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Fertility Effects of Retained Trees with Vegetation Development on Landslide Area

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ABSTRACT
Typhoon Aere, of Taiwan in 2004, caused landslides of Shihmen reservoir watershed of Sule creek, and this damaged area was recovered with hydro-seeding vegetation engineering forming three retained trees island on the slopeland in 2006. This study investigated the fertility effect of retained trees for vegetation development on landslide area. The relevant results that the Rhodes grass is the dominant plant and near the three retained trees area, 192 trees for 18 species, which sources of seeds are carried and spread by wind and wildlife, increases in this landslide area from 2006 to 2013, meanwhile, the tree island is getting formed. The three trees islands change micro-climate, and they gather nutrients and moisture as much as possible so that the vegetation community could develop from tree island area to external side gradually.
Keywords **-** retained trees, landslide area, vegetation community, trees islan;

I. INTRODUCTION

Trees Islands is a very popular topic in the recent years. Especially in desert, wetland and tundra zone, the trees islands are seldom discussed the importance on the landslide regulation (〔1〕). Due to the dry weather, steep slopeside, thin soil layer, and serious erosion, such living situations give the disadvantage for plant growth and the development of vegetation community. In this study, we select the landslides of Shihmen reservoir watershed of Sule creek as the research site to investigate the evolution of this vegetation community from 2004 to 2013 (see Fig. 1) and, meantime, based on the micro-climate from retained trees, the three trees islands they gather nutrients and moisture as much as possible so that the vegetation community could develop extensionally.

II. RESEARCH METHODS

The landslides, with land slope about 60°, and area 1.32 hectares, of Shihmen reservoir watershed of left bank of Sule creek (Taiwan 7th line, station 42K) was caused by Typhoon Aere in 2004. 40％ of the geological compositions are argillite, sandstone-shale, and sandstone of Oligocene Tatungshan Formation. The three retained trees are *Celtis formosana hayata, ficus superba*, and paper mulberry. The hydroseeding copes with mixed plant seeds, including *Sesbania cannabiana, Chloris gayana, Axonopus affinis, Cynodon dactylon,Koelreuteria henryi, Acacia confuse, Roxburg hiana, Lespedeza cuneata,*


(1)2005.11.11 Landslide after one year


(2) 2006.6.3 Retained trees
Lespedeza bicolor, and Cosmos sulfureus.


(3) 2006.6.22 On engineering regulation

(4) 2008.9.17 Straw growing

(5) 2012.9.19 Trees Islands

(6) 2013.3.6 Vegetation community

Fig. 1 Variation of Vegetation community

In order to recognize the physical and chemical properties of the landslide area, we divide the area into three subareas as trees island, tree-straw mixed and straw. For the deep investigation of the trees island, three zones indexed as A, B, and C respectively (see Fig. 2). Sampling the soils from these 5 zones with thickness 10-15cm, we screen the samples with a sieve to separate the stones away. 200 grams of soil each are sent to analyze the contain quantities of organic carbon (OC), nitrogen (N2), nitric acid-nitrogen (NAN), and ammonium-nitrogen (AN).

Fig. 2 Sampling Sites

To research the plant group space distribution in this 611m^2 area, three methods, such as distributions of random, uniform and group, are used. LAN Guo-yu, *et al*,(〔2〕) calculated the phenomena by Spatial Dispersion Index-SDI by 0.2m grids with the following equation:

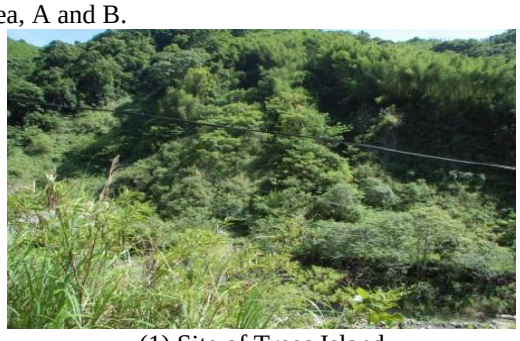
$$\mathrm{SDI} = \frac{1}{\sqrt{A}}\frac{1}{2(n-1)}\sum_{i=1}^{n}\sum_{j=1}^{n}(\alpha_i\% + \alpha_j\%)\bar{d}_{(i,j)} \quad \text{……..(1)}$$

where $\alpha_i\%$、$\alpha_j\%$ =i、j are the percentage of occupied areas of separated plants. A= is the area of selected plant SDI shows the distribution situation with the range from 0 (high gathering density) to 1 (high dispersion).

The structure of stand for both trees island and the surroundings is the other index to be studied. The diameter breast height, DBH, for different plants in the trees inland is measured based on the definition of America Forest Inventory and Analysis Program which defines the diameter is obtained at the position above the ground 130 cm. Because the woody tree is usually mixing in the trees island, the maximum diameter is recorded when the branches exist. Whether does the structure of stand in the trees island have any relationship with the surrounding in the case of no disturbance or not? We need to give investigations on the zones of trees island, straw area, and forest (see Fig. 3) representatively. With 10m grids, the similarities of the structure of stand can be calculated with importance value index-IVI of Motyka, which is different from the method of Jaccard and Sorensen with only paying attention to the kinds of plants but not the quantities. The equation is shown as: I

$$IS_{MO} = \frac{2M_w}{M_A + M_B} \times 100 \quad \text{……(2)}$$

In which, M_A, the IVI of plants in measured area, A; M_B, the IVI of plants in measured area, B; M_w, the minimum IVI of common plants in this two measured area, A and B.



(1) Site of Trees Island

(2) Straw Land

(3) Around of Forest

Fig. 3 Vegetation community of Each Site

III. RESULTS OF THIS STUDY

Applying fertilizer uniformly spreading on the net-covered trees island in 2006, the surface soils was taken to test for analyzing the fertilizer ingredients on December 2012. The results are as followings (see Table 1):

Table 1 Fertilizer ingredients and moisture in different zones

Items	Zone A	Zone B	Zone C	Straw-forest	straw
OC (%)	6.29	13.0	11.3	5.57	5.97
N2 (%)	0.525	0.807	0.741	0.444	0.489
NAN (mg/kg)	15.6	29.6	24.9	13.6	14.8
AN (AN(mg/kg)	33	48.6	47.4	27.8	31
OC/N2(mg/kg)	12	16.1	15.2	12.5	12.2
Moisture (%)	2	35	41	32	18

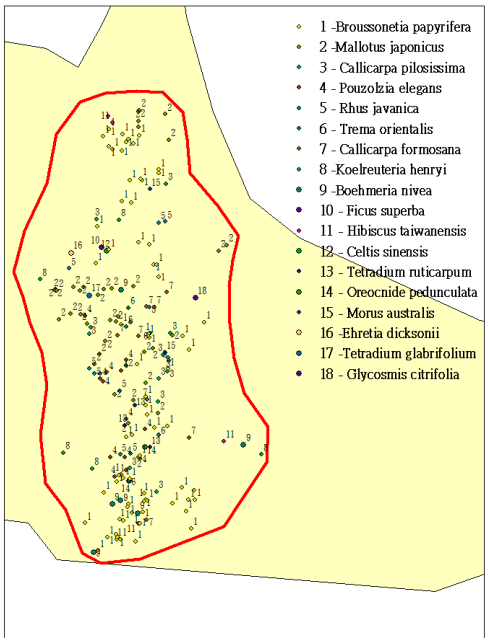
Remark: Sampling sites seen in Fig. 2

Five items are researched and the corresponding results are also shown in Table 1. The trees island is the cluster zone of fertilizer ingredients and moisture, and gradually decreasing to the outside and OC/N2 are less than 20, while the forest zone has the largest OC/N2 ratio (〔3〕, 〔4〕) due to the putrid degree of the land surface on the zone of forest reducing with the increasing of the withered leaves and bough, at the meantime, the putrid degree of the deep land on the zone of forest adding. The plant group has the function of collecting fertilizer and moisture (〔5〕, 〔6〕). The infertile zone can accumulate the fertilizer and moisture from trees island to improve itself (〔7〕). Trees island, oval-shaped 40m long along the land side-slope and with width of 15m as Fig. 4, presents the plant group distribution with 18 kinds of woody plants, and *Japaneese Mallotus* and *Celtis formosana hayata* are the high priority potential plants with the magnitude of SDI 0.2 and 0.14, separately. The SDI of the plant group in trees island is 0.2, in which the values of SDI for *Tetradium ruticarpum*, *Oreocnide pedunculata*, and *Pouzolzia elegans* are 0.46, 0.05, and 0.08, respectively (see Table 2). The retained trees in the region are also increasing from 3 to about 200. The landslide area develops to the property of straw-wood mixed zone.

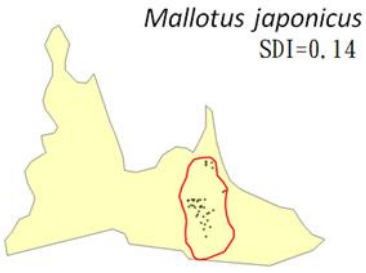
Table 2 The values of SDI of woody plants in trees island

1 B.p.	2 M.j.	3 C.p.	4 P.e.	5 R.j.	6 T.o.	7 C.f.
0	0	0	0	0	0.0458	0.0505
8 K. h.	9 B.n.	10 F.s.	11 H.t.	12 C.s.	13 T.r.	14 O.p.
0.08	0.1096	0.1156	0.1296	0.1367	0.1408	0.1592
15 M.a.	16 E.d.	17 T.g.	18 G.c.	Average		
0.1799	0.1903	0.2378	0.3242	0.1719		

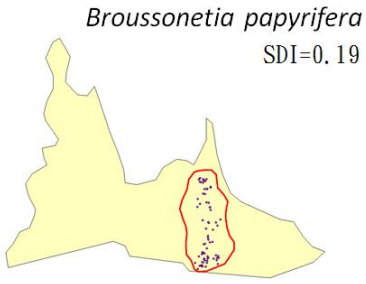
The distribution of woody plants is presented in Fig. 4. The abbreviations in Table 2 can be referenced in Fig. 4 (1). Measurements of woody plant diameters express three kinds of distribution curves, named anti J-shape, J-shape, and bell-shape. Here, anti J-shape gives that there are full of juveniles for easily making replacements to get with the circumstance. Fig. 5 gives us the diameters structure of the stands in the



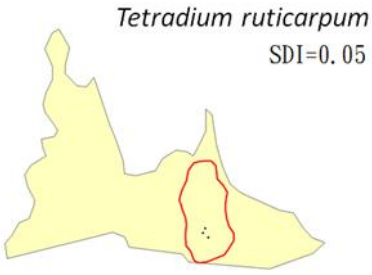
(1)Profile of distribution of woody plants



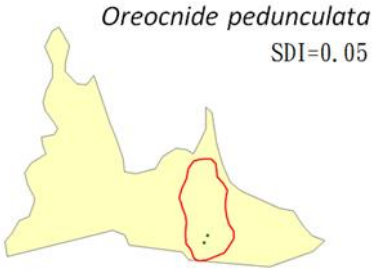
(2) SDI of *Mallotus japonicus*



(3) SDI of *Broussonetia papyrifera*



(4) SDI of *Tetradium ruticarpum*



(5) SDI of *Oreocnide podunculata*

Fig. 4 Tree Distributing Situation on Tree Islands

trees island, and Fig. 6 presents the distribution curves which are shaped anti J- curve, especially *Mallotus japonicas* and *Broussonetia papyrifera*.

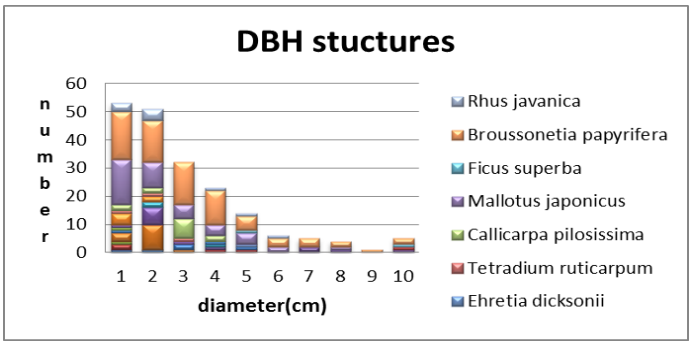
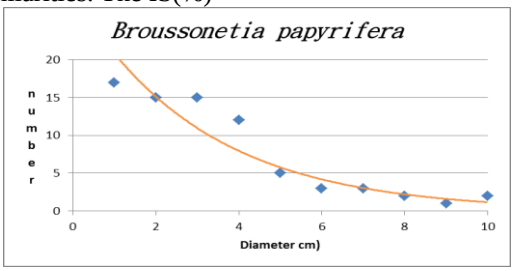
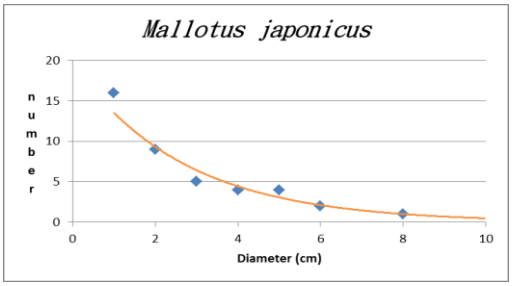


Fig. 5 Diameters structure in the trees island

Comparing the similities of plant group among trees island, atraw area, and forest zone, there composes 8 dominant plants and *Chloris gayana* owns the most priority. The 34 plant compositions is located in trees island, while 56 kinds of plants are in the forest zone.The results of the investigation is given in Table 3 with the IVI values and the similarities. The IS(%)



(1)Anti J-shaped of Broussonetia papyrifera



(2)Anti J-shaped of Mallotus japonicus

Fig. 6 Diameter distribution of dominant plants

is 0 for straw area and the forest region because of the extreme plant properties tending to sunshine or not . The value of IS(%) for trees island and straw area is 22.86% which is higher than that one for trees island and forest , 13.35%, and it means the development of trees island has not much relationship with forest region. The development at the beginning has obvious mutual competition between island zones and straw area (〔8〕), and also the complication of forest, at the meantime, using Motyka index as the measuring tool is another reason. Based on the strong priority for the environmental adaption of *Chloris gayana*, The value of IS(%) for trees island and straw area becomes significant.

Table 3. The IVI value for different plants and positions

Plant Name	Straw	Tree Island	Forest Around
Chloris gayana	62.27	12.72	
Bidens pilosa	58.14	10.85	
Boehmeria nivea	32.04	10.85	
Miscanthus floridulus		8.44	1.93
Trema orientalis		4.71	3.23
Toddalia asiatica		4.58	5.16
Macaranga tanarius	7.36	4.57	
Koelreuteria henryi	18.86	4.30	
Celtis sinensis		4.14	3.75
Polygonum multiflorum		4.02	2.82
Glochidion rubrum Blume		4.02	1.41
Lophatherum gracile		3.29	1.54
Alpinia zerumbet		2.86	5.79
Davallia mariesii		2.58	3.08
Clematis crassifolia	7.11	2.43	
Litsea hypophaea		2.15	6.33
Carex baccans		2.01	3.21
Remark：The above numbers are IVI indexes			
Straw and Forest IS (%)			0%
Straw and Tree Island IS (%)			22.86%
Tree Island and Forest IS(%)			13.35%

IV. CONCULUSIONS

The trees island on the landslide is similar to that on the harsh geological area internationally. The plants on the trees island have the abilities to improve the abominable environments into better situations for the new plant group growing up. The fertility and moisture, gradually reducing to the outside region, of the trees island is obviously higher than that of straw area. The distribution density has strong relationship with fertility and moisture of the soil layers. The mainly plant group is under the original, or called old trees, and this may due to the landside slope direction, which is different to other research result of wind direction. There is no significant similarity to the forest zone, this is because the forest region has no plant kept for covering. The geographical condition, better than that of forest region, is suitable for plant growing and this is also one of the important factors for the development of plant group. Three efficiencies and effects are presented by comparing the soil fertility, composes of plant group, and the similarities with that of the surrounding : (1) Sheltering from shade of high tree, the soil layers easily get the fertility and moisture for supporting the plant growth, and the grown plant can reinforce the erosion resistance of the land; (2) Highly concentrated trees island is able to supply a seedling for preparing the development of the dominant plants; (3) The similarity between trees island and forest region, and it is because trees island can reduce the wind speed resulting in the wind-blowing seeds down on the land, and also the seeds from birds while they are resting on the trees.

V. ACKNOWLEDGEMENTS

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