RELATIONSHIP BETWEEN PLANT SPECIES DIVERSITY AND SOIL EROSION ON DIFFERENT SECONDARY SUCCESSION PHASES OF A SEMI-HUMID EVERGREEN BROAD-LEAVED FOREST

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Abstract
The different secondary succession phases of semi-humid evergreen broad-leaved forests covering different species diversity were chosen to study relationship between plant species diversity and canopy interception, soil erosion, surface runoff and phosphorus erosion at runoff plot scales. The conclusions indicated that plant diversity resulted in hygroscopic water increase and improved the canopy hydrological effect of plant communities and that plant diversity acted on surface runoff and soil erosion control depending on the improvement of canopy interception, soil penetrability and erosion resistance. Plant diversity was also able to reduce the risk of phosphorus releases in runoff. So, plant diversity was verified indirectly to improve ecosystem productivity, sustainability and stability.

Additional Keywords: plant species diversity, canopy interception, runoff, soil and total phosphorus erosion

Introduction
The most striking feature is the existence of life, and the most striking feature of life is it's diversity. Biodiversity of Earth' s ecosystem has been reducing continually for human beings' domination of the earth and it is very urgent for human beings to understand ecosystem functioning of biodiversity (Vitousek, 1997; Tilman, 2000). Primary productivity of ecosystem is the most important ecosystem functioning of biodiversity. But ecologists have had different points of view if biodiversity will result in the primary productivity of ecosystem for a long time because there were not "over-yielding effect" for ecosystems that had many species than one that had one species in model ecosystem, and there was no consistent effect of biodiversity on productivity in natural ecosystem else. The direct check of the effects of biodiversity on productivity of ecosystem has reached an impasse (Huston, 2000; Loreau, 2001). However, soil erosion will give rise to degradation of ecosystem productivity regardless of simple or diverse ecosystem, which has been verified by many scientists early. Logically, the effect of plant species diversity on productivity of ecosystem will be testified indirectly as long as plant diversity acts directly on soil conservation (Williams, 1983). Moreover the research is helpful to us to understand the effect of biodiversity on warm-house effect (Schlesinger, 1997).

David Tilman inferred that plant diversity would produce decreasing functioning of nutrient leaching based on the data that content of soil nutrients increased continually with plant species richness of ecosystem. But soil erosion volume of ecosystem had not been determined directly with gradient change of species richness in past (Naneem, 1994; Tilman 1996). So, different secondary succession phases of semi-humid ever-greenbroad -leaved forest, CMET (*Elsholtzia fruticosa Vaccinium fragile , Ternstroemia gymnanthera, Imperata cylindrical,Comm.*), PYC(*Pinus yunnanensis ,Myrsine africana, Oplismenus compsitus* Comm.), PYKC(*Pinus yunnanensis,Keteleeria evelyniana, Cyclobalanopsis glaucoides* Comm.), SMC(*Eucalyptus Smith, Myrsine africana, Oplismenus compsitus* Comm.), CLKC(*Cyclobalanopsis glaucoides,Lithocarpus dealbtus,Keteleeria evelyniana* Comm.) were chosen as research material to check the effects of plant diversity on soil and water erosion for plant species richness shows gradient change in succession process of plant community. The following questions are addressed, ie. what are relationships between plant species diversity and canopy interception, soil surface runoff and erosion, total P erosion, when slope degree, slope position and soil type were controlled based on choosing.

Method
Canopy interception
Spiral channels techniques ware used to observe canopy interception traditionally. It will be very troublesome for the method to be used to evaluate the effect of plant diversity on canopy interception. In present work, the determination of hygroscopic water of leaves replaced canopy interception. Hygroscopic water of leaves and branch is rainwater adhered on leaves in rain, which is most of canopy interception except the minority of rainwater evaporating from the leaves in rain. It should be able to reflect the canopy interception. After samples of leaves were collected and weighed, they were put on the tela awning put up by wood frame. Water were sprinkled on them by sprayer to wet through their surface when turn over them again and again. Wet samples were weighed as water drips did not drop down from the tela awning and hydroscopic rate of samples of leaves was calculated with the fomula, $P_{il}=(S_w-S_h)*100/S_h$. In the formula, P_{il}, hygroscopic water rate of fresh sample of certain organ; S_w,

weight of fresh sample of certain organ wet through by water; S_h, weight of fresh sample of certain organ before wet through by water. Hydroscopic water rate of herb layer was calculated based on the mixed samples of leaves. After fresh standing crop of arbor, bush and herb layers were respectively determined by relative growth method and cropping method, hydroscopic water volume of every species of arbor and bush layer and gross hydroscopic water volume of herb layer were calculated according to hydroscopic water rate of plant organ of every species and mixed samples of herb layer. Effects of plant species diversity on canopy interception were evaluated by above-mentioned findings.

Surface runoff
Runoff plots (40 m ×10 m) were built on the secondary succession phases that plant species richness changed gradient. Plastic film was put on the inner surface of the boundary wall of plots under ground and pressed tightly with loose soil for the prevention of penetration on the two sides. Runoff volume were calculated by water table parameters observed by limnimeters that was fitted on angle weir of runoff collecting pool in the lower reaches of runoff plots.

Surface soil erosion and total phosphorus erosion
After runoff process, runoff was stirred fully in collecting pool and sand were mixed fully in runoff. 1000ml of runoff sample was took with layer-runoff sampler and keep them under 2□. Soil erosion volume was determined by weighing method. Total phosphorus was determined by ammonium molybdate spectrophotometric method.

Results and Discussion

Relationship between plant diversity and canopy interception
Hygroscopic water volume of leaves increased with plant species richness gradient in series plots (Figure 1. There was significant relationship between hygroscopic water volume and species richness on woody plant layer (r^2=0.5,p<0.05,n=15), on herb layer (r^2=0.57, p<0.01,n=15). The past research indicated that plant species diversity resulted in intense inter-specific competition in assembled community, and as a result, the ecological niche of plant species was differentiated and plant communities` structure became complex and complex, which increased leaf area index of plant communities (Spehn, 2000). My work supported the points on the data that plant species richness was related positively to fresh standing crop of leaves of plots. Because hygroscopic water of leaves went up with fresh standing crop increases of leaves in series plots, plant diversity resulted in hygroscopic water functioning and improved the canopy hydrological effect of plant communities.

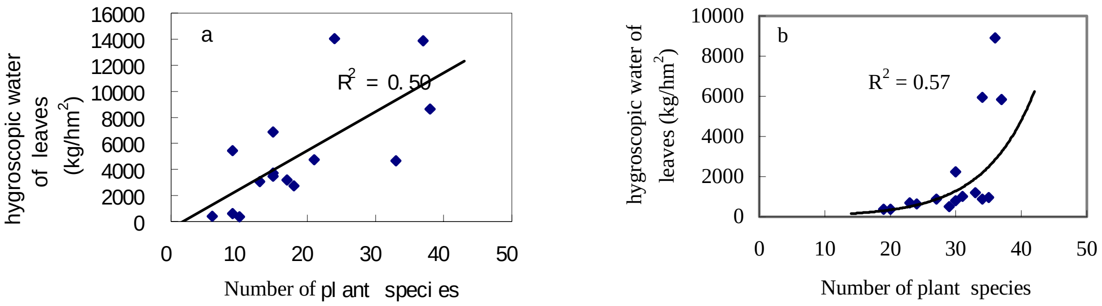

Figure 1. Hygroscopic water change of plant leaves with plant species richness. (a) woody plant layer; (b) herbaceous plant layer

Relationship between plant diversity and surface runoff volume
Surface runoff volume of plots decreased with plant species richness (Fig 2) and the relationship between them showed the negative exponential function on arbor layer (r^2=0.75,p<0.01,n=15),bush layer(r^2=0.44,p<0.01,n=15) and three layers(r^2=0.49,p<0.01,n=15) .Surface runoff volume of plot with 30 species was 10 times more than one of plot with 70 species on arbor-bush-herb layer. Surface runoff volume of plots for PYC was five times more than one of plots for PYKC with the difference of plant richness although the two communities were of same vegetation type. It was worth mentioning that surface runoff volume of plots for CMET with high species diversity was much less than one of plots for PYC with low species diversity, although CMET was regarded as low degree of phase that should not show good ecosystem functioning, and PYC was done as high degree of phase in secondary succession series. Because experiments ware carried out under same precipitation, slope degree, soil type in choosing suitable experimental communities, and vegetation and plant diversity changed gradient, the effects of plant diversity should be able to be discriminated. Plant diversity controlled partly surface runoff depending on the canopy interception

above-mentioned. On the other hand, plant diversity gave rise in the differentiation of ecological niche of root system of plant community else (Wang zhenhong 2002), and may influence the depth and number, root-soil ecological process such as root-soil marginal effect, of root system of plant community, and at last acted on soil penetrability for some experiments verified that soil physical and chemical nature was improved with plant diversity (Ewel J J 1986).

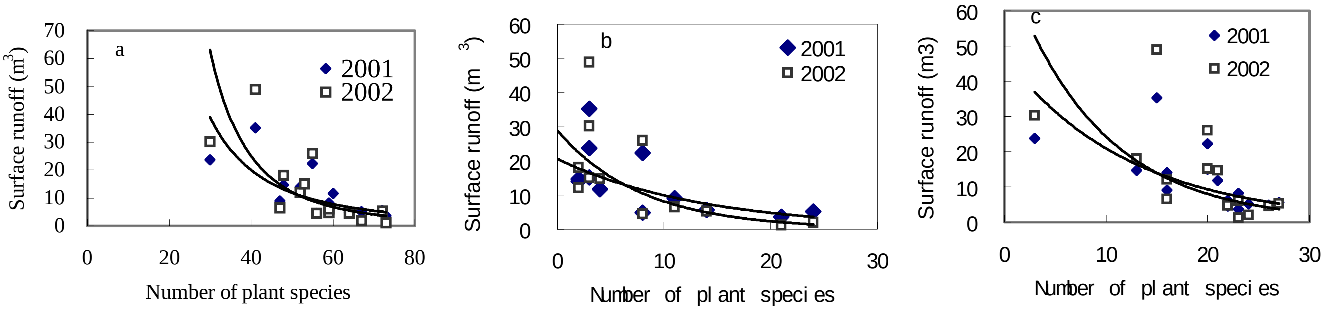

Figure 2. Relationship between surface runoff and plant species richness. (a) arbor-bush-herb layer; (b) bush layer; (c) herb layer

Relationship between plant species diversity and soil erosion
Soil erosion weakened obviously with the species increases and the relationship showed negative exponential function between soil erosion and plant species diversity (Figure 3). When runoff plot had 70-80 of species on arbor, bush and herb layers, there had almost not been obviously soil erosion. Perhaps, the critical species number of runoff plots was distributed among 70-80 on different secondary succession phosphorus of semi-humid evergreen broad-leaved forest. Because plant diversity was able to promote project area and biomass increases of plant communities (Tilman, 1996), and regulate rain process in communities, plant diversity weakened splash erosion on the soil surface. We had reason to infer that soil erodibility may go down in high plant diversity community as well for organic matter content increased with plant diversity and soil structure was improved (Schulze, 1993).

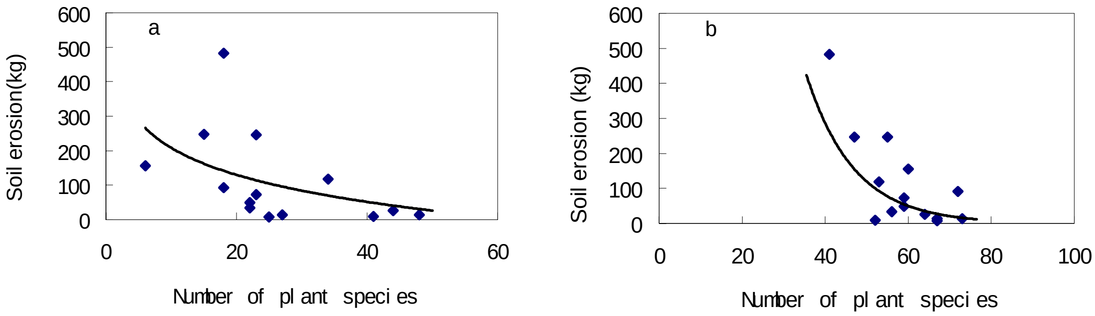

Figure 3. Relationship between soil erosion and plant species richness. (a) woody plant layer and (b) herb layer

Relationship between plant species diversity and erosion of total phosphorus
The power function and exponential function could descript respectively the relationship between total phosphorus erosion and plant species diversity on arbor-bush layer (r^2=0.66,p<0.01,n=15) and arbor-bush-herb layer (r^2=0.18,p<0.1,n=15) based on 31 times of the determination of total phosphorus of runoff from 2001 to 2002. Erosion of total phosphorus on the water-soil boundaries ware influenced by phosphorus fixation capability, available phosphorus content, organic matter content, pH, active Fe and Al content in soil. Phosphorus fixation capability and available phosphorus content of soil were the key factor acting on erosion of total phosphorus among them (Gao chao.2001). Available phosphorus content in surface soil at 10cm depth and total phosphorus content in runoff was obviously more in the CLKC, PYKC that had high species richness than in the CMET, PYC, SMC, that had poor species richness (Xi xiaoyong 2002). The result indicated that soil might release more phosphorus in plant communities with high species diversity. However, there was high organic matter content related to positively phosphorus fixation in surface soil in high species diversity communities and plant species

diversity controlled total runoff volume because of good canopy interception and runoff control effects. So, plant diversity reduced the risk of phosphorus releases to runoff.

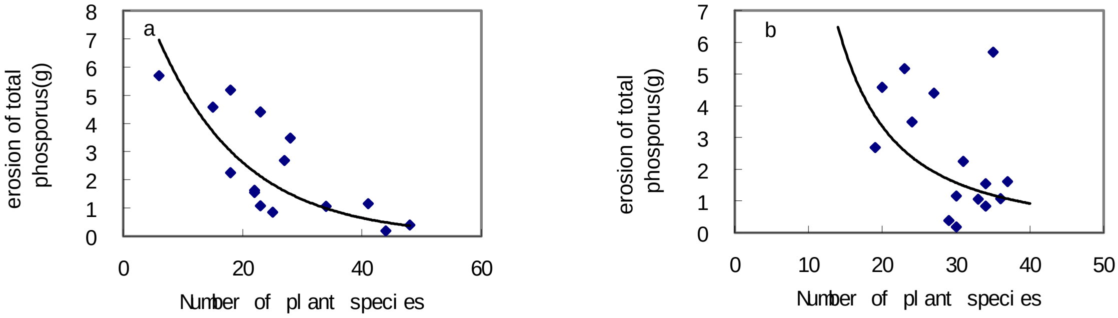

Figure 4. Relationship between erosion of total phosphorus and plant species richness. (a) arbor-bush-herb layer; (b) herb layer

Conclusions

There were positively effects of plant species diversity on controlling of surface runoff, soil erosion, erosion of phosphorus and plant species diversity prevented from the degradation of soil environment. As a result of them, plant diversity resulted in ecosystem productivity, sustainability and stability of ecosystem. Plant species diversity conserved organic carbon pool and obstructed greenhouse effect of the earth else.

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