

Study on Ecological Restoration Countermeasures of Mountains on the East Bank of Erhai Lake from the Perspective of Special Habitat

Yin Yifan^{1, *}, Yu Jingke², Zhao Ouyi¹ and Hu Duocai^{3, *}

¹Yunnan Normal University, Yunnan Kunming 650500

²Yunnan University of Finance and Economics

³China Forest Exploration & Design Institute In Kunming

* Yin Yifan: yinyifan-33@163.com * Hu Duocai: 532738559@qq.com

ABSTRACT

The special habitat of mountains on the east bank of Erhai Lake not only seriously affects the ecological integrity and landscape harmony of Cangshan Erhai Nature Reserve, but also affects the ecological security around Erhai Lake. The ecological restoration of the mountains on the east bank of Erhai Lake is an important part of the protection and management of Erhai Lake and the transformation and development of the river basin. It is also the objective reflection and requirement of improving the ecological environment of Erhai Lake basin and realizing the comprehensive management of "mountain, water, forest, field, lake and grass". This paper makes a comprehensive analysis on the special habitat diversity characteristics of the mountains on the east bank of Erhai Lake, such as topography, climate, hydrology, soil, forest vegetation and so on, and puts forward some countermeasures and suggestions for ecological restoration, so as to provide support for scientifically solving the eco-environmental problems of the mountains in Erhai Lake basin.

Keywords: Mian Mountain on the east bank of Erhai Lake; habitat diversity; ecological restoration.

1. INTRODUCTION

The mountains on the east bank of Erhai Lake are important parts of the national scenic spot Cangshan Erhai Scenic Area and National Cangshan Erhai Nature Reserve. For a long time, the barren hills on the east bank of the Erhai Lake are in obvious contrast to the lush forest vegetation of Cangshan in the west of the lake[1]. The mountains on the east bank of Erhai Lake belong to the Paleozoic carbonate karst subarea of the fold system in western Yunnan[2], where the karst land is extremely developed, the topsoil is easy to be lost, and the formation of soil is slow. In addition, the mountains in the east of Erhai Lake are high and steep, and the rain falls abundantly and concentratedly in particular periods here. All these factors above have provided erosion and dissolution conditions for rocky desertification, resulting in its wide distribution and severity all over the area. It is difficult to control the ecological degradation caused by rocky desertification, especially in the Erhai Lake basin, which not only seriously affects the ecological integrity and landscape

harmony of the Cangshan Erhai Nature Reserve, but also affects the ecological security and the production and life of the people around Erhai Lake.

At present, Erhai Lake is in the initial stage of eutrophication and the "turning point" of protection and management. As the environmental bearing pressure of Erhai Lake continues to increase, the protection and management of Erhai Lake has launched a rescue mode, and the greening project on the east bank of Erhai Lake has been implemented, which is regarded as an important part of the ecological restoration of water-saving and water control in the "Seven Major Actions" of Erhai Lake protection and the ecological restoration around the lake in the "eight battles"[3, 4]. The ecological restoration of the mountains on the east bank of Erhai Lake is an important part of the protection and management of Erhai Lake and the transformation and development of the river basin. It is also the objective reflection and requirement of improving the ecological environment of Erhai Lake basin and realizing the comprehensive management of "mountain, water, forest, field, lake and grass".

Therefore, it is necessary to continuously and steadily carry out the restoration of the mountain ecosystem in the Erhai basin[5], restore and increase the forest vegetation in the rocky desertification area of the mountain on the east bank of Erhai Lake, optimize the forest community structure, improve the coverage of forest and grass vegetation, and create a high-quality ecological space with green water and green mountains. Furthermore, it is imperative to effectively solve the problems concerning the ecological environment of the mountain basin, enhance the effect of the green landscape of the land and space, and promote the coordinated development of ecological environment and social economy in Erhai Lake basin. They are the objective reflection and requirement of realizing the comprehensive management of "mountain, water, forest, field, lake and grass", and the need of implementing the concept of "Green mountains and clear water are equal to mountains of gold and silver" and building an important national ecological security barrier.

2. ANALYSIS OF THE DIVERSITY CHARACTERISTICS OF THE SPECIAL HABITATS ON THE EAST BANK OF ERHAI LAKE

2.1. Topographic characteristics

The area is the junction area between the Hengduan Mountains in western Yunnan and the Central Yunnan Plateau. The terrain is high in the east and low in the west, and the mountains are north-south. There are mainly two types of landforms: low mountain landform and karst landform. The total area of the mountains on the east bank of Erhai Lake is 38724hm² and the rocky desertification land reaches 11,000 hm², accounting for about 28% of the area of the mountains on the east bank. Among them, the area of rocky desertification land with bare rocks is nearly 9100 hm², the rocky desertification of agricultural land is about 1500 hm², and the rocky desertification land of industrial and mining type is about 400hm². The sloping land with potential rocky desertification risk and rapid development into rocky desertification in the short term is 150 hm², accounting for 0.4% of the mountain area in the east. The forest vegetation in the mountain area on the east bank of the Erhai Lake is severely damaged, and large areas of rocks are exposed. The capacity of soil and water conservation has gradually lost, intensifying soil erosion and alternating droughts and floods. The area around the mountains on the east bank of Erhai Lake has high population density, relatively poor economy, low ecological awareness of the masses, and frequent unreasonable land resource development activities in history, which aggravated the process of land rocky desertification.

2.2. Climate characteristics

Dali City, located at the southern end of the Hengduan Mountains, is the windward zone of the southwest monsoon belt of the Bay of Bengal. It belongs to the subtropical plateau monsoon climate, with the characteristics of moderate cold and heat, mild climate, small annual temperature difference, large daily temperature difference, distinct dry and wet seasons, and unclear four seasons[6]. Affected by topography, slope orientation and other factors, the temperature and rainfall levels have obvious zonal differences. The temperature in the eastern part of Erhai Lake is higher than that in the western part, but the rainfall is less than that in the western part, forming a distinctly dry and less rainy mountainous climate in the eastern part of the Lake and humid and warm in the west. The regional slope is mainly sunny or semi-sunny, and affected by rainfall and climate, it is dry and windy here with low air humidity. The water required for forest growth depends on natural rainfall, which is obviously insufficient, resulting in a low survival (preservation) rate. The main meteorological disasters in the region include hail, frost, drought, and strong winds, which also have a certain impact on forest growth.

2.3. Hydrological characteristics

Erhai Lake belongs to the Lancang River system, with 117 large and small rivers in the runoff area. The Miao River, Luoshi River and Yongan River ("North three Rivers") flow into Erhai Lake in the north, which is the main water source of Erhai Lake. In the west, the "Eighteen Streams" of Cangshan empties into the catchment on the eastern slope of Cangshan Mountain with short runoff and large slope; there are Boro River and Jinxing River in the south; Fengwei Qing and Yulong River in the east. As the only natural river flowing out of the Erhai Lake, the Xi'er River flows into the Lancang River from Pingpo in Yangbi County and enters the Heihui River; the other outlet involves the project of "diverting Er to Bin", and the outflow is controlled manually and mainly used for agriculture irrigation and domestic water supply in Binchuan County[7]. In recent years, the quality of Erhai Lake has been maintained as Class II or III, and large-scale cyanobacteria blooms have not occurred in some years. However, due to the rapid increase of population around Erhai Lake and the fast development of agriculture and tourism, a large number of nutrients are discharged into Erhai Lake. As a result, the water quality of Erhai Lake has changed from oligotrophic type to mesotrophic type, and the comprehensive nutrition status index has an upward trend [8]. The ecological system of Erhai Lake is weak in stability, and aquatic plants does not

have competitive advantages over algae. Cyanobacteria have a clear advantage in summer and autumn, the risk of large-scale water blooms is still high, and the situation of water conservation and cyanobacteria prevention in Erhai Lake is still severe.

2.4. Soil characteristics

Under the influence of mountain climate and vegetation, the vertical differentiation of regional soil is obvious. The soil types include red soil, purple soil, brown soil, dark brown soil, paddy soil, limestone soil, subalpine meadow soil, etc [9].

The altitude of 1980-2500m is the main distribution area of red soil, and it is embedded with lime soil and purple soil. Lime soil is widely distributed in the planned area, and purple soil is mainly distributed in the partial foothills of Shuanglang Town, but is less distributed. The soil at an altitude of 2500-2846m is mainly yellow brown soil, which is mainly distributed in the upper part of the Yezhutang Mountain and the Sanfeng Mountain in the northeast. The regional zonal soil is red soil, and the rock body embedded in thin soil has obvious distribution characteristics of high mountain, steep slope, thin soil layer, loose and barren soil, and poor water retention, hence there being a large plenty of water loss for plant growth.

2.5. Characteristics of forest vegetation

The regional forest coverage rate is 26.97%, lower than the forest coverage rate of 39.5% in Dali City and 37.0% in the watershed area[10]. The regional zonal vegetation community belongs to the subtropical semi-humid evergreen broad-leaved forest in central Yunnan, and the horizontal zonal vegetation is mainly semi-humid evergreen broad-leaved forest and Yunnan pine forest. The main distributions are *Dodonaea viscosa*, *Osteomeles schwerinae* Schneid, Birchleaf Pear and *Heteropogon contortus*, and local distributions include solitary woods and residual communities such as *Castanopsis delavayi* Franch, *Quercus franchetii* Skan, *Ternstroemia gymnanthera* (Wight et Arn.) Beddome, *Cyclobalanopsis glauca*(Thunb.) Oerst, etc. Restricted by site conditions, the existing Yunnan pine forests with isolated island distribution are a type in the succession series of semi-humid evergreen broad-leaved forests after destruction, and are linked to semi-humid evergreen broad-leaved forests through mixed pine and oak forests. It belongs to secondary plant community. A large area of *Dodonaea viscosa* evolved the region, through a large number of artificial and air-seeded afforestation, from grass and stony bare land to a low-end community with single vegetation hierarchy, poor overall landscape effect, and low ecosystem service function.

In general, the surface rocks of the mountains on the east bank of the Erhai Lake are relatively exposed, and drought and water shortage are prominent. The soil is barren, water retention is poor, the forest community and stand structure are single, and the ecosystem service function is seriously degraded. Despite years of efforts that the mountains on the east bank of the Erhai Lake have been upgraded from the original shrub-grass vegetation system such as *Heteropogon contortus*, *Schizachyrium delavayi*, and *Osteomeles schwerinae* Schneid to the arbor-shrub vegetation system such as *Dodonaea viscosa* and *Juniperus chinensis* Linnaeus, the state cannot be restored to the advanced community structure level of zonal plants through natural succession. At the same time, restricted by site conditions and cost input, it is more difficult to afforest and upgrade the landscape, which seriously threatens the ecological security of the Erhai Lake Basin. In addition, the scarcity and low quality of regional rocky mountain vegetation is too far from the forest landscape effect it should have, and it is extremely inconsistent with the beautiful lakes and mountains of Cangshan and Erhai, which affects the overall landscape effect. Therefore, in order to effectively solve the problems of the ecological environment of the mountains in the Erhai Lake Basin, it is urgent to improve the effect of the green landscape of the land and space, promote the coordinated development of the regional ecological environment and social economy, and enhance the restoration of the ecological environment of the mountains in the eastern Erhai Basin.

3. COUNTERMEASURES FOR ECOLOGICAL RESTORATION OF MOUNTAINS ON THE EAST BANK OF ERHAI LAKE

3.1. Establish a research area for breeding and screening of improved species with the main zonal tree species in the Erhai Lake Basin as the focus

Focus on the main zonal tree species in the Erhai Lake Basin, carry out the evaluation of native dominant tree species and research on the selection and breeding technology of forest trees, establish a technical system for the selection and utilization of improved varieties for ecological restoration in the plateau lake basin with the Erhai Basin as a model, and build a research area for breeding and selection of improved varieties. Firstly, establish a collection and preservation nursery for germplasm resources in the study area, comprehensively collect high-quality species of forest trees in the mountains around plateau lakes, and establish a genetic resource bank to provide experimental materials for the final selection and breeding of high-quality afforestation species. Manage

the collected excellent germplasm resources, analyze and compare the growth habit, growth volume, branching ability, resistance, adaptability, pests and diseases, etc. of the varieties, and implement fixed-point and item-by-item observation of biological characteristics and economics such as phenological period and character of fruitage to conduct comprehensive analysis and evaluation. Secondly, establish a research park for selection and breeding of improved varieties to systematically observe and compare the original materials of improved varieties introduced into the study area, so as to screen for those with higher yields, better quality, stronger resistance to stress, and the ability to meet the needs of ecological restoration in the mountainous area around plateau lakes. In addition, select typical plots in the study area, build experimental demonstration forests, and conduct observational experiments on the selection and breeding of improved varieties and their configuration methods. Adopt advanced cultivation technology, and play a leading role in technology promotion and demonstration to improve the afforestation level of plateau lake areas.

3.2. Construct a restoration model that develops from the terminal level of succession to the top-level community

Due to excessive damage, the carrying capacity of the mountains on the east bank has been exceeded and the environment there cannot be restored by nature solely. Only the combination of artificial and natural succession can be used to restore the high-level community structure of the mountains on the eastern side of Erhai Lake and cultivate the ecosystem structure of subtropical evergreen coniferous and broad-leaved mixed forest. Based on the investigation and analysis of some local isolated trees and residual community composition, it is confirmed that the local zonal vegetation is a semi-humid evergreen broad-leaved forest maintained by similar climatic factors at the same altitude in central Yunnan. Therefore, through comprehensive management of engineering measures and biological measures, a restoration model that develops from the terminal level of succession to the top community is constructed, according to the characteristics of different site conditions and the distribution of native vegetation.

On the basis of the investigation and selection of germplasm resources, combined with the supply of seedlings in the market, 19 seedlings are selected as listed in Table1, including 16 trees, 2 shrubs, and 1 vine. Adopt the method of artificial promotion of succession, and select fast-growing, drought-tolerant and barren species to establish pioneer communities. Starting from the terminal level of succession, plant some easy-to-survival tree species, such as *Alnus nepalensis*, *Pistacia weinmannifolia*, *Pistacia chinensis*,

etc., together with certain shrubs to make the land canopy closed and reach certain soil environmental conditions to ensure the possibility of the restoration model’s development into the top community. When the soil conditions reach a certain level, plant species such as *Cinnamomum glanduliferum* (Wall.) Nees, *Pinus yunnanensis*, *Photinia glomerata* and other tree species to gradually build up the community. Then select *Cyclobalanopsis glaucoides*, *Quercus acutissima* Carruth, etc. to build top-level communities. After a certain period of time, the biomass in the area will be noticeably increased, the biodiversity will be significantly improved, the ecological service function will be remarkably improved, and the soil erosion will be effectively controlled. Natural factors such as animals and plant propagules enter the ecosystem, and through the succession and exchange of material flow, information flow and energy flow in the ecosystem, presenting a subtropical evergreen coniferous and broadleaf mixed forest with zonal plants living in the upper layer of the forest canopy, so that the ecosystem function can be fully utilized.

Table 1. Statistics of preferred seedlings.

	Plant Name	Number
Arbor	<i>Cerasus cerasoides</i> , <i>Photinia glomerata</i> , <i>Ligustrum compactum</i> Ait, <i>Taxus yunnanensis</i> , <i>Cinnamomum glanduliferum</i> (Wall.) Nees, <i>Cyclobalanopsis glaucoides</i> , <i>Pistacia weinmannifolia</i> , <i>Quercus acutissima</i> Carruth, <i>Celtis kunmingensis</i> , <i>Pinus yunnanensis</i> , <i>Alnus nepalensis</i> , <i>Pistacia chinensis</i> , <i>Jacaranda mimosifolia</i> D. Don, <i>Prunus cerasoides</i> , <i>Robinia pseudoacacia cv.idaho</i> , <i>CV.Salvador</i>	sixteen
Shrub	<i>Lespedezabicolor</i> Turcz., <i>Rosa sp.</i>	Two
Vine	<i>Mucuna sempervirens</i>	One

3.3. Use water-saving and drought-resistant afforestation technology to improve the construction of irrigation facilities

On the land suitable for afforestation of the mountains on the east bank of Erhai Lake, the slope is mainly sunny and semi-sunny, forming a dry mountain

climate with little rain. Because the amount of evaporation is greater than the rainfall, coupled with the development of karst landforms, less surface water, and poor soil water retention, water has become the main restricting factor for afforestation in the mountains east of Erhai Lake. Therefore, in order to make a difference in afforestation and greening of the mountains on the east bank, it is necessary to continuously improve the construction of irrigation facilities, adopt water-saving and drought-resistant afforestation technologies, and employ precise irrigation techniques to restore the forest vegetation in the rocky desertification areas on the east bank of Erhai Lake, so as to effectively protect and build the ecological environment of Erhai Lake and promote the construction of ecological civilization in Erhai Lake Basin.

Through the construction of water conservancy facilities such as reservoirs and irrigation pipelines, the full use of reclaimed water as an irrigation water source can effectively protect the Erhai Lake, so that regional water resources can be used more effectively, the survival rate and preservation rate of seedlings can be improved, and the output rate of the land can be increased, improving people's production and life. For one thing, after extraditing the artificially generated domestic sewage around Erhai Lake to the sewage treatment plant to be treated as reclaimed water, it is pumped by high-pressure pumps and transported to various production and operation areas through diversion equipment such as canals. The main irrigation and drainage channels are arranged along the main road and forest roads to satisfy the irrigation of afforestation and green areas. For another, continuously improve the construction of water conservancy and irrigation projects and other supporting projects, make full use of the 13 large and small rivers that merge into the afforestation area on the east side of the Erhai Lake, and promote the restoration of vegetation on the east side of the mountains.

3.4. Attach importance to ecological greening and the creation of landscape pattern

The ecological restoration of the mountains on the east bank of the Erhai Lake is supposed to, from the perspective of the overall landscape of the Erhai Lake Basin, pay attention to the coordination and connectivity of the Erhai Lake Basin landscape pattern, and combine vegetation restoration with landscape construction to reshape the regional visual landscape effect. Those mountains are visible on both sides of the main lines such as Dali Railway, Dali Expressway and East Huanhai Road, so high-quality scenic forests should be built in these areas to form a green walkway that integrates landscape, ecological and economic benefits. The native evergreen landscape arbor and flower-appreciating plants are mainly used to create a

good landscape ecological environment through the multi-layer mixed configuration of arbors, shrubs, grasses, vines and flowers. Meanwhile, through the reasonable selection and use of flowering trees and color-leaf tree species, the mountain environment is beautified and the mountain landscape is improved. Take water resources irrigation projects and surface soil covering measures as main engineering measures, and adopt precise irrigation techniques at the key landscape nodes to highlight landscape functions.

4. CONCLUSIONS AND RECOMMENDATIONS

The threat of soil erosion and rocky desertification in the runoff area is still serious, and the ecological environment is extremely fragile, particularly in the mountain areas on the east bank of the Erhai Lake. Therefore, it is of great significance to carry out research on the ecological protection and restoration of the mountains on the east bank of the Erhai Lake Basin. First, through the establishment of a scientific research base for ecological restoration of the mountains on the east bank of the Erhai Lake, long-term positioning observational research on the special habitats and important ecological processes of the mountains on the east bank of the Erhai Lake can not only reveal the structure, function and dynamic process of typical artificial forest ecosystems, but also effectively promote the quality of water bodies, increase forest coverage, reduce soil erosion, prevent geological disasters, improve the ecological environment, boost biodiversity, so as to provide a scientific basis for the management and sustainable development of China's plateau lakes and surrounding mountains. Secondly, conduct dynamic monitoring and research on the plateau lake ecosystems such as Erhai Lake by relying on scientific research bases, and establish an early warning and evaluation system, which can serve the ecological restoration of important lakes in the upper reaches of the Yangtze River and ecologically degraded areas in China and the sustainable development of regional social economy. In addition, long-term scientific research on the ecological system of the Erhai Lake and surrounding mountains can provide high-level demonstration projects for the effective management of other plateau lakes, and make significant social contributions to the improvement of the living environment of local people.

Project Name: National Permanent Scientific Research Base Project for Ecological Restoration of Mountains in the East Bank of Erhai Lake, Dali (2020132559)

REFERENCES

- [1] F. Jinyuan. Dali Daily (Chinese), 003,1(2018)

- [2] Y. Su. Distribution status and characteristics of rocky desertification in China, 2 (2003)
- [3] X. Zhaoyan. Research on the "Seven Major Actions" Policy for the Governance of Erhai Lake. Yunnan University, (2018)
- [4] R. Hanjiao. The practice of Xi Jinping's ecological civilization thought in the protection and governance of Erhai Lake, Dali University, (2020)
- [5] Y. Biao. On the restoration and reconstruction of forest vegetation in the limestone mountains of The east bank of Erhai Lake, 2 (2003)
- [6] X. Wangjing, Y. Liu, F. SongTeng. Journal of Dali University, 3 (2018)
- [7] S. ChuZhao, J. Gaosi, Y. Pang, Journal of Environmental Engineering Technology, 9 (2019):.
- [8] P. Li, Environmental Science Guide, 39 (2020)
- [9] T. ZhangWen, Y. Xing, Y. Lushao, Bulletin of Soil and Water Conservation, 35 (2015)
- [10] H. YongTao, C.Min, Comparative study on species diversity of evergreen broad-leaved forest in central Yunnan, 4 (2000)