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Delineation of eco-geographic regional system of China

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Eco-geographic regionalization has been one of the most important topics in China´s regionalization researches since the end of the 20th century. It is a major ecosystem in geographic zonality. A hierarchical system, which is formed by division or combination of natural features based on geographic relativity and comparison of major ecosystem factors (including biological and non-biological) and geographic zonality, is called eco-geographic regional system. This paper introduces process of China´s regionalization development. The first level unit, temperature zone, is delineated with main criteria of temperature. The second level unit, humidity region, is based on criteria of water/moisture states. The third level unit, natural region, is divided according to medium geomorphologic units. Vegetation types and soils are applied as supplementary criteria to indicate temperature and water/moisture states. Mapping process from qualitative to quantitative and China´s eco-geographic regional system are also explained in this paper.

Delineation of eco-geographic regional system of China WU Shaohong, YANG Qinye, ZHENG Du (Inst. of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China) 1 Introduction Eco-geographic region is a major ecosystem in geographic zonality. A hierarchical system, which is formed by division or combination of natural features based on geographic relativity and comparison of major ecosystem factors (including biological and non-biological) and geographic zonality, is called eco-geographic regional system. The system indicates patterns of temperature, water/moisture, biomass, soil and their corresponding resources and environment. Eco-geographic regional system is a way to recognize environment and ecosystem. It is important for environmental conservation, vegetation restoration, ecosystem construction and sustainable regional development. As early as 500 B.C., China, based on soil types and fertility, was delineated into nine areas limited by mountains, rivers, lakes and seas. The other work was delineating land of the whole country into three main groups with 25 types (Zhao et al., 1988). The modern regionalization work of China began in 1931 as the publication of Study on Climatic Regions of China by Zhu Kezhen. Later in the early 1940s, Huang Bingwei started the first vegetation division work in China (Huang, 1993). In 1956, the Chinese Academy of Sciences (CAS) organized "Natural Regionalization Work Commission", which began the systematic modern regionalization in China. Under the leadership of Huang Bingwei, the integrated natural regionalization has been widely applied in different industries. The regionalization, consisting of nine "species" of regionalizations: physico-geographical, climatic, geomorphologic, hydrologic, hydrogeological, pedological, vegetational, zoogeographical, and emtomological, aimed at serving agriculture, forestry, livestock farming, and water conservancy. The integrated regionalization (Huang, 1959; 1960) gave prominence to rule of natural geographic zonality, delineating China into three natural realms with 6 heat zones, 18 natural divisions/sub-divisions, 28 natural zones/sub-zones, and 90 natural provinces. In the 1960s, Huang modified the project of the regionalization. The heat zones were identified as temperature zones. In the 1980s, he systematically modified the project again, delineating the whole country into 12 temperature zones, 21 divisions and 45 regions (Huang, 1989). In the 1960s-1980s, there were some studies of regionalization, which differed from Huang´s scheme (Ren et al., 1961; 1982; 1992). At the beginning of the 1980s, Chinese geographers started to introduce ecosystem and to apply principles and methodology of ecology to regionalization. Hou Xueyu (1963; 1988) delineated eco-regions of China based on vegetation distribution and discussed the regions with agricultural development strategy, in which he divided the whole country into 20 natural eco-regions. Some eco-regions were further divided into sub-regions. Zheng Du´s study group carried out a systematic and detailed study on eco-geographic regional system by the end of the 20th century (Zheng, 1999). The study brought regionalization into a new stage of eco-geographic regions, which is

the main content of this paper. Other scholars, such as Fu Bojie, also had delineation of eco-regions of China (2001). 2 Hierarchical units Eco-geographic regional system divides or combines natural features of such a region as China, based on geographic relativity, comparison of major ecosystem factors (including biological and non-biological) and geographic zonality. Internal complexity in ecosystems is not always the same. An ecosystem at lower level has high homogeneous eco-factors. Eco-geographic regional system serving different objectives should indicate different complexity degrees of ecosystems. Therefore, eco-geographic regional system is a hierarchical system. The most important way to recognize regional differentiation is thought delineation at different levels of regional system. China´s eco-geographic regions are delineated based on principles of hierarchical, relative regional coherence, regional genesis and regional conjugation. Regional dominant ecosystem type, stability, succession orientation, and regional environmental problems, degree of eco-risk, geographic distribution, and "eco-construction" are taken into consideration. Units of different levels indicate various homogeneousness of ecosystem. Marking the definite difference (boundary) forms this hierarchical system. Ecological climate relation between ecological features and the environment is the best factor to indicate the differences of ecosystem. Within climatic scope, temperature and water/moisture have definite geographical differences. For further subclassification beyond climate, the macrofeatures of the vegetation appear to be the appropriate criteria for defining secondary divisions (Bailey, 1983). Soils reflect regional natural states of a former period (Wu et al., 2000). So they are always applied as a supplementary indicator to climate and regions. Medium geomorphologic units have a profound influence on climate, vegetation and soils. The boundary of the units is always coincident to that of eco-geographic regions. Therefore, in delineation of eco-geographic regions of China, temperature is the main criteria for zone, water/moisture for region and medium geomorphologic unit for natural region. An example is given as Figure 1. 3 Index system and mapping In climatic factors, in terms of biology, daily temperature $\geqslant$10oC ensures that most plants and crops grow in the course of nature. Period of daily temperature $\geqslant$10oC is the season that most crops and plant grow well. Hence the number of days and accumulating temperature $\geqslant$10oC are used as the main criteria of temperature zones. Average temperatures of the coldest and warmest months indicate regional temperature states impersonally, which is used as supplementary criteria of temperature zones (Table 1). Annual aridity shows the relationship between regional precipitation and potential evaporation. It indirectly indicates moisture used by plant except evaporation. Annual precipitation is an important source of regional water recharge. It also indicates regional water/moisture state. Aridity has been calculated with Селянинов model and modified with ecological types (Yang et al., 2002). Annual aridity and precipitation is employed as criteria of regions (Table 2). Natural vegetation types and soils are taken to indicate temperature and water/moisture. Prior to the 1960s, China´s lacked records on climate and other natural factors. The boundary of regional system was determined with "typical" landscape type. At that time, there was an expert group that discussed how to draw the boundary. The boundary was decided by the expert group´s opinion. For example, they "agreed" that hot climate without winter season, growth of tropical plants such as coconut (Cocos nucifera), pepper (Piper nigrum), and rubber trees (Hevea brasiliensis), and cocoa (Theobnoma cacao), and laterize soil were the indicators for tropical and subtropical zones. The boundary between evergreen and deciduous broad-leaved forests served as delineation of warm temperate and subtropical zones. Limitation of steppe was taken as the boundary between semi-arid and sub-humid regions. Of course such delineation was somewhat subjective. Since the 1960s, China has established network for eco-geographic factor observation and records gradually. Using the international relative researches as reference, China´s regionalization researches have been orientated to a quantitative way. Ecological factors of the former typical landscapes have been quantified forming an index system for eco-geographic regional delineation. The boundary of the regions is determined according to such an index system. Since the 1980s, development of remote sensing and geographical information system (GIS) has provided technical support for eco-geographic regional mapping. In recent years, supported with GIS techniques data of ecological factors from observation stations are generated into isolines of the index items. With modification of vegetation and soil maps the boundary of eco-geographic regions has been mapped. Database of China´s eco-geographic factors has been set up according to the mapping methodology described above. Climatic data (1951-1995) used are from the basic weather observation stations of the National Meteorological Administration. Isolines of climatic items for temperature zones and humidity regions are generated with ArcView GIS software on map of 1:4,000,000. The isolines are integrated with Vegetation Map of China (1:1,000,000) (Hou et al., 2001) and Soil Map of China (1:20,000,000) (Editorial Committee of Physical Geography of China et al., 1982) to generate the boundary for temperature zones and humidity regions. The boundary of natural regions is delineated according to medium units of Geomorphologic Map of China (1:4,000,000) (Li et al., 1994). 4 Eco-geographic regions of China Eco-geographic regions of China are showed in Figure 2 and Table 3. Roman numerals I to IX stand for cold temperate zone to the equator tropical zone. HI and HII stand for plateau sub-cold tempera

te and plateau temperate zones. Letter A means humid region, B sub-humid, C semi-arid, and D arid. Arabic numbers stand for natural regions. 5 Comparison International regionalization has been a long-term research work. In Germany, many scholars link ecosystem with geography together. Schultz studies ecozone or geozonal ecosystem. Others, such as Passarge, Maull, Mueller- Hohenstein, Bramer, Haggett, study landscape belts, geographic zones, or geozones (Schultz, 1995). Their system describes spatial distribution of ecosystems, but not a hierarchical system. Robert G. Bailey systematically studies ecoregions, which is a hierarchical system. He edited maps of ecoregions of the United States, North America, the Continents and the Oceans (Bailey, 1985; 1995; 1998). The main criteria for the first level domain of his system are climatic zone or group, the second level division K??ippen´s climatic type, the third level province climax plant formations, and the fourth level section K??ichler´s climax plant associations. The system of Bailey´s ecore-gions is a type regionalization, which means that the same type of ecoregion would possibly repeat in different locations. The China´s system is a spatial regionalization, in which regions do not repeat anywhere. Of the above-discussed systems of regionalization, Bailey´s system is most similar to China´s system (Table 4). Because of differences in the study areas, detailedness and study background, the eco-geographic regional system of China and Bailey´s ecoregional system take similar criteria but obtain both similar and dissimilar results in regional delineation. Overlapping the China´s part on his Map of Ecoregion of the Continents with China´s eco-geographic regional map will find that for temperate states, boundaries of cold temperate (about 50oN) and warm temperate-subtropical (about 32o-34oN) zones are almost unanimous (Bailey, 1983; Wu et al., 2001). However, the difference in location of boundary of tropical-subtropical is as much as 4 degrees of latitude (Wu et al., 2001; Bailey, 1989). His northern boundary of tropical is as northbound as to Fuzhou City of Fujian Province lying about 26oN. In China, climax vegetation northward to the Tropic of Cancer could hardly find species of tropical plants and so is the case of tropical rainforest. For water/moisture states, delineation of eastern China between Bailey´s system and China´s system is almost the same. But for the western China system, it has much larger arid area. Arid region in China´s system was delineated according to that dryness is 4 or more, annual precipitation less than 200 mm with desert landscape. Bailey applies K??ippen´s climatic types that have no criteria of dryness. 6 Summary Eco-geographic region delineation becomes one of the dominant works of regionalization in China. Delineation of eco-geographic regions is based on ecological principles and factors. Methodology and mapping procedure are determination of criteria for delineation, generating isolines of items of the criteria and then dividing eco-geographic regions by integrated cartographic methods. For China´s system temperature zone based on temperature is similar to domain of Bailey´s system, humidity region based on water/moister state is similar to division and natural region based on medium geomorphologic units is similar to province.

关键词： China; eco-geographic region; regionalization

