	90-104	105-119	120-134	135-149	/	/	/
Canopy closure/%	20-30	31-41	42-52	53-63	64-74	75-85	/	/	/
Total vegetation coverage	35-46	47-58	59-70	71-82	83-94	95-106	/	/	/
Tree height/cm	40-63	64-87	88-111	112-135	136-159	160-183	/	/	/
Age group/year	<5	5-10	11-15	16-25	>26	/	/	/	/
Altitude/m	5-160	161-316	317-472	473-628	629-784	785-940	/	/	/
Aspect	North	Northeast	East	Southeast	South	Southwest	West	Northwest	None
Slope position	ridge	top	middle	bottom	valley	Flat	/	/	/
Slope/°	0-7	8-15	16-23	24-31	32-39	40-47	/	/	/

Table 2. Evaluation of forest management grade

Management level	Assessment of forest management	Grade
Excellent	The management measures are correct and timely, the management intensity is appropriate, and the productivity and quality of the forest stand will be improved after management.	1
medium	The management measures were correct, timely, and the management intensity was acceptable. After the management, the productivity and quality of the forest stand improved.	2
worst	Management measures are not carried out in time or management is rarely carried out, the productivity of the forest stands has not been brought into play, and the quality is poor.	3

Table 3. Evaluation of wind damage grade

Wind damage grade	Wind damage Level	Assessment criteria for wind damage
1	No wind damage	number of damaged trees is less than 10%
2	Light wind damage	number of damaged trees is 10~29%
3	Moderate wind damage	number of damaged trees is 30~59%
4	Severe wind damage	number of damaged trees is more than 60%

3. Results and discussion

The results of stepwise regression model showed that the best wind damage model of eucalyptus is:

$$Y=0.2061X_1-0.5213X_2+0.2890X_3-0.2847X_4-0.1312X_5+4.1966 \quad (2)$$

Y is eucalyptus wind damage grade, X_1 is slope, X_2 is age group, X_3 is management grade, X_4 is soil thickness; X_5 is total vegetation coverage. The eucalyptus wind damage rating model is shown in Table 4. The constant term, age group factor, slope factor, soil thickness factor, management grade, and total vegetation coverage factor have significant effects on wind damage of eucalyptus. This combination has the lowest AIC value of -90.05. The adjusted R square of the model is 0.8527, and a p-value < 2.2e-16, which satisfies the requirements of fitting accuracy and has an excellent goodness of fit.

Table 4. Grade of wind damage on Eucalyptus

Coefficients	Estimate	Std.Error	t Value	Pr> t
(Intercept)	4.19663	0.36562	11.478	5.46e-16***
Slope	0.20612	0.06154	3.349	0.0015**
Age class	-0.52127	0.06526	-7.988	1.17e-10***
Management grade	0.28896	0.11773	2.454	0.0174*
Soil depth	-0.28466	0.06341	-4.489	3.89e-05***
Vegetation cover	-0.13118	0.05555	-2.361	0.0219*

Eucalyptus is a shallow-rooted tree species, the root system is shallower and finer, the main root is not obvious, the lateral root growth is not strong, and it does not grow into the deep soil. As a result, the growth of eucalyptus plants above and below ground is unbalanced, top-heavy, which is more apparent in the young forest stage. If it is shaken by a strong wind, it is very prone to fall down, which will cause significant losses to the eucalyptus planting economy. Many studies have shown that wind damage mainly occurs in eucalyptus forests of 1-2 years old.

When other factors are the same, the slope is directly proportional to the level of wind damage, which means that the greater the slope is, the greater level of wind damage occurs. The reason is that the steeper slope tends to produce more serious soil erosion, and less surface soil and weaker adhesion of the root system leads to more serious wind damage. While when other factors are the same, the soil thickness is inversely proportional to the wind damage level, which means that the greater the soil thickness has the lower the wind damage level. The greater thickness of the soil contains more organic matter. Thus, more

nutrients needed for plant growth promote the growth of trees and the enhanced ability to resist wind damage.

4. Conclusion

The advantage of this study lies in using multiple linear regression methods, combining frequent wind damage factors with national forest inventory data for quantitative research, and deriving the most appropriate and realistic model. When planting eucalyptus, pay attention to the place where the slope is as small as possible, and the soil thickness is thicker and the total vegetation coverage is large, to avoid the risks caused by wind damage. With proper soil preparation methods, scientific fertilizer operations, careful cultivation and management, it is expected to increase yields and better economic benefits. Therefore, it is necessary to protect the vegetation coverage of forest land and strengthen the management of forest land to improve the wind resistance of eucalyptus forests in the future management.

Acknowledgments

We would like to thank the financial support of China National Key R&D Program (2017YFD0600906) and Shandong Province Natural Science Foundation (NO. ZR2018PC006).

References

- [1] Zhang C L, Fu S L. (2009) Allelopathic effects of eucalyptus and the establishment of mixed stands of eucalyptus and native species. *Forest Ecology and Management*, 258(7): 1391-1396.
- [2] Chen Z J, Gao S K, Chen Y, He P H, He Q, Qiu Q, Li J Y. (2020) Effects of short-term fertilization on soil fungal community structure and functional group in Eucalyptus artificial forest. *Acta Ecologica Sinica*, 40(11): 3813-3821.
- [3] Cook R L, Binkley D, Stape J L. Eucalyptus plantation effects on soil carbon after 20 years and three rotations in Brazil. *Forest Ecology and Management*, 2016, 359: 92-98.
- [4] Li J Y, Lin J Y, Pei C Y, Huang L, Huang R Z, Tang G D. (2019) Diversity and structure of the soil arbuscular mycorrhizal fungal community are altered by Eucalyptus plantations. *Acta Ecologica Sinica*, 39(8): 2723-2731.
- [5] Chen F L, Zheng H, Zhang K, Ouyang Z Y, Lan J, Li H L, Shi Q. (2013) Changes in soil microbial community structure and metabolic activity following conversion from native *Pinus massoniana* plantations to exotic Eucalyptus plantations. *Forest Ecology and Management*, 291: 65-72.
- [6] Laclau J P, Deleporte P, Ranger J, Bouillet J P, Kazotti G. (2003) Nutrient dynamics throughout the rotation of Eucalyptus clonal stands in Congo. *Annals of Botany*, 91(7): 879-892.
- [7] Behera N, Sahani U. (2003) Soil microbial biomass and activity in response to Eucalyptus plantation and natural regeneration on tropical soil. *Forest Ecology and Management*, 174(1/3): 1-11.
- [8] Zhang C L, Li X W, Chen Y Q, Zhao J, Wan S Z, Lin Y B, Fu S L. (2016) Effects of Eucalyptus litter and roots on the establishment of native tree species in Eucalyptus plantations in South China. *Forest Ecology and Management*, 375: 76-83.
- [9] Cao Y S, Fu S L, Zou X M, Cao H L, Shao Y H, Zhou L X. (2010) Soil microbial community composition under Eucalyptus plantations of different age in subtropical China. *European Journal of Soil Biology*, 46(2): 128-135.
- [10] Zheng H, Ouyang Z Y, Wang X K, Fang Z G, Zhao T Q, Miao H. (2005) Effects of regenerating forest cover on soil microbial communities: a case study in hilly red soil region, Southern China. *Forest Ecology and Management*, 217(2/3): 244-254.
- [11] Silva J S, Nereu M, Pinho S, Queiros L, Jesus C, Deus E. Post-Fire Demography, Growth, and Control of Eucalyptus globulus Wildlings. *Forests*. 2021;12(2):16.