A Scheme of Vegetation Classification of Taiwan, China

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Abstract: The complexity of natural conditions leads to the complexity of vegetation types of Taiwan of China, which has both tropical and cold-temperate vegetation types, and could be depicted as the vegetation miniature of China or even the world. The physiognomic-floristic principle was adopted for the vegetation classification of Taiwan. The units of rank from top to bottom are: class of vegetation-type, order of vegetation-type, vegetation-type, alliance group, alliance and association. The high-rank units (class, order and vegetation-type) are classified by ecological physiognomy, while the median and lower units by the species composition of community. At the same time the role of dominant species and character species will also be considered. The dominant species are the major factor concerned with the median ranks (alliance group and alliance) because they are the chief components of community, additionally their remarkable appearance is easy to identify; the character species (or diagnostic species) are for relatively low ranks (association) because they will clearly show the interspecies relation-ship and the characteristics of community. According to this principle, vegetation of Taiwan is classified into five classes of vegetation-types (forests, thickets, herbaceous vegetation, rock fields vegetation, swamps and aquatic vegetation), 29 orders of vegetation-types (cold-temperate needle-leaved forests, cool-temperate needle-leaved forests, warm-temperate needle-leaved forests, warm needle-leaved forests, deciduous broad-leaved forests, mixed evergreen and deciduous broad-leaved forests, evergreen mossy forests, evergreen sclerophyllous forests, evergreen broad-leaved forests, tropical rain forests, tropical monsoon forests, coastal forests, warm bamboo forests, evergreen needle-leaved thickets, sclerophyllous thickets, deciduous broad-leaved thickets, evergreen broad-leaved thickets, xerothermic thorn-succulent thickets, bamboo thickets, meadows, sparse shrub grasslands, savannahnic grasslands, sparse scree communities, chasmophytic vegetation, woody swamps, herbaceous swamps, moss bogs, fresh water aquatic vegetation, salt water aquatic vegetation) and 53 vegetation-types. The main alliances of each vegetation-type are described.

Key words: vegetation classification; physiognomic-floristic principle; physiognomic approach; dominance-types; Braun-Blanquet approach; Taiwan

Taiwan is located in the subtropical region, close to the margin of the tropics and isolated in the ocean. A number of high mountains cross the island in continuity. Since the Tertiary it was connected with or separated from the mainland of China alternately through the regression and the transgression. During the glacial period, most of the species migrated southward to escape from the bitter cold; subsequently the mild and humid environment in Taiwan turned out to be their ideal shelter. Once the weather warmed up again, they moved northward or upward to cooler locations on the island. After repeated migration the species of animals and plants in Taiwan became closely connected with their continental counterparts, while maintaining their own local features. Although the area of Taiwan is only about 36 000 km², the community types have both the tropical and cold-temperate types; it could be depicted as the vegetation miniature of China or of the world for that matter.

Modern botanical research in Taiwan began in the mid nineteen century. As the first investigators the British collected herbariums in Jilón, Danshui in North Taiwan, and in Gaoxiong, and Hengchun in South Taiwan. From the time when the Japanese occupied Taiwan in 1895, the survey of plants was carried out throughout the island, but this work relied heavily on collecting herbariums with occasional concerned for vegetation and general descriptions of plant community. Tokio SUZUKI, an outstanding researcher, classified the forest communities of northeastern and southwestern Taiwan into association-level based on the Braun-Blanquet Method (Huang,1993; Chen,1995). After the recovery of Taiwan in 1945, the survey of vegetation at first focused on analyzing the forest-type, the nomination of which was set up by dominant species. At the end of the 1960s a series of theses on the vegetation in Taiwan was published by Liu (1968; 1970; 1971a; 1971b), and the vegetation of
Taiwan was divided into three formation-groups and eight formations according to the classification system of Clements. Until today these articles are still important classical literatures of the vegetation of Taiwan for researchers. Later on, the first edition of “Flora of Taiwan” was published and in the 1980s the botanical surveys launched by various universities were gradually shifting focus to studying plant community. A number of publications about vegetation in Taiwan were continuously published (Su, 1984a; 1984b; 1992; Chen, 1995; Lai et al., 2001). Owing to the different points of view and methods of survey, the vegetation classification system of Taiwan was a subject of controversy, even the terms and concepts are different. In order to promote academic communication, the authors are bringing forward this scheme based on the field work and previous literatures.

1 Principle of Vegetation Classification in Taiwan

The vegetation classification is a most complicated issue on the research of vegetation. There are two different theories concerned with the plant community: “continuity theory” and “discontinuity theory”. Therefore the different approaches result in a varied understanding on the classification of the plant community results. From our point of view, the community is continuous on one hand and discontinuous on the other hand. Emphasizing the continuity is not necessarily denying the real existence of community, and admitting the discontinuity does not mean that the type is very rigid and totally natural (Song, 2001). Generally, the classification of community is always confined to the understanding level of people, therefore, the subjectivity can not be ruled out. Our objective is to reach a consistence of subjectivity and objectivity as much as possible. That is the fundamental aim for the vegetation classification.

The physiognomic-floristic principle was adopted for the vegetation classification of Taiwan. The high-rank units of classification are based on eco-physiognomy, while the median and lower units on the species composition. At the same time the role of dominant species and character species will also be considered. The dominant species are the major factor concerned with the median ranks because they are the chief components of community, additionally their remarkable appearance is easy to identify. The character species (or diagnostic species) are for relatively low ranks because they will clearly show the interspecies relationship and the characteristics of community. This point of view tends to be consistent with Beard’s. He had pointed out “the physiognomic approach to vegetation is still a vital and valuable one... Formations can be reasonably subdivided into floristic units (dominance types or associations). Floristic treatment of vegetation on a local level can thus be combined with physiognomic treatment, which is almost indispensable for broader biogeographic interpretation of plant communities”, and also emphasized that “the floristic approach is undoubtedly the more suited to detailed studies of local areas and the physiognomic approach to broadly-based studies on an international scale. It would seem that a desirable goal for the future should be the marrying of the two approaches into a single system of classification wherein floristic units are combined by their structure into physiognomic units.” (Beard, 1980).

Similar to Beard’s idea, Wu et al. (1980) in the book “The Vegetation of China” claimed “the classifying principle for the vegetation of China is the principle of phytocoenology, or so-called phytocoenological-ecological principle, i.e. the classification is based on the inherent characteristics of plant community, but also highly concerned about ecological relationships of community, making effort to use every aspect of the features, ...the higher unit is stressed on eco-physiognomy, while that of median and low unit is based on the species composition and community structure”. Lately the Federal Geographic Data Committee of the United States (Federal Geographic Data Committee USA, 1997) established a classification system for vegetation of the United States. The standard of higher units of this system is also set up by the physiognomy and the lower units by the species composition.

2 System and Units of Vegetation Classification in Taiwan

The system of vegetation classification of Taiwan from top level down is assumed as: class of vegetation-type, order of vegetation-type, vegetation-type, alliance group, alliance and association. The main criteria for identifying the three high-ranked units are eco-physiognomy, while species composition is used for median and lower ranked units, concerning with both dominant species and character species.

2.1 Class of vegetation-type

It is the union of communities for which the first class growth form of their dominant layer is in coincidence. This class is in equivalence with the “basic vegetation type” of both classification system of Rübel (1930) and Alechin (1950), or equivalent to the “formation class” by classification system of Ellenberg and Mueller-Dombois (1967), such as forests, thickets, herbaceous vegetation, etc.
2.2 Order of vegetation-type

It is the union of communities with identical growth form in dominant synusia and similar physiognomy. Which is relevant to the macroclimate of certain areas or to some unique habitats and is also equivalent to the "vegetation type" by a classification system suggested by Wu et al. (1980), such as evergreen broad-leaved forest, deciduous broad-leaved forest, etc.

2.3 Vegetation-type

It is the combination of communities with the same growth form of dominant synusia and similar physiognomy, as well as sharing the same hydrothermal condition or occasion in identical habitats. Among them the zonal vegetation type reflects a certain bio-climatic zone, while non-zonal vegetation types are formed by unique environmental conditions. This rank is equivalent to the "vegetation subtype" according to the classification system suggested by Wu et al. (1980), in certain sense it is also equivalent to "formation" identified by American and European scholars based on the physiognomy (Beard, 1980; Whittaker, 1980), such as typical evergreen broad-leaved forest, subtropical seasonal evergreen broad-leaved forests, subtropical ombrophilous evergreen broad-leaved forests.

In case of necessity subtypes could be set up under the three high-ranked units described above.

2.4 Alliance group

This is the combination of alliances with same dominant species (or species in the same genera), or the same ecological character. Generally they should have certain character species (or diagnostic species). This rank is equivalent to the "formation group" by classification system of Wu et al. (1980).

2.5 Alliance

The combination of associations with the same dominant species in dominant synusia and similar ecological features, they should also have certain character species (or diagnostic species). This class might be equivalent to "dominance type" specified by American and British school (Whittaker, 1980), as well as the term "formation" by classification system of Wu et al. (1980). However those definitions are slightly different from each other. Since the alliance in this paper emphasizes more heavily on the character species (or diagnostic species), therefore, it is closer to the concept of "alliance" of Braun-Blanquet System (Westhoff and Maarel, 1980).

2.6 Association

It is the basic unit of the vegetation classification system of Taiwan. The term is consistent with that of Brun-Blanquet School. The criteria of association are: "a combination of communities with the same physiognomy, the same synusia structure, relatively high coincidence of species composition and interspecies proportion, and also with same group of character species or diagnostic species." The association classified by this definition could be compared with those identified by Braun-Blanquet System. In some cases the contents of association such classified may be bigger than the association classified according to dominant species in each layer. The high-ranked units of vegetation classification in Taiwan are shown as follows (Table 1).

3 Outline of Vegetation Types in Taiwan

In the following classification units of different ranks are distinguished by various symbols: I, II, etc. are Class of vegetation-type; A, B, etc. are Subclass of vegetation-type; 1, 2, etc. is Order of vegetation-type; and a, b, etc. is -type.

1. Forests

Formed by trees at least 5 m tall with their canopy of coverage over 30%, including closed forests and woodlands.

A. Needle-leaved forests These forests are widely distributed in the mountainous region of Taiwan (Wang, 1968; Liu, 1971a). Most of the constituting dominant species such as *Taiwania cryptomerioides*, *Chamaecyparis obtusa* var. *formasana*, *Chamaecyparis formosensis*, *Tsuga chinensis* var. *formosana*, *Pseudotsuga wilsoniana*, *Cunninghamia konishii*, *Picea morrisonicola* are the endemic. They have significant value for scientific research and economy. This subclass can be divided into four orders of vegetation-type.

1. Cold-temperate needle-leaved forests Cold-temperate needle-leaved forests are distributed over areas of the cold-temperate zone or the regions of high elevation. The north border is exactly the border of the world wide forest zone. The borderline of high elevation area is the same as the timber line. It has only one vegetation-type in Taiwan.

   a. Subalpine cold-temperate needle-leaved forests These forests in Taiwan mostly are distributed over areas with an elevation of 2 800–3 700 m. The main alliance is: Alliance (All.) *Abies kawakamii*, occurring in high elevation of Xueshan, Dabajianshan, Nanjudashan, Zhongyangjianshan, Yushan, Qilaizhushan, Xiuguluanshan, Hehuanshan, etc.

2. Cool-temperate needle-leaved forests These forests consist of cool-temperate favorable coniferous trees. In Taiwan they spread over high or medium mountainous
Table 1 Units of high-rank of vegetation classification in Taiwan

<table>
<thead>
<tr>
<th>Class of vegetation-type</th>
<th>Subclass of vegetation-type</th>
<th>Order of vegetation-type</th>
<th>Vegetation-type</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Forests</td>
<td>A. Needle-leaved forests</td>
<td>1. Cold-temperate needle-leaved forests</td>
<td>a. Subalpine cold-temperate needle-leaved forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Cool-temperate needle-leaved forests</td>
<td>a. Montane cool-temperate needle-broad leaved forests</td>
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<td></td>
<td>b. Montane cool-temperate mixed needle-broad-leaved forests</td>
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<td>3. Warm-temperate needle-leaved forests</td>
<td>a. Montane warm-temperate needle-leaved forests</td>
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<td></td>
<td></td>
<td>b. Montane warm-temperate mixed needle-broad-leaved forests</td>
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<td></td>
<td></td>
<td>4. Warm needle-leaved forests</td>
<td>a. Warm evergreen needle-leaved forests</td>
</tr>
<tr>
<td></td>
<td>B. Broad leaved forests</td>
<td>5. Deciduous broad-leaved forests</td>
<td>a. Montane deciduous broad-leaved forest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Riverside deciduous broad-leaved forest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Mixed evergreen deciduous broad-leaved forests</td>
<td>a. Montane mixed evergreen deciduous broad-leaved forests</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>b. Dry land mixed evergreen deciduous broad-leaved forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Evergreen mossy forests</td>
<td>a. Montane dwarf evergreen mossy forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. Evergreen sclerophyllous forests</td>
<td>a. Montane evergreen sclerophyllous forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Evergreen broad-leaved forests</td>
<td>a. Montane evergreen broad-leaved forests</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>b. Subtropical seasonal evergreen broad-leaved forests</td>
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<td></td>
<td></td>
<td></td>
<td>c. Subtropical ombrophilous evergreen broad-leaved forests</td>
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<tr>
<td></td>
<td></td>
<td>10. Tropical rain forests</td>
<td>a. Tropical seasonal rain forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11. Tropical monsoon forests</td>
<td>a. Tropical semi-deciduous monsoon forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. Coastal forests</td>
<td>a. Subtropical rock-sandy coastal forests</td>
</tr>
<tr>
<td></td>
<td>C. Bamboo forests</td>
<td>13. Warm bamboo forests</td>
<td>a. Tropical coral reef coastal forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Scatter bamboo forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Cluster bamboo forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Mixture bamboo forests</td>
</tr>
<tr>
<td></td>
<td>II. Thickets</td>
<td>A. Needle-leaved thickets</td>
<td>a. Subalpine evergreen needle-leaved thickets</td>
</tr>
<tr>
<td></td>
<td>B. Broad-leaved thickets</td>
<td>14. Evergreen needle-leaved thickets</td>
<td>a. Subalpine evergreen needle-leaved thickets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15. Sclerophyllous thickets</td>
<td>a. Subalpine sclerophyllous thickets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16. Deciduous broad-leaved thickets</td>
<td>a. Montane deciduous broad-leaved thickets</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>b. River flat deciduous broad-leaved thickets</td>
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<td></td>
<td></td>
<td></td>
<td>c. Dry land deciduous broad-leaved thickets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17. Evergreen broad-leaved thickets</td>
<td>a. Hill-montane evergreen broad-leaved thickets</td>
</tr>
<tr>
<td></td>
<td>C. Thorn-succulent thickets</td>
<td>18. Xerothermic thorn-succulent thickets</td>
<td>a. Temperate bamboo thickets</td>
</tr>
<tr>
<td></td>
<td>III. Herbaceous vegetation</td>
<td>A. Pratoherbosa</td>
<td>20. Meadows</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Subalpine meadows</td>
</tr>
<tr>
<td></td>
<td>B. Xeropoium</td>
<td>21. Sparse shrub grasslands</td>
<td>a. Flood plain meadows</td>
</tr>
<tr>
<td></td>
<td>A. Scree vegetation</td>
<td>22. Savannahic grasslands</td>
<td>a. Warm sparse shrub grasslands</td>
</tr>
<tr>
<td></td>
<td>B. Chasmosphytic vegetation</td>
<td>23. Sparse scree vegetation</td>
<td>a. Xerothermic savannahic grasslands</td>
</tr>
<tr>
<td></td>
<td>A. Swamps and aquatic vegetation</td>
<td>25. Woody swamps</td>
<td>a. Alpine chasmosphytic communities</td>
</tr>
<tr>
<td></td>
<td>B. Aquatic vegetation</td>
<td>26. Herbaceous swamps</td>
<td>b. Montane scree communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27. Moss bogs</td>
<td>b. Montane chasmosphytic communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28. Fresh water aquatic vegetation</td>
<td>a. Sea shore chasmosphytic communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29. Salt water aquatic vegetation</td>
<td>a. Mangrove</td>
</tr>
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<td></td>
<td></td>
<td>b. Fresh water woody swamps</td>
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<td></td>
<td>a. Sedge swamps</td>
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<td>b. Peat moss bogs</td>
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<td>a. Submerged plant communities</td>
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<td>b. Free floating plant communities</td>
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<td></td>
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<td>c. Rooted floating-leaved plant communities</td>
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<td></td>
<td>d. Emergent plant communities</td>
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<td>a. Salt water aquatic plant communities</td>
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areas, and can be divided into two vegetation-types.

a. Montane cool-temperate needle-leaved forests
These forests in Taiwan are characterized by species of genera *Picea* and *Tsuga*, and are mostly distributed in areas of 2,500–3,000 m above sea level (a.s.l.), such as All. *Picea morrisonicola*, All. *Tsuga chinensis* var. *formosana* and All. *Pinus armandi* var. *masteriana*.

b. Montane cool-temperate mixed needle-broad-leaved forests
These mixed forests in Taiwan are composed of cool-temperate needle-leaved trees and other deciduous broad-leaved trees, and mostly located in areas of 1,800–3,000 m a.s.l. Examples, All. *Trochodendron aralioides-Tsuga chinensis* var. *formosana-Picea morrisonicola*.

3. Warm-temperate needle-leaved forests
Warm-temperate needle-leaved forests are composed of warm-temperate needle-leaved trees, mostly distributed over medium and low mountainous areas in Taiwan. They can be divided into two vegetation-types.

a. Montane warm-temperate needle-leaved forests
These kinds of forests in Taiwan used to be made up of *Pinus taiwanensis*, *Chamaecyparis* and *Cunninghamia*. Main alliances are All. *Chamaecyparis formosensis-Chamaecyparis obtusa* var. *formosana*, which is endemic and distributed in areas of 1,500–2,800 m a.s.l. of Zhongyangshan mountains, Yushan mountains and Alishan mountains. Two others All. *T. cryptomerioides* and All. *Cunninghamia konishii* are also endemic. In addition, the All. *P. taiwanensis* is also frequently seen.

b. Montane warm-temperate mixed needle-broad-leaved forests
Dominated by warm-temperate needle-leaved trees, more or less mixed with broad-leaved trees. The community in Taiwan is All. *Cyclobalanopsis stenophylloides-Chamaecyparis formosensis*, etc.

4. Warm needle-leaved forests
Composed of therophilic coniferous trees, some of which are deciduous while other evergreen. They are distributed over areas of low elevation.

a. Warm evergreen needle-leaved forests
Main communities in Taiwan are All. *Pinus massoniana*, distributed in the area of 250 m. a.s.l. of Huoyanshan in central part of Taiwan, and All. *Calocedrus formosana*, All. *P. wilsoniana*, as well as All. *Keteleeria davidi* var. *formosana*.

B. Broad-leaved forests
Composed of broad-leaved species. According to their eco-physiognomy and their relationship with hydrothermal conditions they can be classified into eight orders of vegetation-type.

1. Deciduous broad-leaved forests
These forests are also called summer-green forests (Aestisilvæ). Being a kind of zonal vegetation-type, they widely spread over the coastal area of the Atlantic ocean and also in Europe and East Asia. These forests in Taiwan include two vegetation-types.

a. Montane deciduous broad-leaved forests
In Taiwan they are located in the vertical belt of mountainous region in central and northern part, such as All. *Fagus hayatae*, which are distributed on 1,700 m. a.s.l. of North-Chatainshan, and the All. *Quercus dentata* distributing on the mountainous region of central Taiwan.

b. Riverside deciduous broad-leaved forests
They are referred to arbor communities composed by meso-hygrophyte and are distributed on the river bank. For example, the All. *Alnus formosana* is distributed on river banks of mid- and low-elevation, being the secondary communities grown up after destruction.

2. Mixed evergreen deciduous broad-leaved forests
This is a transitional type between deciduous and evergreen broad-leaved forest. In Taiwan they are distributed in the mountain land of medium and high elevation, and also in the arid habitats.

a. Montane mixed evergreen-deciduous broad-leaved forests
In Taiwan these forests distribute themselves over the areas above 1,500 m. a.s.l. The features of the location are low temperature, high humidity and high precipitation. The All. *Trochodendron aralioides-Acer morrisonense* distributed in mid elevation of Zhongyangshan Mountains, is often found in Taiwan.

b. Dry land mixed evergreen-deciduous broad-leaved forests
They are characterized by species of Ulmaceae and drought tolerant calciphilous plants in species composition and located on slopes of sunlit rocks or lime rocks at low elevation, such as All. *Cyclobalanopsis glauca-Carpinus kawakami*, and All. *Cyclobalanopsis glauca-Zelkova serrata*, occurring in Tianxiang of Tailuge and Tamsanshan as well as Alashan, etc.

3. Evergreen mossy forests
This is a unique vegetation type formed in the habitat with high atmospheric moisture. Its habitat is temperate-cool and extremely damp, as well as cloudy and foggy for year long. This kind of vegetation is identified typically by extremely abundant epiphytes, like mosses, which will cover thickly over ground, rocks, trunks, branches even old leaves. The thickness of mosses adhered to the trunks generally measures about 3–5 cm, sometimes even 10 cm. The scenery inside the forest of the mossy epiphytic greenery is quite different from evergreen broad-leaved forest in general.

a. Montane dwarf evergreen mossy forests
They are formed in the windy and foggy habitats in mountainous districts of tropics and subtropics. The tree layer is rather short, hardly distinguishable from the shrub layer. There is
an abundance of epiphytes of moss, which thickly covers the surface of trunks, branches, ground and rocks. The species composition of communities is predominated by Ericaceae, while the herbaceous layer includes pteridophyte, and also many species of Cyparaceae, Urticaceae, Liliaceae, Polygonaceae, Labiatae, Balsaminaceae, Primulaceae and Begoniaceae. Furthermore the evergreen trees of FAGaceae, Lauraceae, and Theaceae fall to the second rank of the composition, and can hardly be found in some areas. The epiphytic bryophyte and pteridophyte luxuriates in the forest; epiphytes of Orchidaceae and Hymenophyllum can be found; woody lianas are hardly seen, while herbaceous climbers appear often. In Taiwan the community of All. Skimmia reevesiana-Rhododendron formosanum distributing themselves in Yuanyanghu can be taken as an example.

4. Evergreen sclerophyllous forests It is a type of community closely related to a weather pattern of mild and wet winter, as well as a long arid summer. The typical evergreen sclerophyllous forests distribute themselves in the regions of Mediterranean Sea and Crimea, as well as in California of the United States in North America, middle part of Chile in South America, southwest cape of Africa and the southwestern region of Australia. Therefore they can be recognized as a vegetation type developing under the Mediterranean climate. It mainly consists of sclerophyllous evergreen trees and shrubs; their leaves are small, thick and leathery. The dorsal sides of the leaves are hairy and the edge of leaf has acute or pointed serration, and the bark is coarse. There is no typical evergreen sclerophyllous forest in Taiwan, except for a kind of variant occurring in some special habitats.

a. Montane evergreen sclerophyllous forests They are composed of high mountainous oak trees. In Taiwan there are the communities of All. Quercus spinosa distributing over the areas of high elevation, and All. Quercus tarokoensis, occurring in the limestone mountainous region in Tianxiang of Tailug.

5. Evergreen broad-leaved forests There are different opinions regarding the term “evergreen broad-leaved forest” (Song, 1994; 1995). In this study the broad definition of the concept was accepted. It is referred to the type of forest vegetation distributed over areas besides of tropics and with canopies composed of evergreen broad-leaved trees. In Taiwan it includes montane evergreen broad-leaved forests, subtropical seasonal evergreen broad-leaved forests and subtropical ombrophilous evergreen broad-leaved forests (Song et al., 2003).

a. Montane evergreen broad-leaved forests This type is mostly distributed over the mountainous land at the 800–2 300 m height, visible throughout the whole island. The climatic characteristics of the area is warm and moist, the annual precipitation is over 2 000 mm, and there are normally heavy cloud cover and high humidity. Although the rainfall in winter is scarce, it is not arid at all. The community structure and physiognomy are similar to the typical evergreen broad-leaved forest on the Mainland. The tree layer is mainly composed of Castanopsis, Cyclobalanopsis, and Lithocarpus. In the herbaceous layer the pteridophyte are often seen. This type of forests is equivalent to the “Quercus forest” (Su, 1984b), and to the “evergreen broad-leaved forest type III and IV” (Hsieh et al., 1997). This type of forests is the most complicated and diversified in Taiwan. The major communities are as below: All. Cyclobalanopsis morii-Castanopsis carlesii, occurring on the slope of 1 400–2 230 m.a.s.l. of central and northern part of island, such as Xueshankexi, Shuangguihu. Meifeng, Cuifeng and the All. Litholarpus rawakami-Cyclobalanopsis longinux occurs in Bilu at an elevation of 2 000 m, as well as from Lupingshan to Nanchaitanshan. Additionally, in the regions at an elevation of 1 400–1 600 m of the Coastal Mountains there is the Ternstroemia gymnanthera-Castanopsis carlesii community; the Trochodendron aralioides-Cyclobalanopsis sessilifolia community is located at the height of 1 750 m in the mountainous region of Daguanshan.

b. Subtropical seasonal evergreen broad-leaved forests This kind of forest is also named as “subtropical evergreen seasonal forest” by Ellenberg and Mueller-Dombois (1967), which is a transitional type from the tropical seasonal rain forest or semi-deciduous monsoon forest to the evergreen broad-leaved forest” (Song, 1994; 1995). This is a zonal vegetation type in subtropical region of Taiwan, mainly distributed over the area under an elevation of 500 m (in northern part) and 1 000 m (in southern part). The same vegetation type is also found in southern Fujian and Guangdong, as well as Guangxi, Yunnan, Guizhou and the southern slope of the Himalayas. It was named distinctly in various areas, such as “monsoon evergreen broad-leaved forests”, “subtropical monsoon rain forest” and “subtropical evergreen broad-leaved forests” (Wu et al., 1980). The main communities in Taiwan are the All. Lithocarpus amygadalifolius-Cyclobalanopsis longinux var. koui, occurring on the lower slope of Hengchun Peninsula, the All. Engelhardtia roxburghiana-Castanopsis uraiana are located in Lianhuachi, Riyuetan, etc., the All. Machilus japonica-Castanopsis carlesii var. sessilis grow in Wulai. Additionally, there is found Diospyros
morrisciana-Cryptocarya chinensis community located on slopes at 300–1 100 m in anaonanxi, and All. Styrax suberifolia-Machilus zhuoehsies occurring in Fushan, etc.

c. Subtropical ombrophilous evergreen broad-leaved forests They are usually referred to as “subtropical rain forests” and are located primarily over humid habitats in low ravines with annual precipitation of 3 500–4 000 mm, and an annual average temperature at approximately 18–20 °C. The communities are relatively tall, their stratification is rather complicated, uneven and slightly irregular with canopies, large-sized woody vines and vascular epiphytes are booming inside the forest, and sometimes buttress, cauliflory and strangler can be found. The tree fern and large-sized herbages are present very often. The physiognomy approximates the characteristics of a tropical rain forest. This kind of forest is partly equivalent to the so-called “Ficus-Machilus forest” (Su, 1984b). The communities frequently occurred in Taiwan are as follows: All. Ficus septica - Ficus irisana, spraying in the ravines of Coastal Mountains in areas of 250–500 m a.s.l.; the All. Ficus fistulosa - Machilus japonica var. kusaneni occurs in the ravines of Yangmingshan. Additionally, the Turpinia ternata-Machilus japonica var. kusanoi community is found in the coastal mountains and the southern part of Taiwan.

6. Tropical rain forests They are also called “tropical ombrophilous forests”. Regarding the physiognomic structure they are characteristically featured by the followings: quite complicated stratification, erect smooth and tall trunks, 30 m height at least, with smooth bark, few sproutings, (usually 3–4 classes), obvious buttress, cauliflory and drip-tip leaves, and gorgeous and colorful new leaves. At the same time, there is an abundance of coarse and large woody vines and flowering epiphytes, plus hemi-epiphytes or strangler, etc., while the herbages develop with stain-leaves. All of the above features are characteristics of a tropical rain forest. Furthermore there are extraordinarily plentiful species of plants in the tropical rain forest; most of the components are from tropical flora of Dipterocarpaceae, Myristicaceae, Moraceae, Euphorbiaceae, Myrtaceae, Sterculiaceae, Sapotaceae, Palmae, Rubiaceae, Sapindaceae, Annonaceae, and Samyaceae. The tropical rain forests in Taiwan have a seasonal character because of the monsoon influence. For this reason they are also called tropical seasonal rain forests (Ellenberg and Mueller-Dombois, 1967).

a. Tropical semi-deciduous monsoon forests This kind of forests mainly occur in the southern part of Taiwan, composed of mixed tropical evergreen and deciduous trees. This kind of vegetation in Taiwan includes the following main types: All. Macaranga tanarius-Kleinhovia hospita, occurring in Hengchun Peninsula; All. Bridelia tomentosa-Albizia procera occurs at the foot of mountains of Pingdong; All. Vitex negundo-Acacia confusa, is wildly distributed on the Hengchun Peninsula.

7. Tropical monsoon forests This kind of forest is distributed in tropical regions where dry and wet seasons periodically alternate. It is a zonal vegetation of tropical monsoon climate zone. The typical monsoon rain forests are characterized by fully or sometimes partly shedding leaves in dry season. The seasonal variation is very remarkable. The height of the communities is usually less than that of rain forests. The trunk is erect, with thick and coarse bark, while the sprouting occurs in lower part of the stem and the buttress is underdeveloped. The cauliflory, large woody vines and epiphytes do not flourish as much as in rain forest. These forests are distributed discontinuously over the tropical monsoon area in Asia, Africa and America. However, the communities in Southeast Asia are the most typical ones. The climate in South Taiwan belongs to tropical monsoon type; since it is under control of southeast monsoon, the drought is not severe in dry season. For this reason the tropical monsoon forest in Taiwan is not as typical as that in Southeast Asia; it could be named as “tropical semi-deciduous monsoon forest” (Ellenberg and Mueller-Dombois, 1967) or “tropical semi-evergreen monsoon forest” (Wu et al., 1980).

8. Coastal forests This is a kind of vegetation that occurs on the tropical and subtropical rock-sandy seashore
(Wang, 1975). It can be divided into two vegetation-types.

a. **Subtropical rock-sandy coastal forests** They mainly exist in the rocky-sandy coast in the middle-north part of Taiwan. Most of them however are deficient due to damage. The types frequently seen are: All. *Pittosporum tobira-Hibiscus tiliaacus*, and All. *Liodendron formosanum-Pistacea chinsensis*.

b. **Tropical coral reef coastal forests** They are distributed on the beaches of seaside coral reefs in southern Taiwan and on the coral reefs in archipelagoes of the South China Sea. Because of the special environmental condition, the structure of community is rather simple; the tree layer is always a single and height is generally about 8-10 m. The constituents of species are from widespread families in tropics, such as Moraceae, Hernandiaceae, Goodeniaceae, Leguminosae, Euphorbiaceae, Rubiaceae, Nyctaginaceae, Apocynaceae, etc. Most of the plants developed an ecological adaptation such as saline-tolerance, wind-resistance and a heliophilic trait. On the coast of southern Taiwan the common communities are as follows: All. *Hernandia sonora-Barringtonia asiatica*, occurring in coastal area of Kending and Lanyu. Additionally, the All. *Diospyros maritima-Palaquium formosanum*, and All. *Cerbera manghas-Terminalia catappa-Heritiera littoralis* are found on the uplifting coral reef.

C. **Bamboo forests** They are composed of perennial evergreen bamboo. The height and sturdiness of bamboo are very similar to that of trees and therefore the term “bamboo forests” is used. In regard to species composition, community structure, and eco-physiognomy, the bamboo forests are very special. They are always a monodominant community. The bamboo forest in Taiwan is composed of thermophilous bamboo.

1. **Warm bamboo forests** This kind of bamboo forest could be divided into three vegetation-types according to the characteristics of differentiated reproduction and morphological features of rhizome.

   a. **Scatter bamboo forests** The rhizomes are monopodium, which are slender and long, and extend transversely underground, as they grow in the soil. Some buds develop into bamboo shoots which burst through the earth forming poles. They further develop and become a scarcely scattering bamboo forest. The common type of community in Taiwan is All. *Phyllostachys makinoi*.

   b. **Cluster bamboo forests** The rhizomes are sympodium, which are usually short and robust, with dense nodes; the apical buds always burst through the earth developing into bamboo shoots, while the younger stems are generally close to elder ones. Altogether a dense bamboo forest is formed. The common community of this type in Taiwan is All. *Bambusa utilis*.

   c. **Mixture bamboo forests** The rhizomes are compound-podium, which have both the reproduction characteristics of monopodium and sympodium, i.e., it is able to grow transversely into rhizomes for a certain distance and become bamboo shoots; then it further develops into scarcely scattering poles, at the same time it is able to develop into bamboo shoots from the basis of the pole, forming bushes of young bamboo, therefore it is named as mixed bamboo forest. The common type of the mixed bamboo forest in Taiwan are as follows: All. *Sinobambusa tootsik*, and All. *Chimonobambusa quadrangularis*.

II. **Thickets**

They are composed of thick woody plants, of which the height is generally below 5 m, or incidentally above 5 m. The difference between thicket and forest not only depends on their height, but moreover on the dominant species. Most of the dominant species of thicket are dumpy shrubs. The thickets here not only include the primary types of community, but also those relatively stable secondary type, rising from the influence of human activities and other factors and standing for a long-time.

A. **Needle-leaved thickets** They are composed of needle-leaved shrubs or dwarf trees, and usually are located in the areas of high-elevation above the cold-temperate needle-leaved forest belt, and form a belt of subalpine shrub-meadow.

   1. **Evergreen needle-leaved thickets** The primary plants of this type of shrubs are mostly species of *Juniperus*. Their stalks are creeping and extending along the surface of ground, growing into a low, short, dense and solid thicket. They are able to tolerate the alpine harsh conditions such as gusty wind, cold, aridity and violent radiation. In terms of drought-tolerance they are better than evergreen sclerophyllous thickets.

   a. **Subalpine evergreen needle-leaved thickets** This kind of thickets frequently occurs in high elevation, likely above 3 500 m of Taiwan, predominated by species of *Juniperus*. The common community is All. *Juniperus squamata var. mormisonicola*, found in Yushan, Dabajianshan, Zhongyuanjianshan, Nanhudashan, etc.

   B. **Broad-leaved thickets** It is the genera name of plant community composed of broad-leaved shrubs. According to eco-physiognomic features it can be divided into three orders of vegetation-type.

   1. **Sclerophyllous thickets** These thickets are constituted by edificato synusia composed of cold-tolerance, meso-xeric evergreen sclerophyllous shrub.
a. Subalpine sclerophyllous thickets These thickets typically grow in areas above the cold-temperate needle-leaved forest belt. Together with the meadow they always build up the subalpine shrub-meadow belt. It is the relatively stable of primary vegetation type on the vertical zone of mountainous region. The constituting plants are mainly cold-tolerant species from genera Rhododendron and Cassiope. The community is evergreen all the year round, with clustered thick dense branches, large coverage, and regular canopy. The structure of community is rather simple. In addition to the shrub layer, there is a remarkable moss synusia, while the herbaceous layer is weak and underdeveloped. The common communities of this type in Taiwan are All. Rhododendron pseudochrysanthum and All. Rhododendron hyperythrum.

2. Deciduous broad-leaved thickets This kind of thicket is made up of deciduous broad-leaved shrubs. Because of the cold or drought, the leaves tend to shed in the winter. It is widely distributed, both in primary or secondary types. Based on the habitat it is subdivided into three vegetation-types.

a. Montane deciduous broad-leaved thickets These thickets are made up of medium-temperate xeric shrubs with distribution in areas of median to high elevation and at the site volcanic ash, as well as other special surroundings. The common communities are: All. Lyonia ovalifolia- Flex asprella and All. Hydrangea paniculata.

b. River flat deciduous broad-leaved thickets These thickets develop mostly on the gravely surface of sands and river terraces. Generally the habitats are rather damp. The shrub layer and herbaceous layer are made up of hygrophilous species of deciduous shrubs and herbage. The common community is All. Homonoia riparia.

c. Dry land deciduous broad-leaved thickets They distribute mostly on areas of limestone or dryland. Main communities are All. Styax formosana- Glochidion rubrum, and All. Salix fulvopubescent var. fulvopubescent.

3. Evergreen broad-leaved thickets
This kind of thickets consists mostly of evergreen broad-leaved shrubs and has distribution mainly in the hilly mountainous land in the tropics and subtropics. The physiognomy is evergreen all the year round. Its structure is rather simple; there are always few trees scattering in the community. Most of the communities are secondary, but if human disturbance comes to an end, it will gradually develop into evergreen broad-leaved forest. If to the contrary in the case of repetitive deforestation and fire, it will degenerate into shrub-grassland or even become barren. It could be divided into three vegetation-types by different habitats.

a. Hill-montane evergreen broad-leaved thickets This is a kind of secondary vegetation after frequent deforestation, widely found in areas of hilly terrace. The common communities are All. Rhodomyrtus tomentosa and All. Cinnamomum reticulatum.

b. Dry land evergreen broad-leaved thickets They mainly grow on the upland of limestone or dry rocky slopes. The common community is All. Dodonaea viscosa.

c. Sandy flat evergreen broad-leaved thickets They are mainly distributed on the sands of seaside or river beach, such as All. Buddleja asiatica-Pyracantha koidzumii.

d. Coral reef evergreen broad-leaved thickets This type of thickets typically grows on the coral reef. The soil of coral reef is rich in calcium and also contains high contents of salt due to the effect of ocean; therefore some calciphytes and halophytes always appear. Moreover, since coral reef can not hold the water very well, the plants over there are developing an ecological adaptation of xeromorphism, like the succulent stems and leaves, hairy or waxy on leaf surface. Because of the guano on the coral reef, the soil is rich in nitrogen too, in turn many nitrophilous plants will appear. The common community is All. Pemphis acidula-Scaevola serica.

C. Thorn-succulent thickets Composed of strong xeromorphic shrubs, distributed on sands of tropical seaside or in hot and arid valley. Only one order of vegetation-type

1. Xerothermic thorn-succulent thickets There is only one vegetation-type in this kind of thickets:

a. Seashore xerothermic thorn-succulent thickets They are mainly comprised of evergreen thorny shrubs and succulent or climber shrubs with distinct xeromorphic characteristics and distributed in hot and arid areas. The common communities in Taiwan are All. Severinia (Atalantia) buxifolia-Maytenus diversifolia, All. Opuntia monacantha, and All. Pandanus odoratissimus var. sinensis.

D. Bamboo thickets This kind of thicket is made up of dwarfing bamboo and was called grassland in the past in Taiwan. Because of the woody stalk, its height is only 30-40 cm, the communities are attributed to thickets, however it will reach 2-3 m if the condition is favorable.

1. Bamboo thickets This kind of bamboo thickets can be divided into two vegetation-types according to the hydrothermic conditions.

a. Temperate bamboo thickets They are mainly distributed on high mountains of an elevation above 2 500 m. Their structure is rather simple. Most communities are
natural community, and with a crisscross distribution with
mountainous thickets. The common community in Taiwan
is All. Yushania niitakayamensis.

b. Warm bamboo thickets They are mainly distributed
in areas of subtropical hills and plains. The common com-
munities in Taiwan are All. Sinobambusa kunishii and All.
Sinobambusa usawai.

III. Herbaceous vegetation
It is also called terrestrial herbaceous communities which
is predominated by grasses graminoid and other herba-
ceous plants, furthermore woody plants are sparsely ap-
pear (the coverage will not be more than 30%). It can be
divided into two subclasses by the ecological adaptation
characteristics.

A. Praetoherbosa It is developed under the condition
of appropriate aqueous contents (including rainfall, sur-
face run-off, underground water, and thawing of ice and
snow), and contents two orders of vegetation-types.

1. Meadow It is comprised of mesophytic perennial
herbaceous plants. The mesophytic environment required
by meadows is exactly the favorable environment for forests;
therefore most meadows are secondary vegetation formed
after the destruction of forest, such as pasture and lawn.
However in areas of high latitude or high elevation they
would probably be the primary type. Most meadows in
Taiwan are located in the uplands on high elevation, also in
plains and seashore.

a. Subalpine meadows They are found in the uplands
of high elevation, dominated by cold-tolerance mesophytic
perennial plants. The grasses are short. The community
structure is simple, and always made up of some endemic
alpine plants. Owing to the strong illumination in high
mountains, the flowers of the dicotyls are big and colorful;
throughout the summer the variant flowers give rise to a
scenery of brilliant color. The common communities are All.
Agrostis firma-Deschampsia caespitosa var. festucifolia
and All. Deschampsia flexuosa.

b. Flood plain meadows They are distributed in the
floodplains of rivers or lakes. The communities are devel-
oped owing to the synthetic effect of periodical flooding.
The communities are relatively young, and the species com-
position rather poor. In the dryer sites most constituting
species are dicotyls, while in the sites of medium humidity
are grasses, and in the wet sites are sedges. The common
communities in Taiwan is All. Saccharum spontaneum.

c. Seashore salt meadows They generally appear on
the beach, and develop under the influence of tide current.
Communities are composed of salt-tolerance plants. The
main types of communities are All. Ixeris repens-Calystegia
soldanella, and All. Ipomoea pes-caprae- Sesuvium
portulacastrum.

2. Sparse shrub grasslands These kinds of meso-
phytic grasslands are referred to communities established
by mesophytic or xerophytic perennial herbaceous plants,
and sparse shrubs scattering in between (cover degree less
than 30%). Most communities are secondary vegetation
formed in the dry-up habitats due to repetitive felling and
fire in the forest. Subdivisions will be according to climatic
conditions.

a. Warm sparse shrub grasslands They flourish in
subtropical and tropical region, and are composed of
synusia dominated by mesophytic or xero-mesophytic her-
baceous plants. Generally they are a kind of secondary
vegetation formed after the destruction of forest, and are
the main type of community on the barrens in subtropical
and tropical region. The communities in common are All.
Phyllanthus emblica-Thysanolaena maxima, All. Vitex
negundo-Heteropogon contortus, and All. Chrysopogon
aciculatus-Arundinella setosa.

B. Xeropodium It is a type of community made up
mainly of perennial xerophytes. Subdivisions are based on
climatic conditions.

1. Savanahic grasslands Dominated by perennial
grases, but woody plants may be sparingly present, most
of them are formed after the forest or shrubbery was
destroyed, and the habitat gradually dried out. They mainly
distribute themselves in tropical and subtropical region.

a. Xerothermic savannahic grasslands They grow in
the southern part of Taiwan and are predominated by spe-
cies of Gramineae and sometimes sparse trees scattering in
between can be seen. The common community in Taiwan is
All. Bambux malabarica-Imperata cylindrica var. major.

IV. Rock field vegetation
It is referred to the communities on scree, talus, or fisses
of rocks or walls.

A. Scree vegetation This vegetation is growing on
unstable steep slopes of stones beneath weathering rocks.
There is only one order of vegetation-type.

1. Sparse scree vegetation They are mainly composed
of permanent herbs or half-woody plants adapted to sur-
viving the rolling stones at the scree surface, sometimes
even stopping them. There are two vegetation-types.

a. Alpine scree communities This kind of communi-
ties is sparsely distributed in the subnival zone. The main
constituents are the frigo-xeric or frigo-mesic perennial
herbaceous plants and cushion plants which are adapted to
the icy cold habitat. The common communities in Taiwan
are as follows: All. Epilobium nankotaizanense, All.
Artémisia oligocarpa and All. Festuca ovina.

b. Montane scree communities They occur mainly in low- and mid-mountain areas. The common community is All. Pouzolzia elegans-Boehmeria densiflora.

B. Chasmophytic vegetation Permanent plants are rooting in fissures of rocks or walls. Only one order of vegetation-type.

1. Chasmophytic vegetation As mentioned above, according to the nature of rock and hydrothermal conditions, it can be divided into three vegetation-types.

a. Alpine chasmophytic communities They are distributed mainly in fissures of rocks in alpine and subalpine area. The common community such as: All. Brachypodium kawakamii-Artemisia kawakamii and All. Artemisia niitakayamensis-Sedum morrisonensis.

b. Montane chasmophytic communities They are distributed mainly in fissures of rocks in mid- and low mountain area. The common communities are All. Hypericum geminiflorum-Arundo formosana, and All. Pteridium aquilinum-Miscanthus sinensis.

c. Seashore chasmophytic communities They find distribution mainly in cliffs of sea shore. The typical community in Taiwan is All. Ficus tinctoria-Phoenix hanceana, occurring in Hengchun Peninsula and Lanyu.

V. Swamps and aquatic vegetation

Both kinds of vegetation are related to overflowing water in the habitat. Since the condition in the water is rather consistent, the constituting species are mostly cosmopolitans, and the communities are always azonal community, but sometimes constituents of local flora, in the community even zonal types will be found in different natural belts.

A. Swamps They are distributed in habitats of overly moist earth, or habitats logged with a thin layer of water and peat accumulation, or habitats where organic substance starting peat formation. They comprised mainly herbaceous helophytes, but woody plants also will root in the sludge. They can be divided into three orders of vegetation-type.

1. Woody swamps Most of them are forests developed in low depressions, which are flooded throughout the year; therefore they can be called forest swamps and can be further classified into two vegetation-types.

a. Mangrove (Hydrophyllum) These are made up of mangroves plants growing on the tidal beach of the tropical and south subtropical coast. Their habitat and physiognomy are similar and also with the same physiological characteristics and ecological adaptation. Many trees are developed with buttresses and pneumatophores. The common communities in Taiwan are All. Kandelia candel occurring in the estuary of Danshuihe River, and All. Avicennia marina occurring in the coast of Taizhong and Gaoxiong.

b. Fresh water woody swamps The freshwater woody swamp found in Taiwan is the All. Salix kusanoi.

2. Herbaceous swamps They are also called nonraised bogs. The surface of these swamps will not raise or not very markedly raise the mineral water table of the surrounding landscape. The constituting plants are able to directly use the nutrients from the underground water enriched with inorganic substances. As a result the swamps are eutrophic. The dominant species are hygrophytes of genera Carex, Eriophorum, Typha, etc., occasionally some short shrubs will be dispersed, but mosses are seldom found.

a. Sedge swamps They are mainly composed of sedge (graminoid hemicyrptophytes or geophytes). The common communities in Taiwan are as follows: All. Isachne globosa-Oenanthe javanica and All. Phragmites karka.

3. Moss bogs They are also called raised bogs. The surface of these swamps has been raised above the surrounding landscape by the growth of peat moss, then their own water table will be formed. The connection with groundwater was out off, the swamps enter into the atmospheric trophic stage. The organic substances and minerals carried by the dust particle, precipitation, and the animal feces turn to be the major source of nitrogen and minerals for peat moss, therefore they are also called oligotrophic bogs. Their acidity is very strong, pH value approximates 3–5. The species composition is inadequate, tree species are almost disappear, but there are many insectivorous plants.

a. Peat moss bogs The common community in Taiwan is All. Sphagnum palustre.

B. Aquatic vegetation They are composed of vascular hydrophytes that tolerate or need water-covering soil surface constantly. According to the salt contents of the water it is divided into two orders of vegetation-type.

1. Fresh water aquatic vegetation It can be classified into four vegetation-types according to the life form of the constituting plants.

a. Submerged plant communities This kind of aquatic community is mainly made up of submerged hydrophytes. The plant body totally merges into the water, and includes rooted underwater hydrophytes and suspended (nonrooted) hydrophytes. The distribution of these communities can be 4–5 m depth in water. Sometimes these communities are accompanied with rooted floating-leaved hydrophytes. The typical communities are All. Potamogeton octandrus, All. Ceratophyllum demersum,
and rare community is All. Isoetes taiwanensis occurring in Menghuanhu Lake.

b. Free floating (nonrooted) plant communities They are composed of floating hydrophytes. These plants float on the surface of water, touching only the water and air, but not the substratum of bottom under water. The common communities are All. Azolla pinnata-Salvinia natans, All. Spirodela polyrhiza-Lemna perpusilla, and All. Eichhornia crassipes.

c. Rooted floating-leaf plant communities They are composed of floating-leaved anchored hydrophytes and generally exists in waters of 3 m depth. The common communities are All. Nymphoides indica-Trapa natans var. japonica and All. Nuphar shimaodai.

d. Emerged plant communities They are composed of emerged hydrophytes and generally exist in shallow lakes and slow-flowing rivers. In general, the depth of water is about 1.5 m. They are hard to distinguish from the herbaceous swamps when the water tends to dry out and become shallow. The common communities are All. Scirpus mucronatus and All. Sparganium fallax

2. Salt water aquatic vegetation This vegetation type typically grows in the coastal zone and in the ponds or lakes with salt water. At present it is defined as one vegetation-type.

a. Salt water aquatic plant communities In Taiwan there is All. Diplanthera uninervis-Thalassia hemprichii, a kind of submerged plant community, occurring in coastal areas of the southern part of Taiwan.

References:


台湾植被分类方案

宋永昌  徐国士

摘要：复杂的自然条件导致面积仅为36000多平方公里的台湾呈有热带和寒温带的群落类型，堪称中国乃至世界植被之缩影。它的植被分类也是对中国乃至世界植被分类的补充。台湾植被分类采用的是外貌-区系原则，分类单位和系统自上而下是：植被型纲、植被型目、植被型、群组组、群组和群丛。高级单位（植被型纲、植被型目和植被型）以群落的生态外貌为依据；中、低级单位主要依据种类组成，兼顾优势种和标志种的指示意义。在中级单位中（群组组、群组）重视优势种的作用，在低级单位中（群丛）则更重视特征种（或标志种）的意义。按此原则将台湾植被划分为5个植被型纲（森林、灌丛、草木植被、沼泽和水生植被），29个植被型目（寒温性针叶林、暖温性针叶林、暖温性针叶林、落叶阔叶林、常绿阔叶落叶阔叶混交林、常绿阔叶林、常绿阔叶林、热带雨林、热带季雨林海岸林、湿性竹林、常绿针叶灌丛、革质灌丛、落叶阔叶灌丛、常绿阔叶灌丛、草本灌丛、草本、疏灌草地、干热旱生草地、岩屑块状群落、石隙植被、木本沼泽、草本沼泽、藓类沼泽，淡水水生植被和咸水水生植被），53个植被型。列出了各个植被型中的重要群丛。

关键词：植被分类；外貌-区系原则；外貌分类法；优势度类型；布朗-布朗凯分类法；台湾

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