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Advancement of Research on Wetland Vegetation

Chen Ming-ye, Zhou Guo-na, Gao Bao-jia*

Forestry College, Agricultural University of Hebei, Baoding, Hebei 071000, China
*Corresponding Author: *baojiagao@163.com*

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Abstract

Wetland vegetation is an important component of the whole wetland ecosystem, it plays a vital role in maintaining the ecological functions of the wetland and the stability of ecological system. This paper presents the development of wetland vegetation from wetland plant diversity, biomass, productivity, leaf area index, and the special function of wetland vegetation. Aiming to point out the insufficient in the current study and the research directions in the future, and to maintain the stability of the wetland ecosystem and function. We also hope to make some contribution to the global wetland protection.

Introduction

Wetland is a transition ecosystem between open water and terrestrial land, and it has a unique structure and function which plays an irreplaceable role in improving the ecological environment and maintaining the ecological balance. Wetland can adjust the global climate, control soil erosion, stimulate biomass production, maintain biodiversity, prevent the flood and drought, prevent natural disasters, strength water conservation and pollutants degradation, and so on. So the wetland is known as "the kidney of the earth", "the cradle of life", "natural reservoir", and "gene pool of species"(Wang XL *et al*., 1997; Huang GL *et al*., 2000; Wu HT *et al*., 2005; Yang YX *et al*., 2002).The health of the wetland ecosystem is an important part of the security of the national and regional ecosystem, and it is also the important foundation of economic and social sustainable development (Sun ZG *et al*., 2006).

Wetland vegetation is an important component of the wetland ecosystem which is the primary producer of the wetland ecosystem and is the foundation of all functions of the wetland. It grows in an interface location, which is formed by the interaction of water and land, and it is a kind of transition vegetation between aquatic vegetation and terrestrial vegetation (Cheng Z *et al*., 2010). It belongs to the non-zonal vegetation. Compared with the zonal vegetation, the community composition and the structure of non-zonal vegetation is relatively simpler, which shows obviously spatial differentiation sequences, rapidly succession. And the change of the type, quantity, distribution characteristics and biomass are the specific reflection of the change of the wetland ecological environment (Zhang XL *et al*., 2009; Cui BS *et al*., 2008). Wetland vegetation plays a vital role in maintaining the balance of the wetland ecosystem, it has fatal research significance. Therefore, no matter from the scientific research value, environmental value, economic value and social value, the wetland vegetation should be systematic and comprehensive researched (Wang C *et al*., 2004). In recent years, scientists have done a lot of research work on wetland vegetation, including biodiversity of wetland vegetation, biomass, leaf area index and the special function of wetland vegetation, and so on. This article reviews the advancement of wetland vegetation, aiming to point out the insufficient in the current study and the study directions in the future, and then providing theoretical support to maintain the stability of the wetland ecosystem.

1Diversity of Wetland Vegetation

Wetland is of great significance which is an important gene pool, preserving wildlife species and diversity. The richness of the plant species in wetland is not only beneficial to improve the system itself against outside interference of uncertainty factors and the recovery ability after interference, but also contribute to the system of sustainable utilization of nutrient elements and fertility. And the productivity improved with the increases of species diversity (Yuan WJ *et al*., 2015; Kennedy TA *et al*., 2002; Wang CT *et al*., 2005).

The richness of the plant species in China's wetland: about 101 families, 94 families of vascular plants, about 1548 kinds of higher plants in inland wetlands, more than 5000 kinds of coastal zones, including about 100 kinds of endangered species (Sun ZG *et al*., 2006). However, with the changing of ecological environment and anthropogenic disturbance, wetland plant diversity is facing a serious of problems. In recent years, the problems have received widely attention, the administrative departments of the government and the scholar shave done a lot of work in legislation and rules, setting up the reserve mechanism, investigating and evaluating of the present situation, and so on. Thereby it played a great role in promoting wetland plant diversity protection (Zhang L *et al*., 2008). But the wetland plant diversity research carried out late in China had not formed a set of system theory yet, and most of the research mainly through the basic research method, from the investigation of the wetland plant species diversity resource and the influence factors two aspects, and studied the plant diversity from different types of wetlands, like coastal wetland, river wetland, lake wetland, low temperature cold swamp wetland and artificial wetland, etc. Finally, how to put new technologies such as “3S” technology, molecular biology technology, and mathematical model into the study of plant diversity is the central issue of the biodiversity research in future.

1.1 Resources Survey of Wetland Vegetation

At present, the ecologists mainly use the basic field investigation and the species diversity index analysis method, to study the wetland plant species diversity and succession process.

Liu K *et al*. (2014) through the field investigation combined with literature data investigated the diversity of wetland vascular plants in Anhui, which systematically analyzed the main wetland vegetation types and the classification system in Anhui. And he divided wetland vegetation in Anhui into different vegetation type groups, vegetation subtypes and formation. Wang JG (2014) and Zheng ZM *et al*. (2010) not only introduced the wetland types and distribution, vegetation types and type, etc., analyzed the factors influencing the development and evolution of wetland vegetation diversity, but also proposed constructive suggestions for protection and restoration of wetland vegetation classification. Cheng LX *et al*. (2013) and Dai XA *et al*. (2012) analyzed some importance values, richness, diversity, evenness and similarity index of different types of wetland plant communities, and discussed the different types of plant diversity and the characteristics of the changes. In the final, he analyzed the reasons for the formation of different wetland plant diversity patterns. Zhang XZ *et al*. (2011) and HaoYQ *et al*. (2008) studied the vascular plant species, quantity and rarity in Zoige wetland and Hengshui lake wetland by simple basic investigation, and further discussed the evaluation index system and method of wetland biodiversity. Yang WB *et al*. (2013) and Wu QL *et al*. (2012) investigated the plant diversity of tidal wetland in Anhui and Sanyang wetland in Wenzhou respectively, and these studies had shown that the plant diversity in wetland has been a certain degree of damage, species richness was low, proportion of aquatic plants and national protection plant species were low, the alien species invasion was very serious, plant growth under the threat of severe environment. So protect and restore the wetland plant diversity is clearly imminent.

In conclusion, many researches of wetland plant diversity mainly through traditional basic survey, and were measured by species indicators, alpha-diversity index and beta-diversity index, etc. However the diversity index is extremely sensitive to sampling methods and the sample size, so the different sampling methods and sample size will have a significant impact on the results of plant diversity (Magurran A E, 1998). In view of the defects of traditional survey, Qin XJ *et al*. (2015) in her research paper used the average taxonomic difference index (Δ +) and taxonomic difference variation index (Δ +) studied the plant taxonomic diversity in Shanxi Pinglu Yellow River wetland, this method compensated some deficiencies of traditional method. At the same time this method is more stable when facing the uncontrolled sampling and various kinds of variables, and also consider the collection of taxonomic evenness. It is not only reflected the diversity of plant communities, but also can indirectly reflected the relationship between environment and disturbance, it could use to identify the ecological system or habitat whether degradation or not. Therefore the later research should be paid attention to the selection and improvement of evaluation index.

1.2 The Influential Factors of Wetland Plant Diversity

The landscape, hydrological conditions, physical and chemical properties of the wetland have strong influence to the formation, structure, spatial differentiation and succession of the wetland vegetation (Tian YB *et al*., 2002). So dose anthropogenic disturbance. So people researched the relationship between wetland plant diversity and its influence factors mainly from the soil, hydrological conditions and anthropogenic disturbance, etc.

1.2.1The Effects of Soil Conditions on Plant Diversity

Soil is the cradle of plants which is the foundation of plant development. The conditions of soil directly affect the primary productivity of the ecosystem, in other words, no soil no ecosystem function. Plant growth, in turn, also affects the nature of the soil and fertility conditions. Hu JY *et al*. (2014) analyzed the Carex’s community characteristic and the influential factors of Dongting lake and believed that the key factors are soil organic carbon content, nitrogen content, moisture content and soil bulk density. Yang XB *et al*. (2002) studied the relationship between species diversity and soil fertility in Hainan, and he stated that soil organic matter content was mainly associated with the development of late succession species. While the total N, P was associated with the community coverage, succession of plant species and plant diversity, and other factors. Finally he put forward the vegetation recovery was the premise condition of soil restoration, which had an important ecology significance in soil and vegetation restoration. Xiao DR *et al*. (2008) studied the relationship between plant diversity and soil fertility in Napa lake wetland, and he suggested that when the native swamp became into swamp meadows, the plant diversity increased, and the hydrogen peroxide enzyme, protease, invertase activity increased, but the organic matter, total nitrogen content and urease activity decreased. Indicated that there was a negative correlation relationship between plant diversity and soil organic matter, total nitrogen content in wetland. But there were also studies had shown a significant positive correlation relationship between soil fertility levels and plant community species diversity, that is plant community species diversity increased with the increase of soil fertility level (Brosofske KD *et al*., 2001; Centry AH *et al*., 1988). Li X *et al*. (2007) analyzed the influence of Na element content on plant diversity and dominance in Hangzhou bay beach, and documented that there was a very significant negative correlation between soil sodium content and the species diversity index, richness index, mean that with the increase of soil sodium content, species richness index and diversity index is on the decline. Wang PP *et al*. (2015) studied the changes of plant community in response to salinity environment gradient in Ebinur lake, and found the plant diversity in lower soil salinity gradient (0.03%-0.73%) is not affected, but when the soil salt content increased to 2.40%-3.12% high level, the plant diversity decreased significantly, and the soil salt impact on diversity dynamic mainly through the enrichment effect.

Above studies show that the wetland ecosystem had a more complex and fragile structure and function characteristics than terrestrial ecosystem, and there is a very complicated relationship between soil fertility and plant diversity. One swallow does not make a summer, there may be exist an opposite result between the wetland plant diversity and soil fertility in different conditions. So study on the relationship between wetland soil and plant diversity still need from the influence mechanism in-depth, and previous studies focused on a smaller scale, little is known about the relationship between plant diversity and soil fertility under different landscape types of wetlands in larger scale pattern, so need to do more researches in larger scales.

1.2.2 The Effects of Hydrology Conditions on Plant Diversity.

Hydrology is the primary factor determining the formation and succession of wetland vegetation (Mitsch and Gosselink, 1986); any changes in hydrological conditions will affect the structure and function of the wetland ecosystem (Gilvear and Mcinnes, 1994;)Both the domestic and foreign research had shown that hydrological conditions has great significance on wetland plant diversity, especially on the submerged species, floating species, emergent species.

Riis, T. and Hawes, I.(2002)investigated the hydrological conditions and plant diversity in New Zealand coastal lakes, and they found monthly water-level change within 0.25-1.00m, the plant diversity increased. White SD and Deegan BM (2007) studied the relationship between emergent species and water - level fluctuation in Australia, found that the life cycles of emergent species was closely related to the water-level fluctuation. Guo XL *et al*. (2008) studied the wetland biomass dynamic characteristics on different water-level gradient in Sanjiang plain, concluded that water changes had directly effect on the distribution and production of wetland plant communities. Shen YQ *et al*. (2010) found that the depth of the water, transparency, and total nitrogen are the main factors affected the distribution and species richness of submerged species community. Yuan J *et al*. (2009) found that the flow rate and concentration of total nitrogen, chemical oxygen demand (cod), electrical conductivity and REDOX electricity also affected the submerged species community composition in the Beijing area. Cui LJ *et al*. (2012) analyzed the relationship between 12 water environment factors and the submerged species community in Beijing, found Cl^- concentration and the concentration of dissolved oxygen and water depth are the main factors that influence the submerged species distribution. And different types of submerged species has different physiological characteristics, the response to the pH value also different. Zhang M *et al*. (2009) studied the mechanism how water environment affect plant distribution pattern in Taihu, and the result showed that the different forms of N, P in the basin water or content of N, P in sediment is the main factors influencing the aquatic plant species composition and distribution. The above researches show that wetland plant diversity is not only closely related to the physical factors such as water depth, transparency but also related to the chemistry of the water environment. So we should pay attention to the water pollution which is caused by human.

Wetland plant diversity is very sensitive to water change. The spatial variation law of plant species is mainly caused by the differences in topography, geomorphology and water. Climate also has important influence on the spatial variation law of plant species, but the impact only clearly shown in significant geographical areas with different temperature and precipitation in large scale (Hu JY *et al*., 2014; Yang XB *et al*., 2002; Xiao DR *et al*., 2008; Riis T and Hawes I, 2002; White SD *et al*., 2007; Guo XL *et al*., 2008). Hydrological conditions not only affects the growth of plant development, but also indirectly influence the wetland plant diversity by influencing the soil condition. Like soil of land/inland eco tones is not only affected by gravitational erosion and water wave impact which were caused by fluctuation of water level, also affected by rain wash, under the long-term influence the physical and chemical properties of soil of land/inland eco tones may change. Most native terrestrial plants are under existential threat because they can't change their biological and ecological habits which formed in the long system development in a short term. So when study the wetland hydrological effects on plant diversity, the relationship between vegetation soil and the wetland hydrological situation becomes the most critical problem (Li Y *et al*., 2015).

1.2.3 The Influence of Anthropogenic Disturbance on Plant Diversity

As the human population expansion, pollution from human activity also increases, anthropogenic disturbance to the wetland has become a new research hotspot. Zhao HD *et al*. (2014) analyzed the relationship between the intensity of anthropogenic disturbance and wetland vegetation types, found that the strength of the different anthropogenic disturbances is negatively correlated with wetland vegetation diversity. Cheng ZH *et al*. (2014) studied the relationship between anthropogenic disturbance and plant diversity in Wutai mountain scenic spot. Results showed that the more intense of anthropogenic disturbance, the plant genus and species decreased obviously, the floristic composition of species tend to be singler; The proportion of annual plants increased significantly, the proportion of chamaephytes in significantly reduced; Wet plant decrease and a growing proportion of the xerophytes and mesophyte plants. Jiao YM and Li F (2005) studied the influential factors of estuary wetland plant diversity from human activities, natural disasters, and ecosystem vulnerability three aspects, it concluded that the wetland plant diversity is damaged and increasingly aggravated constantly, it had become a very fragile and unstable ecosystem, so the wetland urgently need to protect and restore. Li R*et al*. (2011) through the analysis of the plant community species diversity of Xingkai lake, explored the local agricultural development and the impact on the conservation of biodiversity. Anthropogenic disturbance is one of the key factors of wetland ecosystem degradation, in which the tourism disturbance has become a hot spot of society in today's environment and tourism research. Tourism activities brought significant negative impact to the environment of tourist area, especially to plants and soil directly. Liu SD and Gao J (2012) and Tang MY and Yang YX (2014) studied the effect of tourism disturbance on wetland vegetation and soil, which indicated that interference could change community height, density, coverage, biodiversity, plant important value and the species of the plant, and decrease the content of soil organic matter, total nitrogen, porosity and available N, P, K of wetland.

Wetland plant diversity is closely related to wetland soil condition and hydrological condition. The soil fertility and hydrological condition are the foundation of the plant resources, have significant influence on vegetation, at the same time, the change of wetland plant diversity also affected by anthropogenic disturbance. Within the limitation of some extent, moderate anthropogenic disturbance can change the heterogeneity of surrounding environment, and improve the plant diversity index to some extent. With the increase of the intensity of anthropogenic disturbance, plant diversity index will be significantly reduced and ecological environment deteriorated (Zhao HD *et al*., 2014; Cheng ZH *et al*., 2014). Previous studies have emphasized on the influence of environmental factors on plant diversity, but the influence of changes of environmental factors on plant diversity are less, the effect of the microclimate on plant diversity is relatively large. So the effect of climate change on wetland plant diversity should be strengthened. The establishment of wetland plant population gene pool, seed bank and the impact factor is the starting point for the study of wetland plant diversity.

2 Biomass and Primary Productivity of Wetland Plant Community

2.1 Biomass

Biomass is biological material derived from living, or recently living organisms. In this context biomass refers to plants or plant-based materials which are not used for food or feed. The biomass of wetland vegetation community is not only an important indicator to the health of wetland ecosystem, but is the basis for study the material cycle, energy flow and productivity of wetland ecosystem (Pan YZ *et al*., 2004). Since the implementation of the International Biological Program (IBP) in 1960s, the research on biomass has been a research hot spot, and has provided a large amount of basic data (Fang JY *et al*., 1996).Vegetation biomass can reflect the growth of vegetation and the changes of the local natural environment. It is very important to analyze the material cycle and energy flow of wetland ecosystem.

Domestic and foreign experts and scholars have done a lot of research work on biomass, including the biomass, its dynamic change and its influencing factors. Yang YX (2002) studied the biomass and its dynamic changes of *Carex lasiocarpa-glyceria spiculosa* wetland ecosystem and *Calamagrostis angustifolia* wetland ecosystem in the Sanjiang plain, he discussed the aboveground biomass, belowground biomass, total biomass, and the relationship between them, than calculated the absolute growth rate and relative growth rate of the two types of wetland according to the changes of time. Finally he established a three time parabola simulation model, the correlation coefficients is above 0.97.Guo XL *et al*. (2008) studied the biomass and it's structure dynamics by comparing different hydraulic gradient in the Sanjiang plain, analyzed the growth rate of biomass, the formation rule of the primary productivity of different hydraulic gradient wetland, stated the response and adaptation mechanism of the wetland material production process to the wetland hydrological pattern. Zan XX *et al*. (2011) and Wu HF *et al*. (2014) researched on the biomass and its temporal dynamics of *Phragmites australis*. They analyzed the relationship between aboveground biomass and belowground biomass, the effect of soil moisture content on the biomass of *Phragmites australis*. Above researches all used the traditional method to measuring biomass, including sampling, and weighting methods which are not only time-consuming, but also very hard to do accurate estimation of dynamic on large-scale (Wang SG *et al*., 2005).

With the development of satellite remote sensing technology and its widely application in wetland research, the research of wetland vegetation has a broad application prospect in recent years. Satellite remote sensing technology has a macro, continuous and long-term observation ability, and it can provide the dynamic monitoring of the vegetation biomass of wetland on large-scale. Han Y *et al*. (2014) take the Honghe wetland as the research location. They took the biomass data of August 2007and Landsat5 TM image during this period as the data source, modeling the biomass of study area. And through the comparative analysis they determined the optimal model, and then estimated the biomass in the study area. Finally they analyzed the relationship between the whole wetland biomass distribution with the changes in elevation combined with 30m resolution DRM data. Based on environmental satellite remote sensing data and field sampling data, the vegetation biomass of the Yellow River Wetland Nature Reserve in Zhengzhou was estimated by Gao Wenliang. The biomass distribution map of the study area was estimated. And the accuracy and prediction ability of the model was compared with that of a regression model, which can be used as a reliable method for estimating wetland biomass (Gao WL *et al*., 2013).

Previous studies mostly focus on the biomass estimation by remote sensing method, but the limitation of the remote sensing data limited biomass to a certain time point. So far, the work of overall spatial pattern of the wetland vegetation biomass and the continuous spatial variation of the wetland are weak. Based on this background, Wu GP *et al*. (2015) obtained the longtime series of Landsat data of vegetation biomass of Poyang lake nature reserve from 2001 to 2010 year, use the model and field measured biomass data, combined with the GIS spatial analysis technology, systematically studied the spatial distribution and seasonal variation characteristics of wetland vegetation biomass in the protected areas, he better grasped the wetland ecological environment and its changing trend, and provided a scientific support for the further ecological protection measures.

2.2 Net Primary Productivity

In an ecosystem, green plants can transfer solar energy into chemical energy by photosynthesis, this energy accumulation process is called primary production or net primary productivity of ecosystem (NPP). NPP is one of the important indicators of wetland ecological environment and its health status. Not only directly reflects the production capacity of vegetation communities in the natural environment and the quality of terrestrial ecosystem, also is the main factor to determine the carbon source, carbon sequestration (Zong W *et al*., 2011). NPP is sensitive to climate change, and it also influences the adjustment function of wetland ecological system to the ecological environment. The method of estimating NPP is used mostly model methods both at home and abroad. Commonly used models are statistical models, process models, and light energy utilization models. The statistical model is mainly based on the principle of correlation between climate factors and NPP. It uses the NPP data to establish a simple statistical regression model, the model parameters input is simple, but lack of strict plant physiological and ecological mechanism, so it is suitable for large area NPP estimation. The process model is also called mechanism model, the model takes the physiological processes of plant photosynthesis, organic matter decomposition and nutrient cycling into account. It has strong mechanism and systematicness, but the model is often designed complicated which has some problem in parameters acquired, reliability and scale conversion. The light energy utilization model based on the resource balance view, considered that the biomass of the vegetation is the result of the interception, absorption and transformation of the canopy of the solar radiation.

In recent years, with the wide application of remote sensing and geographic information system, the combination of remote sensing and process model has become an important trend of NPP research. Guo ZX *et al*. (2008) analyzed the relationship between the temporal variation, spatial variation of net primary productivity and the climate factor like temperature and precipitation based on the MOD17A3 data set of EOS/MODIS satellite 2000-2005 in the Three-River Plain of twenty-first Century. And using spatial analysis method they analyzed the effect of road, river and residential area on the productivity of marsh wetland. Wang F *et al*. (2011) calculated the vegetation NPP of Qixinghe wetland using the grid interpolation of daily temperature and precipitation of 1961-2008 with the Miami (R) model. Selected the temperature, precipitation, aridity index they analyzed the influence of the nearly 50 year climate change of Qixinghe wetland on natural vegetation net primary productivity. Wang LW and Wei YX(2012) classified the land cover type of Panjin wetland using the (CBERS), synthetic aperture radar (SAR) and digital elevation model (DEM) data, through the mothed of principal components of the fusion algorithm, the classification of regression tree CART algorithm and the mixed pixel decomposition model combined with neural network algorithm. They considered the typical characteristics of wetland ecosystem and took salt stress as one of the environmental factors which affecting the net primary productivity (NPP) of wetland salt tolerant vegetation, then they finally constructed a wetland vegetation net primary productivity model based on light energy utilization and remote sensing data, analyzed the temporal and spatial distribution characteristics of NPP, and studied the response characteristics of NPP to temperature and precipitation in Panjin wetland.

Natural wetlands are considered to be the largest natural source of release of methane on earth (IPCC, 1995), therefore, the research on the biomass and productivity of wetland will be helpful to the understanding of the source of methane. However, in recent years, the study of wetland productivity mainly focused on the estimation of wetland vegetation biomass, and the study on the NPP of wetland vegetation is a rough estimate on the large scale area. Most wetlands are classified as a class in these studies, without further consideration of the specific vegetation composition and the characteristics of the hydrological and ecological environment. Therefore, according to the characteristics of the specific hydrological environment, we need to improve the estimate method of the main vegetation NPP in order to improve the accuracy of NPP and the estimation of wetland productivity is mostly used the NPP mechanism model which is established based on the vegetation index. The model is established based on the vegetation in North America. Model parameter modification is more difficult, only in the process of estimating FPAR, the different vegetation types were considered when determining the ratio vegetation index SR max (Potter CS *et al*., 1993).But it cannot essentially reveal the relationship between vegetation types and NPP. Accurate estimation of light energy utilization is one of the key factors in the simulation of CASA model. Model's author proposed that in the ideal condition, the maximum light energy utilization of vegetation is exist, and the monthly value of different vegetation types is 0.389g CMJ-1(IPCC, 1995). In fact, there is a big difference between different vegetation types of light energy utilization, which is influenced by temperature, water, soil and plant individual development. It will cause a lot of errors when use it as a constant in the world (Dong D and Ni J, 2011). Model in estimating water stress factor used the soil water molecular model, the process is complicated, which involves a large number of parameters like precipitation, field holding capacity, wilting moisture content, soil clay and sand percentage, soil depth, soil volume containing water, etc. Data is difficult to obtain and usually soil parameters are determined by soil classification map, and its accuracy is difficult to guarantee. Therefore to establish suitable estimation model for China wetland NPP is the focus of future research.

3 Leaf Area Index of Wetland Vegetation

Leaf area index (LAI) is defined as the one-sided green leaf area per unit ground area in broadleaf canopies and as half the total needle surface area per unit ground area in coniferous canopies (Barclay HJ, 1998).LAI is not only an important indicator of the primary productivity of wetland ecosystem, but also the important parameter of wetland ecological environment and its health status. It controls the process of photosynthesis, respiration, transpiration, rainfall interception, and energy exchange, and provides the structural quantitative information for the initial energy exchange of the plant canopy surface. The structure and function of wetland ecosystem are determined by the influence of the canopy energy exchange, water balance and carbon absorption. And it is also an important variable or critical data that affect the biological and chemical processes in the climate system model, which includes the ecological and the land surface processes (Bonan GB, 1995; Huang M and Ji JJ, 2010), so that more and more attention should be paid to the study of global climate change. Leaf area index determination method basically has two kinds of method: the direct measurement and indirect measurement method. Direct determination of LAI includes the method of canopy, litter collection, and the allometric growth equation method (Ryu Y *et al*., 2010), that is a relatively mature and accurate method, which can be used as an effective verification method for indirect method. However, due to the complex condition of nature wetland, and the traffic inconvenience, many places are difficult to achieve, if use the direct measurement method, we need to spend a lot of manpower, material and financial resources, the investigation period will be relatively long. The wetland plants are destructive, so this method is difficult to adapt to the new situation of wetland vegetation research. Remote sensing technology provides a new research tool for wetland research, which is characterized by large scale synchronous observation, high efficiency, and high economic benefits (Jin AH, 2008; Yu YJ, Zhang SW and Bao CH, 2005). It IS not only avoids the disadvantages of traditional harvest method, but also can provide the seasonal dynamic data of LAI, which is convenient and easy to operate. Jordan first proposed the ratio vegetation index RVI, and used it to estimate the leaf area index of tropical rain forest (Jordan CF, 1969). Gao S *et al*. (2013) Studied on the artificial forest in Heihe area of China, extracted the key factors by analyzing the correlation between the leaf area index and radar signatures. On the basis of the research, he studied the construction strategy of the topological neural network which suitable for the characteristics of artificial forest And analyzed the radar backscatter characteristics of different tree species, On the basis of correlation analysis of LAI and multi polarization radar scattering intensity finally discussed the neural network algorithm for the inversion of leaf area index of artificial forest. Xing LW *et al*. (2013) took the Sanjiang Plain River National Nature Reserve as the research area, established the regression model of LAI in the swamp vegetation by high spectral and multi spectral vegetation index based on the data of LAI in the field, and they predicted the capacity of LAI in the swamp vegetation by comparing the multi spectral and Hyperspectral Vegetation index estimation model, and then discussed the feasibility of the model and the identification of the optimal model which to achieve the purpose of improving the accuracy of the LAI extraction of the swamp vegetation. Further provide the application of remote sensing technology level, so as to better service for wetland restoration and protection of realistic demand.

Remote sensing data products has been widely used in the research of wetland leaf area index with its unique advantage of temporal and spatial continuity. However, due to the complexity of the surface coverage, the difference of spectral data, the method of leaf area index inversion, the different research scales, and the different atmospheric correction models, the results are different. Such as Ren HC *et al*. (2014) analyzed the spatial and temporal characteristics of LAI in China and its correlation with climatic factors by comparing the 3 groups of LAI products of MODIS data inversion. Found the consistency of different LAI data products in terms of temporal and spatial variation and climatic conditions, the availability of research in the climate and climate change. But the difference of local area and quantity in different LAI data products would affect the quantitative analysis in leaf area index. Liu XC *et al*. (2008) compared the different methods of leaf area index inversion like vegetation index method, two order differential method, model inversion method and directional two order differential method, the results showed that the accuracy of inversion method is different in different conditions. Gu ZY *et al*. (2014) respectively using 6s model and FLAASH model do the atmospheric correction on TM images, set up some regression relationship between leaf area index and a variety of vegetation under the two different models. Compared with the correction accuracy of leaf area index model of remote sensing inversion of different atmospheric, the results shown that the correlation between different atmospheric correction models and LAI-VI regression equation was significant, and the 6S model is better than FLAASH model. Therefore, when using of remote sensing technology to quantitatively extract the physiological parameters of vegetation, we should choose the appropriate atmospheric correction model.

4 Special Functions of Wetland Vegetation

With the rapid development of cities, and the sharp expansion of city population, the water pollution is becoming more and more serious. Industrial waste water is discharged into rivers and lakes without treatment, and a large number of domestic sewage is the main factor leading to the eutrophication of water body; The development of tourism accelerated the process of eutrophication of water body, at the same time, a large number of pesticides, fertilizers, nitrogen and phosphorus of the agricultural production through the flow of agricultural runoff into the lake (Jing YY *et al*., 2015); In the process of large-scale production and development of livestock and poultry breeding, a large amount of organic matter, nitrogen, phosphorus, potassium, sulfur and pathogenic bacteria and other pollutants into the water body in the development process. The dissolved oxygen content in the water body is rapidly decreased, and aquatic organisms over propagation, which lead to eutrophication of water body (Zhou YT *et al*., 2009). After 1960s, experts do a lot of research work found that wetland aquatic plants (including emerged species, floating-leaved species and submerged species) in the growth process can absorb the nitrogen, phosphorus and other nutrients to produce their own material. At the same time decomposing, purifying the other toxic and harmful substances to reduce the hazardous substances in water (Wang H and Wang Q, 2011). Based on this physiological and biochemical characteristics of wetland plant, we should plant a certain kind or some kind of highly effective absorption of nitrogen and phosphorus nutrient element aquatic plants in the polluted water, this method will purify the polluted water, reduce the nutrient content in polluted water, lower the eutrophication level of water (Jiang HQ *et al*., 2012; Wang JT *et al*., 2013). Therefore, the special function of wetland vegetation is one of the key issues in the sustainable development of wetland.

Chen ZC *et al*. (2015) took the eutrophication water in Dianchi lake as research area, by using the method of artificial simulation, taking the typical floating plants *Eichhornia crassipes*, *Pistia stratiotes* Linn and typical submerged plant *Hydrilla varticillata* and *Typha augustifolia* as experimental materials, analyzed the purification effect of different ecological types of aquatic plants on phosphorus, and studied the main source of phosphorus which plants absorbed. To provide reference for the rational allocation of aquatic plants in eutrophic lake bioremediation engineering. Liu JW *et al*. (2015) studied the water body eutrophication purification effect of three kinds of water plant, the results showed that the purification effect of water plants on the eutrophic water body was increased with the increase of nitrogen and phosphorus contents. At the same time, there were some differences between different kinds of plants in the growth law, the demand for nitrogen, phosphorus and other nutrients, the proportion of demand and the absorption of plant roots and the promotion of the growth and propagation of plants. Gao Y *et al*. (2014) compared the removal effect of nitrogen and phosphorus at different growth stages of *Eichhornia crassipes* living in different level eutrophic water, and studied on their removal effect of the absorption capacity of nitrogen and phosphorus nutrients and the influence for sediment nutrient content. Song H *et al*. (2014) studied the ability of water removing nitrogen of *Iris pseudacorus* L, *Acorus calamus* Land *Iris sanguine* three hydrophytes through hydroponic experiments, and results shown that three hydrophytes had already played a big role in the first 2 weeks, the removal effect was not obvious after 2 weeks. The nutrient removal efficiency of *Iris pseudacorus* L and *Iris sanguinea* reached the maximum on 17-23 days. Zhang XL *et al*. (2014) studied the purification effect of *Phragmites australis* and *Scirpus triqueter* in different degrees eutrophic water. Results shown that *Phragmites australis* and *Scirpus triqueter* could normally grow in 3 kinds of gradient of eutrophication water, and had obvious removal effect of N, P. *Scirpus triqueter* has advantage to *Phragmites australis* in the mild and moderate eutrophication water body, in severe eutrophication water body, *Phragmites australis* removal ability of TP is higher than that of *Scirpus triqueter*, and the total phosphorus purification effect is better than that of total nitrogen in the water. Future research should strengthen the research on the model and mechanism of the wetland vegetation restoration of eutrophic water body.

5 Other Aspects

In addition to plant diversity, biomass, productivity, leaf area index and special function, the wetland vegetation types, distribution, mapping and monitoring of dynamic changes of vegetation is also studied. Schmidt K and Skidmore A (2003) analyzed spectrum differences between different vegetation types in coastal wetland. The study shown that if the high spectral resolution RS image and the reference spectral database is used, the different types of vegetation can be identified. Wang Y *et al*. (2011) used the method of combining remote sensing interpretation with field investigation, combined the present situation investigation with historical data analysis analyzed the evolve characteristics and its causes of the wetland in Daqing in recent 20 years. Found that human factor was the main factor that threatened the wetland vegetation. Zhao GM *et al*. (2011) studied the dynamic changes of vegetation in the Yellow River Delta using remote sensing and geographic information system. Drew a conclusion that the natural factors (1976, the Yellow River diversion, seawater intrusion and 1992 catastrophic storm tide) and human activities (1998 seal breeding natural tamarix and later a large area of cotton planting) had great influence on the change of wetland vegetation types in the northern area. Sun LG *et al*. (2014) analyzed the spatial temporal variation in vegetation cover in Bashang area of Hebei Province. Concluded that vegetation cover in east is better than west in spatial distribution, the vegetation cover had the trend of improvement in temporal scale.

Conclusion

In recent years, with the development of science and technology which based on the traditional research methods, some new technologies and new methods are widely used in the study of wetland vegetation, such as remote sensing dynamic monitoring, geographic information systems, global positioning system, and all kinds of mathematical methods. And the "3S" technology has greatly improved the accuracy of the research in which provide technical support for wetland vegetation research. But because of involving conservation biology, urban ecology, plant ecology, and other research fields, wetland vegetation research should form an integrated system. First, we should study wetland vegetation in the integrated perspective from ecology, environment, hydrology, meteorology, geography, and so on. We should use the hydrological, ecological, meteorological, soil and environmental models to predict the degradation of wetland vegetation, and to reveal the regularity and characteristic of wetland vegetation changes in different regions of the world. And strengthen the research of response and adaptation of the vegetation to global climate change in different temporal and spatial scales, which is one of the key research of wetland vegetation in the future. Second, we should strengthen our research techniques in the combination use of long phase, multi-resolution remote sensing image in wetland vegetation identification, especially the radar data combined with optical data; strengthen the application of multiple classifier in the vegetation classification, and optimize the combination; increase the computer intelligent application model research that including wetland vegetation model, and strengthen the wetland vegetation dynamic simulation research based on virtual reality and 3d visualization technology. Third, we should strengthen the "3S" technology application in the research of wetland plant diversity. At present, there is little application of 3S technology in the research of wetland plant diversity. But with the popularization and application of "3S" technology in wetland research, it is becoming a more and more mature method, and achieved many technical requirements that conventional methods cannot met. Its application in wetland plant diversity has begun to receive more and more attention. In the analysis on spatial temporal variation on vegetation in Jiuduansha wetland, Shen F *et al*. (2006) found that multi-spectral remote sensing data are enough to distinguish the *Scirpus mariqueter* and *Spartina alterniflora* vegetation communities. Therefore, the research on wetland plant diversity based on "3S" technology, presents a broad development and application prospect. In the near future, it will play an important role in constructing the dynamic model of wetland plant diversity and predicting the dynamic changes of wetland plant diversity. Additionally, we should combined with the changes of the landscapes, ecosystems, soil matrix, etc. which brought by anthropogenic influence, and through multi-disciplinary collaboration research the internal mechanism on plant diversity loss and characteristics change, especially research the processes and mechanisms of the interaction between alien species and native species.

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