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Preliminary Research on Plant Community and Vegetation Restoration in Different Vegetation Succession Species on a Post-Seismic Landslide in Hongchun Gully, China

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Abstract

After the Wenchuan earthquake on May 12, 2008 and the rainstorm and debris flow on August 14, 2010, the vegetation in Hongchun Gully, Yingxiu town is gradually recovering naturally, and the plant community is gradually undergoing community succession. Based on the field vegetation survey data of 46 quadrats in 5 field plots, this study comprehensively analyzed the plant community, species number changes and vegetation characteristics of Hongchun Gully in Yingxiu town at different stages of vegetation succession after the earthquake by using the unified method. The results show that: 1) There are 61 families, 96 genera and 110 species of plants on the Hongchun Gully landslide. Among them, *Cunninghamia lanceolata* is the most widely distributed, and together with *Cryptomeria japonica*, it constitutes the main dominant species in the tree layer; The dominant species in shrub layer are *Rubussp*., *Hydrangea strigosa*, *Rubus tephrodes*, etc. The dominant species in herb layer are *Artemisia argyi*, *Stellaria media* and *Senecio scandens*. 2) The vegetation restoration in Hongchun Gully is relatively good, with herbs as the main species in the early stage of succession, shrubs and herbs as the main species in the middle stage of succession and trees as the main species in the late stage of succession; And the longer the succession time, the better the vegetation restoration and the richer the species. 3) Vegetation succession is related to the succession time, and the succession is always in the direction of strong adaptability. The study provides important data reference for further discussing the natural restoration and succession process and mechanism of plant communities on the damaged landslide formed after the earthquake, and provides theoretical basis for vegetation restoration and ecological reconstruction in the hardest hit areas in southwest

China after the earthquake.

Keywords

Landslide, Community Succession, Vegetation Restoration, Dominant Species, Earthquake, Yingxiu Town

1. Introduction

Sudden earthquakes will induce secondary disasters, which will seriously damage the original vegetation, topography and landscape, which is not conducive to the secondary succession process of vegetation (Zhong, Sun, Cheng et al., 2016). The "5.12" Wenchuan earthquake and secondary disasters such as landslides, collapses and mudslides have directly buried or destroyed large areas of forest vegetation. The total area of affected forests is about 946 km^2, and the vegetation coverage rate has decreased by 1.87% (Hull, Xu et al., 2011; Yang, Li, Yang et al., 2017; Huang, Du, He et al., 2023). On August 14, 2010, due to the continuous heavy rainfall and aftershocks, a large mudslide occurred in Hongchun Gully, which triggered a large number of landslides in Yingxiu town, resulting in most areas with vegetation becoming bare flat land (Huang, Han, Tang et al., 2017). After the earthquake and secondary disasters, most of the damaged vegetation has naturally recovered to the secondary succession stage, which makes some landslide slopes in different ages grow plant communities in different succession ages. The long-term change of vegetation coverage after the earthquake is a macroscopic indication of the degree of vegetation restoration, and it is also the most intuitive index to understand vegetation succession (Kang & Zou, 2019). Therefore, it is of great significance to discuss the vegetation and plant resources of different succession age groups after the earthquake for vegetation restoration and succession.

Vegetation succession is an important concept in ecology, which refers to the restoration process of vegetation after disturbance or the formation and development process in the area where plants have never grown (Peng, Ren, & Zhang, 2003; Zeng, Luo, Mou et al., 2014). In the process of natural restoration, the species diversity will change through a long-term natural succession process, and eventually a stable plant community structure will be formed. However, for the ecosystems that were seriously damaged after the earthquake, the vegetation can not be well restored through the process of natural restoration or the required succession time is particularly long (Hu & Guo, 2012). In recent years, many scholars in China have paid more and more attention to the restoration of forest vegetation after Wenchuan earthquake. Sun Liwen and others (Sun, Shi, Zhao et al., 2015) have studied the effect of vegetation restoration in the landslide control area after Wenchuan earthquake, which shows that it is difficult to restore vegetation due to the thin soil layer and high soil gravel content after the earthquake.

Artificial control can accelerate its vegetation restoration, but the influence of soil factors on vegetation restoration effect has not been considered, so the research on the process and mechanism of vegetation restoration succession after the earthquake is not detailed enough. Li et al. (Li, Xiong, Chen et al., 2023) used high-precision remote sensing images with multi-temporal and long time series (2000-2020) to study the vegetation restoration process in a large area of Wenchuan earthquake. Ye et al. (Ye & Kuang, 2022) in order to study the restoration of damaged vegetation in Wangjiayan, Beichuan County, where a serious coseismic landslide occurred after the Wenchuan earthquake, remote sensing technology was used to monitor the long-term vegetation dynamics in Wangjiayan area after the earthquake. Based on the multi-temporal Landsat remote sensing images in the study area from 2007 to 2020, normalized vegetation index (NDVI) and vegetation cover recovery rate (VRR) were used to quantitatively evaluate the vegetation growth and restoration status. Wang et al. (Wang, Yang, Chen et al., 2021) used MODIS13Q1 and ALOS PALSAR remote sensing data to extract vegetation coverage, vegetation recovery rate and surface deformation in the study area by using pixel dichotomy and D-InSAR technology. Quantitatively analyze the temporal and spatial variation law of damaged vegetation coverage after the earthquake, and analyze the relationship between topographic deformation and vegetation restoration in arid valleys after the Wenchuan earthquake. Wu et al. (Wu, He, Yang et al., 2019) studied the vegetation restoration of landslide after Xiejiadian earthquake, which showed that in the early stage of restoration, the habitat space was abundant, the competition among plants was weak, the plant community was dominated by herbs, and the vegetation species recovered quickly; In the later stage of restoration, the plant community took place in succession, and the single community structure dominated by herbs gradually changed to a balanced and stable community structure of trees, shrubs and grasses, and the number of species increased slowly and tended to be stable. However, the research on vegetation restoration in the landslide control area after the earthquake is mostly focused on the investigation of plant community in a single landslide, and there are few studies on the dynamic restoration and succession of vegetation in long time series on multiple landslides in different places. For example, Zhang et al. (Zhang, Jin, Zhou et al., 2023) investigated the temporal and spatial dynamics of the structure and species diversity of restored plant communities on different types of slopes (soil matrix slope, soil-rock mixed matrix slope, rock matrix slope and residual vegetation patch matrix slope) in Wolong area of Giant Panda National Park after the Wenchuan earthquake. Based on the field investigation and sample collection of vegetation and plant resources at different succession stages in the landslide area, this study further discusses the natural restoration and succession process and mechanism of plant communities on the damaged landslide formed after the earthquake, in order to provide theoretical basis for vegetation restoration and ecological reconstruction in Hongchun Gully, Yingxiu town after the earthquake.

2. Overview of the Study Area

Hongchun Gully is located in the northeast of Yingxiu town, Wenchuan County, Sichuan Province (31˚03'N - 31˚04'N, 103˚29'E - 103˚31'E), on the left bank of Minjiang River, with a total area of 27 375 m^2 and an altitude range of 899 - 495 m. It is located on Yingxiu-Beichuan fault zone (Li, Xu, Ji et al., 2013) and belongs to the subtropical monsoon climate (Zhang, Wang, Wang et al., 2010). According to statistics for many years, the average annual rainfall in this area is 1253 mm, and the maximum annual rainfall is 1688 mm (Tang, Li, Ding et al., 2011). Hongchun Gully is one of the most serious debris flow disasters in Wenchuan earthquake area, and a large number of landslides appeared after Wenchuan earthquake and rainstorm and debris flow. At the same time, Hongchun Gully extra-large debris flow is a typical post-earthquake debris flow in high earthquake intensity area (Chang, Tang, Jiang et al., 2014), and the vegetation on this landslide is mainly natural restoration, which belongs to secondary succession, and the vegetation succession is progressing smoothly (Huang, Han, Tang et al., 2017).

3. Research Methods

3.1. Sample Plot Setting

According to the actual topographical conditions, horizontal transects (Huang, Han, Tang et al., 2017) are respectively set for typical damaged landslides and undamaged landslides from low to high along the coast. According to the field investigation, a total of 8 damaged slides and 2 undamaged slides were found. Through the secondary data collation and analysis of mountain disasters in the region in the past 100 years, according to historical documents and tree ring data collected in the field, four slopes with similar elevation, slope, slope direction and soil parent material were selected from the damaged landslide, and they were divided into four succession age groups: the sample plot with the shortest succession time (1 - 5 years, A1); A plot with a succession time between the middle and the shortest time (5 - 10 years, A2); The plot with the middle succession time (10 - 30 years, A3) and the plot with the longest succession time (30 years and above, A4). At the same time, in order to determine the vegetation diversity and restoration profile of the landslide, the undamaged sample plot on the right side of a typical large landslide is selected as the control plot (A5). Specifically, A1 is dominated by herbs, which will naturally recover for about six months to one year after being destroyed. The overall coverage is 13%, and there are only six grasses in total. A2 is rich in shrub and grass, with *Cunninghamia lanceolata* and *Cyclobalanopsis glauca* as trees, *Camellia sinensis* as shrubs and *Stellaria media* as herbs. A3 is dominated by trees, with abundant shrub and grass, and the species of trees are increasing. On the left side, there is an artificial forest (*Cunninghamia lanceolata* forest planted around 1982), with few vegetation, and *Camellia sinensis* are scattered along the road. A4 has been in succession for nearly 35 years under natural conditions (the second batch of forests was planted after 1978), with tall trees as the main species, rich undergrowth species, rich diversity of trees, shrubs and grasses, total vegetation coverage of 80% and about 74 species of vegetation. A5 is located in the undamaged area of large landslide, with gentle slope and small gradient.

3.2. Quadrat Survey of Plant Communities

On March 21-25, 2017 and March 23-28, 2018, the three-dimensional coordinates of each plot were measured by the Global Positioning System (GPS), and the slope and aspect of the plot were measured by the compass (Cui, Shi, Sun et al., 2018; Wu, Ren, Xu et al., 2022). At the same time, randomly set 3 - 5 10 m × 10 m tree quadrats on each plot, add 5 m × 5 m shrub and 1 m × 1 m herb quadrats in each plot diagonally, and investigate 46 arbor and shrub quadrats (**Table 1**), record plant species name, number of plants, height, coverage and other indicators in each quadrat, and investigate the environment such as latitude and longitude, altitude and slope.

Table 1. Geographical distribution and vegetation survey of quadrats.

Sample plot type	Sample number	latitude	longitude	slope	Altitude/m	Vegetation canopy density/%	Number/species of plants
A1	1	31˚03.1511'	103˚29.3358'	15˚	1192	36	4
	2	31˚03.1593'	103˚29.3276'	38˚	1195	23	3
	3	31˚03.1720'	103˚29.3160'	53˚	1198	0	0
	4	31˚03.1708'	103˚29.3490'	42˚	1220	3	1
	5	31˚03.1896'	103˚29.3360'	23˚	1235	5	5
	6	31˚03.2029'	103˚29.3145'	30˚	1242	4	3
	7	31˚03.1040'	103˚29.3114'	27˚	1137	23	6
	8	31˚03.1232'	103˚29.3119'	32˚	1140	0	0
	9	31˚03.1153'	103˚29.2084'	5˚	1103	0	0
	10	31˚03.0861'	103˚29.1917'	38˚	1093	45	12
A2	1	31˚04.2667'	103˚30.3305'	11˚	1271	73	18
	2	31˚04.2722'	103˚30.3199'	23˚	1283	83	25
	3	31˚04.2917'	103˚30.3215'	26˚	1302	81	26
	4	31˚04.2936'	103˚30.3294'	16˚	1300	84	25
A3	1	31˚04.2470’	103˚30.7355'	12˚	1337	83	24
	2	31˚04.2208'	103˚30.7444'	23˚	1347	84	23
	3	31˚04.2221'	103˚30.7543'	14˚	1352	82	24
	4	31˚04.8205'	103˚30.7583'	13˚	1354	82	22
	5	31˚04.2356'	103˚30.7575'	15˚	1351	60	5
	6	31˚04.2225'	103˚30.7860'	10˚	1368	84	23

Continued

A4	1	31˚04.1438'	103˚30.5232'	2˚	1245	79	21
	2	31˚04.1380'	103˚30.5287'	15˚	1244	81	25
	3	31˚04.1252'	103˚30.4977'	13˚	1234	80	23
	4	31˚04.1238'	103˚30.5014'	17˚	1241	83	25
	5	31˚04.1218'	103˚30.5088'	15˚	1233	84	25
	6	31˚04.1196'	103˚30.5122'	25˚	1240	84	24
	7	31˚04.1206'	103˚30.5244'	8˚	1234	83	25
	8	31˚04.1244'	103˚30.5249'	5˚	1246	84	26
	9	31˚04.1306'	103˚30.5219'	11˚	1253	85	26
	10	31˚04.1352'	103˚30.5323'	28˚	1244	84	25
	11	31˚04.1438'	103˚30.5232'	2˚	1245	79	21
	12	31˚04.1380'	103˚30.5287'	15˚	1244	81	25
A5	1	31˚03.4423'	103˚29.6185'	22˚	952	84	27
	2	31˚03.4432'	103˚29.6543'	6˚	954	85	28
	3	31˚03.4347'	103˚29.6380'	11˚	963	65	19
	4	31˚03.4203'	103˚29.6625'	41˚	975	84	23
	5	31˚03.3893'	103˚29.6819'	38˚	982	63	25
	6	31˚03.3972'	103˚29.6854'	27˚	983	65	24
	7	31˚03.3943'	103˚29.6612'	35˚	995	64	23
	8	31˚03.3863'	103˚29.6879'	34˚	1012	73	26
	9	31˚03.3757'	103˚29.6648'	39˚	1031	83	27
	10	31˚03.3593'	103˚29.6692'	33˚	1037	84	25
	11	31˚03.3520'	103˚29.6915'	24˚	1045	85	28
	12	31˚03.3439'	103˚29.6086'	39˚	1073	0	0
	13	31˚03.3312'	103˚29.5973'	33˚	1106	5	8
	14	31˚03.2499'	103˚29.5626'	25˚	1146	82	19

4. Results and Analysis

4.1. Species Composition of Vegetation Community

According to the data from the quadrat survey of field plant communities (Table 2), there are 110 species of trees, 33 species of shrubs and 62 species of herbs on the Hongchun Gully landslide, mainly composed of Compositae, Cupressaceae and Rosaceae. The most representative plants in A1 are *Cunninghamia lanceolata*, *Cerasus pseudocerasus*, *Rubus sp*., *Hydrangea strigosa*, *Pilea notata*, *Artemisia argyi*, etc. A2 The most representative plants are *Cryptomeria japonica*, *Cunninghamia lanceolata*, *Cyclobalanopsis glauca*, *Hydrangea strigosa*, Rubus glauca, Polygonum chinensis, etc. A3 The most representative plants are *Cunninghamia lanceolata*, *Cryptomeria japonica*, *Castanea mollissima*, *Coriaria nepalensis*, *Debregenasia edulis*, *Anemone vitifolia*, *Leontopodim leontopodioides*, etc. A4 The most representative plants are *Cunninghamia lanceolata*, *Cerasus pseudocerasus*, *Rhododendron simsii*, *Rubus*, *Hydrangea strigosa*, *Artemisia argyi* and *Senecio scandens*. A5 The most representative plants are Cunninghamia lanceolata, *Cyclobalanopsis glauca*, *Cerasus pseudocerasus*, *Loropetalum chinense*, *Rubus*, *Cyperus rotundus*, *Artemisia argyi*, etc. There are more species. Combined with the statistical analysis in **Table 2**, these 14 plants all account for a relatively high proportion in the community, which can play a good role as the main species in the community.

Table 2. Statistics of main plant species on slope of vegetation succession age groups.

Plant life form	stage of succession									
	A1		A2		A3		A4		A5	
	Species and Latin name	Quantity ratio	Species and Latin name	Quantity ratio	Species and Latin name	Quantity ratio	Species and Latin name	Quantity ratio	Species and Latin name	Quantity ratio
arbor	*Cunninghamia lanceolata*	5%	*Cryptomeria japonica*	9.3%	*Cunninghamia lanceolata*	9.3%	*Cunninghamia lanceolata*	5%	*Cunninghamia lanceolata*	28.9%
	Cerasus pseudocerasus	5%	*Cunninghamia lanceolata*	8%	*Cryptomeria japonica*	8%	*Cerasus pseudocerasus*	5%	*Cyclobalanopsis glauca*	1.3%
	Rhododendron simsii	1.7%	*Cyclobalanopsis glauca*	2.7%	*Castanea mollissima*	2.7%	*Rhododendron simsii*	1.7%	*Cerasus pseudocerasus*	1.3%
	Garuga pierrei	1.7%	*Rhus chinensis*	1.3%	*Cerasus pseudocerasus*	1.3%	*Garuga pierrei*	1.7%	*Magnolia officinalis*	1.3%
Bush	*raspberry Rubus sp.*	20%	*Hydrangea Strigosa*	18.7%	*Coriaria nepalensis*	18.7%	*raspberry Rubus*	20%	*Loropetalum chinense*	6.6%
	Hydrangea Strigosa	5%	*Rubus tephrodes*	10.7%	*Debregenasia edulis*	10.7%	*Hydrangea Strigosa*	5%	*Rubus sp.*	2.6%
	Buddleja lindleyana	3.3%	*Camellia sinensis*	4%	*Hydrangea Strigosa*	4%	*Buddleja lindleyana*	3.3%	*Mahonia fortunei*	2.6%
	Rosaroxburghii	3.3%	*Hypericum monogynum*	2.7%	*litsea pungens*	2.7%	*Rosaroxburghii*	3.3%	*Rubus tephrodes*	1.3%
Herbal	*Pilea notata*	8.3%	*Polygonum chinensis*	8%	*Anemone vitifolia*	8%	*Pilea notata*	8.3%	*Cyperus rotundus*	17.1%
	Artemisia argyi	6.7%	*Stellaria media*	5.3%	*Leontopodim leontopodioides*	5.3%	*Artemisia argyi*	6.7%	*Artemisia argyi*	7.9%
	Cardamine hirsuta	6.7%	*Artemisia argyi*	2.7%	*Erigeron annuus*	2.7%	*Cardamine hirsuta*	6.7%	*Erigeron annuus*	3.9%
	Senecio scandens	5%	*Portulaca oleracea*	2.7%	*Youngia japonica*	2.7%	*Senecio scandens*	5%	*Senecio scandens*	3.9%
	Lysimachia christinae	5%	*Pilea notata*	2.7%	*Saccharum spontaneum*	2.7%	*Lysimachia christinae*	5%	*Youngia japonica*	3.9%
	Setaria palmifolia	5%	*Artemisia argyi*	2.7%	*Artemisia argyi*	2.7%	*Setaria palmifolia*	5%	*Stellaria media*	3.9%

4.2. Plant Resources and Their Changes in Different Age Groups of Vegetation Succession

The results of pteridophytes show (**Table 3**): There are 11 species of pteridophytes belonging to 7 families, 8 genera in Hongchun Gully, Yingxiu town, among which sample plots A4 and A5 are the most abundant, accounting for 63.64%, 66.67%, 68.75%, 54.55%, 50% and 43.75% of the total respectively. The plots A1 and A2 are the second, with 6 species in 4 families, 4 genera and 5 species in 4 families, respectively. The plot A3 is the least, with only 1 species in 1 family, 1 genus (Table 3).

The survey results of gymnosperms show (Table 3) that there are 2 gymnosperms belonging to 2 families, 2 genera and 2 species in Hongchun Gully, Yingxiu town, and only 2 families, 2 genera and 2 species of gymnosperms are distributed in plots A4 and A2, namely *Cryptomeria japonica* and *Cunninghamia lanceolata*, accounting for 66.67% and 50% of the gymnosperms belonging to 3 families and 4 genera in Hongchun Gully. There is only one species of *Cryptomeria japonica* in plots A1, A3 and A5, accounting for 33.33% and 25% of the gymnosperms belonging to 3 families and 4 genera.

The survey results of angiosperms show (Table 3) that there are 101 species of angiosperms belonging to 86 genera in 52 families in Hongchun Gully, Yingxiu town. Among the four age groups of damaged landslides with different ages, the A4 plot with the longest succession time has the richest species of angiosperms, with 101 species belonging to 86 genera in 52 families. Followed by A3, with 64 species belonging to 51 genera and 23 families; In addition, there are 49 species in 44 genera of 26 families in plot A2. Finally, plot A1, with 19 families, 28 genera and 32 species, decreased in turn; It shows that the longer the succession time, the richer the angiosperm species on the landslide and the better the vegetation restoration. At the same time, the survey also found that there were 39 species of angiosperms belonging to 31 families, 38 genera in the undamaged plot A5. Not only is it not the most abundant, but it is also poorer than A4, A3 and A2 landslide sample plots, but A5 sample plot is second only to A4 sample plot at the department level. Combined with the number of vascular plant species in Yingxiu landslide succession age group, it is found that A4 and A5 sample plots are the most abundant, which further shows that with the extension of natural succession time of vegetation, vascular plant species are increasing synchronously without external geological disasters and human activities, and the vegetation restoration on the landslide is more perfect.

It can be seen from Table 3 that with the extension of succession time, the number of pteridophytes has increased from the initial 4 families, 4 genera and 6 species to the last 7 families, 8 genera and 11 species, and the number of families, genera and species has nearly doubled. Gymnosperms are relatively stable in several stages, with little change and no obvious growth trend. The angiosperms changed obviously in four stages, and the number of families increased from 19 to 52, an increase of 173.68%. The number of genera increased from 28 to 86, an increase of 207.14%; The number of species increased from 32 to 101, an increase of 215.63%; The number of species in the last three stages (A2, A3 and A4) with longer succession time is 49, 64 and 101 respectively, showing a steady growth trend, which is 1.53, 2.00 and 3.16 times of the number of species in the initial stage (A1) respectively, showing a rapid growth trend.

Table 3. Changes of plant families, genera and species in different successive year groups in Hongchun Gully, Yingxiu Town.

Stage of succession	Pteridophyte			Gymnosperm			Angiosperm		
	Number of subjects	Genus number	Number of species	Number of subjects	Genus number	Number of species	Number of subjects	Genus number	Number of species
A1	4	4	6	1	1	1	19	28	32
A2	4	4	5	2	2	2	26	44	49
A3	1	1	1	1	1	1	23	51	64
A4	7	8	11	2	2	2	52	86	101
A5	6	6	7	1	1	1	31	38	39

4.3. Vegetation Characteristics of Different Vegetation Succession Age Groups

The plant community composition of different landslide succession age groups is obviously different (Table 4), and it is also different from that of undamaged sample plots:

1) The sample plot A1 with the shortest succession time: the tree layer is dominated by the mixed forest of *Cryptomeria japonica*, *Cunninghamia lanceolata* and *Cerasus pseudocerasus*; In the shrub layer, *Debregenasia edulis*-*Hydrangea strigosa*-*Coriaria nepalensisca*-*Buddleja lindleyana* is the constructive species or dominant species; The herb layer is dominated by *Anemone vitifolia*-*Leontopodim leontopodioides*-*Erigeron annuus*.

2) The sample plot A2 with the middle and shortest succession time: the tree layer is dominated by the mixed forest of *Cryptomeria japonica*, *Cunninghamia lanceolata* and *Cyclobalanopsis glauca*; The shrub layer is dominated by *Hydrangea strigosa*-*Rubus tephrodes*-*Camellia sinensis*; The herb layer is dominated by *Polygonum chinensis*-*Stellaria media*-*Festuca ovina*-*Pilea notata*.

3) Sample plot A3 with middle succession time: the tree layer is dominated by mixed forest of *Cryptomeria japonica*-*Cunninghamia lanceolata*-*Rubus tephrodes*; The shrub layer is dominated by *Rubus*; The herb layer is dominated by *Gynura divaricata*-*Artemisia argyi*.

4) The sample plot A4 with the longest succession time: the tree layer is dominated by the mixed forest of *Cunninghamia lanceolata* and *Cerasus pseudocerasus*; The shrub layer is mainly *Rubus*-*Hydrangea strigosa*; The herb layer is dominated by *Pilea notata*-*Artemisia argyi*.

5) undamaged plot A5: The tree layer is dominated by mixed forest of *Cunninghamia lanceolata*, *Cyclobalanopsis glauca*, *Cerasus pseudo Cerasus* and *Magnolia officinalis*; The shrub layer is dominated by *Loropetalum chinense*-*Rubus*-*Camellia sinensis*; The herb layer is dominated by *Artemisia argyi*-*Erigeron annuas*-*Senecio scandens*.

5. Conclusion and Discussion

After the Wenchuan earthquake in 2008 and the debris flow in 2010, there were 110 species of plant communities in 61 families, 96 genera in the landslide

Table 4. Vegetation characteristics of different successive year groups in Hongchun Gully.

Succession stage	Plant composition			Formation	Vegetation form
	arbor	bushwood	herbal		
A1	*Cunninghamia lanceolata* + *Cerasus pseudocerasus*	*Rubus* + *Hydrangea strigosa* + *Buddleja lindleyana* + *Rosaroxburghii.*	*Pilea notata* + *Festuca ovina* + *Lysimachia christinae*	*Cerasus* pseudocerasus; *Cunninghamia lanceolata* forest *Buddleja lindleyana* shrub; *Rubus* bush; *Buddleja lindleyana*, *Hydrangea strigosa-Raspberry* Shrub *Artemisia argyi* grass; *Lysimachia christinae* grass	Deciduous leaves of needles in low mountains; Broad-leaved mixed forest; Low mountain deciduous broad-leaved forest; Deciduous broad-leaved shrubs in mountainous areas; Mountain grass grass; Mountain fern grass;
A2	*Cryptomeria japonica* + *Cunninghamia lanceolata* + *Cyclobalanopsis glauca*	*Hydrangea strigosa* + *Rubus tephrodes* + *Camellia sinensis*	*Polygonum chinensis* + *Stellaria stellata* + *Festuca arundinacea*	*Cryptomeria japonica* forest *Rubus* bush; *Hydrangea strigosa-Raspberry* shrub; *Camellia sinensis* bush *Stellaria media* grass	Deciduous leaves of needles in low mountains; Deciduous broad-leaved shrubs in mountainous areas;
A3	*Cryptomeria japonica* + *Cunninghamia lanceolata* + *Castanea mollissima* + *Cerasus pseudocerasus*	*Coriaria nepalensis* + *Debregenasia edulis* + *Hydrangea strigosa*	*Anemone vitifolia* + *Artemisia argyi*	*Cryptomeria japonica* forest; *Cunninghamia lanceolata* forest; *Castanea mollissima* forest; Bamboo forest *Debregenasia edulis* shrub; *Coriaria nepalensis* shrub *Anemone vitifolia* grass; *Leontopodim leontopodioides* grass	Low mountain evergreen coniferous forest; Low mountain deciduous broad-leaved forest; Mountain grass grass; Mountain fern grass;
A4	*Cryptomeria japonica* + *Cunninghamia lanceolata* + *Castanea mollissima* + *Cerasus pseudocerasus*	*Rubus* + *Hydrangea strigosa*	*Artemisia argyi* + *Pilea notata*	*Cunninghamia lanceolata* forest; *Cryptomeria japonica* forest *Rubus*, *Hydrangea strigosa-Raspberry* shrub *Artemisia argyi* grass	Low mountain evergreen coniferous forest; Deciduous broad-leaved shrubs in mountainous areas;
A5	*Cunninghamia lanceolata* + *Cyclobalanopsis glauca* + *Cerasus pseudocerasus* + *Magnolia officinalis*	*Pterocarya rubra* + *Rubus* + *Camellia sinensis* + *Rubus tephrodes*	*Cyperus rotundus* + *Artemisia argyi* + *Erigeron annuus*	*Cunninghamia lanceolata* forest; *Cyclobalanopsis* forest *Rubus* bush; *Camellia sinensis* bush *Artemisia argyi* grass	Deciduous leaves of needles in low mountains; Deciduous broad-leaved shrubs in mountainous areas;

surveyed in the field, among which *Cryptomeria fortunei*, *Cunninghamia lanceolata* and *Cerasus pseudocerasus* were the dominant species in the arbor layer, *Cunninghamia lanceolata* was distributed in all five plots, and *Cryptomeria fortunei* was distributed in A1, A2 and A3. Cerasus pseudocerasus is distributed in A1, A3, A4 and A5; *Rubus*, *Rubus glabra* and *hydrangea strigosa* are the dominant species in the shrub layer, among which Rubus is distributed in A2, A3, A4 and A5; *Rubus tephrodes* is distributed in A2, A3 and A5. *Hydrangea strigosa* is distributed in A1, A2 and A4; *Artemisia argyi* and *Pilea notata* are the dominant species in herb layer, among which *Artemisia argyi* is distributed in five regions, and *Pilea notata* is mainly distributed in A2 and A4. The plant community on the Hongchun Gully landslide is gradually undergoing community succession, and the vegetation is gradually recovering naturally.

There are a large number of loose gravel on the surface of the secondary disaster site caused by the earthquake (Huang, Han, Tang et al., 2017), which is insufficient in soil nutrients, low in soil fertility, low in water retention capacity and high in soil erosion, which is not conducive to vegetation restoration. Through the analysis of the main species on the landslide in different age groups of vegetation succession, it can be known that the main plants on the landslide are composed of trees and herbs, and the ground cover layer has not yet developed, and the shrub layer is the main level of the community at present. According to the field sampling, there are slight differences in vegetation development in each succession stage. The plots A3, A4 and A5 are all tall trees, while the vegetation in the tree layer of plots A1 and A2 is still in the seedling stage. As can be seen from **Table 4**, there are also some differences in vegetation types of each successive age group. There are large coniferous broad-leaved forests and deciduous broad-leaved shrubs in plots A2, A3, A4 and A5. A1 plot is the youngest succession plot, with a large number of grasses and ferns, and a small number of coniferous broad-leaved forests and shrubs. Combined with the study of vegetation restoration on Xiejiadian landslide (Wu, He, Yang et al., 2019), it shows that in the early stage of restoration from 2009 to 2014, the vegetation is mainly herbaceous, and the vegetation species recover quickly; In the late recovery period from 2015 to 2018, the plant community has undergone succession, and the single community structure dominated by herbs has gradually changed to a balanced and stable community structure of trees, shrubs and grasses, and the succession is always in the direction of strong adaptability. The vegetation succession on the landslide body is basically consistent with the classic three stages: herb stage, shrub stage and tree stage. Due to the Wenchuan earthquake in 2008 and the catastrophic mudslide in 2010, the vegetation on the landslide is mainly shrub grass.

Specifically, the A1 plot is the youngest landslide vegetation, and the latest plants after the landslide are mainly herbs, with an overall coverage of 13%. The soil in this sample plot contains more particles, the particle size is larger, there are larger sandstone stones exposed, the slope is steep and the soil is loose. There is a mountain stream flowing in the middle section, and the soil moisture near the mountain stream is high and there are many plants; Wild *Eleusine indica* herb is the dominant species, and the rape left by artificial planting also has a certain distribution; Far away from the mountain stream, the soil moisture is low, the water content is less, the vegetation is sparse and there is rockfall. Sample A2 is a relatively young landslide, with trees as the main part and abundant grass. Trees mainly include *Cryptomeria japonica*, *Cunninghamia lanceolata* and *Cyclobalanopsis glauca*, shrubs mainly include *Hydrangea strigosa*, *Rubus tephrodes* and *Camellia sinensis*, and herbs include *Charcoal*, *Stellaria stellata* and *Festuca arundinacea*. Sample A3 is a landslide with a middle succession time, located in the valley, with good vegetation growth, high soil water content, well-developed topsoil, more tree species and abundant shrub grass. On the left is an artificial forest (*Cunninghamia lanceolata* forest planted in about 82 years), with few vegetation and scattered *Camellia sinensiss* along the road. Sample A4 has been in succession for nearly 35 years under natural conditions, with more humus (litter layer), deeper soil layer, higher soil organic matter, stronger fertility, lower slope and relatively gentle; Mainly tall trees, the undergrowth is rich in species, and the diversity of trees, shrubs and grasses is rich, with a total vegetation coverage of 80% and about 74 plant species.

Through the comparative analysis of vegetation composition in different vegetation succession years, it is found that the vegetation damage and recovery caused by earthquake in Hongchun Gully of Yingxiu town is relatively good, and herbs are still dominant in the early stage of succession, shrubs and herbs are dominant in the middle stage of succession, and trees are dominant in the late stage of succession. The longer the succession time, the more plant species, the richer the vegetation and the better the vegetation restoration. With the natural succession of landslide, the community structure becomes more and more complex, and its stability becomes stronger and stronger. Because this area belongs to the typical ecological fragile area after the earthquake, the landform conditions are complex, the geological tectonic activities are still active, and the slope stability is poor. However, because the climatic conditions and precipitation are suitable for the growth of local plant species and human disturbance activities are completely prohibited, it is suggested that natural vegetation restoration should be the main thing in this area in the next five years. At the same time, fully considering the topographic conditions of different landslides in Hongchun Gully, for some accumulations with loose topsoil and steep slope, it is not only not conducive to the artificial planting of vegetation, but also has problems in plant survival rate and regeneration; However, for landslides along the banks of the ditch and with gentle slopes, artificial forests can be planted appropriately to assist vegetation restoration in the area when the soil thickness is richer under natural action; At the same time, the selection of specific plantation vegetation species needs to pay special attention to the ecological suitability, pioneer and environmental stress adaptability of species.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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