Full Length Research Paper

A new model of dynamic of plant biodiversity in changing farmlands: Implications for the management of plant biodiversity along differential environmental gradient in the Yellow River of Henan Province in the spring

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The intermediate disturbance hypothesis (IDH) is often used as a model or investigating the linkages between disturbance intensity and biodiversity. However, the relationship between plant diversity and disturbance gradient makes it difficult to compare data from different researches and draw general models. It is importance to assess the relationship between disturbance gradients and herbaceous species diversity in the farmland center/farmland ridge/farmland boundary on varying spatial scales along the Yellow River watershed ecosystem of Henan Province in the arctic. Using community ecology techniques and quantitative measurements of disturbance, results show a linear relationship between weighted values of disturbance intensity and herbs species diversity (Shannon index), which were significantly, negatively correlated ($P<0.01$) in the differential ecosystem types (farmland center/farmlandridge/farmland boundary) along differential disturbance gradient. Thus, understanding a linear relationship between herbs diversity dynamics and disturbance gradient in the differential type's landscapes is important for further research of local ecosystem functions and the goal of agricultural sustainable development in the context of biodiversity conservation. These results indicated that a synthesis quantitative index of disturbance (e.g. weighting values of disturbance) is the most essential environmental factors affecting herbs species diversity in the ecosystem to building a model. Therefore, this model plays a vital part in conserving global biodiversity and maintaining global ecosystem function.

Key words: Model, herbs species diversity, disturbance gradient, significantly, the Yellow River.

INTRODUCTION

Ecological model of the relationship between species diversity and environment is important along environment gradient (Boyd, 2012; Liao and Wang, 2010; Keeling et al., 2000). Ecosystems are composed of large numbers

Figure 1. A digital cadastre map in the Yellow River of Henan Province.

Table 2. The selection of the weighting values of disturbance.

Quantitative measurements of disturbance to select and identify different disturbance	Differential agro-ecosystem types
Values of weighting of disturbance=Usage amount of herbicide	
+100/Return interval of using herbicide	Farmland center
+ 100/Return interval of tillage	Farmland ridge
+100/ The width of different types	Farmland boundary

Table 3. Investigation index along the elevation gradient variable.

Investigation	Layer	Community	Species	Height	Crow	Diameter
Community Investigation	Tree/shrub /herbaceous	Coverage /community's age structure	Species/ individual number	Layer's Height	Crow height/ width	Basal diameter

complement of H: $H'=-\Sigma\ p_i \log(p_i)$. Where $_i$ is the number of species and p_i is the proportion of the sample belonging to the i th species.

RESULTS

Disturbance is an important environmental factor affecting weed species diversity in anthropogenic activities in the farmland center/the farmland ridge areas/the farmland boundary areas. The relationship between values of weighing disturbance and the weed species diversity investigated vary significantly in the herbaceous layer along the environmental gradient on varying disturbance scales in the different disturbance intensity farmland (Figures 2 to 4).

These results which shows that herb diversity (e.g. Shannon index) is expected to increase when weighting values of disturbance is reduced along disturbance gradients in the farmland areas of the Yellow River in the
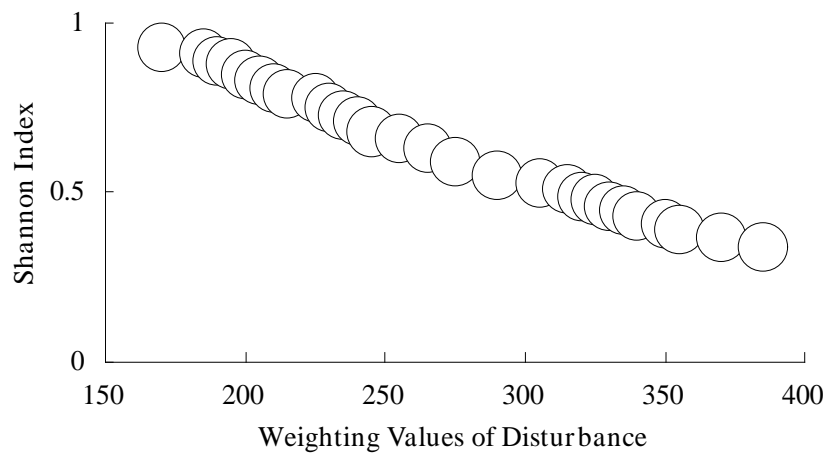
Figure 2. The relationship between Shannon index and disturbance in the farmland center areas.
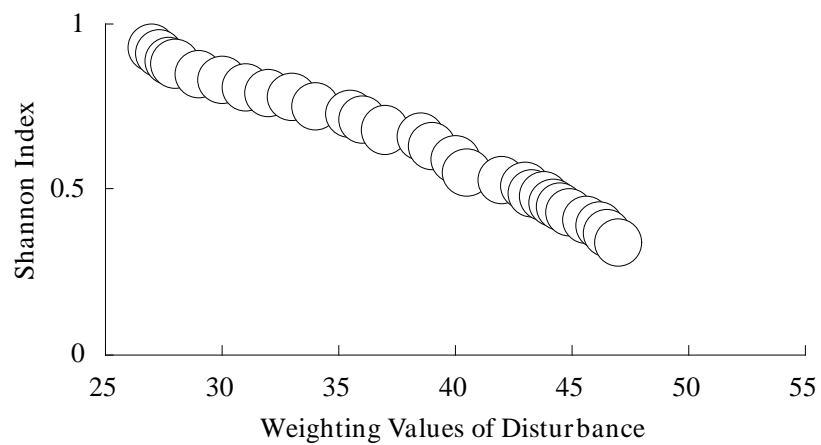
Figure 3. The relationship between Shannon index and disturbance in the farmland boundary areas.

Figure 4. The relationship between Shannon index and disturbance in the farmland ridge.

Table 4. The negative correlation between Shannon index and weighting values of disturbance.

Differential ecosystem types	Shannon index
Farmland center	-0.974**
Farmland ridge	-0.983**
Farmland boundary	-0.989**

Henan Province (Figures 2 to 4). Secondly, herbaceous diversity (e.g. Shannon index) is expected to decrease when weighting values of disturbance is increased along disturbance gradients in the farmland. Thus, our result implies that weak disturbance should lead to higher herbs diversity in the farmland.

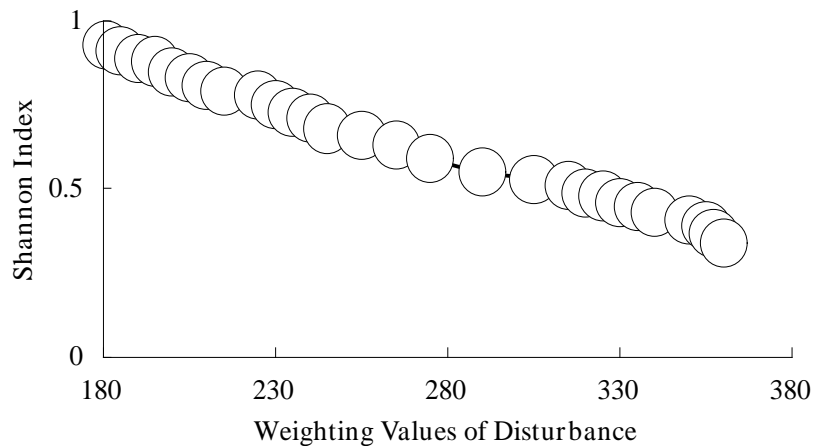These results suggest that herb species diversity (e.g. Shannon indicator) is expected to increase when weighting values of disturbance is reduced along disturbance gradients in the farmland boundary areas and the ridge of farmland of the Yellow River in the Henan Province (Figures 3 and 4). In addition, herb species diversity is expected to decrease when weighting values of disturbance is increased along disturbance gradients in the farmland boundary areas and the ridge of farmland (Figures 3 and 4). Therefore, this result implies that weak disturbance should lead to higher herbs species diversity in the farmland boundary areas. However, is there relationship between the species biodiversity and disturbance gradient in the Yellow River of Henan Province? To show this, the correlation between species biodiversity and the weighting values of disturbance was then analyzed (Table 4).

This results suggest a linear relationship between weighting values of disturbance and herb species diversity (Shannon index), which were significantly, negatively correlated ($P<0.01$). The results indicated that disturbance, largely determined by values of weighting of disturbance, are the most important environmental factors affecting herb species diversity (Table 4).

A general model of the links between herbs diversity and disturbance gradient from IDH perspective

The IDH is used as a framework for investigating the linkages between disturbance and species diversity. Unfortunately, the various IDH makes it difficult to compare data from different studies in order to draw general conclusions (Connell, 1978). It is therefore important to develop the model which is universally applicable across a range of agro-ecosystems so that the relationship between herbaceous species diversity and disturbance gradient can be more accurately quantified with quantitative measurements of disturbance intensity. Here, we proposed the use of model framework that

incorporates model (Figures 2 to 5) operating on varying spatial-temporal and disturbance scales for in-depth studies of the relationship between herbs species diversity and disturbance gradient (e.g. anthropogenic disturbance and natural disturbance) (Figures 5).

The model can help identify the relationship between herbaceous species diversity and disturbance intensity most relevant to tolerating environmental fluctuations or recovering from IDH perspective (Figure 5). The model is useful for ecosystem sustainable development in the context of biodiversity conservation. For example, Bartels and Chen (2010) explained that whether resource quantity or resource heterogeneity is the determinant of under story plant diversity in individual studies, was dependent on stand succession stage(s), presence or absence of intermediate disturbance, and forest biome within which the studies were conducted. Carvalheiro et al. (2011) suggest that presence of weeds allowed pollinators to persist within sunflower fields, maximizing the benefits of the remaining patches of natural habitat to productivity of this large-scale crop.

Applying general model to species conservation and ecosystem management

The model can use more theoretical ecology (e.g. diversity dynamics, species composition, food web structure, diversifying plant-microbial system, ecosystem stability/functioning, organic agriculture, biodiversity law, watershed ecosystem management, assessment of ecosystems and biodiversity, scale dependence) (Stutter et al., 2009; Shennan, 2008; Menalled et al., 2001, Bartels and Chen, 2010; Crowder et al., 2010; Bai et al., 2004; Davis et al., 2007; Bernez et al., 2002; Marris, 2010; Crawley and Harral, 2001). For instance, Menalled et al. (2001) suggested that agricultural management systems can have both immediate and long-term effects on weed species density, abundance and diversity. Shennan (2008) proposed that important elements for understanding biotic interactions include consideration of the effects of diversity, species composition and food web structure on ecosystem processes; the impacts of timing, frequency and intensity of disturbance; and the importance of multitrophic interactions in agro-ecosystem. Stutter et al. (2009) proposed a mechanism whereby the establishment of vegetated buffer strips between cropland and watercourses on previous agricultural land causes a diversifying plant-microbial system. Bartels and Chen (2010) explained that whether resource quantity or resource heterogeneity is the determinant of under-story plant diversity in individual studies was dependent on stand succession stage(s), presence or absence of intermediate disturbance, and forest biome within which the studies were conducted.

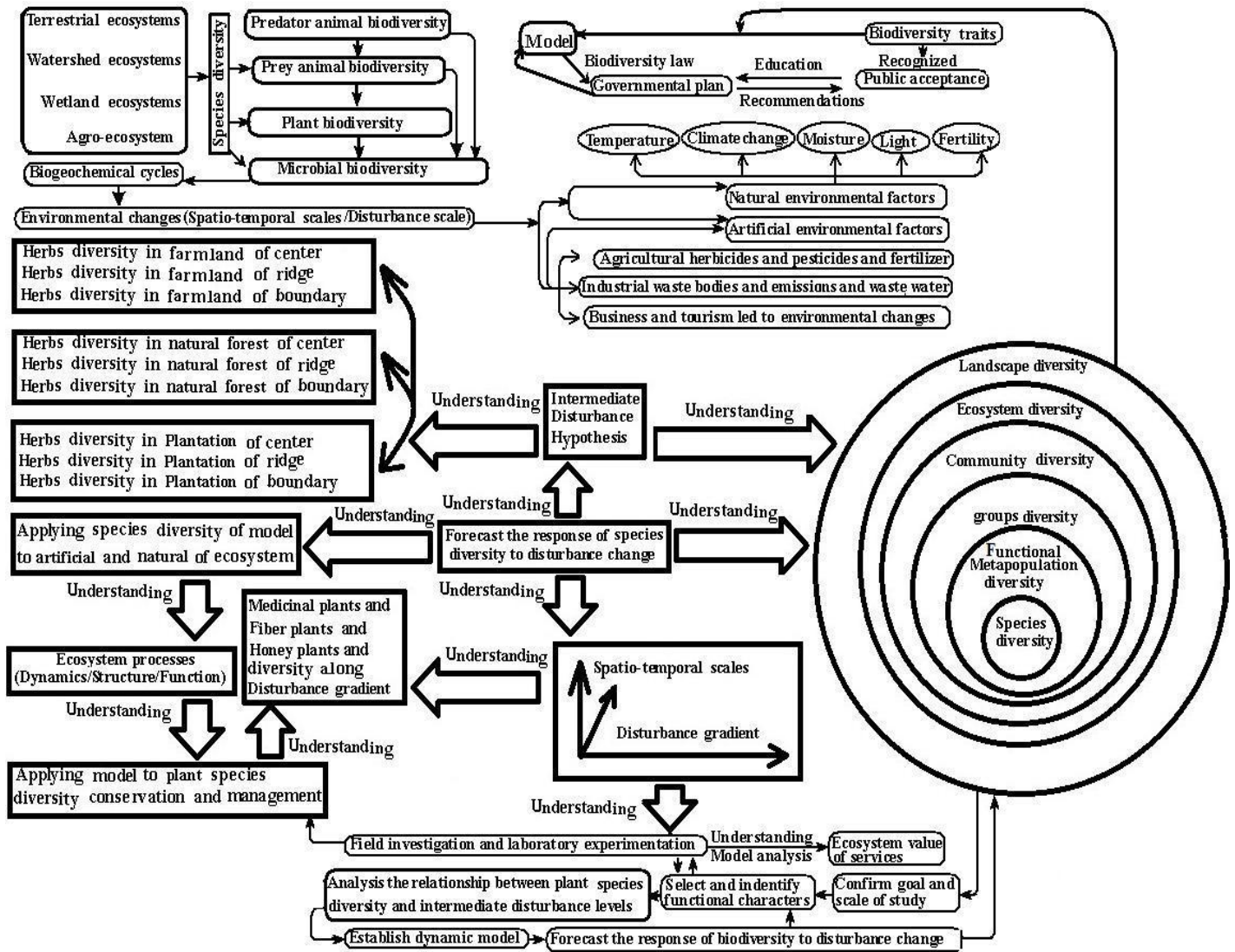Therefore, it will nonetheless be a substantial challenge

Figure 5. The proposed framework of relationship between herbs species diversity and disturbance gradient that incorporates herbs species diversity dynamic from the intermediate disturbance level, and operating on varying spatial-temporal and disturbance scales. The model was based on some studies (Liao and Wang, 2010; Liao et al., 2011a, b).

to apply this model to specific real world policy problems (Gilbert, 2010; James and Vorhies, 2010; Marris, 2010).

Conclusion

Progress in three key areas will substantially increase efforts to gain a rigorous understanding on how the links between herbaceous species diversity (Shannon index) and disturbance intensity, and their interactions, influence the response of ecosystem properties to changing biodiversity. First, better understanding of the relationship between herbaceous species diversity and disturbance intensity is correlated, particularly with respect to the

predominant forces of human activities. Secondly, the model based on both field investigation of community ecology techniques of 450 herbs layer quadrates and scientific analysis, can use more and more theoretical ecology. Finally, the model can be useful in understanding the plant species diversity and disturbance intensity from IDH perspective. Understanding the model is essential for further research of local ecosystem functions and the goal of agricultural sustainable development in the context of herbs biodiversity conservation in natural or artificial disturbance ecosystem. Therefore, the model may help to ameliorate this situation of losses of plant species diversity (e.g. medicinal plants, honey plants, fiber plants, etc.).

Future work

The watershed ecosystems are results of the historical, natural and anthropogenic activities along differential environmental gradient in the Yellow River of Henan Province. However, there is an important question in the future: what are the change patterns for watershed landscape, habitat and biodiversity in the region.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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