Evaluation of Ecological Effect in Vegetative Planning for 921 Earthquake's Landslide in Taiwan

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Abstract: The Planning of ecological model is to evaluate the changes scale of temporal and spatial for exploring processes during local biota-dynamic change. This study chooses Suai-Jin area to discuss the ecological indices and to establish ecological model within the artificial and natural vegetation landslide after earthquake. The model of ecology not only applied the ecological patch theory and geostatistics method, but also supported by GIS and FRAGSTATS to enforce the ecosystem analysis of earthquake's landslides.

The results revealed the ecological indices such as invasive plant area, patch size coefficient of variation, mean patch fractal dimension, and mean proximity index that have significant correlation with managing method of landslide. The destruction and recovery of ecological patch also have obvious differences with artificial or natural vegetation landslide. That should be useful for landslide to design ecological method in the future.

Keywords: landscape, patch, geostatistics, eco-heterogeneity

1 Introduction

The consciousness of ecological conservation and the conservation of nature landscape is getting higher and higher. It results in the management of landslide not only pay attention to water and soil conservation, stability of sloping fields, but also consider the ecological efficiency. This is a big challenge and opportunity to Taiwan's landslide that experienced earthquake 921.

Evaluation of the ecological efficiency, usually use indicators animals and plants as references. But landslide plant flock is a heterogeneous. Different managements and scales will cause different constitutions, constructions, functions and dynamic processes. The variety of the natural environment, difference of vegetation consolidation, intrusion of factitious activity, would cause different effect on different time and dimensions. And the variety of the ecological process would also be different. Evaluation of landslide which is used the single direction, is difficult to explain and discuss the complicated process of ecological change and influential mechanism.

In recent years, ecologists point out the study of ecology need calculative ways , such as quantity of space, comparison of topographic position, definition of the disparity, and relativity of index, etc. Use index and calculative way to discuss the pattern, size, shape, long-lost, fractal and difference in the geographic construction.

Lin and Lin (1999) combine geographic information system to discuss the difference in farmland. And analyze changes and ecological meanings of pond landscape by statistics and shape index of patch. Further apply the theory of Patch to establish the hydrological model of watershed ecosystem.

The geographic covariance is also extensive application in the ecosystem, forest plant flock and chemical element of soil contain. Reed (1996) use patch index to discuss changes of the regional construction. Li and Archer (1997), Hainesyoung and Chopping (1996) quantified the forest landscape construction with the index of ecosystem.Obeysckera and Rutchey (1997), use the diversity, fractal

dimension removal rate to discuss the scale of mode, and measure the geographic space diagram of the headwater sanctuary.

Nikora *et al*. (1999) Use autocorrelation of fractal geometry to classify the spatial distribution of patch. Hokit *et al*. (1999) use GIS to discuss the geographic construction, separation of scrub patch, and lizard's distribute. And use variables analyses to analyze the relativity with vegetative density and moving of lizard. Wallace (2000) establishes the model of desert plant by semi-variograms, and compares the difference in space construction of the different category of plant. Bellehumeur and Legendre(1998) discuss the variables degree of ecological variables in different space and scale by semi-variograms and fractal dimension. That we would figure out the way of sampling partition and ecological distribution in different ecological variables.

2 Discussion on the ecological system

Landscape ecology is the science of studying the reactions of biological features under changes in different scales of time and space, including the cause-and-effect relationship between geographical-varying creatures, non-living things and geographical regions, it is also the science of discussing (1) Space graph diagram and structure (2) Connection between landscape diagram and process (3) The effect of human interference to the diagram, processing and changes of geography (4) The importance of the cross-effects in variations of different geography on the planning of biological preservation.

Ecological research put its emphasis on Structure, Function and Change. Structure, the space relationship in difference of "factors" or ecosystems。 Function, the interaction of space factors. Change, the structural and functional changes of ecological patch through time, induced from (a) system structure and function (b) Biodiversity (c) movement and migration of biological species (d) redistribution and transport of nutrients (e) movements and balance of energy (f) landscape changes and recovery (g) the stability of a landscape.

The stability of patch inclines toward (1) Physical stability (2) Fast recovery after interference (3) Higher resistance to interference. These landscape-forming factors, classified by shape, is sorted into Patch, Corridor and Matrix.

3 The meaning of biological indicators

(1) Ecological patch

The choice of a patch for conservation is base on two characteristics (a) The contribution of the patch to the whole system (b) The specialty of the patch.

(2) The shapes and structure of biological margins

Horizontal or vertical structured vegetation margins have high Biodiversity, perhaps due to its ability to offer shelter for many biological species living on the margin. Patches usually have filtering abilities, keeping biological species from moving towards the core of the patch. When the patch's fractal increases, movements of biological species along the margin increases; on the contrary, when the fractal on the margin decreases, biological species might cross the margin.

(3) The effect of the patch's shape

Patches with more twist-and-turns consists a higher proportion of marginal habitat, and will increase the population of biological species living on the margin, and also increase the patch's chances of interaction with surrounding matrix .

(4) The network system

The display of network connection shows the complexity of the network, and the efficiency of biological species movements. Usually on the intersecting point of two natural vegetation corridors, some inner species will be found, and the abundance of these biological species tops all other place on the network; Small patches or node enables network corridors to hold more species, efficiently supplying temporary shelter or habitat for some specific animal, lowering its chances of regional extinction.

4 Research material and method

Ecology-variation evaluation, use SPOT and Land sat TM to monitor the changes of bio-spatial, use ERDAS IMAGINE soft to manage image, and use Gaussian maximum likelihood classifier to classify and recognize the image. Classify the sample areas into vegetated and non-vegetated, or even more specific into patches of vegetation, this method is more appropriate when used on research of large surface areas； another method is to focus on smaller areas, only that this method requires preparations of changing information such as the location the exact area, vegetation distribution, range, etc. into statistical figures, and into shape file, and also establish a databank of data in every property. Since the sample area for this research is relatively small, the latter method was chosen.

After the basic data are transformed into statistical data, proceed with spatial index variogram, and apply the appropriate model parameter, analyzing the vegetation space, ecological continuity and variance of the landslide area after the act of planting vegetation on it. Calculate the ecological patch index of the landslide area, analyze it with the vario-parameter of geographical statistics. Using the spatial interpolation of agro-climatic data FAO soft developed by the FAO in 1996, calculate the semi-variograms for relative parameters. The FRAGSTATS soft of USDA, Forest Service, Pacific Northwest Research station is applied to the ecosystem evaluation in order to calculate the biological index of different areas.

FRAGSTATS for ArcView computes 3 groups of metrics. For a given landscape mosaic, FRAGSTATS for ArcView computes several statistics for (1) each patch in the mosaic, (2) each patch type (class) in the mosaic, and (3) the landscape mosaic as a whole. In the assessment of landscape structure, patch indices serve primarily as the computational basis for several of the landscape metrics; the individual patch indices may have little interpretive value. However, sometimes patch indices can be important and informative in landscape-level investigations. For example, many vertebrates require suitable habitat patches larger than some minimum size (Robbins *et al*., 1989), so it would be useful to know the size of each patch in the landscape. Similarly, some species are adversely affected by edges and are more closely associated with patch interiors (Temple, 1986), so it would be useful to know the size of the core area for each patch in the landscape. The probability of occupancy and persistence of an organism in a patch may be related to patch insularity (Kareiva, 1990), so it would be useful to know the nearest neighbor of each patch and the degree of contrast between the patch and its neighborhood. The utility of the patch characteristic information will ultimately depend on the objectives of the investigation.

The biological index is used to analyze the corresponding reaction of animal, plant land use and human distribution, in order to understand the whole ecosystem. Each index is deduced from fractal theory, shape stability, and expressed in patches, classes and landscape variation. Used in the recent years mainly on the Environmental Effect Evaluation of watershed management show in Table 1 and our flow chart of study as shown in Figure 1.

Table 1 Overall ecological evaluation and index

Integrity	Stability and resilience tow	Biotic integrity and diversity
continuity	Continuity	Continuity
Dominance	Dominance	Dominance
Fractal dimension	Fractal dimension	Fractal dimension
Lacunarity	Lacunarity	Lacunarity
Influence of matrix	Rate of diffusion	Size of patch
	Infiltrability	Patch distributes
		Internal distance of patch
		Total length of edge
		The edge length of each patch
		Nexus of corridor
		The proportion of the type

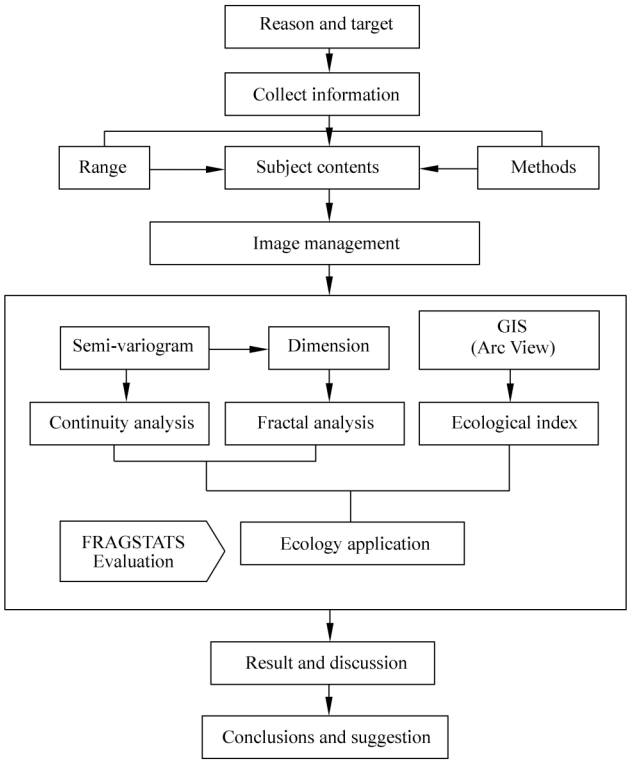

Fig. 1 Flow chart of study

5 Results and discussion

(1) Analyses about the continuity and fractal of landslide plant flock

Space data that semi-variograms could present follows variable situation. Proceeding a distance, variable situation would become stable. This critical value is called Sill. From Table 2, we could figure out, at Suai-Jin area landslide, before vegetation managing is 22.3 m, after one year vegetation managing is 123.8 m. In the relativity of space data, plant flock construction is better, after vegetation managing.

Table 2 Semi-variograms fit model and parameter form of landslide vegetation managing

Time	(Fit Model)	(Nugget)	(Sill)	(Range)	(Fractal Dimension)	(Pairs)
Before vegetation managing	Exponential model	0.42	0.57	22.3	1.21	9
After vegetation managing	Exponential model	0.11	0.37	123.8	1.58	15

In Nugget, before vegetation managing is 0.42, after that is 0.11. It means that Nugget is smaller than before after vegetation managing. Diversity and fractal analysis presents that after vegetation managing, the higher the plant flock diversity and fractal dimension is, the lower the dominance of matrix is, and the lower the proportion of outcropped rocks covers. In this circumstance shows that in vegetation restoration with factitious assistant, patch vegetations are more and chaos. The bigger change of the variation (0.26), the lower controlling ability of landslide's plant flock distribute to Bermuda grass.

(2) Discussion of index about overall plant ecological

It could divided into 4 types, namely for the indicators of patch, edge index of patch, indicators of patch shape, and indicators of diversity. The quantity of patch increase from 12(before vegetation

managing) to 45(after vegetation managing).Mean size of patch decrease from 0.041 hm^2 (before vegetation managing) to 0.0023 hm^2(after vegetation managing). The patches size standard deviations (PSSD) also decrease little by little. Mean patch index(MPI) increase from 38.43 (before vegetation managing)to 183.22(after vegetation managing). It expresses that the patch get closer after vegetation managing. Compare the patch ecological index and the survey of geographic statistics, the result demonstrates the fractal condition of patch are the same.

In the shape index, the mean shape index come from the comparison of patch and the square's area, the bigger the number is, the more complicated the shape is. The mean shape index (MSI) is 1.25 before vegetation managing and it turns to 3.16 after vegetation managing. It expresses irregularity and diversification of vegetation shape. The changes of vegetation spatial about landslide. The mean fractal dimension, patch and diversity are enlarged by vegetation managing. Therefore, we could figure out the performance of vegetation managing in ecological diversity.

Table 3 The ecological index of landslides

Time	(a) Patch index				(b) Edge index		(c) Shape index		(d) Diversity and dominance index	
	NP	MPS	PSSD	MPI	TE	ED	MSI	MPFD	SHDI	SD
Before vegetation managing	12	0.041	0.089	38.43	163.2	20.49	1.25	1.18	1.37	3.27
After vegetation managing	45	0.0023	0.0061	183.2	487.6	4.31	3.16	1.59	3.26	1.89

(3) Relationship between landslide vegetation distribution and ecosystem

It can find out that the spatial distribution of effect the change of ground surface temperature by measuring the perpendicular temperature of sample district. Inconsecutive vegetation spatial results in inconsecutive of ground surface temperature. In this condition, it cause to changes of microclimate. So the stability of migration of species, fluxion of energy and material are decrease. And make ecological process become unstable and frangible. If the vegetation construction is over disperse would make the habitat be isolated. Consequently, it would result in the difficulty of species survive. After five months, fluxion of energy and material in the district get more stable before vegetation managing. And performance of ecological value and every different management of vegetation managing of landslide could be discussed and evaluated in detail, and could be predict.

6 Conclusion and suggestion

Combine geographic statistical techniques with the theory of ecological patch, applying to the effect of different methods of handling landslide areas. This research is aimed at landslide areas after an earthquake, propose the initial base and method for evaluation of effect after engineering project of vegetation growth to the ecosystem.

(1) The increase of MPFD, number of patches and diversity index in the change of vegetation space change on landslide areas. Indicating increase on spatial range, and high variability of vegetation space. Higher fragmentation degree, and higher continuity, these helps the transportation of materials and energy between patches, and also increase the Biodiversity. It is apparent to see the positive effect to the ecology.

(2) After the progress of vegetating landslide areas, plant species diversity and MPFD increases, the advantage of the matrix decreases, shrinking the percentage of bare ground. Showing that human aid on landslide area vegetating increases vegetation patches, and increase complexity. The advantage of specific matrix (Bermuda grass)decreased(1.89), indicating its controlling ability over vegetation growth of landslide areas is also decreased, on areas without human interference the advantage of specific matrix(outcropped rock) is high(3.27), this lead to an disadvantageous influence on the vegetation growth,

distribution and on the whole ecosystem. The safety of neighboring life and property, may cause the worsening of the ecology and postpone the time limit of recovery.

(3) Applying high resolution satellite image or aviation photography to analyze the vegetation distribution and special structure on large mass landslide areas, and also use the ecological index to evaluate its ecological benefit. This is the most efficient methods.

(4) Using geographic statistical techniques and the ecological index method on the measuring of landslide area vegetation and vegetation special structure, enabling the situation simulation before planning the landslide area ecology project, with the geographic statistics and geographic biological index, measure the planned result, evaluate and see if it reaches the standard of ecological benefit, in order to foresee the tendency of regional landscape ecologic structural changes.

(5) The ecology is a very complicated system , single index evaluation may lead to failure of covering all the results. Human aid on landslide area vegetating has its benefit to the ecology, the passive way of indulging it to grow generate on its own is a good threatment for land.

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