Classification of Biochores in Korea

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Abstract – **Through multiple stage analysis, the biochores in Korea were classified and organized as a hierarchy system. In the 1st step, the isopleth lines of warmth index 100°C, 85°C, 55°C · month and the coldness index −8°C or −10°C · month, which indicate the boundaries of plant formation zones (Yim and Kira 1975; Yim 1977), were applied in the determination of major biochores. In the 2nd step, these biochores were subdivided into the five classes based on Thornthwaite's moisture index (Im) and Yim and Kira (1976), as follows: 100≤Im, 100<Im≤80, 80<Im≤60, 60<Im≤20, and 20<Im≤−20. In the 3 rd step, the analysis of topographic features yielded three categories of flatlands, gentle slope, and steep slope areas. These were obtained by adopting the 100×100-meter gridded DEM and by considering the physical features of the Korean Peninsula. The features of relief in mountainous areas, waters, islands, etc. were converted into climatic indices. This grouping of biochores serves as a useful tool for the interpretation of the distributional patterns of vegetation of vascular plants and similar phenomena.**

Key words : biochore, CI, DEM, moisture index (Im), WI

INTRODUCTION

The term "biochore" means a group of similar biotopes. A biotope is defined as the smallest geographical unit of a biosphere or a habitat, which can be delimited by convenient boundaries and is characterized by its biota. A biochore is considered as a hierarchy system composed of the world zone, main landscape level, land system level, mosaic or land unit level, single stand level, and special level (Zonneveld 1988). Therefore, a biochore is represented as a three-dimensional space of a certain scale, which is affected by topographic features, vegetations, and various life activities.

The mountainous landscape of the Korean Peninsula in East Asia has its ecological peculiarity, particularly its climatic conditions, vegetations, and biota. The forest zone in Korea is determined by thermal climate (Yim and Kira 1975; Yim 1977).

No studies, however, have been made regarding the factors that determine a scale unit that is smaller than the plant formation level, such as a community or single stand level. And, there have few domestic studies about the biochore, and in some foreign studies, Neumayr (1883) had defined the term province as a large region that has specific fauna habitats and geographic conditions including geographic distance, barriers, temperature etc. Uhlig (1911) has added term realm biochore to indicate a more inclusive and higher rank. Westermann (2000) has carried out studies on classification rules, nomenclature and definitions of the biochore to be recognized in the paleobiogeography and neobiogeography.

This study was carried out in order to suggest a classification of biochores, which can be used for the interp-

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retation of the distributional range or floristic composition of vegetation.

MATERIALS AND METHODS

1. First stage analysis

According to Yim and Kira (1975), the boundaries of forest zones (formation level) in the Korean Peninsula are determined largely by the warmth index (WI) 100°C, 85°C, and 55°C · month, and the coldness index (CI) −8°C or −10°C · month. Therefore, the values of WI and CI were calculated based on the data from 101 meteorological stations (1970∼1999) and were compared with those reported by Yim and Kira (1975). The comparative analysis did not reveal any significant differences between the two sets of values. In addition, multiple regression equations by SAS (1999) were attained in order to measure the changes in WI or CI changes alongside the altitudinal and latitudinal changes, as follows:

WI = 296 − 5.27 latitude − 0.0341 altitude (R^2 = 0.92), and
CI = 169 − 4.97 latitude − 0.0374 altitude (R^2 = 0.90).

The multiple regression equations yielded a new WI Grid Data File using the Grid Analyst Tools of MGE. In short, the major biochores were determined by the isopleth lines WI 100°C, 85°C, 55°C · month, and CI −8°C or −10°C · month, according to the thermal zones that were identified by Yim and Kira (1975).

1st step (Classification by thermal climate): I II III IV V
⇩
2nd step (Classification by climatic humidity/aridity): A B_{12} B_3 B_4 C
⇩
3rd step (Classification by slope degree class): a b c
⇩
4th step (Integration of biochore construction and mapping): Hierarchy system construction

Fig. 1. Steps of biochore classification.

2. Second stage analysis

The second ranks of the biochore were divided according

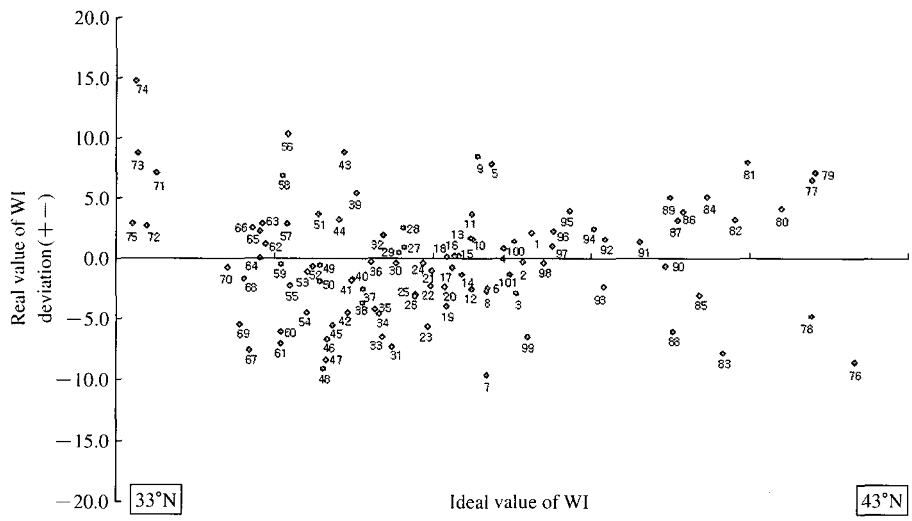

Fig. 2. Diagram showing the deviation of real values from the ideal values of WI obtained by SAS at 101 stations. The figures correspond to the station no. 1: Sokcho, 2: Cheorwon, 3: Inje, 4: Chuncheon, 5: Gangneung, 6: Gangwha, 7: Daegwallyeong, 8: Hongcheon, 9: Seoul, 10: Donghae, 11: Ulleungdo, 12: Yangpyeong, 13: Incheon, 14: Samcheok, 15: Wonju, 16: Suwon, 17: Icheon, 18: eongwol, 19: Taebaek, 20: Jecheon, 21: Uljin, 22: Chungju, 23: Chunyang, 24: Yeongju, 25: Cheonan, 26: Seosan, 27: Cheongju, 28: Mungyeong, 29: Andong, 30: Yeongdeok, 31: Boeun, 32: Daejeon, 33: Uiseong, 34: Boryeong, 35: Buyeo, 36: Chupungnyeong, 37: Gumi, 38: Geumsan, 39: Pohang, 40: Gunsan, 41: Yeongcheon, 42: Iksan, 43: Daegu, 44: Jeonju, 45: Buan, 46: Geochang, 47: Jangsu, 48: Imsil, 49: Jeogeup, 50: Hapcheon, 51: Ulsan, 52: Miryang, 53: Sancheong, 54: Namwon, 55: Jinju, 56: Masan, 57: Gwngju, 58: Busan, 59: Muan, 60: Suncheon, 61: Hampyeong, 62: Geoje, 63: Tongyeong, 64: Mokpo, 65: Namhae, 66: Yeosu, 67: Jangheung, 68: Goheong, 69: Haenam, 70: Wando, 71: Jeju, 72: Seongsanpo, 73: Jejugosan, 74: Seogwipo, 75: Daejeong, 76: Seonbong, 77: Samjiyeon, 78: Cheongjin, 79: Junggangjin, 80: Hyesan, 81: Ganggye, 82: Pungsan, 83: Gimchaeg, 84: Supung, 85: Jangjin, 86: Huicheon, 87: Sinuiju, 88: Sinpo, 89: Guseong, 90: Hamheung, 91: Anju, 92: Wonsan, 93: Yangdeog, 94: Pyeongyang, 95: Jangjeon, 96: Sariwon, 97: Singye, 98: Pyeonggang, 99: Yongyeon, 100: Haeju, 101: Gaeseong.

to Thornthwaite's moisture index (Im) classes (Yim and Kira 1976), as follows: 100≤Im (per humid, A), 80≤Im<100 (humid, B_4), 60≤Im<80 (humid B_3), 20≤Im<60 (humid, B_{12}), and −20≤Im<20 (subhumid, C). The isopleth lines of the Im value distribution are somewhat rough in terms of accuracy, with immeasurable local variations compared to those of WI or CI. At present, the information on local hydro climate is not enough to improve their accuracy.

In order to take this and other factors into consideration, the isopleth lines of the Im by Yim and Kira (1976) were partially modified in this study.

3. Third stage analysis

In the third stage of the classification of biochores, the slope degree classes (sd) were selected among several examined topographic features, including the slope aspect. Based on the grid map of the 100×100-m cell, the slope degrees were classified into three classes (a, b, and c), namely: flatland (0~5°), gentle-slope area (5~15°), and steep-slope area (15°≤), considering the 5-rank system of Hudson (1936) and the 6-rank system of Lee (1999). Among the topographic features, the factors affecting continentally, such as altitudinal variables, waters, and island distribution, were converted into the portion of

Table 1. Categories of biochores in Korea

Thermal condition (WI or CI)	Humid/Arid condition (Im)	Slope degree class (Sd)	Index or class			
			WI or CI	Im	Sd	Remarks
I	A	a b	CI>−10 or −8	100≤	0~5° 5~15°	Warm temperate forest
	B_{12}	a b c		20~60	0~5° 5~15° 15°≤	
	B_3	a b c		60~80	0~5° 5~15° 15°≤	
	B_4	a b c		80~100	0~5° 5~15° 15°≤	
II	B_{12}	a b c	WI>100	20~60	0~5° 5~15° 15°≤	Cool temperate forest, southern zone
	B_3	a b c		60~80	0~5° 5~15° 15°≤	
	C	a b		−20~20	0~5° 5~15°	
III	B_{12}	a b c	WI 85-100	20~60	0~5° 5~15° 15°≤	Cool temperate forest, central zone
	B_3	a b c		60~80	0~5° 5~15° 15°≤	
	C	b c		−20~20	5~15° 15°≤	
IV	B_{12}	b c	WI 55-85	20~60	5~15° 15°≤	Cool temperate forest, northern zone
	B_3	b c		60~80	5~15° 15°≤	
	C			−20~20		
V	B_{12} B_3 C		WI<55	20~60 60~80 −20~20		Sub-arctic forest

Ultimately, the biochores were classified into five districts in the 1st stage, 16 districts in the 2nd stage, and 35 districts in the 3rd stage.

climatic index values in the calculation process.

4. Construction and mapping of the hierarchy system

As was mentioned above, the classification of the biochores was undertaken in three steps. The categories were scaled down from the first step to the third step, or from the macro scale to the micro scale. The classification of the biochores (Fig. 1) was then mapped.

RESULTS AND DISCUSSION

1. Thermal zone

Yim and Kira (1975) reported that thermal zones divided by WI 100°C, 85°C, 55°C CI−8°C or −10°C · month isopleth lines were useful for the interpretation of natural vegetation zones in Korea. This means that thermal climatic conditions can be considered determinants of macro-biochores for the interpretation of the irregular macro-biochore shape.

A comparison of the real values of WI, and the ideal values calculated by the multiple regression equation (SAS 1999), showed that the deviations (d) from the ideal values (theoretical values) ranged from +14.8°C · month to −9.6°C · month, with a mean of ±10°C · month (Fig. 2). These deviations take into account the effect of many factors, including topography and the thermal climate. In particular, among the stations with large deviation values, two groups are worth noting: $+5 \leq d$ group of 13 stations and $-5 \geq d$ group of 11 stations. It is noticeable that the former covers the urban area, islands, and river basin areas, while the latter includes the East Sea coastal areas and inland areas. These findings suggest that topographic features and their effects on the hydro climate and other factors should be considered in the interpretation of the thermal zone or vegetation zone.

2. Humidity/Aridity zones

Based on the distribution of climatic humidity/aridity, the Korean Peninsula is classified into three climatic zones as the follows: humid zone ($Im > 60$), subhumid zone ($60 > Im > 20$), and semi-arid zone ($20 > Im > -20$) (Yim and Kira 1976). These zones were subdivided into 4 categories as the follows: $100 \leq Im$, $20 \leq Im < 60$, $60 \leq Im < 80$, and $80 \leq Im < 100$ (Table 1). This subdivision, however, is not enough since the geographical distribution of precipitation is strongly affected by topography and altitude. In addition, precipitation records in mountainous areas are too meager to draw climatic boundaries. Therefore, the isopleth lines of Yim and Kira (1976) were partly modified for the classification of biochore subdivision (Fig. 3). The biochore map of Fig. 3 shows that the thermal zonee (I, II, III, IV, V) of Korean Peninsula closely corresponding with the forest vegetation zones are divided and then humidity zones are done afterwards.

3. Slope-degree classes

The distribution area, frequency of slope aspects, and

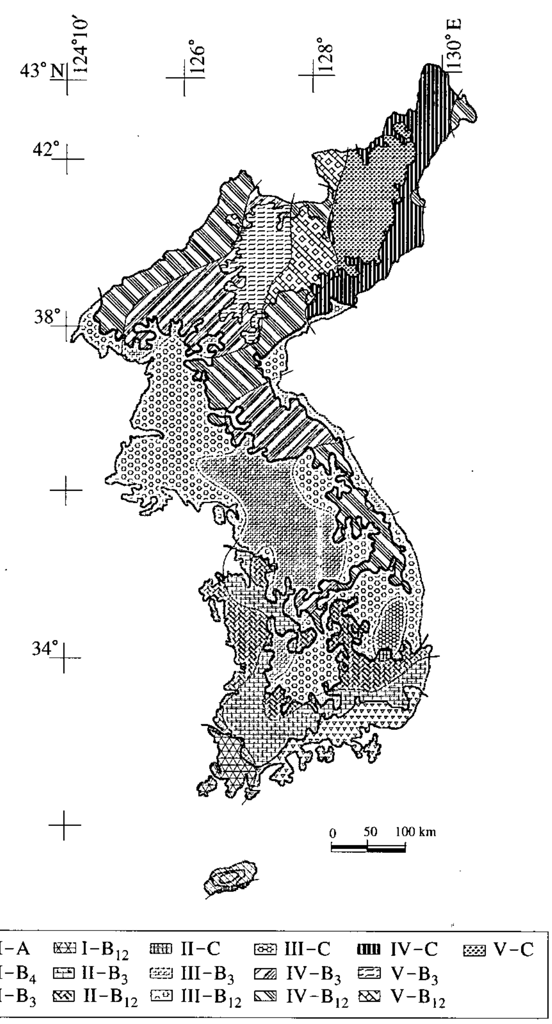

Fig. 3. A biochore map of the Korean Peninsula depicted by thermal and humid or arid conditions. A thin line shows moisture index (Im). For symbols see table 1.

altitudinal variations of mountainous areas in the digital map were analyzed by statistical treatment. The aspects data, however, were neglected because of reliability problems due to the complexity of the mountain chain. Moreover, the effect of mountain elevation was partially converted into thermal climate. Accordingly, the slope degree was regarded as a key factor for the evaluation of topographic features. The three classes of slope degrees, however, do not contain additional details. Based on the classification of Hudson (1936), the area of slope degree calculated by DEM was classified according to 4.3% (flatland), 20.6% (1 ~ 5°), 14.8% (5 ~ 10°), 14.2% (10 ~ 15°), 14.3% (15 ~ 20°), and 31.8% (20° ≤) (Fig. 4).

On the other hand, the slope aspects in South Korea, based on 100 × 100 m-altitude Grid File analysis, appeared as follows: 12.73% (N), 10.59% (NE), 11.98% (E), 14.64% (SE), 10.83% (S), 10.64% (SW), 14.38% (W), 12.89% (NW), and 1.34% (flatland).

4. Analysis of biochore classes

Fig. 5 shows that the ecological space of South Korea is primarily divided into five formations (I, II, III, IV, V) at the formation level by Yim & Kira (1975). Each formation is divided into five habitats (A, B_{12}, B_3, B_4, C) by Thornthwaite's moisture index (Im), which are in turn, classified into three by the slope gradient defined by Hudson (1939) and Lee (1999).

The different levels in the biochores present various functions. The 1st rank is useful for the interpretation of the distribution of plant formation or subbiome. On the other hand, the 2nd and 3rd ranks can be used for selected plant community levels or alliance units in plant sociological viewpoints, and for the distribution of some plant taxa or particular ecosystem, respectively. Of the 31 ecological habitats in South Korea, the habitat I-B_{12}-a has CI of −10, moisture index of $20 \leq Im < 60$ and slope degree of 0 ~ 5°. This administratively comprises the neighboring area of the estuary of Yeongsan River at the southwest coast, where there are currently few forest vegetations. They are generally used as arable land and residental areas. This is because the slope degree of this habitat is primarily plain

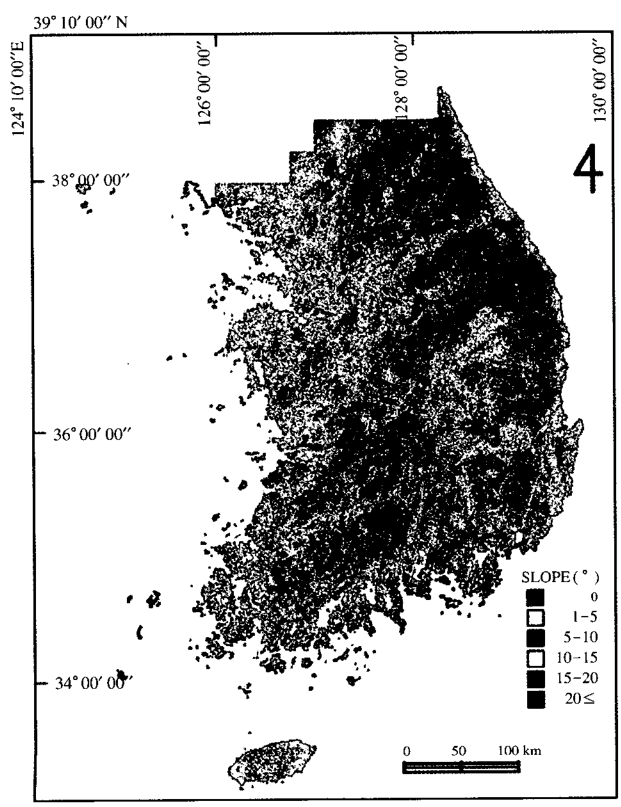

Fig. 4. A map showing the slope degree in the South Korea.

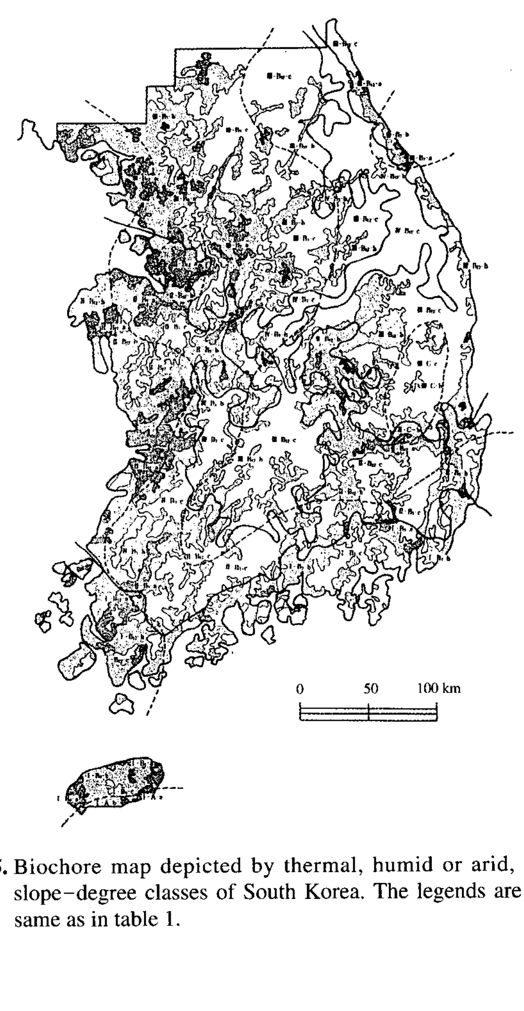

Fig. 5. Biochore map depicted by thermal, humid or arid, and slope-degree classes of South Korea. The legends are the same as in table 1.

and does not limit crop cultivation. The area is appropriate for land development, contour cultivation, orchards and patches. The habitat IV-B_{12}-c has WI of 85~55, moisture index of $20 \leq Im < 60$ and slope degree of more than 15°. This comprises some areas of the Sobaek Mountains and the Taebaek Moutains. This habitat is characterized by steep slope and high altitude to limit the use of lands, where *Quercus mongolica*, the indicator of the northern cold and temperate zones, has formed a community covering most of the area. And, the results of this multiple analysis were applied to the formation of the hierarchy system, although critical discussion would be required to analyze the details of the classification.

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