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Diversity of mountain forest vegetation in Taiwan

Ph.D. Dissertation

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ABSTRACT

In Taiwan, vegetation studies began from the beginning of the 20th century. Due to different approaches applied in vegetation classification, different methods of vegetation data analysis and diverse nomenclature systems used among studies, there is still a lack of a general concept which can be used to understand the ecological patterns of vegetation distribution. In order to have a comprehensive description and definition of plant communities, to provide systematic documentation of plant communities and to understand the relationships of plant communities in Taiwan with those in the neighbouring areas, the use of representative vegetation-plot data to generate a vegetation classification system is necessary. For this purpose, the main aims of this dissertation are:

1) To determine the main forest vegetation types in Taiwan at higher hierarchical levels.
2) To delimit selected vegetation types at the association level.
3) To create formal definitions for all defined forest vegetation types, describe their habitat affinities and their distribution in Taiwan.
4) To construct a hierarchical vegetation classification system.

To achieve these aims, vegetation classification was performed following the Braun-Blanquet approach, using the National Vegetation Database of Taiwan, which contains 9822 vegetation plots. Formal definitions of each forest vegetation type were given by unequivocal assignment rules via classification and regression trees or the Cocktail Determination Key. Habitat affinities were explored by ordination analyses. While constructing the hierarchical vegetation classification system, corresponding forest vegetation types in the surrounding area were evaluated by both floristic composition and habitat requirements. The first question was how many main forest vegetation types are there in the whole of Taiwan. The next question focused on the associations and the hierarchical vegetation classification system of forests dominated by coniferous trees, including both the species-poor high-mountain coniferous forests with *Abies*, *Juniperus*, *Picea* and *Tsuga*, and species-rich subtropical montane cloud forests with *Chamaecyparis* mixed with evergreen broad-leaved trees. The main conclusions are:

1) Twenty-one main forest vegetation types were distinguished, mainly corresponding to the temperature and moisture differences among habitats, in the subtropical and tropical region in Taiwan. The classification was formalized by the Cocktail Determination Key.
2) In the high-mountain coniferous forests, two alliances and nine associations were recognized based on dominant species. Altitude, topography, snow, wind and soil conditions explain the habitat requirements of these associations. A dichotomous key to determining associations was prepared based on the results of classification and regression trees.
3) In the subtropical montane cloud forests dominated by *Chamaecyparis* spp., two alliances and eleven associations were recognized and their diagnostic species groups defined. Altitude, soil conditions and the seasonality of moisture in different ecoregions explain the habitat requirements of these associations. The classification was formalized by the Cocktail Determination Key.
4) Altitude and topography explain the differences of floristic composition at the level of alliance in the high-mountain coniferous forests and the subtropical montane cloud forests, respectively.
5) Forest vegetation types in the subalpine, upper-montane and montane cloud zones of Taiwan, and those in subtropical mainland China, should be classified to the same phytosociological classes, which are different from those occurring in the temperate and boreal zones of eastern Asia because of the dominance of evergreen broad-leaved species.

ABSTRAKT

První vegetační studie na Tchaj-wanu začaly na počátku 20. století. Dodnes však chybí jednotný koncept vegetační klasifikace, který by umožnil pochopení ekologických zákonitostí v rozšíření vegetačních typů. Je to především proto, že autoři jednotlivých studií používali různé přístupy ke klasifikaci vegetace, různé metody analýzy vegetačních dat a různou nomenklaturu. Pro získání detailního popisu, definice a systematické dokumentace rostlinných společenstev a pro pochopení vztahu vegetace na Taiwanu k vegetaci v okolních zemích je zapotřebí vybudovat jednotný klasifikační systém, založený na reprezentativní databázi vegetačních zápisů. K naplnění tohoto cíle má pomoci i tato disertační práce, jejíž hlavní cíle jsou:

1) popsat hlavní typy lesní vegetace Tchaj-wanu na vyšších hierarchických úrovních,
2) pro některé z nich popsat vegetační typy na úrovni asociací,
3) vypracovat formální definice pro všechny popsané typy lesní vegetace a popsat jejich stanovištní nároky a rozšíření na Tchaj-wanu,
4) sestavit hierarchický systém vegetační klasifikace.

Pro vybudování hierarchického klasifikačního systému, založeného na Braun-Blanquetově metodě, byla použita Národní vegetační databáze Tchaj-wanu, která aktuálně obsahuje 9822 vegetačních zápisů. Formální definice jednotlivých vegetačních typů byly založeny na jednoznačných přiřazovacích pravidlech, které byly získány jednak metodou klasifikačních a regresních stromů, jednak pomocí determinačního klíče založeného na metodě Cocktail. Stanovištní nároky byly popsány pomocí ordinačních metod. Při sestavování hierarchického klasifikačního systému lesní vegetace Tchaj-wanu bylo přihlíženo k existenci analogických vegetačních typů v okolních zemích, k jejich floristickému složení a stanovištním nárokům. Nejdříve bylo třeba zjistit, kolik hlavních typů lesní vegetace je možné na Tchaj-wanu vlastně rozlišit. V dalším kroku byl připraven popis asociací a sestavena hierarchická klasifikace lesní vegetace s dominancí jehličnatých dřevin, zahrnující jak druhové chudé vysokohorské jehličnaté lesy s druhy rodů *Abies, Juniperus, Picea* a *Tsuga*, tak i druhově bohaté subtropické horské mlžné lesy s charakteristickým výskytem rodu *Chamaecyparis* a stálezelených listnatých dřevin. Hlavní závěry této práce jsou následující:

1) Bylo rozlišeno 21 hlavních typů lesní vegetace Tchaj-wanu, které se odlišují hlavně nároky na teplotu a vlhkostními poměry stanoviště. K formalizaci této klasifikace byl použit determinační klíč založený na metodě Cocktail.
2) V rámci vegetace vysokohorských jehličnatých lesů byly rozlišeny dva svazy a celkem devět asociací, a to především na základě dominance některých druhů. Stanovištní nároky těchto asociací se liší faktory prostředí jako je nadmořská výška, topografie, výskyt sněhové pokrývky, síla větru a vlastnostmi půdy. Metodou klasifikačních a regresních stromů byl získán dichotomický klíč k určování jednotlivých asociací.
3) V rámci vegetace horských cypřiškových mlžných lesů byly rozlišeny dva svazy a celkem 11 asociací a definovány skupiny diagnostických druhů. Rozdíly ve stanovištních nárocích jednotlivých asociací jsou dány především rozdíly v nadmořské výšce, vlastnostech půdy a sezónnosti srážek mezi jednotlivými ekoregiony. Pro formalizaci klasifikace byl použit determinační klíč založený na metodě Cocktail.
4) Svazy rozlišené v rámci vysokohorských jehličnatých lesů lze vysvětlit především rozdíly v nadmořské výšce, zatímco rozdíly mezi svazy cypřiškových mlžných lesů jsou způsobeny především rozdíly v topografii.
5) Vegetační typy lesní vegetace v subalpinské, vysokohorské a mlžné vegetační zóně na Taiwanu a v subtropické části kontinentální Číny by měly být zahrnuty do stejných tříd, které jsou zároveň odlišné od tříd vyskytujících se v temperátní a boreální zóně východní Asie. Důvodem je především výskyt a někdy i dominance stálezelených listnatých dřevin.

中文摘要

台灣的植群研究開始於 20 世紀初期；在植群分類的研究上，不同的研究採用不同的分類概念，不同的資料分析方法，和不同的命名系統，使得台灣的植群分類系統一直缺乏很明確的植相定義，尤其是統一的而且可以完整陳述台灣生態系統的植相定義。為了對台灣的植群做完整的定義和描述，並對台灣的植群提供系統性的建檔記錄，以及瞭解台灣的植群和鄰近地區的植物社會彼此間的關聯，本論文的主要目的如下：

1) 瞭解台灣的森林植群在較高的分類階層中有幾種主要的類型。
2) 判識所選定的森林植群中各有多少種群叢 。
3) 對已判識出的森林植群型做出正式的定義，並描述其生育地特性以及在台灣的地理分布狀況。
4） 建立具有層級關係的植相植群分類系統。

為了達成上述的目的，本論文使用台灣植群資料庫中的 9822 個植群樣區，依據法瑞學派中的診斷種概念，對台灣的森林植群進行分類。每一個被判識出的森林植群型均被賦予明確的判識準則，此一判識準則可精確地將單一樣區指定到判識出的植群型中；上述的判識準則由分類樹及 Cocktail 檢索表所產生和進行運算，而棲地特性的描述則藉由分布序列的分析來呈現。建構植群分類系統的架構時，臨近地區類似的植群型會加入比較；比較時，主要比較相對應的植群型中的物種組成和棲地特性。首先要問的問題是：在台灣，主要的森林植群類型到底有幾種？接下來要問的問題是：在選定的森林植群類型中，有多少種群叢？以及其分類層級架構為何？這篇論文選定了以針葉樹為優勢的森林來進行群叢的判識以及分類層級架構的測試。這些以針葉樹為優勢的森林包括了物種組成較為單純的上部山地針葉林，其主要的優勢種為：圓柏、冷杉、雲杉和鐵杉。另一類以針葉樹為優勢的森林則是物種較為豐富的亞熱帶山地雲霧林，主要是以檜木和其他常綠闊葉樹為優勢的針闊葉混淆林。本論文的主要結論有：

1） 台灣的森林植群在較高的分類階層中有 21 種主要的類型，造成其差異的原因包括有熱帶和亞熱帶的植物地理區系以及溫度和溼度等三項因子。植群類型的判識由 Cocktail 檢索表賦予正式的分類判讀。
2) 在台灣的上部山地針葉林中，依照不同層次的優勢種的組合，二個群團共九個群叢可被判識出 。海拔差異、地形位置、風雪的影響以及土壤條件的不同可用來解釋各群叢對棲地的要求。參考分類樹的結果所做出的定距式檢索表，可用以做為正式的分類判讀。
3） 在以檜木為優勢的亞熱帶山地雲霧林中，二個群團共十一個群叢可被判識出；兩個群團主要由各自的診斷種群所定義並判識出來。海拔、土壤條件和各生態氣候區間季節性的溼度差異，可用來解釋各群叢對棲地要求的差異。Cocktail 檢索表賦予正式的分類判讀。
4) 關於不同群團間在棲地要求上的差異，海拔解釋了上部山地針葉林的二個群團對棲地要求的差異；地形位置則解釋了亞熱帶山地雲霧林的二個群團對棲地要求的差異。
5） 台灣的亞高山針葉林、上部山地針葉林以及山地雲霧林，和中國大陸亞熱帶地區相對應的植群型，應歸類為相同的群級；其和位於東亞溫帶及北方針葉林帶的相對應植群型應為不同的群級。其依據的論述為：在台灣及中國大陸的亞熱帶地區，常綠闊葉樹在以針葉樹為優勢的森林中仍占有相當比例的優勢度。

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CONTENT

Contributions of authors to the papers presented in this dissertation

PAPER 1

Li, C.-F., Chytrý, M., Zelený, D., Chen, M.-Y., Chen, T.-Y., Chiou, C.-R., Hsia, Y.-J., Liu, H.-Y., Yang, S.-Z., Yeh, C.-L., Wang, J.-C., Yu, C.-F., Lai, Y.-J., Chao, W.-C., & Hsieh, C.-F. 2013. Classification of Taiwan forest vegetation. *Applied Vegetation Science* 16: 698–719.

CFL, MC and DZ conceived the idea, CFL led the paper writing and developed the Cocktail Determination Key, DZ prepared the CoDeK program, CFL, TYC, CFH and DZ proposed the classification scheme, MYC, TYC, CRC, YJH, HYL, SZY, CLY, JCW, CFY, CWC and CFH contributed the plot data from the field, LYJ contributed data from GIS layers, all co-authors commented on the manuscript.

PAPER 2

Lin, C.-T., Li, C.-F., Zelený, D., Chytrý, M., Nakamura, Y., Chen, M.-Y., Chen, T.-Y., Hsia, Y.-J., Hsieh, C.-F., Liu, H.-Y., Wang, J.-C., Yang, S.-Z., Yeh, C.-L. & Chiou, C.-R. 2012. Classification of high-mountain coniferous forests in Taiwan. *Folia Geobotanica* 47: 373–401.

CFL, CTL and MC conceived the idea and led the writing, CTL, CFL, YN, TYC, CFH and DZ proposed the classification scheme, MYC, TYC, CRC, YJH, HYL, SZY, CLY, JCW and CFH contributed the plot data from the field, CTL, CFL and DZ made the classification and regression trees, all co-authors commented on the manuscript.

PAPER 3

Li, C.-F., Zelený, D., Chytrý, M., Chen, M.-Y., Chen, T.-Y., Chiou, C.-R., Hsia, Y.-J., Liu, H.-Y., Yang, S.-Z., Yeh, C.-L., Wang, J.-C., Yu, C.-F., Lai, Y.-J., Guo, K. & Hsieh, C.-F. 2014. *Chamaecyparis* mountain cloud forest in Taiwan: ecology and vegetation classification. (Manuscript).

CFL, DZ and MC conceived the idea and led the writing, CFL, TYC, SZY, CLY and CFH proposed the classification scheme, MYC, TYC, CRC, YJH, HYL, SZY, CLY, JCW, CFY and CFH contributed the plot data from the field, LYJ contributed data from GIS layers, CFL constructed the Cocktail Determination Key, all co-authors commented on the manuscript.

Introduction

Taiwan (21˚55'–25˚20'N, 119˚30'–122˚00'E) is a mountainous island in the western Pacific. The Tropic of Cancer runs through the middle part of Taiwan. The highest peak in the Backbone Mountains (or the Central Ridge) of this island is 3952 m. Two monsoon systems influence the climate in Taiwan, the summer monsoon from the south-western direction and the winter monsoon from the north-eastern direction. The warm and humid environment, long altitudinal gradients, different monsoon systems and complex topography cause the highly diverse flora and vegetation in Taiwan. According to the Flora of Taiwan (Huang & Hsieh 1994−2003), there are 235 families, 1419 genera and 4340 species within an area of about 36 000 km^2. Among the 4340 species, 262 are naturalized and 1069 are endemic. Forests are the most dominant vegetation types in Taiwan, covering almost 60% of the land (www.forest.gov.tw). More than half of the natural forests are evergreen broad-leaved forests and there are 463 evergreen broad-leaved woody species in the flora of Taiwan.

IMPORTANT FACTORS INFLUENCING THE FLORISTIC DISTRIBUTION IN TAIWAN

What are the geographical distribution patterns of the highly diverse flora and vegetation in Taiwan? What are the possible explanations for these patterns? There have been a lot of studies addressing these questions. Scientists tried to use the floristic survey or vegetation plots to describe and explain these patterns. Phytogeography, climate, soil and topography are the most important environmental factors which have been proposed and studied with the floristic distribution.

Phytogeography

Floristic collections and taxonomy studies in Taiwan began from the mid-19th century. At the end of the 19th century, Augustine Henry used the list of collected specimens and described three vegetation zones in the lowland areas of Taiwan. He also compared the floristic elements among Taiwan, Japan, China and south-eastern Asia (Henry 1896). Three vegetation zones that he addressed in that study are: the coastal zone, the plain zone and the montane zone. He described that (1) the coastal zone had almost no endemic species, (2) the montane zone was rich in endemic species, (3) the species in the plain zone were closely related to China and India, (4) the species in the montane zone were related to both China and Japan, and (5) the species related to south-eastern Asia were few except in the southern tip of Taiwan. The latter studies (Hayata 1908; Li & Keng 1950; Hosokawa 1958; Hsieh 2002) agreed with some of these descriptions. The most important phytogeographical feature of Taiwan is that it occurs on the boundary of two floristic kingdoms. Most of the island is in the

Holarctic Kingdom, whereas the southern tip of Taiwan, the Henchung Peninsula, is in the Palaeotropical Kingdom.

Climate

Altitude is a complex gradient that includes the effects of temperature, precipitation and others (He & Gallaway 2009). It is another important factor related to the floristic distribution in Taiwan. Altitudinal zones attracted the attention of vegetation scientists (Sasaki 1924; Wang 1957; Liu 1968; Su 1984; Chen 1995; Lai 2003). Different studies proposed different numbers of vegetation altitudinal zones based on the climate data or forest physiognomy, and different names of these zones were applied by different scholars. Su (1984) proposed a scheme of altitudinal zones in Taiwan and used both dominant genera and climate data to compare the altitudinal zones published in eastern Asia (Kawakita 1956; Numata 1974; 1983). This scheme was broadly accepted by Taiwanese vegetation scientists. In his scheme, the lowland, which is at altitudes lower than 500 m (annual mean temperature higher than 23 °C) is named *Ficus-Machilus* zone (foothill zone). Altitudes of 500–1500 m, 1500–2500 m, 2500–3100 m and 3100–3600 m with mean annual temperatures of 17–23 °C, 11–17 °C, 8–11 °C and 5–8 °C comprise *Machilus-Castanopsis* zone (submontane zone), *Quercus* zone (montane zone), *Tsuga-Picea* zone (upper-montane zone) and *Abies* zone (subalpine zone), respectively. Altitudes higher than 3600 m (with annual mean temperature lower than 5 °C) comprise the alpine zone. *Ficus-Machilus* zone and *Machilus-Castanopsis* zone are mainly evergreen broad-leaved forests, while *Tsuga-Picea* zone and *Abies* zone are coniferous forests. The *Quercus* zone, which is also called the montane cloud zone because of the frequent occurrence of uplifted cloud, is further separated into the upper- and lower-*Quercus* zone. The upper-*Quercus* zone is a forest mixed of coniferous and evergreen broad-leaved trees, while the lower-*Quercus* zone is an evergreen broad-leaved forest.

The annual precipitation in Taiwan is about 2000–4000 mm. The Backbone Mountains run through the island in a roughly north-to-south direction. This mountain system together with two monsoon systems causes differences in the amount of rain in each month within the island. Summer monsoon from the south-western direction brings moisture to the whole island because the warm and humid air is high above the surface and it can cross the high mountains. Winter monsoon from the north-eastern direction brings moisture only to the windward area because the cool and humid air is close to the surface and it cannot cross the high mountains. Scholars used the monthly mean temperature and precipitation to classify the ecoregions within Taiwan (Kudo 1931; Liu 1962; Su 1985; Huang 1999). The common conclusion is that the north-eastern part of Taiwan has no drought period during the year while the south-western part has a long winter drought period up to six months. One of the purposes to recognize the ecoregions is similar to recognize the altitudinal zones, namely to understand how moisture influences the physiognomy. For this purpose, the north-eastern part of Taiwan should be dominated by evergreen broad-leaved forests while the south-western part should be dominated by semi-evergreen broad-leaved forests, which are also called subtropical seasonal monsoon forests (Liu 1962; Huang 1999). However, there are different opinions on the relationships between semi-evergreen broad-leaved forests and climate. Su (1985) used 155 weather stations throughout Taiwan to define six ecoregions based on temperature and the length of the winter drought period. He suggested that each ecoregion has its characteristic species of *Fagaceae* in the submontane zone according to his empirical experience. Tseng (2003) analyzed the distribution of endemic species in different altitudinal zones and ecoregions proposed by Su (1984; 1985). His results showed that the eastern part of Taiwan (from north to south) had a higher number of endemic species per altitudinal zone. Focusing on altitudinal zones, the *Machilus*-*Castanopsis* zone and the *Quercus* zone had the highest number of endemic species. However, he did not find all the characteristic species of *Fagaceae* for each ecoregion proposed by Su (1985).

Another climatic factor influencing the vegetation of Taiwan is wind (Chao et al. 2010). On the ridges, especially the ridges directly facing the north-eastern monsoon, there is a special formation composed of short and dense sclerophyllous species. These forests on windward slopes usually have simple vertical structure (Su & Su 1988; Hsieh 1990). On leeward slopes, forests contain big tall trees and multiple vertical layers.

Soil and topography

Physical structures of soil and soil chemistry are often correlated with floristic composition (Paul 2007; Chang et al. 2013). In Taiwan, the studies of the relationship between floristic composition and soil are rare, but published results indicate that soil conditions explain the floristic composition well (Yang 1991; Chen et al. 1997; Shen et al. 2002; Hseu et al. 2004). At the same time, soil physical structure and soil chemistry are also correlated with altitude and topography, which also have a high explanatory ability for floristic distribution.

Topography is often used as a surrogate for soil water conditions and light input (Sørensen et al. 2006; Tromp-van Meerveld & McDonnell 2006). In Taiwan, topography is correlated with soil conditions. Lower slopes and valleys are steep with shallow soils, high rockiness and high accumulation of nutrients (Chen et al. 1997). In contrast, upper slopes and ridges commonly have deep soil with low rockiness. Well-developed soils in Taiwan are usually acid and nutrient-poor (Chen & Hseu 2002), which is caused by the bedrock and high precipitation. The effect of topography on floristic composition is mostly described in the *Machilus*-*Castanopsis* zone by previous studies, with *Fagaceae* dominant on the ridges and *Lauraceae* dominant in the valleys (Suzuki 1938; Su 1984). Several recent studies found relationships between topography and floristic composition (Chen & Su 2003; Chao et al. 2007;

Wei & Chen 2007; Yang et al. 2008; Su et al. 2010), while some did not (Chung 1995; Liou & Tseng 1999; Hsieh et al. 1997; Kao & Su 2001). The differences are not correlated with the study region or the altitudinal zones. Most probably, the existence of these relationships depended on the size of the study area. When the study area is large (e.g. the whole watershed with an altitudinal gradient broader than 1500 m), the relationship between topography and floristic composition is usually absent (Su & Wang 1988; Yang 1991; Chian et al. 2010). In contrast, when the study area is small such as one nature reserve with an altitudinal gradient shorter than 1500 m, this relationship is usually present (Chen 1993; Shen et al. 2002).

Considering the effect of geology on vegetation, it matters whether it is limestone. In Taiwan, limestone occurs mainly in the eastern part, where it is of metamorphic origin, and in the southern part, where it is derived from the uplifted coral reef (Hseu et al. 2004). Few studies compared the flora and vegetation on limestone with other substrates. Shimizu (1962) recorded the species growing on limestone in Taiwan and Japan. In his list, most of the species in Taiwan are not restricted to limestone. Yeh (1991) made another limestone study using floristic records, in which he defined 35 species as limestone character species. Most of them were herbs and 28 of them were endemics. Liu & Liao (1979) studied the vegetation on limestone in eastern Taiwan. They concluded that because the eastern part of Taiwan has no drought period, high annual precipitation causes soil cation leaching by heavy rains. This is why the soil is acid although developed on limestone. Apart from the scrub community dominated by *Juniperus chinensis* var. *taiwanensis* growing on the limestone outcrops (Liu & Liao 1979) and the forests growing on the uplifted coral reef in the southern coast of Taiwan (Yeh 1994), there is no other specific limestone vegetation described so far.

Although a number of studies showed the main factors influencing the floristic distribution in Taiwan, a comprehensive description and definition of vegetation communities, which could be used in systematic documentation of the nature in Taiwan, is still not available. The studies mentioned above, which described relationship between environmental factors and vegetation on the scale of the whole island, focused mainly on vegetation physiognomy, while floristic comparisons based on plot-sampling data were done only on a local or regional scale. There are also some other factors, such as succession after the disturbances from fires, landslide and human activities in the past, which can influence the vegetation and which usually interact with the main factors such as altitude and topography. It is a challenge for future studies to describe the relationship of species composition to this complex set of environmental factors.

THE AIM OF VEGETATION CLASSIFICATION AND THE CRITERIA APPLIED

The purpose of vegetation classification in ecology is to provide a framework which can organize and interpret ecological information in a given area (Jennings et al. 2009;

Chytrý et al. 2011). The aim is to construct an empirical model in a given area based on biotic and abiotic features of vegetation such as floristic composition, habitat types, physiognomy, life forms or functional types (Moore 1962; Mueller-Dombois & Ellenberg 1974; Ewald 2003; van der Maarel & Franklin 2013). Such models can be different from each other according to the purpose and the features (or criteria) used for their construction (Whittaker 1962; Westhoff & van der Maarel 1978; Grabherr et al. 2003; De Cáceres et al. 2009; Kent 2012). There are no universal criteria that could be applied to all kinds of vegetation classification. Because each criterion has certain advantages and disadvantages, a particular classification scheme can use one or multiple criteria and this decision is case dependent (De Cáceres & Wiser 2012; Kent 2012; Peet & Roberts 2013). The most commonly used criteria in constructing the vegetation classification system are: 1) physiognomy, with emphasis on dominant species, and 2) floristic species composition, focusing on the presence or absence of diagnostic species (Mueller-Dombois & Ellenberg 1974; Mucina 1997).

Using physiognomy and floristic composition as criteria for vegetation classification

The use of the criterion of physiognomy and dominant species was characteristic of the Anglo-American school (Tansley 1920; Clements 1936). In eastern Asia, China has a relatively stable classification system based on physiognomy and dominant species (Wu 1980). These criteria were first applied in vegetation classification to outline the relationship among different physiognomies of vegetation and their phytogeographical meaning (Whittaker 1978). In most cases, it is not easy to have so-called homogeneous stands defined by only one dominant species, and the use of two or even more dominant species in classification might be necessary especially in cases of vegetation with different structural layers (Mueller-Dombois & Ellenberg 1974). The hierarchical structure of a classification system based on this criterion is usually created in a top-down way (Grossman et al. 1998). The higher units of the hierarchical system are usually defined by vegetation zonation and physiognomy, while the dominant species are used to define the lower hierarchical levels. Dominant species and physiognomy themselves can represent the habitat requirements and they can be simply understood and easily applied. However, they can only be used to classify communities on a large scale or in species-poor regions. In a heterogeneous landscape, community classifications based on dominant species might lose their ecological meaning (Whittaker 1962).

The use of floristic composition focusing on the presence or absence of diagnostic species as a criterion is prevalent on the European continent and is typical for the Braun-Blanquet approach, also called the Zürich-Montpellier school (van der Maarel 1975), which uses plot-based data for classification. In eastern Asia, the vegetation classification system based on the Braun-Blanquet approach was applied in Japan (Miyawaki 1980–1989). Vegetation types or communities are summarized in a synoptic table, which contains information about the diagnostic species of each vegetation type. One vegetation type may contain several diagnostic species of its own and should not contain diagnostic species of the other types. The hierarchy of this classification system is usually build in bottom-up direction, in which basic vegetation types are aggregated into higher hierarchical units if they share similar species (Mueller-Dombois & Ellenberg 1974). The presence or absence of diagnostic species groups can be used as a surrogate of environmental conditions. However, before the era of easily available numerical tools, to apply this criterion to vegetation classification required knowledge of rather complicated table-sorting methods, which was very time-consuming and the training of an expert took a lot of time. Mucina (1997) notes that “Without having a textbook available, students have to work under a master.” and that the traditional approach was based on “mystification of the table-sorting method, [and] adoring gurus”. Kent (2012) adds that “… approach can only be applied by very experienced workers in the field. This is unfortunate and makes the topic a difficult one for students and young ecologists.” Additionally, the table-sorting method includes number of subjective decisions, which are not easy to be formalized and communicated. Thanks to the development of numerical classification methods, some of these issues seem to be solved.

Unsupervised methods of numerical classification

Application of numerical methods for the purpose of vegetation classification started to occur more frequently after 1970, during the so called “innovative period” (Mucina 1997), which was marked by significant theoretical and methodological shifts toward modern vegetation classification. The further increase in the use of numerical classification was fuelled by the increasing power and sophistication of personal computers and the growing number of vegetation plots used for classification (Kent 2012). The basic assumption of numerical classification is that similar plots are grouped together by an algorithm in a consistent way (De Cáceres & Wiser 2012). Three main decisions must be made prior to application of the numerical classification: 1) how to measure the dissimilarities in species composition, representing the distances among samples, 2) which clustering algorithm to apply to group the samples, and 3) how many groups of samples to distinguish. All these three decisions heavily influence the results (Peet & Roberts 2013). Numerical classification methods can be divided into non-hierarchical and hierarchical, depending whether they create hierarchical relationship between groups or not (Legendre & Legendre 2012). Hierarchical methods can be further divided into divisive, which divides the whole dataset into smaller groups according to selected criteria (in top-down direction), and agglomerative methods, agglomerating individual samples into groups according to their similarity (bottom-up direction). An example of a non-hierarchical method is k-means, where the assignment of samples to groups is based on distances of samples to group centroids. A commonly used hierarchical and divisive method is the Two-way Indicator Species Analysis (TWINSPAN, Hill 1979), based on dividing the dataset to groups according to the position of samples on opposite parts of compositional gradients (recovered by unconstrained ordination). TWINSPAN became favoured by vegetation scientists mainly due to its similarity to the traditional table-sorting method and because it returns sets of indicator species, characteristic for individual groups. Hierarchical and agglomerative numerical classification methods are cluster analyses (Legendre & Legendre 2012). A number of clustering algorithms exist (e.g. Ward's algorithm, creating spherical clusters, or beta-flexible method, allowing to regulate a degree of cluster chaining), which, in combination with numerous dissimilarity indices, creates high diversity of possible methods. Along with methods which assign sample to only one cluster, there are also alternative fuzzy clustering methods (De Cáceres et al. 2009), which allow fuzzy assignment of samples into several groups with various degrees of probabilities.

The benefit of numerical classification is that it offers clear rules for plot assignment to the vegetation types. Although a number of subjective decisions are carried out in numerical classification (see the three decisions described above), a degree of subjectivity in numerical classification is perceived to be lower than in manual table sorting. However, most of the assignment rules, especially those derived from unsupervised methods (Richards 2013), are often valid only in the same data set as used in the analysis (Bruelheide & Chytrý 2000). Also, it is not clear which clustering algorithm should be actually preferred to create ecologically meaningful vegetation classification, because there is no intuitive link between a certain method (e.g. beta-flexible) and its ability to successfully recover some processes or gradients (e.g. succession or gradient of temperature). One must always, therefore, question whether the ecological data set in hand is suitable for the chosen statistical analysis or not (Podani 2005).

Supervised concept of vegetation classification

To synthesize the ecological knowledge from the vegetation studies, it is important to formalize the process of vegetation classification (Bruelheide & Chytrý 2000; Kočí et al. 2003; Roleček 2007; Jennings et al. 2009; Chytrý et al. 2011). A formalized classification is consistent and repeatable. It provides a platform for communicating the subjective opinions and interpretations by applying unequivocal assignment rules, which can be used by different researchers to classify different data sets. These unequivocal assignment rules can be practically discussed and improved. An example of the practical assignment rules are dichotomous keys based on the presence or absence of diagnostic species (Rodwell 2006). These keys can be directly applied in the field without the need for numerical analysis. The other published assignment rules used for vegetation classification need computers for running the models.

Supervised classification is using the training data set to teach the machine to learn how to recognize individual groups (e.g. different vegetation types in a vegetation classification system) according to their features (e.g. floristic composition) in the training data set (Richards 2013). Results from this learning (assignment rules) can be applied to a new data set and the machine after learning from the training data set can figure out the similar individual groups as defined ones in the training data set. In the field of vegetation classification, fuzzy clustering (De Cáceres et al. 2010), neural networks (Černá & Chytrý 2005), classification and regression trees (Lin et al. 2012) and Cocktail formulas (Bruelheide 1997; Chytrý 2007) have applied the concept of supervised classification to formalize the classification. The assignment rules generated by fuzzy clustering and neural networks cannot be easily translated into ecological meaning, while classification and regression trees and Cocktail formulas offer more straightforward ecological interpretation such as the cover of species or presence and absence of species groups.

In Taiwan, there is a representative database of vegetation plots. At the same time, there is a lack of a firmly-held belief about how many vegetation types (groups) there are. The training data set can be generated by the plots which belong to the defined vegetation types based on expert judgement. The assignment rules can be generated by the selected supervised method. Then these assignment rules can be further applied to the whole database. After the new plots, which are in the whole database but not in the training data set, are classified to the defined vegetation types by these assignment rules, the next step would be to check whether these plots classified into the defined vegetation types obey the expert knowledge. If it does not, the next question would be why it does not correspond with the expert knowledge. Is the expert knowledge wrong? Do those plots belong to new vegetation types which still need to be defined? Or, are the assignment rules inappropriate? To answer these questions, the use of supervised classification methods which can be easily translated into ecological meaning would be necessary.

The criteria used in Taiwan for vegetation classification

Different criteria derived from floristic composition have been applied to vegetation classification in Taiwan. Until the Second World War, presences or absences of diagnostic species were used for classifying Taiwanese vegetation (Suzuki 1938; Suzuki et al. 1939). After the war, the floristic comparison was mainly carried out based on dominant species and physiognomy (Tsoong & Chang 1954; Liu et al. 1961; Liu 1968; Liu & Su 1978). Clements's climax concept was widely applied in the vegetation classification in Taiwan until the 1980s. After the 1980s, plot-based classification and the use of numerical classification methods became dominant (Su & Su 1988; Hsieh 1990; Liu et al. 2006; Chao et al. 2010). However, environmental factors which might be important to explain the ecological pattern of vegetation, such as soil, wind, fog or others, were not easy to measure. That is one of the reasons why altitude or topography have been the most or the only important explanatory variables used in numerical analyses of Taiwanese vegetation.

Professor Horng-Jye Su studied the vegetation of Taiwan for more than 30 years. He examined the problems of Taiwanese vegetation classification and the possible ways to overcome them. He supposed that the vegetation classification system based on vegetation plots sampled across the country is necessary for understanding and documenting the nature in Taiwan. This system could provide hypotheses that could contribute to ecological knowledge, as well as supporting the policy decision making in nature resource management. One problem he pointed out is that vegetation classification studies in Taiwan used different concepts (criteria), different methods of data analysis and diverse nomenclature systems used in different regions by different researchers. This created barriers for communication and made the literature comparison practically impossible. Another problem was that the number of plots and their geographical distribution were not representative. He suggested increasing the number of vegetation plots sampled following a stratified sampling design and standard protocols, to unite the concepts, analysis techniques and nomenclature system. He recommended the Braun-Blanquet approach as a good way to go especially for the classification of highly diverse evergreen broad-leaved forests in Taiwan. Before his retirement, Professor Su wrote the paper "The diversification and synthesis of vegetation classification" (Su 2002). After this paper was published, the government started the Vegetation survey and mapping project in 2003 (Chiou et al. 2009). One of the goals of this project was to build a unified vegetation classification system of Taiwan on a national scale. This dissertation thesis uses the high-quality data collected within this large project and contributes to the development of the unified vegetation classification system of Taiwan, following the vision of Professor Su.

QUESTIONS ASKED IN THIS DISSERTATION

The aim of this dissertation is to define the main forest vegetation types and their relationships to major environmental variables using the National Vegetation Database of Taiwan. After the definition of these major forest vegetation types, two of them, dominated by coniferous species, were chosen for classifying to the association level. One of these two types is a species-poor forest dominated by *Abies kawakamii*, *Picea morrisonicola* or *Tsuga chinensis* var. *formosana* in the subalpine and upper-montane zone. Another type is the species-rich forest dominated by *Chamaecyparis formosensis* or *C. obtusa* var. *formosana* in the montane cloud zone. Formalized assignment rules were developed for each vegetation type. The following questions were asked:

Paper 1

What are the main forest vegetation types in Taiwan? What are their habitat affinities and distribution?

Paper 2

Which forest associations and alliances can be recognized in the subalpine and upper-montane coniferous forest zone in Taiwan? What is the relationship between these subalpine and upper montane coniferous forests in Taiwan and those in nearby areas? How could the classification results be formalized?

Paper 3

Which environmental factors are the most important for the floristic composition of the *Chamaecyparis* forest in Taiwan? Which associations and alliances can be recognized in these forests? How similar are the *Chamaecyparis* forests in Taiwan and other subtropical montane cloud forests in eastern Asia?

Methods

In this dissertation, classification of vegetation plots, on the scale of the whole of Taiwan, was performed in order to obtain a comprehensive understanding of the ecological patterns in Taiwan's vegetation. National Vegetation Database of Taiwan (AS-TW-001), which contains a set of representative plots, was used. By the end of 2011, there were 3564 plots sampled following a standard methodology and 6258 plots digitalized from 157 published studies in the National Vegetation Database of Taiwan. Classification was performed by expert judgement and the unequivocal rules for assigning plots to each vegetation type were included. The following text outlines the structure of the vegetation database and the methods used in formalizing the classification.

THE STRUCTURE OF THE VEGETATION DATABASE

Plots sampled following the standard methodology for the Vegetation survey and mapping project

To achieve a representative distribution of sample plots, the whole area of Taiwan was firstly divided into 33 watersheds. Secondly, the distribution of primary forests in each watershed was delineated on maps from orthophotos at the scale of 1:5000. Thirdly, plot numbers and locations were determined according to these maps following the stratified sampling concept and possible accessibility.

Plot size was standardized to 20 × 20 m. The plot shape could occasionally be changed from the standard square because of the topographic limitation, but the rule of homogeneous structure and species composition had to be followed. There were still a few plots of a smaller size due to the topographical limitation and around 5% of the plots had a larger sampling size of up to 40 × 40 m due to their origin from experimental studies. All the vascular plant species inside the plot were recorded (including trees, shrubs, herbs, lianas and epiphytes) and their estimated covers were given. For tree species, two types of methods were applied to estimate the cover of each species. One method was a direct estimation of the crown cover of each species in the plot. This method was applied after 2006 and only 484 plots were made by this method. Another method was measuring the diameter at breast height (DBH) and using DBH to calculate the importance value index (IVI, Curtis & McIntosh 1951) per species per plot. IVIs were used as the cover estimation of the recorded species.

Header data, such as environmental information and vegetation structure information for the plots were recorded. The environmental information included the plot's land use type (Anon. 1995), GPS coordinates and their precision, measured altitude, measured slope, measured aspect, category of topography (1 = ridge; 2 = upper slope; 3 = middle slope; 4 = lower slope; 5 = valley and 6 = flat plain), estimated percentage of bare land without vegetation or litter cover inside the plot, estimated percentage of stones with diameter of 1–10 cm in the soil, and estimated percentage cover of rock outcrops on the ground surface. The vegetation information included the estimation of canopy height and canopy cover. The names of researchers who sampled each plot and determined the species were also recorded.

Plots compiled from published literature

Vegetation plots published in the literature were digitalized. Their coordinates were also extracted from the maps provided in the literature if they were available. These plots usually came from the studies focused on phytosociology, ecological or timber production monitoring or habitat survey for nature conservation. Most of these plots recorded only woody species and their IVIs. Header data and the information about the vegetation types of each plot were usually absent. The revision of scientific names of plant species was conducted following the nomenclature of the second edition of Flora of Taiwan (Huang & Hsieh 1994–2003).

Data from GIS layers

Some of the header data were extracted from the available Geographic Information System (GIS) layers based on the plot coordinates. All the plots sampled by standard methodology for the Vegetation survey and mapping project had precise coordinates. Two thirds of the plots compiled from published studies had precision higher than 100 m. For these plots, aspect, slope, altitude and whole-light-sky space (WLS) were calculated. WLS is the proportion of topographical shading by the surrounding landscape, which influences the input of radiation (Lai et al. 2010). These data were derived from GIS layers with a resolution of 40 × 40 m. Other climatic variables such as mean temperature of each month were extracted from the MODIS satellite thermal data (Lai et al. 2012), while the information on monthly precipitation was extracted from the WorldClim database (www.worldclim.org; Hijmans et al. 2005). These temperature and precipitation layers had a resolution of 1 × 1 km.

VEGETATION CLASSIFICATION AND DESCRIPTION

In the traditional Braun-Blanquet approach, the vegetation units were determined by the table-sorting method and presented in a synoptic table (also called synthesis table, Mueller-Dombois & Ellenberg 1974). This approach is recently being replaced by supervised and unsupervised numerical classification methods, which aim to clarify and formalise the procedure of vegetation classification. In this dissertation, both traditional and numerical approaches were used. First, to gain a deeper insight into the structure of vegetation data, several cluster analyses were applied with different combinations of dissimilarity measures and clustering algorithms. Then, after comparing the results of different methods with published vegetation descriptions and environmental factors of plots, species-plot raw tables were manually re-sorted to figure out the vegetation units in the data set. Data sorting was conducted in the JUICE program (www.sci.muni.cz/botany/juice; Tichý 2002).

Species composition of each unit was summarized in a synoptic table. Phi (Φ) coefficient was used to measure the fidelity of species in order to determine the diagnostic species of each vegetation unit (following Tichý & Chytrý 2006). Since unequal numbers of plots in particular groups would affect the measure of fidelity, the size of each association was virtually standardized to 5% of the total dataset and Fisher's exact test was applied with a threshold value of $P = 0.01$. Five categories of species life forms were used for description of vegetation units: T (tree), S (shrub), H (herb), L (liana) and E (epiphyte). All of the classified associations and alliances were named following the International Code of Phytosociological Nomenclature (Weber et al. 2000). Ordination diagrams and box-plots were used to describe the relationship between vegetation units and environmental factors.

SUPERVISED CLASSIFICATION

Formalized rules for assigning single plots into vegetation units were prepared base on classification and regression trees (Breiman et al. 1984) and Cocktail Determination Key (Appendix S1 in Li et al. 2013). The former was used to classify species-poor high-mountain coniferous forests in Taiwan. The other two studies in this dissertation used the Cocktail Determination Key.

The Cocktail Determination Key contains *n* Cocktail formulae (X_i). While running this key, each vegetation plot is compared with each formula in a stepwise manner (X_1 → X_2 → X_3 → … → X_n). If the plot fulfils the conditions defined by formula X_i, it is assigned to the vegetation type defined by this formula. If the plot does not fit to any formula, it remains unclassified. Cocktail formulas in the Cocktail Determination Key contains five main parts: the rank of the formula, species groups, numbers in front of the species groups, logical operators (AND, OR, WITH, WITHOUT, NOT) connecting the species groups, and the code of vegetation unit assigned by this formula. The numbers in front of the species groups define how many species from the given species group should be present in the plot so that the whole species group is considered to be present. If there are fewer or no species from the species group in the plot, the species group is considered to be absent. The meaning of logical operators is as follows: WITH – the following species group should be present (the formula must start with this logical operator); WITHOUT – the following species group should be absent; AND – the two conditions connected by AND should be both true; OR – one of the two conditions connected by OR should be true; NOT – the following condition should not be true. The Cocktail Determination Key can be operated by CoDeK (Appendix S2 & S3 in Li et al. 2013), which is a software application, based on the R program (www.r-project.org; R Development Core Team 2012), which allows automatic classification of vegetation plots into vegetation types defined by the Cocktail Determination Key.

Main results

PAPER 1

Temperature and moisture are the main gradients influencing forest vegetation types in both subtropical and tropical region of Taiwan. Temperature determines the altitudinal vegetation zones and the azonal vegetation occurs in relatively dry habitats. Five altitudinal zones are defined according to the temperature: subalpine zone, upper-montane zone, montane cloud zone, submontane zone and foothill zone. Azonal forest types develop in habitats affected by the winter monsoon, on steep slopes, rocky soils, in seashore saline habitats and in places disturbed by fire, landslides and human activities. Applying the concept of altitudinal zones and zonal vs. azonal vegetation types, the following 21 main forest vegetation types are recognized:

Zonal forest types

C1 High mountain coniferous woodlands and forests

C1A01 *Juniperus* subalpine coniferous woodland and scrub

C1A02 *Abies-Tsuga* upper-montane coniferous forest

C2 Subtropical mountain zonal forests

C2A03 *Chamaecyparis* montane mixed cloud forest

C2A04 *Fagus* montane deciduous broad-leaved cloud forest

C2A05 *Quercus* montane evergreen broad-leaved cloud forest

C2A06 *Machilus-Castanopsis* submontane evergreen broad-leaved forest

C2A07 *Phoebe-Machilus* submontane evergreen broad-leaved forest

C2A08 *Ficus-Machilus* foothill evergreen broad-leaved forest

C3 Tropical mountain zonal forests

C3A09 *Pasania-Elaeocarpus* montane evergreen broad-leaved cloud forest

C3A10 *Drypetes-Helicia* submontane evergreen broad-leaved forest

C3A11 *Dysoxylum-Machilus* foothill evergreen broad-leaved forest

C4 Tropical forests of Green Island and Orchid Island

C4A12 *Aglaia-Ficus* foothill evergreen broad-leaved forest

Azonal forest types

C5 Tropical mountain azonal forests

C5A13 *Illicium-Cyclobalanopsis* tropical winter monsoon forest

C5A14 *Diospyros-Champereia* tropical rock-outcrop forest

C6 Subtropical mountain azonal woodlands and forests

C6A15 *Pyrenaria-Machilus* subtropical winter monsoon forest

C6A16 *Zelkova-Quercus* subtropical rock-outcrop forest

C6A17 *Pinus* successional woodland

C6A18 *Alnus* successional woodland

C6A19 *Trema-Mallotus* successional woodland

C7 Seashore woodlands and mangroves

C7A20 *Scaevola-Hibiscus* seashore woodland

C7A21 *Kandelia* mangrove

Zonal vegetation contains a higher ratio of endemic and Pacific species and occurs in wetter habitats, whereas azonal vegetation contains coexisting species from different regions. Cocktail Determination Key is provided to give unequivocal assignment rules for assigning plots to forest vegetation types.

PAPER 2

Two alliances of high-mountain coniferous forests and scrub were defined in this study. The alliance *Juniperion squamatae* represents woodlands and forests scattered in the subalpine zone, in which *Juniperus squamata* dominates the canopy and subalpine meadow species occur in the understorey. The alliance *Abieti kawakamii-Tsugion formosanae* includes forests dominated by *Abies kawakamii* and *Tsuga chinensis* var. *formosana* with shade-tolerant herb species in the upper-montane zone. Nine associations based on dominant tree species and the dominance of dwarf bamboo (*Yushania niitakayamensis*) in the shrub layer were recognized. In addition to regional vegetation description, an identification key for the studied forests was developed based on the technique of classification and regression trees. The syntaxonomical synopsis is:

Alliance: 1. *Juniperion squamatae* Suzuki et al. 1939

Associations:

1.01 *Geranio hayatanum-Juniperetum squamatae* Tokio Suzuki et al. 1939

1.02 *Aconito fukutomei-Juniperetum squamatae* Cheng-Tao Lin et al. 2012

1.03 *Junipero squamatae-Abietetum kawakamii* Cheng-Tao Lin et al. 2012

Alliance: 2. *Abieti kawakamii-Tsugion formosanae* Lin et al. 2012

Associations:

2.04 *Yushanio niitakayamensis-Abietetum kawakamii* Cheng-Tao Lin et al. 2012

2.05 *Tsugo formosanae-Abietetum kawakamii* Cheng-Tao Lin et al. 2012

2.06 *Yushanio niitakayamensis-Tsugetum formosanae* Cheng-Tao Lin et al. 2012

2.07 *Pino mastersianae-Tsugetum formosanae* Cheng-Tao Lin et al. 2012

2.08 *Rhododendro pseudochrysanthum-Tsugetum formosanae* Cheng-Tao Lin et al. 2012

2.09 *Ellisiophyllo pinnati-Piceetum morrisonicolae* Cheng-Tao Lin et al. 2012

Geranio hayatanum-Juniperetum squamatae grows at the highest altitudes on the upper slopes and is influenced by strong winds. It forms the timberline in the upper subalpine zone. *Aconito fukutomei-Juniperetum squamatae* grows on the bottom of cirques. *Junipero squamatae-Abietetum kawakamii* grows on the stony slopes; the herb species are abundant because of the lack of competition from *Yushania* *niitakayamensis*. *Yushanio niitakayamensis-Abietetum kawakamii* grows in the habitats influenced by snow in winter with well-developed soil in the upper-montane zone. *Tsugo formosanae-Abietetum kawakamii* grows at sites influenced by strong wind, with well-developed soil. *Yushanio niitakayamensis-Tsugetum formosanae* grows in the habitats which are rarely covered by snow in winter, with well-developed soil. *Pino mastersianae-Tsugetum formosanae* grows at the concave landforms with frequent accumulation of water. *Rhododendro pseudochrysanthum-Tsugetum formosanae* grows in the stony habitats, where the cover of *Yushania niitakayamensis* is low, while the number of herb species in the understorey is higher than in *Yushanio niitakayamensis-Tsugetum formosanae*. *Ellisiophyllo pinnati-Piceetum morrisonicolae* grows in nutrient-rich habitats.

The proportion of endemic species is high in all associations. There are very few common species between the Taiwanese upper-montane coniferous forest and the other coniferous forests in mainland China, Japan and Korea. Which order and which class should these two alliances belong to is not clear. We suggest that a new order may be proposed in the future. However, to decide whether or not this new order should belong to *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 needs more data and a comparison with other regions in eastern Asia.

PAPER 3

Two alliances with contrasting habitat requirements, described by topography and altitude, were defined in this paper. The alliance *Chamaecyparidion formosanae* (in Li et al. 2013 named *Chamaecyparis* montane mixed cloud forest) is distributed on slopes and ridges in the subtropical montane cloud zone in Taiwan. The vegetation of this alliance is characterized by a thick layer of undecomposed material on the soil suface and a high cover of bryophytes on both the soil surface and on the trunks and branches. The alliance *Pasanio kawakamii-Machilion japonicae* (in Li et al. 2013 named *Quercus* montane evergreen broad-leaved cloud forest), grows on slopes and in valleys. Seasonality of moisture, soil properties and altitude explain the differences in floristic composition at the association level. The syntaxonomical synopsis is:

Order: *Fagetalia hayatae* Hukusima et al. 2005

Alliance: 1. *Chamaecyparidion formosanae* Tokio Suzuki 1952 nom. mut. propos.

Associations:

1.01 *Tsugo formosanae-Chamaecyparidetum formosanae* Ching-Yu Liou ex Ching-Feng Li et al. 2014

1.02 *Vaccinio lasiostemonis-Tsugetum formosanae* Ching-Feng Li et al. 2014

1.03 *Schefflero taiwanianae-Chamaecyparidetum formosensis* Ching-Long Yeh et Chien-Chun Liao ex Ching-Feng Li et al. 2014

1.04 *Elatostemato trilobulati-Tsugetum formosanae* Tokio Suzuki 1952

1.05 *Rhododendro formosani-Chamaecyparidetum formosanae* Tokio Suzuki 1952

Alliance: 2. *Pasanio kawakamii-Machilion japonicae* Ching-Feng Li et al. 2014

Associations:

2.06 *Adinandro lasiostylae-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014

2.07 *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* Ching-Yu Liou ex Ching-Feng Li et al. 2014

2.08 *Castanopsio carlesii-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014

2.09 *Arachniodo rhomboideae-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014

2.10 *Symploco wikstroemiifoliae-Machiletum thunbergii* Ching-Feng Li et al. 2014

2.11 *Pileo brevicornutae-Machiletum japonicae* Ching-Feng Li et al. 2014

Chamaecyparidion formosanae is mostly dominated by both coniferous trees and evergreen broad-leaved trees. The coniferous trees form a continuous canopy layer, while evergreen broad-leaved trees form a sub-canopy layer. Five associations were recognized in this alliance. *Tsugo formosanae-Chamaecyparidetum formosanae*, *Vaccinio lasiostemonis-Tsugetum formosanae* and *Schefflero taiwanianae-Chamaecyparidetum formosensis* distributed at high altitudes grow throughout the whole of Taiwan except the tropical region. *Tsugo formosanae-Chamaecyparidetum formosanae* is confined to wide upper slopes and ridges; *Vaccinio lasiostemonis-Tsugetum formosanae* grows on narrow upper slopes and ridges while the habitats of *Schefflero taiwanianae-Chamaecyparidetum formosensis* are found on the slopes and ridges which are often covered by large rocks. *Elatostemato trilobulati-Tsugetum formosanae* is a bog-like forest distributed in the north-eastern ecoregion. *Rhododendro formosani-Chamaecyparidetum formosanae* grows on warm south-facing slopes and is strongly influenced by the summer monsoon.

Pasanio kawakamii-Machilion japonicae is mostly dominated by evergreen broad-leaved species. *Lauraceae* are commonly dominant species in the canopy and sub-canopy layers, especially the genera of *Litsea* (sub-canopy layer) and *Machilus* (canopy layer). Coniferous trees are emergent above the canopy layer without any seedlings and saplings in the understorey. Six associations in this study were recognized under *Pasanio kawakamii-Machilion japonicae*. *Adinandro lasiostylae-Chamaecyparidetum formosensis* is mainly distributed in the north-western ecoregion. *Castanopsio carlesii-Chamaecyparidetum formosensis* occurs in the south-western ecoregion. *Symploco wikstroemiifoliae-Machiletum thunbergii* is found in the north-eastern lowland, where fog events mainly occur in winter because of the winter monsoon. *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* and *Pileo brevicornutae-Machiletum japonicae* occur in the eastern ecoregion, the latter growing on limestone. *Arachniodo rhomboideae-Chamaecyparidetum formosensis* is distributed across the whole island except the tropical region, and is usually found in the stony and shaded valleys.

Hukusima et al. (2013) used 2717 plots to define the classification system of *Fagus* forest in eastern Asia and proposed the following two classes: *Fagetea crenatae* (temperate *Fagus* forests in Japan and Korea) and *Litseo elongatae-Fagetea* sp. div. (subtropical montane *Fagus* forests in both mainland China and Taiwan; invalid name). Under *Litseo elongatae-Fagetea*, two orders were proposed: *Sinarundinario nitidae-Fagetalia* Hukusima et al. 2013, distributed in mainland China, and *Fagetalia hayatae* Hukusima et al. 2005 occurring in Taiwan. *Fagus* and *Chamaecyparis* forest are classified into the subtropical montane cloud forest in Taiwan (Li et al. 2013). The character species of *Fagetalia hayatae* are often occurring in the *Chamaecyparis* forest. In this study, the *Fagetalia hayatae* was used as the order which represents the subtropical montane cloud forest in Taiwan. In the class level, the subtropical montane cloud forest in eastern Asia should be in the same classes as Hukusima et al. (2013) proposed.

Cocktail Determination Key is provided to give unequivocal assignment rules for assigning each plot to the associations.

Conclusions

1) Twenty-one main forest vegetation types were distinguished, mainly corresponding to the temperature and moisture differences among habitats, in the subtropical and tropical region in Taiwan. The classification was formalized by the Cocktail Determination Key.
2) In the high-mountain coniferous forests, two alliances and nine associations were recognized based on dominant species. Altitude, topography, snow, wind and soil conditions explain the habitat requirements of these associations. A dichotomous key to determining associations was prepared based on the results of classification and regression trees.
3) In the subtropical montane cloud forests dominated by *Chamaecyparis* spp., two alliances and eleven associations were recognized and their diagnostic species groups defined. Altitude, soil conditions and the seasonality of moisture in different ecoregions explain the habitat requirements of these associations. The classification was formalized by the Cocktail Determination Key.

4) Altitude and topography explain the differences of floristic composition at the level of alliance in the high-mountain coniferous forests and the subtropical montane cloud forests, respectively.

5) Forest vegetation types in the subalpine, upper-montane and montane cloud zones of Taiwan, and those in subtropical mainland China, should be classified to the same phytosociological classes, which are different from those occurring in the temperate and boreal zones of eastern Asia because of the dominance of evergreen broad-leaved species.

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Paper 1

Classification of Taiwan forest vegetation

Li, C.-F., Chytrý, M., Zelený, D., Chen, M.-Y., Chen, T.-Y., Chiou, C.-R., Hsia, Y.-J., Liu, H.-Y., Yang, S.-Z., Yeh, C.-L., Wang, J.-C., Yu, C.-F., Lai, Y.-J., Chao W.-C. & Hsieh C.-F.

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Classification of Taiwan forest vegetation

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ABSTRACT

Aim: We identify the main forest vegetation types in Taiwan, provide their formal definitions and describe their species composition, habitat affinities and distribution.

Location: Taiwan.

Methods: Data set of 9822 vegetation plots with environmental characteristics recorded in the field or derived from digital maps in GIS was compiled from historical literature and an extensive field survey. Using expert knowledge, 6574 of these plots were used to build a classification into broad vegetation types. The units of the resulting classification were formally defined by a Cocktail determination key, which can be used for the automatic assignment of new vegetation plots to these vegetation types.

Results: Twelve vegetation types of zonal forests and nine types of azonal forests were distinguished. Zonal types in the subtropical region, from high mountains to foothills, are *Juniperus* subalpine coniferous woodland, *Abies-Tsuga* upper-montane coniferous forest, *Chamaecyparis* montane mixed cloud forest, *Fagus* montane deciduous broad-leaved cloud forest, *Quercus* montane evergreen broad-leaved cloud forest, *Machilus-Castanopsis* submontane evergreen broad-leaved forest, *Phoebe-Machilus* submontane evergreen broad-leaved forest and *Ficus-Machilus* semi-evergreen foothill forest. Zonal types in the tropical region, from high mountains to foothills, are *Pasania-Elaeocarpus* montane evergreen broad-leaved cloud forest, *Drypetes-Helicia* submontane evergreen broad-leaved forest, *Dysoxylum-Machilus* foothill evergreen broad-leaved forest and *Aglaia-Ficus* foothill evergreen broad-leaved forest. Azonal types are *Illicium-Cyclobalanopsis* tropical winter monsoon forest, *Pyrenaria-Machilus* subtropical winter monsoon forest, *Diospyros-Champereia* tropical rock-outcrop forest, *Zelkova-Quercus* subtropical rock-outcrop forest, *Pinus* successional woodland, *Alnus* successional woodland, *Trema-Mallotus* successional woodland, *Scaevola-Hibiscus* seashore woodland and *Kandelia* mangrove.

Conclusions: The diversity of forest vegetation in Taiwan is strongly structured by the temperature and moisture gradient. Along the temperature gradient, five altitudinal zones can be recognized. Azonal forest types develop at sites affected by the winter monsoon, on steep slopes, rocky soils, in seashore saline habitats and in places disturbed by fire, landslides and human activities. Zonal vegetation contains a higher ratio of endemic and Pacific species and occurs in wetter habitats, whereas azonal vegetation contains coexisting species from different regions and usually occurs in drier habitats.

Keywords: Altitudinal zones; Azonal vegetation; Cocktail determination key; Eastern Asia; Montane forest; Plant community; Subtropical forest; Supervised classification; Tropical forest; Zonal vegetation.

Nomenclature: Huang & Hsieh (1994–2003)

INTRODUCTION

In eastern Asia, diversity of forest vegetation based on the floristic composition has been reasonably well studied in boreal and temperate zones (Nakamura et al. 2007), including the Russian Far East (Krestov 2003), China (Qian et al. 2003), Korea (Song 1992) and Japan (Miyawaki 1980–1988). However, very few data concern species composition and diversity of vegetation types from more southern, warm temperate and subtropical regions of eastern Asia. Taiwan, a subtropical island situated on the Tropic of Cancer, is rich in natural forests. Its mountainous topography with the highest peak of 3952 m results in the formation of distinct altitudinal vegetation zones, which harbour vegetation corresponding to several latitudinal zones from subarctic to tropical. Therefore, knowledge of the vegetation diversity of Taiwan can significantly contribute to understanding diversity patterns on the scale of the whole of eastern Asia.

In Taiwan, vegetation studies based on floristic composition began with descriptions of zonal forest types along the altitudinal gradient (Sasaki 1924). After World War II, many inventory plots were established to measure timber production (Liu et al. 1961). Although some phytosociological studies were already carried out before 1940 (e.g. Suzuki 1938), comparative studies of species composition within small regions started to appear only since the 1970s (Liu & Su 1972; Chang 1974). Su (1984) evaluated overall vegetation patterns on the island and proposed six altitudinal vegetation zones in mesic to humid habitats. He also observed that in drier habitats, vegetation did not follow the same zonal pattern as in the mesic-humid habitats, and that drier habitats were more suitable for deciduous or coniferous trees than for broad-leaved evergreens. This scheme was commonly accepted by Taiwanese foresters and vegetation ecologists and widely applied in nature resource management. Song & Xu (2003) used a large-scale vegetation classification scheme developed for mainland China (Editorial Committee for Vegetation of China 1980) and applied it to Taiwan. Chiu et al. (2008) proposed a scheme based on a combination of Chinese (Song & Xu 2003) and American (Grossman et al. 1998) systems. All of these schemes, especially the latter, mainly reflected vegetation physiognomy. Synthetic comparative studies of vegetation types across the whole of Taiwan based on floristic composition are lacking, except for the recent classification of the beech forest (Hukusima et al. 2005) and high-mountain coniferous forests (Lin et al. 2012). Even less attention than to zonal forests has been paid to forests in azonal habitats, which are more influenced by specific soil characteristics than by climate (Walter 1973), and therefore occur across more than one vegetation zone. Although azonal forests have been largely neglected in eastern Asia so far, their contribution to regional biodiversity might be high, and some might even act as refuges of Tertiary relict species (Tang & Ohsawa 1997).

Developments in the field of vegetation classification during the last two decades are shifting the focus towards the use of formalized approaches (Mucina 1997; Ewald

2003; Jennings et al. 2009; De Cáceres & Wiser 2012). Formalized vegetation classification can be defined as the one that is repeatable and/or accompanied by unequivocally-described rules for the assignment of individual vegetation stands to classification units (Chytrý et al. 2011). Formalization can be applied at several phases of the classification process. In the phase of constructing vegetation classification, formalization can involve the use of unsupervised numerical classification methods, such as TWINSPAN (Hill 1979) or cluster analysis (Legendre & Legendre 1998), which consistently apply selected classification criteria to the whole data set. At the phase of description and parameterization of recognized vegetation types, formalization can be achieved by the use of supervised classification methods, which create unequivocal rules and criteria for the determination of vegetation types. An example is the Cocktail method (Bruelheide 1997, 2000; Bruelheide & Chytrý 2000; Kočí et al. 2003), which describes each vegetation type using a logical formula that combines statements concerning the presence or absence of typical or dominant species. At the phase of identification of newly-collected vegetation plots in terms of their assignment to classification units, formalization is represented by consistent application of the assignment rules or definitions of vegetation types. Cocktail formulae can be used for this purpose.

In this paper, we present a new classification scheme of both zonal and azonal forest vegetation of Taiwan, based on species composition. We use the National Vegetation Database of Taiwan, which contains vegetation plots distributed in different altitudinal zones and different habitats across the island. The classification scheme is based on expert knowledge and description of vegetation types is formalized by creating a determination key, based on the concept of Cocktail. This key offers a detailed description of individual steps in which the assignment of vegetation plots to vegetation types is made. It performs the automatic assignment of new vegetation plots to units of the presented classification scheme, using a computer application which we developed to facilitate the use of the proposed national forest vegetation classification.

STUDY AREA

Taiwan (21˚55’–25˚20’N, 119˚30’–122˚00’E) is a mountainous island located on the Tropic of Cancer. Within the area of 36 000 km^2, the Central Ridge of NNE–SSW direction contains over 200 peaks above 3000 m a.s.l., with the highest one (Mt. Yushan) reaching 3952 m. Except for the lowland sedimentary plains (located mainly in the west of the island and covering approximately 27% of the island’s area), metamorphic rocks are the main bedrock. Steep and fragile slopes are common, with frequent landslides occurring after heavy rains, earthquakes or road constructions.

Temperature is mostly driven by altitude, with a mean altitudinal lapse rate of 0.55 ˚C / 100 m, whereas precipitation differences are mainly due to exposure to the monsoons, especially the northeastern monsoon in winter. In the foothills, mean annual temperature in the area north of the Tropic of Cancer is about 22 ˚C with a few frost events in the coldest month. Mean annual temperature in the area south of the Tropic of Cancer is 24 ˚C and no frost events occur there. Mean annual precipitation is about 2500 mm in the east and 1500 mm in the west. Southwestern Taiwan experiences a dry season of six months from late October to early April, but no obvious dry season occurs in northeastern Taiwan. On average two typhoons hit Taiwan every year in the period from June to September. Strong typhoon winds (over 60 km/h) and heavy rains (over 500 mm per typhoon in two days) repeatedly disturb large areas of forests (www.cwb.gov.tw/V7e/climate/).

According to an inventory made by the Taiwan Forestry Bureau in 2005, forests cover 58% of Taiwan territory. Natural forests (including successional forests after natural disturbance) are concentrated on poorly-accessible steep slopes, in remote mountain areas and in areas protected for drinking water, soil resources and seed of timber species. Of the remaining natural forests, 53% are broad-leaved forests and the rest are coniferous or mixed forests. Large areas of original broad-leaved evergreen forest below 500 m a.s.l. have been converted into urban or agricultural land, including bamboo plantations (www.forest.gov.tw).

METHODS

Vegetation database and plot selection

The National Vegetation Database of Taiwan (AS-TW-001) was established in 2003 and contained 9822 plots at the end of 2011. Of these, 6258 plots were excerpted from 157 published studies that focused on phytosociological surveys, ecological or timber production monitoring, and contained both permanent plots and plots from habitat surveys for nature conservation. Plots from published studies were made in 1979–2006, using different plot sizes and sampling methods. In most of these 6258 plots, only trees and shrubs were recorded. The species importance value used in the published studies was the Importance Value Index (IVI; Curtis 1959) with an interval from 0 to 100. The other 3564 plots were sampled in 2003–2007 as a part of a Vegetation survey and mapping project organized by the Taiwan Forestry Bureau (Chiou et al. 2009). The standardized size of these 3564 plots was 20 × 20 m, although 5% of them were larger, with a maximum size of 50 × 20 m. All the vascular plant species including trees, shrubs, lianas, epiphytes and herbs were recorded in these 3564 plots. The diameter at breast height (DBH) was measured for trees and shrubs taller than 2 m. In the tree and shrub layers, the IVI of each species was calculated and rescaled into intervals of 0 to 100 from intervals of 0 to 300. For species of lianas, epiphytes and herbs, percentage cover was estimated and used as a measure of abundance.

In our study, we selected plots lager than 100 m^2 from natural and semi-natural forests. Plots from forestry plantations or plots containing fewer than three species were deleted, except in naturally species-poor forest types such as mangroves, seashore woodlands and upper-montane coniferous forests. In total, 8804 plots containing 922 tree and shrub species were selected. For the purpose of classification, herbs, lianas and epiphytes were removed from the data set because they were only recorded in about one third of the plots. As the database used IVI as a measure of abundance, we used the value of IVI (from 0 to 100) as dominance or cover in this study.

Environmental variables

Nine abiotic variables were available for each plot. Five of them were recorded in the field: altitude, slope, aspect, topography and soil rockiness. Aspect was recalculated as southernness with a value of 180° representing a south-facing slope and 0° a north-facing slope. Topography was recorded on an ordinal scale of 1−6 (1 = ridge or the area within 30 m from the ridge divide; 2 = upper slope, i.e. the upper one third of the slope length; 3 = middle slope; 4 = lower slope, i.e. the lower one third of the slope length; 5 = valley, which is an area close to a stream with slopes on both sides within a range of 30 m, and 6 = flat plain, which includes large river terraces or plains outside the mountain region with an inclination of less than 5º). Soil rockiness was an estimation of the percentage rock content in the soil. A further four variables were derived from digital maps using ArcGIS version 9.0 (www.esri.com) for plots located with an accuracy within 100 m. The whole-light sky space (WLS; Lai et al. 2010), with a resolution of 40 × 40 m, indicates the ratio of clear sky which is not shaded by surrounding topography on a scale from 0 to 1. Kira's warmth index (WI; Kira 1945), defined as the annual sum of positive temperature differences between monthly means and 5 °C, was calculated from the monthly mean temperatures computed from satellite images (Lai et al. 2012) with a resolution of 1 × 1 km. Temperature data derived from satellite images were more sensitive to topography than the temperature data calculated from the regression model of weather stations. Two precipitation variables, namely annual precipitation and the winter precipitation (the ratio of the sum of precipitation of December, January and February divided by the annual precipitation), with a resolution of 1 × 1 km, were taken as interpolated values from the WorldClim database (www.worldclim.org; Hijmans et al. 2005).

Species data

To understand the evolutionary and functional differences within vegetation types, we grouped species by families, leaf types and geographic distribution types according to the Flora of Taiwan (Huang & Hsieh 1994–2003; Hsieh 2002). Three categories of leaf type were recognized: coniferous, evergreen broad-leaved (evergreen) and deciduous broad-leaved (deciduous). Geographic distribution included six categories: widespread, Pacific, Himalayan, tropical, endemic and naturalized. Widespread species have geographic ranges which go beyond eastern and southeastern Asia; Pacific species are those shared with other Pacific islands such as Japan and the Philippines; Himalayan species occur in eastern Asia (mainly in China) but not in tropical southeastern Asia; tropical species occur only in Taiwan and southeastern Asia; endemic species were defined as those occurring naturally only in Taiwan or on adjacent small islands; naturalized species are those introduced to Taiwan as a result of human activity.

Classification of vegetation and construction of the Cocktail determination key

Vegetation classification presented in this study was created in four steps. Firstly, we developed a classification scheme consisting of 21 vegetation types, which reflects our experience with Taiwanese vegetation and previous concepts of vegetation classification used in Taiwan (mainly the concept of Su 1984). We also used several cluster analysis methods and TWINSPAN to reveal the pattern of discontinuities in our database; however, these numerical analyses were used only as an exploratory tool and did not serve to create the final classification.

Secondly, all plots were individually checked and manually assigned into one of the 21 vegetation types. Altogether, 3864 plots were properly assigned into vegetation types as "type plots", leaving plots with unclear assignment to these 21 vegetation types (atypical or transitional plots) unclassified. Hereafter, we name the data set of the 3864 type plots as the training data set. The remaining 4940 plots, which could not be unequivocally assigned to any vegetation type by our expert knowledge, were aggregated as a validation data set.

Thirdly, the training data set composed of 3864 plots was used to construct the Cocktail determination key (hereafter called CoDeK), which contains n formulae X. While running this key, each vegetation plot is compared with each formula in a step-wise way ($X_1 \rightarrow X_2 \rightarrow X_3 \rightarrow \cdots \rightarrow X_n$). If the plot fulfils the conditions defined by formula X_i, it is assigned to the vegetation type defined by this formula. If the plot does not fit any formula, it remains unclassified. Each formula has three important elements: species groups, logical operators (AND, OR, WITH, WITHOUT, NOT) and numbers defining the criteria that specify how many species from a species group must occur in the plot in order for the group to be considered as present in the plot. In the species groups, the cover of each species can be added to improve the definition; alternatively, only presence/absence is considered. Technical details on the definition of species groups and construction of CoDeK are found in Appendix S1.

In the last step, the 4940 plots from the validation data set were identified using CoDeK. Plots assigned to vegetation types in this way were checked for their floristic composition to decide whether the assignment was appropriate. If the floristic composition of the assigned plots in the validation data set did not fit our concept of vegetation type, then the formula X_i, which led to misidentification, was revised and the key was run again until no inappropriate plots from the validation data set were assigned into any vegetation types. The training data set and validation data set contained 922 species of trees and shrubs altogether, and 494 of them were included in at least one species group and were used for construction of CoDeK.

An application based on the R program platform was developed to run CoDeK automatically (see Appendix S2 & Appendix S3 for technical details). CoDeK can accept vegetation plot data in a spreadsheet format (e.g. MS EXCEL) or data exported from the JUICE program (Tichý 2002). The key for identifying 21 vegetation types presented in this study in the format accepted by the application is also provided, together with the checklist of the whole Taiwanese flora, which is necessary for unifying species nomenclature. An example data set of 50 vegetation plots from Taiwanese forests (Li, unpublished data) is included, to demonstrate the use of CoDeK.

Ordination, synoptic table and software

Ordination by detrended correspondence analysis (DCA; Hill & Gauch 1980) was applied to extract and visualize main gradients in species composition. Square-root transformation was applied to IVI data of trees and shrubs prior to the analysis. Species composition of the 21 resulting vegetation types was summarized in a synoptic table, in which diagnostic species were identified using a fidelity calculation. The Phi coefficient of association (Φ) was used as a measure of fidelity, and before the calculation, each group of plots was virtually equalized to 5% of the total data set size (Tichý & Chytrý 2006). Species with a Φ>0.2 were considered diagnostic, provided that the *P*-value of their concentration in the plots of the target vegetation unit (calculated by the Fisher's exact test with non-equalized group sizes) was lower than 0.001. Plot data were edited and output tables were prepared using the JUICE program (version 7, Tichý 2002). Satellite image treatment and calculation, data extraction from GIS layers and map drawing were performed using ArcGIS software. DCA ordination was calculated and graphs were drawn using the R program (version 2.13.0, R Development Core Team, Vienna, AT, www.R-project.org).

RESULTS

Among the 8804 plots selected from 9822 plots in total, 6574 plots (3864 plots from the training data set and 2710 from the validation data set) were assigned into 21 forest types based on their floristic composition (Table 1; Appendix S4). These forest types can be grouped into seven types at a higher hierarchical level. These two levels are reflected here by codes C (potentially at the level of class or order) and A (potentially at the level of order or alliance) for the higher and lower hierarchical level, respectively:

Zonal forest types

- **C1** High-mountain coniferous woodlands and forests
  - **C1A01** *Juniperus* subalpine coniferous woodland and scrub
  - **C1A02** *Abies-Tsuga* upper-montane coniferous forest
- **C2** Subtropical mountain zonal forests
  - **C2A03** *Chamaecyparis* montane mixed cloud forest
  - **C2A04** *Fagus* montane deciduous broad-leaved cloud forest
  - **C2A05** *Quercus* montane evergreen broad-leaved cloud forest
  - **C2A06** *Machilus-Castanopsis* submontane evergreen broad-leaved forest
  - **C2A07** *Phoebe-Machilus* submontane evergreen broad-leaved forest
  - **C2A08** *Ficus-Machilus* foothill evergreen broad-leaved forest
- **C3** Tropical mountain zonal forests
  - **C3A09** *Pasania-Elaeocarpus* montane evergreen broad-leaved cloud forest
  - **C3A10** *Drypetes-Helicia* submontane evergreen broad-leaved forest
  - **C3A11** *Dysoxylum-Machilus* foothill evergreen broad-leaved forest
- **C4** Tropical forests of Green Island and Orchid Island
  - **C4A12** *Aglaia-Ficus* foothill evergreen broad-leaved forest

Azonal forest types

- **C5** Tropical mountain azonal forests
  - **C5A13** *Illicium-Cyclobalanopsis* tropical winter monsoon forest
  - **C5A14** *Diospyros-Champereia* tropical rock-outcrop forest
- **C6** Subtropical mountain azonal woodlands and forests
  - **C6A15** *Pyrenaria-Machilus* subtropical winter monsoon forest
  - **C6A16** *Zelkova-Quercus* subtropical rock-outcrop forest
  - **C6A17** *Pinus* successional woodland
  - **C6A18** *Alnus* successional woodland

C6A19 *Trema-Mallotus* successional woodland

C7 Seashore woodlands and mangroves

C7A20 *Scaevola-Hibiscus* seashore woodland

C7A21 *Kandelia* mangrove

The definition of forest, woodland and scrub followed the system of formation according to Mueller-Dombois & Ellenberg (1974). Forest was formed by trees at least 5 m tall with their crowns interlocking; woodland was formed by trees at least 5 m tall with most of their crowns not overlapping each other and scrub was mainly composed of caespitose woody phanerophytes 0.5–5 m tall.

The main factors responsible for the differentiation of Taiwanese forests are temperature and moisture (Figs. 1 and 2). In the DCA ordination diagram, the first axis is correlated with altitude, which is a surrogate for temperature. The second axis is correlated with annual precipitation, winter precipitation, whole-light sky space and also represents unmeasured soil conditions (soil nutrients, structure and moisture). In Taiwan, topography is usually correlated with soil rockiness: lower slopes and valleys are usually steep and have a high accumulation of nutrients although the soil contains more rocks and is shallower. When the soil contains a higher ratio of rocks or stones, it is drier in the dry season than deep soil with fewer stones. The second axis also has a positive correlation with slope southernness and it reflects soil moisture.

At the higher hierarchical level, differentiation of forest vegetation types in Taiwan is explained mainly by temperature and moisture. High-mountain coniferous woodlands and forests (C1) are at the coldest extreme, whereas tropical forests of Green Island and Orchid Island (C3) and seashore woodlands and mangroves (C7) are at the warmest extreme. Zonal vegetation types (C1, C2, C3 and C4) tend to occur in the wetter part of the gradient and azonal types (C5, C6 and C7) in the drier part. Altitudinal distribution of forest types, especially zonal ones, reflects five altitudinal vegetation zones: subalpine zone, upper-montane zone, montane cloud zone, submontane zone and foothill zone.

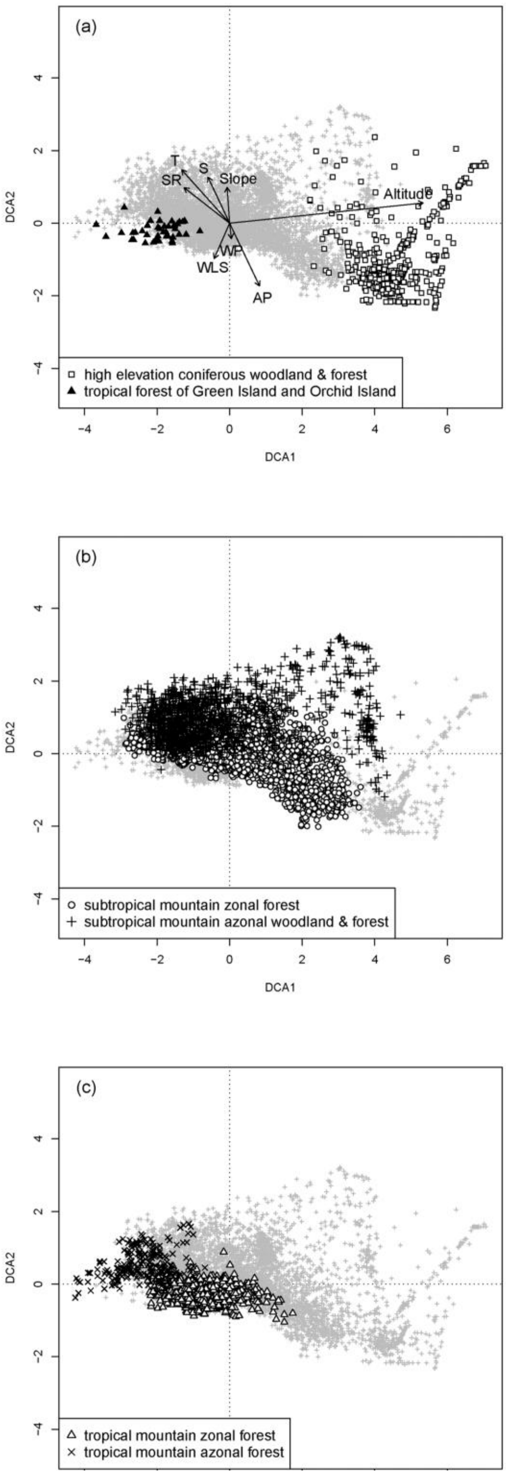

Figure 1. Distribution of 6478 plots projected onto the first two ordination axes of detrended correspondence analysis (DCA). Seashore woodlands and mangroves were not included because they were outliers. (a) Distribution of the high altitude coniferous woodlands and forests and the tropical Green Island and Orchid Island forests. Environmental factors significantly ($p<0.001$) correlated with the first two ordination axes are projected as vectors. (b) The distribution of plots of subtropical mountain zonal forests and subtropical mountain azonal woodlands and forests on a DCA diagram. (c) The distribution of plots of tropical mountain zonal forests and tropical mountain azonal forests on a DCA diagram. The grey crosses in all three figures indicate the other plots which have been classified in this study, excluding the outliers of seashore woodlands and mangroves. AP = Annual precipitation; S = Southernness; SR = Soil rockiness; T = Topography; WLS = Whole-light sky space; WP = Ratio of winter precipitation.

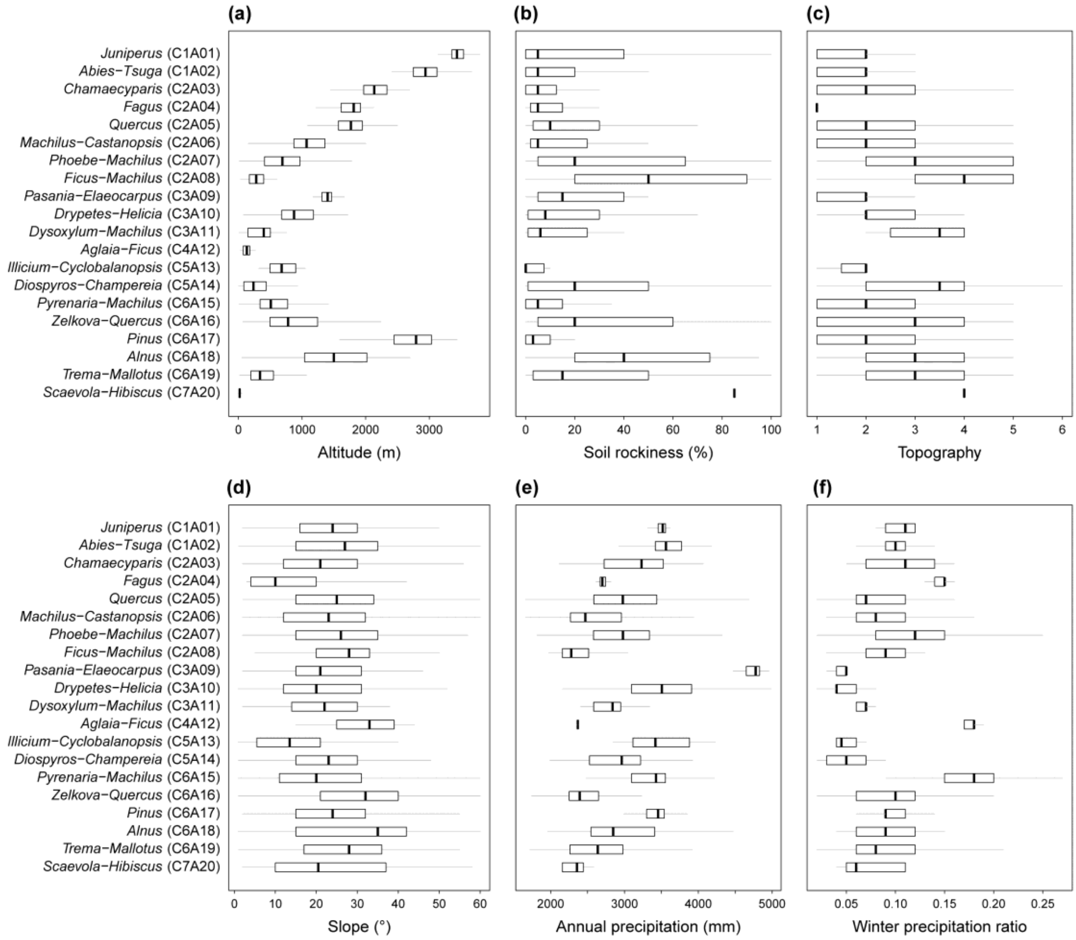

Figure 2. The box-plots of environmental factors. In (c) Topography, 1 indicates the ridge, 2 indicates the upper slope, 3 indicates the middle slope, 4 indicates the lower slope, 5 indicates the valley and 6 indicates the flat plain. Boxes indicate the interquartile range (25–75% of values), the thick horizontal bar is the median, whiskers are ± 1.5 times the interquartile range, and outliers have been removed.

C1 *High-mountain coniferous woodlands and forests*

Subalpine and upper-montane zones are classified into high mountain coniferous woodlands and forests. This vegetation is dominated by the coniferous trees of *Cupressaceae* and *Pinaceae*. Over 50% cover of the dominants are endemic species (Fig. 3). In the understory, tropical species such as *Gaultheria itoana*, *Rubus rolfei* and *Yushania niitakayamensis* predominate. Lianas and epiphytes are rare.

C1A01 *Juniperus subalpine coniferous woodland and scrub*

Altitude: 3200–3700 m; Warmth Index: 40–80 °C.

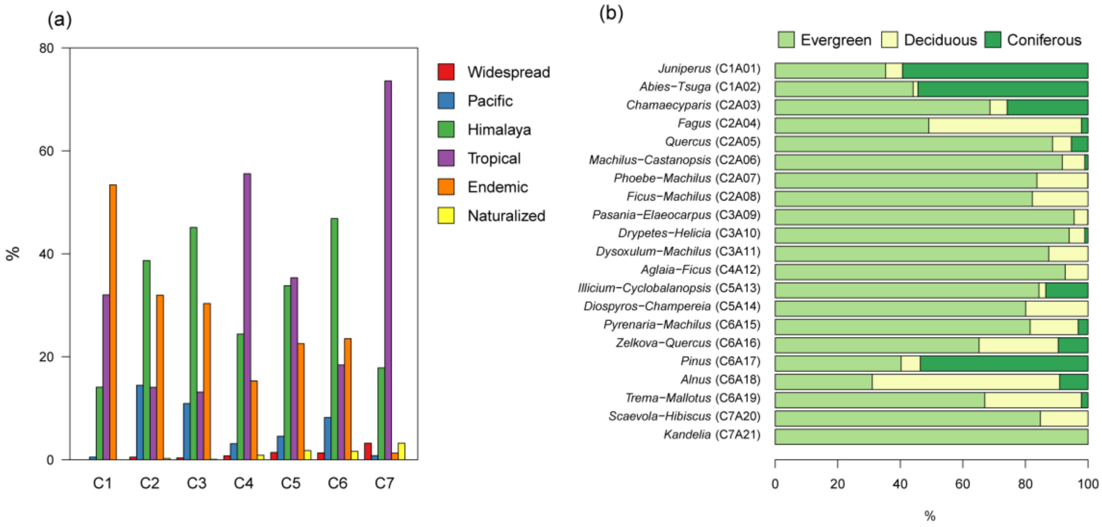

Figure 3. The bar-plot of different groups in individual forest types. (a) Proportion of species according to their geographical distribution (the y axis represents the ratio of mean cover in percentages). C1 = High altitude coniferous woodlands and forests; C2 = Subtropical mountain zonal forests; C3 = Tropical mountain zonal forests; C4 = Tropical Green Island and Orchid Island forests; C5 = Tropical mountain azonal forests; C6 = Subtropical mountain azonal woodlands and forests; C7 = Seashore woodlands and mangroves. (b) Proportion of evergreen, deciduous and coniferous species (the x axis represents the proportion of mean cover of each category in the canopy).

The timberline in Taiwan is formed by *Juniperus squamata*, occurring as a krummholz with a cover of about 60% together with other shrubs of *Ericaceae* and *Salicaceae*. In some flat and sheltered areas, such as cirque bottoms, *J. squamata* becomes an erect tree and forms a 15 m high woodland with an admixture of scattered *Abies kawakamii*. Frequent shrubs are *Berberis*, *Gaultheria*, *Rhododendron* and dwarf bamboo, *Yushania niitakayamensis*. Lin et al. (2012) assigned this vegetation type to the alliance *Juniperion squamatae* Suzuki et al. 1939.

C1A02 *Abies-Tsuga upper-montane coniferous forest*

Altitude: 2500–3400 m; Warmth Index: 60–110 °C.

Either *Abies kawakamii* or *Tsuga chinensis* var. *formosana* forms monodominant canopy of the upper-montane coniferous forest, which is about 20 m high with a mean canopy cover of 70%. In places, the dominant canopy species are replaced by *Picea morrisonicola* or *Pinus armandii* var. *mastersiana*. Very dense, 2–5 m high understory comprised of *Yushania niitakayamensis* develops on deep soils, whereas in stony places, *Yushania* is absent and the forest floor is covered by a thick layer of mosses with some herbs and ferns. Except for *Yushania*, evergreen broad-leaved sclerophyllous shrubs (e.g. *Berberis*, *Eurya*, *Ilex*, *Osmanthus*, *Pieris* and

Rhododendron) are common in the understory. *Photinia*, *Sorbus* and *Viburnum* are small trees scattered in canopy gaps. Lin et al. (2012) classified this forest as the alliance *Abieti kawakamii-Tsugion formosanae* Lin et al. 2012.

C2 *Subtropical mountain zonal forests*

This vegetation type occurs in the montane, submontane and foothill zones in the areas north of the N22.3° meridian. It is dominated by species of *Fagaceae*, *Lauraceae* and *Theaceae*. Species belonging to categories of Himalayan and endemic species have a high cover. Each zone has a different canopy structure, depending on the crown shape of dominant trees, and also a different cover of lianas and epiphytes. The montane cloud zone is characterized by clouds frequently descending to the ground. The Yuanyang Lake weather station in northern Taiwan reported 1752 hours per year with fog, distributed across 343 days (Lai et al. 2006). Dominant tree species are adapted to frequent fogs by spherical crowns, which are efficient in making the best use of diffuse light (Suzuki 1952). Lianas, vascular plant epiphytes and mosses on tree trunks are common. The submontane zone is dominated by umbrella-shaped tree crowns which are more efficient for the interception of direct sunlight. The epiphyte cover is not as high as in forests of the montane cloud zone, but a distinctive feature of these forests is the occurrence of large lianas. Due to strong human impact, most of the old-growth forests in the foothill zone are restricted to stony slopes and shaded valleys, which cannot be used for agriculture. The crown shape is round because of the shaded habitat. These forests have the lowest number of epiphytic species, the highest cover of lianas, and the high incidence of cauliflory and aerial roots from fig trees.

C2A03 *Chamaecyparis* montane mixed cloud forest

Altitude: 1700–2600 m; Warmth Index: 100–150 °C.

Chamaecyparis forest, located at higher altitudes of the montane cloud zone, is characterized by a multi-layered vertical structure. The average canopy cover is 75%. There is an emergent layer composed of large coniferous trees such as *Chamaecyparis formosensis, C. obtusa* var. *formosana, Picea morrisonicola* and *Tsuga chinensis* var. *formosana*. These trees are often taller than 30 m with a DBH over 1 m. In the 20th century, large areas of these forests were logged to obtain valuable timber, even in poorly-accessible places. Beneath the emergent layer, there is a continuous canopy layer composed of evergreen broad-leaved trees, with a mean canopy height of 20 m. The dominant genera are *Castanopsis*, *Cyclobalanopsis*, *Symplocos* and *Trochodendron*. Understory small-sized trees up to 8 m height are represented by *Eurya, Illicium*, *Neolitsea* and *Rhododendron*; frequent shrubs are *Barthea, Eurya, Microtropis, Rhododendron, Skimmia, Viburnum* and *Yushania*.

C2A04 *Fagus* montane deciduous broad-leaved cloud forest

Altitude: 1400–2100 m; Warmth Index: 130–160 °C.

Taiwanese beech forest has a three-layered structure with a mean canopy cover of 80%. It occurs on the ridges in the northern part of Taiwan which are assumed to be the western and southern boundaries of winter monsoon. The canopy is dominated by *Fagus hayatae* with a mean height of 15 m. On the wide and flat ridges at altitudes above 1900 m, conifers such as *Chamaecyparis obtusa* var. *formosana* or *Tsuga chinensis* var. *formosana* are scattered in the canopy as emergent trees. The accompanying tree species of the main canopy layer include *Cyclobalanopsis*, *Dendropanax* and *Symplocos*. Understory small-sized trees up to 8 m in height include *Camellia*, *Daphniphyllum*, *Enkianthus, Eurya, Illicium, Neolitsea*, *Osmanthus, Pourthiaea* and *Rhododendron*. Frequent shrubs are *Camellia*, *Eurya, Viburnum* and *Yushania*.

C2A05 *Quercus* montane evergreen broad-leaved cloud forest

Altitude: 1400–2300 m; Warmth Index: 90–180 °C.

This forest type occurs at lower altitudes of the montane cloud zone. The canopy height is 20 m with a mean cover of 80%. Dominant trees are *Beilschmiedia, Castanopsis*, *Cinnamomum*, *Cyclobalanopsis*, *Elaeocarpus*, *Engelhardia*, *Lithocarpus*, *Litsea*, *Machilus*, *Michelia*, *Pasania*, *Schima* and *Ternstroemia*. Some forests located in the valleys close to the Central Ridge contain large conifers as emergent trees, a feature similar to the *Chamaecyparis* forest. The key difference between the *Chamaecyparis* forest and the *Quercus* forest is that the latter has a higher cover of *Lauraceae* as accompanying trees. At the same altitude, *Quercus* forest usually occurs on more shaded steeper slopes with shallower, rockier soil than *Chamaecyparis* forest. Although the genus *Quercus* is not dominant, Taiwanese vegetation scientists traditionally name this forest a *Quercus* forest, because both *Castanopsis* and *Cyclobalanopsis* are phylogenetically related to *Quercus* and this name fits the zonal vegetation scheme of eastern Asia (Su 1984). Dominant small-sized trees include *Neolitsea*, *Prunus, Rhododendron* and *Turpinia*; frequent shrubs are *Callicarpa, Eurya*, *Hydrangea*, *Microtropis*, *Pittosporum, Prunus*, *Symplocos* and *Viburnum*.

C2A06 *Machilus-Castanopsis* submontane evergreen broad-leaved forest

Altitude: 400–1800 m; Warmth Index: 150–215 °C.

The canopy of *Machilus-Castanopsis* forest has a mean height of about 18 m and a mean cover of 80%. The soil is usually well developed, especially on the ridges. Dominant trees are *Beilschmiedia*, *Castanopsis*, *Cinnamomum*, *Cyclobalanopsis*, *Elaeocarpus*, *Engelhardia*, *Litsea*, *Machilus*, *Michelia*, *Pasania*, *Schefflera* and *Schima*. Under the canopy, the individuals and species of small-sized trees are abundant. *Ardisia*, *Daphniphyllum*, *Diospyros*, *Helicia*, *Illicium*, *Itea*, *Mallotus*, *Neolitsea*, *Prunus*, *Syzygium*, *Tricalysia* and *Turpinia* are dominant genera of small trees up to 6 m high; frequent shrubs are *Ardisia*, *Blastus*, *Euonymus*, *Eurya*, *Ficus*, *Hydrangea*, *Lasianthus* and *Psychotria*.

C2A07 *Phoebe-Machilus* submontane evergreen broad-leaved forest

Altitude: 0–1400 m; Warmth Index: 150–225 °C.

Phoebe-Machilus forest has a mean canopy height of about 15 m and a mean canopy cover of 80%. In the tree layer, *Beilschmiedia*, *Cryptocarya*, *Ficus*, *Lagerstroemia*, *Litsea*, *Machilus*, *Michelia*, *Neolitsea*, *Phoebe* and *Schefflera* are dominant genera. Small-sized trees up to 6 m high such as *Ardisia*, *Cleyera*, *Cyathea*, *Diospyros*, *Ficus*, *Helicia*, *Oreocnide*, *Saurauia*, *Turpinia* and *Wendlandia* are dominant in the understory. Frequent shrubs are *Ardisia*, *Blastus*, *Callicarpa*, *Eurya*, *Ficus*, *Glycosmis*, *Hydrangea*, *Lasianthus*, *Maesa*, *Psychotria*, *Styrax* and *Symplocos* and large ferns such as *Asplenium* and *Pseudodrynaria* are frequent epiphytes. In more humid habitats, tree ferns are common. In dry habitats such as on sandy or stony soil in the valley bottoms, the forest is dominated by deciduous trees such as *Lagerstroemia* and *Celtis*. Where the *Machilus-Castanopsis* forest and the *Phoebe-Machilus* forest occur at the same altitude, the latter has a very low abundance and frequency of *Fagaceae* and occurs in narrow, shaded valleys or very humid habitats.

C2A08 *Ficus-Machilus* foothill evergreen broad-leaved forest

Altitude: 0–600 m; Warmth Index: 195–225 °C.

The mean canopy height of this forest is 12 m and the mean canopy cover is 80%. *Bischofia*, *Celtis*, *Ficus*, *Lagerstroemia*, *Machilus*, *Melanolepis*, *Neolitsea*, *Radermachia*, *Sapindus*, *Schefflera* and *Trema* are dominant trees; *Ardisia*, *Dendrocnide*, *Diospyros*, *Ficus*, *Macaranga*, *Mallotus*, *Murraya*, *Oreocnide* and *Turpinia* are small trees up to 6 m high and frequent shrubs are *Ardisia*, *Boehmeria*, *Glycosmis*, *Hydrangea*, *Ilex*, *Maesa*, *Psychotria* and *Symplocos*. In dry and stony habitats, *Arenga* is dominant and frequent in the shrub layer; however, this genus was not recorded in most of the plots compiled from the literature because the investigators did not measure its DBH. The habitats of the *Ficus-Machilus* forest are usually warmer and drier than those of the *Phoebe-Machilus* forest although both of them are common in the valleys at low altitudes. In northern Taiwan, *Ficus-Machilus* foothill forest is rare (Appendix S5; Appendix S6) because of colder and wetter weather, especially in winter. Another structural feature of the *Ficus-Machilus* foothill forest is a higher ratio of species with compound rather than simple leaves, but the reason for this remains unknown.

C3 *Tropical mountain zonal forests*

Tropical mountain zonal forests are located south of the N23.2° meridian. There are three zones, including the montane cloud zone, submontane zone and foothill zone.

Similar to subtropical mountain zonal forests, dominants are species of *Fagaceae*, *Lauraceae* and *Theaceae*. The forest structure of each zone is also similar to that of subtropical mountain zonal forests. Himalayan and endemic species have a high cover. Unlike subtropical mountain zonal forests, there are no conifers among the dominant species and deciduous species are rare. *Myrtaceae* and *Proteaceae* are more dominant in tropical mountain zonal forests.

C3A09 *Pasania-Elaeocarpus* montane evergreen broad-leaved cloud forest

Altitude: 1200–1600 m; Warmth Index: 175–190 °C.

Pasania-Elaeocarpus forest has a mean canopy cover of 65%. Geographically, *Pasania-Elaeocarpus* forest occurs to the south of Yi-Ding Shan, which is the southernmost peak with an altitude above 2000 m in Taiwan, whereas *Chamaecyparis* forest and *Quercus* forest occur to the north of it. Most of the sites with *Pasania-Elaeocarpus* montane evergreen broad-leaved cloud forest are found on the Central Ridge, which is characteristic by stronger winds due to a lack of topographic shading. Canopy height is about 10 m and the density of individuals is high. Trees are dominated by *Castanopsis*, *Cinnamomum*, *Cyclobalanopsis*, *Dendropanax*, *Elaeocarpus*, *Engelhardia*, *Helicia*, *Litsea*, *Machilus*, *Pasania*, *Schima* and *Trochodendron*. The small-sized trees of 4 m in height are represented by *Cleyera*, *Cyathea*, *Helicia*, *Ilex*, *Illicium*, *Itea*, *Litsea*, *Myrsine*, *Neolitsea*, *Osmanthus*, *Prunus*, *Rhododendron* and *Ternstroemia*. The frequent shrubs are *Ardisia*, *Aucuba*, *Barthea*, *Euonymus*, *Eurya*, *Hydrangea*, *Lasianthus*, *Litsea*, *Microtropis*, *Psychotria*, *Symplocos* and *Vaccinium*.

C3A10 *Drypetes-Helicia* submontane evergreen broad-leaved forest

Altitude: 200–1600 m; Warmth Index: 175–220 °C.

This forest has a mean canopy cover of 75% and mean canopy height of 12 m. When *Drypetes-Helicia* forest and the other two subtropical submontane evergreen broad-leaved forest types occur at the same latitudes, *Drypetes-Helicia* forest is usually present at lower altitudes or further from the Central Ridge. The tree layer is dominated by *Beilschmiedia*, *Castanopsis*, *Cinnamomum*, *Cyclobalanopsis*, *Dysoxylum*, *Elaeocarpus*, *Engelhardia*, *Helicia*, *Litsea*, *Machilus*, *Michelia*, *Pasania*, *Schefflera*, *Schima* and *Sloanea*. The height of small-sized trees is 6 m; they are represented by *Ardisia*, *Daphniphyllum*, *Glochidion*, *Ilex*, *Illicium*, *Itea*, *Litsea*, *Machilus*, *Neolitsea*, *Prunus*, *Syzygium*, *Tricalysia* and *Turpinia*. Frequent shrubs are *Antidesma*, *Ardisia*, *Aucuba*, *Callicarpa*, *Decaspermum*, *Euonymus*, *Eurya*, *Ficus*, *Glycosmis*, *Hydrangea*, *Lasianthus*, *Maesa*, *Microtropis*, *Psychotria*, *Symplocos*, *Tarenna* and *Vaccinium*.

C3A11 *Dysoxylum-Machilus* foothill evergreen broad-leaved forest

Altitude: 0–700 m; Warmth Index: 195–220 °C.

Similar to *Ficus-Machilus* forest, *Dysoxylum-Machilus* forest is confined to shaded valleys which cannot be used for agriculture. It is also characterized by a dominance of figs and compound-leaf species. Furthermore, tropical foothill forest usually occurs at lower altitudes or further from the Central Ridge than subtropical foothill forest in the transition zone from subtropical to tropical. The canopy cover of *Dysoxylum-Machilus* forest is 75% and the canopy height is 12 m. Dominant tree genera are *Bischofia*, *Castanopsis*, *Dysoxylum*, *Ficus*, *Glochidion*, *Helicia*, *Lagerstroemia*, *Machilus*, *Michelia*, *Neonauclea*, *Schefflera*, *Sloanea* and *Trema*; dominant small-sized trees up to 6 m are *Aglaia*, *Ardisia*, *Astronia*, *Dendrocnide*, *Diospyros*, *Drypetes*, *Ficus*, *Glochidion*, *Ilex*, *Lasianthus*, *Macaranga* and *Turpinia*; frequent shrubs are *Callicarpa*, *Clerodendrum*, *Glycosmis*, *Lasianthus*, *Leea*, *Maesa*, *Psychotria*, *Strobilanthes* and *Viburnum*.

C4 *Tropical forests of Green Island and Orchid Island*

These forests occur on two islands located southeast of Taiwan. Dominant species are those of tropical distribution. Unlike in most forests in Taiwan, *Fagaceae* and *Lauraceae* are not dominant on these islands, being replaced by *Araliaceae*, *Meliaceae*, *Moraceae* and *Rubiaceae*.

C4A12 *Aglaia-Ficus* foothill evergreen broad-leaved forest

Altitude: 0–250 m; Warmth Index: NA.

Aglaia-Ficus foothill evergreen broad-leaved forest is a tropical forest in areas without a dry season. The canopy height is low because of the strong sea wind that occurs throughout the year. The mean canopy height is 10 m and mean canopy cover is 60%. Dominant trees are *Dysoxylum*, *Endiandra*, *Ficus*, *Ilex*, *Machilus*, *Michelia*, *Osmoxylon*, *Palaquium*, *Rhus*, *Schefflera*, *Semecarpus*, *Sterculia* and *Symplocos*. Dominant small-sized trees up to 5 m are *Aglaia*, *Ardisia*, *Astronia*, *Champereia*, *Dendrocnide*, *Eurya*, *Ficus*, *Garcinia*, *Leucosyke*, *Melicope*, *Murraya*, *Neolitsea*, *Syzygium*, *Timonius* and *Wendlandia*. Frequent shrubs are *Antidesma*, *Ardisia*, *Dracaena*, *Euonymus*, *Excoecaria*, *Ficus*, *Geniostema*, *Hydrangea*, *Leea*, *Maesa*, *Melastoma*, *Pittosporum*, *Psychotria*, *Tabernaemontana* and *Tarenna*.

C5 *Tropical mountain azonal forests*

Two types of tropical mountain azonal forests occur south of the N23.1° meridian. One of them occurs on the slopes facing the north-eastern monsoon in winter, and the other on shallow rocky soil. Tropical and Himalayan species are usually dominant. Common dominant families are *Ebenaceae*, *Euphorbiaceae* and *Fagaceae*. The coniferous species *Keteleeria davidiana* var. *formosana* dominates these forests in places, as opposed to tropical mountain zonal forests, which have no dominant coniferous trees. The vertical structure of azonal forests is not as distinct as that of the zonal forests due to frequent disturbances by wind, tide or landslides.

C5A13 *Illicium-Cyclobalanopsis* winter monsoon forest

Altitude: 0–1200 m; Warmth Index: 195–220°C.

Illicium-Cyclobalanopsis winter monsoon forest is an evergreen broad-leaved forest with a high density of individuals. It occurs in the southeastern part of Taiwan on the ridges or upper slopes. The mean canopy cover is 70% and mean canopy height is 9 m. There is no clear boundary between the tree and small-sized tree layers. Dominant genera are *Adinandra*, *Ardisia*, *Astronia*, *Beilschmiedia*, *Castanopsis*, *Cyclobalanopsis*, *Daphniphyllum*, *Dendropanax*, *Diospyros*, *Drypetes*, *Elaeocarpus*, *Engelhardia*, *Gordonia*, *Helicia*, *Ilex*, *Keteleeria*, *Lithocarpus*, *Litsea*, *Machilus*, *Magnolia*, *Myrsine*, *Osmanthus*, *Pasania*, *Prunus*, *Schefflera*, *Schima*, *Symplocos*, *Syzygium* and *Tricalysia*. Frequent shrubs are *Antidesma*, *Ardisia*, *Aucuba*, *Barthea*, *Callicarpa*, *Decaspermum*, *Euchresta*, *Euonymus*, *Eurya*, *Ficus*, *Hydrangea*, *Lasianthus*, *Melastoma*, *Microtropis*, *Psychotria*, *Rhaphiolepis*, *Symplocos*, *Tarenna*, *Viburnum* and *Wikstroemia*. The floristic composition mixes warmth-demanding and cold-adapted species because of hot summers at low altitudes, but cold winters caused by the north-eastern monsoon.

C5A14 *Diospyros-Champereia* rock-outcrop forest

Altitude: 0–900 m; Warmth Index: 200–255 °C.

This evergreen broad-leaved forest occurs on uplifted coral-reef tableland at an altitude of more than 50 m, on an uplifted coral reef right beside the seashore, and on stony soil or talus slopes in the tropical region of Taiwan. The ratio of deciduous species is higher than in the other tropical forest types. The mean canopy cover is 75% and mean canopy height is 10 m. Dominant trees are *Acacia*, *Acer*, *Aglaia*, *Bischofia*, *Calophyllum*, *Celtis*, *Cryptocarya*, *Cyclobalanopsis*, *Ficus*, *Fraxinus*, *Gordonia*, *Lagerstroemia*, *Machilus*, *Melanolepis*, *Palaquium*, *Planchonella*, *Sapindus* and *Schefflera*. Dominant small-sized trees up to 6 m in height are *Aphananthe*, *Ardisia*, *Champereia*, *Cinnamomum*, *Dendrocnide*, *Diospyros*, *Drypetes*, *Ficus*, *Gardenia*, *Glochidion*, *Litsea*, *Macaranga*, *Mallotus*, *Murraya*, *Scolopia*, *Styrax*, *Syzygium* and *Wendlandia*. Frequent shrubs are *Antidesma*, *Boehmeria*, *Breynia*, *Callicarpa*, *Clausena*, *Croton*, *Glycosmis*, *Ilex*, *Maesa*, *Maytenus*, *Psychotria*, *Severinia*, *Tarenna* and *Viburnum*. The coral reef at the sea shore is a habitat for *Barringtonia asiatica*, *Hernandia nymphiifolia*, *Pandanus odoratissimus* and *Planchonella obovata*, whose seeds can drift on the sea from the Philippines or southeastern Asia.

C6 *Subtropical mountain azonal woodlands and forests*

Five types of subtropical mountain azonal woodlands and forests occur in areas north of N22.4°. The effects of winter monsoon, rock outcrops and disturbance are the main factors that explain the differences between these forests. Himalayan species are most common, followed by endemic and tropical species. *Lauraceae*, *Fagaceae* and *Pinaceae* are dominant families. The deciduous families, *Betulaceae* and *Ulmaceae*, are more dominant than in subtropical mountain zonal forests. The vertical structure of azonal forests is not as clear as that of zonal forests, and the cover and numbers of species of epiphytes and lianas are also lower in azonal forests.

C6A15 *Pyrenaria-Machilus* winter monsoon forest

Altitude: 0–1200 m; Warmth Index: 165–220 °C.

This type occurs in the north-eastern part of Taiwan and is dominated by trees of *Castanopsis*, *Cleyera*, *Cyclobalanopsis*, *Dendropanax*, *Elaeocarpus*, *Engelhardia*, *Gordonia*, *Helicia*, *Ilex*, *Keteleeria*, *Limlia*, *Litsea*, *Machilus*, *Meliosma*, *Michelia*, *Pinus*, *Schefflera*, *Symplocos* and *Trochodendron* with a mean canopy cover of 80% and mean canopy height of 10 m. A strong north-easterly wind for more than four months a year makes the habitats colder and lack a dry season. This area has the highest frequency of clouds in Taiwan. The density of small-sized trees is very high. Their height is about 5 m and the dominant genera are *Adinandra*, *Ardisia*, *Blastus*, *Bretschneidera*, *Cyathea*, *Daphniphyllum*, *Diospyros*, *Eurya*, *Ficus*, *Hydrangea*, *Illicium*, *Itea*, *Mallotus*, *Myrsine*, *Prunus*, *Psychotria*, *Pyrenaria*, *Randia*, *Syzygium*, *Turpinia* and *Wendlandia*. Frequent shrubs are *Antidesma*, *Blastus*, *Callicarpa*, *Camellia*, *Clerodendrum*, *Cyathea*, *Eurya*, *Ficus*, *Hydrangea*, *Ilex*, *Lasianthus*, *Maesa*, *Melastoma*, *Psychotria*, *Sarcandra*, *Styrax* and *Viburnum*.

C6A16 *Zelkova-Quercus* rock-outcrop forest

Altitude: 0–1900 m; Warmth Index: 115–245 °C.

This forest has a variable physiognomy and environment. It occurs on limestone outcrops (e.g. coniferous scrub or evergreen broad-leaved forests dominated by *Juniperus* or *Quercus*), scree slopes (e.g. mixed forests or semi-deciduous broad-leaved forests dominated by *Calocedrus*, *Carpinus*, *Cycas*, *Pinus*, *Pseudotsuga* and *Quercus*), steep slopes with shallow and rocky soil (e.g. the evergreen broad-leaved forests or semi-deciduous broad-leaved forests dominated by *Carpinus*, *Cinnamomum*, *Cyclobalanopsis*, *Liquidambar*, *Quercus*, *Ulmus* or *Zelkova*) and on gravel sediment on the wide fluvial terraces (e.g. the evergreen broad-leaved forests or semi-deciduous broad-leaved forests dominated by *Acer*, *Fraxinus* or *Machilus*). The canopy cover is 60−80% and the canopy height 6−25 m. The common feature of the forests within this group is a similar floristic composition within the category of small-sized trees and shrubs. Small-sized trees up to 2−8 m are *Ardisia*, *Bridelia*, *Daphniphyllum*, *Diospyros*, *Eriobotrya*, *Ficus*, *Gardenia*, *Glochidion*, *Ilex*, *Itea*, *Litsea*, *Mallotus*, *Morus*, *Murraya*, *Oreocnide*, *Osmanthus*, *Prunus*, *Rhododendron*, *Rhus*, *Styrax*, *Syzygium*, *Tetradium*, *Tricalysia*, *Turpinia*, *Vitex* and *Wendlandia*. Frequent shrubs are *Ardisia*, *Callicarpa*, *Deutzia*, *Eurya*, *Ficus*, *Glycosmis*, *Hydrangea*, *Maesa*, *Murraya*, *Pittosporum*, *Psychotria*, *Rhododendron*, *Styrax* and *Viburnum*. Except for the trees mentioned above, other common accompanying trees are *Alnus*, *Archidendron*, *Beilschmiedia*, *Celtis*, *Elaeocarpus*, *Engelhardia*, *Gordonia*, *Lagerstroemia*, *Litsea*, *Michelia*, *Neolitsea*, *Pasania*, *Rhus*, *Sapindus*, *Sapium*, *Schefflera* and *Trema*.

C6A17 *Pinus* successional woodland

Altitude: 1900–3600 m; Warmth Index: 45–130 °C.

This coniferous or mixed woodland mainly dominated by *Pinus taiwanensis* occurs in warm and dry habitats such as south-facing slopes at high altitudes or at post-fire sites. The mean canopy height is 12 m with a mean cover of 60%. Other dominant trees are *Abies*, *Alnus*, *Cyclobalanopsis*, *Pasania*, *Quercus* and *Tsuga*. A small-sized tree layer is not obvious. Frequent small-sized trees and shrubs are *Eurya*, *Juniperus*, *Lindera*, *Lyonia*, *Photinia*, *Pieris* and *Rhododendron*, accompanied by *Yushania* bamboo.

C6A18 *Alnus* successional woodland

Altitude: 200–3100 m; Warmth Index: 60–200 °C.

Alnus successional woodland, mainly dominated by *Alnus formosana*, occurs on landslides. On north-facing slopes, landslides are usually covered by deciduous woodland, whereas on the south-facing slopes, deciduous trees are mixed with species from *Pinus* successional woodland. The mean canopy height and cover are 15 m and 70%, respectively. Other dominant trees are *Acer*, *Alnus*, *Aralia*, *Chamaecyparis*, *Fraxinus*, *Juglans*, *Lagerstroemia*, *Pinus*, *Quercus* and *Rhus*. A small-sized tree layer is not obvious. Frequent small-sized trees and shrubs are *Boehmeria*, *Callicarpa*, *Debregeasia*, *Deutzia*, *Eurya*, *Fatsia*, *Ficus*, *Glochidion*, *Itea*, *Oreocnide*, *Rubus*, *Stachyurus* and *Turpinia*. The *Pinus* successional woodland differs from the *Alnus* successional woodland in that the former has a more acid soil and the common accompanying species are from *Ericaceae*, *Pinaceae* and *Theaceae*.

C6A19 *Trema-Mallotus* successional woodland

Altitude: 0–800 m; Warmth Index: 180–235 °C.

This is semi-deciduous or evergreen woodland at low altitudes, occurring on forest edges, abandoned agricultural land, abandoned construction sites, reforested land or badlands, the latter being dominated by *Pinus massoniana* or *Bambusa stenostachya*. The mean canopy height is 12 m with a mean canopy cover of 70%. Dominant trees and small-sized trees are *Acacia*, *Aleurites*, *Broussonetia*, *Cyathea*, *Euphoria*, *Ficus*, *Lagerstroemia*, *Macaranga*, *Machilus*, *Mallotus*, *Pinus*, *Rhus*, *Schefflera*, *Trema* and *Zanthoxylum*. Frequent small-sized trees and shrubs are *Ardisia*, *Bridelia*, *Callicarpa*, *Clerodendrum*, *Cyathea*, *Diospyros*, *Dodonaea*, *Eurya*, *Ficus*, *Gardenia*, *Glochidion*, *Lantana*, *Litsea*, *Maesa*, *Melastoma*, *Morus*, *Murraya*, *Oreocnide*, *Psychotria*, *Saurauia*, *Styrax*, *Turpinia* and *Wendlandia*. As in other successional woodlands in

Taiwan, the species number in this woodland is usually low. The similarity among plots assigned to this woodland is lower than in other successional woodlands because few woody species are common to most sites.

C7 *Seashore woodlands and mangroves*

There are two kinds of evergreen seashore broad-leaved forests. One is found on sand dunes or rock outcrops overlaid by sand, and the other is mangrove occurring on clayey soil in the intertidal zone such as in river deltas. Few plots of these woodlands and mangroves are available, because the pristine seashore woodlands or mangroves have been mostly destroyed. *Goodeniaceae* and *Malvaceae* are dominant families and tropical species prevail. Compared to other woody vegetation types, seashore woodlands and mangroves have a high cover of widespread and naturalized species, whereas endemic species are the least represented among all vegetation types dealt with in this paper. This indicates that the seashore habitats are open to most species which can tolerate windy and saline environment.

C7A20 *Scaevola-Hibiscus* seashore woodland

Altitude: 0–50 m; Warmth Index: NA.

Scaevola-Hibiscus seashore woodland is a 5-m-tall evergreen broad-leaved woodland. It occurs along the seashore except on the uplifted coral reef at the seashore in the southern Heng-Chung peninsula, where it is replaced by *Diospyros-Champereia* rock-outcrop forest. Its mean canopy cover is 80%. There are only two layers: woody layer and herb layer. The dominant and frequent woody plants are *Acacia*, *Breynia*, *Dodonaea*, *Ficus*, *Glochidion*, *Hibiscus*, *Lagerstroemia*, *Leucaena*, *Macaranga*, *Maytenus*, *Morinda*, *Pandanus*, *Premna*, *Rhus*, *Scaevola*, *Terminalia* and *Vitex*.

C7A21 *Kandelia* mangrove

Altitude: 0–5 m; Warmth Index: NA.

In Taiwan, four species form mangroves in the deltas: *Avicennia marina*, *Kandelia obovata*, *Lumnitzera racemosa* and *Rhizophora mucronata*. Nowadays, very few mangrove sites remain, most of them being monodominant stands of *A. marina* or *K. obovata*, which also commonly grow together. Mangroves have a single vegetation layer, reaching about 5 m in height and with a canopy cover of about 80%.

Table 1. Diagnostic species of 21 forest vegetation types. Values are the percentage constancy and species are sorted by decreasing fidelity (Φ). Dark grey and light grey shading indicate Φ>0.40 and Φ>0.20, respectively. Only species with a constancy greater than 10% are listed; exceptions are vegetation types 15, 16 & 20, for which species with >20% constancy are listed, types 4, 9 & 14, for which species with >30% are listed, and types 12 & 13 for which only species with constancy >40% are listed. The reason for using different criteria is differences in species richness among vegetation types. From the species which are diagnostic for more than one vegetation type, only those having a constancy >30% in all vegetation types for which the species is diagnostic are listed. The complete version of this table is available in Appendix S3. 1 = *Juniperus* subalpine coniferous woodland and scrub; 2 = *Abies-Tsuga* upper-montane coniferous forest; 3 = *Chamaecyparis* montane mixed cloud forest; 4 = *Fagus* montane deciduous broad-leaved cloud forest; 5 = *Quercus* montane evergreen broad-leaved cloud forest; 6 = *Machilus-Castanopsis* sub-montane evergreen broad-leaved forest; 7 = *Phoebe-Machilus* sub-montane evergreen broad-leaved forest; 8 = *Ficus-Machilus* foothill evergreen broad-leaved forest; 9 = *Pasania-Elaeocarpus* montane evergreen broad-leaved cloud forest; 10 = *Drypetes-Helicia* sub-montane evergreen broad-leaved forest; 11 = *Dysoxylum-Machilus* foothill evergreen broad-leaved forest; 12 = *Aglaia-Ficus* foothill evergreen broad-leaved forest; 13 = *Illicium-Cyclobalanopsis* winter monsoon forest; 14 = *Diospyros-Champereia* rock-outcrop forest; 15 = *Pyrenaria-Machilus* winter monsoon forest; 16 = *Zelkova-Quercus* rock-outcrop forest; 17 = *Pinus* successional woodland; 18 = *Alnus* successional woodland; 19 = *Trema-Mallotus* successional woodland; 20 = *Scaevola-Hibiscus* seashore woodland; 21 = *Kandelia* mangrove. C1 = High-mountain coniferous woodlands and forests; C2 = Subtropical mountain zonal forests; C3 = Tropical mountain zonal forests; C4 = Tropical forests of Green Island and Orchid Island; C5 = Tropical mountain azonal forests, C6 = Subtropical mountain azonal woodlands and forests, C7 = Seashore woodlands and mangroves.

Forest vegetation type	C1		C2						C3			C4	C5		C6					C7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of plots	135	303	576	136	1195	486	490	152	73	633	43	41	88	200	697	638	172	106	314	82	14
Juniperus squamata	96	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.
Berberis morrisonensis	50	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Gaultheria itoana	25	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Rosa sericea var. *morrisonensis*	19	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lonicera kawakamii	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rubus taitoensis var. *aculeatiflorus*	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ilex bioritsensis	.	11	3	.	1	1	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.
Viburnum betulifolium	.	11	2	.	2	1	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.
Sorbus randaiensis	4	10	2	.	1	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Cyclobalanopsis morii	.	1	56	1	11	1	.	.	4	1	.	.	5	.	1	1	.	1	.	.	.
Schefflera taiwaniana	.	8	31	1	1	1	.	.	.	1	.	.	.	.	1	1	2	1	.	.	.
Chamaecyparis formosensis	.	3	36	6	11	3	1	.	.	1	.	.	.	.	1	1	5	11	.	.	.
Chamaecyparis obtusa var. *formosana*	.	3	22	6	1	.	1	.	.	.	.	.	.	.	1	1	1	2	.	.	.
Ilex tugitakayamensis	.	.	23	8	3	1	1	.	7	.	.	.	.	.	.	1	.	.	.	.	.

Forest vegetation type	C1		C2						C3			C4	C5		C6					C7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of plots	135	303	576	136	1195	486	490	152	73	633	43	41	88	200	697	638	172	106	314	82	14
Fagus hayatae	.	.	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pourthiaea villosa var. *parvifolia*	.	.	1	71	1	1	1	.	.	1	.	.	.	1	11	1	1	.	1	.	.
Viburnum sympodiale	.	2	12	57	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Osmanthus heterophyllus	.	12	10	51	2	3	.	.	.	1	.	.	.	.	4	2	.	.	1	.	.
Eurya crenatifolia	.	3	19	55	5	1	1	.	3	.	.	.	.	.	11	1	5	3	.	.	.
Symplocos caudata	.	.	5	51	2	2	2	.	15	1	.	.	3	1	12	1	.	.	.	.	.
Camellia tenuifolia	.	.	7	44	3	4	1	.	1	1	.	.	1	.	16	1	.	.	1	.	.
Daphniphyllum himalaense subsp. *macropodum*	.	1	13	43	9	1	1	.	1	.	.	.	.	.	5	3	.	.	1	.	.
Camellia brevistyla	.	.	8	40	3	1	2	.	8	4	.	.	19	.	7	1	.	.	3	.	.
Litsea elongata var. *mushaensis*	.	1	17	32	9	1	1	.	.	1	.	.	.	.	3	5	.	5	.	.	.
Pasania kawakamii	.	.	10	4	61	11	11	5	15	9	9	.	1	.	3	10	1	2	1	.	.
Cyclobalanopsis stenophylloides	.	6	26	6	40	8	3	.	5	2	.	.	1	.	2	15	9	6	1	.	.
Neolitsea sericea	.	.	1	1	11	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Lithocarpus lepidocarpus	.	.	4	.	18	5	6	1	.	2	.	.	.	.	1	2	.	1	.	.	.
Machilus zuihoensis var. *mushaensis*	.	.	1	.	16	5	4	.	.	.	.	.	.	1	1	4	.	2	.	.	.
Symplocos formosana	.	1	4	1	11	2	1	.	.	1	.	.	.	.	1	1	.	.	.	.	.
Osmanthus matsumuranus	.	.	3	2	37	30	7	1	34	21	.	.	25	2	19	12	.	.	1	.	.
Euonymus laxiflorus	.	.	.	.	1	16	1	.	.	.	.	.	.	.	6	1	.	.	1	.	.
Cinnamomum subavenium	.	.	5	2	29	37	2	.	5	18	.	.	25	1	11	7	1	.	1	.	.
Castanopsis fargesii	.	.	.	.	1	13	1	.	.	1	.	.	.	.	.	5	1	.	1	.	.
Cryptocarya chinensis	.	.	.	.	1	30	20	14	4	19	5	.	8	2	24	7	.	1	6	.	.
Turpinia formosana	.	.	1	.	19	25	66	17	5	18	5	.	8	6	25	29	.	4	15	.	.
Saurauia tristyla var. *oldhamii*	.	.	.	.	1	10	47	30	4	21	19	2	19	4	16	9	.	1	28	2	.
Phoebe formosana	.	.	1	.	3	3	17	5	.	1	5	.	.	2	1	7	.	1	2	.	.
Boehmeria wattersii	.	.	.	.	.	.	1	28	.	2	2	.	.	18	1	6	.	1	3	.	.
Ficus nervosa	.	.	.	.	.	1	8	30	.	8	16	.	.	10	3	8	.	.	9	.	.
Celtis formosana	.	.	1	.	2	1	17	41	.	12	28	.	.	26	1	31	.	3	9	.	.
Ficus fistulosa	.	.	.	.	1	7	39	53	5	29	42	20	30	6	21	7	.	3	32	.	.
Neolitsea konishii	.	.	1	.	2	8	26	31	.	6	19	.	.	8	2	20	.	1	5	.	.
Radermachia sinica	.	.	.	.	.	1	5	20	.	5	14	.	.	10	1	6	.	1	4	.	.
Celtis sinensis	.	.	.	.	1	1	4	18	.	2	2	.	.	9	1	10	.	2	11	.	.
Pasania dodoniifolia	.	.	.	.	1	.	.	.	48	2	.	.	1	.	.	.	.	.	.	.	.
Barthea barthei	.	.	16	.	6	1	1	.	64	3	.	.	10	.	2	1	.	.	.	.	.

Forest vegetation type	C1		C2						C3			C4	C5		C6					C7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of plots	135	303	576	136	1195	486	490	152	73	633	43	41	88	200	697	638	172	106	314	82	14
Cyathea loheri	.	.	.	.	.	.	.	.	41	1	.	.	.	.	.	.	.	.	.	.	.
Litsea lii	.	.	1	.	3	1	1	.	37	5	.	.	1	1	.	1	.	.	.	.	.
Pasania cornea	.	.	1	.	3	4	2	.	37	10	2	.	.	2	.	1	.	.	.	.	.
Castanopsis kusanoi	.	.	.	.	1	1	1	.	23	3	.	.	.	.	.	.	.	.	.	.	.
Ternstroemia gymnanthera	.	.	27	29	31	20	1	.	73	12	.	.	38	.	8	7	.	1	.	.	.
Itea parviflora	.	.	6	4	26	33	24	9	77	34	5	.	19	8	32	21	1	16	8	.	.
Ilex goshiensis	.	1	29	13	19	13	.	.	51	10	.	.	19	1	8	5	1	1	.	.	.
Rhododendron formosanum	.	2	24	26	5	2	.	.	40	1	.	.	15	.	1	2	2	.	.	.	.
Cleyera japonica var. *morii*	.	.	5	.	5	5	12	5	37	7	.	.	.	1	24	5	.	.	2	.	.
Pourthiaea beauverdiana var. *notabilis*	.	.	6	1	18	3	1	1	30	2	2	.	.	1	5	3	.	1	1	.	.
Lasianthus fordii	.	.	1	.	8	32	17	5	47	26	.	.	28	1	35	5	.	.	4	.	.
Prunus phaeosticta	.	1	20	15	46	49	17	.	63	39	.	.	48	2	48	14	.	3	3	.	.
Beilschmiedia erythrophloia	.	.	1	.	30	44	23	30	25	74	37	.	47	23	3	30	.	2	1	1	.
Sloanea formosana	.	.	.	.	8	21	15	5	7	49	30	.	32	4	7	6	.	.	1	.	.
Viburnum odoratissimum	.	.	1	.	4	3	7	1	3	32	21	.	10	17	.	2	1	1	.	.	.
Reevesia formosana	.	.	.	.	.	1	.	1	.	21	12	.	10	10	.	1	.	.	1	.	.
Amentotaxus formosana	.	.	.	.	.	.	.	.	1	12	.	.	6	.	.	.	.	.	.	.	.
Lasianthus hiiranensis	.	.	.	.	.	.	.	.	.	1	12	.	.	1	.	.	.	.	.	.	.
Melicope semecarpifolia	.	.	.	.	1	1	5	9	.	15	33	.	13	13	3	2	.	1	4	2	.
Strobilanthes longespicatus	.	.	.	.	.	.	1	8	.	3	16	.	.	1	.	1	.	1	1	.	.
Neonauclea reticulata	.	.	.	.	.	.	.	2	.	1	14	7	2	8	.	.	.	1	1	.	.
Leea philippinensis	.	.	.	.	.	.	.	1	.	.	.	66	.	.	.	.	.	.	.	.	.
Ilex kusanoi	.	.	.	.	.	.	.	.	.	.	.	56	.	.	.	.	.	.	.	.	.
Excoecaria kawakamii	.	.	.	.	.	.	.	.	.	.	.	51	.	.	.	.	.	.	.	.	.
Timonius arboreus	.	.	.	.	.	1	.	.	.	.	.	51	.	.	.	.	.	.	.	.	.
Leucosyke quadrinervia	.	.	.	.	.	.	.	.	.	.	.	49	.	.	.	.	.	.	.	.	.
Osmoxylon pectinatum	.	.	.	.	.	.	.	.	.	.	.	46	.	.	.	.	.	.	.	.	.
Ficus fistulosa f. benguetensis	.	.	.	.	1	1	1	.	.	1	.	46	.	.	.	.	.	.	1	.	.
Tarenna zeylanica	.	.	.	.	.	.	.	.	.	1	.	46	6	1	1	.	.	.	.	.	.
Ficus benjamina	.	.	.	.	.	1	.	8	.	3	28	66	1	25	.	1	.	2	1	2	.
Ficus ampelas	.	.	.	.	.	1	6	20	.	1	21	66	.	15	2	2	.	.	6	1	.
Ardisia sieboldii	.	.	1	.	3	36	55	64	11	66	63	78	57	48	69	32	2	4	33	2	.
Symplocos shilanensis	.	.	1	.	.	.	.	.	.	5	.	.	48	1	.	.	.	.	.	.	.
Osmanthus marginatus	.	.	1	.	1	4	2	3	27	27	2	.	81	5	1	4	.	.	.	.	.

Forest vegetation type	C1		C2						C3			C4	C5		C6					C7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of plots	135	303	576	136	1195	486	490	152	73	633	43	41	88	200	697	638	172	106	314	82	14
Magnolia kachirachirai	.	.	.	.	1	2	.	.	8	12	.	.	56	.	.	1	.	.	.	.	.
Ilex lonicerifolia var. *matsudai*	.	.	2	.	1	1	.	.	1	3	.	.	45	.	1	1	.	.	.	.	.
Ilex maximowicziana	.	1	.	.	1	1	.	.	19	19	.	.	64	.	9	1	.	.	.	.	.
Neolitsea buisanensis	.	.	.	.	.	.	.	.	4	4	.	.	40	1	.	.	.	.	.	.	.
Garcinia multiflora	.	.	.	.	.	1	1	.	3	17	2	22	50	3	.	1	.	.	.	.	.
Astronia formosana	.	.	.	.	1	1	.	.	5	13	5	20	47	1	.	.	.	.	.	.	.
Melastoma candidum	.	.	.	.	1	1	3	1	8	5	.	.	43	1	15	4	.	1	16	.	.
Lithocarpus amygdalifolius	.	.	11	.	20	16	1	.	27	11	.	.	45	.	.	4	.	1	.	.	.
Ardisia quinquegona	.	.	.	.	4	20	12	6	1	23	12	.	45	6	30	11	.	.	4	.	.
Gordonia axillaris	.	.	17	.	25	19	4	1	15	29	2	.	55	8	23	26	7	4	8	.	.
Ficus formosana	.	.	.	.	2	14	25	8	12	23	5	.	41	2	30	11	.	.	12	.	.
Elaeocarpus sylvestris	.	.	3	1	23	35	20	18	12	37	5	.	55	17	32	40	4	2	11	.	.
Aglaia formosana	.	.	.	.	.	.	.	.	.	1	2	.	.	58	.	1	.	.	1	5	.
Drypetes littoralis	.	.	.	.	.	1	.	1	.	.	.	10	.	34	.	1	.	.	.	.	.
Cryptocarya concinna	.	.	.	.	.	1	4	5	1	12	21	.	7	39	4	2	.	.	2	.	.
Macaranga tanarius	.	.	.	.	.	.	2	24	.	1	30	10	.	38	1	4	1	7	22	30	.
Syzygium formosanum	.	.	1	.	2	13	3	7	3	17	12	.	31	36	6	28	1	.	3	1	.
Itea oldhamii	.	.	.	.	1	1	3	.	.	.	.	.	.	.	38	1	.	.	4	.	.
Randia cochinchinensis	.	.	.	.	1	11	9	1	.	1	.	.	2	1	43	6	2	.	5	.	.
Antidesma japonicum var. *densiflorum*	.	.	.	.	1	2	2	.	.	.	.	.	15	.	27	1	.	.	1	.	.
Pyrenaria shinkoensis	.	.	3	1	3	6	3	.	.	1	.	.	.	.	26	1	.	.	1	.	.
Wendlandia formosana	.	.	.	.	1	9	35	14	7	22	9	.	23	6	59	11	.	1	25	.	.
Myrica rubra	.	.	1	4	1	4	2	.	5	.	.	.	.	.	25	5	2	.	2	.	.
Castanopsis cuspidata var. *carlesii* f. *sessilis*	.	.	.	.	.	5	4	.	15	1	.	.	11	.	24	3	.	.	2	.	.
Ilex asprella	.	.	1	.	1	3	7	11	.	4	5	.	2	13	27	8	.	3	7	4	.
Ilex ficoidea	.	.	2	.	15	15	8	5	7	13	.	.	1	.	27	10	.	1	.	.	.
Cyclobalanopsis glauca	.	.	2	.	1	8	9	7	11	5	.	.	9	13	21	61	3	4	3	.	.
Zelkova serrata	.	.	.	.	1	1	1	3	.	1	.	.	.	11	.	35	.	.	4	.	.
Carpinus kawakamii	.	1	2	.	2	1	1	.	1	1	.	.	.	3	.	22	2	11	1	.	.
Acer albopurpurascens	.	.	1	.	4	6	4	11	1	11	16	.	2	19	1	32	.	5	3	.	.
Styrax suberifolia	.	.	.	.	1	15	9	18	.	6	9	.	18	16	16	35	.	2	5	1	.
Fraxinus griffithii	.	.	.	.	1	2	3	9	1	5	7	.	1	17	1	22	.	8	5	1	.
Pinus taiwanensis	1	8	8	.	1	1	1	.	.	.	.	.	.	.	1	14	97	20	1	.	.

Forest vegetation type	C1		C2						C3			C4	C5		C6					C7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of plots	135	303	576	136	1195	486	490	152	73	633	43	41	88	200	697	638	172	106	314	82	14
Rhododendron rubropilosum	4	17	8	.	1	1	.	.	1	1	.	.	7	.	1	4	56	7	.	.	.
Pieris taiwanensis	4	14	10	12	1	.	1	.	.	.	.	.	.	.	2	1	41	1	1	.	.
Pinus armandii var. *mastersiana*	.	17	7	.	1	.	.	.	.	.	.	.	.	.	.	1	35	5	.	.	.
Juniperus formosana	13	7	.	.	.	.	.	.	.	.	.	.	.	.	.	1	30	.	.	.	.
Quercus spinosa	.	3	1	.	1	.	.	.	.	.	.	.	.	.	.	1	16	3	.	.	.
Alnus formosana	.	1	7	.	5	2	2	.	.	1	.	.	.	1	1	11	9	88	3	.	.
Deutzia pulchra	.	2	2	.	1	1	2	3	.	1	.	.	.	3	1	12	3	70	6	1	.
Debregeasia orientalis	.	.	1	.	1	1	2	2	1	1	.	.	.	1	1	2	.	41	9	.	.
Stachyurus himalaicus	.	1	3	.	1	.	2	2	.	.	.	.	.	.	.	3	.	28	4	.	.
Aralia bipinnata	.	1	1	.	1	1	2	.	.	1	.	.	.	.	1	2	1	19	3	.	.
Rubus formosensis	.	1	1	.	1	.	.	.	.	.	.	.	.	.	1	1	.	10	1	.	.
Ulmus uyematsui	.	1	1	.	2	.	1	.	.	.	.	.	.	.	.	2	1	10	1	.	.
Acer morrisonense	.	4	18	4	8	1	.	.	.	.	.	.	.	.	1	6	8	21	.	.	.
Boehmeria densiflora	.	.	.	.	1	1	2	1	.	1	2	.	.	1	1	2	.	14	7	7	.
Mallotus japonicus	.	.	1	.	1	7	17	8	.	2	.	.	1	5	16	14	3	8	48	1	.
Acacia confusa	.	.	.	.	.	1	4	.	.	3	2	5	.	11	4	2	.	.	31	4	.
Trema orientalis	.	.	.	.	1	3	7	17	.	4	21	.	.	9	1	10	.	4	43	6	.
Morus australis	.	.	.	.	2	1	14	28	.	1	23	.	.	15	4	18	.	6	45	10	.
Mallotus paniculatus	.	.	.	.	1	19	23	34	1	18	23	.	14	20	24	26	6	8	48	.	.
Cyathea lepifera	.	.	.	.	1	5	17	11	5	9	2	12	9	4	14	3	.	3	30	.	.
Scaevola taccada	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	72	.
Pandanus odoratissimus	.	.	.	.	.	.	.	.	.	.	2	2	.	4	.	.	.	.	.	38	.
Hibiscus tiliaceus	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	33	.
Premna serratifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	1	.	.	.	20	.
Maytenus diversifolia	.	.	.	.	.	.	.	.	.	.	.	.	1	12	.	1	.	.	.	24	.
Rhus javanica var. *roxburghiana*	.	.	.	.	1	1	2	4	.	1	5	.	.	7	.	5	1	16	18	23	.
Leucaena leucocephala	.	.	.	.	.	.	.	1	.	.	2	17	.	10	.	1	.	3	7	20	.
Kandelia obovata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	64
Avicennia marina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29
Lumnitzera racemosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14
Pluchea indica	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1	.	.	1	.	14
Clerodendrum inerme	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	14
Rhododendron pseudochrysanthum	59	33	14	16	1	1	.	.	1	.	.	.	.	.	1	1	13	.	.	.	.
Abies kawakamii	39	54	1	.	1	.	.	.	.	.	.	.	.	.	.	.	12	.	.	.	.

Forest vegetation type	C1		C2						C3			C4	C5		C6					C7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of plots	135	303	576	136	1195	486	490	152	73	633	43	41	88	200	697	638	172	106	314	82	14
Neolitsea acuminatissima	.	7	91	83	25	4	.	.	12	1	.	.	.	.	3	2	2	7	.	.	.
Symplocos morrisonicola	.	4	54	5	16	10	.	.	41	13	.	.	10	.	1	2	3	.	1	.	.
Trochodendron aralioides	.	4	61	34	13	1	1	.	71	2	.	.	7	.	10	2	1	5	.	.	.
Symplocos arisanensis	.	1	31	30	15	3	1	.	.	2	.	.	.	.	1	1	.	.	.	.	.
Microtropis fokienensis	.	2	42	16	12	5	1	.	30	13	.	.	23	.	1	3	1	1	.	.	.
Rhododendron leptosanthum	.	1	45	8	36	13	2	.	18	5	.	.	20	.	19	12	2	7	1	.	.
Cyclobalanopsis sessilifolia	.	.	30	58	9	2	1	.	42	1	.	.	.	.	23	4	1	.	.	.	.
Cleyera japonica	.	.	22	41	15	14	7	1	45	9	.	.	27	1	15	4	.	3	2	.	.
Machilus japonica	.	.	13	3	68	15	14	2	68	20	.	.	2	3	6	10	.	7	3	.	.
Michelia compressa	.	.	18	6	58	54	27	11	23	36	30	10	36	12	40	25	.	4	4	.	.
Neolitsea aciculata var. *variabillima*	.	1	12	13	31	30	4	.	27	9	.	.	.	.	8	5	1	.	.	.	.
Pasania harlandii	.	1	2	.	17	54	9	2	12	33	2	.	45	.	14	12	.	1	1	.	.
Tricalysia dubia	.	.	1	.	16	59	10	1	32	45	9	.	75	10	28	32	2	1	4	.	.
Diospyros morrisiana	.	.	1	.	3	41	15	1	.	15	.	.	20	.	71	20	6	.	9	.	.
Ilex formosana	.	.	5	1	16	31	16	1	5	9	.	.	1	.	41	11	.	.	1	.	.
Oreocnide pedunculata	.	.	.	.	17	13	69	64	8	14	5	.	1	8	15	26	.	36	34	.	.
Ficus erecta var. *beecheyana*	.	.	.	.	4	11	53	9	.	8	2	.	.	8	41	25	1	10	30	.	.
Ficus irisana	.	.	.	.	.	1	6	76	.	2	40	.	.	19	1	7	.	2	11	.	.
Sapindus mukorossii	.	.	.	.	1	2	7	41	.	3	12	.	.	45	1	20	1	2	9	1	.
Murraya paniculata	.	.	.	.	.	.	2	38	.	2	12	.	.	56	1	17	.	.	11	11	.
Lagerstroemia subcostata	.	.	1	.	2	9	46	55	.	14	33	.	.	58	9	36	.	15	34	15	.
Melanolepis multiglandulosa	.	.	.	.	.	.	1	30	.	2	19	12	.	38	.	2	.	2	7	5	.
Ficus septica	.	.	.	.	.	2	9	45	.	12	35	59	.	37	2	5	.	2	27	15	.
Bridelia balansae	.	.	.	.	.	1	15	38	.	12	35	.	18	15	22	13	1	1	18	.	.
Mallotus philippensis	.	.	.	.	.	3	9	30	.	6	19	.	.	42	2	23	1	.	3	.	.
Ilex uraiensis	.	.	1	1	1	1	1	.	75	39	14	.	90	6	9	1	.	.	.	.	.
Elaeocarpus japonicus	.	.	27	14	43	48	9	.	84	30	.	.	30	1	51	19	2	1	4	.	.
Helicia rengetiensis	.	.	1	.	2	8	1	.	44	16	.	.	38	1	1	1	.	.	.	.	.
Cinnamomum insularimontanum	.	1	1	.	11	4	3	3	48	8	.	.	3	10	2	28	2	6	3	.	.
Ardisia cornudentata	.	.	.	.	2	2	1	.	52	15	.	22	40	7	3	8	2	3	1	1	.
Illicium arborescens	.	1	5	22	13	20	3	.	59	17	.	.	66	.	10	3	.	.	.	.	.
Cyclobalanopsis championii	.	.	.	.	.	.	.	.	38	12	.	.	58	.	.	.	.	.	.	.	.
Symplocos congesta	.	.	3	.	7	13	1	.	40	16	.	.	59	.	1	1	.	.	.	.	.
Helicia formosana	.	.	.	.	2	37	31	3	48	66	14	.	36	2	31	6	.	.	9	.	.

Forest vegetation type	C1		C2						C3			C4	C5		C6					C7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of plots	135	303	576	136	1195	486	490	152	73	633	43	41	88	200	697	638	172	106	314	82	14
Hydrangea chinensis	.	.	9	1	17	19	19	11	45	39	.	29	48	3	9	20	1	5	7	.	.
Drypetes karapinensis	.	.	.	.	1	2	3	1	8	55	42	.	26	12	.	.	.	1	2	.	.
Dysoxylum hongkongense	.	.	.	.	1	1	1	2	1	32	58	.	3	3	.	1	.	.	1	.	.
Euonymus tashiroi	.	.	1	.	2	10	2	.	29	38	.	.	65	1	2	2	.	1	.	.	.
Turpinia ternata	.	.	.	.	4	21	21	38	10	46	51	10	18	4	4	6	.	10	11	.	.
Daphniphyllum glaucescens subsp. *oldhamii*	.	1	5	18	8	28	9	1	18	43	.	.	80	2	39	10	1	1	2	.	.
Aglaia elliptifolia	.	.	.	.	.	.	.	.	.	3	40	73	.	11	.	.	.	.	.	2	.
Champereia manillana	.	.	.	.	.	.	1	1	.	5	21	59	3	90	.	2	.	.	1	9	.
Planchonella obovata	.	.	.	.	.	.	.	.	.	.	2	34	.	34	.	.	.	.	.	2	.
Archidendron lucidum	.	.	.	.	1	12	12	5	.	21	14	.	42	3	32	10	1	.	11	.	.
Syzygium buxifolium	.	.	1	7	4	19	2	2	4	8	.	.	39	1	41	10	2	.	1	.	.
Diospyros eriantha	.	.	.	.	1	7	16	40	.	25	33	.	58	71	20	28	.	2	11	2	.
Adinandra formosana	.	.	9	5	10	15	4	.	29	30	2	.	47	.	42	10	5	1	5	.	.
Glochidion rubrum	.	.	1	.	2	16	26	9	7	37	14	5	52	35	28	56	3	10	31	26	.
Tsuga chinensis var. *formosana*	5	80	49	3	3	.	.	.	.	.	.	.	.	.	.	2	41	3	.	.	.
Eurya glaberrima	.	45	36	46	3	1	1	.	1	.	.	.	.	.	1	2	19	3	.	.	.
Eurya loquaiana	.	1	58	8	60	31	12	1	59	18	.	.	9	2	32	12	3	17	5	.	.
Dendropanax dentiger	.	1	53	72	26	13	2	.	97	10	.	.	25	.	33	5	1	2	.	.	.
Litsea acuminata	.	.	23	15	91	83	28	4	73	31	.	.	9	2	39	32	5	9	5	.	.
Cyclobalanopsis longinux	.	.	21	33	39	52	6	.	55	38	2	.	75	.	24	8	.	.	1	.	.
Machilus thunbergii	.	.	26	21	52	72	37	5	68	51	7	63	83	8	93	20	.	6	24	.	.
Machilus japonica var. *kusanoi*	.	.	.	.	2	17	71	74	1	32	74	.	5	33	19	25	.	5	32	.	.
Bischofia javanica	.	.	.	.	.	1	6	58	.	6	49	5	.	34	1	7	.	1	6	.	.
Dendrocnide meyeniana	.	.	.	.	1	1	3	63	.	10	79	.	.	38	.	2	.	2	7	5	.
Glycosmis citrifolia	.	.	.	.	1	3	13	47	.	29	70	.	3	42	2	24	.	.	4	.	.
Myrsine seguinii	.	.	1	.	2	9	6	.	55	9	.	.	61	.	64	6	.	.	1	.	.
Schima superba var. *kankaoensis*	.	.	1	.	2	5	1	1	38	42	2	.	63	6	.	1	.	.	.	.	.
Litsea acutivena	.	.	1	.	2	9	3	2	45	74	.	.	86	2	1	1	.	.	2	.	.
Psychotria rubra	.	.	.	.	1	37	46	59	23	78	67	5	90	33	56	39	4	2	35	.	.
Schefflera octophylla	.	1	2	.	7	76	75	68	37	87	77	85	90	27	77	51	2	8	53	.	.
Yushania niitakayamensis	46	59	35	44	6	1	.	.	11	.	.	.	.	.	1	1	41	6	.	.	.
Castanopsis cuspidata var. *carlesii*	.	1	39	.	60	51	7	2	49	40	.	.	56	1	24	4	.	2	2	.	.
Engelhardia roxburghiana	.	.	1	.	16	88	16	5	53	61	.	.	74	3	32	24	1	.	2	.	.

DISCUSSION

Historical and geographical context of the current classification scheme

Our classification is consistent with the traditional scheme of altitudinal vegetation zones of Taiwan, recognized mainly on the basis of stand physiognomy (Su 1984), with the only exception being the modified position of the montane coniferous forests. Su (1984) assigned *Juniperus* woodland and scrub and *Abies* forest to the subalpine zone, and *Tsuga* and *Picea* forests to the upper-montane zone. In contrast, we show that monodominant stands of *Abies* and *Tsuga* at altitudes of 2500–3500 m are very similar in their species composition. Therefore, we have merged them into a single vegetation type within the upper-montane zone. This treatment fits the scheme of montane vegetation zones in the Himalayas. Ni (2001) classified the *Abies*, *Picea* and *Tsuga* forests surrounding the Tibetan Plateau as warm temperate/cool temperate evergreen coniferous forest. In the scheme of Vegetation of China (Editorial Committee for Vegetation of China, 1980), this is similar to the "Mountain conifer forest zone", a subunit within the "Tibetan Plateau high elevation vegetation district".

The altitudinal vegetation zones of Taiwan have their counterparts in other regions of eastern Asia (Fig. 4), but the names used for these zones are far from being unified. Therefore, we prefer to maintain the traditional names of Taiwanese vegetation zones (Su 1984) as they are in current use in this country. The subalpine and upper-montane zones of Taiwan correspond to subarctic/boreal and cool-temperate zones, respectively, as recognized in Japan, Korea, China and the eastern Himalayas (Numata 1974; Ohsawa & Numata 1983; Yim 1977; Kira 1991; Fang et al. 1996; Song 1999). Unlike in Taiwan, however, in more northern regions with winter frosts, the temperate zone contains a significant component of deciduous trees (e.g. *Acer*, *Betula*, *Carpinus*, *Quercus* and *Tilia*), usually in association with conifers. This deciduous forest zone is not present in all the subtropical altitudinal zones of eastern Asia. The montane zone in Taiwan is a transition zone between a coniferous forest and lucidophyllous oak-laurel forest (Tagawa 1995). Lucidophyllous forest is a temperate rain forest or tropical mountain rain forest dominated by *Fagaceae*, *Hamamelidaceae*, *Lauraceae*, *Magnoliaceae* and *Theaceae*, characterized by glabrous, entire, leathery, thick leaves with a developed cuticle and glossy upper surface. In Taiwan, the dominance of *Hamamelidaceae* is replaced by *Araliaceae*. Su (1984) classified this montane zone into two parts: the upper part corresponds to the latitudinal temperate zone and is dominated by coniferous trees, whereas the lower part corresponds to the latitudinal warm-temperate zone and is what Tagawa (1995) defined as lucidophyllous oak-laurel forest. This pattern exists in the vegetation-plot database of Taiwan; however, it cannot be simply delineated based on altitude or temperature data because of heterogeneous topography and the climatic influence of clouds. In this study, we present this transition zone as a single zone, namely the montane cloud zone, because the cloud effect causes the similarity in crown type and

Reference	This study	Su (1984)	Ohsawa & Numata (1983)	Fang et al. (1996)	Numata (1974)	Körner et al. (2011)	Song (1999)
Locality, latitudinal / altitudinal zones	Taiwan, altitude	Taiwan, altitude	Nepal, altitude	East Asia at N30°, altitude	Japan, altitude	The world, altitude	East China, latitude
Subarctic / Subalpine zone	**Subalpine** Coniferous woodland WI: 40–80°C	***Abies*** Coniferous forest WI: 12–36°C	***Abies*** Coniferous forest WI: 30–70°C	**Subalpine** Coniferous forest T: 2–7.6°C WI: 14.4–53.5°C	***Picea–Abies*** Coniferous forest WI: 15–45°C	**Upper montane** T: 6.4–10°C	**Boreal** Coniferous forest T: < -2°C, WI: < 50°C
Cool-temperate / Upper-montane zone	**Upper-montane** Coniferous forest WI: 60–110°C	***Tsuga–Picea*** Coniferous forest WI: 36–72°C	***Tsuga–Picea*** Coniferous forest & mixed forest WI: 70–85°C	**Cool-temperate** Coniferous forest, mixed forest, deciduous broad-leaved forest & evergreen broad-leaved forest T: 7.6–11°C WI: 53.5–81.8°C	***Fagus*** Deciduous broad-leaved forest WI: 45–85°C		**Cool-temperate** Mixed needle-broad-leaved forest T: -2–7°C WI: 50–80°C
Temperate / Montane zone	**Montane** Mixed forest, deciduous broad-leaved forest and evergreen broad-leaved forest WI: 90–180°C	***Quercus* (upper)** Mixed forest and deciduous broad-leaved forest WI: 72–108°C				**Lower montane** T: 10–15°C	**Temperate** Deciduous broad-leaved forest T: 7–14°C WI: 80–120°C
Warm-temperate / Montane zone		***Quercus* (lower)** Evergreen broad-leaved forest WI: 108–144°C	***Quercus*** Evergreen broad-leaved forest WI: 85–125°C	**Warm-temperate (Subtropical)** Evergreen broad-leaved forest T: 11–19.2°C WI: 81.8–170.6°C	***Castanopsis–Machilus*** Evergreen broad-leaved forest (from lowland up to submontane) WI: 85–180°C		**Warm temperate** Mixed evergreen deciduous broad-leaved forest T: 14–16°C WI: 120–135°C
Subtropical / Submontane zone	**Submontane** Evergreen broad-leaved forest WI: 150–225°C	***Machilus–Castanopsis*** Evergreen broad-leaved forest WI: 144–216°C	***Schima–Castanopsis*** Evergreen broad-leaved forest WI: 125–165°C			**Remaining mountain area with frost** T: > 15°C	**Subtropical** Evergreen broad-leaved forest T: 16–22°C WI: 135–210°C
Tropical / Foothill or lowland zone	**Foothill** Evergreen broad-leaved forest WI: 195–225°C	***Ficus–Machilus*** Evergreen broad-leaved forest WI: >216°C	***Shorea*** Deciduous broad-leaved forest WI: 165–240°C	**Tropical** Evergreen & semi-evergreen broad-leaved forest T: > 19.2°C WI: > 170.6°C	***Pandanus–Cycas*** Evergreen broad-leaved forest (in the lowland of southern subtropical islands) WI: > 180°C	**Remaining mountain area without frost** T: > 15°C	**Tropical** Rain forest and monsoon forest T: > 22°C WI: > 210°C

Figure 4. Comparison of the names, physiognomy and temperature ranges of the altitudinal and latitudinal vegetation zones from different literatures. T indicates the annual mean temperature and WI indicates the Kira's warmth index. The widths of the rows do not represent the widths of particular zones.

species composition. The submontane zone corresponds to the lower part of the warm-temperate zone or subtropical zone of other schemes (Numata 1974; Yim 1977; Ohsawa & Numata 1983; Kira 1991; Song 1999). Finally, the foothill zone of Taiwan corresponds to the tropical zone in the schemes of Fang et al. (1996) and Song (1999). There is an east-west gradient of increasing climate continentality in eastern Asia (Editorial Committee for Vegetation of China 1980). These zonal vegetation types in Taiwan represent the most oceanic vegetation types in subtropical eastern Asia, which also occur along the coast of mainland China, but have been destroyed in most of their mainland area.

The concept of zonal and azonal vegetation types

An important feature of the present concept of Taiwanese forest classification is the recognition of zonal and azonal vegetation types. The latter are more strongly influenced by specific soil properties, whereas climate has less influence, and they are usually warmer and drier or colder and wetter than zonal habitats (Walter 1973; Mueller-Dombois & Ellenberg 1974). In Taiwan, azonal forests, except those on seashore and in winter monsoon areas, contain more deciduous species than zonal forests (Fig. 3b), which demonstrates the role of many deciduous woody plants as successional pioneers or stress-tolerant colonizers of dry sites. Taiwanese flora has four main geographical elements (Hsieh 2002), including endemics (26.1%), species of the continental part of eastern Asia (Himalayan species, 25.5%), tropical species (24.4%) and species of the oceanic part of eastern Asia (Pacific species, 10.0%). The mesic to humid zonal forests of Taiwan have either high ratios of endemic and Pacific species or many of these species among their dominant species (e.g., *Litsea acuminata*, *Machilus japonica*, *Michelia compressa* and *Rhododendron leptosanthum*). In contrast, azonal forests are more frequently dominated by Himalayan and tropical species. Widespread and naturalized species are also more common in azonal than zonal habitats, especially in the seashore woodlands and mangroves. This indicates that azonal habitats are warmer, drier and open to species which are not adapted to a specific climatic zone. Tang & Ohsawa (1997) reported patches of deciduous forest in Sichuan, which are found particularly on scree slopes and which are dominated by the Tertiary relic trees, such as *Cercidiphyllum japonicum* var. *sinense*, *Davidia involucrata* and *Tetracentron sinense*. Similarly, in Taiwan, some Tertiary relic species are confined to azonal habitats. For example, *Keteleeria davidiana* var. *formosana* occurs in winter monsoon areas, whereas *Calocedrus macrolepis* var. *formosana*, *Cycas taitungensis*, *Liquidambar formosana* and others occur on rock-outcrop habitats. Other examples are *Chamaecyparis formosensis* and *Taiwania cryptomerioides*, which often regenerate on humid landslides at cool sites to avoid competition from evergreen broad-leaved species. After hundreds to thousands of years of soil accumulation and development on these originally azonal habitats, these conifers became emergent trees above the evergreen broad-leaved crowns and coexist with broad-leaved species in zonal habitats.

Notes on the adopted classification approach

At the beginning of our study, we applied several methods of unsupervised numerical classification to the whole vegetation-plot data set and its various subsets, including TWINSPAN (Hill 1979), and its modified version (Roleček et al. 2009) and several variants of cluster analysis (Legendre & Legendre 1998). Although some methods yielded ecologically meaningful classification in parts of the data set, none of them offered satisfying results when applied to the data set as a whole. For example, distinct vegetation types of *Juniperus* woodland, *Fagus* forest and *Aglaia-Ficus* forest usually merged with other vegetation types and the separation of tropical and subtropical vegetation types was unclear, even though their species composition was remarkably different. This probably reflects enormous heterogeneity within the data set, which includes extremely species-poor mangrove or high-mountain coniferous forests on the one hand and species-rich tropical forests on the other, as well as vegetation types of variable heterogeneity and uneven numbers of plots from different vegetation types (Bruelheide & Chytrý 2000). In such cases, methods of numerical classification applying selected criteria (clustering algorithm, distance measure) consistently to the whole data set are likely to fail, because the structure of the data set is inconsistent (see Schmidtlein et al. 2010). In a region with a lack of expert knowledge of vegetation diversity such as Taiwan, the application of standard numerical methods might appear to be the most logical choice, but a possible drawback is that the result would mostly reflect the structure of the available data set and the properties of the numerical method used, instead of the actual vegetation pattern. Therefore, we decided to create the classification scheme subjectively, based on our expert knowledge, although we acknowledge that unsupervised classification methods offered a useful tool to detect existing groups and discontinuities in our data. In the subsequent step, we formalized our expert-based classification to the form of the CoDeK.

Our approach to vegetation classification thus combines the subjective process of creating a vegetation classification scheme and the formalized process of its description and application. It resembles the approach employed recently in some countries influenced by a long tradition of the Braun-Blanquet phytosociology (e.g. Chytrý 2007; Janišová 2007). However, Taiwan does not have a widely-accepted scheme of vegetation classification: Taiwanese vegetation scientists are still in the phase of establishing a widely acceptable scheme, and this study is an attempt to propose one. For the first time, our proposal is based on the analysis of an extensive and representative data set covering almost the whole territory of Taiwan. The CoDeK, which is an important part of this study, offers a solid platform for future discussions concerning the logic of the presented classification scheme and delimitation of individual vegetation types. Such a platform based on explicit criteria is highly necessary, because debates concerning something as subjective and abstract as vegetation classification often lack concrete arguments (De Cáceres & Wiser 2012).

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article (http://onlinelibrary.wiley.com/doi/10.1111/avsc.12025/suppinfo):

Appendix S1. Technical explanations and examples of the Cocktail determination key.

Appendix S2. User's guide for the program CoDeK.

Appendix S3. Program CoDeK and example data described in Appendix S2 (ZIP format).

Appendix S4. Synoptic table of 21 Taiwan forest vegetation types (two files in PDF and CSV format)

Appendix S5. Description of distribution maps of 21 Taiwan forest vegetation types

Appendix S6. Distribution maps of 21 Taiwan forest vegetation types, described in **Appendix S5** (ZIP format)

Note: Appendix S1 and S2 are included in printed version of the thesis. To see Appendices S3-6, which are *not* included in printed version of the thesis, please visit the Wiley Online Library website.

APPENDIX S1. TECHNICAL EXPLANATIONS AND APPLICATION EXAMPLES OF THE COCKTAIL DETERMINATION KEY

The Cocktail determination key (CoDeK) contains a set of formulae for assigning vegetation plots to appropriate vegetation types. Each formula comprises several symbols, operators and species groups. The assembly of these symbols, operators and species groups follows unequivocal rules to allow the automatic processing of the formula by the CoDeK program (see Appendix S2 for more details). This Appendix contains a technical explanation of how to assemble the CoDeK. Firstly, we define the terms and logic of the CoDeK. Secondly, we list all the symbols and operators available for assembling the CoDeK. Thirdly, we introduce the rules for assembly of the component parts. Fourthly, we describe the procedure of defining the species groups and constructing the CoDeK.

I. Definition of terms and logic used in the CoDeK

Species group	One species group contains one or more species which represent certain ecological meaning. The number of species in each group and the species included are selected subjectively.
Subset formula	The subset formula contains at least two species groups which are connected by operators.
Determinant component	The determinant component is either a subset formula or a species group with an operator before it.
Formula serial number	The serial number is placed at the beginning of each formula and provides a name to each formula in the CoDeK.
Vegetation type code	The vegetation type code is placed at the end of each formula. It determines to which vegetation type a plot should be assigned to by the formula.

Logic of the formulae

Each formula contains one formula serial number, at least one determinant component and the vegetation type code. When the species composition of a certain plot fulfils all the conditions of the connected determinant components, the plot is assigned to the vegetation type corresponding to the vegetation type code at the end of the formula.

Logic of the CoDeK

The CoDeK contains at least one formula. In the course of the determination process, each plot is checked by the list of formulas in the CoDeK sequentially, i.e. the determination starts with the first formula at the beginning of the CoDeK and continues to the next formula in the order. The process terminates when plot fits a particular formula, in which case the plot is assigned to the vegetation type associated with the formula, or when the determination reaches the end of the key, in which case the plot remains unclassified.

II. List of symbols and operators used in the CoDeK

[ ]	This symbol defines a species group.
( )	This symbol creates a subset formula.
>	This symbol means more than the specified species cover (dominance).
<	This symbol means less than the specified species cover (dominance).
WITH	This operator requires the following species group to be present in the plot. All formulae or subset formulae should start with "WITH".
WITHOUT	This operator requires the following species group to be absent.
AND, OR	These logical operators connect species groups or subset formulae. "AND" requires both connected components to be present if the formula or subset formula is true. "OR" requires at least one of the connected components to be present if the formula or subset formula is true.
NOT	This operator requires the following subset formula to be absent in the plot. This operator can be only used to follow "AND" and to precede a subset formula afterwards.

Here we give some examples to explain the method in detail:

1. A formula without information on species cover

Example 1 in the box is formula no. 103 which does not contain any information about species cover. This formula contains three determinant components (with green, blue and orange font colour).

Example 1

103 WITH 3 [*Cyclobalanopsis glauca*, *Eriobotrya deflexa*, *Quercus tarokoensis*, *Syzygium formosanum*, *Viburnum formosanum*, *Zelkova serrata*] AND (WITH 3 [*Acer albopurpurascens*, *Callicarpa formosana*, *Cinnamomum insularimontanum*, *Glochidion rubrum*, *Pittosporum illicioides*] OR WITH 3 [*Carpinus kawakamii*, *Fraxinus insularis*, *Lagerstroemia subcostata*, *Schefflera octophylla*, *Styrax suberifolia*, *Vitex quinata*] OR WITH 2 [*Alnus formosana*, *Firmiana simplex*, *Glycosmis citrifolia*, *Murraya paniculata*, *Pinus taiwanensis*, *Sapindus mukorossii*]) AND WITHOUT 3 [*Bischofia javanica*, *Champereia manillana*, *Drypetes karapinensis*, *Ilex uraiensis*, *Schima superba* var. *kankaoensis*] C6A16

In Example 1, there are five species groups. The first, composed of six species, is included in the first determinant component:

Example 1.1

WITH 3 [*Cyclobalanopsis glauca*, *Eriobotrya deflexa*, *Quercus tarokoensis*, *Syzygium formosanum*, *Viburnum formosanum*, *Zelkova serrata*]

This determinant component (Example 1.1) determines that at least three of the six listed species should be present in the plot to make it true.

The last species group composed of five species is included in the third determinant component (Example 1.2):

Example 1.2

WITHOUT 3 [*Bischofia javanica*, *Champereia manillana*, *Drypetes karapinensis*, *Ilex uraiensis*, *Schima superba* var. *kankaoensis*]

This determines that three of the five species should not be present in the plot. If at least three of the five listed species are present in the plot, this determinant component is false. If fewer than three of the five species are present in the plot, the determinant component is true.

The remaining three species groups form a subset formula as the second determinant component (Example 1.3):

Example 1.3

(WITH 3 [*Acer albopurpurascens*, *Callicarpa formosana*, *Cinnamomum insularimontanum*, *Glochidion rubrum*, *Pittosporum illicioides*] OR WITH 3 [*Carpinus kawakamii*, *Fraxinus insularis*, *Lagerstroemia subcostata*, *Schefflera octophylla*, *Styrax suberifolia*, *Vitex quinata*] OR WITH 2 [*Alnus formosana*, *Firmiana simplex*, *Glycosmis citrifolia*, *Murraya paniculata*, *Pinus taiwanensis*, *Sapindus mukorossii*])

The three species groups in this determinant component are connected by "OR" which determines that the presence of any of these species groups in the plot results in this determinant component being true.

In Example 1, the three determinant components are connected by "AND". This means that when a plot fulfils all the conditions of the three determinant components, it will be assigned to vegetation type C6A16.

2. A formula with information on species cover

Example 2 in the box (formula no. 149) provides the information on cover to define the determinant component:

Example 2

149 WITH 1 [*Juniperus squamata* > 30] AND WITHOUT 1 [*Abies kawakamii* > 15] AND WITHOUT 1 [*Juniperus formosana* > 10] AND WITHOUT 1 [*Pinus taiwanensis* > 5] C1A01

There are four determinant components (with green, blue, orange and violet font colour) in Example 2. If the first determinant component is true, the plot must have *Juniperus squamata* with a cover of more than 30%. If the second determinant component is true, the plot should not have *Abies kawakamii* with a cover more than 15%. When a plot fulfils all the conditions of the above four determinant components, it will be assigned to vegetation type C1A01.

3. A formula with "NOT"

Example 3 in the box is formula no. 71, which contains "NOT":

Example 3

> 71 (WITH 3 [*Diospyros morrisiana*, *Hydrangea angustipetala*, *Lasianthus fordii*, *Myrsine seguinii*, *Prunus phaeosticta*] OR WITH 3 [*Ardisia sieboldii*, *Bretschneidera sinensis*, *Castanopsis cuspidata* var. *carlesii* f. *sessilis*, *Cyathea lepifera*, *Keteleeria davidiana* var. *formosana*]) AND WITH 3 [*Ardisia cornudentata* subsp. *morrisonensis*, *Astronia formosana*, *Beilschmiedia erythrophloia*, *Litsea acutivena*, *Machilus konishii*] AND **NOT** (WITH 3 [*Cyclobalanopsis championii*, *Illicium arborescens*, *Microtropis japonica*, *Symplocos congesta*, *Symplocos shilanensis*, *Syzygium buxifolium*] AND WITH 3 [*Cyclobalanopsis pachyloma*, *Ilex lonicerifolia* var. *matsudai*, *Ilex maximowicziana*, *Myrsine seguinii*, *Neolitsea buisanensis*, *Ternstroemia gymnanthera*]) C3A10

This formula (Example 3) contains three determinant components (with green, blue and orange font colour): the first is defined by a subset formula, the second by one species group and the third by another subset formula with "NOT". If, for a given plot, the third determinant component after "NOT" is true (both species groups in the subset formula co-exist), then this plot cannot be assigned to vegetation type C3A10 by this formula. The ecological meaning of this "NOT" is that both species groups in the third determinant component (with orange font colour) usually grow together in cool and windy habitats in the tropical region. If both species groups co-occur, the plot is more likely to be vegetation type C3A13 (*Illicium-Cyclobalanopsis* tropical winter monsoon forest). However, C3A10 (example F) is *Drypetes-Helicia* tropical sub-montane evergreen broad-leaved forest, which should not contain both species groups simultaneously. *Drypetes-Helicia* tropical sub-montane evergreen broad-leaved forest (C3A10) might contain the species group of [*Cyclobalanopsis championii*, *Illicium arborescens*, *Microtropis japonica*, *Symplocos congesta*, *Symplocos shilanensis*, *Syzygium buxifolium*] in cool microhabitats without the species group of [*Cyclobalanopsis pachyloma*, *Ilex lonicerifolia* var. *matsudai*, *Ilex maximowicziana*, *Myrsine seguinii*, *Neolitsea buisanensis*, *Ternstroemia gymnanthera*]. Another exception is that C3A10 might contain the species group of [*Cyclobalanopsis pachyloma*, *Ilex lonicerifolia* var. *matsudai*, *Ilex maximowicziana*, *Myrsine seguinii*, *Neolitsea buisanensis*, *Ternstroemia gymnanthera*] at the wind-shaded ridges without the species group of [*Cyclobalanopsis championii*, *Illicium arborescens*, *Microtropis japonica*, *Symplocos congesta*, *Symplocos shilanensis*, *Syzygium buxifolium*]. If we use "WITHOUT" in this case, it means that only one of the species group can cause the determinant component to be false. That illustrates the difference between "WITHOUT" and "NOT".

III. The format of formulas used in the CoDeK

The correct format of the Cocktail formulae is important for programming by CoDeK. In this chapter, we use some examples to introduce the format to assemble species groups, subset formulae and formulae from symbols, operators and species names together.

Example 1.1 specifies how to define a species group:

“[” + “*Cyclobalanopsis glauca*” + “,” + “space” + “ *Eriobotrya deflexa*” + “,” + “space” + “*Quercus tarokoensis*” + “,” + “space” + “*Syzygium formosanum*” + “,” + “space” + “*Viburnum formosanum*” + “,” + “space” + “*Zelkova serrata*” + “]”

One kind of determinant component is a species group with a logical operator and a number that precedes it (Example 1.1):

“WITH” + “space” + “number” + “space” + “[” + “*Cyclobalanopsis glauca*” + “,” + “space” + “*Eriobotrya deflexa*” + “,” + “space” + “*Quercus tarokoensis*” + “,” + “space” + “*Syzygium formosanum*” + “,” + “space” + “*Viburnum formosanum*” + “,” + “space” + “*Zelkova serrata*” + “]”

A space and comma are used as separators between all the symbols, operators, numbers and species names. A comma is used after species names only and a space is needed after a comma. Between the species name and both “[” and “]”, there is no space. Otherwise, all the elements are separated by a space.

Example 2 illustrates the format of a determinant component using cover information.

“WITH” + “space” + “number” + “space” + “[” + “species name” + “space” + “>” + “space” + “number” + “]”

Symbol “>” can be replaced by symbol “<”.

Example 1.3 specifies the format of a subset formula:

“(” + “space” + “WITH” + “space” + “number” + “space” + “species group” + “OR” + “space” + “WITH” + “space” + “number” + “space” + “species group” + “OR” + “space” + “WITH” + “space” + “number” + “space” + “species group” + “space” + “)”

Example 1, example 2 & example 3 in the boxes illustrate the format of a formula. Three rules are used for assembling a formula:

1. The structure of the formula:

“formula serial number” + “tab” + “determinant component(s)” + “tab” + “vegetation type code”

These three parts are separated by tabs only. The vegetation type code can consist of numbers, characters or mixed numbers and characters.

2. Connecting the determinant components:

"determinant component" + "space" + "AND" + "space" + "determinant component"

The determinant components are connected by "AND" or "OR". "AND" can be replaced by "OR". The first determinant component of each formula must begin with "WITH".

3. The determinant component containing "NOT":

"determinant component" + "space" + "AND" + "space" + "NOT" + "space" + "subset formula"

Please note that "NOT" should be followed by "AND" and the determinant component after "NOT" must be composed of a subset formula.

IV. Defining the species groups and constructing the CoDeK

Application of the Cocktail formula concept for defining vegetation types commonly encounters two problems: how to define species groups and how to ensure that even vegetation types with few species do not remain unrecognized (Bruelheide 2000; Bruelheide & Chytrý 2000; Kočí et al. 2003; Roleček 2007). Chytrý (2007) defined the species groups a priori using a combination of expert judgement and analysis of species co-occurrences, calculated from a large national vegetation database. However, if a region does not have a long phytosociological tradition and a large phytosociological database, it is not possible to define species groups in this way. Therefore, in the case of Taiwan, we defined species groups and constructed the CoDeK together using a reciprocal procedure, consisting of the following steps:

1. We separated the database into two data sets: one with the plots assigned to vegetation types by expert judgement (training data set), and the second with the remaining plots (validation data set). Cocktail formulae were constructed using the training data set and further refined using the validation data set.
2. In the training data set, we chose one vegetation type with floristic composition most different from the others. This difference can be judged by inspecting the DCA ordination diagram, the number of diagnostic species or field experience. We determined the species groups for selected vegetation types by experience and information such as synoptic tables and species co-occurrences extracted from the vegetation database. Two types of species groups were usually created in this step: (1) positive species group(s), used to select plots for the target vegetation types, and (2) negative species group(s), used to exclude other similar vegetation types whose plots could be selected by the positive species group(s). In this step, the Cocktail formula for a particular vegetation type was constructed by the created species group. The group required to be present was connected by "WITH" and the group required to be absent, by "WITHOUT". In this way, the formula identifies most plots

assigned to the target vegetation type but excludes plots which do not belong to that type.

3. We applied this formula to the validation data set to see which plots are identified by the formula as the target vegetation type. If some plots from the validation data set that were identified as a particular target vegetation type obviously did not belong to that type (judged by their floristic composition, information about the location and other available data), then species groups of the formula and the formula itself were modified until the formula did not identify any plot which should not be assigned to the target vegetation type in the validation data set.
4. We deleted plots assigned to the target vegetation types by the formula constructed in step 3 (in both training data set and validation data set).
5. We repeated steps 2 to 4 using both remaining data sets until most plots belonging to the training data set were assigned to relevant vegetation types.
6. We assembled all the formulae into the CoDeK.

This reciprocal procedure is subjective but flexible and its flexibility can solve the problem of defining species groups and recognizing vegetation types in species-poor vegetation. For example, in Taiwan, coniferous species such as *Tsuga chinensis* var. *formosana* can form pure stands at high altitudes, but also mixed stands with broad-leaved species at intermediate altitudes. In mixed stands, forests are dominated by either *Tsuga chinensis* var. *formosana* or by other coniferous species such as *Chamaecyparis formosensis*. The forests dominated by *T. chinensis* var. *formosana* in mixed stands are influenced by strong wind or grow in stony habitats with acid soil. The forests dominated by *C. formosensis* in the mixed stands are usually protected from wind, and their habitat might be a large landslide from hundreds of years ago, with usually a less acid soil. Both mixed forest types have their own diagnostic species, but these species are usually neither frequent nor dominant. Alternatively, both mixed forests have the same frequent and dominant broad-leaved species such as *Cyclobalanopsis morii*, *Neolitsea acuminatissima*, *Rhododendron leptosanthum* and *Trochodendron aralioides*. Although these two forest types can easily be identified in the field by their structure, floristic composition and habitat properties, it is difficult to classify them by numerical methods, because they share frequent and dominant species with very broad distribution in different vegetation types at intermediate altitudes. The flexible rule of forming species groups (even one species can form a species group) makes it possible to determine different types of *T. chinensis* var. *formosana* forests from intermediate to high altitudes and to distinguish them from forests dominated by *Chamaecyparis formosensis*.

Another advantage of this flexibility is that this procedure can formalize vegetation classification at different hierarchical levels. In our study, some vegetation types can be recognized as associations (such as C7A21 *Kandelia* mangrove) and other types as alliances (such as C2A04 *Fagus* montane deciduous broad-leaved cloud forest) or higher level units (such as C2A06 *Machilus-Castanopsis* sub-montane evergreen broad-leaved forest). In the CoDeK for Taiwan forest classification, one vegetation type can be determined by several formulae. This can occur in the case of vegetation types which are more broadly defined (e.g. on the alliance or order level), and each formula might be the definition of a more narrowly-defined vegetation type (e.g. on association level). In the developing stage of vegetation classification in Taiwan, one of the important functions of this key is that it proposes unequivocally defined vegetation types and ecologically-meaningful species groups. These can generate the argument for future vegetation studies. This flexibility of the species grouping rule and the number of formulae existing for one vegetation type offers the opportunity to describe vegetation pattern by data mining in a database.

The CoDeK as used in this study is also complicated by the high diversity of vegetation types in Taiwan. Apart from the fact that CoDeK assembly is very time-consuming, another obvious disadvantage is that it easily suffers from over-learning, the problem common to all supervised classification methods (Černá & Chytrý 2005). Over-learned classifications lose generality and are of limited use outside the training data set. To avoid over-learning, each formula in the CoDeK should not be based on information from just a few plots. The rule of thumb we used was that the group size in constructing a formula should be at least five, and preferably more than ten plots. Other ways to avoid over-learning are restricting the number of species per group and fixing the determinant ratio of present species number per species group in a determinant component. In our study, most of the species groups contain four to six species and 50–60% of the species present in a species group as determinant criteria.

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APPENDIX S2. USER'S GUIDE FOR THE PROGRAM CODEK (COCKTAIL DETERMINATION KEY)

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Related website: http://bit.ly/cocktail-determination-key

INTRODUCTION

CoDeK is a software application, based on R program (R Development Core Team 2012), which allows automatic classification of vegetation samples into vegetation types defined by Cocktail determination key. To run this application, you need the table of one or more vegetation plots (samples, relevés), file with the Cocktail determination key and optionally also species checklist, which allows checking for correct use of species nomenclature in both files of vegetation plots and Cocktail determination key.

DOWNLOAD

Unzip the supplementary materials in Appendix S3 into your computer; directory CoDeK will be automatically created. This directory contains the following files:

1) CoDeK program: CoDeK_bat, CoDeK_v1.0.r;
2) Cocktail determination key for Taiwan forest vegetation (Li et al. 2013): *Det_key_Taiwan_forest_vegetation.txt*;
3) Checklist for Taiwan flora: Checklist_Taiwan_flora_20111214.txt;
4) Example vegetation data in txt format (Li 1997): *example_data.txt*;
5) Example vegetation data in JUICE format (Li 1997): example_data_JUICE.wct, example_data_JUICE.exp, example_data_JUICE.str.

Important: you need to change the file name *CoDeK_bat* into *CoDeK.bat* (i.e., replace "_" by ".", using file manager).

Example vegetation data represent succession stages from secondary to primary subtropical lowland forest (Li 1997). Example data in txt format and JUICE format are identical (JUICE format additionally contains header data such as geographical coordinates and few environmental factors).

SOFTWARE REQUIREMENTS

CoDeK is basically an R script, which must be run in **R program** (R can be downloaded for free at www.r-project.org). The application has been tested in R

version 2.15, however, it should run also in newer R version (and probably also in older ones).
CoDeK can be launched in two ways:

1) using batch file *CoDeK.bat*, or
2) from JUICE program (Tichý 2002); JUICE is a program for editing and analysis of vegetation data and it can be downloaded for free at http://www.sci.muni.cz/botany/juice/. JUICE version 7.0.67 has been tested. Note, that even if you launch CoDeK from JUICE, you still need to have R program installed on your computer.

OPERATION SYSTEM REQUIREMENTS

Windows XP, Vista, 7 (other OS which can run R program can be probably also used, but the application has to be launched manually by copying the script in *CoDeK_v1.0.r* into R console). If using also JUICE, consult the http://www.sci.muni.cz/botany/juice/ website for details.

PROGRAM SETTINGS

Option 1: Running CoDeK directly using batch file CoDeK.bat

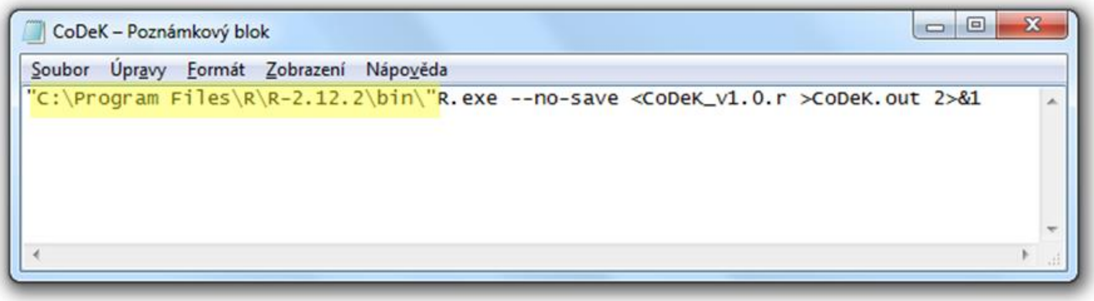
If you will run CoDeK directly using the batch file *CoDeK.bat*, to set it up you have two options:

1) to save the files *CoDeK.bat* and *CoDeK_v1.0.r* into the R directory, where is located the file *R.exe*. In standard situation, this should be somewhere like "c:\Program Files\R\R-2.12.2\bin" (R-2.12.2 is the version of R; if you use different version, the numbers will be different); or

2) to keep both files in the directory CoDeK, and to change the directory name in the file *CoDeK.bat.* This can be done in the following way:

   a. open the file *CoDeK.bat* using notepad (in Windows, right click on the file *CoDeK.bat* and select *Edit*);
   b. add the directory name (**surrounded by quotation marks**) in front of the script (Fig. 1). If you have e.g. R version 2.12.2, it will be probably installed in the directory c:\Program Files\R\R-2.12.2\. Ad this directory in a format "c:\Program Files\R\R-2.12.2\bin\" (don't forget to add "bin\" at the end of the directory, as the *R.exe* file is inside the folder *bin*). Note the differences between a forward slash ("/") and a backslash ("\") – the latter need to be used!
   c. save the edit and close notepad.

Figure 1

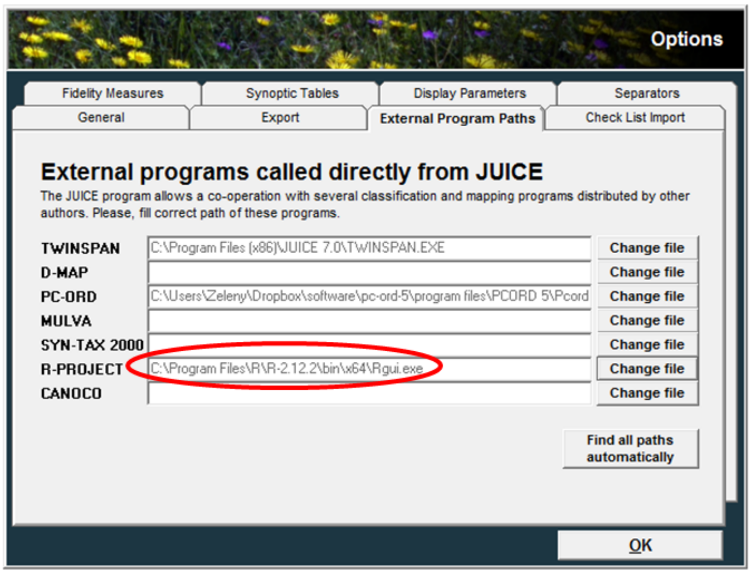


Option 2: Running CoDeK from JUICE program

To launch the CoDeK application from JUICE program, you need to install the JUICE program first (JUICE can be operated under Windows OS (optionally other OS using Windows emulator such as Wine for Linux) and it can be downloaded at http://www.sci.muni.cz/botany/juice/?idm=3). Consult JUICE website and JUICE manual if you encounter problems while installing the program.

In JUICE, you need to setup the path to R program. In JUICE menu, go to *File > Options*, and choose the folder *External Program Paths* (Fig. 2). At the line of *R Project*, click on *Change Path* button and navigate to the directory of *Rgui.exe* file (if you installed R version 2.12.2, you will probably find it in the directory *c:\Program Files\R\R-2.12.2\bin*, either in subfolder *i386* (if you are using 32 bit version of R) or *x64* (if you use 64 bit version). If you use R version older than 2.9.0, you will find *Rgui.exe* file directly in the folder *bin*, which does not contain subfolder mentioned above. Click on *OK* button to leave the Options. Note: in JUICE options, you MUST specify the file *Rgui.exe* file, not *Rterm.exe* or *R.exe*!

Figure 2



REQUIRED FORMAT OF VEGETATION DATA FILE

Option 1: Running CoDeK directly using batch file CoDeK.bat

Table of vegetation plots contains percentage data about species relative IVI or cover; **species are in rows, plots are in columns**. First row contains sample names (without spaces), first column contains species names. Species names must be identical as those listed in Checklist, otherwise the Determination key may not identify the plots appropriately. CoDeK offers simple function to check compatibility between the species names in the table of vegetation plots and the Checklist. All plots stored in the file will be used for determination of vegetation types; if you wish to determine only part of the data, remove them from this file.

Vegetation data should be stored in a plain text format, with cells separated by tabulator. This format can be created e.g. using Excel spreadsheet program (use the function *Save as* and choose *Text (separated by tabulators)*). For details of the format, see *example_data.txt* file directly (it can be opened in Notepad program or imported into Excel).

Option 2: Running CoDeK from JUICE program

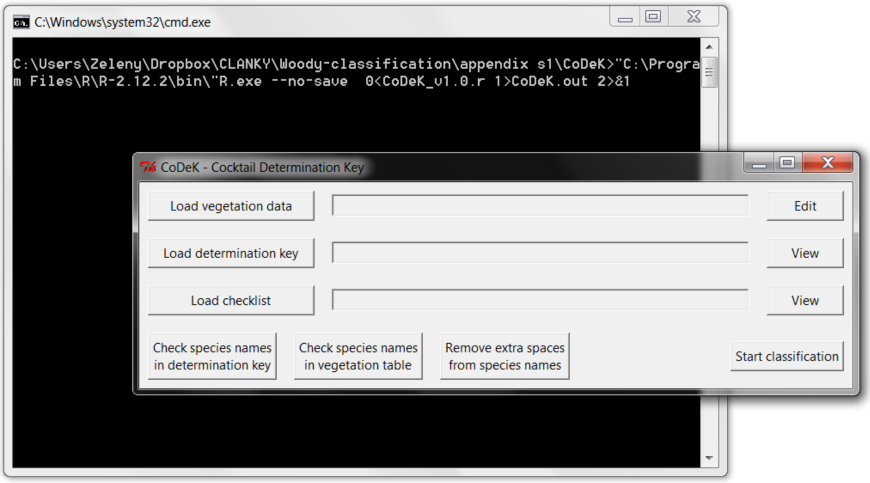
To run CoDeK from JUICE, you need to import vegetation data to JUICE program first. Spreadsheet format data (e.g. from Excel) can be imported into JUICE directly; however, note that you need to add manually three rows at the beginning of the file (for details about this, see JUICE manual, part 1, section *1.4.4 Spreadsheet Format (Microsoft® Excel® Table)*, which is available at JUICE website http://www.sci.muni.cz/botany/juice/ at the section *Manuals*). Optionally, vegetation data can be imported into JUICE from Turboveg program (Hennekens & Schaminée 2001; see JUICE manual for more details).

RUNNING THE PROGRAM USING EXAMPLE DATASETS

Option 1: Running CoDeK directly using batch file CoDeK.bat

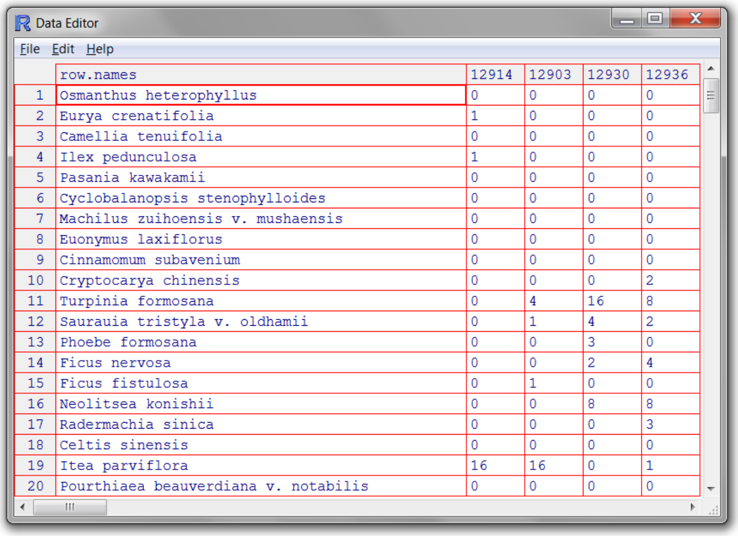
1. Launch the program by executing *CoDeK.bat* file. The Command Prompt window will open, and after that will pop up the graphical user interface of the CoDeK program (Fig. 3). If the Command Prompt window disappears immediately and the user interface does not occur, you have probably set up wrong directory for the R.exe program and the *CoDeK.bat* application cannot find it. Check it again following the steps described in the section *Program settings, Option 1*.

Figure 3



2. Load appropriate files into CoDeK. Click on Load vegetation data and select example_data.txt file, click on Load determination key and select Det_key_Taiwan_forest_vegetation.txt, and finally click on Load checklist and select Checklist_Taiwan_flora_20111214.txt. The buttons Edit or View are intended for viewing the files in order to check if the files were loaded correctly (see Fig. 4 for vegetation data, Fig. 5 for determination key and Fig. 6 for checklist). In case of vegetation table, the data can be also edited (changes will be saved into the data), in case of determination key and checklist the files can be only viewed. Note: **changes in the vegetation data made in CoDeK application will not be saved into the original file (e.g. example_data.txt) – they will influence only currently loaded data and their determination**.

Figure 4



	row.names	12914	12903	12930	12936
1	Osmanthus heterophyllus	0	0	0	0
2	Eurya crenatifolia	1	0	0	0
3	Camellia tenuifolia	0	0	0	0
4	Ilex pedunculosa	1	0	0	0
5	Pasania kawakamii	0	0	0	0
6	Cyclobalanopsis stenophylloides	0	0	0	0
7	Machilus zuihoensis v. mushaensis	0	0	0	0
8	Euonymus laxiflorus	0	0	0	0
9	Cinnamomum subavenium	0	0	0	0
10	Cryptocarya chinensis	0	0	0	2
11	Turpinia formosana	0	4	16	8
12	Saurauia tristyla v. oldhamii	0	1	4	2
13	Phoebe formosana	0	0	3	0
14	Ficus nervosa	0	0	2	4
15	Ficus fistulosa	0	1	0	0
16	Neolitsea konishii	0	0	8	8
17	Radermachia sinica	0	0	0	3
18	Celtis sinensis	0	0	0	0
19	Itea parviflora	16	16	0	1
20	Pourthiaea beauverdiana v. notabilis	0	0	0	0

Figure 5

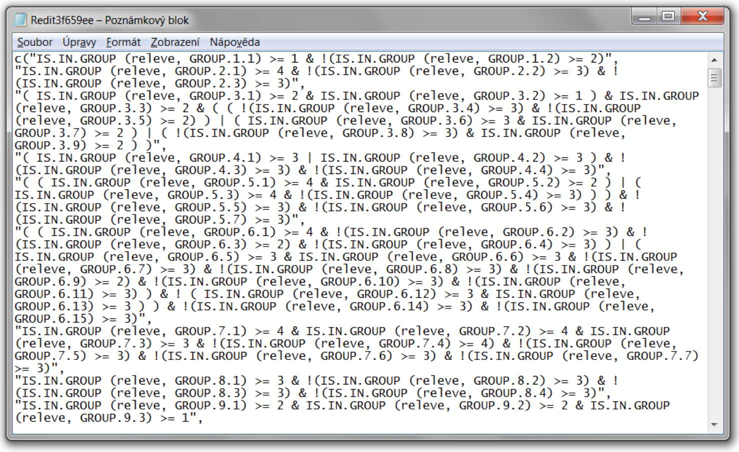
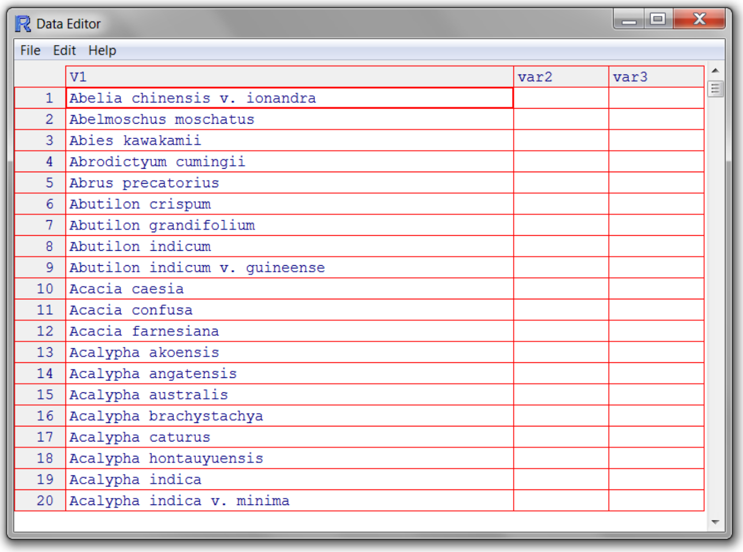


Figure 6

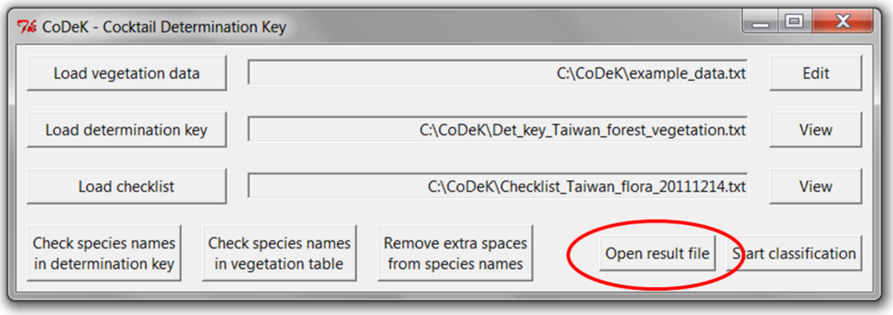


3. Check the nomenclature of species names used in the determination key (click on *Check species names in determination key*) and vegetation data (*Check species names in vegetation table*). If there is a wrong name, it will be copied into clipboard – to see it, open some text editor (Word, notepad) and past the content of the clipboard (CTRL+V). Optionally, if the species names in the vegetation table contain extra spaces after the name (e.g. „Pasania kawakamii_____________“ instead of „Pasania kawakamii“), you can remove these spaces by clicking on button *Remove extra spaces from species names*. Note: only spaces at the end of the species names are removed, not the spaces between genus and species name; only spaces in the species of vegetation data will be considered, not the spaces in species of determination key or checklist.

You can see the changes in vegetation data by clicking *Edit* button at the top right corner.

4. If all the species names have been treated, click on *Start classification* to run the determination key. Progress bar will appear, and after the determination is finished, the button *Open result file* will appear (Fig. 7).

Figure 7



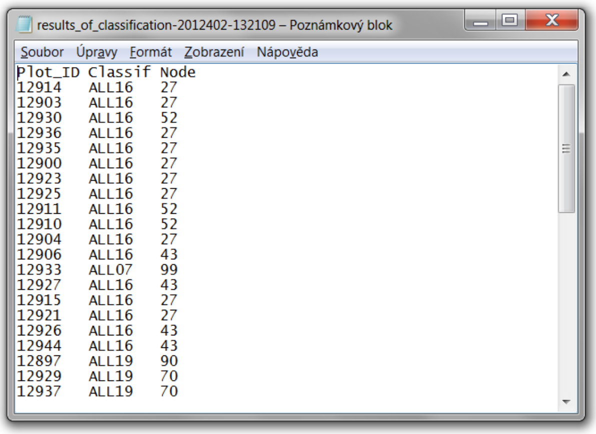
5. Click *Open result file* button. The result file will open in notepad (Fig. 8). It contains three columns:

    a. Plot_ID – codes of vegetation plots;

    b. Classif – code of resulting assignment into vegetation type;

    c. Node – the row in the key, which lead to the assignment of the vegetation plot (for reference, to know which formula in the determination key is responsible for assignment of particular plot).

Figure 8

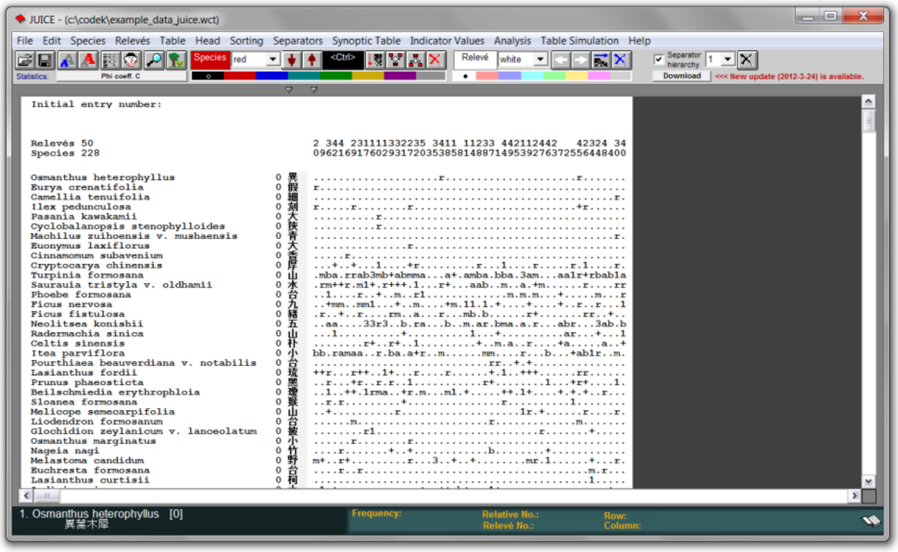


Plot_ID	Classif	Node
12914	ALL16	27
12903	ALL16	27
12930	ALL16	52
12936	ALL16	27
12935	ALL16	27
12900	ALL16	27
12923	ALL16	27
12925	ALL16	27
12911	ALL16	52
12910	ALL16	52
12904	ALL16	27
12906	ALL16	43
12933	ALL07	99
12927	ALL16	43
12915	ALL16	27
12921	ALL16	27
12926	ALL16	43
12944	ALL16	43
12897	ALL19	90
12929	ALL19	70
12937	ALL19	70

Option 2: Running CoDeK from JUICE program

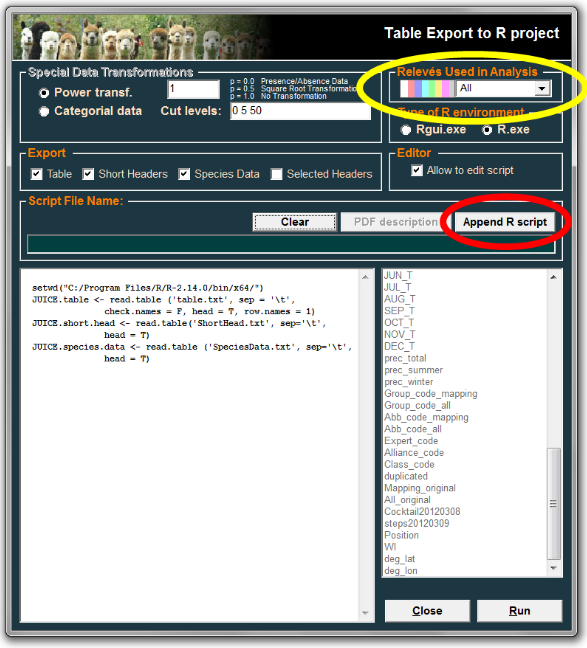
1. Open JUICE program and open the file with example data (in JUICE menu, go to *File* > *Open* and find the file *example_data_JUICE.wct*). Vegetation table in JUICE looks like those on Fig. 9.

Figure 9



2. In JUICE, launch the export into R (so called JUICE-R function) using the keyboard shortcut CTRL+W (or, in JUICE menu, go to *File* > *Export* > *Table* > *To R project TXT file*). The export wizard will launch (Fig. 10).

Figure 10



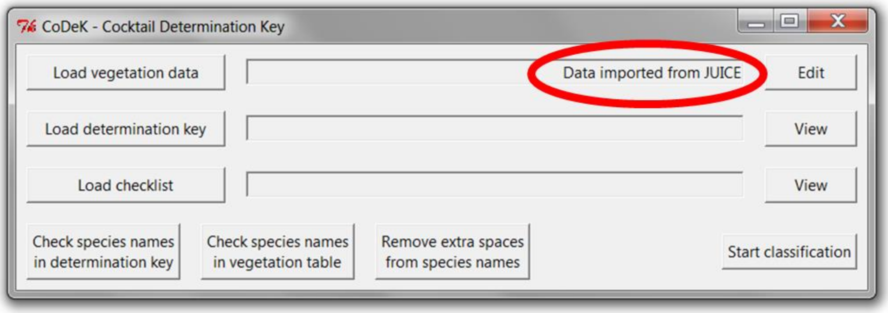
3. In the JUICE-R wizard, you need to select two things:

a. color of plots used in analysis (option *Relevés Used in Analysis*, yellow marking in Fig. 10) – if you have not specify any color in JUICE, choose option All;

b. *Append R script* (red marking in Fig. 10) – choose *CoDeK_v1.0.r* file, which contains the R script running the CoDeK application.

4. Click on *Run* button. The wizard will close, and data will be exported from JUICE. In a while, graphical user interface identical to the one on Fig. 3 should appear.

Figure 11

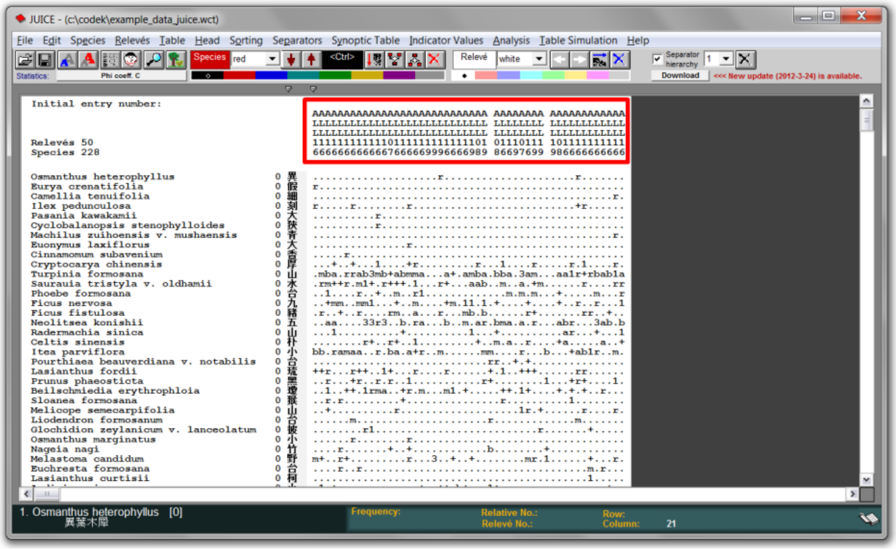


5. Vegetation data are already imported from JUICE (Fig. 11). Load the determination key and the checklist. Also, you can check species names in determination key and vegetation table. There should not be any extra spaces in species names in vegetation data, as these are automatically removed while the data are imported from JUICE.

6. Click on *Start classification* button. After running determination key, *Open result file* button will appear (Fig. 7) and clicking it will open notepad with the results (Fig. 8).

7. If you wish to import the result of determination back to JUICE, you can copy the table in the result file (Fig. 8) onto clipboard (CTRL+A will select the whole table, CTRL+C will copy it to the clipboard) and go to JUICE program menu *Edit* > *Paste Clipboard To White Short Header* (if you have changed the color, you need to paste it as a selected color – to select appropriate color, in JUICE menu click the color under the heading Relevé). The codes of vegetation types will be copied into the short header in JUICE (Fig. 12).

Figure 12



Result files

After running the determination key, the **.txt* file with the results of classification is created, either in CoDeK directory or the R program directory (if you use CoDeK.bat option, it will be at the same folder as CoDeK.bat file; if you use JUICE to run the key, the file will be in R program directory). The name of the file is *results_of_classification-YYYYMMDD-hhmmss.txt*, where YYYYMMDD-hhmmss is a time stamp (e.g. 20120402-104338, which means 2nd April 2012 at 10:43:38). Each run of determination key will produce new result file with relevant time stamp. The file can be opened in notepad, Excel or any other editing program.

Error handling

After running CoDeK application, new file *CoDeK.out* is created (either in CoDeK directory or R program directory). This file contains technical report about the process of calculation. If error occurs, this file can serve as a reference for searching the potential bugs (follow Error or Warning messages in the file). If error occurs, first check the website http://bit.ly/cocktail-determination-key for availability of updates of the CoDeK program or trouble shooting. In case you still experience troubles in using the CoDeK program, do not hesitate to contact us (zeleny@sci.muni.cz, chingfeng.li@gmail.com). Providing the *CoDeK.out* file and optionally also example of your data will greatly improve our ability to determine where the error happened.

References

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Paper 2

Classification of the high-mountain coniferous forests in Taiwan

Lin, C.-T., **Li, C.-F.**, Zelený, D., Chytrý, M., Nakamura, Y., Chen, M.-Y., Chen, T.-Y., Hsiah, Y.-J., Hsieh, C.-F., Liu, H.-Y., Wang, J.-C., Yang, S.-Z., Yeah, C.-L. & Chiou, C.-R.

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Classification of the high-mountain coniferous forests in Taiwan

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ABSTRACT

Vegetation of boreal coniferous forests has been extensively studied in many areas of northern Eurasia and North America, but similar forests in the high mountains of subtropical and tropical eastern Asia have been poorly documented so far. This paper, focusing on such forests, is the first phytosociological study at the national scale in Taiwan. The relevés from the National Vegetation Diversity Inventory and Mapping Project database were used to define vegetation types of the high-mountain coniferous forests and to characterise their distributions in Taiwan. Environmental variables such as aspect, elevation, soil rockiness and slope were related to species composition. Cluster analysis was used to classify vegetation plots and establish groups that were interpreted as nine associations belonging to two alliances. The alliance *Juniperion squamatae* represents woodlands and forests scattered in the subalpine belt, in which *Juniperus squamata* dominates the canopy and subalpine meadow species occur in the understorey. The *Abieti kawakamii-Tsugion formosanae* alliance includes forests dominated by *Abies kawakamii* and *Tsuga chinensis* var. *formosana* with shade-tolerant herb species in the upper montane belt. In addition to regional vegetation description, an identification key for the studied forests was developed based on the classification tree technique.

Keywords: Braun-Blanquet approach; Phytosociology; Plant communities; Syntaxonomy; Vaccinio-Piceetea; Vegetation classification; Woodland.

Nomenclature: Huang and Hsieh (1994–2003)

INTRODUCTION

Coniferous forests occupy over 19 million km^2 in the boreal zone and mountainous areas of the temperate zone of the northern hemisphere (Archibold 1995; Spribille and Chytrý 2002). They are dominated by several species of the genera *Abies*, *Larix*, *Picea* and *Pinus*, as well as *Chamaecyparis*, *Juniperus*, *Tsuga* and *Thuja* and some others in transitional zones (Walter and Breckle 2002). In Europe, northern Asia and North America, these forests have been described in numerous phytosociological studies, which classified them as various alliances and associations within the class *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 (e.g., Jahn 1985; Rodwell 1991; Peinado et al. 1998; Ermakov et al. 2002; Krestov and Nakamura 2002; Spribille and Chytrý 2002; Rzedowski 2006; Krestov et al. 2009; Ermakov & Morozova 2011). Similar coniferous forests occur in humid subtropical mountains above 2500 m at latitudes south of 30˚ N, such as in Mexico, the eastern Himalayas and Taiwan (Liu T 1968; Wu ZY 1980; Rzedowski 2006). However, species composition and diversity of vegetation types in these southern mountain coniferous forests have been rarely described. In particular, phytosociological approach has hardly ever been applied to these forests, which seriously restricts our understanding of diversity of the Northern Hemisphere coniferous forest vegetation.

In oceanic and maritime sectors of eastern Asia (Krestov 2003; Nakamura et al. 2007), boreal coniferous forests of *Vaccinio-Piceetea* have been most extensively studied in Japan, where the order *Abieti veitchii-Piceetalia jezoensis* Miyawaki et al. 1968 was established for forests dominated mostly by *Abies* and *Picea* (Krestov and Nakamura 2002). This order includes five alliances in different climatic zones (Song 1992; Krestov and Nakamura 2002; Nakamura and Krestov 2008; Krestov et al. 2009). Of these, *Abietion koreanae* Song 1991 and *Abietion mariesii* Suzuki-Tokio 1954 occur in oceanic and suboceanic sectors at the mountainous and subalpine levels of the temperate mountains of Honshu, Shikoku and the Korean Peninsula (Song 1991; Krestov and Nakamura 2002). The latter two alliances may be similar to the high-mountain coniferous forests of Taiwan because of the oceanic climate and geographic proximity, but comparative studies are lacking.

Taiwan harbours 29 species and 17 genera of gymnosperms, including 18 endemic species. Most of these species occur at elevations above 1000 m, either mixed with evergreen broad-leaved trees at elevations up to 2600 m or in pure coniferous stands higher up (Huang and Hsieh 1994). Two broad physiognomic types of zonal forests and one of azonal forest were recognised in the high mountains of Taiwan in the classification scheme proposed by Su (1984). The zonal forest at elevations 3100–3600 m was called subalpine coniferous forest. It is mainly characterised by *Abies kawakamii*, but *Juniperus squamata* can dominate in places. Another zonal forest at elevations 2500–3100 m was called upper montane coniferous forest. It is largely dominated by *Tsuga chinensis* var. *formosana*, but pure stands of *Picea morrisonicola* can also occur. Azonal forests dominated by *Pinus taiwanensis* in warm and dry habitats of south-facing slopes at elevations of 700–3300 m are usually regarded as post-fire communities (Liu T and Su 1978; Su 1984).

Pioneer phytosociological studies on the high-mountain vegetation of Taiwan were done by Suzuki (1935; 1936) and Suzuki et al. (1939). Using the Braun-Blanquet approach, Suzuki et al. (1939) classified *Juniperus squamata* woodland in the cirque of Nahu-Da Shan into three associations. Suzuki (1952) integrated the mountain coniferous forests in Taiwan and Japan in a single association called *Elatostema trilobulatum-Tsuga chinensis* var. *formosana*. Unfortunately, Suzuki was repatriated to Japan after World War II and his Taiwanese data, manuscript and herbarium specimens were not allowed to be taken with him. Therefore his paper (Suzuki 1952) lacked detailed description and comparative table of floristic composition of this vegetation type. After Suzuki, no studies applying the Braun-Blanquet approach were done in the high-mountain coniferous forests in Taiwan.

The aim of this study is to classify the high-mountain coniferous forest vegetation of Taiwan, describe alliances and associations according to the Braun-Blanquet approach and compare them with similar vegetation in the nearby geographical areas. It is also the first phytosociological study based on the new National Vegetation Diversity Inventory and Mapping Project database of Taiwan (Chiou et al. 2009). It intends to develop and demonstrate vegetation classification standards, which will subsequently be applied to forthcoming studies on vegetation diversity in other types of Taiwanese forest communities. We also introduce classification trees as a novel method for constructing practical dichotomous key for identification of vegetation types.

MATERIAL AND METHODS

Study Area

Taiwan is an island located in the Pacific Ocean off the coast of China on the Tropic of Cancer. The study area includes the high-mountain region consisting of the Central Range, Hsueh Shan Range and Yu Shan Range. The area of this high-mountain region above 2500 m a.s.l. (22.5–24.5º N, 120.5–121.5º E) is approximately 2400 km^2, i.e. about 7% of the whole island. There are more than 200 summits over 3000 m, with the highest peak reaching 3952 m a.s.l. Although topography and geology of the high-mountain regions are complex, the temperature is consistent with altitudinal gradient. The mean annual temperature increases from 5 ºC to 11 ºC as the elevation decreases from timberline (around 3500–3800 m a.s.l.) to 2500 m. The mean temperature of the coldest month (January) and warmest month (July) is -1 ºC and 8 ºC at timberline and 6 ºC and 14 ºC at 2500 m, respectively. Annual precipitation varies from 3071 mm

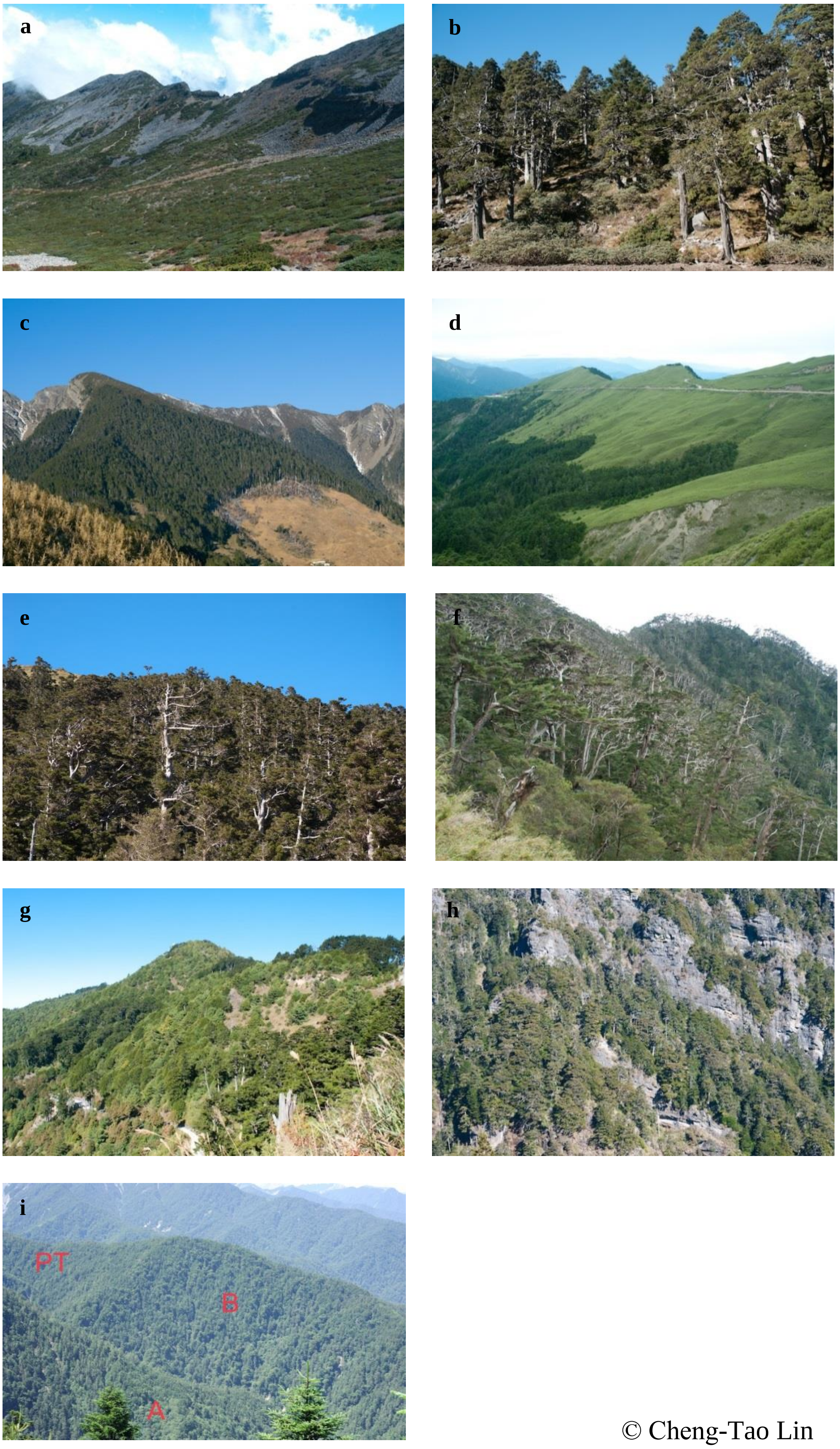
(Yu Shan, around 3800 m a.s.l.) to 3932 mm (Ali Shan, around 2500 m a.s.l.). Over 50% of precipitation falls in summer (from June to August). Snow cover occurs patchily above 3000 and 3300 m in northern and central Taiwan, respectively, from late December to March. Although elevation is the key factor influencing climate above 2500 m, the high insolation at high elevations together with complex topography also plays an important role in shaping the local climate (Lai et al. 2010). For example, in winter the south facing slopes have higher input of radiation than the north facing slopes. This supports wild fire occurrence on the south-facing slopes, because winter is usually a dry season in Taiwan. After fire, there is a quick regeneration of *Pinus taiwanensis* forests. At elevations of 1500–2500 m, there is a distinct cloud belt which makes an obvious boundary for the high-mountain coniferous forest occurring above 2500 m and evergreen broad-leaved forest dominated by Fagaceae and Lauraceae occurring under 1500 m. Within the cloud belt, forests are dominated by both coniferous species (e.g., *Chamaecyparis formosensis, C. obtusa* var. *formosana*, *Picea morrisonicola* and *Tsuga chinensis* var. *formosana*) and broad-leaved species (e.g., *Castanopsis cuspidata* var. *carlesii*, *Cyclobalanopsis morii*, *C. longinux*, *C. stenophylloides* and *Trochodendron aralioides*) (Su 1984). The species composition within the cloud belt is quite different from that in the high-mountain coniferous forest.

Data set

The relevés (vegetation-plot records) used in this study were sampled during the Taiwanese National Vegetation Diversity Inventory and Mapping Project (Chiou et al. 2009). Vegetation was sampled in plots of standard size of 400 m^2 across the whole National Forests of Taiwan. A total of 3564 plots were sampled in 2003–2008. In each plot, canopy height and total canopy cover were estimated. Environmental factors such as soil rockiness (the proportion of the rock particles greater than 5 mm in soil) and the percentage cover of bare soil were estimated. Topography of each plot was recorded using the following scale: 1 (ridge), 2 (upper slope), 3 (middle slope), 4 (lower slope) and 5 (valley bottom). Geographical coordinates of all plots were recorded using GPS. Other environmental factor such as slope inclination, aspect, elevation and site openness were taken from GIS layers derived from a digital terrain model (DTM) with a resolution of 40 by 40 meters. The site openness is the percentage number indicating how much sky view is not shaded by the surrounding topography (Lai et al. 2010). The floristic data were recorded separately for two layers. The first layer included trees and shrubs taller than 1.5 m. The diameter at breast height (DBH) of all individuals in this layer was measured and DBH data were used to calculate the importance value index (IVI = relative dominance, represented by the basal area + relative density, represented by the number of individuals; Curtis and McIntosh 1951). Since IVI itself is a relative parameter within one plot that cannot be compared among plots, IVI should be converted to a constant parameter such as percentage cover. To achieve this, IVI of each species was multiplied by the total canopy cover of the plot. The second layer included herbs, epiphytes and other woody species (including lianas and juveniles); the percentage cover of each species in this layer was estimated in the field.

The data set for this study was selected from these 3564 plots according to the criteria published by Su (1984). Natural zonal coniferous vegetation on moist to mesic substrates above 2500 m was selected, while vegetation related to dry soils, such as Taiwan red pine forest dominated by *Pinus taiwanensis*, high-mountain oak forest dominated by *Quercus spinosa* and *Q. tatakaensis* or other woodland types dominated by *Salix* spp., *Rhododendron* spp. and *Juniperus formosana*, as well as plantations, were excluded. The final data set consisted of 333 plots distributed across the whole high-mountain area of Taiwan.

Figure 1. Photos of the nine associations of the high-mountain coniferous forests of Taiwan. a – *Geranio hayatanum-Juniperetum squamatae*: the krummholz is *Juniperus squamata* and *Rhododendron pseudochrysanthum*; b – *Aconito fukutomei-Juniperetum squamatae*; c – *Junipero squamatae-Abietetum kawakamii*; d – *Yushanio niitakayamensis-Abietetum kawakamii*: the dark green colour is *Abies kawakamii* and the light green is *Yushania niitakayamensis*; e – *Tsugetum formosanae-Abietetum kawakamii*: the triangular crown with branches pointing down is *Abies kawakamii*, while the flat umbrella-like crown with horizontal twisted branches is *Tsuga chinensis* var. *formosana*; f – *Yushanio niitakayamensis-Tsugetum formosanae*; g – *Pino mastersianae-Tsugetum formosanae*: the light green trees are *Pinus armandii* var. *mastersiana* and the dark green on the ridge (top-right) is *Tsuga chinensis* var. *formosana*; h – *Rhododendro pseudochrysanthum-Tsugetum formosanae*; i – *Ellisiophyllo pinnati-Piceetum morrisonicolae*; on the northeastern-facing slope (A and B), the darker green trees with horizontal branches slightly pointing up are *Picea morrisonicola*; on the southeastern-facing slope (PT) the lighter green trees are *Pinus taiwanensis*. Photo credit: Cheng-Tao Lin.


a
b
c
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e
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i
PT
B
A

Data analysis

Vegetation classification on the level of association was based on cluster analysis, using Euclidean distance and flexible-beta clustering algorithm with $\beta = -0.3$ (percentage cover of species was log transformed prior to analysis). Results of cluster analysis were slightly modified using expert judgement and summarised in a synoptic table. Diagnostic species of each association were determined using the phi (Φ) coefficient of association (based on presence/absence data) as a measure of fidelity (Tichý and Chytrý 2006). The size of each association, measured by the number of plots belonging to it, was virtually standardised to 3% of the total data set. All species with $\Phi > 0.25$ and significant occurrence concentration in a particular association (Fisher's exact test, $P < 0.01$) were considered as diagnostic species of that association. Cluster analysis was performed using the PC-ORD program (version 5; McCune and Mefford 2006), while data editing and determination of diagnostic species were carried out in the JUICE program (version 7.0; Tichý 2002). Vegetation units of association and alliance were named following the International Code of Phytosociological Nomenclature (Weber et al. 2000).

In addition to classification, ordination analysis was performed to visualise dissimilarities between classified phytosociological associations and their position along the main environmental gradients. As an ordination method, we selected principal component analysis (PCA) combined with Hellinger transformation of log transformed species data. As a result of applying Euclidean distance (which is inherent to PCA) on Hellinger transformed species data, distribution of plots in the ordination space preserves the Hellinger distance. Legendre and Gallagher (2001) consider this to be an appropriate alternative to ordination methods based on chi-square distance such as correspondence analysis (CA; Hill 1974) and its detrended version (DCA; Hill and Gauch 1980). Ordination was calculated using the R program (R Development Core Team 2009) and its *vegan* package (Oksanen et al. 2010).

In order to facilitate understanding and application of the newly proposed phytosociological classification, we compiled a key for identification of associations, combining knowledge about species composition and associated environmental factors. The key was compiled using the results of classification tree analysis, based on the Classification and Regression Trees algorithm (CART; Breiman et al. 1984). Classification tree method allows the selection of the best predictors describing assignment of samples into particular groups (predictors being independent variables and assignment of samples into groups being dependent categorical variable). In our case, assignment of samples into groups was based on our classification into associations, and as predictors we used both species and environmental variables. To make the resulting key suitable for application in the field, we selected only species with frequency higher than 60% in at least one association (frequent species are applicable in most stands) and only environmental factors directly measurable in the

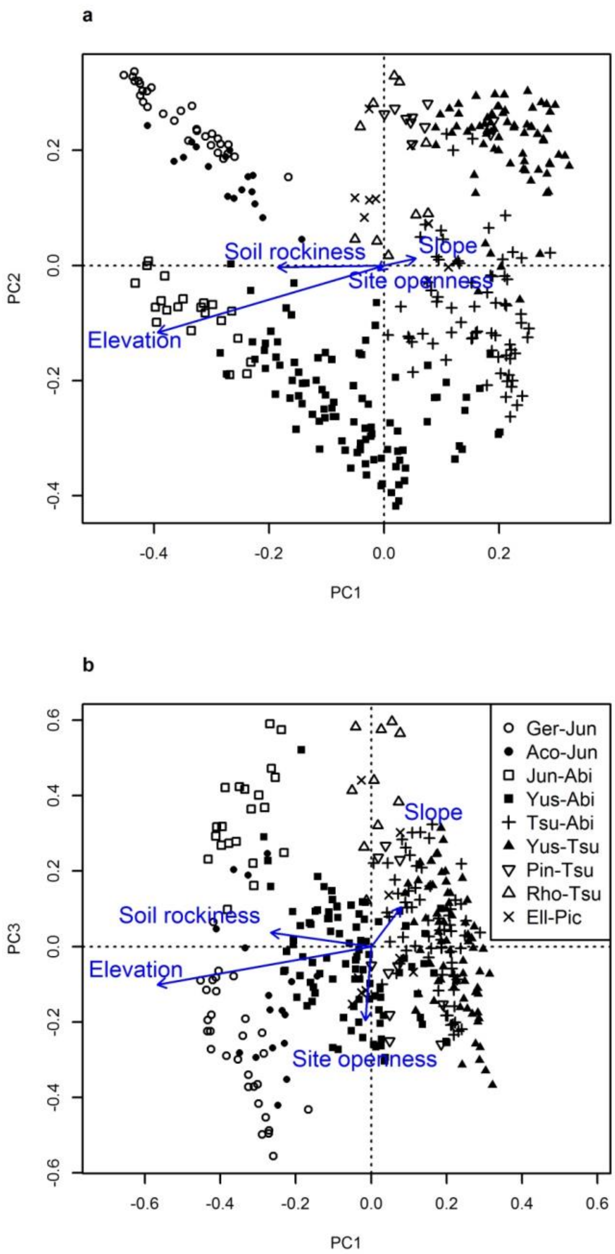

Figure 2. PCA ordination diagram of the nine associations of the high-mountain coniferous forests in Taiwan, with passively projected environmental variables: (a) first and second ordination axes, (b) first and third ordination axes. Association names are abbreviated with the first three letters of the genus names.

field (elevation, slope and soil rockiness). Classification tree was calculated using the R program's *rpart* package (Therneau and Atkinson 2010). Resulting identification key takes into consideration also surrogate variables selected for each split and its final form was further modified by expert judgement.

RESULTS

Two alliances with three and six associations, respectively, of the Taiwanese high-mountain coniferous forests were distinguished in this study (Table 1, Fig. 1). Relationships between associations were summarised in a PCA ordination diagram with passively projected environmental variables (Fig. 2) and in box plots with environmental variables (Fig. 3). Four variables were significantly related to the first and the third PCA axes, with importance decreasing in the following order: elevation, soil rockiness, site openness and slope. In our data set, there is no recorded environmental factor which can explain the second ordination axis. The plots with higher value on the second axis are dominated by *Juniperus squamata* or *Tsuga chinensis* var. *formosana*, while the plots with lower value are dominated by *Abies kawakamii* or *Picea morrisonicola*. In the field, large and old individuals of *Abies kawakamii* and *Picea morrisonicola* are frequently destroyed by strong wind, therefore we suggest the second axis is correlated with the strength of wind: the plots with higher scores on the second axis experience stronger wind than the plots with lower scores.

The two alliances are separated by elevation: *Juniperion squamatae* occurs above 3000 m a.s.l., whereas *Abieti kawakamii-Tsugion formosanae* occurs between 2400 and 3300 m. The soil of *Juniperion squamatae* is also stonier than that of *Abieti kawakamii-Tsugion formosanae* because the soil development is slower at higher elevations. Within *Juniperion squamatae*, habitat differences among its three associations can be characterised by wind, slope and site openness. *Junipero squamatae-Abietetum kawakamii* occurs at less windy sites with lower site openness, usually on steeper slopes than the other two associations dominated by *Juniperus squamata*. *Geranio hayatanum-Juniperetum squamatae* occurs at higher elevation and its habitat is influenced by stronger wind than *Aconito fukutomei-Juniperetum squamatae*. Comparing the six associations of the *Abieti kawakamii-Tsugion formosanae* alliance, *Yushanio niitakayamensis-Abietetum kawakamii* occurs at the highest elevation; *Rhododendro pseudochrysanthum-Tsugetum formosanae* occurs on the stony soils of steep slopes and *Ellisiophyllo pinnati-Piceetum morrisonicolae* on steep slopes with low site openness. The other three associations dominated by *Tsuga chinensis* var. *formosana* also in similar habitats, which are however less stony and differentiated with respect to wind conditions. *Tsugo formosanae-Abietetum kawakamii* occurs in less windy habitat than *Yushanio niitakayamensis-Tsugetum formosanae* and *Pino mastersianae-Tsugetum formosanae*.

The associations of high-mountain coniferous forests in Taiwan have similar structure except *Geranio hayatanum-Juniperetum squamatae*. There are usually three layers in above coniferous forests: the tree layer is usually composed of one or two 10–20 m tall coniferous species. Their herb and shrub layers are often not clearly separated, being dominated by a 1–2 m tall bamboo (*Yushania niitakayamensis*),

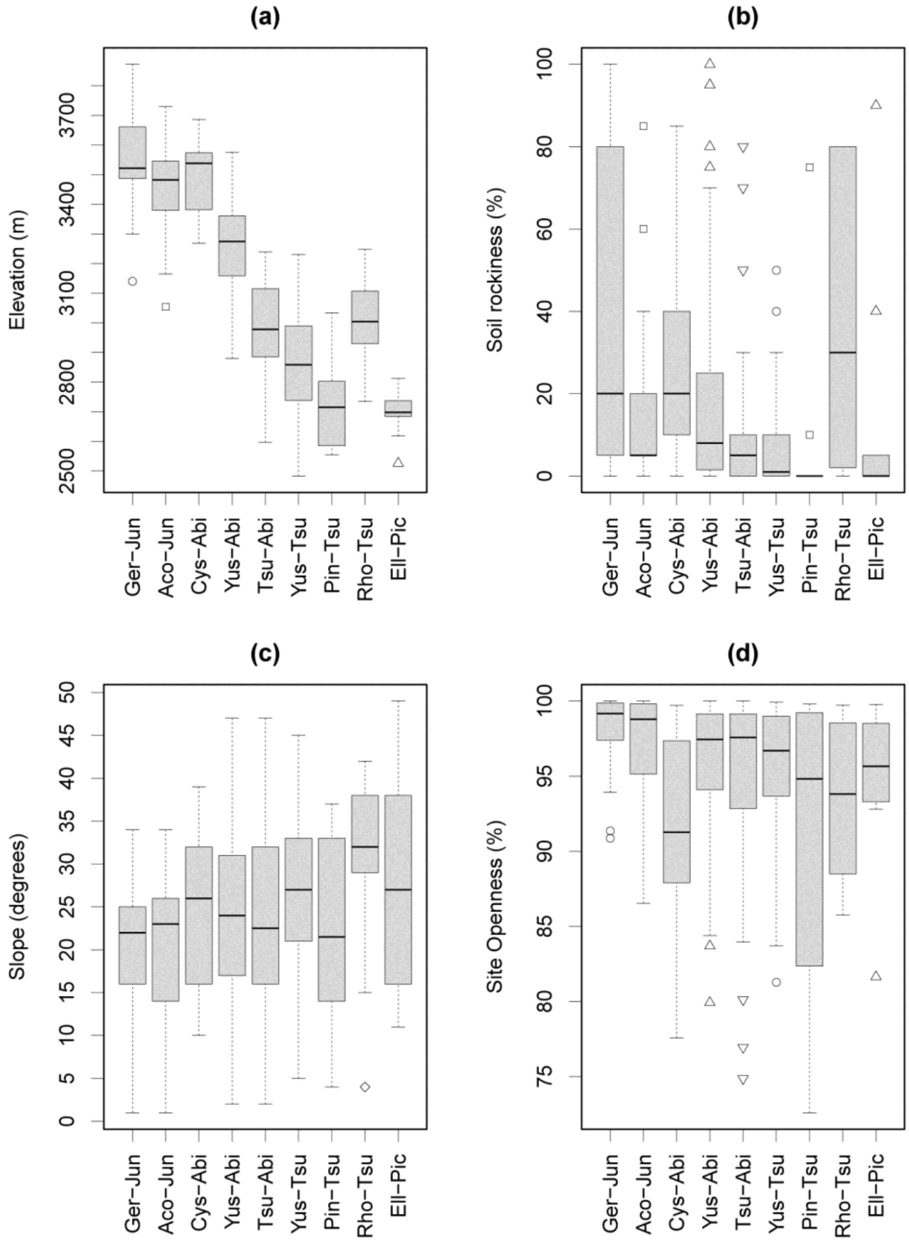

Figure 3 Environmental variables recorded in vegetation plots assigned to different associations. The association names are abbreviated using the first three letters of the genus names. Whiskers are between 5% and 95%; horizontal bars are the median; the upper edge of the box is the third quartile and the lower edge is the first quartile.

except on soils with the highest rockiness. Lianas and vascular plant epiphytes are rare both in terms of species number and cover.

SYNTAXONOMICAL SYNOPSIS

I. *Juniperion squamatae* Suzuki et al. 1939

1. *Geranio hayatanum-Juniperetum squamatae* Suzuki et al. 1939

2. *Aconito fukutomei-Juniperetum squamatae* Lin et al. 2012

3. *Junipero squamatae-Abietetum kawakamii* Lin et al. 2012

II. *Abieti kawakamii-Tsugion formosanae* Lin et al. 2012

4. *Yushanio niitakayamensis-Abietetum kawakamii* Lin et al. 2012

5. *Tsugo formosanae-Abietetum kawakamii* Lin et al. 2012

6. *Yushanio niitakayamensis-Tsugetum formosanae* Lin et al. 2012

7. *Pino mastersianae-Tsugetum formosanae* Lin et al. 2012

8. *Rhododendro pseudochrysanthum-Tsugetum formosanae* Lin et al. 2012

9. *Ellisiophyllo pinnati-Piceetum morrisonicolae* Lin et al. 2012

DESCRIPTION OF ASSOCIATIONS

1. *Geranio hayatanum-Juniperetum squamatae* Suzuki et al. 1939

Subalpine juniper scrub association

Synonyms: *Cystopterido moupinensis-Juniperetum squamatae* Suzuki et al. 1939, *Aulacolepido-Juniperetum squamatae* Suzuki et al. 1939

Nomenclature type (lectotypus hoc loco designatus): Suzuki et al. 1939: Table 3, relevé no. T2

This association forms the timberline at elevations of approximately 3500–3800 m. It usually occurs on wind-exposed summits of mountain ridges, which have a shallow, stony or rocky soil. There is usually no significant tree layer, while the shrub layer is formed of dense thicket of *Juniperus squamata*. In places, the canopy is composed of small trees (3–5 m) of *Juniperus squamata* in half-wind-shaded habitats. Other species such as *Berberis morrisonensis* and *Rosa sericea* var. *morrisonensis* are also common in the shrub layer. Shrubs are usually shorter than 2 m and form a cushion-like krummholz. On better-developed soils, *Yushania niitakayamensis* and broad-leaved shrubs, such as *Lonicera kawakamii* and *Rhododendron pseudochrysanthum* can be common. The herb layer is characterised by *Anaphalis nepalensis*, *Festuca ovina* and *Leontopodium microphyllum*, which occur in rocky or open habitats. The herb species typical of high-mountain springs and stream sides, such as *Athyrium reflexipinnum*, *Cystopteris moupinensis* and *Primula miyabeana*, occur at humid sites with better developed soil. Suzuki et al. (1939) described three associations of *Juniperus squamata* dominated vegetation, included in one alliance (Electronic Supplementary Material 2). All of them include sparse *Juniperus squamata* krummholz or small trees in the canopy layer, mixed with *Berberis morrisonensis*, *Lonicera kawakamii* and *Rosa sericea* var. *morrisonensis* in the shrub layer and *Aconitum fukutomei*, *Cystopteris moupinensis* and *Potentilla leuconota* in the herb layer. The plot size used by Suzuki et al. (1939) was 5 × 5 m. Therefore, we suppose the differences among these three associations proposed by Suzuki et al. (1939) are due to the small-scale variation within one community and we merge them into a single association, *Geranio hayatanum-Juniperetum squamatae* Suzuki et al. 1939.

2. *Aconito fukutomei-Juniperetum squamatae* ass. nov. hoc loco

Subalpine juniper woodland association

Nomenclature type (holotypus): relevé no. 27-0037 in Table 3.

This association has scattered occurrences on the bottom of cirques or on lower slopes in the mountainous regions of the Nanhu-Da Shan, Mabolasih Shan and Siouguluan Shan. The soil is better developed, with less stone or rock content than in the previous association. The canopy is around 10 m high, with sparse gaps, mainly dominated by Juniperus squamata. The shrub layer is composed of shrubs Berberis morrisonensis and Rhododendron pseudochrysanthum and the bamboo Yushania niitakayamensis. The rich herb layer includes species typical of different microhabitats. For example, the shade-tolerant species such as Arenaria takasagomontana, Chaerophyllum involucratum and Viola senzanensis are associated with more light-demanding species such as Hemiphragma heterophyllum, Hypericum nagasawae and Potentilla leuconota that occur in canopy gaps.

3. *Junipero squamatae-Abietetum kawakamii* ass. nov. hoc loco

Subalpine scree slope Taiwan fir forest association

Nomenclature type (holotypus): relevé no. 08-1044 in Table 3.

This association is distributed over the high mountains at 3300–3700 m a.s.l. It usually occurs on rocky slopes or screes with a thick moss layer. A subcanopy tree layer is formed of scattered individuals of *Sorbus randaiensis* that are up to 3 m high. The shrub layer is poorly developed with *Abies kawakamii* saplings, *Berberis morrisonensis*, *Rhododendron pseudochrysanthum*, *Ribes formosanum* and *Rosa transmorrisonensis*. The rich herb layer includes several species adapted to shaded, humid or rocky habitats. *Ainsliaea latifolia* subsp. *henryi*, *Cystopteris moupinensis*, *Oxalis acetosella* subsp. *griffithii* and *Saussurea glandulosa* are typical of humid and shaded habitats. *Cystopteris fragilis*, *Deschampsia flexuosa*, *Sedum morrisonense* and *Viola adenothrix* var. *tsugitakaensis* are common on rock outcrops or shallow soil.

4. *Yushanio niitakayamensis-Abietetum kawakamii* ass. nov. hoc loco

Taiwan fir forest association

Nomenclature type (holotypus): relevé no. 30-0191 in Table 3.

This association is also widely distributed in the high mountains at 2900–3600 m a.s.l. on slopes of various aspects with well-drained and deep soil. The canopy layer is dominated by *Abies kawakamii*. In the shrub layer the bamboo *Yushania niitakayamensis* occurs together with few saplings of *Abies kawakamii* and *Juniperus squamata* in the understorey. Due to high density of *Yushania niitakayamensis* coupled with a closed canopy, there are very few species in the herb layer: they include mainly shade-tolerant herbs such as *Ainsliaea latifolia* subsp. *henryi*, *Galium echinocarpum* and *Oxalis acetosella* subsp. *griffithii*.

5. *Tsugo formosanae-Abietetum kawakamii* ass. nov. hoc loco

Taiwan fir and Taiwan hemlock forest association

Nomenclature type (holotypus): relevé no. 02-0471 in Table 3.

This association occurs at 2600–3250 m a.s.l., mainly on north- to east-facing slopes with deep soil. The canopy layer is composed of *Tsuga chinensis* var. *formosana* mixed with *Abies kawakamii*. Its open canopy, twisted shape of tree crowns and typical location in saddles between mountain peaks suggest that this vegetation is frequently disturbed by wind. *Eurya glaberrima* forms the shrub layer together with dense stands of *Yushania niitakayamensis*. The herb layer is poorly developed with a few shade-tolerant and moisture-demanding species such as *Ainsliaea latifolia* subsp. *henryi* and *Elatostema trilobulatum*.

6. *Yushanio niitakayamensis-Tsugetum formosanae* ass. nov. hoc loco

Taiwan hemlock forest association

Nomenclature type (holotypus): relevé no. 20-0293 in Table 3.

This association is widespread between 2500 and 3250 m a.s.l. in the upper montane regions of Taiwan. It occurs either on the main ridges or the side ridges which extend from the main ridges above 3100 m. The habitat is moist, with thick soil, poor in rock and stone content, and with high value of topographic site openness. There are usually four layers in this association. The canopy layer is dominated by *Tsuga chinensis* var. *formosana*, while *Eurya glaberrima*, *Ilex bioritsensis* and *Viburnum betulifolium* are often scattered in the lower tree layer. The shrub layer is approximately 2–3 m high and always dominated by very dense stands of *Yushania niitakayamensis*. The herb layer is poorly developed with a few moisture-demanding species, including ferns such as *Crypsinus quasidivaricatus* and *Plagiogyria formosana*. Lianas or epiphytic ferns such as *Hydrangea integrifolia* and *Lepisorus thunbergianus* occur sparsely.

7. *Pino mastersianae-Tsugetum formosanae* ass. nov. hoc loco

Upper montane Masters pine forest association

Nomenclature type (holotypus): relevé no. 09-3060 in Table 3.

This association is distributed in the upper montane regions at 2600–2800 m a.s.l. It is confined to south-facing slopes with deep soil, which is rich in clay, poor in stones and rocks, and with a thick humus layer. This association usually occurs on the lower valley slopes. The canopy is mainly dominated by *Pinus armandii* var. *mastersiana* and *Tsuga chinensis* var. *formosana*. Occasionally, they are mixed with *Juniperus formosana* or *Pinus taiwanensis.* The shrub layer is composed of well-developed *Yushania niitakayamensis* stands mixed with saplings of *Tsuga chinensis* var. *formosana* and other broad-leaved species such as *Lonicera acuminata*, *Lyonia ovalifolia*, *Rhododendron rubropilosum* and *Vaccinium japonicum* var. *lasiostemon*. Tall grass *Miscanthus sinensis* forms dense stands at sites with recently disturbed canopy. Lianas and ferns such as *Hydrangea integrifolia* and *Dryopteris formosana* are prevalent in moist places. Compared to the other high-mountain coniferous forests, cloud-forest species occasionally occur in this association (e.g., evergreen broad-leaved species such as *Schefflera taiwaniana* and *Symplocos morrisonicola*, coniferous species such as *Chamaecyparis formosensis* or epiphytic ferns such as *Mecodium polyanthus* and *Araiostegia parvipinnula*).

8. *Rhododendro pseudochrysanthum-Tsugetum formosanae* ass. nov. hoc loco

Scree slope Taiwan hemlock forest association

Nomenclature type (holotypus): relevé no. 25-0035 in Table 3.

This association occurs on ridges or steep slopes of the upper montane belt at 2700–3250 m a.s.l. The soil of this association is shallow and rocky. It is dominated by *Tsuga chinensis* var. *formosana* in the canopy layer and contains a species-rich herb layer. The shrub layer is composed of *Eurya glaberrima*, *Rhododendron pseudochrysanthum*, *R. rubropilosum* and *Ribes formosanum*. Like in the subalpine scree slope Taiwan fir forest, *Yushania niitakayamensis* stands are scarcer than in the other types of high-mountain coniferous forests occurring on deep soil. The herb layer is dominated by *Ainsliaea latifolia* subsp. *henryi*. *Cirsium arisanense* and *Sedum morrisonense* indicate a rocky substrate. *Circaea alpina* subsp. *imaicola*, *Myriactis humilis* and epiphytic ferns such as *Araiostegia parvipinnula*, *Crypsinus quasidivaricatus* and *Mecodium polyanthos* indicate humid site conditions.

9. *Ellisiophyllo pinnati-Piceetum morrisonicolae* ass. nov. hoc loco

Upper montane Taiwan spruce forest association

Nomenclature type (holotypus): relevé no. 08-1028 in Table 3.

This association has scattered occurrences in various types of nutrient-rich and wet habitats in the upper montane regions, such as the Nanhu-Da Shan and Yu Shan at 2600–2850 m a.s.l. It is often found in stream valleys, on unstable steep slopes affected by erosion and landslides. The soil is often thick and has low rockiness. The tree layer is dominated by *Picea morrisonicola*, with and admixture of *Abies kawakamii* and *Tsuga chinensis* var. *formosana* in places. *Neolitsea acuminatissima*, *Quercus spinosa* and *Yushania niitakayamensis* are prevalent in the shrub layer together with *Berberis kawakamii*, *Eurya leptophylla*, *Osmanthus heterophyllus* and *Prinsepia scandens*. The herb layer is rich in species. *Elatostema trilobulatum* and *Ellisiophyllum pinnatum* indicate a humid and shaded understorey. *Urtica thunbergiana* and ferns with frond length up to 1 m (e.g. *Dryopteris wallichiana* and *Polystichum parvipinnulum*) indicate a nutrient-rich habitat. Lianas such as *Hydrangea integrifolia* have high cover, while other epiphytes such as *Araiostegia parvipinnula*, *Smilax vaginata* and *Tripterospermum lanceolatum* have low cover.

DESCRIPTION OF ALLIANCES

I. *Juniperion squamatae* Suzuki et al. 1939

Subalpine juniper woodland alliance

Nomenclature type: *Geranio hayatanum-Juniperetum squamatae* Suzuki et al. 1939 (lectotypus hoc loco designatus)

Diagnostic species: see Table 1.

This alliance includes the associations *Geranio hayatanum-Juniperetum squamatae*, *Aconito fukutomei-Juniperetum squamatae* and *Junipero squamatae-Abietetum kawakamii*, which represent woodlands and forests scattered across the mountain ridges and slopes of the Central Range, Hsueh Shan Range and Yu Shan Range at elevation from 3100 to 3800 m. They occur under extreme environmental conditions such as strong wind, shallow soil with a high content of stones and low temperature with winter snow cover. The canopy layer is formed mainly by *Juniperus squamata* and *Abies kawakamii*. The shrub layer is usually composed of *Berberis morrisonensis*, *Lonicera kawakamii*, *Rhododendron pseudochrysanthum*, *Rosa sericea* var. *morrisonensis* and *Yushania niitakayamensis*. The herb layer is characterised by a combination of subalpine species such as *Anaphalis nepalensis*, *Deschampsia flexuosa*, *Hypericum nagasawae*, *Gentiana arisanense* and *Sedum morrisonense* on rocky substrates, and *Ainsliaea latifolia* subsp. *henryi*, *Chaerophyllum involucratum*, *Oxalis acetosella* subsp. *griffithii* and *Saussurea* *glandulosa* in shaded and humid habitats. Ferns are not common. *Cystopteris fragilis*, *Dryopteris alpestris* and *Polystichum morii* are indicators of rocky habitats, while *Cystopteris moupinensis* indicates nutrient-rich and humid environment.

II. *Abieti kawakamii-Tsugion formosanae* all. nov. hoc loco

Upper montane Taiwan fir and Taiwan hemlock forest alliance

Nomenclature type (holotypus): *Tsugo formosanae-Abietetum kawakamii* Lin et al. 2012

Diagnostic species: see Table 1.

This alliance occurs at elevations from 2500 to 3600 m and includes six associations of coniferous forests mainly dominated by *Abies kawakamii* and *Tsuga chinensis* var. *formosana* on slopes of various aspects in the upper montane belt. Their habitat is characterised by humid, well-developed soil. Their lower elevation limit (2500 m) coincides with the upper boundary of the montane cloud belt. *Picea morrisonicola* occurs on nutrient-rich soils, whereas *Pinus armandii* var. *mastersiana* on not well-drained soils (some of them are swampy during the rainy season). The lower tree layer is usually formed of evergreen broad-leaved trees (e.g. *Eurya glaberrima*) or deciduous trees (e.g. *Sorbus randaiensis* and *Viburnum betulifolium*). The shrub layer is mainly dominated by dense stands of *Yushania niitakayamensis* on soils with lower rockiness. *Berberis kawakamii*, *Ilex yunnanensis* var. *parvifolia* and *Rhododendron pseudochrysanthum* also occur under sparse canopy in the shrub layer. The herb layer is poorly developed due to shading by dense stands of *Yushania niitakayamensis*. It is usually formed of shade-tolerant species of wet habitats, such as *Ainsliaea latifolia* subsp. *henryi*, *Elatostema trilobulatum* and *Oxalis acetosella* subsp. *griffithii*. Ferns such as *Cystopteris moupinensis* and *Plagiogyria formosana* are also common on nutrient-rich and humid soils. Lianas and epiphytic ferns such as *Araiostegia parvipinnula*, *Crypsinus quasidivaricatus* and *Hydrangea integrifolia* attain a low cover in this alliance. On rocky soils *Yushania niitakayamensis* is less dominant, and such sites are rich in herb species such as *Chimaphila japonica*, *Ctenis transmorrisonensis* and *Dryopteris lepidopoda*.

IDENTIFICATION KEY TO THE ASSOCIATIONS

A1 *Tsuga chinensis* var. *formosana* tree cover ≤ 10%, *Eurya glaberrima* cover < 0.5%

B1 *Abies kawakamii* tree cover < 5%, *Ainsliaea latifolia* subsp. *henryi* cover ≥ 10%

C1 *Juniperus squamata* tree cover > 5%, *Abies kawakamii* tree cover ≥ 0.5%, *Rhododendron pseudochrysanthum* cover ≥ 10%, *Juniperus squamata* shrub cover

≤10 %, *Hypericum nagasawae* cover ≥ 0.5%, occurrence on lower slopes or on valley bottoms .... **2 *Aconito fukutomei-Juniperetum squamatae***

C2 *Juniperus squamata* tree cover ≤ 5%, *Abies kawakamii* tree cover < 0.5%, *Rhododendron pseudochrysanthum* cover < 10%, *Juniperus squamata* shrub cover > 10%, *Hypericum nagasawae* cover < 0.5%, middle and upper slopes or ridges

D1 *Picea morrisonicola* tree cover < 3%, *Tsuga chinensis* var. *formosana* tree cover < 2%, *Juniperus squamata* shrub cover ≥ 5%, *Berberis morrisonensis* cover > 0.5%, *Hydrangea integrifolia* cover < 0.5%, elevation > 3100 m a.s.l. .... **1 *Geranio hayatanum-Juniperetum squamatae***

D2 *Picea morrisonicola* tree cover ≥ 3%, *Tsuga chinensis* var. *formosana* tree cover ≥ 2%, *Juniperus squamata* shrub cover < 5%, *Berberis morrisonensis* cover ≤ 0.5%, *Hydrangea integrifolia* cover ≥ 0.5%, elevation ≤ 3100 m a.s.l.

E1 *Pinus armandii* var. *mastersiana* tree cover ≥ 2%, *Picea morrisonicola* tree cover < 30%, *Miscanthus sinensis* cover > 5% .... **7 *Pino mastersianae-Tsugetum formosanae***

E2 *Pinus armandii* var. *mastersiana* tree cover < 2%, *Picea morrisonicola* tree cover ≥ 30%, *Miscanthus sinensis* cover ≤ 5% .... **9 *Ellisiophyllo pinnati-Piceetum morrisonicolae***

B2 *Abies kawakamii* tree cover ≥ 5%, *Ainsliaea latifolia* subsp. *henryi* cover < 10%.

C1 *Rhododendron pseudochrysanthum* cover ≥ 2%, *Ainsliaea latifolia* subsp. *henryi* cover ≥ 10%, *Deschampsia flexuosa* cover > 5%, elevation > 3500 m a.s.l. . ... **3 *Junipero squamatae-Abietetum kawakamii***

C2 *Rhododendron pseudochrysanthum* cover < 2%, *Ainsliaea latifolia* subsp. *henryi* cover < 10%, *Deschampsia flexuosa* cover ≤ 5%, elevation ≤ 3500 m a.s.l.

D1 *Juniperus squamata* shrub cover > 30%, *Yushania niitakayamensis* cover ≤ 0.5%, *Hydrangea integrifolia* cover ≤ 0.5% ....**3 *Junipero squamatae-Abietetum kawakamii***

D2 *Juniperus squamata* shrub cover ≤ 30%, *Yushania niitakayamensis* cover > 0.5%, *Hydrangea integrifolia* cover > 0.5% .... **4 *Yushanio niitakayamensis-Abietetum kawakamii***

A2 *Tsuga chinensis* var. *formosana* tree cover > 10%, *Eurya glaberrima* cover ≥ 0.5%

B1 *Abies kawakamii* tree cover ≥ 5%, elevation > 2900 m a.s.l.

C1 *Abies kawakamii* tree cover ≥ 20%, *Tsuga chinensis* var. *formosana* tree cover ≤ 70%, *T. chinensis* var. *formosana* sapling cover ≤ 5%, *Yushania niitakayamensis* cover > 5%, *Ainsliaea latifolia* subsp. *henryi* cover < 5% .... **5 *Tsugo formosanae-Abietetum kawakamii***

C2 *Abies kawakamii* tree cover < 20%, *Tsuga chinensis* var. *formosana* tree cover > 70%, *T. chinensis* var. *formosana* sapling cover > 5%, *Yushania niitakayamensis* cover ≤ 5%, *Ainsliaea latifolia* subsp. *henryi* cover ≥ 5% .... **8 *Rhododendro pseudochrysanthum-Tsugetum formosanae***

B2 *Abies kawakamii* tree cover < 5%, elevation ≤ 2900 m a.s.l.

C1 *Yushania niitakayamensis* cover > 10%, *Rhododendron pseudochrysanthum* cover ≤ 5%, *Ainsliaea latifolia* subsp. *henryi* cover ≤ 15%, soil rockiness ≤ 50%

D1 *Tsuga chinensis* var. *formosana* tree cover ≥ 30%, *Yushania niitakayamensis* cover > 80%, *Miscanthus sinensis* cover < 2% and forest height ≥ 10 m

E1 *Elatostema trilobulatum* cover ≥ 5%, *Ainsliaea latifolia* subsp. *henryi* cover ≥ 5 %, *Berberis morrisonensis* cover ≤ 0.5%, elevation ≥ 2700 m a.s.l., slope > 10˚ .... **5 *Tsugo formosanae-Abietetum kawakamii***

E1 *Elatostema trilobulatum* cover < 5%, *Ainsliaea latifolia* subsp. *henryi* cover < 5%, *Berberis morrisonensis* cover > 0.5%, elevation < 2700 m a.s.l., slope ≤ 10˚ .... **6 *Yushanio niitakayamensis-Tsuga formosanae***

D2 *Tsuga chinensis* var. *formosana* tree cover ≤ 30%, *Yushania niitakayamensis* cover ≤ 80%, *Miscanthus sinensis* cover ≥ 2% and forest height < 10 m .... **7 *Pino mastersianae-Tsugetum formosanae***

C2 *Yushania niitakayamensis* cover ≤ 10%, *Rhododendron pseudochrysanthum* cover > 5%, *Ainsliaea latifolia* subsp. *henryi* cover > 15%, soil rockiness > 50% ... . **8 *Rhododendro pseudochrysanthum-Tsugetum formosanae***

DISCUSSION

The pioneer phytosociological classification of the high-mountain vegetation of Taiwan according to the Braun-Blanquet approach, proposed by Suzuki (Suzuki et al. 1939), was based on limited data sets and the background data are not available today. Suzuki et al. (1939) focused on rock outcrops and surrounding vegetation in the cirque region (Nanhu-Da Shan, northeastern Taiwan), which is covered by grassland with scattered scrub of *Juniperus squamata*. Although Suzuki et al. (1939) used Japanese plant names in their tables of individual relevés, their synoptic table (Table 15) contains both Japanese and scientific names, therefore their descriptions are valid according to the International Code of Phytosociological Nomenclature (Weber et al. 2000). We accept one association and one alliance of their classification within our classification scheme. In order to facilitate interpretation of their data in the future we present the tables of their *Juniperus squamata* dominated associations with scientific names in Electronic Supplementary Material 2.

In eastern Asia, *Abies* and *Tsuga* dominated forests have been described from the oceanic climate sector (e.g., *Abieti koreanae-Piceetum jezoensis* Song 1991, *Abietetum veitchio-mariesii* Maeda et Shimazaki 1951, *Maiantho-Tsugetum diversifoliae* Suzuki-Tokio 1949 and *Saso-Abietetum koreanae* Song et Nakanishi 1985), but their diagnostic species such as *Abies homolepis*, *A. veitchii*, *Acer micranthum*, *Rhododendron tschonoskii*, *Sasa palmata*, *Sorbus commixta*, *Streptopus streptopoides* var. *japonicus* and *Vaccinium yatabei* (Song 1991; Nakamura and Krestov 2005) are absent in Taiwanese coniferous forests.

Regarding the *Abies kawakamii* dominated vegetation, most of the previous classification schemes (e.g., Liu T 1971; Chiu et al. 2008; Chiou et al. 2009) relied on physiognomy and were similar to the concept of Su (1984), which also used the dominant woody species as the main classification criterion. Considering physiognomy of *Abies kawakamii* forests, previous studies usually treated them as "*Abies kawakamii* community" (e.g., Liu T 1971) or "*Abies kawakamii-Yushania niitakayamensis* community" (e.g., Chen 1998; Chen TY 2004; Chen YF 2004). The forests of *Abies kawakamii* mixed with *Juniperus squamata* in rocky habitats were also treated as a variation of *Abies kawakamii* forest (Su 1988). In phytosociological classification concept presented here, the *Abies kawakamii* and *Juniperus squamata* forest containing several subalpine species adapted to rock outcrop habitats is assigned to the association *Junipero squamatae-Abietetum kawakamii*. The above mentioned "traditional" *Abies kawakamii* forest communities can be recognised as *Yushanio niitakayamensis-Abietetum kawakamii* in our study.

Yushanio niitakayamensis-Abietetum kawakamii together with *Tsugo formosanae-Abietetum kawakamii* and *Yushanio niitakayamensis-Tsugetum formosanae* have only few diagnostic species in our analysis. They contain dense stands of *Yushania niitakayamensis* in the shrub layer and species-poor herb layer composed of a few shade-tolerant species. Therefore, most of the previous studies that considered dominant woody species as the only classification criterion regarded these forest communities as a single unit, "*Abies kawakamii* or *Tsuga chinensis* var. *formosana* dominated forest" (e.g., Liu T 1971; Su 1984). We used the same criteria, the dominant species, and classified the *Abies kawakamii* or *Tsuga chinensis* var. *formosana* dominated forests into three associations. Although there are no obvious diagnostic species besides the dominants, these three associations have quite different crown shapes: *Abies kawakamii* dominated forests triangular shape, *Tsuga chinensis* var. *formosana* dominated forests open umbrella-like shape, and the mixed type both of these crown shapes and usually twisted trunks. The dominant *Tsuga chinensis* var. *formosana* is gradually replaced by *Abies kawakamii* with increasing elevation. Chen YF (1998) observed that in the high-mountain area, habitats at elevations lower than the snow line are dominated by *Tsuga chinensis* var. *formosana*, while those above the snow line are dominated by *Abies kawakamii*. Around the snow line, both trees are mixed. Here we suggest that this dominance change is caused by combined effects of temperature, snow and wind. *Tsugo formosanae-Abietetum kawakamii* often occurs in saddles where the wind passes. In winter, habitats influenced by strong wind (usually affected by monsoon) are much wetter and colder than the wind-shaded habitats at the same elevation. At night, the habitats influenced by strong wind have a higher chance to be covered by snow. In such habitats neither *Abies kawakamii* nor *Tsuga chinensis* var. *formosana* is competitively stronger: they can grow together with similar dominance. Their twisted trunks indicate that the habitat is influenced by wind, which is not optimal for any of these two species even though they can still grow there.

In previous literature, the *Pinus armandii* var. *mastersiana*, *Picea morrisonicola* and *Tsuga chinensis* var. *formosana* dominated forests were included in *Tsuga-Picea* zone (Su 1984) or treated as various *Tsuga* or *Picea* dominated communities, such as "*Picea morrisonicola-Tsuga chinensis* var. *formosana-Pinus armandii* var. *mastersiana* dominated community" or "*Picea morrisonicola-Pinus taiwanensis* associes" (Liu TS and Su 1978; Chen YF 2004). In our study, we treat forests dominated by *Pinus armandii* var. *mastersiana* and *Picea morrisonicola* as two associations belonging to the alliance *Abieti kawakamii-Tsugion formosanae*. *Pinus armandii* var. *mastersiana* grows in concave landforms with deep soil, which can become swampy after heavy rains as a consequence of impaired drainage. These habitats attract more human activities (e.g., camping, shelter and road construction) than steep and stony slopes. Consequently, *Pino mastersianae-Tsugetum formosanae* association is characterised by pioneer or disturbance-adapted species such as *Berberis kawakamii*, *Miscanthus sinensis* and *Ribes formosanum*. *Picea morrisonicola* is geographically limited and confined to occurrence of phyllites. To our knowledge, there is no explanation of this phenomenon. These phillite sites usually form unstable steep slopes that are difficult to access. The soil and humus layer is thick and humid but it contains large amount of fine stones (the stone size is usually less than 5 mm). *Ellisiophyllo pinnati-Piceetum morrisonicolae* occurs in such kind of habitat. In the canopy layer, *Picea morrisonicola* is often mixed with other high-elevation coniferous tree. Unlike in the other associations, many herbaceous species can grow with dense *Yushania niitakayamensis* in the understorey. This association is unique by a number of diagnostic species of its own comparing to the other associations of *Abieti kawakamii-Tsugion formosanae*.

In northern regions of eastern Asia, the *Pinus pumila* krummholz communities (*Vaccinio-Pinion pumilae* Suzuki-Tokio 1964) have similar physiognomy as the *Juniperus squamata* scrub, but the climate (short growing seasons with low temperature) and floristic composition of zonal *Pinus pumila* krummholz is quite different from the *Juniperus squamata* scrub. There are also *Juniperus communis* (including *J. sibirica*) communities in northeastern Asia and *Juniperus squamata* communities in the Himalayas (Flora of China Editorial Committee 1999), but phytosociological studies on them are still absent. Therefore, the alliance *Juniperion squamatae* published by Suzuki et al. (1939) is suitable for *Juniperus squamata* communities in Taiwan. Besides the dominant *Juniperus squamata*, it is characterised by many subalpine herbaceous species, such as *Arabis lyrata* subsp. *kamtschatica*, *Cystopteris fragilis*, *Deschampsia flexuosa* and *Festuca ovina* representing boreal and temperate element (Hsieh et al. 1994; Al-Shehbaz and O'Kane 2002); *Anaphalis nepalensis*, *Hemiphragma heterophyllum*, *Potentilla leuconota* and *Solidago virgaurea* var. *leiocarpa* representing the southwestern China and Taiwan vicariance element (Chen 1979; Wang 1989; Hsieh 2002); and also *Gaultheria itoana* and *Chaerophyllum involucratum* representing South Pacific Basin element (Heads 2003; Chung et al. 2005; Chung 2007).

Similar *Abies*- or *Picea*-dominated forests in eastern Asian oceanic sector are represented by *Abietion koreanae* Song 1991, *Abietion mariesii* Suzuki-Tokio 1954 and *Piceion jezoensis* Suzuki-Tokio ex Jinno et Suzuki 1973 (Nakamura et al. 2007), while their diagnostic species (e.g. *Abies koreana*, *A. mariesii*, *A. veitchii*, *Acer micranthum*, *Angelica polymorpha*, *Berberis amurensis* var. *quelpaertensis*, *Coptis japonica* var. *dissecta*, *C. quinquefolia*, *Streptopus streptopoides* var. *japonicus*, *Tsuga diversifolia* and *Vaccinium yatabei*) are absent in the high-mountain coniferous forests of Taiwan. The *Tsuga* dominated forests in similar oceanic sector of cool temperate zone in mountainous Japan are represented by the *Tsuga sieboldii* forest (alliance *Tsugion sieboldii* Suzuki-Tokio 1952 belonging to *Fagetea crenatae* Miyawaki et al. 1964), which usually forms edaphic climax communities on the ridges and is characterised by many deciduous broad-leaved genera, such as *Acer*, *Carpinus*, *Fagus* and *Quercus* (Nakamura and Krestov 2005). However, the *Tsuga sieboldii* forest has quite different floristic composition from the upper montane *Tsuga chinensis* var. *formosana* forest in Taiwan. Therefore, we introduce a new alliance *Abieti kawakamii-Tsugion formosanae*, which is characterised by species of the eastern Himalayan and southwestern Chinese element, such as *Abies kawakamii*, *Eurya glaberrima* and *Tsuga chinensis* var. *formosana* (Shen 1994; Mitsui et al. 2007; Havil et al. 2008).

On the order level, the high-mountain coniferous forests in Taiwan could be compared with orders *Abieti-Piceetalia* Miyawaki et al. 1968 or *Saso-Fagetalia crenatae* Suzuki-Tokio 1966 of the maritime or oceanic sectors in East Asia. The floristic composition of *Vaccinio-Pinetalia pumilae* Suzuki-Tokio 1964 in the subalpine regions is different from *Juniperion squamatae,* just as the species composition of *Abieti-Piceetalia* and *Saso-Fagetalia crenatae* is different from *Abieti kawakamii-Tsugion formosanae* (Song 1992; Nakamura and Krestov 2005; Nakamura et al. 2007). Furthermore, the alliance *Abieti kawakamii-Tsugion formosanae* is no clearly differentiated in Table 1 and most of its diagnostic species are endemic or related to the species of southwestern China and the Himalayas. Therefore, it would be premature to describe a new phytosociological order until phytosociological data from China are available and used for comparison.

An important question is whether the high-mountain coniferous forests of Taiwan belong to the phytosociological class *Vaccinio-Piceetea*. The forests of *Vaccinio-Piceetea* class are generally recognised by the dominant coniferous species of the genera *Abies*, *Larix*, *Picea*, *Pinus*, *Thuja* and *Tsuga* and deciduous species of the genera *Alnus*, *Betula* and *Populus* with evergreen dwarf shrubs of *Vaccinium* spp. (Ericaceae) in the understorey, while the well-developed moss layer is dominated by widely distributed species such as *Hylocomium splendens* and *Pleurozium schreberi* (Spribille and Chytrý 2002; Hytteborn et al. 2005). Considering the floristic composition in tree layer of high-mountain coniferous forests in Taiwan, the dominant coniferous species are *Abies kawakamii*, *Juniperus squamata*, *Tsuga chinensis* var. *formosana* and *Picea morrisonicola*. Although the genera *Abies*, *Tsuga* and *Picea* are key character of *Vaccinio-Piceetea*, recent phylogenetic studies indicate that above-mentioned species are closely related to species of southwestern China (Havil et al. 2008; Xiang et al. 2009). *Alnus*, *Betula* and *Populus* are absent in the Taiwanese high-mountain coniferous forests, as well as evergreen *Vaccinium* in the shrub layer, being replaced by evergreen *Rhododendron* spp. In the herb layer, most of the diagnostic species of *Vaccinio-Piceetea* are absent although it contains some boreal and temperate genera of Eurasian origin, such as *Deschampsia*, *Festuca* or *Leontopodium*. Elements of southwestern China and the Himalayas (e.g., *Anaphalis* and *Hemiphragma*; Wang 1989; Huang and Hsieh 1994) and also Sino-Japanese elements (e.g., *Ainsliaea* and *Eurya*; Mitsui et al. 2007; Wu et al. 2007) are also common in the high-mountain coniferous forests of Taiwan. Unfortunately, we do not have sufficient data for analysis of the species composition of bryophytes occurring in these forests although several diagnostic bryophyte species of *Vaccinio-Piceetea*, such as *Hylocomium splendens*, *Dicranum majus* and *Pogonatum japonicum* were discovered in the Taiwan fir and hemlock forests. In general, floristic composition and the climatic conditions with no harsh winter or heavy snow cover do not provide strong support for the assignment of Taiwanese high-mountain coniferous forests to *Vaccinio-Piceetea*. The system of orders and classes may be only established after more phytosociological studies are conducted in humid subtropical and tropical mountainous regions in the future.

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Table 1. Shortened synoptic table of the high-mountain coniferous forest vegetation in Taiwan. The association number 1 is *Geranio hayatanum-Juniperetum squamatae*; 2: *Aconito fukutomei-Juniperetum squamatae*; 3: *Junipero squamatae-Abietetum kawakamii*; 4: *Yushanio niitakayamensis-Abietetum kawakamii*; 5: *Tsugo formosanae-Abietetum kawakamii*; 6: *Yushanio niitakayamensis-Tsugetum formosanae*; 7: *Pino mastersianae-Tsugetum formosanae*; 8: *Rhododendro pseudochrysanthum-Tsugetum formosanae*; 9: *Ellisiophyllo pinnatum-Piceetum morrisonicolae*. The alliance number I and II indicates the *Juniperion squamatae* and *Abieti kawakamii-Tsugion formosanae*. The numbers in the table are percentage occurrence frequencies (constancies). Species are sorted by their occurrence in canopy and subcanopy (C; individuals higher than 1.5 m) or understorey (U; individuals lower than 1.5 m), and within them by decreasing fidelity (phi coefficient) within each association. Light and dark grey background indicates fidelity of $\Phi > 0.25$ and $\Phi > 0.5$, respectively; these species are considered as diagnostic. The species with fidelity of $\Phi < 0.25$ and frequency less than 20% are excluded in this shortened synoptic table. See Table S1 in Electronic Supplementary Material for the full version of this table.

Alliance number		I	I	I	II	II	II	II	II	II
Association number		1	2	3	4	5	6	7	8	9
Number of plots		30	17	21	95	70	71	10	10	9
Mean number of vascular plant species per plot		23	23	22	14	16	16	31	22	29
Mean height of the tree layer (m)		-	10	20	15	20	20	15	15	30
Mean total vegetation cover (%)		70	70	75	70	75	75	70	85	75
Association 1. *Geranio hayatanum-Juniperetum squamatae*										
Dryopteris alpestris	U	27	6	.	2	.	.	.	.	.
Leontopodium microphyllum	U	23	6	5	1	.	.	.	.	.
Potentilla tugitakensis	U	20	6	.	.	.	.	.	.	.
Helictotrichon abietetorum	U	20	.	.	2	1	1	.	.	.
Brachypodium kawakamii	U	23	.	.	2	.	.	.	.	.
Angelica morrisonicola	U	20	.	5	.	.	.	.	.	.
Lycopodium veitchii	U	40	18	.	2	1	.	10	.	.
Dianthus pygmaeus	U	23	6	.	5	.	.	.	.	.
Festuca rubra	U	20	.	14	1	.	.	.	.	.
Platanthera brevicalcarata	U	23	18	.	7	.	1	20	10	.
Rubus pungens var. *oldhamii*	U	27	18	5	16	13	10	.	20	11
Solidago virgaurea var. *leiocarpa*	U	43	18	19	6	1	1	20	10	.
Association 2. *Aconito fukutomei-Juniperetum squamatae*										
Hemiphragma heterophyllum	U	3	47	19	6	.	.	.	20	.
Hypericum nagasawae	U	17	65	24	9	1	.	.	.	.
Fragaria hayatai	U	3	24	10	7	.	1	.	.	.
Agrostis infirma	U	17	35	24	12	3	1	10	.	.
Viola senzanensis	U	13	24	.	4	.	.	10	10	.
Association 3. *Junipero squamatae-Abietetum kawakamii*										
Cystopteris fragilis	U	.	.	29	1	1	.	.	.	.
Saussurea glandulosa	U	3	.	24	1	.	.	.	.	.
Agropyron mayebaranum	U	13	.	29	.	.	.	.	.	.
Rosa transmorrisonensis	U	23	.	43	9	9	7	30	20	22

Alliance number		I	I	I	II	II	II	II	II	II
Association number		1	2	3	4	5	6	7	8	9
Agropyron formosanum	U	23	6	29	.	4	.	.	.	11
Association 6. *Yushanio niitakayamensis-Tsugetum formosanae*										
Eurya glaberrima	U	.	.	.	1	36	52	40	10	11
Pieris taiwanensis	U	.	6	.	7	13	41	10	.	.
Association 7. *Pino mastersianae-Tsugetum formosanae*										
Pinus armandii var. *mastersiana*	C	.	.	.	.	7	23	90	.	11
Poa annua	U	.	.	.	1	1	1	20	.	.
Vaccinium japonicum var. *lasiostemon*	U	.	.	.	1	.	7	40	.	.
Rhododendron rubropilosum	U	.	.	.	5	7	37	50	10	.
Lonicera acuminata	U	.	6	.	2	14	10	50	20	33
Miscanthus sinensis	U	3	24	.	6	3	6	70	10	11
Association 8. *Rhododendro pseudochrysanthum-Tsugetum formosanae*										
Ribes formosanum	C	.	12	.	2	3	1	.	30	.
Rhododendron pseudochrysanthum	C	.	35	29	20	30	32	10	70	.
Prinsepia scandens	C	.	.	.	1	3	.	.	20	11
Polystichum nepalense	U	.	.	.	2	3	.	.	30	.
Ctenitis transmorrisonensis	U	.	.	.	.	13	13	.	40	11
Circaea alpina subsp. *imaicola*	U	.	6	5	12	10	1	.	30	11
Sedum actinocarpum	U	3	.	.	1	.	.	.	20	.
Goodyera nankoensis	U	.	.	.	4	3	.	.	20	.
Asplenium trichomanes	U	3	12	.	5	.	.	.	30	11
Rubus rolfei	U	20	29	10	12	1	1	20	40	22
Association 9. *Ellisiophyllo pinnati-Piceetum morrisonicolae*										
Picea morrisonicola	C	.	.	.	.	9	1	30	.	100
Photinia niitakayamensis	C	.	.	.	.	9	8	20	.	44
Viburnum betulifolium	C	.	6	.	4	11	8	20	10	33
Ellisiophyllum pinnatum	U	.	.	14	4	9	3	20	.	78
Sanicula petagnioides	U	.	.	.	.	1	.	.	.	22
Polystichum stenophyllum	U	.	6	.	3	16	1	10	.	33
Hydrocotyle setulosa	U	.	.	.	.	4	3	.	10	44
Ribes formosanum	U	.	6	14	9	9	1	10	10	33
Mitella formosana	U	.	.	.	2	4	.	.	.	22
Elatostema trilobulatum	U	.	6	10	28	36	14	20	40	78
Berberis kawakamii	U	7	29	5	19	26	13	20	10	56
Lepisorus pseudoussuriensis	U	.	6	.	1	4	1	.	20	33
Dryopteris wallichiana	U	.	6	19	1	1	7	.	.	33
Urtica thunbergiana	U	.	.	.	4	6	1	.	10	44

Alliance I. *Juniperion squamatae*
[Diagnostic species: *Anaphalis nepalensis*, *Arabis lyrata* subsp. *kamtschatica*, *Berberis morrisonensis*, *Cirsium kawakamii*, *Deschampsia flexuosa*, *Festuca ovina*, *Gaultheria itoana*, *Gentiana arisanensis*, *Geranium hayatanum*, *Juniperus squamata*, *Lonicera kawakamii*, *Luzula taiwaniana*, *Pimpinella niitakayamensis*, *Potentilla leuconota*, *Rhododendron pseudochrysanthum*, *Rosa sericea* var. *morrisonensis*, *Sedum morrisonense*, *Veronica morrisonicola***]**

Alliance number		I	I	I	II	II	II	II	II	II
Association number		1	2	3	4	5	6	7	8	9
Juniperus squamata	C	.	100	48	37	9	1	.	30	.
Juniperus squamata	U	100	59	71	14	1	.	.	.	.
Berberis morrisonensis	U	87	71	52	15	3	1	20	.	.
Lonicera kawakamii	U	40	24	38	12	1	.	.	10	.
Rosa sericea var. *morrisonensis*	U	43	29	19	5	.	.	.	.	.
Cirsium kawakamii	U	30	35	29	6	.	.	.	.	.
Gaultheria itoana	U	57	47	48	18	6	7	30	30	.
Deschampsia flexuosa	U	47	24	76	19	9	1	20	10	.
Chaerophyllum involucratum	U	20	41	29	18	7	.	.	10	11
Sedum morrisonense	U	50	35	48	15	6	3	.	40	11
Cirsium arisanense	U	30	24	24	7	3	.	10	40	.
Alliance II. *Abieti kawakamii-Tsugion formosanae*										
[Diagnostic species: *Abies kawakamii*, *Eurya glaberrima*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis***]**										
Abies kawakamii	C	.	12	100	100	96	13	10	50	33
Tsuga chinensis var. *formosana*	C	.	.	.	21	100	100	100	100	56
Eurya glaberrima	C	.	6	.	1	43	68	50	60	33
Crypsinus quasidivaricatus	U	.	.	.	4	11	31	.	50	11
Constant species										
Oxalis acetosella subsp. *griffithii*	U	10	24	57	21	16	4	10	30	22
Rhododendron pseudochrysanthum	U	50	47	76	8	16	11	20	40	.
Yushania niitakayamensis	U	53	71	19	96	100	100	90	40	89
Ainsliaea latifolia subsp. *henryi*	U	17	18	95	62	44	52	20	80	44
Galium echinocarpum	U	3	12	38	31	24	4	10	20	22
Cystopteris moupinensis	U	3	24	19	18	16	11	.	30	11
Athyrium reflexipinnum	U	7	18	19	11	11	4	.	10	22
Juniperus formosana	U	20	35	5	8	4	4	20	10	.

Table 2. Species composition of the nomenclature type relevés of the nine associations. The name of each association is abbreviated with the first three letters of the genus name. The codes in the table are the Braun-Blanquet cover scale values. Layer C indicates canopy and subcanopy individuals higher than 1.5 m; layer U indicates understorey individuals lower than 1.5 m. The species are sorted by their diagnosti values. Relevé 1 is taken over from Suzuki et al. (1939).

Association number		1	2	3	4	5	6	7	8	9
Association name		Ger-Jun	Aco-Jun	Jun-Abi	Yus-Abi	Tsu-Abi	Yus-Tsu	Pin-Tsu	Rho-Tsu	Ell-Pic
Species	Layer									
Juniperus squamata	C	2	3	.	.	.	.	.	.	.
Potentilla leuconota	U	2	.	.	.	.	.	.	.	.
Cystopteris moupinensis	U	2	.	.	.	r	.	.	r	.
Geranium hayatanum	U	1	.	.	.	.	.	.	.	.
Arabis lyrata subsp. *kamtschatica*	U	+	r	.	.	.	.	.	.	.
Dianthus pygmaeus	U	+	.	.	.	.	.	.	.	.
Aconitum fukutomei	U	.	r	r	.	.	.	.	.	.
Chaerophyllum involucratum	U	.	r	r	.	.	.	.	.	r
Hemiphragma heterophyllum	U	.	r	r	.	.	.	.	r	.
Arenaria takasagomontana	U	.	r	.	.	.	.	.	.	.
Artemisia kawakamii	U	.	r	.	.	.	.	.	.	.
Festuca ovina	U	.	r	.	.	.	.	.	.	.
Hypericum nagasawae	U	.	r	.	.	.	.	.	.	.
Rubus pungens var. *oldhamii*	U	.	r	.	.	.	.	.	r	.
Sedum morrisonense	U	.	r	.	r	r	.	.	.	.
Veronica morrisonicola	U	.	r	.	.	.	.	.	.	.
Berberis morrisonensis	U	.	r	2	.	.	.	.	.	.
Cirsium kawakamii	U	.	r	2	.	.	.	.	.	.
Abies kawakamii	C	.	.	5	5	3	.	r	.	.
Agropyron formosanum	U	.	.	2	.	.	.	.	.	.
Juniperus squamata	U	.	.	2	.	.	.	.	.	.
Rosa transmorrisonensis	U	.	.	2	.	.	.	r	.	r
Deschampsia flexuosa	U	.	.	1	.	.	.	.	.	.
Oxalis acetosella subsp. *griffithii*	U	.	.	1	.	.	.	.	.	r
Fragaria hayatai	U	.	.	r	.	.	.	.	.	.
Lonicera kawakamii	U	.	.	r	.	.	.	.	.	.
Rhododendron pseudochrysanthum	U	.	.	r	.	.	.	.	r	.
Rosa sericea var. *morrisonensis*	U	.	.	r	.	.	.	.	.	.
Saussurea glandulosa	U	.	.	r	.	.	.	.	.	.
Tsuga chinensis var. *formosana*	C	.	.	.	.	4	5	2	5	.
Eurya glaberrima	C	.	.	.	.	.	1	r	2	.
Crypsinus quasidivaricatus	U	.	.	.	.	.	r	.	r	.
Ctenitis transmorrisonensis	U	.	.	.	.	.	r	.	r	.
Hydrangea integrifolia	U	.	.	.	.	.	r	.	.	r
Pinus armandii var. *mastersiana*	C	.	.	.	.	.	.	4	.	.
Miscanthus sinensis	U	.	2	.	.	.	.	5	.	.
Rhododendron rubropilosum	C	.	.	.	.	.	.	2	2	.

Association number		1	2	3	4	5	6	7	8	9
Association name		Ger-Jun	Aco-Jun	Jun-Abi	Yus-Abi	Tsu-Abi	Yus-Tsu	Pin-Tsu	Rho-Tsu	Ell-Pic
Species	Layer									
Gaultheria itoana	U	.	.	.	.	.	.	r	.	.
Tsuga chinensis var. *formosana*	U	.	.	.	.	.	.	r	.	.
Eurya glaberrima	U	.	.	.	.	.	.	r	r	.
Cirsium arisanense	U	.	.	.	.	.	.	.	r	.
Polystichum nepalense	U	.	.	.	.	.	.	.	r	.
Ribes formosanum	C	.	.	.	.	.	.	.	r	.
Rubus rolfei	U	.	.	.	.	.	.	.	r	r
Picea morrisonicola	C	.	.	.	.	.	.	.	.	5
Ellisiophyllum pinnatum	U	.	.	.	.	.	.	.	.	r
Lonicera acuminata	U	.	.	.	.	.	.	.	.	r
Ribes formosanum	U	.	.	.	.	.	.	.	.	r
Elatostema trilobulatum	U	.	.	.	2	r	.	.	1	.
Ainsliaea latifolia subsp. *henryi*	U	.	.	3	2	r	.	.	1	.
Yushania niitakayamensis	U	.	.	2	5	5	5	.	.	5
Circaea alpina subsp. *imaicola*	U	.	.	r	.	r	.	.	r	.
Rhododendron pseudochrysanthum	C	.	.	2	r	.	.	.	2	.
Galium echinocarpum	U	.	.	r	r	r	.	.	.	.

Other species in one or two relevés only:

Layer C species: *Berberis morrisonensis* 1: 2; *Chamaecyparis formosensis* 6: r; *Lyonia ovalifolia 6*: +; *Neolitsea acuminatissima* 8: 2; *Prinsepia scandens* 7: +; *Quercus spinosa* 8: 2; *Rhododendron pachysanthum* 1: 1; *Rhododendron rubropilosum* 6, 7: 2; *Rosa sericea* var. *morrisonensis* 1: 4; *Rosa transmorrisonensis* 7: r.

Layer U species: *Abies kawakamii* 2: 2, 4: r; *Agrostis infirma* 2: r; *Aletris formosana* 2: r; *Anaphalis nepalensis* 1: r; *Arenaria subpilosa* 2: r; *Asplenium trichomanes* 7: r; *Astragalus nankotaizanensis* 1: 1; *Berberis kawakamii* 3: r; *Carex brunnea* 8: r; *Chimaphila japonica* 4: r; *Cotoneaster morrisonensis* 7: r; *Daphne morrisonesis* 8: r; *Galium gracilens* 7: r; *Galium morii* 7: r; *Galium tarokoense* 1: r; *Hydrangea aspera* 2: r; *Hydrocotyle setulosa* 7: +; *Lepisorus morrisonensis* 7: r; *Lepisorus thunbergianus* 4: r; *Ligularia kojimae* 3: r; *Luzula plumosa* 3: r; *Lycopodium veitchii* 8: r; *Lyonia ovalifolia* 6: r; *Maianthemum formosanum* 1: 1; *Mecodium polyanthos* 4, 7: r; *Mecodium wrightii* 5: r; *Mitella formosana* 8: r; *Myriactis humilis* 2, 7: r; *Pellionia radicans* 8: r; *Plagiogyria formosana* 5: r; *Polygonum pilushanense* 5: r; *Polystichum morii* 2, 4: r; *Polystichum piceopaleaceum* 7: r; *Polystichum prionolepis* 8: r; *Prinsepia scandens* 8: r; *Pteridium aquilinum* subsp. *wightianum* 6: 2; *Rubus buergeri* 8: r; *Rubus formosensis* 6: r; *Rubus pectinellus* 7, 8: r; *Rubus sumatranus* 2: r; *Sedum actinocarpum* 7: r; *Senecio nemorensis* var. *dentatus* 2: r; *Sibbaldia procumbens* 1: 1; *Thalictrum rubescens* 1: r; *Thalictrum urbaini* var. *majus* 2: r; *Tripterospermum lanceolatum* 6: r; *Trisetum spicatum* var. *formosanaum* 1: 1; *Urtica taiwaniana* 8: r; *Urtica thunbergiana* 7: r; *Viburnum betulifolium* 6, 8: r; *Viola senzanensis* 7: r; *Xiphopteris okuboi* 5: r.

Table 3. Characteristics and locations of the type relevés of each association (see Table 2). The names of associations are abbreviated with the first three letters of the genus name.

Assoc. No.	Assoc.	Plot ID	Authors	Longitude (°E)	Latitude (°N)	Locality, County	Elevation (m a.s.l.)	Aspect	Slope (°)	Number of species	Date
1	Ger-Jun	T2	Suzuki, Tokio, Fukuyama, N. & Simada H.	~121.4407	~24.3697	Nanhu-Da Shan, Ilan	~3390	SW	10	13	1937-7
2	Aco-Jun	27-0037	Lin, Chuan-Ya & Yeh, Ding-Hong	121.4543	24.3632	Shougu-Ping, Nantou	3579	SE	34	18	2006-04-19
3	Jun-Abi	08-1044	Chen, En-Lun & Chen, Wen-Min	121.2395	24.3959	Hsueh Shan, Taichung	3394	E	18	32	2005-08-20
4	Yus-Abi	30-0191	Chen, Tien-Tsai	121.3405	24.1453	Pingfong Shan, Hualien	3174	NW	47	10	2005-10-30
5	Tsu-Abi	02-0471	Lin, Shih-Jieh	121.2817	24.4302	Chihyo Shan, Taichung	3158	NE	35	14	2007-08-02
6	Yus-Tsu	20-0293	Liu, Chi-Pin, Liao, Jia-Hong & Liao, Chien-Chun	120.7544	22.6178	Bei-Dawu Shan, Pingtung	2821	NW	39	10	2005-07-09
7	Pin-Tsu	09-3060	Chen, En-Lun & Chen, Wen-Min	121.1400	24.1953	Baigu-Da Shan, Taichung	2802	SE	25	15	2003-08-12
8	Rho-Tsu	25-0035	Lin, Yi-Ying & Yi, Hsiang-Ling	120.9717	23.2766	Chitou Shan, Taitung	2990	SE	38	38	2006-06-22
9	Ell-Pic	08-1028	Chen, En-Lun & Chen, Wen-Min	121.3789	24.3686	Nanhu-Da Shan, Ilan	2698	NE	43	22	2005-04-06

Paper 3

Chamaecyparis mountain cloud forest in Taiwan: ecology and vegetation classification

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Manuscript

Chamaecyparis mountain cloud forest in Taiwan: ecology and vegetation classification

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ABSTRACT

Montane cloud forest is one of the most endangered ecosystems in the world. However, there are few comprehensive studies about the distribution pattern of subtropical montane cloud forest. *Chamaecyparis* forest is one type of subtropical montane cloud forest in Taiwan and it has wide geographical distribution across the whole island. This study tried to ask: which factors are important for explaining the differences of floristic composition in *Chamaecyapris* forest and how many types of *Chamaecyparis* forest are there based on the Braun-Blanquet approach. Plots used for this study were selected from the National Vegetation Database of Taiwan. Two alliances were defined in this paper and both alliances belong to the order, *Fagetalia hayatae*, which presents the subtropical montane cloud forest in Taiwan. Topography and altitude explain their contrasting habitat requirements of these two alliances while seasonality of moisture, soil properties and altitude explain the differences of the floristic composition at the association level. Alliance of *Chamaecyparidion formosanae* distributed on slopes and ridges are coniferous forests or mixed forests (mix of coniferous and evergreen broad-leaved trees). It is at higher altitudes and is more influenced by summer monsoon than another alliance. Five associations can be determined under this alliance: *Tsugo formosanae-Chamaecyparidetum formosanae* is on the wide upper slopes to ridges; *Vaccinio lasiostemonis-Tsugetum formosanae* is on the narrow upper slopes to ridges; *Schefflero taiwanianae-Chamaecyparidetum formosensis* grows on slopes having cover of big stones; *Elatostemato trilobulati-Tsugetum formosanae* is distributed in the north-eastern ecoregion and it is a bog-like forest. *Rhododendro formosani-Chamaecyparidetum formosanae* grows on warm south-facing slopes with heavy summer fog. Alliance *Pasanio kawakamii-Machilion japonicae* growing on the slopes to valleys are evergreen broad-leaved forests or forests mixed of coniferous and evergreen broad-leaved species. Six associations under this alliance can be determined: *Adinandro lasiostylae-Chamaecyparidetum formosensis* is mainly distributed in the north-western ecoregion; *Castanopsio carlesii-Chamaecyparidetum formosensis* occurs in the south-western ecoregion; *Symploco wikstroemiifoliae-Machiletum thunbergii* is found in the north-eastern lowland, where fog events mainly happen in winter because of the winter monsoon; *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* and *Pileo brevicornutae-Machiletum japonicae* occur in the eastern ecoregion and the later one grows on limestone; *Arachniodo rhomboideae-Chamaecyparidetum formosensis* distributed across the whole island except the tropical region is usually found in the stony and shaded valleys. Classification of each syntaxon was formalized by the Cocktail Determination Key.

Keywords: alliance; altitude; association; Braun-Blanquet approach; Cocktail Determination Key; coniferous forest; evergreen broad-leaved forest; eastern Asia; floristic composition; mixed forest; monsoon; seasonality of moisture; species group; supervised classification; topography

Nomenclature: Huang & Hsieh (1994–2003)

INTRODUCTION

Mountain cloud forests belong to the world's most endangered ecosystems due to their sensitivity to changes in their unique ecological conditions (Hamilton et al. 1995; Bruijnzeel et al. 2010). Distribution of montane cloud forests is highly fragmented, and a high degree of isolation of these fragments is supposed to promote speciation and endemism (Still et al. 1999). Most of the previous studies focused on montane cloud forests in the tropical regions. There are several networks established for the protection and study of Tropical Mountain Cloud Forest (TMCF), such as the World Conservation Monitoring Centre, Tropical Montane Cloud Forest Initiative and UNESCO International Hydrological Programme (Bruijnzeel 2001). In contrast, Subtropical Montane Cloud Forest (SMCF) is by far less studied, although its biological and conservation value is not less significant.

In subtropical eastern Asia, a high propotion of the mountain cloud forests are dominated by deciduous broad-leaved or coniferous trees (Chang 1981; Hou 1983; Su 1984; Da et al. 2009). They can be pure coniferous forests dominated by *Abies* spp. or *Picea* spp. or mixed forests of coniferous and evergreen broad-leaved trees (or mixed forests of deciduous and evergreen broad-leaved trees). The common dominant genera in the mixed forests include the conifers *Chamaecyparis*, *Cryptomeria*, *Cunninghamia*, *Picea*, *Pseudotsuga*, *Taiwania* and *Tsuga*, and the deciduous *Fagus*. These are different from the TMCFs, which are only dominated by the evergreen broad-leaved trees (Bruijnzeel et al. 2010). In Japan, one of the typical SMCF is a coniferous and evergreen broad-leaved mixed forest dominated by *Cryptomeria japonica* (Miyawaki 1980). In Taiwan, the most representative coniferous and deciduous broad-leaved genera of SMCF are *Chamaecyparis* and *Fagus* (Suzuki 1954; Su 1984; Chen 2001; Li et al. 2013). The *Fagus* forest has a very limited distribution in Taiwan (Hsieh 1989; Hukusima et al. 2005). In contrast, the *Chamaecyparis* forest grows across the whole island, varying in species composition and habitat conditions.

Adult trees of both native *Chamaecyparis* species, *Chamaecyparis formosensis* Matsum. and *Chamaecyparis obtusa* Sieb. & Zucc. var. *formosana* (Hayata) Rehder are usually taller than 30 m, with trunks commonly thicker than 1 m at breast height. The *Chamaecyparis* forest in Taiwan has received broad attention from local people as evidenced by many legends of the native Taiwanese people. Before the 20th century, native Taiwanese people usually preserved the largest *Chamaecyparis* forest in their ethnic group territory as a sacred place, where the spirits of ancestors rest in peace. Nobody was allowed to enter these places to collect anything or hunt there, which helped to preserve the pristine *Chamaecyparis* forests. However, in the 20th century these forests were extensively logged by the immigrants from mainland China and Japan because of the valuable timber. After 1991, a law prohibited the cutting down of any primary forests in Taiwan. Horng et al. (2000) estimated around 60% of the *Chamaecyparis* forest has been cut since the early 20th century and about 48,000 ha remained in Taiwan (although the later number might be an optimistic overestimation; Chen 2001).

Across an altitudinal range of almost 4000 m that exists in Taiwan, *Chamaecyparis* species mostly grow between 1500 and 2500 m a.s.l. This altitudinal distribution is associated with two ecological features. Firstly, there is a prominent fog formation caused by the uplift of air masses from the sea, which occurs almost every day. The climatic station at Yuan-Yang Lake (altitude of about 1700 m; Fig. 1a) records on average 342 days with fog events annually (Lai et al. 2006). Secondly, the mid-altitudinal range of 1500–2500 m is a transition zone for forest physiognomy. Above this range, the climate corresponds to cool-temperate or high-montane zone (Su 1984; Zhong 1994) and forests are dominated by coniferous trees such as *Abies kawakamii*, *Picea morrisonicola* and *Tsuga chinensis* var. *formosana* (Lin et al. 2012). The upper limit of this mid-altitudinal range is a hard boundary for evergreen broad-leaved species. Below this range, subtropical or submontane zone and foothills develop and forests are dominated by evergreen broad-leaved species mainly belonging to *Fagaceae*, *Lauraceae* and *Moraceae* (Su 1984; Chen 2004; Chao et al. 2010).

The aim of this study is to understand which vegetation types of *Chamaecyparis* forest occur in Taiwan and what their relationships to environmental factors are. We defined the *Chamaecyparis* forest as a forest containing *Chamaecyparis* spp. as diagnostic, dominant or frequent species. Although several vegetation classification studies conducting in Taiwan focused at least partly on the *Chamaecyparis* forest (Appendix S1), the ecological patterns of the *Chamaecyparis* forest across the whole of Taiwan has remained ambiguous because of non-representative samples, the lack of comparison across the whole island and the absence of standardized nomenclature among studies (Su 2002). Most studies were conducted in one watershed with a broad altitudinal range (Chen 2004; Yeh & Liao 2009; Chian et al. 2010) or focused on a single protected area (Yang 1991; Chou et al. 2000; Chen et al. 2002; Wei & Chen 2007). Vegetation units described in these studies often have only one or two character species, and in some cases even no diagnostic species. Except the unambiguous conclusion that the *Chamaecyparis* forest is distributed in the mid-altitudinal range, there is no other generally recognized pattern relating floristic composition to environmental variables.

An important requirement of modern vegetation classification is the transparent and formalized procedure of how individual plots are assigned to particular vegetation types (Jennings et al. 2009; Chytrý et al. 2011). There are several statistical techniques applying the so-called objective classification (Kent 2012; Peet and Roberts 2013). However, few of them offer unequivocal rules, especially those with ecological meaning, for assigning individual plots to vegetation types. The Braun-Blanquet approach, using plot-based information on floristic composition to produce a hierarchical classification system, is one of the widely used ways to classify vegetation (Mueller-Dombois & Ellenberg 1974; van der Maarel 2013). In the Braun-

Blanquet approach, presence or absence of several species or species groups is the key argument for defining the vegetation types which represent different habitats. Bruelheide (1997; 2000) developed the Cocktail method based on the combination of specific ecologically meaningful species groups. Cocktail formulas give unequivocal rules for assigning plots into different vegetation types (Bruelheide & Chytrý 2000; Kočí et al. 2003; Janišová & Dúbravková 2010). The challenge for constructing the Cocktail formulas is to define ecologically meaningful species groups. In central Europe, vegetation scientists define the species groups by using large integrated vegetation databases and expert systems (Chytrý 2007). Li et al. (2013) proposed the Cocktail Determination Key for applying the Cocktail method to a region that lacks the expert knowledge about the species groups and their representative ecological meaning. In this Cocktail Determination Key, species groups and vegetation units are generated iteratively while sorting plots and species in a species-by-sites table.

While the aim of building an ecologically relevant vegetation classification of *Chamaecyparis* mountain cloud forest in Taiwan, we asked the following questions: (1) Which environmental factors are the most important determinants of floristic composition in the *Chamaecyparis* forest in Taiwan? (2) What are ecologically meaningful types of the *Chamaecyparis* forest in Taiwan? We addressed these questions using an extensive vegetation data set stored in the National Vegetation Database of Taiwan and applying the Cocktail method to define unequivocal assignment rules for each vegetation type.

MATERIALS AND METHODS

Study area

Taiwan (21˚55'–25˚20'N, 119˚30'–122˚00'E) is a mountainous island located in the subtropical region of eastern Asia (Fig 1). The Backbone Mountains roughly run a north-south direction. The climate in Taiwan is mainly controled by altitude and the monsoon systems. Altitude is strongly correlated with temperature, which has a lapse rate of 0.55 ˚C / 100 m. In summer, the warm south-western monsoon and typhoons bring abundant precipitation for the whole island. In winter, the cool north-eastern monsoon brings moderate precipitation only to the windward slopes. The area which is not influenced by the winter monsoon has a dry period of two to six months. Su (1985) classified Taiwan into six ecoregions (north-eastern, eastern, south-eastern, south-western, central-western and north-western) based on climatic data, especially the amount of winter precipitation. Here, we separate the Henchung peninsula in the southernmost Taiwan from the south-western region of Su (1985) and define it as the seventh ecoregion (Fig. 1), characterized by tropical flora and strong constant wind in winter. Su (1985) also divided the eastern region into northern and southern sections because of the warmer temperature and longer drought period in winter in the

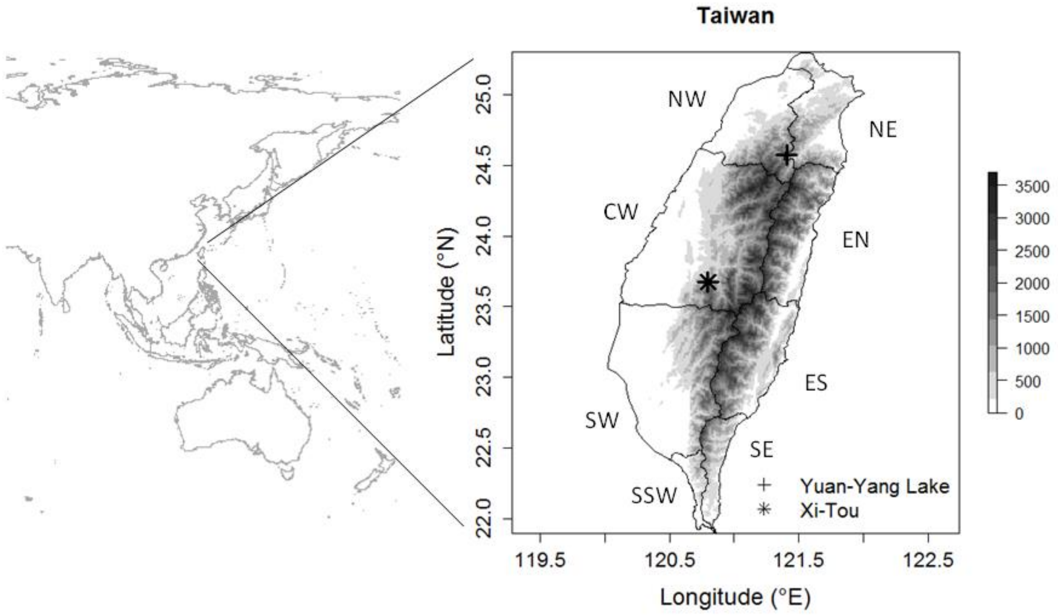

Figure 1. Geographic position of Taiwan and two climatic stations with mountain fog observation. The gradient of black and white colours indicates the altitudes in meters a.s.l. NE: north-eastern ecoregion; EN: northern section of the eastern ecoregion; ES: southern section of the eastern ecoregion; SE: south-eastern ecoregion; SSW: southern sectoin of the south-western ecoregion; SW: south-western ecoregion; CW: central-western ecoregion; NW: north-western ecoregion.

southern sections. In the lowland of north-eastern region, the winter precipitation ratio is the highest (on average higher than 10% of one year), while it is the lowest in the lowland of the south-western region (www.cwb.gov.tw/V7e/climate/). The lower the winter precipitation ratio, the longer is the winter drought period at altitudes below 1500 m. There is no dry season in any part of the island at altitudes above 1500 m because of the fog formation at altitudes of 1500–2500 m and constant precipitation at altitudes above 2500 m.

The frequency of fog in the mountain cloud zone differs among ecoregions because of the monsoon regime. The ecoregions influenced by the winter monsoon (such as the north-eastern region, the northern section of the eastern region and the north-western region) are covered by heavy fog for a longer time than the other ecoregions. The Yuan-Yang Lake weather station, located in a region influenced by the winter monsoon (Fig. 1), has a fog event for about 40% of the hours of a year (Lai et al. 2006). From October to February, the fog events occur for more than 50% hours per month and more than one-third of them are heavy fogs. The Xi-Tou weather station (Wey et al. 2011), located in a region not influenced by winter monsoon, has fog events for about 25% hours of a year. Except the very few fog events in

November and a very heavy one in March, all the months have a similar hourly ratio of fog events.

Vegetation-plot and species data

There are records from 3564 plots in the National Vegetation Database of Taiwan (AS-TW-001) that were sampled from 2003 to 2007 for the purpose of vegetation mapping. These plots cover the whole of Taiwan and are representative of different ecoregions and altitudes. The size of most plots is 20 × 20 m, although 14 of them have an area of 200−300 m^2 because of the topographic limitation such as steep slopes, and 182 of them have an area of 500−1600 m^2 caused by their origin from experimental studies. All the vascular plants species including trees, shrubs, herbs, lianas and epiphytes were recorded. The cover of each species was estimated in percentages for shrubs, herbs, lianas and epiphytes. The cover of trees was estimated from their diameter at breast height (Curtis 1959). Relative dominance of each species per plot calculated from basal area, and relative frequency of each species per plot calculated from the number of individuals, were summed up and divided by two. These values, having a range of 0 to 100, were used as a cover estimate for tree species. The data set of 3564 plots was analyzed in JUICE v. 7.0.84 (www.sci.muni.cz/botany/juice; Tichý 2002).

Information about life forms of all the species (tree, shrub, herb, liana or epiphyte) and leaf types of tree species (coniferous, deciduous broad-leaved or evergreen broad-leaved) was used for the description of vegetation types. This information came from the species description in the Flora of Taiwan (Huang & Hsieh 1994–2003; Hsieh 2002). The proportion of each leaf type in each plot was calculated in order to compare the physiognomic structure of different vegetation types. This proportion was defined as the sum of cover of one leaf type in a plot divided by the sum of cover of all trees in the same plot.

Environmental factors

Environmental factors were recorded in the field or derived from the digital maps in geographic information system (GIS). Altitude, slope inclination, aspect and geographic coordinates of plots were measured by Global Positioning System (GPS), compass and clinometer in the field. Other data recorded in the field were topography, rock cover and rockiness. Topography was recorded on an ordinal scale of 1−6 (1 = ridge; 2 = upper slope; 3 = middle slope; 4 = lower slope; 5 = valley; and 6 = flat plain, which includes large river terraces or plains outside the mountain regions). Topography was used as a surrogate of the soil water availability and light input. Lower values on this scale indicated drier habitats with higher light input (Sørensen et al. 2006). Rock cover was estimated as the percentage area covered by stones larger than 10 cm inside the plot, and rockiness was estimated as the percentage content of stones with a size of 1–10 cm in the soil. Rock cover and rockiness were usually positively correlated with soil pH, which might indicate soil nutrient conditions. Southernness was calculated from the cosine of slope aspect with a value of 1 representing a SSW-facing slope and 0° a NNE-facing slope (Geiger 1966). The southernness can be used as an indication of the monsoon system affecting a plot: higher values indicate the plot might be influenced by summer monsoon, while lower values indicate the plot might be influenced by winter monsoon. Canopy cover and height were also estimated in the field for each plot. Light transmission through the canopy influences understory species composition. The canopy cover was used as a surrogate of the light conditions in the understory. Altogether, seven environmental variables including altitude, canopy cover, inclination, rock cover, rockiness, southernness and topography were used. In a pilot analysis, altitude was identified as a complex gradient and had high correlation with almost all the other environmental factors.

GIS layers from Digital Terrain Model (DTM, www.csrsr.ncu.edu.tw), Global Climate Data (www.worldclim.org; Hijmans et al. 2005) and Moderate Resolution Image Spectroradiometer (MODIS, modis.gsfc.nasa.gov) were other sources of environmental data. Whole-light sky derived from DTM represented the topographical shading, which was correlated with the input of solar energy (Lai et al. 2010). Monthly precipitation was obtained from Global Climate Data. To represent the seasonality, the precipitation of June, July and August were summed up and divided by annual precipitation to obtain the ratio of summer precipitation. The same was done for December, January and February precipitation to obtain the ratio of winter precipitation. Cloud frequency, soil moisture and temperature data were derived from MODIS for the period of 2000–2009. Cloud frequency is considered to be a good index to describe the relationship between plant species and air moisture (Sklenář 2008). From the temperature layers, monthly mean temperature was calculated (Lai et al. 2012). Soil moisture was derived from the monthly mean temperatures and the monthly mean Normalized Difference Vegetation Index (NDVI) following the triangle method (Gillies et al. 1997; Sandholt et al. 2002). Altogether, 14 variables originated from the GIS layers: one environmental factor from DTM (whole-light sky), three environmental factors from Global Climate Data (annual precipitation, ratio of summer precipitation and ratio of winter precipitation) and ten environmental factors from MODIS data (annual mean cloud frequency, January cloud frequency, July cloud frequency, annual mean soil moisture, monthly mean January soil moisture, monthly mean July soil moisture, annual mean temperature, monthly mean January temperature, monthly mean July temperature and Kira's warmth index, which was derived from the monthly mean temperature; Kira 1945). All of these GIS-derived variables and further seven variables recorded in the field represented the climate, energy input, light condition in the understory and soil physical condition with seasonal differences of each plot. ArcGIS v. 9.0

(www.esri.com) and R v. 3.0.1 (www.R-project.org) were used for manipulating and calculating the environmental factors.

Associations and alliances

Association is the basic vegetation unit in the Braun-Blanquet system. In this study, we define association as a community unit with homogeneous floristic composition and similar habitat requirements among plots (Mueller-Dombois & Ellenberg 1974). Alliance is a vegetation unit at a higher hierarchical level than association. In this study, two criteria were used to group the associations into alliances. The first one is that the associations under the same alliance have the same dominant species. The second one is that the associations under the same alliance have at least one defined species group in common. As each species group represents a kind of habitat requirements, associations under the same alliance must share some similar habitat requirements that are correlated to the defined species group. Nomenclatures of associations and alliances follow the International Code of Phytosociological Nomenclature (Weber et al. 2000)

Vegetation classification and the construction of Cocktail Determination Key

Vegetation classification and construction of the Cocktail Determination Key (Li et al. 2013) were made according to the structure of the data set and expert knowledge from the field experience (Fig. 2). Several numerical methods were applied to explore the structure of the data set. Whether the plots should be classified to a particular association or not was judged by the expert knowledge based on both environmental factors and species composition defined by the Cocktail formula. The Cocktail formula, in this study, contains five main parts: the rank of the formula, species groups, numbers in front of the species groups, logical operators connecting the species groups (AND, OR, WITH, WITHOUT, NOT), and the code of association assigned by the formula. The numbers in front of the species groups define the minimum number of species from the given species group that should be present in the plot to consider the whole species group as present. The meaning of logical operators is as follows: WITH – the following species group should be present and a formula must start with this logical operator; WITHOUT – the following species group should be absent; AND – the two conditions connected by AND should be both true; OR – one of the two conditions connected by OR should be true; NOT – the following condition should not be true. When all the presences or absences of species groups fit the combination set up by the logical operators, the plot is assigned to the vegetation type defined by the Cocktail formula. The Cocktail Determination Key is created as a set of Cocktail formulae defining different vegetation types. These formulae are sorted by their rank. Usually, the higher rank of the formula, the more distinctive the corresponding vegetation type is. When a plot is submitted to the Cocktail Determination Key, it is checked to see whether it fits to the first Cocktail formula. If it fits, this plot is assigned to the vegetation type defined by this formula. Otherwise, the plot is compared with the next Cocktail formulae following their ranks in the Cocktail Determination Key until it fits to one of the formula. If the plot does not fit to any formula, it remains unclassified.

In the first step of classification, the National Vegetation Database of Taiwan was divided into three parts: textual description of published vegetation types, matrix of environmental factors of individual plots and matrix of floristic composition of the plots. This data set (the whole data set) contained 3564 plots. In the second step, a subset called Training data set was created by selecting the plots with a cover of either *C. formosensis* or *C. obtusa* var. *formosana* higher than 10%. We checked the Training data set and corrected errors before the numerical analyses were applied. Plots that belonged to secondary forests such as *Alnus* or *Pinus* forest, scree-slope forests dominated by *Pseudotsuga*, plots made in *Chamaecyparis* spp. plantations or plots containing obviously wrong species determinations were deleted from the data set. At the end, this Training data set was composed of 230 plots and 951 species.

Two-way indicator species analysis (TWINSPAN) and cluster analysis using five different combinations of resemblance measure and clustering algorithm (Legendre & Legendre 2012) were applied to explore the data set structure and to find the most distinctive groups in the data set. These five combinations included Euclidean distance with Ward algorithm, Euclidean distance with Flexible beta algorithm (with ß = -0.25), Jaccard dissimilarities with Ward algorithm, Sørensen dissimilarities with Flexible beta algorithm (with ß = -0.3) and Sørensen dissimilarities with Flexible beta algorithm (with ß = -0.25). In TWINSPAN, three pseudospecies were generated by species cover of 0–5%, 5–25% and >25%. In cluster analysis, the cover was square-root transformed before calculating the Euclidean distance, the Jaccard dissimilarities and the Sørensen dissimilarities. These six methods of numerical classification were applied to the Training data set and eight groups were yielded while applying each method. Different methods of numerical classification usually classified plots into different groups. We took the plots that were always classified into the same group by the above six analyses as determined groups. The number of determined groups was much higher than eight groups. The number of plots in each determined group varied from one to more than ten. The determined group with the largest number of plots was taken as the target cluster which was considered as being an association. This target cluster was used for constructing the Cocktail formula. At this stage, the Cocktail formula was made to select the plots of the target cluster from the Training data set. At the same time, this Cocktail formula should have included as few plots as possible which were not in the target cluster. Several species groups were generated by comparing the species composition between the target cluster and the other plots in the Training data set. While generating the species groups, the co-occurrences of species in both the whole data set and the Training data set were considered. Field

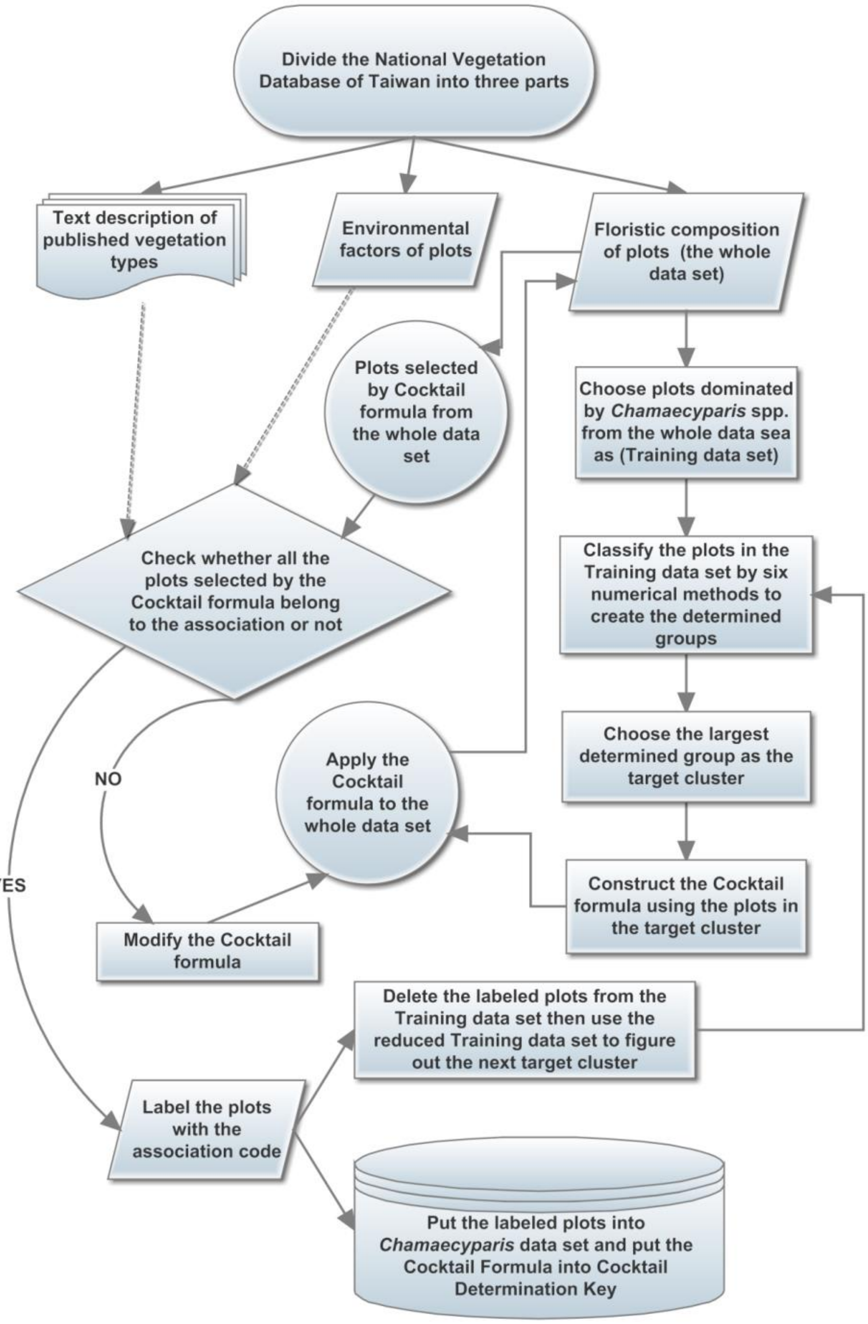

Figure 2. Flow chart of the procedure of classifying the plots and constructing the Cocktail Determination Key.

experience and information on the habitat requirements of species were taken into consideration while generating species groups with ecological meaning.

After the Cocktail formula was constructed, it was applied to the whole data set and a new group of selected plots was generated. Floristic composition and environmental factors of each plot in this new group were checked and judged by expert knowledge. Literature description was taken into consideration in this step to help make the decision. If there was any plot that was misclassified to this association defined by the target cluster, judged by expert knowledge, the Cocktail formula was modified and then re-applied to the whole data set again. This loop stopped when all plots selected by the Cocktail formula from the whole data set were accepted to be in the same association. While modifying the Cocktail formula, the composition of each species group should not be changed too much and the plots belonging to the target cluster should be chosen by the formula as much as possible. These were the basic rules for modifying the Cocktail formula.

When the final Cocktail formula was accepted, plots selected from the Training data set were removed from the Training data set. Then the reduced Training data set was analyzed again by the six numerical methods to identify the next target cluster. At the same time, plots from the whole data set selected by the Cocktail formula were marked with the code of association and put into the *Chamaecyparis* data set. The rank and the code of this association were added to this Cocktail formula and the Cocktail formula was added to the Cocktail Determination Key (Appendix S2). When there was no determined group with at least five plots, we produced only 4 groups instead of 8 groups in proceeding each six numerical classification. All steps were repeated until no ecologically meaningful target cluster could be found. At the end, eleven associations were determined in this way. Seventy plots remained unclassified in the Training data set while 335 plots were classified and stored in the *Chamaecyparis* data set. All the figures and tables in this study were made from the *Chamaecyparis* data set. Cocktail formulas and the Cocktail Determination Key were run by the CoDeK program (Li et al. 2013, their Appendix S2 & S3).

Synoptic table

The synoptic table summarizes how similar or different the floristic composition is among different vegetation types (Mueller-Dombois & Ellenberg 1974). Species in the synoptic table were sorted by their fidelity to each vegetation type. In this study, fidelity was represented by the phi coefficient of association (Φ) computed with the group size equalized to 5% of the whole data set (Tichý & Chytrý 2006). Fisher's exact test was applied to establish whether the concentration of species occurrence in a particular vegetation type was significant at $P < 0.001$ (Chytrý et al. 2002). Species with non-significant concentration in any vegetation type were sorted alphabetically within each layer. The synoptic table was made by JUICE v. 7.0.84.

Ordination

Nonmetric Multidimensional Scaling (NMDS; Kruskal 1964) was used to visualize the relationship among vegetation types and the relationship between vegetation types and environmental factors. NMDS calculation was based on a matrix of Bray-Curtis

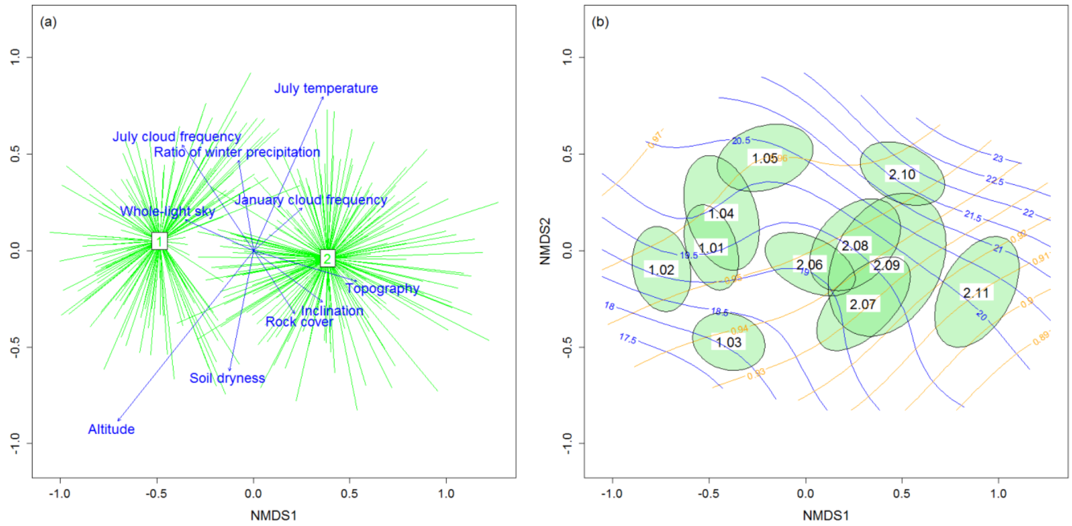

Figure 3. Syntaxa and environmental factors in the ordination space of Non-metric Multidimensional Scaling. (a) Two alliances and 10 environmental factors which were significantly correlated with the floristic composition. 1 = *Chamaecyparidion formosanae* and 2 = *Pasanio kawakamii-Machilion japonicae*. The soil moisture was replaced by soil dryness because of the negative relationship between the values and soil moisture itself. (b) Eleven associations and the contours of monthly mean July temperature (˚C) in blue and July cloud frequency in orange (on a scale of 0–1). The ellipse polygons represented the range of standard deviation calculated from the points of each association in the ordination space. 1.01 = *Tsugo formosanae-Chamaecyparidetum formosanae*; 1.02 = *Vaccinio lasiostemonis-Tsugetum formosanae*; 1.03 = *Schefflero taiwanianae-Chamaecyparidetum formosensis*; 1.04 = *Elatostemato trilobulati-Tsugetum formosanae*; 1.05 = *Rhododendro formosani-Chamaecyparidetum formosanae*; 2.06 = *Adinandro lasiostylae-Chamaecyparidetum formosensis*; 2.07 = *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis*; 2.08 = *Castanopsio carlesii-Chamaecyparidetum formosensis*; 2.09 = *Arachniodo rhomboideae-Chamaecyparidetum formosensis*; 2.10 = *Symploco wikstroemiifoliae-Machiletum thunbergii*; 2.11 = *Pileo brevicornutae-Machiletum japonicae*.

dissimilarities (Odum 1950) and square-root transformed species covers. The relationships between environmental factors and two axes of NMDS were analysed by a set of multiple regressions; the strength of the relationship was quantified by the adjusted coefficient of determination (R^2_{adj}) and tested by F-test ($P < 0.001$). As some of the environmental variables had missing values for some plots, individual regressions were based on different numbers of samples. The R^2_{adj} rather than R^2 was applied to facilitate the comparison between environmental variables under such conditions (Zar 1999). The ordination diagram and the related test were computed using R v. 3.0.1. (R Core Team 2013), library *vegan* (Oksanen et al. 2013).

RESULTS

Relationship between floristic composition and environmental factors

Altitude, as a complex gradient, was the most important variable closely related to the variation in floristic composition in the ordination space (Fig 3a). All 21 environmental factors except the ratio of summer precipitation and southernness were significantly related with the first two axes of NMDS (Fig. 3a). If several factors had the same direction in the ordination diagram, the one with the highest R^2_{adj} value was chosen to be drawn onto the diagram: altitude was chosen among altitude and annual precipitation; annual mean soil moisture among the three variables representing soil moisture and it was presented as soil dryness in the figure because of the negative relationship between the values and soil moisture itself; topography was chosen among topography and rockiness; monthly mean July temperature among monthly mean July temperature, annual mean temperature, monthly mean January temperature, warmth index and annual mean cloud frequency.

The difference between habitats of *Chamaecyparis formosensis* dominated forest type and *C. obtusa* var. *formosana* dominated forest type was mainly related to topography and similar factors such as inclination, rock cover and whole-light sky (Fig 3a). These environmental factors can be represented by the first axis of NMDS. On the ridges (left side of the ordination diagram in Fig. 3a), there is usually well-developed soil and the whole-light sky value is high, indicating that the habitats are less shaded by the surrounding topography than those in the valleys (right side of the ordination diagram in Fig. 3a). The habitats in the valleys contain high ratio of rock cover and soil rockiness and the slopes are usually steep. Another habitat feature correlated with the first axis of NMDS is that the summer air humidity is higher on the left side than on the right side (Figs. 3b). The forest dominated by *Chamaecyparis obtusa* var. *formosana* (the first alliance in Fig. 3a), requires upper slopes to ridges with less shading by the surroundings topographical features. Forests growing in these habitats are more influenced by summer monsoon than the others because of the higher summer air humidity (see July cloud frequency in Fig. 4). In contrast, the forest dominated by *Chamaecyparis formosensis*, is confined to shaded and stony middle slopes and valleys.

Temperature, monsoon system and their related variables are important factors to explain the habitat differences at the association level (Figs. 3a and 3b). These factors are highly correlated to the second axis of NMDS. In the lower part of the ordination diagram, temperature and soil moisture are lower than in the upper part. The winter precipitation is higher in the upper part because of the winter monsoon. In the lowland, some habitats are influenced by winter monsoon and have cool and foggy winter. As this study focuses on *Chamaecyparis* forest, whose distribution is strongly related to cloud formation, higher temperature and higher ratio of winter precipitation are

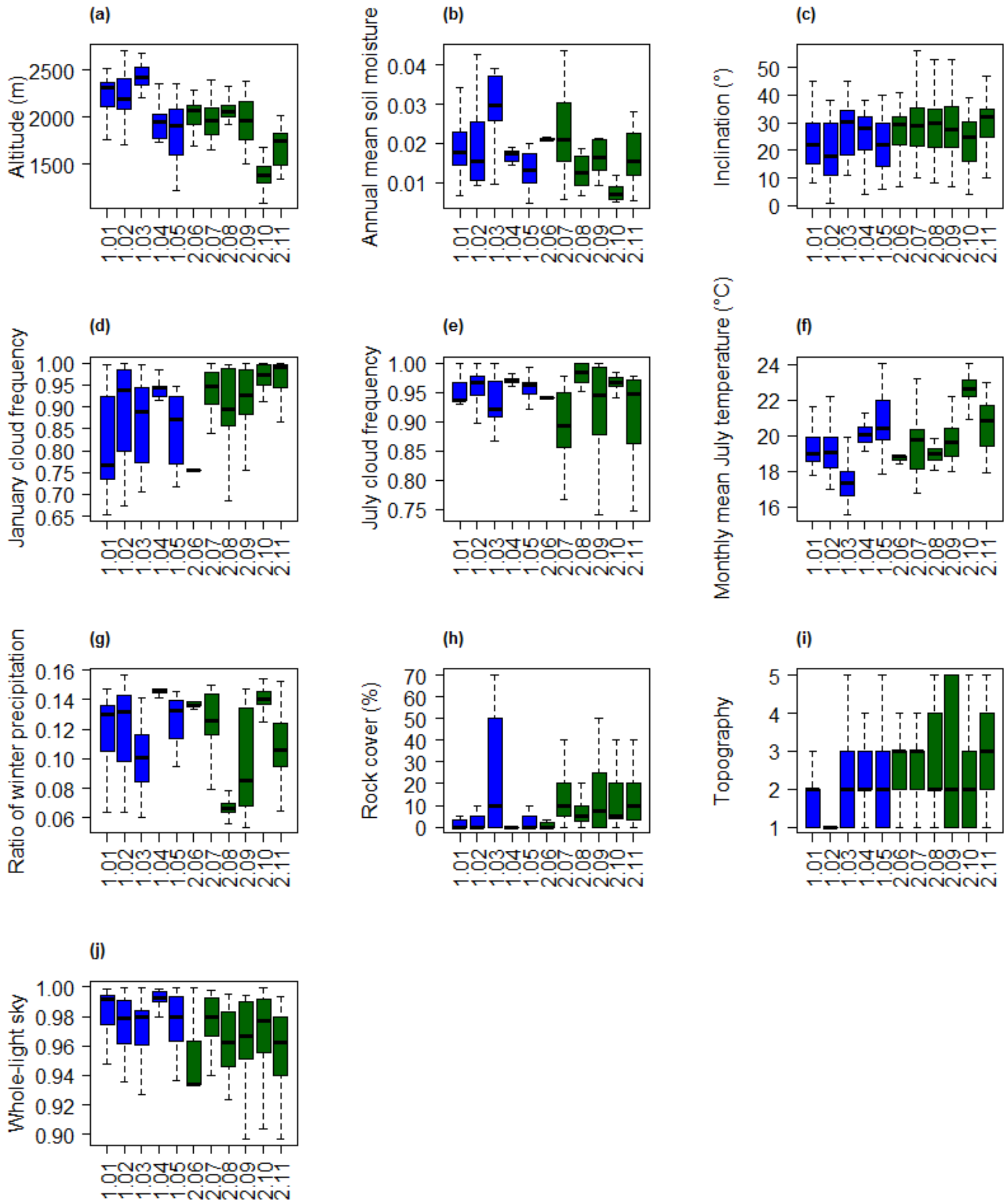

Figure 4. The box plots of 10 most important and representative environmental variables which are highly correlated with the floristic composition in NMDS ordination space. The thick horizontal bars are medians, the boxes represent the inter-quartile ranges, and the ranges of whiskers include 95% of the values. Annual mean soil moisture is on the scale of 0–1; the larger value indicates the lower soil moisture. January cloud frequency, July cloud frequency and Whole-light sky are on the scale of 0–1. Topography code: 1 = ridge; 2 = upper slope; 3 = middle slope; 4 = lower slope; 5 = valley. Boxes with blue colour indicate the associations under the alliance *Chamaecyparidion formosanae* while boxes with green colour indicate the associations under the alliance *Pasanio kawakamii-Machilion japonicae*.

combined at lower altitudes, but this combination would not be common if the whole of Taiwan was considered.

SYNTAXONOMICAL SYNOPSIS

Eleven associations and two alliances were described in this study. All of them belong to the same order:

Order: *Fagetalia hayatae* Hukusima et al. 2005

Alliance: 1. *Chamaecyparidion formosanae* Tokio Suzuki 1952 nom. mut. propos.

Associations:

1.01 *Tsugo formosanae-Chamaecyparidetum formosanae* Ching-Yu Liou ex Ching-Feng Li et al. 2014

1.02 *Vaccinio lasiostemonis-Tsugetum formosanae* Ching-Feng Li et al. 2014

1.03 *Schefflero taiwanianae-Chamaecyparidetum formosensis* Ching-Long Yeh et Chien-Chun Liao ex Ching-Feng Li et al. 2014

1.04 *Elatostemato trilobulati-Tsugetum formosanae* Tokio Suzuki 1952

1.05 *Rhododendro formosani-Chamaecyparidetum formosanae* Tokio Suzuki 1952

Alliance: 2. *Pasanio kawakamii-Machilion japonicae* Ching-Feng Li et al. 2014

Associations:

2.06 *Adinandro lasiostylae-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014

2.07 *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* Ching-Yu Liou ex Ching-Feng Li et al. 2014

2.08 *Castanopsio carlesii-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014

2.09 *Arachniodo rhomboideae-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014

2.10 *Symploco wikstroemiifoliae-Machiletum thunbergii* Ching-Feng Li et al. 2014

2.11 *Pileo brevicornutae-Machiletum japonicae* Ching-Feng Li et al. 2014

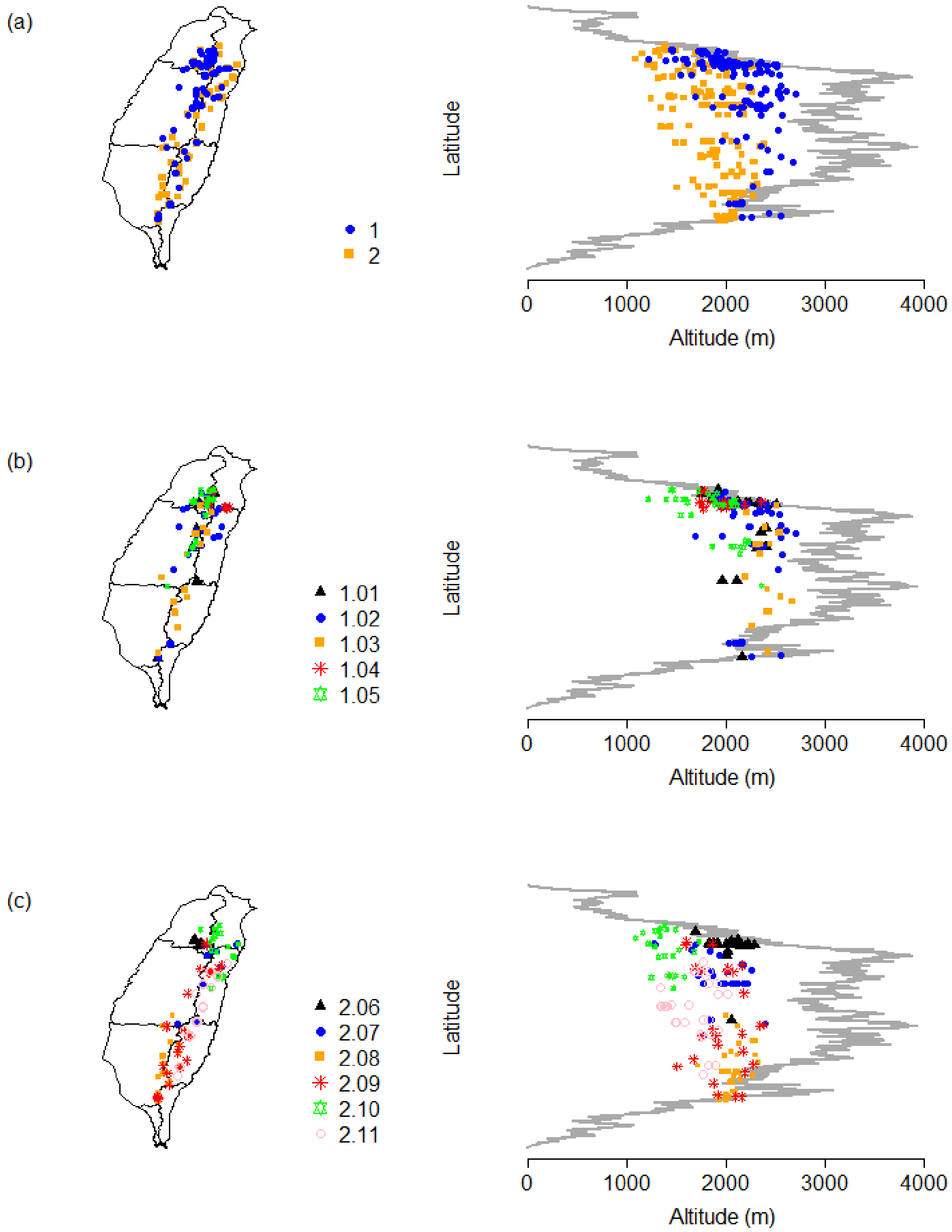

Figure 5. The geographical distribution of syntaxa based on the assigned relevés. On the left, the polygons in the contour map of Taiwan represent different ecoregions (Su 1985). On the right, the grey lines indicate the altitude of the highest Taiwanese peak at the given latitude. (a) Distribution maps of two alliances: 1 = *Chamaecyparidion formosanae* and 2 = *Pasanio kawakamii-Machilion japonicae*. (b) Distribution maps of five associations belonging to *Chamaecyparidion formosanae*. (c) Distribution maps of six associations belonging to *Pasanio kawakamii-Machilion japonicae*.

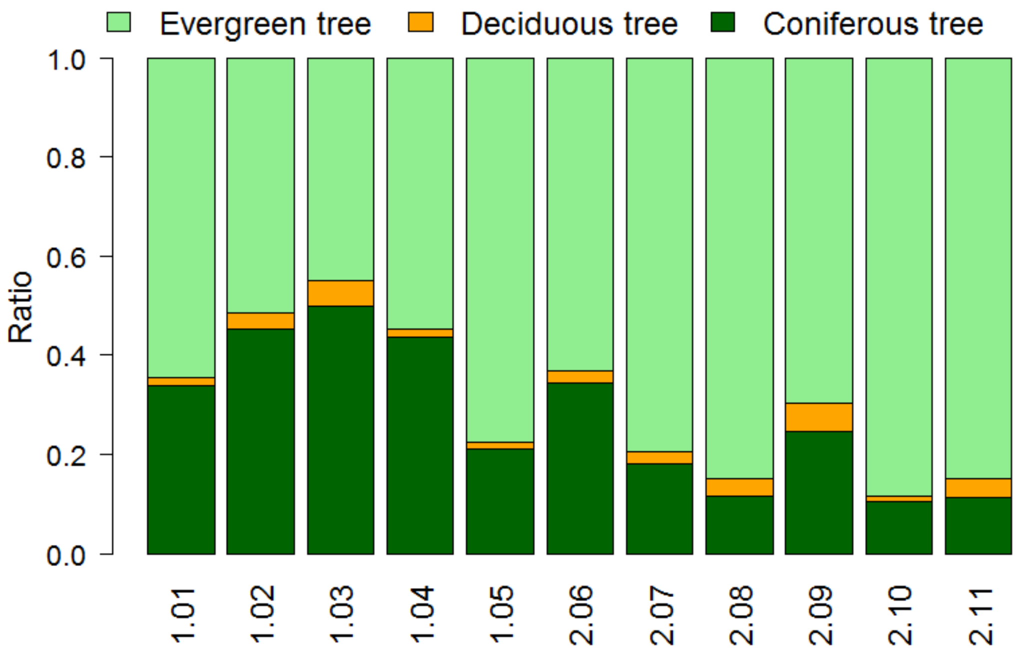

Figure 6. The ratio of cover composed by coniferous tree, deciduous broad-leaved tree and evergreen broad-leaved tree in each association.

DESCRIPTION OF ASSOCIATIONS AND ALLIANCES

Each syntaxon (association or alliance) is characterized by its names used in the previous literature (Appendix S1), floristic composition (Table 1), vertical structure of vegetation, habitat requirements (Fig. 4), geographic distribution (Fig. 5) and information about the differences from similar vegetation or habitat types. Fidelity of species to the syntaxa (based on Φ-value) was used as a criterion for selecting the diagnostic species. The Φ threshold was set at 0.1 for defining diagnostic species and the list of diagnostic species was sorted in alphabetic order within each life form. The species with bold font are those with Φ larger than 0.3. Fig. 6 summarizes the physiognomic structure of trees in each association. In describing the nomenclature type relevés, speices were sorted by their cover within each life form, and covers showed on percentage scale. Appendix and Table 2 contain the species data and header data of each nomenclature type relevé, respectively. Appendix S2 comprises the Cocktail Determination Key for the 11 associations, which can be directly imported into CoDeK program (Li et al. 2013).

Alliance 1: *Chamaecyparidion formosanae* Tokio Suzuki 1952 nom. mut. propos.

English name: Montane mixed coniferous forest (Su 1984); *Chamaecyparis* montane mixed cloud forest (Li et al. 2013)

Original name: *Chamaecyparidion taiwanaensis* Tokio Suzuki 1952 (*Chamaecyparis taiwanensis* = *C. obtusa* var. *formosana*)

Name-giving taxa: *Chamaecyparis obtusa* var. *formosana*

Synonyms: *Tsuga chinensis* var. *formosana* all. Chiou-Feng Yu 2003 (Art. 3h, 3i, 3o); *Rhododendron leptosanthum*-*Chamaecyparis obtusa* var. *formosana* type Jui-Ting Wei et Tze-Ying Chen 2007 (Art. 3c)

Nomenclature type association: *Rhododendro formosani*-*Chamaecyparidetum formosanae* Tokio Suzuki 1952 (lectotypus hoc loco designatus)

Range of altitude and warmth index: 1400–2700 m; 90–155 ˚C

Ecoregions: CW, EN, ES, NE, NW, SE and SW

Diagnostic species:

Trees: ***Chamaecyparis obtusa* var. *formosana***, *Cleyera japonica*, *C. japonica* var. *taipinensis*, *Cunninghamia konishii*, *Cyclobalanopsis sessilifolia*, *Dendropanax dentiger*, *Eurya glaberrima*, *Ilex sugerokii* var. *brevipedunculata*, *I. tugitakayamensis*, *Illicium anisatum*, *Lyonia ovalifolia*, *Neolitsea acuminatissima*, *Osmanthus heterophyllus*, *Photinia niitakayamensis*, ***Rhododendron formosanum***, *R. leptosanthum*, *Schefflera taiwaniana*, *Sorbus randaiensis*, *Symplocos morrisonicola*, *Trochodendron aralioides*, ***Tsuga chinensis* var. *formosana***, *Vaccinium kengii*

Shrubs: *Barthea barthei*, *Damnacanthus angustifolius*, *Litsea cubeba*, *Microtropis fokienensis*, ***Myrsine stolonifera***, *Rhododendron pseudochrysanthum*, *Skimmia arisanensis*, *S. reevesiana*, *Symplocos wikstroemiifolia*, ***Vaccinium japonicum* var. *lasiostemon***, *Viburnum sympodiale*, *V. urceolatum*, *Yushania niitakayamensis*

Herbs: *Ainsliaea macroclinidioides*, *Ardisia japonica*, *Asarum crassusepalum*, *Coptis quinquefolia*, *Crypsinus quasidivaricatus*, *Microlepia tenera*, *Nertera nigricarpa*, *Plagiogyria dunnii*, *P. formosana*, *Pyrola morrisonensis*, *Shortia rotundifolia*, *Smilacina japonica*

Lianas: *Rhus ambigua*, *Smilax arisanensis*, *S. discotis*, *Tripterospermum lanceolatum;*

Epiphytes: *Crypsinus echinosporus*, *Epigeneium nakaharae*, *Rhododendron kawakamii*, *Xiphopteris okuboi*

Chamaecyparidion formosanae is a mixed (mix of conifers and evergreen broad-leaved trees) or coniferous forest. The canopy cover is about 60–80% and the average canopy height is around 25 m. Four layers are commonly developed. The canopy is mostly composed of coniferous trees and *Chamaecyparis formosensis*, *C. obtusa* var. *formosana* and *Tsuga chinensis* var. *formosana* are commonly dominant trees in the canopy. The sub-canopy is usually composed of evergreen broad-leaved trees such as *Cyclobalanopsis morii* and *Trochodendron aralioides*. *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum* and *R. leptosanthum* are commonly dominant in the small-tree layer. The shrub layer is dominated by *Myrsine stolonifera* and *Yushania niitakayamensis*. *Plagiogyria formosana* is dominant in the herb layer. The species group composed of *Chamaecyparis obtusa* var. *formosana*, *Dendropanax dentiger*, *Eurya glaberrima*, *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum*, *Tsuga chinensis* var. *formosana*, *Trochodendron aralioides*, *Vaccinium japonicum* var. *lasiostemon* and *Yushania niitakayamensis* indicates the acid slopes to ridges with less topographical shading in the montane cloud zone in Taiwan (Appendix S2; Appendix S3 in Li et al. 2013). The species number and cover of *Lauraceae* are low while the dominance of *Ericaceae* in both species number and cover is high. At the mid-altitudes in Taiwan, habitats of *Chamaecyparidion formosanae* are often influenced by summer monsoon. The propotion of undecomposed material in the soil is high. A thick bryophyte layer covers the trunks, branches and the ground. Lightnings occasionally hit the tallest emergent coniferous trees in summer, but the fire affects a small area only due to the high humidity. Therefore soil contains a distinct layer of charcoal in places or patches with post-fire species such as *Lyonia ovalifolia*, *Photinia niitakayamensis*, *Pieris taiwanensis*, *Pinus taiwanensis* and *Rhododendron rubropilosum*. This alliance is distributed across the whole of Taiwan except the tropical region.

1.01 *Tsugo formosanae-Chamaecyparidetum formosanae* Ching-Yu Liou ex Ching-Feng Li et al. 2014 ass. nova hoc loco

Name-giving taxa: *Tsuga chinensis* var. *formosana*, *Chamaecyparis obtusa* var. *formosana*

Synonyms: *Pinus taiwanensis-Tsuga chinensis* var. *formosana* type Tze-Ying Chen 2002 (Art. 3c); *Cyclobalanopsis sessilifolia-Tsuga chinensis* var. *formosana* subass. Chiou-Feng Yu 2003 (Art. 3e); *Tsuga chinensis* var. *formosana-Chamaecyparis obtusa* var. *formosana* ass. Ching-Yu Liou 2003 (Art. 3h, 3i, 3o)

Nomenclature type relevé: 02-0609 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1800–2600 m; 105–145 ˚C

Ecoregions: CW, EN, ES, NE, NW, SE and SW

Canopy cover: 60–80%

Canopy height: 15–25 m

Diagnostic species:

Trees: *Cyclobalanopsis sessilifolia*, *Dendropanax dentiger*, *Eurya glaberrima*, *Ilex goshiensis*, *I. tugitakayamensis*, *Neolitsea acuminatissima*, *Photinia niitakayamensis*, *Rhododendron leptosanthum*, *Schefflera taiwaniana*, *Symplocos migoi*, *S. morrisonicola*, *S. stellaris*, *Trochodendron aralioides*, *Tsuga chinensis* var. *formosana*

Shrubs: *Damnacanthus angustifolius*, *Microtropis fokienensis*, *Skimmia arisanensis*, ***Viburnum urceolatum***, *Yushania niitakayamensis*

Herbs: *Ainsliaea macroclinidioides*, *Dryopteris wallichiana*, *Leptorumohra quadripinnata*, *Plagiogyria formosana*, *Pyrola alboreticulata*

Lianas: *Rhus ambigua*, *Smilax arisanensis*

Epiphytes: *Araiostegia parvipinnata*

Coniferous trees such as *Chamaecyparis obtusa* var. *formosana* and *Tsuga chinensis* var. *formosana* dominate the canopy. Other conifers, such as *Chamaecyparis* *formosensis*, *Pinus armandii* var. *mastersiana* and *Taiwania cryptomerioides* are sometimes also dominant in the canopy. The sub-canopy at a height of about 10–15 m is dominated by broad-leaved trees such as *Cyclobalanopsis morii*, *C. sessilifolia* and *Trochodendron aralioides*. Small trees such as *Neolitsea acuminatissima*, *Rhododendron formosanum*, *R. leptosanthum*, *Schefflera taiwaniana* and *Symplocos morrisonicola* are dominant in the understory of about 3–8 m in height. Dwarf bamboo, *Yushania niitakayamensis*, is dominant in the shrub layer and *Plagiogyria formosana* in the herb layer. Because *Chamaecyparis obtusa* var. *formosana* occurs only north of the Tropic of Cancer, these forests are mainly dominated by *Tsuga chinensis* var. *formosana* and *Cyclobalanopsis morii* in the southern part of Taiwan. This association occurs on wide ridges or upper slopes with well-developed soil. The amount of non-decomposed logs and litter is high and the soil contains a high proportion of organic material. In humid air typical of this habitat, the organic material on the forest floor is covered by thick layer of bryophytes. This association occurs across the whole island. The wide ridges where this association occurs are relatively stable in geology and it is suitable for road construction to connect places in the complex mountain terrain. At the same time, the well developed soil is favourable to agricultures. Most of the habitats of this association were clear-cut and then reforested by plantation or used for planting temperate crops such as tea, apples, peaches or cabbage.

1.02 *Vaccinio lasiostemonis-Tsugetum formosanae* Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Vaccinium japonicum* var. *lasiostemon*, *Tsuga chinensis* var. *formosana*

Synonyms: none

Nomenclature type relevé: 30-0097 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1800–2700 m; 95–150 ˚C

Ecoregions: CW, EN, ES, NE, NW, SE and SW

Canopy cover: 60–90%

Canopy height: 10–20 m

Diagnostic species:

Trees: *Chamaecyparis obtusa* var. *formosana*, *Eurya glaberrima*, *Ilex sugerokii* var. *brevipedunculata*, *Illicium anisatum*, *Lyonia ovalifolia*, *Neolitsea acuminatissima*, *Osmanthus heterophyllus*, *Photinia niitakayamensis*, *Rhododendron formosanum*, *Schefflera taiwaniana*, *Sorbus randaiensis*, *Tsuga chinensis* var. *formosana*

Shrubs: *Rhododendron pseudochrysanthum*, *Vaccinium japonicum* var. *lasiostemon*, *V. merrillianum*, *Yushania niitakayamensis*

Herbs: *Elaphoglossum angulatum*, *Myrmechis drymoglossifolia*, *Plagiogyria formosana*

Lianas: none

Epiphytes: *Mecodium javanicum, Xiphopteris okuboi*

Coniferous trees such as *Chamaecyparis obtusa* var. *formosana* and *Tsuga chinensis* var. *formosana* are dominant in the canopy. The sub-canopy layer is absent or composed of few individuals of *Elaeocarpus japonicus* or some species of *Fagaceae* such as *Castanopsis cuspidata* var. *carlesii*, *Cyclobalanopsis longinux* or *C. stenophylloides*. Small trees such as *Illicium anisatum*, *Lyonia ovalifolia*, *Neolitsea acuminatissima* and *Rhododendron formosanum* are dominant in the understory, which is about 3–10 m in height. *Yushania niitakayamensis* is dominant in the shrub layer. *Plagiogyria formosana* is dominant in the herb layer. This association occurs on narrow ridges with moderately developed soil. The dead logs which would offer good microhabitat for herbs, shrubs and seedlings are rare because they easily fall down from the narrow ridges. Shrub and herb layers in this association are sparse. The soil is characteristic by undecomposed organic material and covered by a thick layer of bryophytes. Several species of *Ericaceae* are frequent in this vegetation, indicating acid soil. This association is widespread across the whole of Taiwan, but in the southern part of the island, the dominance of *Chamaecyparis obtusa* var. *formosana* is mostly replaced by *Cyclobalanopsis morii*. Vegetation growing on the narrow ridges is usually species poor. There is one vegetation type whose canopy is almost purely composed of *Rhododendron formosanum* at narrow ridges lower than 1800 m a.s.l. inside the montane cloud zone. However, this is another vegetation type, which is not dealt with in this paper.

1.03 *Schefflero taiwanianae-Chamaecyparidetum formosensis* Ching-Long Yeh et Chien-Chun Liao ex Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Schefflera taiwaniana*, *Chamaecyparis formosensis*

Synonyms: *Schefflera taiwaniana-Chamaecyparis formosensis* ass. Ching-Long Yeh et Chien-Chun Liao 2009 (Art. 3h, 3i, 3o)

Nomenclature type relevé: 20-0295 (holotypus hoc loco designatus)

Range of altitude and warmth index: 2150–2650 m; 80–135 ˚C

Ecoregions: CW, EN, ES, NE, NW, SE and SW

Canopy cover: 40–80%

Canopy height: 10–20 m

Diagnostic species:

Trees: *Acer morrisonense*, *Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Eurya glaberrima*, ***Ilex bioritsensis***, *Litsea morrisonensis*, *Neolitsea acuminatissima*, *Osmanthus heterophyllus*, *Pinus armandii* var. *mastersiana*, *Schefflera taiwaniana*, *Tsuga chinensis* var. *formosana*

Shrubs: *Eurya leptophylla, Rubus formosensis, R. pungens, Yushania niitakayamensis*

Herbs: ***Ainsliaea latifolia* subsp. *henryi***, *Carex brunnea*, *Carpesium nepalense*, *Dryopteris lepidopoda*, *Ellisiophyllum pinnatum*, ***Hydrocotyle setulosa***, *Oxalis acetosella* subsp. *griffithii* var. *formosana*, *Peranema cyatheoides*, *Polystichum parvipinnulum*, *Rubia lanceolata*

Lianas: *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Lonicera acuminata*

Epiphytes: none

Coniferous trees such as *Chamaecyparis formosensis*, *Pinus armandii* var. *mastersiana* and *Tsuga chinensis* var. *formosana* mixed with evergreen broad-leaved trees such as *Cyclobalanopsis morii*, *C. stenophylloides* and *Trochodendron aralioides* are dominant in the canopy. *Picea morrisonicola* is also sometimes dominant in the canopy. Small trees such as *Eurya glaberrima*, *Neolitsea acuminatissima* and *Symplocos morrisonicola* are dominant at a height of 3–6 m. *Yushania niitakayamensis* is dominant in the shrub layer and *Plagiogyria formosana* in the herb layer. Deciduous trees such as *Acer kawakamii* and *A. morrisonense* are frequent in the canopy. Species group of montane rocky habitats, including *Acer morrisonense*, *Hydrocotyle setulosa*, *Peranema cyatheoides*, *Rubia lanceolata* and *Rubus formosensis*, is frequent in this association. This association occurs at high altitudes on slopes and ridges with large rock outcrops. It is the coldest and driest among all *Chamaecyparis* forests in Taiwan. Its habitats are similar to those of the association *Rhododendro pseudochrysanthum-Tsugetum formosanae* (Lin et al. 2012), which grows above the montane cloud zone and does not contain the species group of montane rocky habitats. Tree species such as *Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Dendropanax dentiger*, *Neolitsea acuminatissima*, *Schefflera taiwaniana* and *Trochodendron aralioides*, which are common in *Schefflero taiwanianae-Chamaecyparidetum formosensis*, are also absent from *Rhododendro pseudochrysanthum-Tsugetum formosanae*. At the same time, *Schefflero taiwanianae-Chamaecyparidetum formosensis* grows inside the montane cloud zone and does not contain any subalpine species such as *Abies kawakamii*, *Circaea alpina* subsp. *imaicola*, *Galium echinocarpum*, *Ribes formosanum*, *Rubus rolfei* and *Sedum actinocarpum*. This association is distributed across the whole of Taiwan.

1.04 *Elatostemato trilobulati-Tsugetum formosanae* Tokio Suzuki 1952 nom. mut. propos.

Original name: *Pellionieto-Tsugetum sinensis* Tokio Suzuki 1952 (*Pellionia trilobulatum* = *Elatostema trilobulatum*, *Tsuga sinensis* = *Tsuga chinensis* var. *formosana*)

Name-giving taxa: *Elatostema trilobulatum*, *Tsuga chinensis* var. *formosana*

Synonyms: *Chamaecyparis obtusa* var. *formosana* forest Chang-Hung Chou et al. 2000 (Art. 3c); *Rhododendron formosanum-Chamaecyparis obtusa* var. *formosana* ass. Tze-Ying Chen et al. 2002 (Art. 3h, 3i, 3o); *Tsuga chinensis* var. *formosana-Chamaecyparis obtusa* var. *formosana* type Jui-Ting Wei et Tze-Ying Chen 2007 (Art. 3c)

Nomenclature type relevé: 02-2077 (neotypus hoc loco designatus)

Range of altitude and warmth index: 1600–2300 m; 120–145 ˚C

Ecoregions: NE and NW

Canopy cover: 70–90%

Canopy height: 15–20 m

Diagnostic species:

Trees: ***Chamaecyparis obtusa* var. *formosana***, *Cleyera japonica*, *C. japonica* var. *taipinensis*, *Cunninghamia konishii*, *Dendropanax dentiger*, *Eurya glaberrima*, ***I. hayataiana***, *I. sugerokii* var. *brevipedunculata*, ***I. suzukii***, *I. tugitakayamensis*, ***Illicium anisatum***, *Ligustrum liukiuense*, *Litsea elongata* var. *mushaensis*, *Neolitsea acuminatissima*, ***Prunus matuurai***, *Rhododendron formosanum*, *Symplocos arisanensis*, *S. morrisonicola*, *Taiwania cryptomerioides*, *Vaccinium kengii*

Shrubs: *Ardisia crenata*, ***Barthea barthei***, ***Berberis kawakamii***, *B. mingetsuensis*, *Damnacanthus angustifolius*, ***Eurya crenatifolia***, *Myrsine stolonifera*, ***Rubus corchorifolius***, *Skimmia reevesiana*, ***Vaccinium japonicum* var. *lasiostemon***, *Viburnum erosum*, ***V. sympodiale***, *V. urceolatum*

Herbs: *Acrophorus stipellatus*, ***Ardisia japonica***, *Arthromeris lehmannii*, ***Asarum crassusepalum***, ***Coptis quinquefolia***, *Crypsinus engleri*, *Ctenitis kawakamii*, *Diplopterygium glaucum*, ***Elaphoglossum commutatum***, *Elatostema trilobulatum*, ***Microlepia tenera***, ***Nertera nigricarpa***, *Oxalis acetosella* subsp. *griffithii* var. *formosana*, *Plagiogyria formosana*, *Polypodium amoenum*, *P. argutum*, *Sarcopyramis napalensis* var. *bodinieri*, *S. napalensis* var. *delicata*, ***Shortia rotundifolia***, ***Smilacina japonica***

Lianas: ***Maclura cochinchinensis***, ***Rhus ambigua***, ***Rubus liuii***, *Smilax arisanensis*, ***S. discotis***, *Tripterospermum lanceolatum*

Epiphytes: *Araiostegia parvipinnata*, *Crypsinus echinosporus*, *Mecodium polyanthos*, *Rhododendron kawakamii*, *Vittaria flexuosa*, ***Xiphopteris okuboi***

Chamaecyparis obtusa var. *formosana* and *Tsuga chinensis* var. *formosana* are dominant in the tree layer. *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum* and *R. leptosanthum* are dominant at a height of 3–8 m. *Barthea barthei*, *Myrsine stolonifera* and *Yushania niitakayamensis* are dominant in the shrub layer. *Plagiogyria formosana* and *P. euphlebia* are dominant in the herb layer. *Coptis quinquefolia*, *Shortia rotundifolia* and *Viburnum sympodiale* represent this cool and very humid habitat. *Monachosorum henryi*, *Plagiogyria euphlebia*, *P. stenoptera* and *Sarcopyramis napalensis* var. *bodinieri* form a species group representing a high accumulation of organic material on the forest floor. The habitats of this association are on the slopes which are less shaded by the surrounding topography with shallow soils. This is the most humid association among all *Chamaecyparis* forests in Taiwan. The forest floor is bog-like, covered by a thick layer of *Sphagnum* spp. All trunks are covered by a thick layer of bryophytes. Tree seedlings often grow on the living tree trunks or standing stumps. When the seedlings germinating on the standing trunks grow up, they make the trunks heavy and the trunks incline to some directions. There is no specific direction the trunks inclining to because this inclination is not caused by some force with constant direction such as the wind. When the trunks get inclined more and more from strait up, they have more germinated seedlings growing on them. These processes are responsible for a complex three-dimensional structure of this vegetation, which is composed of many small stems at different height above ground and leaning in different angles. There are few *Fagaceae* species in the canopy or sub-canopy; these species can grow only on the bare soil exposed due to up-rooting of large coniferous trees, germination usually on the top of the up-roots at a height of 3 m above ground. It has been suggested that the high ground water table and humidity prevent the *Fagaceae* to grow in this association (Chou et al. 2000). Such a high heterogeneity of humidity caused by the peculiar spatial structure within one stand makes *Elatostemato trilobulati-Tsugetum formosanae* the most species-rich community among the forests dominated by *Chamaecyparis obtusa* var. *formosana*. Geographically, this association is confined to the slopes and ridges in the north-eastern part of Taiwan that are reached by the winter monsoon, especially around Cuei-Fong Lake, Song-Luo Lake and Yuan-Yang Lake.

1.05 *Rhododendro formosani-Chamaecyparidetum formosanae* Tokio Suzuki 1952 nom. mut. propos.

Original name: *Rhodoreto-Chamaecyparidetum taiwanensis* Tokio Suzuki 1952 (*C. taiwanensis* = *C. obtusa* var. *formosana*)

Name-giving taxa: *Rhododendron formosanum*, *Chamaecyparis obtusa* var. *formosana*

Synonyms: *Chamaecyparis formosensis-Symplocos caudata* ass. Chiou-Feng Yu 2003 (Art. 3h, 3i, 3o)

Nomenclature type relevé: 02-2040 (neotypus hoc loco designatus)

Range of altitude and warmth index: 1300–2400 m; 110–160 ˚C

Ecoregions: NW and CW

Canopy cover: 70–90%

Canopy height: 15–25 m

Diagnostic species:

Tree: *Castanopsis cuspidata* var. *carlesii*, *Chamaecyparis obtusa* var. *formosana*, *Cinnamomum subavenium*, *Cleyera japonica*, *C. japonica* var. *taipinensis*, *Cyclobalanopsis sessilifolia*, *Dendropanax dentiger*, *Elaeocarpus japonicus*, *Ilex goshiensis*, *Ilex tugitakayamensis*, *Machilus thunbergii*, *Michelia compressa*, *Neolitsea acuminatissima*, ***Rhododendron formosanum***, *Rhododendron leptosanthum*, *Sassafras randaiense*, ***Schima superba***, *Symplocos heishanensis*, *S. stellaris*, *Ternstroemia gymnanthera*, *Vaccinium kengii*

Shrub: *Barthea barthei*, *Damnacanthus angustifolius*, *Lasianthus japonicus*, ***Litsea cubeba***, ***Myrsine stolonifera***, *Skimmia reevesiana*, ***Symplocos wikstroemiifolia***, *Vaccinium japonicum* var. *lasiostemon*, *Viburnum integrifolium*, *V. urceolatum*

Herb: *Collabium chinense*, *Crypsinus engleri*, *Lycopodium serratum* var. *longipetiolatum*, ***Plagiogyria dunnii***

Liana: *Smilax arisanensis*, *Tripterospermum taiwanense*

Epiphyte: *Pyrrosia lingua*

Chamaecyparis obtusa var. *formosana*, *C. formosensis* and *Tsuga chinensis* var. *formosana* are dominant in the canopy. *Castanopsis cuspidata* var. *carlesii*, *Machilus thunbergii* and *Elaeocarpus japonicus* are dominant in the sub-canopy at a height of 10–15 m. Species of *Theaceae* such as *Pyrenaria shinkoensis*, *Schima superba* and *Ternstroemia gymnanthera* are frequent accompanying trees in the canopy and sub-canopy. *Neolitsea acuminatissima*, *Rhododendron formosanum* and *R. leptosanthum* are dominant small trees reaching a height of 3–8 m. *Myrsine stolonifera* and *Yushania niitakayamensis* are dominant in the shrub layer. *Dryopteris formosana, Plagiogyria dunnii*, *P.* euphlebia and *P. formosana* are dominant in the herb layer. The number of species and cover of *Lauraceae* and *Fagaceae* in the canopy and sub-canopy layers are the highest among all the *Chamaecyparis obtusa* var. *formosana* dominated forests. The proportion of coniferous trees is the lowest among the associations of the same alliance (Fig. 6). This association occupies the south-facing slopes in the western part of central and northern Taiwan. This indicates that there is heavy fog in summer derived from the summer monsoon. The habitat is the warmest among all *Chamaecyparis obtusa* var. *formosana* dominated forests. Rockiness and rock cover are high. Some south-facing slopes in the same region and at similar altitudes may be less affected by fog than the habitats of this association; such habitats may be dry and dominated by deciduous species such as *Quercus variabilis* or other coniferous species such as *Pinus taiwanensis*. These *Q. variabilis* or *P. taiwanensis* dominated forests are not dealt with in this study.

Alliance 2: *Pasanio kawakamii-Machilion japonicae* Ching-Feng Li et al. 2014 all. nov. hoc loco

English name: Montane evergreen broad-leaved forest (Su 1984); *Quercus* montane evergreen broad-leaved cloud forest (Li et al. 2013)

Name-giving taxa: *Pasania kawakamii*, *Machilus japonica*

Synonyms: none

Nomenclature type association: *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* Ching-Yu Liou ex Ching-Feng Li et al. 2014 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1000–2300 m; 100–165 ˚C.

Ecoregions: CW, EN, ES, NE, NW, SE and SW

Diagnostic species:

Trees: *Adinandra lasiostyla, Chamaecyparis formosensis, Cyclobalanopsis stenophylloides, Fatsia polycarpa, Ligustrum pricei, L. sinense, L. lepidocarpus, Litsea acuminata, L. elongata* var. *mushaensis, Machilus japonica, M. zuihoensis* var. *mushaensis, Neolitsea aciculata, Osmanthus lanceolatus,* ***Pasania kawakamii****, Perrottetia arisanensis, Pourthiaea beauverdiana* var. *notabilis, Prunus phaeosticta, Sycopsis sinensis, Symplocos arisanensis, S. migoi*

Shrubs: *Ardisia crenata, Bredia oldhamii, Callicarpa randaiensis, Damnacanthus indicus, Eurya leptophylla, E. loquaiana, Helwingia japonica* subsp. *taiwaniana, Hydrangea angustipetala, Rhamnus pilushanensis, Rubus kawakamii, Swida controversa, Symplocos formosana, S. modesta, Viburnum taitoense*

Herbs: *Acrophorus stipellatus, Arachniodes festina,* ***A. rhomboidea****, Arisaema taiwanense* var. *brevipedunculatum, Asarum macranthum, Asplenium ensiforme, A. normale, Athyrium arisanense, A. subrigescens, Calanthe puberula, Carex brunnea, Coniogramme intermedia, Cornopteris fluvialis, Cyrtomium hookerianum, Diplazium amamianum, D. kawakamii, D. mettenianum,* *Disporopsis fuscopicota* var. *arisanensis*, *Dryopteris formosana*, *D. sparsa*, *Elatostema microcephalanthum*, *E. parvum*, *E. trilobulatum*, *Loxogramme remotefrondigera*, *L. salicifolia*, *Lysimachia ardisioides*, *L. capillipes*, *L. pauciflorus*, *Microsorium buergerianum*, *Monachosorum henryi*, *Ophiorrhiza japonica*, *Pellionia radicans*, *Peperomia reflexa*, *Pilea aquarum* subsp. *brevicornuta*, *P. melastomoides*, *Plagiogyria euphlebia*, *P. stenoptera*, *Polygonum thunbergii*, *P. formosanum*, *Polypodium transpianense*, *Polystichum acutidens*, *P. hancockii*, *P. parvipinnulum*, *P. prionolepis*, *Pteris setulosocostulata*, *Rubus pectinellus*, *Salvia formosana*, *Selaginella mollendorffii*, *S. remotifolia*, *Stellaria arisanensis*, *Strobilanthes rankanensis*, *Teucrium taiwanianum*, *Urtica thunbergiana*, *Viola shinchikuensis*, *Woodwardia unigemmata*

Lianas: *Celastrus punctatus*, *Clematis henryi*, *Embelia laeta* var. *papilligera*, *Ficus sarmentosa* var. *henryi*, *F. sarmentosa* var. *nipponica*, *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Pileostegia viburnoides*, *Schisandra arisanensis*, *S. integrifolium* var. *fauriei*, *Smilax hayatae*, *S. lanceifolia*, *Stauntonia obovatifoliola*, *Tetrastigma umbellatum*, *Trachelospermum formosanum*

Epiphytes: *Araiostegia parvipinnata*, *Asplenium wilfordii*, *Pittosporum daphniphylloides*, *Pyrrosia sheareri*, *Vaccinium emarginatum*, *Vandenboschia auriculata*, *Viburnum arboricolum*, *Vittaria flexuosa*

Pasanio kawakamii-Machilion japonicae is a mixed (mix of coniferous trees and evergreen broad-leaved trees) or evergreen broad-leaved forest. The canopy cover is about 70–90% and the average canopy height is about 20 m. Most of the associations of this alliance, except *Pileo brevicornutae-Machiletum japonicae*, which grows over limestone, have five layers. The canopy is mostly composed of evergreen broad-leaved trees and dominated by *Castanopsis cuspidata* var. *carlesii*, *Cyclobalanopsis morii*, *Machilus japonica*, *M. thunbergii* and *Pasania kawakamii*. *Chamaecyparis formosensis* is usually an emergent tree above the canopy. The sub-canopy is dominated by *Litsea acuminata*. The small-tree layer is dominated by *Neolitsea acuminatissima* and *Eurya loquaiana*. *Yushania niitakayamensis* dominates the shrub layer. The dominant herbs are *Dryopteris formosana*, *Monachosorum henryi* and *Plagiogyria formosana*. Species group composed of *Castanopsis cuspidata* var. *carlesii*, *Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Eurya strigillosa*, *Litsea acuminata*, *Machilus japonica*, *Machilus thunbergii* and *Neolitsea acuminatissima* represents the habitats on slopes or valleys with stony soil in the mountain cloud zone in Taiwan (Appendix S2; Appendix S3 in Li et al. 2013). The seedlings of *Chamaecyparis formosensis* are usually found on landslides. Habitats of the associations under this alliance described in this study are supposed to be landslides hundreds to thousands years ago (Chen 2001). Comparing to *Chamaecyparidion formosanae*, the cover of bryophytes is lower, the species number and cover of *Lauraceae* is much higher, the cover of *Ericaceae* is lower and the total number of species is higher, especially in herbs, lianas and epiphytes. This alliance is distributed across the whole of Taiwan except the tropical region.

2.06 *Adinandro lasiostylae-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Adinandra lasiostyla*, *Chamaecyparis formosensis*

Synonyms: *Acer morrisonense-Daphniphyllum himalaense* subtype Nien-June Chung 1995 (Art. 3c); *Cyclobalanopsis sessilifolia-Chamaecyparis obtusa* var. *formosana* ass. Tze-Ying Chen 2004 (Art. 3h, 3i, 3o)

Nomenclature type relevé: 02-0614 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1800–2300 m; 100–135 ˚C

Ecoregions: CW, ES and NW

Canopy cover: 50–70%

Canopy height: 25–35 m

Diagnostic species:

Trees: ***Adinandra lasiostyla***, *Chamaecyparis formosensis*, *Cleyera japonica* var. *taipinensis*, ***Cyclobalanopsis sessilifolia***, *C. stenophylloides*, *Daphniphyllum himalaense* subsp. *macropodum*, *Fatsia polycarpa*, *Ilex goshiensis*, *I. lonicerifolia* var. *matsudai*, *I. tugitakayamensis*, ***Ligustrum sinense***, *Malus doumeri*, *Neolitsea aciculata*, *N. acuminatissima*, *Pasania kawakamii*, *Prunus campanulata*, *P. phaeosticta*, ***Sycopsis sinensis***, *Symplocos arisanensis*, ***S. heishanensis***, ***S. migoi***, *S. morrisonicola*, *S. stellaris*, *Ternstroemia gymnanthera*, *Trochodendron aralioides*

Shrubs: *Ardisia crenata*, *Berberis mingetsuensis*, *Camellia tenuifolia*, *Damnacanthus angustifolius*, *D. indicus*, ***Euonymus spraguei***, *Eurya leptophylla*, *E. loquaiana*, ***Helwingia japonica* subsp. *taiwaniana***, *Microtropis fokienensis*, ***Rhamnus pilushanensis***, *Rubus kawakamii*, *Skimmia reevesiana*, ***Viburnum foetidum* var. *rectangulatum***, *V. integrifolium*

Herbs: *Ainsliaea latifolia* subsp. *henryi*, *Arachniodes rhomboidea*, *Arisaema taiwanense*, *Arthromeris lehmannii*, ***Asarum macranthum***, *Athyrium arisanense*, *Athyrium erythropodum*, *A. subrigescens*, *Calanthe arcuata*, ***C. puberula***, *Coniogramme intermedia*, *Ctenitis eatonii*, *C. transmorrisonensis*, *Diplazium mettenianum*, ***Disporopsis fuscopicota* var. *arisanensis***, *Dryopteris formosana*, *D. sparsa*, *Elatostema trilobulatum*, *Goodyera velutina*, *Lepisorus obscurevenulosus*, *Leptorumohra quadripinnata*, *Lycopodium serratum* var. *longipetiolatum*, *Lysimachia ardisioides*, *L. capillipes*, *L. pauciflorus*, *Monachosorum maximowiczii*, ***Ophiopogon japonicus***, *Oxalis acetosella* subsp. *griffithii* var. *formosana*, *Pellionia radicans*, *Plagiogyria euphlebia*, *P. formosana*, *Polypodium transpianense*, *P. parvipinnulum*, *P. wilsonii*, *Pyrola alboreticulata*, *Rubus pectinellus*, ***Salvia formosana***, *Strobilanthes rankanensis*, *Teucrium taiwanianum*, *Viola formosana*, ***V. shinchikuensis***, *Woodwardia unigemmata*, *Zeuxine reflexa*

Lianas: ***Akebia trifoliata* subsp. *australis***, ***Celastrus punctatus***, *Hedera rhombea* var. *formosana*, *Hydrangea anomala*, *H. integrifolia*, *Kadsura japonica*, *Lonicera acuminata*, *Sabia transarisanensis*, *Schizophragma integrifolium* var. *fauriei*, *Smilax arisanensis*, *Stauntonia obovatifoliola*, ***Trachelospermum formosanum***, *Tripterospermum taiwanense*, ***Zanthoxylum scandens***

Epiphytes: *Araiostegia parvipinnata*, *Asplenium wilfordii*, ***Dendrobium furcatopedicellatum***, *Drymotaenium miyoshianum*, *Gastrochilus rantabunensis*, *Pyrrosia linearifolia*, *P. sheareri*, *Vittaria flexuosa*

Chamaecyparis formosensis, *Pinus armandii* var. *mastersiana* and *Tsuga chinensis* var. *formosana* dominate the canopy. In places, *Taiwania cryptomerioides* is an emergent tree above the canopy. *Cyclobalanopsis sessilifolia*, *Sycopsis sinensis* and *Trochodendron aralioides* are dominant in the sub-canopy, reaching a height of 10–15 m. *Eurya loquaiana* and *Neolitsea acuminatissima* are dominant small trees, usually 3–8 m high. *Yushania niitakayamensis* is dominant in the shrub layer. *Arachniodes rhomboidea*, *Dryopteris formosana*, *Pellionia radicans* and *Plagiogyria formosana* are dominant in the herb layer. The amount of bryophytes is low in this association while the number of vascular plant species is high. *Adinandra lasiostyla* and *Sycopsis sinensis* indicate the relatively basic and dry soil in the montane cloud zone while *Rhododendron leptosanthum* and *Tsuga chinensis* var. *formosana* represent the relatively acid and dry soil. Another representative species group of this association is composed of lianas including *Ficus sarmentosa* var. *nipponica*, *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Lonicera acuminata*, *Smilax arisanensis*, *Schizophragma integrifolium* var. *fauriei* and *Stauntonia obovatifoliola*. These lianas occurs frequently also in the *Picea morrisonicola* dominated forest which grows on the nutrient-rich soil in the montane cloud zone in Taiwan. In the western part of Taiwan, this association occupies north-facing slopes while in the eastern part it grows on south-facing slopes. Geographically, this association is confined to the north-western ecoregion, central-western ecoregion and southern section of the eastern ecoregion. This might be the result of interaction between monsoon effects and soil conditions. Such habitats are less influenced by both summer and winter monsoon; although they experience some fog, there are rarely dense fog events, than the other forests dominated by *Chamaecyparis formosensis*. The soil is well-developed with some big stones of argillite which might be nutrient-rich after weathering. However, it is lack of information about the distribution of argillite in fine scale.

2.07 *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* Ching-Yu Liou ex Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Cyclobalanopsis stenophylloides*, *Chamaecyparis formosensis*

Synonyms: *Chamaecyparis formosensis-Machilus japonica* forest type Yui-Ching Kao et Horng-Jye Su 2001 (Art. 3c); *Cyclobalanopsis stenophylloides-Chamaecyparis formosensis* ass. Ching-Yu Liou 2003 (Art. 3h, 3i, 3o); *Litsea elongata* var. *mushaensis-Chamaecyparis formosensis* ass. Ching-Yu Liou 2003 (Art. 3h, 3i, 3o); *Tsuga chinensis* var. *formosana-Chamaecyparis formosensis* ass. Ching-Yu Liou 2003 (Art. 3h, 3i, 3o)

Nomenclature type relevé: 30-0096 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1400–2500 m; 95–160 ˚C.

Ecoregions: CW, EN, ES, NE, NW and SE

Canopy cover: 60–80%

Canopy height: around 15–20 m

Diagnostic species:

Trees: *Acer kawakamii*, *A. palmatum* var. *pubescens*, *Camellia brevistyla*, *Carpinus rankanensis*, *Chamaecyparis formosensis*, *Cyclobalanopsis longinux*, *C. morii*, *C. stenophylloides*, *Fatsia polycarpa*, *Ilex hayataiana*, ***Ligustrum pricei***, *Litsea elongata* var. *mushaensis*, *L. morrisonensis*, *Machilus japonica*, *Pasania hancei* var. *ternaticupula*, *P. kawakamii*, ***Pourthiaea beauverdiana* var. *notabilis***, *Prunus phaeosticta*, *Sycopsis sinensis*

Shrubs: *Damnacanthus indicus*, *Eurya leptophylla*, *Swida controversa*, *Symplocos formosana*, *Viburnum taitoense*

Herbs: *Arachniodes festina*, *A. rhomboidea*, *Arisaema taiwanense* var. *brevipedunculatum*, *Carex brunnea*, *Coniogramme intermedia*, *Cornopteris fluvialis*, *Cyrtomium hookerianum*, *Diplazium amamianum*, *D. kawakamii*, *Dryopteris formosana*, *Loxogramme remotefrondigera*, *Microsorium buergerianum*, *Monachosorum henryi*, *Ophiopogon intermedius*, *O. japonica*, *Paris polyphylla* var. *taitungensis*, *Pellionia radicans*, *Pilea aquarum* subsp. *brevicornuta*, *Pilea matsudai*, *Polygonum posumbu*, *Polystichum hancockii [6]*, *P. parvipinnulum*, *Sedum erythrospermum*, *Selaginella mollendorffii*, *Strobilanthes rankanensis*, *Urtica thunbergiana*, *Woodwardia unigemmata*

Lianas: *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Schisandra arisanensis*, *Schizophragma integrifolium* var. *fauriei*, *Stauntonia obovatifoliola*

Epiphytes: *Pittosporum daphniphylloides*, *Pyrrosia sheareri*, ***Viburnum arboricolum***

Cyclobalanopsis morii, *Machilus* japonica and *M. thunbergii* are dominant in the canopy; *Chamaecyparis formosensis* is an emergent tree above the canopy. *Litsea acuminata*, *Prunus phaeosticta* and *Symplocos formosana* are dominant small trees at a height of 3–8 m. *Yushania niitakayamensis* is dominant in the shrub layer. *Monachosorum henryi*, *Pellionia radicans* and *Plagiogyria formosana* are dominant in the herb layer. Species group composed of *Cyclobalanopsis longinux*, *Litsea elongata* var. *mushaensis*, *L. morrisonensis*, *Pasania hancei* var. *ternaticupula*, *P. kawakamii* and *Pourthiaea beauverdiana* var. *notabilis* is frequent in this association. This species group indicates sites with high rockiness in the cloud zone. Deciduous broad-leaved trees indicating relatively dry habitat such as *Acer palmatum* var. *pubescens*, *A. kawakamii*, *A. morrisonensis*, *Carpinus kawakamii* and *C. rankanensis* are the most common compared to the other *Chamaecyparis formosensis* dominated forests (Fig. 6). This association occurs mainly in the eastern part of Taiwan, but it is also found in some places in western Taiwan which are not influenced by summer monsoon and have a high humidity in winter. Such habitats in western Taiwan are close to the valleys right beside the main ridges of Backbone Mountains.

2.08 *Castanopsio carlesii-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Castanopsis cuspidata* var. *carlesii*, *Chamaecyparis formosensis*

Synonyms: *Chamaecyparis formosensis-Castanopsis cuspidata* var. *carlesii* subtype Sheng-Zehn Yang 1991 (Art. 3c); *Chamaecyparis formosensis* ass. Ching-Long Yeh et Chien-Chun Liao 2009 (Art. 3h, 3i, 3o); *Symplocos caudata-Chamaecyparis formosensis* ass. Yi-Shin Chian et al. 2010 (Art. 3h, 3i, 3o)

Nomenclature type relevé: 20-0123 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1800–2300 m; 110–140 ˚C

Ecoregions: CW, ES, SE and SW

Canopy cover: 70–90%

Canopy height: 15–20 m

Diagnostic species:

Trees: *Adinandra formosana*, *A. lasiostyla*, ***Castanopsis cuspidata* var. *carlesii***, *Cyclobalanopsis morii*, *Eurya strigillosa*, ***Gordonia axillaris***, *Illicium arborescens*, ***Lithocarpus amygdalifolius***, *L.*

lepidocarpus, *Litsea acuminata*, *Machilus japonica*, *M. thunbergii*, *Neolitsea aciculata* var. *variabillima*, *N. acuminatissima*, *Osmanthus enervius*, *O. kaoi*, *O. lanceolatus*, *Pourthiaea beauverdiana* var. *notabilis*, *Symplocos arisanensis*, *S. glauca*, *S. sonoharae*, *S. trichoclada*

Shrubs: *Ardisia crenata*, ***Bredia oldhamii***, ***Callicarpa randaiensis***, *Damnacanthus indicus*, *Eurya chinensis*, *E. loquaiana*, ***Hydrangea chinensis***, *Vaccinium dunalianum* var. *caudatifolium*, *Viburnum integrifolium*

Herbs: *Arachniodes rhomboidea*, *Asplenium ensiforme*, *A. normale*, *Athyrium arisanense*, *Carex orthostemon*, *Dryopteris sparsa*, *Elatostema trilobulatum*, *Goodyera bilamellata*, *Lepisorus kawakamii*, *L. thunbergianus*, *Liriope minor* var. *angustissima*, *Lysionotus pauciflorus*, *Microsorium buergerianum*, *Monachosorum henryi*, ***Peliosanthes teta* var. *kaoi***, *Peperomia reflexa*, *Plagiogyria euphlebia*, *P. stenoptera*, *Polypodium amoenum*, *P. biaristatum*, ***Polystichum prionolepis***, *Sarcopyramis napalensis* var. *bodinieri*, *Strobilanthes cusia*

Lianas: *Clematis formosana*, *Embelia laeta* var. *papilligera*, *Hedera rhombea* var. *formosana*, *Rubus pyrifolius*, *Smilax bracteata*, *S. lanceifolia*, *S. menispermoidea*, *S. sieboldii*, *Stauntonia obovatifoliola*

Epiphytes: *Araiostegia parvipinnata*, ***Lemmaphyllum diversum***, *Vaccinium emarginatum*

Castanopsis cuspidata var. *carlesii*, *Cyclobalanopsis morii*, *Lithocarpus amygdalifolius*, *Machilus japonica* and *M. thunbergii* are dominant in the canopy. *Chamaecyparis formosensis* is an emergent tree above the canopy. *Eurya loquaiana*, *Litsea acuminata* and *Neolitsea acuminatissima* are dominant small trees reaching a height of 3–8 m. *Hydrangea chinensis* and *Yushania niitakayamensis* are dominant in the shrub layer. *Asplenium normale* and *Monachosorum henryi* are dominant in the herb layer. Species group composed of *Cyclobalanopsis morii*, *Eurya strigillosa*, *Lithocarpus amygdalifolius*, *L. lepidocarpus*, *Machilus japonica* and *Symplocos sonoharae* in the tree layer represents warm habitats with small annual temperature fluctuation in the montane cloud zone. *Blastus cochinchinensis*, *Callicarpa randaiensis*, *Damnacanthus indicus*, *Eurya loquaiana* and *Hydrangea chinensis* form a representative species group of this association in the shrub layer. This association grows mainly in the area south of the Tropic of Cancer and it is mostly on the slopes. The cover of evergreen broad-leaved species in this association is one of the highest among all *Chamaecyparis* forests.

2.09 *Arachniodo rhomboideae-Chamaecyparidetum formosensis* Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Arachniodes rhomboidea*, *Chamaecyparis formosensis*

Synonyms: none

Nomenclature type relevé: 11-0096 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1500–2500 m; 105–150 ˚C

Ecoregions: CW, EN, ES, NE, NW, SE and SW

Canopy cover: 70–90%

Canopy height: 15–30 m

Diagnostic species:

Trees: *Cyclobalanopsis morii*, *Eurya strigillosa*, *Litsea acuminata*, *Machilus japonica*, *Malus doumeri*, *Osmanthus lanceolatus*

Shrubs: *Callicarpa randaiensis*, *Damnacanthus indicus*, *Eurya loquaiana*, *Symplocos formosana*

Herbs: *Arachniodes rhomboidea*, *Monachosorum henryi*, *Stellaria arisanensis*

Lianas: none

Epiphytes: *Vittaria flexuosa*

Cyclobalanopsis morii, *C. longinux*, *Machilus japonica* and *M. thunbergii* are dominant in the canopy. *Chamaecyparis formosensis* is frequently an emergent tree above the canopy. In places *Taiwania cryptomerioides* is an emergent tree above the canopy. *Litsea acuminata* and *Neolitsea acuminatissima* are dominant in the subcanopy at a height of 3–8 m. *Hydrangea chinensis* is dominant in the shrub layer. *Plagiogyria formosana* and *Strobilanthes flexicaulis* are dominant in the herb layer. This association is widespread across the whole of Taiwan on the steep slopes that are shaded by the topography. The rock cover and rockiness are high. The species richness of this association is the lowest among the *Chamaecyparis formosensis* dominated forests. It does not contain any species groups indicating special soil or weather conditions. However, the plots of this association were often classified to other vegetation types by numerical methods which were commonly used in all the vegetation studies done previously in Taiwan due to the common species composition and the low number of species.

2.10 *Symploco wikstroemiifoliae-Machiletum thunbergii* Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Symplocos wikstroemiifolia*, *Machilus thunbergii*

Synonyms: *Chamaecyparis formosensis* ass. Tze-Ying Chen 2004 (Art. 3h, 3i, 3o); *Litsea acuminata-Chamaecyparis formosensis* type Jui-Ting Wei et Tze-Ying Chen 2007 (Art. 3o)

Nomenclature type relevé: 02-2069 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1100–1700 m; 140–170 ˚C

Ecoregions: EN, NE and NW

Canopy cover: 70–80%

Canopy height: 15–20 m

Diagnostic species:

Trees: *Camellia brevistyla*, ***Cinnamomum subavenium***, ***Cyclobalanopsis gilva***, *C. longinux*, *Elaeocarpus japonicus*, *Fatsia polycarpa*, ***Itea parviflora***, *Litsea acuminata*, ***Machilus thunbergii***, *Michelia compressa*, ***Osmanthus matsumuranus***, ***Pasania harlandii***, *P. kawakamii*, ***P. konishii***, *Prunus phaeosticta*, ***Pyrenaria shinkoensis***, *Symplocos caudata*

Shrubs: *Camellia tenuifolia*, *Damnacanthus indicus*, *Eurya crenatifolia*, ***Maesa japonica***, ***Pachycentria formosana***, *Symplocos formosana*, *S. wikstroemiifolia*, *Vaccinium bracteatum*

Herbs: *Acrophorus stipellatus*, *Acrorumohra diffracta*, ***Alpinia japonica***, *Arachniodes rhomboidea*, *Asarum caudigerum*, *A. macranthum*, *Asplenium normale*, *Calanthe densiflora*, *Carex perakensis*, ***Davallia mariesii***, *Diplazium kawakamii*, *D. mettenianum*, *Histiopteris incisa*, *Lepisorus thunbergianus*, *Microsorium buergerianum*, *Monachosorum henryi*, *Pellionia radicans*, *Plagiogyria euphlebia*, *Polygonum thunbergii*, ***Rubus buergeri***, *Salvia nipponica* var. *formosana*, *Sarcopyramis napalensis* var. *bodinieri*, ***Selaginella doederleinii***, ***S. involvens***, *Stellaria arisanensis*, *Strobilanthes rankanensis*

Lianas: *Ficus sarmentosa* var. *nipponica*, ***Pileostegia viburnoides***, *Schizophragma integrifolium* var. *fauriei*, ***Smilax hayatae***, *S. lanceifolia*, *Stauntonia obovatifoliola*

Epiphytes: ***Asplenium antiquum***, *A. wilfordii*, *Bulbophyllum retusiusculum*, *Elaphoglossum yoshinagae*, *Lycopodium fordii*, *Mecodium badium*, *M. polyanthos*, *Prosaptia contigua*, ***Pyrrosia lingua***, *Vaccinium emarginatum*

Chamaecyparis formosensis, *Cyclobalanopsis longinux*, *Machilus thunbergii* and *M. japonica* are dominant in the canopy and *Cyclobalanopsis gilva* and *Litsea acuminata* in the sub-canopy at a height of 10–15 m. *Prunus phaeosticta* is dominant small tree reaching a height of 3–6 m. *Yushania niitakayamensis* is dominant in the shrub layer. *Diplazium dilatatum*, *Dryopteris formosana*, *Monachosorum henryi* and *Selaginella doederleinii* are dominant in the herb layer. When compared to other associations dominated by *Chamaecyparis formosensis*, this association has frequently higher cover of evergreen broad-leaved species and more lowland species such as *Cinnamomum subavenium*, *Cyclobalanopsis gilva*, *Itea parviflora*, *Pasania harlandii* and *P. konishii* in the tree layer and *Alpinia japonica* and *Begonia formosana* in the herb layer. This association occurs at lower altitudes than other *Chamaecyparis* forests. It is characterized by very high air humidity and high proportion of winter precipitation. It is mostly found on north-facing slopes and ridges with low topographical shading. Such habitats are heavily influenced by winter monsoon. However, only humidity but no strong wind reaches the sites of this association.

2.11 *Pileo brevicornutae-Machiletum japonicae* Ching-Feng Li et al. 2014 ass. nov. hoc loco

Name-giving taxa: *Pilea aquarum* subsp. *brevicornuta*, *Machilus japonica*

Synonyms: none

Nomenclature type relevé: 29-0166 (holotypus hoc loco designatus)

Range of altitude and warmth index: 1200–2100 m; 105–165 ˚C

Ecoregions: EN, ES

Canopy cover: 60–80%

Canopy height: 15–20 m

Diagnostic species:

Trees: *Itea parviflora*, ***Lithocarpus lepidocarpus***, *Litsea acuminata*, ***Machilus japonica***, ***Machilus zuihoensis* var. *mushaensis***, ***Oreocnide pedunculata***, *Pasania cornea*, ***P. kawakamii***, ***Perrottetia arisanensis***

Shrubs: ***Symplocos modesta***, *Viburnum taitoense*

Herbs: *Acrophorus macrocarpus*, *Arachniodes festina*, *A. rhomboidea*, *Asarum albomaculatum*, *Asplenium ensiforme*, *A. filipes*, ***Begonia formosana***, *Carex brunnea*, *C. filicina*, *Coniogramme intermedia*, *Cornopteris fluvialis*, *Cyrtomium hookerianum*, ***Diplazium amamianum***, *D. kawakamii*, *D. wichurae*, *Dryopteris sparsa*, ***Elatostema parvum***, *Hemiboea bicornuta*, *Loxogramme salicifolia*, *Lysimachia ardisioides*, *Microsorium buergerianum*, *Ophiorrhiza japonica*, ***Oplismenus hirtellus***, *Peperomia reflexa*, *Peracarpa carnosa*, *Pilea angulata*, ***P*. *aquarum* subsp. *brevicornuta***, *P. funkikensis*, ***P. melastomoides***, ***P. rotundinucula***, *Polypodium formosanum*, ***Polystichum acutidens***, *P. deltodon*, *P. hancockii*, *P. lepidocaulon*, *P. parvipinnulum*, *Pteris setulosocostulata*, *Sarcopyramis napalensis* var. *delicata*, ***Selaginella delicatula***, *S. mollendorffii*, *S. remotifolia*, ***Thelypteris esquirolii***, *Urtica thunbergiana*, *Whytockia sasakii*

Lianas: ***Ficus pumila* var. *awkeotsang***, *F. sarmentosa* var. *henryi*, ***Piper kadsura***, *Schisandra arisanensis*, *Tetrastigma dentatum*, ***T. umbellatum***

Epiphytes: *Prosaptia urceolaris*, *Vandenboschia auriculata*

The canopy cover is 60–80% and the canopy height is 15–20 m. *Chamaecyparis formosensis*, *Litsea acuminata*, *Machilus japonica*, *M. zuihoensis* var. *mushaensis* and *Pasania kawakamii* are dominant in the canopy. There is not obvious sub-canopy layer or small-tree layer. *Symplocos modesta* is dominant in the shrub layer. *Arachniodes rhomboidea*, *Diplazium amamianum*, *D. kawakamii*, *Elatostema lineolatum* var. *majus* and *Monachosorum henryi* are dominant in the herb layer. *Elatostema* and *Pilea* species are common, indicating high rockiness and high rock cover. The ratio of deciduous broad-leaved trees in the canopy is relatively high which indicates the relatively low soil moisture. *Araiostegia parvipinnata*, *Pyrrosia sheareri*, *Vandenboschia auriculata* and *Vittaria flexuosa* are frequent epiphytes. Species groups composed of *Arachniodes rhomboidea*, *Carex brunnea*, *Coniogramme intermedia*, *Diplazium kawakamii*, *Ellisiophyllum pinnatum*, *Microsorium buergerianum*, *Polypodium formosanum* and *Thelypteris esquirolii* form a representative species groups for this association. This association is distributed mainly in the eastern part of Taiwan, often on limestone habitats. The soil in this habitat is shallow and the topographical shading is strong.

DISCUSSION

In Taiwan, the mid-altitudinal range of 1500–2500 m a.s.l. is called the temperate and warm temperate zone (Song 1999; Chiu et al. 2008), the *Quercus* zone (Su 1984) or the montane cloud zone (Su 1984; Chen 2001; Li et al. 2013). This zone comprises a mosaic of coniferous forests, deciduous broad-leaved forests, evergreen broad-leaved forests and mixed forests. Li et al. (2013) used the National Vegetation Database of Taiwan to define the following seven types of forests in this mid-altitudinal range: 1) *Chamaecyparis* montane mixed cloud forest, 2) *Fagus* montane deciduous broad-leaved cloud forest, 3) *Quercus* montane evergreen broad-leaved cloud forest, 4) *Pasania-Elaeocarpus* montane evergreen broad-leaved cloud forest, 5) *Zelkova-Quercus* rock-outcrop forest (coniferous, mixed and semi-deciduous forests in the montane cloud zone), 6) *Pinus* successional woodland (coniferous and mixed forests) and 7) *Alnus* successional woodland (mixed and deciduous forests). The forest types 1, 2 and 3 are defined as SMCF, type 4 is tropical montane cloud forest and types 5, 6 and 7 are azonal forests, distributed also outside of the montane cloud zone. Another type of evergreen broad-leaved forests correlated to the fog formation in Taiwan is called *Pyrenaria-Machilus* winter monsoon forest (Li et al. 2013). It is growing on the windward slopes in the north-eastern area and is directly exposed to winter monsoon with cool, foggy and windy climate in winter. Compared to the forests in the montane cloud zone, *Pyrenaria-Machilus* winter monsoon forest is short (usually shorter than 10 m in height) with a dense canopy of small individuals (DBH usually less than 20 cm). Although the real pattern and precise altitudinal range of the forest vegetation types varies among different parts of Taiwan (Liu 2003; Yu 2003), *Chamaecyparis* species are dominant in the *Chamaecyparis* montane mixed cloud forest or individually scattered in both *Fagus* montane deciduous broad-leaved cloud forest and *Quercus* montane evergreen broad-leaved cloud forest.

Phylogenetically, *Chamaecyparis obtusa* var. *formosana* from Taiwan is related to *C. obtusa* from Japan while *C. formosensis* from Taiwan is related to *C. pisifera* from Japan (Wang et al. 2003; Liao et al. 2010). In the Chubu region of central Honshu (N 34˚–N 36˚), there are several types of *Chamaecyparis* forest (Miyawaki 1985). All of them belong to the class *Fagetea crenatae* Miyawaki et al. 1964, which is temperate summer-green broad-leaved forest distributed all over Japanese cool-temperate zone. In the Chubu region, *C. pisifera* grows commonly at altitudes lower than 1000 m in the montane valleys beside rivers or on steep rock outcrops. Sometimes it can grow on soils with high water table. Such forests are usually classified to the alliance *Pterocaryion rhoifoliae* Miyawaki et al. 1964 of the order *Fraxino-Ulmetalia* Tokio Suzuki 1967 (Fujiwara 1996). In the same region, the habitats of *C. obtusa* are influenced by frequent fog. *C. obtusa* grows at altitudes of 400–1400 m on montane sandy to stony soils, which are usually acid due to a thick layer of undecomposed material. These forests are classified to the alliance *Chamaecyparidion obtusae* Yamanaka 1962 of the order *Pinetalia pentaphyllae* Tokio Suzuki 1966 and the alliance *Tsugion sieboldii* Tokio Suzuki 1953 of the order *Saso-Fagetalia crenatae* Tokio Suzuki 1966. Although some of these forests share several genera with the Taiwanese *Chamaecyparis* forests (e.g. *Ilex*, *Rhododendron*, *Trochodendron* and *Tsuga*), the abundance of deciduous broad-leaved trees in *Chamaecyparis* forests is much higher in Japan than in Taiwan. Some deciduous genera such as *Betula*, *Pterocarya* and *Tilia* commonly growing in Japanese *Chamaecyparis* forest are absent from the flora of Taiwan. Hukusima et al. (2013) used 2717 plots from the mainland and islands in eastern Asia to define the classification system of *Fagus* forest in eastern Asia and proposed the following two classes: *Fagetea crenatae* (temperate *Fagus* forests in Japan and Korea) and *Litseo elongatae-Fagetea* sp. div. (subtropical montane *Fagus* forests in both mainland China and Taiwan; invalid name). Japanese *Chamaecyparis* forests belong to the class *Fagetea crenatae*, because the accompanying species mainly belong to the cool-temperate elements. Taiwanese *Chamaecyparis* forests belong to the class *Litseo elongatae-Fagetea*, because the accompanying species are tropical and subtropical elements related to the eastern Himalayas such as *Cyclobalanopsis*, *Litsea* and *Neolitsea*.

Since the habitats of *Fagus* species tend to be related to cloud belts in subtropical eastern Asia, SMCFs in this region should belong to the class *Litseo elongatae-Fagetea*. This class is characterized by some evergreen species such as *Ardisia crenata*, *Cleyera japonica*, *Daphniphyllum macropodum*, *Dryopteris erythrosora*, *Lepisorus thunbergianus*, *Liriope platyphylla* and *Maesa japonica* which are also occurring in the Japanese evergreen broad-leaved forest. However, the Japanese evergreen broad-leaved forest is classified to the class *Camellietea japonicae* Miyawaki et al. 1963. Some *Cryptomeria japonica* dominated forests in Japan (alliance *Quercion auto-myrsinaefoliae*), which are typical SMCFs, are also classified into *Camellietea japonicae* (Miyawaki 1980, 1982). Further comparison among different regions is needed to evaluate how these forests relate to Chinese and Taiwanese SMCFs.

Two orders within *Litseo elongatae-Fagetea* were proposed by Hukusima et al. (2013) in the *Fagus* forest classification system. *Sinarundinario nitidae-Fagetalia* Hukusima et al. 2013 and *Fagetalia hayatae* Hukusima et al. 2005 represent the SMCFs in mainland China and Taiwan, respectively. Besides the *Fagus* forests, montane mossy forest (Shui et al. 2003) and mossy dwarf forest (Xu & Wang 2010) are commonly recognized as SMCF or TMCF in mainland China. Whether the forest is SMCF or TMCF depends on the proportion of tropical elements, which is correlated with latitude. The conifer and evergreen broad-leaved mixed forest in Chinese SMCF is usually described as one type of humid evergreen broad-leaved forests (Wu & Zhu 1987). Such forests occur at altitudes of 1500–2800 m and latitudes from N 24˚ to N 32˚ (He 1998). There are few common species distributed over all Chinese SMCFs because of their isolated occurrence at mid-altitudes, humid habitat requirements which are different from the lowland evergreen broad-leaved forests and the large distances among the isolated patches of SMCFs in mainland China (Song et al. 2005; Hukusima et al. 2013). The evergreen broad-leaved species in Chinese SMCFs usually have medium to small sized leaves with acuminate tip and shiny surface, which are often thick and glabrous on both sides. These phenomena indicate the adaptation to very humid environment (Wu & Zhu 1987). *Ericaceae*, *Fagaceae*, *Hamamelidaceae*, *Lauraceae*, *Magnoliaceae* and *Theaceae* are dominant families. *Lithocarpus* is the most common and dominant genus. Besides the deciduous genera such as *Acer* and *Fagus*, coniferous genera such as *Pinus*, *Taiwania*, *Taxus* and *Tsuga* are frequently mixed with evergreen broad-leaved species in these forests. Wu (1980) mentioned other genera such as *Abies*, *Cryptomeria* and *Picea* which could grow with evergreen broad-leaved species in the foggy subtropical mountains. *Sinarundinaris* and other genera of dwarf bamboo are common in the shrub layer. The cover of bryophytes and epiphytes is high. The physiognomy of SMCF is the same in Taiwan and mainland China, but Taiwanese SMCF has few species of *Hamamelidaceae* and *Magnoliaceae*. The most common and dominant genus is *Cyclobalanopsis* and more than 30% of the species are endemic species in the Taiwanese SMCF (Li et al. 2013).

The SMCF in Taiwan belongs to the order *Fagetalia hayatae*, classified into three alliances: *Fagion hayatae* Tokio Suzuki ex Tsukasa Hukusima et al. 2005, *Chamaecyparidion formosanae* and *Pasanio kawakamii-Machilion japonicae*. The first alliance comprises *Fagus* forest and the other two are *Chamaecyparis* forests. The alliance *Fagion hayatae*, *Fagus* montane deciduous broad-leaved cloud forest (Li et al. 2013), is the coldest SMCF in Taiwan, being the most influenced by winter monsoon with occasional snow cover. Two species groups represent this alliance (Appendix S3 in Li et al. 2013): the species group composed of *Adinandra formosana*, *Camellia tenuifolia*, *Cyclobalanopsis sessilifolia*, *Fagus hayatae, Ilex goshiensis* and *Symplocos caudate* indicates cold and windy habitats, while the species group of *Enkianthus perulatus*, *Eurya crenatifolia*, *Fagus hayatae*, *Symplocos caudata*, *Viburnum sympodiale* and *V. urceolatum* indicates cold and windy habitat with acid soil in Taiwanese SMCF. After the two alliances of *Chamaecyparis* forests defined by this study were included to this order, the list of diagnostic species of *Fagetalia hayatae*, published by Hukushima et al. (2013), should be extended to be *Cyclobalanopsis sessilifolia*, *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum* and *Trochodendron aralioides* in the tree layer; *Damnacanthus angustifolius*, *Eurya leptophylla* and *Yushania niitakayamensis* in the shrub layer; *Acrophorus stipellatus*, *Dryopteris formosana*, *Elatostema trilobulatum*, *Plagiogyria formosana* and *Polypodium amoenum* in the herb layer and *Schizophragma integrifolium* var. *formosana* among lianas.

Distributions of associations in *Pasanio kawakamii-Machilion japonicae* are often restricted to certain ecoregions. *Adinandro lasiostylae-Chamaecyparidetum formosensis* is distributed mainly in the north-western ecoregion and its surrounding area, *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* and *Pileo brevicornutae-Machiletum japonicae* in the eastern ecoregion, *Castanopsio carlesii-Chamaecyparidetum formosensis* in the south-western ecoregion, and *Symploco wikstroemiifoliae-Machiletum thunbergii* in the north-eastern ecoregion. One possible explanation for this locally restricted distribution of vegetation types could be the sampling bias introduced by local investigators (e.g., preference for certain habitats or systematicly wrong determination of certain species). However, because plots belonging to the same association in our study were made by different investigators and plots made by the same investigator were often classified into different associations, we suspect that the sampling bias is not the reason for such pattern. Another possible explanation could be the differences among local floras, which are caused by differences in evolutionary history of individual regions. If this is the reason, the diagnostic species of the above mentioned associations would have locally restricted distribution, which is obviously not the case, because most of the diagnostic species have wide geographical distributions through the whole island. Therefore, we suspect that the most plausible explanation of locally restricted vegetation types is their correlation to environmental factors, which are different among the ecoregions and have the ability to influence the species composition. Microclimate and soil conditions are correlated with the floristic composition in this study (Fig. 3). Empirically, the distribution of the *Chamaecyparis* forest in Taiwan is correlated with fog events. Fog events are correlated with the microclimate and also the soil conditions by the hydrological process (Bruijnzeel et al. 2010). To measuer fog events in a large area is limited by budget and techniques. To understand how fog events influence the composition and structure of communities or ecosystems still need furthure studies.

This study formalized the classification of ecological meaningful vegetation units, the associations, in the Chamaecyparis forest in Taiwan. Any newly added plot can use the Cocktail Determination Key provided by this study to see whether the plot belongs to any of the association defined by this study or not. This can contribute to the future ecological study in experimental design and variables controlling in the field based on the existed expert knowledge.

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Table 1. Synoptic table of the *Chamaecyparis* forest in Taiwan. Value in each cell is the percentage constancy. Diagnostic species of each vegetation type and common species of *Chamaecyparis* forest are sorted by fidelity (Φ). Grey shading indicates Φ>0.10. The other species are sorted by the alphabet within each layer. Grey shading indicates Φ>0.10. Nomenclature of each syntaxon is listed on the corresponding rows in the table. Association 2.09 *Arachniodo rhomboideae-Chamaecyparidetum formosensis* does not have its own diagnostic species in this table due to its low species richness and broad geographical distribution. The meanings of the letters after the Latin names are: T: Tree; S: Shrub; H: Herb; L: Liana, E: Epiphyte.

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Average number of all species per plot		43	28	40	59	51	69	63	63	55	69	54
Average number of tree species per plot		17	11	12	18	24	22	19	19	17	21	12
Average number of shrub species per plot		8	6	7	12	10	10	9	9	8	9	5
Average number of herb species per plot		11	7	14	19	11	23	23	21	19	24	25
Average number of liana species per plot		3	2	4	5	3	8	8	8	7	8	8
Average number of epiphyte species per plot		4	3	2	5	4	5	5	5	5	7	5
Common species of *Chamaecyparis* forest in Taiwan												
Plagiogyria formosana	H	84	82	75	94	65	87	57	54	50	19	15
Neolitsea acuminatissima	T	96	94	95	100	92	95	79	97	65	30	6
Plagiogyria euphlebia	H	44	33	30	71	62	92	50	86	69	96	48
Araiostegia parvipinnata	E	80	49	50	82	46	84	68	83	54	44	52
Symplocos arisanensis	T	52	14	10	59	30	89	25	63	31	26	12
Vittaria flexuosa	E	64	31	30	82	57	92	50	77	81	63	48
Arthromeris lehmannii	H	32	20	15	53	27	68	18	26	23	33	18
Hydrangea integrifolia	L	44	20	90	47	32	95	86	51	73	52	55
Cyclobalanopsis sessilifolia	T	80	16	－	53	57	100	29	3	8	48	－
Symplocos morrisonicola	T	96	45	45	65	51	82	18	46	23	7	12
Elatostema trilobulatum	H	20	20	55	82	3	61	39	69	38	11	18
Mecodium polyanthos	E	36	47	25	94	30	58	32	51	31	70	27
Skimmia reevesiana	S	36	27	25	65	70	55	4	14	19	15	－
Trochodendron aralioides	T	76	33	60	41	51	74	50	34	23	26	9
Acrophorus stipellatus	H	24	16	20	94	38	26	43	43	62	81	36
Eurya loquaiana	S	64	8	25	29	73	97	68	91	88	78	58
Cyclobalanopsis morii	T	48	31	65	－	16	11	54	86	58	－	9
Eurya leptophylla	S	44	24	55	12	3	74	64	43	42	15	21
Dryopteris formosana	H	72	27	65	65	49	97	82	63	69	56	36
Damnacanthus indicus	S	36	18	10	35	70	97	86	100	81	81	48
Sarcopyramis napalensis var. *bodinieri*	H	20	31	20	47	16	8	18	74	12	44	9
Polypodium argutum	H	36	27	5	47	14	26	11	37	12	22	15
Litsea elongata var. *mushaensis*	T	12	－	25	53	22	45	79	17	35	30	30
Ardisia crenata	S	40	16	5	65	46	66	50	63	54	33	36
Lysionotus pauciflorus	H	52	10	35	35	24	66	39	71	42	56	42
Dendropanax dentiger	T	80	55	25	82	86	21	21	46	12	56	3
Rhododendron leptosanthum	T	72	33	15	35	76	45	29	34	31	33	－
Alliance 1 *Chamaecyparidion formosanae*												
Chamaecyparis obtusa var. *formosana*	T	36	49	－	94	51	13	－	－	－	15	－
Vaccinium japonicum var. *lasiostemon*	S	16	47	5	59	27	－	－	－	－	－	－
Rhododendron formosanum	T	24	45	－	53	70	5	4	3	4	－	－
Myrsine stolonifera	S	20	16	－	47	59	3	－	－	－	4	－
Tsuga chinensis var. *formosana*	T	80	94	80	41	38	50	14	6	－	－	－
Eurya glaberrima	T	68	55	60	82	24	32	7	11	19	4	－
Schefflera taiwaniana	T	60	63	45	41	11	11	11	31	19	－	－
Viburnum urceolatum	S	76	22	－	41	49	26	7	6	8	4	－
Damnacanthus angustifolius	S	56	16	－	71	65	45	4	－	4	7	－
Illicium anisatum	T	16	55	5	88	30	8	7	23	15	19	3
Rhus ambigua	L	32	18	5	53	8	5	11	－	4	－	－
Smilax arisanensis	L	76	35	10	82	68	84	11	20	15	4	12
Yushania niitakayamensis	S	68	88	90	53	30	32	61	31	4	22	9
Ilex tugitakayamensis	T	40	18	－	47	57	66	11	6	12	4	－

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Alliance 2 *Pasanio kawakamii-Machilion japonicae*												
Pasania kawakamii	T	—	—	—	—	8	79	82	37	50	67	97
Arachniodes rhomboidea	H	4	6	30	29	22	76	93	86	88	89	79
Diplazium kawakamii	H	—	—	10	18	5	34	57	31	27	48	64
Pilea aquarum subsp. *brevicornuta*	H	—	—	10	—	3	26	54	14	27	37	76
Cyrtomium hookerianum	H	—	—	—	—	—	11	29	9	15	22	36
Machilus japonica	T	—	—	—	18	22	18	86	57	58	37	97
Polystichum hancockii	H	—	—	5	6	—	26	64	26	19	22	42
Arachniodes festina	H	—	—	—	—	3	11	39	3	23	11	39
Polystichum parvipinnulum	H	8	4	55	—	3	68	82	40	38	7	55
Fatsia polycarpa	T	4	—	—	—	14	66	43	17	23	41	30
Monachosorum henryi	H	16	16	20	35	27	24	82	94	77	81	64
Strobilanthes rankanensis	H	—	—	5	6	—	37	39	3	12	30	21
Adinandra lasiostyla	T	12	2	15	—	8	82	4	49	23	—	12
Pellionia radicans	H	12	—	—	24	14	55	46	20	46	67	36
Chamaecyparis formosensis	T	16	6	75	6	16	87	64	31	50	22	36
Asplenium wilfordii	E	—	4	—	35	3	42	36	17	27	52	24
Microsorium buergerianum	H	12	4	20	35	22	53	82	69	65	74	70
Schizophragma integrifolium var. *fauriei*	L	8	4	5	29	3	39	54	23	35	44	15
Dryopteris sparsa	H	4	2	15	6	3	39	25	37	15	4	30
Prunus phaeosticta	T	4	2	5	—	49	63	61	46	54	96	55
Stauntonia obovatifoliola	L	40	8	20	41	38	97	82	71	46	81	18
Hedera rhombea var. *formosana*	L	12	4	55	—	—	63	64	57	42	22	24
Litsea acuminata	T	4	2	10	6	65	18	64	94	81	100	91
Symplocos formosana	S	4	4	—	6	8	5	50	17	38	41	6
Coniogramme intermedia	H	4	—	—	—	—	26	32	9	12	11	30
Ilex hayataiana	T	4	4	—	71	27	3	43	29	31	22	6
Association 1.01 *Tsugo formosanae-Chamaecyparidetum formosanae*												
Microtropis fokienensis	S	88	43	40	29	24	58	21	37	23	15	3
Ainsliaea macroclinidioides	H	32	12	5	12	5	5	—	3	4	—	—
Skimmia arisanensis	S	16	6	—	—	3	3	—	—	—	—	—
Dryopteris wallichiana	H	16	4	—	—	—	5	4	—	—	—	3
Photinia niitakayamensis	T	32	24	20	12	8	—	4	—	4	—	—
Leptorumohra quadripinnata	H	28	4	—	—	16	26	4	6	12	—	3
Association 1.02 *Vaccinio lasiostemonis-Tsugetum formosanae*												
Myrmechis drymoglossifolia	H	—	8	—	—	—	—	—	—	—	—	—
Elaphoglossum angulatum	H	—	6	—	—	—	—	—	—	—	—	—
Mecodium javanicum	E	—	4	—	—	—	—	—	—	—	—	—
Lyonia ovalifolia	T	24	33	15	18	16	3	—	3	4	—	—
Sorbus randaiensis	T	4	12	—	12	—	—	—	—	—	—	—
Rhododendron pseudochrysanthum	S	20	24	30	—	—	3	—	—	4	—	—
Vaccinium merrillianum	S	—	6	—	6	—	—	—	—	—	4	—
Association 1.03 *Schefflero taiwanianae-Chamaecyparidetum formosensis*												
Ilex bioritsensis	T	—	8	30	—	—	—	—	—	—	—	—
Hydrocotyle setulosa	H	—	2	25	—	—	—	4	6	—	—	—
Ainsliaea latifolia subsp. *henryi*	H	16	20	65	—	11	42	14	11	12	4	—
Rubus formosensis	S	4	2	40	—	3	—	18	6	—	11	9
Rubus pungens	S	4	—	15	—	—	—	—	—	—	—	—
Pinus armandii var. *mastersiana*	T	12	10	35	6	—	13	—	—	—	—	—
Dryopteris lepidopoda	H	12	2	30	—	3	3	11	3	4	—	—
Carpesium nepalense	H	—	—	10	—	—	—	—	—	—	—	3
Osmanthus heterophyllus	T	16	18	30	6	5	—	4	3	—	—	—
Rubia lanceolata	H	8	—	25	—	—	11	7	—	8	4	3
Acer morrisonense	T	16	6	45	—	16	13	29	14	23	11	9
Peranema cyatheoides	H	12	2	25	12	3	13	7	6	4	—	—
Ellisiophyllum pinnatum	H	4	2	25	—	—	5	14	14	12	—	9
Lonicera acuminata	L	8	4	35	29	—	32	11	20	19	—	—
Association 1.04 *Elatostemato trilobulati-Tsugetum formosanae*												
Ardisia japonica	H	—	2	—	53	14	3	—	—	4	—	—

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Viburnum sympodiale	S	16	4	–	59	14	3	–	–	–	–	–
Asarum crassusepalum	H	–	2	–	29	–	–	–	–	–	–	–
Coptis quinquefolia	H	12	8	–	65	16	3	4	–	4	4	–
Shortia rotundifolia	H	4	6	–	47	14	–	–	–	–	–	–
Rubus corchorifolius	S	8	6	15	82	22	5	25	9	–	33	3
Ilex suzukii	T	–	–	–	24	–	–	–	3	–	–	–
Maclura cochinchinensis	L	4	6	–	47	11	3	4	–	4	–	–
Prunus matuurai	T	–	–	–	18	–	–	–	–	–	–	–
Eurya crenatifolia	S	4	14	15	76	19	5	25	9	12	37	3
Barthea barthei	S	24	8	–	76	57	5	4	17	15	26	–
Smilacina japonica	H	–	2	–	24	5	–	–	–	–	–	–
Nertera nigricarpa	H	4	12	20	47	3	5	–	–	4	–	6
Smilax discotis	L	–	6	–	24	3	–	–	–	–	–	–
Berberis kawakamii	S	–	2	20	41	–	3	7	–	4	4	–
Elaphoglossum commutatum	H	–	–	–	12	–	–	–	–	–	–	–
Rubus liuii	L	–	–	5	24	–	8	–	–	–	–	–
Microlepia tenera	H	–	2	–	24	8	–	–	–	4	–	–
Xiphopteris okuboi	E	8	33	5	47	11	5	7	–	4	4	–
Ilex sugerokii var. *brevipedunculata*	T	12	18	–	35	11	3	–	–	–	–	–
Cleyera japonica var. *taipinensis*	T	32	2	–	65	51	50	4	–	4	11	–
Diplopterygium glaucum	H	4	2	5	41	11	18	4	6	–	11	–
Cunninghamia konishii	T	8	–	–	18	3	–	–	–	–	–	–
Tripterospermum lanceolatum	L	12	8	15	35	3	–	4	9	–	4	–
Rhododendron kawakamii	E	12	10	5	29	5	5	–	3	–	–	–
Ligustrum liukiuense	T	4	2	5	47	14	8	25	14	8	26	–
Cleyera japonica	T	32	10	–	59	54	–	7	31	15	26	–
Crypsinus engleri	H	–	–	–	24	14	–	7	3	4	4	–
Berberis mingetsuensis	S	4	–	–	24	–	21	7	–	–	–	–
Sarcopyramis napalensis var. *delicata*	H	12	4	15	53	5	18	21	17	23	4	33
Viburnum erosum	S	4	2	5	18	–	3	–	–	–	4	–
Polypodium amoenum	H	28	18	25	59	3	8	14	43	19	26	9
Taiwania cryptomerioides	T	4	2	5	24	11	13	–	–	12	–	–
Crypsinus echinosporus	E	4	16	5	24	8	8	–	11	4	–	–
Ctenitis kawakamii	H	8	2	–	18	3	–	11	9	4	–	–
Association 1.05 *Rhododendro formosani-Chamaecyparidetum formosanae*												
Schima superba	T	–	–	–	–	57	11	–	9	–	11	–
Plagiogyria dunnii	H	12	2	–	29	73	3	4	14	4	26	–
Litsea cubeba	S	–	–	–	12	24	3	–	–	–	–	–
Symplocos wikstroemiifolia	S	4	6	–	24	51	–	–	–	8	44	–
Michelia compressa	T	–	4	–	–	81	50	14	23	46	63	21
Ternstroemia gymnanthera	T	28	4	–	47	81	50	11	3	42	44	9
Vaccinium kengii	T	4	–	5	18	27	–	–	–	8	–	–
Symplocos stellaris	T	36	–	10	–	54	50	4	20	19	7	3
Lasianthus japonicus	S	–	–	–	–	11	–	–	–	4	–	–
Sassafras randaiense	T	–	–	–	–	8	–	4	–	–	–	–
Collabium chinense	H	–	–	–	–	8	–	–	–	–	7	–
Association 2.06 *Adinandro lasiostylae-Chamaecyparidetum formosensis*												
Rhamnus pilushanensis	S	–	2	–	–	–	34	–	–	–	–	–
Calanthe puberula	H	8	2	–	18	5	74	14	9	8	11	–
Sycopsis sinensis	T	8	2	–	18	3	66	25	–	15	–	–
Symplocos migoi	T	56	12	20	–	8	92	29	9	23	19	–
Viburnum foetidum var. *rectangulatum*	S	12	10	35	29	22	84	14	20	8	7	–
Ophiopogon japonicus	H	4	2	5	–	–	37	4	–	–	7	–
Trachelospermum formosanum	L	4	–	–	–	8	50	7	–	–	19	15
Zanthoxylum scandens	L	–	–	–	–	3	50	11	11	8	–	15
Viola shinchikuensis	H	–	–	–	–	–	13	–	–	–	–	–
Disporopsis fuscopicota var. *arisanensis*	H	–	–	–	–	–	13	–	–	–	–	–
Celastrus punctatus	L	4	–	–	–	–	24	4	–	4	–	–
Symplocos heishanensis	T	4	6	–	12	30	58	7	9	23	7	–
Dendrobium furcatopedicellatum	E	4	–	–	–	–	16	–	–	–	–	–

Alliance code		1	1	1	1	1	2	2	2	2	2	2
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Salvia formosana	H	–	–	–	–	–	11	–	–	–	–	–
Helwingia japonica subsp. *taiwaniana*	S	–	–	–	–	–	29	14	3	4	–	3
Akebia trifoliata subsp. *australis*	L	–	–	–	–	–	11	–	–	–	–	–
Asarum macranthum	H	–	–	5	6	5	47	18	3	4	33	–
Euonymus spraguei	S	24	10	20	24	11	61	14	9	15	–	–
Ligustrum sinense	T	–	–	5	6	–	39	11	9	15	4	3
Ilex goshiensis	T	52	18	–	18	81	89	14	29	27	37	9
Oxalis acetosella subsp. *griffithii* var. *formosana*	H	4	–	20	24	–	39	–	6	4	–	–
Teucrium taiwanianum	H	–	–	–	–	–	13	4	–	–	–	–
Ilex lonicerifolia var. *matsudai*	T	–	2	–	–	–	16	–	–	–	4	–
Kadsura japonica	L	–	–	–	–	5	26	7	3	4	7	–
Pyrola alboreticulata	H	28	10	–	6	3	34	–	6	–	–	–
Calanthe arcuata	H	–	–	–	–	–	11	–	3	–	–	–
Lycopodium serratum var. *longipetiolatum*	H	–	2	–	12	19	32	4	11	4	4	–
Rubus kawakamii	S	16	2	30	–	3	50	18	23	19	–	24
Gastrochilus rantabunensis	E	–	–	–	–	–	5	–	–	–	–	–
Zeuxine reflexa	H	–	–	–	–	–	5	–	–	–	–	–
Polystichum wilsonii	H	–	–	–	–	–	5	–	–	–	–	–
Pyrrosia linearifolia	E	4	–	–	–	–	16	4	–	4	–	3
Cyclobalanopsis stenophylloides	T	36	10	30	18	14	68	64	6	27	11	42
Malus doumeri	T	16	4	5	–	11	34	–	6	23	7	3
Camellia tenuifolia	S	20	6	5	18	14	42	4	–	–	37	9
Hydrangea anomala	L	–	–	–	6	3	18	7	–	–	7	–
Rubus pectinellus	H	4	2	25	24	14	47	25	9	12	22	9
Monachosorum maximowiczii	H	4	4	–	6	–	16	–	–	4	–	–
Sabia transarisanensis	L	4	2	10	–	–	18	7	3	–	–	–
Goodyera velutina	H	24	6	10	12	19	39	11	9	8	15	–
Athyrium subrigescens	H	–	–	–	–	–	13	7	–	–	–	6
Lysimachia ardisioides	H	–	–	–	–	–	24	14	–	4	7	18
Ctenitis eatonii	H	–	–	–	–	–	13	4	–	–	4	6
Daphniphyllum himalaense subsp. *macropodum*	T	32	8	10	35	24	55	39	–	12	33	27
Drymotaenium miyoshianum	E	4	–	–	6	–	11	–	–	–	–	–
Athyrium arisanense	H	8	4	15	6	14	45	32	34	23	19	–
Tripterospermum taiwanense	L	8	2	5	–	19	24	4	–	4	7	3
Polypodium transpianense	H	–	–	–	–	–	11	–	3	–	–	9
Athyrium erythropodum	H	–	2	–	12	3	18	4	11	8	–	–
Ctenitis transmorrisonensis	H	–	4	10	–	–	13	4	3	–	–	–
Neolitsea aciculata	T	–	–	5	–	8	24	7	11	15	4	15
Lepisorus obscurevenulosus	H	20	16	5	29	8	34	11	3	19	–	12
Viola formosana	H	–	–	–	12	5	16	11	–	–	7	–
Prunus campanulata	T	16	4	15	6	8	24	7	–	4	4	6
Arisaema taiwanense	H	4	–	10	–	–	11	–	–	–	–	6
Lysimachia capillipes	H	–	–	–	–	–	8	7	–	–	–	6
Association 2.07 *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis*												
Viburnum arboricolum	E	–	–	–	–	–	5	54	6	8	4	18
Ligustrum pricei	T	–	–	–	–	–	–	32	–	–	15	3
Pourthiaea beauverdiana var. *notabilis*	T	4	–	10	–	5	–	57	31	19	15	21
Carpinus rankanensis	T	–	–	5	–	–	3	21	–	–	7	–
Swida controversa	S	–	–	–	–	–	–	14	–	–	–	6
Ophiorrhiza japonica	H	–	–	–	–	3	21	46	9	12	15	30
Litsea morrisonensis	T	–	4	35	–	5	16	46	14	4	7	9
Pyrrosia sheareri	E	40	2	25	6	5	71	71	6	31	–	36
Paris polyphylla var. *taitungensis*	H	–	–	–	–	–	–	7	–	–	–	–
Schisandra arisanensis	L	–	–	10	–	3	3	39	6	8	11	30
Viburnum taitoense	S	–	–	–	–	5	13	32	–	4	–	24
Pilea matsudai	H	–	–	–	–	–	–	11	3	–	–	–
Urtica thunbergiana	H	–	–	10	–	–	–	32	3	12	–	27
Ophiopogon intermedius	H	12	6	5	29	11	21	43	9	–	–	3

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Arisaema taiwanense var. *brevipedunculatum*	H	–	–	–	–	–	–	7	–	–	–	3
Polygonum posumbu	H	–	–	5	–	–	–	11	–	4	–	–
Carex brunnea	H	–	–	35	–	–	21	36	6	12	–	27
Loxogramme remotefrondigera	H	4	–	–	–	–	11	25	9	8	11	12
Sedum erythrospermum	H	–	–	–	–	–	–	7	–	4	–	–
Pasania hancei var. *ternaticupula*	T	32	14	35	12	3	–	39	–	4	11	6
Woodwardia unigemmata	H	–	–	–	–	–	16	21	–	12	4	15
Pittosporum daphniphylloides	E	–	–	–	–	–	3	14	3	4	4	9
Acer palmatum var. *pubescens*	T	4	6	5	12	–	13	18	–	4	–	–
Acer kawakamii	T	–	2	25	6	8	3	25	9	12	15	12
Association 2.08 *Castanopsio carlesii-Chamaecyparidetum formosensis*												
Gordonia axillaris	T	8	2	–	–	11	–	4	69	12	7	3
Polystichum prionolepis	H	–	–	–	–	–	–	–	34	4	4	–
Hydrangea chinensis	S	4	–	10	–	–	3	–	57	27	4	3
Lithocarpus amygdalifolius	T	–	–	–	–	–	–	–	37	12	–	6
Castanopsis cuspidata var. *carlesii*	T	16	2	–	–	49	45	–	77	19	19	–
Callicarpa randaiensis	S	4	–	–	12	5	5	18	60	31	11	9
Bredia oldhamii	S	–	–	–	–	–	–	–	29	12	–	9
Lemmaphyllum diversum	E	–	2	5	–	14	18	–	43	15	–	–
Peliosanthes teta var. *kaoi*	H	–	–	–	–	–	–	–	11	–	–	–
Strobilanthes cusia	H	–	–	–	–	–	–	–	17	4	–	–
Smilax sieboldii	L	–	–	10	–	–	–	–	20	–	–	–
Rubus pyrifolius	L	–	–	5	–	–	–	4	26	12	–	3
Eurya chinensis	S	4	–	15	–	–	–	–	34	12	–	6
Liriope minor var. *angustissima*	H	–	–	5	6	–	–	–	20	–	–	–
Illicium arborescens	T	–	–	–	–	5	–	–	26	8	7	–
Polystichum biaristatum	H	–	–	5	–	–	–	–	14	–	–	–
Clematis formosana	L	–	–	–	–	–	–	–	9	–	–	–
Vaccinium emarginatum	E	16	16	–	–	11	3	–	54	27	37	12
Smilax bracteata	L	–	–	–	–	–	3	7	26	8	4	–
Symplocos sonoharae	T	–	–	–	–	11	–	–	20	4	–	–
Eurya strigillosa	T	–	10	10	24	19	–	4	51	38	7	6
Neolitsea aciculata var. *variabillima*	T	4	–	–	18	30	–	14	51	–	26	21
Osmanthus lanceolatus	T	4	2	5	–	–	–	7	29	19	–	–
Embelia laeta var. *papilligera*	L	–	2	–	12	14	–	11	46	15	30	15
Plagiogyria stenoptera	H	4	8	5	24	16	8	18	51	15	30	6
Osmanthus kaoi	T	–	–	–	–	–	–	–	11	4	–	–
Osmanthus enervius	T	–	–	5	–	–	–	–	11	–	–	–
Carex orthostemon	H	–	–	–	–	–	–	–	6	–	–	–
Asplenium ensiforme	H	–	–	5	–	–	3	–	29	15	4	18
Symplocos glauca	T	–	2	5	6	8	–	–	29	12	11	–
Peperomia reflexa	H	4	4	5	12	8	–	7	43	31	11	42
Adinandra formosana	T	4	18	–	29	19	–	–	34	4	7	3
Viburnum integrifolium	S	4	6	–	6	24	21	4	29	4	–	–
Asplenium normale	H	4	4	–	29	43	24	21	57	38	52	18
Symplocos trichoclada	T	–	2	–	–	–	–	–	9	–	–	6
Vaccinium dunalianum var. *caudatifolium*	S	12	16	–	6	8	5	–	20	8	–	–
Goodyera bilamellata	H	4	–	–	–	3	–	–	9	–	7	–
Smilax menispermoidea	L	4	10	–	18	–	–	–	14	4	–	–
Lepisorus kawakamii	H	8	–	–	–	–	11	–	11	4	–	6
Association 2.10 *Symploco wikstroemiifoliae-Machiletum thunbergii*												
Selaginella doederleinii	H	–	–	–	6	5	3	11	9	15	81	15
Pasania konishii	T	–	–	–	–	–	–	4	6	–	37	–
Maesa japonica	S	–	–	–	–	14	8	14	–	8	59	6
Davallia mariesii	H	–	–	–	–	11	3	11	3	8	52	6
Smilax hayatae	L	–	–	–	–	–	–	7	–	–	26	–
Alpinia japonica	H	–	–	–	–	–	–	–	–	–	19	–
Pachycentria formosana	S	–	–	–	–	–	–	–	–	–	22	3
Osmanthus matsumuranus	T	–	–	–	–	14	–	14	17	27	63	6
Pasania harlandii	T	–	–	–	–	11	–	4	3	4	41	–

Alliance code		1	1	1	1	1	2	2	2	2	2	2
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Cyclobalanopsis gilva	T	–	–	–	–	–	3	–	–	–	19	–
Rubus buergeri	H	–	–	–	6	3	–	4	–	–	26	–
Selaginella involvens	H	12	–	–	24	8	11	11	3	4	52	–
Pileostegia viburnoides	L	4	2	10	6	11	–	25	20	31	74	36
Asplenium antiquum	E	–	–	–	–	14	3	11	–	19	59	36
Pyrrosia lingua	E	–	6	–	6	41	18	14	23	19	74	21
Itea parviflora	T	–	–	–	–	35	11	18	6	27	74	48
Cinnamomum subavenium	T	–	–	–	–	41	–	4	3	–	44	–
Pyrenaria shinkoensis	T	–	–	–	12	8	–	4	–	–	30	–
Lycopodium fordii	E	–	–	5	–	3	–	7	3	–	26	–
Smilax lanceifolia	L	4	10	5	12	35	–	32	74	38	85	45
Cyclobalanopsis longinux	T	4	8	5	12	43	13	50	6	42	78	39
Prosaptia contigua	E	4	2	–	–	3	–	–	–	–	19	3
Salvia nipponica var. *formosana*	H	–	–	–	–	–	–	–	–	–	7	–
Calanthe densiflora	H	–	–	–	–	5	–	–	–	–	19	6
Asarum caudigerum	H	–	–	–	–	3	–	–	–	–	11	–
Carex perakensis	H	–	–	–	–	–	–	–	–	–	7	–
Bulbophyllum retusiusculum	E	–	–	–	–	–	–	4	–	4	15	–
Polygonum thunbergii	H	–	–	–	12	–	3	4	3	4	26	9
Ficus sarmentosa var. *nipponica*	L	4	–	–	–	–	21	39	17	23	52	33
Acrorumohra diffracta	H	–	–	–	–	3	–	–	–	–	15	9
Camellia brevistyla	T	–	2	–	6	–	–	21	–	4	22	–
Vaccinium bracteatum	S	–	4	–	6	5	–	4	–	8	19	–
Histiopteris incisa	H	–	4	–	6	8	–	–	3	12	19	6
Symplocos caudata	T	4	–	–	24	5	3	7	11	4	22	–
Diplazium mettenianum	H	4	–	–	6	8	21	–	11	8	22	6
Mecodium badium	E	4	–	–	6	11	–	–	–	–	15	12
Stellaria arisanensis	H	–	–	15	–	–	–	14	3	19	19	12
Elaphoglossum yoshinagae	E	8	6	5	12	11	13	4	17	8	22	–
Lepisorus thunbergianus	H	16	24	20	29	24	8	21	40	27	41	6
Association 2.11 *Pileo brevicornutae-Machiletum japonicae*												
Ficus pumila var. *awkeotsang*	L	–	–	–	–	–	–	–	–	4	–	30
Machilus zuihoensis var. *mushaensis*	T	–	–	–	–	–	3	14	–	12	7	52
Piper kadsura	L	–	–	–	–	3	–	18	6	8	44	73
Begonia formosana	H	–	–	–	–	–	–	–	–	–	22	39
Oreocnide pedunculata	T	–	–	–	–	–	–	–	3	4	11	42
Diplazium amamianum	H	4	–	–	–	–	–	25	3	15	7	52
Tetrastigma umbellatum	L	–	–	10	–	3	–	25	43	50	19	79
Pilea rotundinucula	H	–	–	–	–	–	–	–	–	–	–	15
Polystichum acutidens	H	–	–	–	–	–	–	–	–	4	–	18
Selaginella delicatula	H	–	–	–	–	8	–	7	3	–	19	42
Lithocarpus lepidocarpus	T	–	–	–	–	–	–	7	31	8	–	42
Elatostema parvum	H	4	–	5	–	–	3	14	3	15	–	39
Oplismenus hirtellus	H	–	–	–	–	–	–	4	3	8	4	30
Perrottetia arisanensis	T	–	–	–	–	–	5	–	–	8	–	24
Symplocos modesta	S	–	–	5	–	3	–	4	29	19	7	48
Pilea melastomoides	H	–	–	–	–	–	–	–	11	8	–	27
Thelypteris esquirolii	H	–	–	–	–	3	–	–	–	–	–	15
Asplenium filipes	H	–	–	–	–	–	–	–	–	–	–	9
Prosaptia urceolaris	E	–	–	–	–	–	–	–	–	–	–	9
Pteris setulosocostulata	H	–	–	–	–	–	–	–	17	12	4	27
Whytockia sasakii	H	–	–	–	–	–	–	–	–	–	–	6
Pasania cornea	T	–	–	–	–	–	–	–	3	4	7	18
Pilea funkikensis	H	–	–	–	–	–	–	–	3	4	7	18
Polystichum deltodon	H	–	–	–	–	–	–	–	–	–	–	6
Acrophorus macrocarpus	H	4	–	–	–	–	3	7	–	–	–	15
Polystichum lepidocaulon	H	–	–	–	–	–	–	–	–	–	4	9
Vandenboschia auriculata	E	–	–	–	–	3	5	21	23	27	41	45
Tetrastigma dentatum	L	–	–	–	–	–	3	4	–	8	22	24
Hemiboea bicornuta	H	–	–	–	6	3	3	4	17	8	19	30
Pilea angulata	H	–	–	–	–	–	3	–	–	4	4	12

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Diplazium wichurae	H	–	–	–	–	–	5	–	–	–	–	9
Loxogramme salicifolia	H	–	2	–	12	–	13	11	6	–	11	24
Cornopteris fluvialis	H	–	2	–	6	–	11	14	3	–	–	18
Polypodium formosanum	H	4	4	5	6	5	11	14	17	23	26	36
Selaginella mollendorffii	H	4	–	10	–	–	–	25	14	15	7	27
Ficus sarmentosa var. *henryi*	L	–	–	–	–	–	–	7	–	12	–	12
Peracarpa carnosa	H	4	2	10	–	–	–	–	6	4	7	15
Asarum albomaculatum	H	–	2	–	–	–	–	4	–	–	–	6
Carex filicina	H	–	2	5	12	–	3	4	3	–	7	15
Selaginella remotifolia	H	–	–	–	6	–	11	11	3	8	4	15
Other species												
Acer albopurpurascens	T	–	–	–	–	–	3	–	–	–	–	–
Acer serrulatum	T	–	–	5	12	–	11	7	6	12	4	9
Alangium chinense	T	–	–	–	–	–	–	4	–	–	–	–
Alniphyllum pterospermum	T	–	2	–	–	–	–	–	–	–	–	–
Alnus formosana	T	4	–	–	–	5	11	7	–	–	–	15
Aralia bipinnata	T	4	–	–	–	–	–	4	–	–	4	–
Aralia decaisneana	T	–	–	–	–	–	–	–	–	4	–	–
Ardisia sieboldii	T	–	–	–	–	–	–	–	–	4	–	–
Aria alnifolia	T	–	–	–	–	–	–	–	–	–	4	–
Beilschmiedia erythrophloia	T	–	–	–	–	–	–	4	9	12	11	6
Callicarpa pilosissima	T	–	–	–	6	–	–	–	–	–	–	–
Camellia salicifolia	T	–	–	–	–	3	–	–	–	8	–	–
Carpinus kawakamii	T	–	–	–	–	–	–	7	–	4	–	–
Cephalotaxus wilsoniana	T	4	–	10	–	3	13	14	6	–	–	6
Cinnamomum insularimontanum	T	–	–	–	–	–	–	14	–	4	–	9
Cinnamomum kanehirae	T	–	–	–	–	–	–	–	–	8	–	–
Cinnamomum macrostemon	T	–	–	–	–	–	–	7	–	8	4	–
Cinnamomum micranthum	T	–	–	–	–	–	–	–	6	–	–	–
Cinnamomum osmophloeum	T	–	–	–	–	–	–	–	–	–	4	3
Cleyera japonica var. *morii*	T	–	–	–	–	14	–	–	–	–	4	–
Cryptocarya chinensis	T	–	–	–	–	–	–	–	–	–	4	–
Cyathea spinulosa	T	–	–	–	–	–	–	–	–	–	4	–
Cyclobalanopsis glauca	T	4	2	–	–	11	–	–	–	–	7	–
Daphniphyllum glaucescens subsp. *oldhamii*	T	–	–	5	6	11	–	–	6	–	15	–
Debregeasia orientalis	T	–	–	–	–	–	–	4	–	–	–	3
Diospyros morrisiana	T	–	–	–	–	–	–	–	–	–	4	–
Elaeocarpus japonicus	T	20	12	–	24	84	13	18	40	31	85	21
Elaeocarpus sylvestris	T	4	–	–	6	8	–	4	3	4	19	9
Engelhardia roxburghiana	T	–	2	–	–	–	–	–	3	4	7	–
Eriobotrya deflexa	T	4	2	–	–	8	8	7	3	35	22	6
Eurya gnaphalocarpa	T	–	–	–	–	–	–	4	3	–	–	6
Eurya nitida	T	–	2	–	–	–	–	–	–	–	–	–
Ficus erecta var. *beecheyana*	T	–	–	–	–	–	–	–	–	–	19	–
Fraxinus insularis	T	–	–	–	–	–	–	–	–	4	–	–
Ilex ficoidea	T	–	–	–	6	19	–	4	6	8	26	–
Ilex formosana	T	–	–	–	6	3	–	–	9	4	11	–
Ilex lonicerifolia	T	–	2	–	6	8	–	–	–	–	11	–
Ilex pedunculosa	T	–	–	–	6	5	–	–	–	–	–	–
Ilex pubescens	T	–	2	–	–	–	3	–	–	–	–	–
Ilex rotunda	T	–	–	–	–	5	–	7	3	–	7	–
Ilex uraiensis	T	–	–	–	–	–	3	–	3	–	11	–
Ilex yunnanensis var. *parvifolia*	T	–	6	10	6	–	–	–	–	4	–	–
Itea oldhamii	T	–	–	–	–	–	–	–	–	–	4	–
Juglans cathayensis	T	–	–	–	–	–	–	7	–	4	–	–
Lagerstroemia subcostata	T	–	–	–	–	–	–	–	–	–	4	15
Lasianthus chinensis	T	–	–	–	–	3	–	–	–	–	–	–
Lasianthus obliquinervis	T	–	–	–	–	–	–	–	–	4	4	–
Lindera communis	T	–	–	–	–	–	–	4	–	–	–	–
Lindera erythrocarpa	T	–	–	–	6	3	–	–	–	–	–	–
Lindera glauca	T	–	–	–	–	–	–	–	3	–	–	–

Alliance code		1	1	1	1	1	2	2	2	2	2	2
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Lindera megaphylla	T	–	–	–	–	–	–	4	–	–	–	–
Litsea akoensis	T	–	–	–	–	–	–	4	6	–	4	–
Litsea hypophaea	T	–	–	–	–	3	–	–	–	–	–	–
Litsea perrottetii	T	–	–	–	–	3	–	–	–	–	–	–
Machilus japonica var. *kusanoi*	T	–	–	–	–	–	–	4	–	–	7	–
Machilus philippinensis	T	–	–	–	–	–	–	–	3	–	–	–
Machilus thunbergii	T	20	4	–	6	70	–	25	80	42	93	9
Machilus zuihoensis	T	–	–	–	12	5	–	–	3	–	4	–
Mallotus japonicus	T	–	–	–	–	3	–	–	–	–	4	–
Malus hupehensis	T	–	–	–	–	–	–	4	–	–	–	–
Meliosma callicarpifolia	T	–	–	–	–	3	–	–	–	–	–	–
Meliosma rhoifolia	T	–	–	–	–	–	–	–	6	–	–	–
Morus australis	T	–	–	–	–	–	–	–	–	–	–	6
Myrica rubra	T	–	–	–	–	5	–	7	–	–	7	–
Myrsine seguinii	T	–	–	5	–	5	–	–	–	–	4	–
Neolitsea daibuensis	T	–	–	–	–	–	–	–	–	4	–	–
Neolitsea konishii	T	–	–	–	–	–	–	–	–	–	4	–
Neolitsea parvigemma	T	–	–	–	–	–	–	–	–	4	–	–
Neolitsea sericea	T	–	–	–	–	–	–	4	–	–	7	–
Osmanthus marginatus	T	–	–	–	–	–	–	–	–	4	4	–
Pasania hancei var. *ternaticupula* f. *subreticulata*	T	4	–	5	–	–	–	4	–	–	–	–
Pasania synbalanos	T	–	–	–	–	–	–	4	–	–	11	–
Phellodendron amurense var. *wilsonii*	T	–	–	–	–	–	3	–	–	–	–	–
Phoebe formosana	T	–	–	–	–	–	–	4	–	–	7	12
Photinia serratifolia	T	–	–	–	–	–	–	4	–	–	–	–
Picea morrisonicola	T	–	2	20	–	–	–	–	–	4	–	–
Pinus morrisonicola	T	8	6	5	–	–	3	–	–	4	–	3
Pinus taiwanensis	T	12	–	10	–	3	–	–	–	–	–	–
Pourthiaea lucida	T	–	–	–	–	3	–	–	–	4	–	3
Pourthiaea villosa var. *parvifolia*	T	–	–	–	–	5	–	14	–	–	7	–
Prunus buergeriana	T	–	2	5	–	–	–	–	–	–	–	–
Prunus phaeosticta var. *ilicifolia*	T	–	–	5	–	5	3	4	–	–	–	3
Prunus spinulosa	T	–	–	–	–	–	–	–	–	4	–	3
Prunus taiwaniana	T	–	–	5	–	3	–	–	–	–	–	–
Prunus takasagomontana	T	–	–	–	–	3	–	–	–	–	4	–
Prunus transarisanensis	T	–	4	–	–	–	5	4	–	–	–	–
Pseudotsuga wilsoniana	T	8	–	–	–	–	5	4	–	4	–	–
Quercus spinosa	T	–	–	–	–	–	3	–	–	–	–	–
Quercus tatakaensis	T	–	2	–	–	–	–	7	–	–	–	–
Rhus hypoleuca	T	4	–	–	–	–	–	–	–	–	–	–
Rhus succedanea	T	–	–	–	–	–	–	–	6	4	–	–
Saurauia tristyla var. *oldhamii*	T	–	–	–	–	–	–	–	–	–	4	–
Schefflera octophylla	T	–	–	–	–	–	–	–	3	–	4	–
Schima superba var. *kankaoensis*	T	–	–	–	–	–	–	–	11	4	–	–
Schoepfia jasminodora	T	–	2	–	–	–	–	–	–	–	–	–
Sinoadina racemosa	T	–	–	–	–	–	–	–	–	4	–	–
Sinopanax formosana	T	–	2	–	–	–	–	4	–	–	–	–
Sloanea formosana	T	–	–	–	–	–	–	–	–	4	4	3
Stachyurus himalaicus	T	–	–	5	–	–	8	11	–	4	4	–
Styrax suberifolia	T	–	–	–	–	–	–	–	3	4	–	–
Symplocos congesta	T	4	–	–	–	3	–	–	9	4	–	–
Symplocos congesta var. *theifolia*	T	–	–	–	–	–	–	–	9	–	–	–
Symplocos decora	T	–	–	5	–	–	–	–	–	4	–	–
Symplocos grandis	T	–	–	–	–	–	–	–	–	4	–	–
Symplocos konishii	T	–	–	10	–	–	–	–	3	4	11	–
Symplocos sasakii	T	–	–	–	6	3	–	–	–	–	7	–
Symplocos setchuensis	T	8	–	5	–	–	–	–	3	–	–	–
Symplocos shilanensis	T	–	–	5	–	–	–	–	–	–	–	–
Symplocos theophrastifolia	T	–	2	–	–	–	–	–	–	–	–	–
Syzygium buxifolium	T	–	–	–	–	14	–	–	–	–	4	–

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Syzygium formosanum	T	–	–	–	–	–	–	–	3	12	4	–
Taxus sumatrana	T	–	–	15	–	–	–	4	–	–	–	–
Tetradium glabrifolium	T	–	–	–	–	–	3	4	–	4	–	–
Tetradium ruticarpum	T	–	–	–	–	–	3	–	–	–	–	–
Tricalysia dubia	T	–	–	–	–	3	–	–	–	–	–	–
Turpinia ternata	T	–	–	–	–	–	–	–	–	4	4	3
Ulmus uyematsui	T	–	–	5	–	5	3	7	–	–	–	–
Vaccinium wrightii	T	–	2	–	–	11	–	7	–	4	–	–
Xylosma congesta	T	–	–	–	–	–	–	–	–	–	4	–
Zanthoxylum ailanthoides	T	–	–	–	–	–	–	4	–	–	–	–
Ardisia cornudentata	S	–	–	–	–	–	–	–	3	–	–	–
Ardisia cornudentata subsp. *morrisonensis*	S	4	2	–	–	5	3	–	6	–	19	3
Ardisia crispa	S	–	–	–	–	–	–	4	–	–	4	–
Ardisia virens	S	–	–	–	12	3	–	–	–	8	11	3
Aucuba chinensis	S	–	–	–	–	3	–	–	17	–	–	–
Aucuba japonica	S	–	–	–	–	–	–	4	6	–	4	–
Berberis aristatoserrulata	S	–	–	10	–	–	–	4	3	8	–	–
Berberis brevisepala	S	–	–	–	–	3	–	–	–	–	–	–
Blastus cochinchinensis	S	–	2	–	–	8	–	–	14	–	–	–
Boehmeria nivea	S	4	–	–	–	–	–	–	–	–	–	–
Bredia gibba	S	–	–	–	–	–	–	–	6	–	–	–
Callicarpa formosana	S	–	–	–	–	–	–	–	–	12	7	21
Camellia transnokoensis	S	4	4	–	–	8	–	–	–	4	–	–
Celastrus paniculatus	S	–	–	–	–	3	–	–	–	–	–	–
Clerodendrum trichotomum	S	–	–	–	–	–	3	7	–	–	4	9
Cyathea metteniana	S	–	–	–	6	–	–	–	–	–	–	–
Daphne arisanensis	S	–	6	20	–	–	11	18	–	8	–	–
Daphne kiusiana var. *atrocaulis*	S	4	6	5	12	3	–	–	14	12	–	–
Daphne morrisonesis	S	–	–	5	–	–	–	–	–	–	–	–
Deutzia pulchra	S	–	–	–	–	–	3	4	–	8	4	–
Deutzia taiwanensis	S	–	–	5	–	–	–	4	–	–	–	–
Euonymus tashiroi	S	–	–	–	–	–	–	–	3	–	–	–
Eurya acuminata	S	–	2	–	6	–	–	11	3	–	–	–
Eurya hayatae	S	–	–	–	–	3	–	–	6	–	–	–
Ficus formosana	S	–	–	–	–	–	–	–	–	–	4	3
Gaultheria cumingiana	S	–	4	5	–	3	3	4	3	–	–	–
Gaultheria itoana	S	–	4	5	–	–	–	–	–	–	–	–
Hydrangea angustipetala	S	–	–	10	–	3	5	29	9	23	22	18
Hydrangea aspera	S	–	–	–	–	–	3	7	–	–	–	3
Hydrangea paniculata	S	–	–	–	6	–	–	–	–	–	–	–
Ilex asprella	S	–	–	–	–	3	–	–	–	–	–	–
Ilex crenata	S	–	2	–	–	–	–	–	–	–	–	–
Lasianthus appressihirtus	S	–	–	–	–	3	–	–	–	–	4	3
Lasianthus appressihirtus var. *maximus*	S	–	–	–	–	–	–	–	–	–	4	–
Lasianthus fordii	S	–	–	–	–	14	–	–	–	4	30	6
Lasianthus microphyllus	S	–	–	–	–	–	–	–	–	4	4	3
Lasianthus microstachys	S	–	–	–	–	8	–	–	–	–	4	–
Ligustrum morrisonense	S	–	–	5	–	–	–	4	9	8	–	3
Lindera akoensis	S	–	–	–	–	–	–	7	–	–	7	–
Maesa perlaria var. *formosana*	S	–	–	–	–	–	–	–	–	8	–	6
Mahonia japonica	S	4	4	15	–	–	8	4	–	8	–	–
Mahonia oiwakensis	S	–	–	5	–	–	3	–	–	8	–	9
Melastoma candidum	S	–	–	–	6	–	–	–	–	–	–	–
Pieris taiwanensis	S	8	16	20	18	11	–	–	–	–	4	–
Pittosporum illicioides	S	4	2	5	–	8	18	14	9	15	–	3
Pittosporum illicioides var. *angustifolium*	S	–	–	5	–	–	–	–	–	–	–	–
Prinsepia scandens	S	–	–	5	–	–	–	–	–	–	–	–
Psychotria rubra	S	–	–	–	–	–	–	–	3	–	–	–
Rhamnus chingshuiensis var. *tashanensis*	S	–	–	–	–	–	–	–	3	–	–	–
Rhamnus crenata	S	–	4	–	6	–	–	–	–	–	–	–
Rhamnus nakaharae	S	–	–	–	–	–	–	–	–	–	–	3

Alliance code		1	1	1	1	1	2	2	2	2	2	2
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Rhaphiolepis indica var. *tashiroi*	S	—	2	—	—	5	—	—	—	—	—	—
Rhododendron breviperulatum	S	—	—	—	—	—	—	—	—	—	4	—
Rhododendron chilanshanense	S	4	—	—	6	—	—	—	—	—	—	—
Rhododendron mariesii	S	—	—	—	—	—	—	—	3	4	—	—
Rhododendron noriakianum	S	4	—	—	—	—	—	—	—	—	—	—
Rhododendron oldhamii	S	8	—	—	—	—	—	—	—	—	—	—
Rhododendron ovatum	S	—	—	—	—	—	—	—	—	4	—	—
Rhododendron ovatum var. *lamprophyllum*	S	—	—	—	—	—	—	—	3	—	—	—
Rhododendron rubropilosum	S	16	10	—	—	3	3	7	—	—	—	—
Rhododendron tashiroi	S	—	—	—	—	—	—	—	3	—	—	—
Ribes formosanum	S	—	—	5	—	—	—	—	—	—	—	—
Rosa sericea var. *morrisonensis*	S	—	2	—	—	—	—	—	—	—	—	—
Rubus croceacanthus	S	—	—	—	—	—	3	4	3	4	—	—
Rubus croceacanthus var. *glaber*	S	—	—	5	—	—	—	—	—	—	—	—
Rubus fraxinifoliolus	S	—	—	—	—	—	—	4	—	—	—	—
Rubus niveus	S	—	—	5	—	—	—	—	—	—	—	—
Rubus pungens var. *oldhamii*	S	4	—	5	—	—	—	—	—	—	—	—
Rubus rolfei	S	—	2	—	—	—	—	—	—	—	—	—
Rubus rosifolius	S	—	—	—	—	—	—	—	—	—	4	—
Rubus sumatranus	S	4	4	—	12	3	—	7	—	—	7	—
Rubus taitoensis var. *aculeatiflorus*	S	—	—	10	—	—	—	—	—	—	—	—
Rubus yuliensis	S	4	—	—	—	—	3	4	—	—	—	—
Sageretia thea	S	—	—	10	—	—	3	11	—	—	—	—
Salix fulvopubescens	S	—	—	—	—	—	—	—	—	4	—	—
Sambucus chinensis	S	—	—	—	—	—	—	—	—	4	—	—
Sarcandra glabra	S	—	—	—	—	8	—	—	—	—	26	—
Sarcococca saligna	S	—	—	5	—	—	—	—	—	—	—	—
Strobilanthes longespicatus	S	—	—	—	—	—	—	—	3	—	—	—
Styrax formosana	S	—	2	—	18	—	3	11	—	—	7	9
Swida macrophylla	S	—	—	—	—	—	—	—	—	4	—	—
Symplocos eriostroma	S	—	2	—	6	—	—	4	—	—	—	—
Symplocos nokoensis	S	—	2	—	—	—	—	—	—	—	—	—
Vaccinium randaiense	S	8	2	—	—	3	—	4	14	15	—	—
Vaccinium wrightii var. *formosanum*	S	—	—	—	—	—	—	—	—	—	4	—
Viburnum betulifolium	S	—	4	—	—	3	—	—	—	4	—	—
Viburnum formosanum	S	—	—	5	6	—	—	7	6	8	22	6
Viburnum luzonicum	S	—	2	5	18	11	—	4	—	—	15	—
Viburnum odoratissimum	S	4	—	—	—	—	—	7	11	12	—	—
Viburnum parvifolium	S	—	—	—	—	—	—	4	—	—	—	—
Viburnum propinquum	S	—	2	—	—	8	—	11	—	—	—	—
Wikstroemia lanceolata	S	—	—	5	—	—	—	—	—	—	—	—
Wikstroemia taiwanensis	S	—	—	—	—	—	—	—	3	—	—	—
Zanthoxylum armatum	S	—	—	—	—	—	—	—	—	—	4	—
Actinidia callosa	L	—	—	—	—	—	5	—	—	—	—	—
Actinidia chinensis var. *setosa*	L	—	2	5	—	3	3	7	—	8	—	3
Actinidia rubricaulis	L	—	—	5	—	—	—	—	—	—	—	—
Actinostemma tenerum	L	—	—	—	—	—	—	—	—	—	4	—
Aeschynanthus acuminatus	L	—	—	—	—	—	—	—	3	—	—	6
Akebia longeracemosa	L	—	—	—	—	—	—	4	—	—	—	—
Ampelopsis brevipedunculata var. *hancei*	L	—	—	—	—	3	—	—	—	—	—	3
Anodendron benthamiana	L	—	—	—	—	—	—	—	—	—	4	—
Aristolochia foveolata	L	—	—	—	—	—	—	—	—	4	—	—
Aristolochia heterophylla	L	—	—	—	—	—	—	4	—	—	7	—
Aristolochia kaempferi	L	—	—	—	—	—	—	—	—	4	—	3
Arthropteris palisotii	L	—	—	—	—	—	—	—	3	—	—	—
Bauhinia championii	L	—	—	—	—	—	—	—	—	—	—	9
Berchemia racemosa var. *magna*	L	—	—	—	—	—	3	—	—	—	—	—
Bredia hirsuta var. *scandens*	L	—	—	—	—	—	—	—	6	—	7	3
Cayratia japonica	L	—	—	—	—	—	—	11	23	12	7	9
Celastrus hindsii	L	—	—	—	—	—	—	7	—	4	—	3
Celastrus kusanoi	L	—	—	—	—	—	11	—	—	—	—	3

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Clematis grata	L	—	—	5	—	3	—	4	—	—	—	—
Clematis henryi	L	4	2	5	—	3	16	18	9	12	7	15
Clematis henryi var. *morii*	L	—	—	5	—	—	3	—	6	4	—	—
Clematis meyeniana	L	—	—	—	—	—	—	—	9	4	—	—
Clematis montana	L	—	—	—	—	—	—	—	—	—	—	3
Clematis parviloba subsp. *bartlettii*	L	—	—	—	—	—	—	—	—	—	—	3
Clematis tashiroi	L	—	—	—	—	—	—	—	—	—	—	3
Clematis uncinata	L	—	—	—	—	—	8	—	—	—	—	—
Coptosapelta diffusa	L	—	2	—	—	—	—	—	—	—	—	—
Dioscorea collettii	L	—	—	—	—	—	—	—	—	4	—	—
Diplocyclos palmatus	L	—	—	—	—	—	—	4	—	—	—	—
Elaeagnus glabra	L	4	—	5	—	3	—	—	9	12	4	—
Elaeagnus grandifolia	L	—	—	—	—	—	3	—	—	—	—	—
Elaeagnus thunbergii	L	—	—	10	—	—	3	4	17	12	4	6
Eleutherococcus trifoliatus	L	—	—	—	—	3	—	—	—	—	—	9
Embelia lenticellata	L	—	—	—	—	—	—	7	9	8	—	12
Embelia rudis	L	—	—	—	—	—	—	—	3	4	—	—
Epipremnum pinnatum	L	—	—	—	—	—	—	—	—	—	4	—
Erycibe henryi	L	—	—	—	—	—	—	—	—	—	4	—
Ficus pumila	L	—	—	—	—	—	—	4	—	—	—	—
Gardneria multiflora	L	—	—	—	—	—	—	—	—	—	4	—
Gynostemma pentaphyllum	L	—	—	10	—	—	11	7	6	4	7	15
Heterosmilax indica	L	—	—	—	—	—	—	—	6	4	—	—
Heterosmilax japonica	L	—	—	—	—	—	5	14	14	4	—	12
Hiptage benghalensis	L	—	—	—	—	—	—	—	3	—	—	—
Jasminum lanceolarium	L	—	—	—	—	—	—	—	—	—	4	—
Jasminum urophyllum	L	—	—	—	—	—	8	—	3	8	—	—
Lonicera apodantha	L	—	—	—	—	—	—	—	3	4	—	—
Lonicera japonica	L	—	—	—	6	—	—	7	—	—	—	—
Lycopodium clavatum	L	—	2	—	—	—	—	—	—	—	—	—
Marsdenia formosana	L	—	—	—	—	—	3	14	—	8	—	6
Morinda parvifolia	L	—	—	—	—	—	—	—	—	—	4	—
Mussaenda pubescens	L	—	—	—	—	3	—	—	—	—	15	15
Paederia foetida	L	—	—	—	—	—	—	—	—	—	7	—
Parthenocissus tricuspidata	L	—	—	—	6	—	—	—	—	—	—	—
Pericampylus formosanus	L	—	—	—	—	3	—	—	—	—	—	—
Polygonum multiflorum var. *hypoleucum*	L	—	—	—	—	—	—	—	—	4	—	3
Psychotria serpens	L	—	—	—	—	—	—	—	—	—	4	—
Pueraria montana	L	—	—	—	—	—	—	—	—	—	4	—
Rosa sambucina	L	—	—	—	—	—	3	—	—	—	—	—
Rubus lambertianus	L	—	—	—	6	—	3	4	—	—	—	3
Rubus mesogaeus	L	—	—	—	—	—	3	7	3	—	11	—
Rubus morii	L	—	—	5	—	—	—	7	3	—	—	—
Rubus swinhoei	L	4	2	—	—	5	—	4	6	19	15	6
Rubus trianthus	L	4	—	10	—	5	—	—	—	—	—	—
Rubus wallichianus	L	—	—	—	—	—	—	4	—	—	—	—
Senecio scandens	L	—	—	5	—	—	—	4	—	—	—	—
Smilax bracteata var. *verruculosa*	L	—	—	—	—	3	—	—	—	—	—	21
Smilax china	L	—	8	5	—	5	—	4	9	12	7	12
Smilax corbularia	L	—	—	—	—	—	—	—	3	—	—	—
Smilax elongatoumbellata	L	4	6	—	—	3	—	7	—	4	—	—
Smilax glabra	L	8	—	—	—	—	5	4	14	4	4	—
Smilax horridiramula	L	—	—	—	—	—	—	—	6	—	—	—
Smilax nantoensis	L	—	—	—	—	—	—	—	—	4	—	—
Smilax nipponica	L	—	2	—	—	—	—	—	—	—	—	—
Smilax riparia	L	—	—	5	—	—	—	7	14	12	4	—
Smilax vaginata	L	—	8	10	—	—	3	—	9	—	—	—
Stauntonia obovata	L	—	—	5	—	—	—	—	6	—	—	—
Stauntonia purpurea	L	—	—	—	—	—	—	—	—	—	—	3
Tetrastigma formosanum	L	—	—	5	—	3	—	11	—	—	26	3
Thladiantha nudiflora	L	—	—	—	—	—	—	4	—	4	—	—

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Toddalia asiatica	L	—	—	5	—	—	16	4	—	—	—	—
Trachelospermum gracilipes	L	—	—	5	—	8	5	32	23	19	33	15
Trachelospermum jasminoides	L	—	—	—	—	—	—	18	6	12	26	6
Uncaria hirsuta	L	—	—	—	—	—	—	—	—	—	4	—
Zehneria mucronata	L	—	—	—	—	—	—	—	—	—	4	—
Appendicula reflexa	E	—	—	—	—	3	—	—	—	—	—	—
Ascocentrum pumilum	E	—	—	—	—	5	—	—	—	—	—	—
Asplenium nidus	E	—	—	—	—	—	—	—	—	—	7	3
Bulbophyllum albociliatum	E	—	—	—	—	—	—	4	—	4	—	—
Bulbophyllum drymoglossum	E	—	8	—	6	5	—	—	—	8	7	—
Bulbophyllum insulsum	E	—	—	—	—	—	—	4	—	—	—	—
Bulbophyllum macraei	E	—	—	—	—	—	—	—	—	4	—	—
Bulbophyllum melanoglossum	E	—	—	—	—	—	—	4	3	—	4	6
Bulbophyllum pectinatum	E	—	2	—	—	3	—	—	—	—	7	—
Bulbophyllum setaceum	E	—	—	5	—	—	—	—	3	—	—	—
Calymmodon cucullatus	E	—	—	—	—	—	—	—	3	—	—	—
Calymmodon gracilis	E	—	—	—	—	—	—	—	—	—	—	3
Cotoneaster morrisonensis	E	—	—	—	6	—	—	—	—	—	—	—
Crepidomanes bilabiatum	E	—	—	—	—	3	—	—	—	—	4	—
Crepidomanes latealatum	E	—	—	—	—	—	—	—	—	—	—	3
Ctenopteris curtisii	E	—	—	—	—	—	—	—	11	8	—	—
Cymbidium dayanum	E	—	—	—	—	—	—	—	—	—	4	—
Davallia formosana	E	8	2	—	—	—	—	—	—	—	—	—
Dendrobium chryseum	E	4	—	—	—	—	—	—	—	—	4	—
Dendrobium leptocladum	E	4	—	—	—	—	—	—	3	—	—	—
Dendrobium moniliforme	E	12	16	—	—	—	11	7	6	8	15	—
Elaphoglossum conforme	E	—	—	—	—	3	3	7	6	—	—	9
Epigeneium nakaharae	E	8	8	—	18	14	8	4	—	4	—	—
Eria amica	E	—	—	—	—	—	3	—	3	—	—	—
Eria japonica	E	—	2	—	—	5	—	7	3	—	—	—
Eria tomentosiflora	E	—	—	—	—	—	—	—	—	4	—	3
Gastrochilus ciliaris	E	4	—	5	—	—	—	—	—	—	—	—
Gastrochilus formosanus	E	8	—	—	—	5	11	4	6	4	—	—
Gastrochilus fuscopunctatus	E	4	—	—	—	5	—	—	—	—	4	3
Grammitis congener	E	—	—	—	—	—	—	—	—	—	4	3
Grammitis intromissa	E	—	—	—	—	—	—	—	—	4	—	—
Holcoglossum quasipinifolium	E	—	—	—	—	3	3	—	—	—	—	—
Humata griffithiana	E	—	—	—	—	—	—	—	—	—	—	3
Humata repens	E	—	—	—	—	—	—	4	—	—	—	—
Lemmaphyllum microphyllum	E	—	4	5	—	14	—	11	29	15	30	18
Lepisorus pseudoussuriensis	E	4	2	10	—	—	—	7	—	4	—	—
Liparis bootanensis	E	—	—	—	—	—	—	—	—	4	7	6
Liparis caespitosa	E	—	—	—	—	—	—	—	—	—	7	6
Liparis nakaharai	E	—	—	—	—	—	—	—	—	—	11	3
Liparis viridiflora	E	—	—	—	—	3	—	—	—	—	—	—
Lycopodium cryptomerianum	E	—	2	—	—	—	—	—	—	—	—	—
Lycopodium fargesii	E	—	—	—	6	—	—	—	—	—	4	3
Lycopodium sieboldii	E	—	—	—	—	—	—	—	—	4	—	—
Lycopodium taiwanense	E	4	—	—	6	—	3	4	—	—	—	—
Oberonia arisanensis	E	8	—	—	—	3	—	—	—	—	4	—
Oberonia caulescens	E	4	4	—	—	3	—	4	3	4	4	—
Oberonia japonica	E	—	2	—	—	—	—	—	—	—	—	—
Oberonia pumila	E	—	—	—	—	—	—	—	3	—	—	—
Ophioderma pendula	E	—	—	—	—	—	—	—	—	—	4	3
Pentapanax castanopsisicola	E	—	—	—	—	—	—	—	—	—	—	3
Pleione bulbocodioides	E	—	2	—	6	—	—	—	—	—	—	—
Procris laevigata	E	—	—	—	—	—	—	—	—	—	4	18
Pyrrosia adnascens	E	—	—	—	—	3	—	—	3	—	—	—
Pyrrosia gralla	E	—	—	—	—	—	5	—	3	—	—	3
Pyrrosia polydactyla	E	—	—	10	—	3	—	—	—	—	—	—
Pyrrosia transmorrisonensis	E	—	—	5	—	3	—	—	—	—	—	—

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Sunipia andersonii	E	–	–	–	–	11	–	11	3	–	4	3
Taxillus liquidambaricolus	E	4	2	–	–	–	–	–	–	–	–	–
Taxillus lonicerifolius	E	–	–	5	–	–	–	–	–	–	–	–
Taxillus ritozanensis	E	–	–	–	–	–	3	–	–	–	–	–
Vandenboschia radicans	E	–	–	–	–	–	–	–	–	–	–	3
Viscum articulatum	E	–	–	–	–	–	3	4	–	–	–	–
Vittaria angusteelongata	E	8	6	10	18	–	5	4	–	8	4	3
Vittaria taeniophylla	E	8	2	5	–	–	3	–	3	–	–	–
Vittaria zosterifolia	E	–	–	–	–	–	–	–	–	–	19	–
Achyranthes aspera var. *rubrofusca*	H	–	–	–	–	–	–	–	–	–	4	6
Achyranthes bidentata	H	–	–	–	–	–	–	–	–	–	–	3
Acorus gramineus	H	–	–	–	–	–	–	–	–	–	4	–
Acrorumohra subreflexipinna	H	–	–	–	–	–	–	–	3	–	–	–
Acystopteris taiwaniana	H	4	–	–	–	–	–	4	–	–	–	3
Agropyron formosanum	H	–	–	–	–	–	–	11	–	–	–	6
Alpinia intermedia	H	–	–	–	–	11	–	4	–	–	37	–
Alpinia pricei	H	–	–	–	–	–	–	–	–	–	–	3
Alpinia shimadae	H	–	–	–	–	–	–	–	–	4	–	3
Alpinia shimadae var. *kawakamii*	H	–	–	–	–	–	–	–	–	4	–	12
Alpinia zerumbet	H	–	–	–	–	–	–	–	3	–	–	–
Amischotolype hispida	H	–	–	–	–	–	–	–	–	–	7	6
Angiopteris lygodiifolia	H	–	–	–	–	–	–	–	–	–	4	3
Anoectochilus formosanus	H	–	–	–	–	5	3	11	–	8	15	–
Antrophyum obovatum	H	–	–	–	–	–	–	4	3	–	–	12
Arachniodes aristata	H	–	–	–	–	–	–	11	3	4	11	9
Arachniodes globisora	H	4	–	–	–	–	–	–	–	–	–	–
Arachniodes pseudoaristata	H	4	–	5	–	3	5	7	3	8	4	3
Arachniodes rhomboidea var. *yakushimensis*	H	8	–	–	–	–	8	–	–	–	–	3
Aralia cordata	H	–	–	5	–	–	–	–	–	–	–	–
Ardisia brevicaulis	H	–	–	–	–	3	–	–	–	–	–	–
Arisaema consanguineum	H	–	2	5	6	–	–	4	–	8	4	3
Arisaema formosanum	H	–	10	5	18	3	–	11	3	–	4	–
Arisaema thunbergii subsp. *autumnale*	H	4	–	–	–	–	–	–	–	–	–	–
Artemisia indica	H	–	–	5	–	–	–	–	–	–	–	–
Asarum epigynum	H	–	–	–	–	–	–	–	–	–	–	3
Asarum hypogynum	H	–	–	–	–	–	–	–	6	–	–	–
Asarum taipingshanianum	H	–	–	–	6	–	–	4	–	–	–	–
Aspidistra elatior var. *attenuata*	H	–	–	–	–	–	–	–	–	–	4	–
Asplenium apogamum	H	–	–	–	–	–	–	–	–	4	–	–
Asplenium cheilosorum	H	–	–	–	–	–	–	–	–	4	–	3
Asplenium cuneatiforme	H	–	–	–	–	–	–	–	–	–	4	3
Asplenium excisum	H	–	–	–	–	–	–	4	–	–	–	–
Asplenium griffithianum	H	–	–	–	–	–	3	–	3	–	–	–
Asplenium laciniatum	H	–	–	–	–	–	–	–	6	–	–	–
Asplenium neolaserpitiifolium	H	–	–	–	–	–	–	–	3	8	–	3
Asplenium oldhami	H	–	4	–	–	–	5	7	–	–	–	3
Asplenium pekinense	H	–	–	–	–	–	–	–	3	–	–	–
Asplenium planicaule	H	4	–	–	–	–	–	–	–	4	–	–
Asplenium pseudolaserpitiifoliom	H	–	–	–	–	–	–	–	3	–	–	–
Asplenium ritoense	H	–	–	–	–	–	–	4	–	–	4	–
Asplenium subnormale	H	–	–	–	–	–	–	–	–	4	–	–
Asplenium tenuifolium	H	–	–	–	–	–	–	–	3	–	–	–
Asplenium trichomanes	H	–	–	5	–	–	3	–	–	–	–	–
Asplenium unilaterale	H	–	–	–	–	–	–	4	–	–	–	6
Asplenium wrightii	H	–	–	–	–	3	3	7	–	4	4	3
Astilbe macroflora	H	–	2	–	–	–	–	–	–	–	–	–
Athyrium delavayi	H	–	–	–	–	–	3	–	3	–	–	–
Athyrium japonicum	H	–	–	–	–	–	–	–	–	–	–	9
Athyrium leiopodum	H	–	–	–	–	–	–	–	3	–	–	–
Athyrium niponicum	H	–	–	–	–	–	–	–	3	–	–	–
Athyrium pycnosorum	H	4	–	–	–	–	–	–	–	–	–	–

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Athyrium tozanense	H	4	–	–	–	–	3	4	–	–	–	–
Athyrium vidalii	H	–	–	–	–	–	5	11	–	4	–	3
Balanophora harlandii	H	–	–	–	–	–	–	–	3	–	–	–
Balanophora laxiflora	H	–	2	5	–	3	–	11	3	–	–	3
Blechnum melanopus	H	–	–	–	–	–	–	–	–	–	4	–
Bolbitis subcordata	H	–	–	–	–	–	–	4	–	–	–	–
Botrychium daucifolium	H	–	–	–	–	–	–	4	–	–	4	–
Brachypodium sylvaticum	H	–	–	–	–	–	–	–	–	–	–	3
Calanthe arisanensis	H	–	–	–	–	3	–	–	3	–	11	–
Calanthe aristulifera	H	–	–	–	–	–	–	4	–	–	4	–
Calanthe sylvatica	H	–	–	–	–	–	–	–	–	–	–	3
Calanthe triplicata	H	–	–	–	–	3	–	–	–	–	4	–
Carex arisanensis	H	–	–	–	6	–	–	–	–	–	–	–
Carex baccans	H	–	–	–	6	–	–	4	–	–	–	9
Carex breviscapa	H	–	–	5	–	–	–	–	–	–	–	–
Carex cruciata	H	–	2	5	–	–	–	7	3	15	4	12
Carex manca subsp. *takasagoana*	H	–	–	–	–	–	–	–	6	4	–	–
Carex morii	H	–	–	–	–	–	–	7	–	–	15	–
Carex nubigena	H	–	2	–	–	–	–	–	–	–	–	–
Carex sociata	H	–	–	–	–	–	–	–	3	–	–	–
Cheilotheca humilis	H	–	4	–	–	3	–	–	9	–	4	–
Cheiropleuria bicuspis	H	–	–	–	–	–	–	–	–	4	–	–
Chimaphila japonica	H	4	–	–	–	–	–	–	–	–	–	–
Chloranthus oldhami	H	–	–	–	–	–	–	–	–	–	–	3
Chrysoglossum ornatum	H	–	–	–	–	–	–	–	–	–	7	–
Chrysosplenium lanuginosum var. *formosanum*	H	–	–	–	6	–	3	–	–	–	–	3
Circaea erubescens	H	4	–	–	–	–	–	–	–	–	–	–
Collabium formosanum	H	–	–	–	–	–	–	–	–	–	4	–
Colysis hemionitidea	H	–	–	–	–	–	–	–	–	4	–	–
Colysis wrightii	H	–	–	–	–	–	–	–	3	–	–	–
Comanthosphace formosana	H	–	–	–	–	–	3	–	–	–	–	6
Coniogramme japonica	H	–	–	–	–	–	–	–	–	–	4	3
Cornopteris decurrentialatum	H	–	–	5	–	–	–	4	–	–	–	3
Cremastra appendiculata	H	–	–	–	–	–	5	–	–	–	–	–
Crepidomanes birmanicum	H	–	–	–	–	–	5	–	–	8	11	–
Crypsinus hastatus	H	–	–	–	–	3	–	–	–	–	4	–
Crypsinus quasidivaricatus	H	12	12	15	–	–	–	4	3	–	–	–
Ctenitis apiciflora	H	16	8	15	6	–	13	11	6	8	–	–
Ctenitis maximowicziana	H	–	–	5	–	–	–	–	–	–	–	–
Ctenitis subglandulosa	H	–	–	–	–	–	–	4	3	–	7	9
Cyclosorus acuminatus	H	–	2	–	–	–	–	–	–	–	4	–
Cyclosorus dentatus	H	–	2	–	–	–	–	–	–	–	–	–
Cyclosorus subpubescens	H	–	–	–	6	–	–	–	–	–	–	–
Cyclosorus truncatus	H	–	–	–	–	–	–	–	–	–	–	3
Cynoglossum furcatum	H	–	–	–	–	–	–	–	–	–	–	3
Cyrtomium caryotideum	H	–	–	–	–	–	–	4	–	4	–	6
Cystopteris moupinensis	H	–	–	15	–	–	–	–	–	–	–	–
Cystopteris tenuisecta	H	–	2	–	–	–	3	–	–	–	–	–
Dennstaedtia scabra	H	12	2	–	–	–	11	4	3	–	–	–
Dicranopteris linearis	H	–	–	–	–	5	–	–	–	–	–	–
Dicranopteris linearis var. *tetraphylla*	H	–	–	–	–	–	–	–	–	–	4	–
Dictyocline griffithii	H	–	–	–	–	–	–	–	–	–	7	–
Diplaziopsis javanica	H	–	–	–	–	–	–	4	–	–	–	–
Diplazium dilatatum	H	–	–	–	–	3	3	11	6	12	48	27
Diplazium doederleinii	H	–	–	–	–	–	–	7	–	8	22	12
Diplazium donianum	H	–	–	–	–	–	–	–	–	4	–	–
Diplazium formosanum	H	–	–	–	–	–	–	–	–	–	4	–
Diplazium petri	H	–	–	–	–	–	–	–	–	4	4	–
Diplazium pseudodoederleinii	H	–	–	5	–	–	–	4	3	4	–	3
Diplazium pullingeri	H	–	–	–	–	–	–	–	–	–	4	–
Diplazium virescens	H	–	–	–	–	–	–	–	–	4	–	6

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Diplopterygium chinensis	H	–	–	5	6	8	3	–	–	4	–	–
Diplopterygium laevissimum	H	–	–	–	6	3	–	–	–	–	–	–
Disporopsis taiwanensis	H	–	–	–	–	3	–	–	–	–	4	–
Disporum kawakamii	H	–	–	–	–	3	–	–	6	–	–	3
Disporum nantouense	H	–	–	–	–	–	–	–	3	–	–	–
Disporum shimadai	H	–	–	–	–	–	3	–	–	–	–	–
Dryopsis fauriei	H	–	4	–	–	–	–	–	–	–	–	–
Dryopteris atrata	H	–	2	5	6	–	5	14	3	4	–	3
Dryopteris austriaca	H	–	–	–	12	3	3	–	–	4	–	–
Dryopteris enneaphylla	H	4	–	–	–	–	–	–	–	–	–	3
Dryopteris enneaphylla var. *pseudosieboldii*	H	–	–	–	–	–	–	–	–	–	–	3
Dryopteris hendersonii	H	4	2	–	–	–	3	–	3	–	–	–
Dryopteris hypophlebia	H	4	4	–	6	–	–	–	–	–	–	–
Dryopteris labordei	H	–	–	–	–	–	–	–	3	–	–	–
Dryopteris reflexosquamata	H	4	2	5	–	–	3	–	–	–	7	–
Dryopteris scottii	H	–	2	–	–	–	3	4	–	–	4	6
Dryopteris serratodentata	H	–	2	–	–	–	–	–	–	–	–	–
Dryopteris sordidipes	H	–	2	5	–	5	11	–	–	4	–	–
Dryopteris squamiseta	H	–	4	–	6	–	–	–	3	–	–	–
Dryopteris subintegriloba	H	–	–	–	–	3	–	–	–	–	–	–
Dysosma pleiantha	H	–	–	–	–	–	5	4	–	–	–	3
Elaphoglossum callifolium	H	–	4	–	–	–	–	–	–	–	–	3
Elatostema acuteserratum	H	–	–	–	–	–	–	–	–	–	–	3
Elatostema lineolatum var. *majus*	H	–	–	–	–	–	–	–	–	12	11	27
Elatostema microcephalanthum	H	–	–	–	–	–	–	–	–	–	7	6
Elatostema platyphylloides	H	–	–	–	–	–	–	–	6	–	4	18
Elatostema strigillosum	H	–	–	–	6	–	–	–	–	–	–	–
Elatostema villosum	H	–	–	5	–	–	–	–	3	–	–	3
Epilobium amurense	H	–	–	5	–	–	–	–	–	–	–	–
Erythrodes blumei	H	–	–	–	–	–	3	–	–	–	–	–
Eupatorium chinense var. *tozanense*	H	–	–	5	–	–	–	–	–	–	–	3
Eupatorium clematideum	H	–	–	–	–	–	–	–	–	–	4	–
Eutrema japonica	H	–	–	–	–	–	–	–	–	4	–	–
Galeola falconeri	H	–	–	–	–	–	–	4	–	–	–	–
Galium echinocarpum	H	–	–	5	–	–	–	–	–	4	–	3
Galium formosense	H	–	–	5	–	–	–	–	–	–	–	–
Gentiana davidii var. *formosana*	H	–	–	–	6	–	–	–	–	–	–	–
Glechoma hederacea var. *grandis*	H	–	–	–	–	–	–	–	–	–	–	3
Goodyera daibuzanensis	H	–	–	–	–	3	–	–	–	–	–	–
Goodyera foliosa	H	–	–	–	–	–	8	4	–	4	7	–
Goodyera kwangtungensis	H	–	–	5	–	3	5	–	–	–	–	–
Goodyera maximowicziana	H	4	2	–	–	–	–	4	–	–	–	3
Goodyera rubicunda	H	–	–	–	–	–	–	–	–	–	–	3
Goodyera schlechtendaliana	H	4	–	–	–	–	–	–	–	–	–	–
Goodyera viridiflora	H	–	–	–	–	3	–	–	–	–	–	–
Helonias umbellata	H	–	–	–	–	5	–	–	–	–	–	–
Hydrocotyle dichondroides	H	–	–	–	–	–	–	4	–	4	–	3
Hydrocotyle nepalensis	H	–	–	–	–	–	–	–	–	4	–	3
Hydrocotyle sibthorpioides	H	–	–	–	–	–	–	–	–	4	–	–
Hymenophyllum barbatum	H	4	–	–	–	5	3	4	–	4	–	3
Hymenophyllum productum	H	–	–	–	6	–	–	–	–	–	–	–
Hypodematium crenatum	H	–	–	–	–	–	3	–	–	–	–	–
Impatiens uniflora	H	–	–	5	–	–	–	–	–	4	7	6
Isachne albens	H	–	–	5	–	–	–	–	–	–	–	3
Isachne globosa	H	–	–	–	–	–	–	–	–	–	–	6
Lecanthus peduncularis	H	4	–	–	–	–	8	4	6	–	–	3
Lepisorus monilisorus	H	16	20	30	12	11	3	4	29	27	30	33
Lepisorus morrisonensis	H	4	8	–	–	–	3	11	3	4	–	3
Lepisorus suboligolepidus	H	8	2	5	–	–	–	–	–	–	–	–
Lepisorus tosaensis	H	–	2	–	–	–	3	–	–	–	–	–
Leptochilus decurrens	H	–	–	–	–	–	–	–	–	4	–	–

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Leptogramma tottoides	H	—	—	—	6	—	—	4	—	—	4	—
Lindsaea odorata	H	—	—	—	—	3	—	—	—	—	—	—
Lindsaea orbiculata	H	—	—	—	—	3	—	—	—	—	—	—
Liparis nigra	H	—	—	—	—	—	—	—	—	—	4	—
Liriope spicata	H	—	—	—	—	3	—	4	3	—	—	—
Listera japonica	H	—	—	—	—	—	—	—	—	—	—	3
Listera macrantha	H	—	—	5	—	—	—	—	—	—	—	—
Lobelia nummularia	H	—	—	—	—	3	—	—	—	—	—	3
Lophatherum gracile	H	—	—	—	—	—	—	—	—	—	4	—
Loxogramme formosana	H	—	2	—	6	—	3	7	—	8	—	6
Loxogramme grammitoides	H	—	—	—	—	—	3	—	—	—	—	—
Luzula effusa	H	—	6	5	—	—	—	4	9	—	—	—
Luzula taiwaniana	H	—	—	5	—	—	—	—	—	—	—	—
Lycianthes biflora	H	—	—	—	—	—	—	4	—	—	—	—
Lycianthes lysimachioides	H	—	—	—	—	—	3	7	—	—	4	—
Lycopodium quasipolytrichoides	H	4	—	—	—	—	—	—	—	—	—	—
Lycopodium serratum	H	—	2	—	—	8	3	4	6	8	4	—
Lycopodium somae	H	—	4	—	—	—	—	—	—	—	—	—
Lysimachia nigropunctata	H	—	—	—	—	—	—	—	3	—	—	—
Melissa axillaris	H	—	—	5	—	—	3	4	—	—	—	3
Mercurialis leiocarpa	H	—	—	—	—	—	—	—	—	4	—	—
Meringium holochilum	H	—	—	—	—	—	—	—	—	4	—	—
Metathelypteris adscendens	H	—	—	5	—	3	—	—	—	4	—	—
Metathelypteris gracilescens	H	—	—	—	6	—	5	4	—	—	—	—
Microlepia strigosa	H	—	—	—	—	8	—	—	—	—	—	9
Microlepia substrigosa	H	—	—	—	—	—	—	—	—	4	—	—
Microsorium fortunei	H	—	—	—	—	5	3	—	—	4	11	24
Microstegium vimineum	H	—	—	—	—	—	—	—	—	—	—	9
Miscanthus floridulus	H	4	4	15	—	—	—	4	9	4	—	6
Miscanthus sinensis	H	—	4	15	12	5	3	15	3	12	4	12
Mitella formosana	H	—	—	—	—	—	—	—	3	—	—	—
Myriactis humilis	H	4	2	—	6	—	—	—	—	—	—	—
Nanocnide japonica	H	—	—	—	—	—	—	—	—	8	—	—
Neocheiropteris ensata	H	—	—	—	—	—	5	—	—	—	—	12
Nephrolepis auriculata	H	4	—	—	—	3	—	4	—	—	11	27
Nephrolepis biserrata	H	—	—	—	—	—	—	—	—	—	4	—
Nephrolepis multiflora	H	—	—	—	—	—	—	4	—	—	—	—
Nertera granadense	H	—	2	5	—	—	—	—	3	—	4	—
Odontochilus brevistylus	H	—	—	—	—	3	—	—	—	—	—	—
Odontochilus inabai	H	—	—	—	—	—	—	4	3	—	—	—
Odontochilus lanceolatus	H	—	—	—	—	3	—	—	6	—	—	6
Onychium japonicum	H	—	—	5	—	—	—	4	—	4	—	—
Ophiopogon reversus	H	—	—	—	—	—	—	—	—	4	—	—
Ophiorrhiza hayatana	H	—	—	—	—	—	—	—	3	—	—	3
Oplismenus compositus	H	—	—	—	—	—	—	4	11	8	—	3
Osmunda banksiifolia	H	—	—	—	—	—	—	—	—	4	—	—
Oxalis acetosella subsp. *griffithii*	H	4	2	20	—	—	13	—	11	12	—	3
Paraphlomis formosana	H	—	—	—	—	—	—	—	3	—	—	—
Parathelypteris angustifrons	H	—	—	—	—	—	—	—	3	—	—	3
Parathelypteris beddomei	H	—	—	—	—	—	—	4	—	—	—	3
Parathelypteris castanea	H	—	—	—	—	—	—	4	—	—	4	—
Parathelypteris glanduligera	H	—	—	—	—	3	—	—	—	—	7	3
Paris polyphylla	H	—	4	—	—	—	—	—	—	4	—	6
Paris polyphylla var. *stenophylla*	H	—	2	—	—	—	—	—	—	—	—	—
Petasites formosanus	H	—	—	—	—	—	—	4	—	—	—	—
Phaius flavus	H	—	—	—	—	—	—	—	3	—	4	—
Pilea cadierei	H	—	—	—	—	—	—	—	3	—	—	—
Pilea elliptifolia	H	—	—	—	—	—	3	—	—	—	—	—
Pilea microphylla	H	—	—	5	—	—	—	—	—	—	—	—
Pilea plataniflora	H	—	—	—	—	—	—	—	6	8	7	6
Plagiogyria rankanensis	H	—	4	—	6	11	—	4	6	8	—	—

Alliance code		**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Plantago asiatica	H	4	–	–	–	–	–	–	–	–	–	–
Pollia miranda	H	–	–	–	–	–	–	–	–	–	4	6
Polygonatum altelobatum	H	–	2	–	–	–	–	–	–	–	–	–
Polygonatum odoratum var. *pluriflorum*	H	–	–	–	–	–	–	–	–	4	–	–
Polygonum chinense	H	16	–	25	–	22	8	18	37	23	37	30
Polygonum filicaule	H	–	–	5	–	–	–	–	–	–	–	–
Polygonum maackianum	H	–	–	–	–	3	–	–	–	–	–	–
Polygonum nepalense	H	–	2	–	–	–	–	–	–	–	–	–
Polygonum pilushanense	H	–	–	5	–	–	–	–	–	–	–	–
Polygonum virginatum var. *filiforme*	H	–	–	–	–	–	–	4	–	–	–	–
Polypodium raishanense	H	–	–	–	–	–	–	–	–	4	–	–
Polystichum acanthophyllum	H	4	–	–	–	–	–	–	–	–	–	–
Polystichum eximium	H	–	–	–	–	–	–	–	–	4	–	3
Polystichum hecatopterum	H	–	–	–	–	–	3	–	6	4	–	–
Polystichum inaense	H	–	–	5	–	–	–	–	–	–	–	–
Polystichum nepalense	H	–	2	–	–	–	–	–	–	–	–	–
Polystichum piceopaleaceum	H	–	–	15	–	–	–	7	11	8	–	6
Polystichum stenophyllum	H	–	–	5	–	–	3	4	–	4	–	3
Polystichum tacticopterum	H	–	–	5	–	–	–	–	3	–	–	–
Pteridium aquilinum subsp. *latiusculum*	H	–	–	5	–	–	–	–	–	–	–	–
Pteridium aquilinum subsp. *wightianum*	H	–	2	–	–	–	–	–	–	–	–	–
Pteris bella	H	–	–	–	–	–	–	4	–	–	4	3
Pteris cadieri	H	–	–	–	–	–	3	–	–	–	–	–
Pteris cretica	H	–	–	–	–	–	5	4	–	4	–	6
Pteris dactylina	H	–	–	5	–	–	–	–	–	–	–	–
Pteris deltodon	H	–	–	–	–	–	–	–	–	–	–	3
Pteris ensiformis	H	–	–	–	–	3	–	–	–	–	–	–
Pteris excelsa	H	–	–	–	–	–	3	4	–	–	–	–
Pteris scabristipes	H	–	–	–	–	–	–	–	3	8	4	6
Pteris tokioi	H	–	–	–	–	–	–	–	–	–	4	–
Pteris wallichiana	H	–	–	10	–	–	–	4	3	–	–	12
Pyrola japonica	H	–	–	5	–	–	–	–	–	–	–	–
Pyrola morrisonensis	H	4	4	–	6	8	–	–	–	–	–	–
Ranunculus cheirophyllus	H	–	–	–	–	–	3	–	–	–	–	–
Rhomboda tokioi	H	4	–	5	–	–	–	–	–	–	7	–
Rhynchoglossum obliquum var. *hologlossum*	H	–	–	–	–	–	–	–	–	–	–	3
Rhynchotechum brevipedunculatum	H	–	–	–	–	–	–	–	–	–	4	–
Rohdea japonica var. *watanabei*	H	–	–	–	–	3	–	–	–	–	–	–
Rubia akane	H	–	–	–	–	–	3	–	–	–	–	–
Rubia linii	H	–	2	–	–	–	–	–	–	–	–	3
Rubus parviaraliifolius	H	–	–	–	–	–	3	–	–	–	–	–
Sagina japonica	H	4	–	–	–	–	–	–	–	–	–	–
Salvia hayatana	H	–	–	–	–	–	–	–	3	–	–	–
Sedum formosanum	H	–	–	–	–	–	–	4	–	–	–	3
Sedum microsepalum	H	–	–	–	–	–	–	–	–	4	–	–
Sedum morrisonense	H	4	–	5	–	–	–	–	–	–	–	–
Sedum parvisepalum	H	–	–	–	–	–	–	–	–	–	4	–
Sedum stellariaefolium	H	–	2	–	–	–	–	4	–	–	–	–
Selaginella labordei	H	–	–	–	–	–	3	4	–	4	–	3
Selaginella nipponica	H	–	–	–	–	3	–	–	–	–	–	–
Selaginella stauntoniana	H	–	–	–	–	–	–	7	–	–	–	–
Selaginella tamariscina	H	4	–	–	–	–	–	–	–	–	–	–
Selenodesmium obscurum	H	–	–	–	–	–	–	–	–	–	4	–
Senecio nemorensis var. *dentatus*	H	–	–	–	–	–	–	4	–	–	–	–
Senecio scandens var. *incisus*	H	4	–	10	–	–	–	–	–	–	–	–
Shortia rotundifolia var. *subcordata*	H	–	–	–	–	5	–	–	–	4	–	–
Strobilanthes flexicaulis	H	–	–	–	–	–	–	4	17	12	–	9
Strobilanthes formosanus	H	–	–	–	–	–	–	–	3	4	–	–
Strobilanthes penstemonoides	H	–	–	–	–	–	–	–	3	–	–	–
Struthiopteris hancockii	H	–	–	–	6	–	–	–	–	–	–	–
Tainia latifolia	H	–	–	–	–	–	–	–	–	–	4	–

Alliance code		1	1	1	1	1	2	2	2	2	2	2
Association code		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Number of plots		25	49	20	17	37	38	28	35	26	27	33
Tectaria phaeocaulis	H	—	—	—	—	—	—	—	—	—	4	—
Teucrium bidentatum	H	—	—	—	—	—	—	—	—	—	—	3
Thelypteris erubescens	H	—	—	—	—	—	—	—	—	—	—	3
Thelypteris japonica	H	—	—	—	—	3	—	—	—	—	—	—
Thelypteris laxa	H	—	—	—	—	—	—	—	3	—	—	—
Thelypteris omeiensis	H	—	—	—	—	—	—	—	—	—	4	—
Thelypteris uraiensis	H	—	—	—	—	—	—	—	—	8	—	6
Tipularia odorata	H	4	4	—	—	—	—	—	—	—	—	—
Tricyrtis suzukii	H	—	—	—	—	—	—	—	—	—	4	—
Tripterospermum cordifolium	H	—	—	5	—	—	—	—	—	—	—	—
Tripterospermum microphyllum	H	—	2	5	—	—	—	—	—	—	—	—
Typhonium blumei	H	—	—	—	—	—	—	4	—	—	—	—
Vexillabium yakushimense	H	—	—	—	—	—	—	—	6	—	—	—
Viola adenothrix	H	—	—	—	6	3	—	—	—	—	4	—
Viola adenothrix var. *tsugitakaensis*	H	—	—	—	—	—	3	—	—	—	—	—
Viola diffusa	H	—	—	5	6	—	—	—	—	—	—	—
Viola formosana var. *stenopetala*	H	—	—	—	—	—	—	—	6	—	—	—
Viola mandshurica	H	—	2	—	—	—	—	—	—	—	—	—
Zingiber kawagoii	H	—	—	—	—	3	—	—	—	—	4	—

Table 2. Headers of nomenclature type relevés of *Chamaecyparis* forest in Taiwan. Topography code: 1 = ridge; 2 = upper slope; 3 = middle slope; 4 = lower slope; 5 = valley.

Association code	1.01	1.02	1.03	1.04	1.05	2.06	2.07	2.08	2.09	2.10	2.11
Relevé_ID	02-0609	30-0097	20-0295	02-2077	02-2040	02-0614	30-0096	20-0123	11-0096	02-2069	29-0166
Sampling area (m^2)	400	400	500	400	400	400	400	400	400	400	400
Author	Tze-Ying Chen	Tien-Chai Chen	Ching-Long Yeh	Tze-Ying Chen	Tze-Ying Chen	Chang-Fu Hsieh	Tien-Chai Chen	Ho-Yih Liu	Chang-Fu Hsieh	Tze-Ying Chen	Tien-Chai Chen
Longitude (˚)	121.2873	121.5316	120.7486	121.403	121.3757	121.2888	121.5303	120.8196	120.8471	121.4493	121.3128
Latitude (˚)	24.53854	24.13714	22.61514	24.569	24.54146	24.53602	24.13749	22.86558	23.47336	24.62187	24.02356
Canopy cover (%)	50	85	90	70	90	60	75	80	60	80	60
Tree height (m)	35	20	20	10	15	35	20	15	30	20	15
Altitude (m)	2150	1985	2470	1950	1895	2130	1855	2137	2325	1086	1819
Aspect (˚)	277	261	306	337	176	45	269	68	47	336	113
Inclination (˚)	10	18	40	29	39	22	40	29	25	6	23
Topography	1	1	5	1	3	3	2	4	5	5	2
Rockiness (%)	5	0	90	0	35	1	30	10	5	0	60
Rock cover (%)	0	0	0	0	0	0	5	50	25	40	10
Sampling year	2005	2004	2005	2005	2005	2005	2004	2004	2003	2005	2007

APPENDIX

Species data of nomenclature type relevés (header data are in Table 2). Species in the list within each life form are sorted by their cover.

1.01 *Tsugo formosanae-Chamaecyparidetum formosanae* Ching-Yu Liou ex Ching-Feng Li et al. 2014 ass. nova hoc loco

Nomenclature type relevé: 02-0609 (holotypus hoc loco designatus)

Trees: *Chamaecyparis obtusa* var. *formosana* 37, *Rhododendron leptosanthum* 10, *Tsuga chinensis* var. *formosana* 8, *Symplocos heishanensis* 6, *Neolitsea acuminatissima* 4, *Ilex goshiensis* 4, *Trochodendron aralioides* 3, *Symplocos morrisonicola* 3, *Adinandra lasiostyla* 3, *Ilex tugitakayamensis* 3, *Ternstroemia gymnanthera* 3, *Cleyera japonica* var. *taipinensis* 3, *Cyclobalanopsis morii* 3, *Elaeocarpus japonicus* 2, *Dendropanax dentiger* 2, *Schefflera taiwaniana* 1, *Cyclobalanopsis sessilifolia* 1, *C. stenophylloides* 1, *Symplocos migoi* 1, *Ilex sugerokii* var. *brevipedunculata* 1, *Symplocos stellaris* 1

Shrubs: *Damnacanthus angustifolius* 6, *Yushania niitakayamensis* 5, *Eurya loquaiana* 3, *Microtropis fokienensis* 2, *Skimmia reevesiana* 1, *Viburnum urceolatum* 1, *Ardisia crenata* 1

Herbs: *Plagiogyria formosana* 8, *P. euphlebia* 4, *Arthromeris lehmannii* 1, *Pyrola alboreticulata* 1, *Lysionotus pauciflorus* 1, *Leptorumohra quadripinnata* 1, *Sarcopyramis napalensis* var. *bodinieri* 1, *Microsorium buergerianum* 1

Lianas: *Smilax arisanensis* 1, *Hydrangea integrifolia* 1

Epiphytes: *Rhododendron kawakamii* 1, *Drymotaenium miyoshianum* 1, *Gastrochilus formosanus* 1, *Mecodium polyanthos* 1, *Dendrobium furcatopedicellatum* 1, *Elaphoglossum yoshinagae* 1, *Vittaria flexuosa* 1, *Pyrrosia linearifolia* 1

1.02 *Vaccinio lasiostemonis-Tsugetum formosanae* ass. nov. hoc loco

Nomenclature type relevé: 30-0097 (holotypus hoc loco designatus)

Trees: *Tsuga chinensis* var. *formosana* 36, *Rhododendron formosanum* 14, *Lyonia ovalifolia* 14, *Elaeocarpus japonicus* 6, *Pinus armandii* var. *mastersiana* 5, *Neolitsea acuminatissima* 3, *Dendropanax dentiger* 3, *Prunus transarisanensis* 1, *Quercus tatakaensis* 1, *Vaccinium wrightii* 1, *Cyclobalanopsis longinux* 0.5, *Ilex hayataiana* 0.5, *Ilex tugitakayamensis* 0.3, *Litsea morrisonensis* 0.3

Shrubs: *Yushania niitakayamensis* 92, *Symplocos wikstroemiifolia* 8, *Myrsine stolonifera* 3, *Microtropis fokienensis* 2, *Vaccinium japonicum* var. *lasiostemon* 0.1, *Rhododendron rubropilosum* 0.1, *Symplocos formosana* 0.1

Herbs: *Plagiogyria formosana* 0.1, *Lepisorus morrisonensis* 0.1, *Myrmechis drymoglossifolia* 0.1, *Lepisorus tosaensis* 0.1, *Arthromeris lehmannii* 0.1, *Crypsinus quasidivaricatus* 0.1, *Dryopteris formosana* 0.1

Lianas: *Pileostegia viburnoides* 0.1, *Smilax arisanensis* 0.1

Epiphytes: *Pyrrosia lingua* 0.1, *Mecodium polyanthos* 0.1, *Vaccinium emarginatum* 0.1

1.03 *Schefflero taiwanianae-Chamaecyparidetum formosensis* Ching-Long Yeh et Chien-Chun Liao ex Ching-Feng Li et al. 2014 ass. nov. hoc loco

Nomenclature type relevé: 20-0295 (holotypus hoc loco designatus)

Trees: *Chamaecyparis formosensis* 33, *Tsuga chinensis* var. *formosana* 11, *Neolitsea acuminatissima* 8, *Symplocos morrisonicola* 3, *Illicium anisatum* 3, *Litsea acuminata* 2, *Schefflera taiwaniana* 2, *Eurya glaberrima* 1, *Symplocos migoi* 1, *Trochodendron aralioides* 0.2, *Osmanthus heterophyllus* 0.1

Shrubs: *Hydrangea chinensis* 21, *Eurya leptophylla* 6, *Symplocos modesta* 4, *Viburnum foetidum* var. *rectangulatum* 0.2, *Microtropis fokienensis* 0.1, *Euonymus spraguei* 0.1, *Berberis kawakamii* 0.1, *Pieris taiwanensis* 0.1, *Rhododendron pseudochrysanthum* 0.1

Herbs: *Plagiogyria formosana* 79, *Dryopteris formosana* 2, *Acrophorus stipellatus* 2, *Ctenitis apiciflora* 1, *Polystichum parvipinnulum* 1, *Ctenitis transmorrisonensis* 1, *Sarcopyramis napalensis* var. *delicata* 1, *Monachosorum henryi* 0.5, *Crypsinus quasidivaricatus* 0.5, *Polypodium amoenum* 0.3, *Elatostema trilobulatum* 0.3, *Peranema cyatheoides* 0.2, *Rubia lanceolata* 0.1, *Dryopteris sparsa* 0.1, *Nertera nigricarpa* 0.1, *Polygonum pilushanense* 0.1, *Lepisorus monilisorus* 0.1, *Oxalis acetosella* subsp. *griffithii* var. *formosana* 0.1, *Arisaema formosanum* 0.1

Lianas: *Hydrangea integrifolia* 2, *Hedera rhombea* var. *formosana* 0.5, *Clematis grata* 0.1, *Smilax arisanensis* 0.1, *Smilax riparia* 0.1, *Stauntonia obovata* 0.1

Epiphytes: *Mecodium polyanthos* 2, *Araiostegia parvipinnata* 1, *Vittaria flexuosa* 0.2, *Bulbophyllum setaceum* 0.1, *Xiphopteris okuboi* 0.1

1.04 *Elatostemato trilobulati-Tsugetum formosanae* Tokio Suzuki 1952 nom. mut. propos.

Nomenclature type relevé: 02-2077 (neotypus hoc loco designatus)

Trees: *Chamaecyparis obtusa* var. *formosana* 35, *Illicium anisatum* 8, *Photinia niitakayamensis* 8, *Eurya glaberrima* 5, *Tsuga chinensis* var. *formosana* 4, *Cleyera japonica* var. *taipinensis* 3, *Prunus matuurai* 3, *Symplocos arisanensis* 3, *Neolitsea acuminatissima* 3, *Ilex hayataiana* 2, *Ilex sugerokii* var. *brevipedunculata* 2, *Dendropanax dentiger* 2, *Litsea elongata* var. *mushaensis* 2, *Neolitsea aciculata* var. *variabillima* 2, *Ilex suzukii* 1, *Symplocos morrisonicola* 0.5, *Schefflera taiwaniana* 0.5, *Ligustrum liukiuense* 0.2, *Ternstroemia gymnanthera* 0.2, *Ilex tugitakayamensis* 0.2

Shrubs: *Yushania niitakayamensis* 66, *Eurya crenatifolia* 3, *Barthea barthei* 2, *Rhamnus crenata* 0.5, *Ardisia crenata* 0.5, *Viburnum erosum* 0.5, *Viburnum luzonicum* 0.5, *Viburnum sympodiale* 0.5, *Rubus corchorifolius* 0.5, *Damnacanthus indicus* 0.2, *Skimmia reevesiana* 0.2, *Berberis kawakamii* 0.2, *Callicarpa randaiensis* 0.1, *Vaccinium japonicum* var. *lasiostemon* 0.1, *Melastoma candidum* 0.1

Herbs: *Plagiogyria formosana* 7, *Plagiogyria euphlebia* 4, *Arthromeris lehmannii* 2, *Dryopteris formosana* 2, *Acrophorus stipellatus* 1, *Oxalis acetosella* subsp. *griffithii* var. *formosana* 0.5, *Elatostema trilobulatum* 0.5, *Asarum macranthum* 0.3, *Athyrium arisanense* 0.3, *Coptis quinquefolia* 0.2, *Arachniodes rhomboidea* 0.2, *Rubus pectinellus* 0.1, *Sarcopyramis napalensis* var. *bodinieri* 0.1, *Nertera nigricarpa* 0.1, *Selaginella involvens* 0.1, *Shortia rotundifolia* 0.1, *Ophiopogon intermedius* 0.1, *Cyclosorus subpubescens* 0.1, *Loxogramme salicifolia* 0.1, *Lycopodium serratum* var. *longipetiolatum* 0.1, *Ardisia japonica* 0.1, *Calanthe puberula* 0.1, *Polypodium amoenum* 0.1, *Diplopterygium glaucum* 0.1, *Pyrola morrisonensis* 0.1, *Microsorium buergerianum* 0.1, *Myriactis humilis* 0.1, *Lepisorus thunbergianus* 0.1, *Crypsinus engleri* 0.1

Lianas: *Hydrangea integrifolia* 3, *Maclura cochinchinensis* 2, *Rhus ambigua* 1, *Smilax discotis* 0.5, *Stauntonia obovatifoliola* 0.5, *Rubus liuii* 0.5, *Pileostegia viburnoides* 0.2

Epiphytes: *Mecodium polyanthos* 1, *Araiostegia parvipinnata* 1, *Vittaria flexuosa* 0.1

1.05 *Rhododendro formosani-Chamaecyparidetum formosanae* Tokio Suzuki 1952 nom. mut. propos.

Nomenclature type relevé: 02-2040 (neotypus hoc loco designatus)

Trees: *Rhododendron leptosanthum* 17, *Chamaecyparis formosensis* 16, *Elaeocarpus japonicus* 15, *Chamaecyparis obtusa* var. *formosana* 6, *Eurya strigillosa* 5, *Symplocos morrisonicola* 4, *Illicium anisatum* 3, *Rhododendron formosanum* 3, *Cleyera japonica* 2, *Machilus japonica* 2, *Schima superba* 2, *Neolitsea acuminatissima* 2, *Taiwania cryptomerioides* 2, *Vaccinium kengii* 2, *Ilex goshiensis* 1, *Litsea acuminata* 0.5, *Cyclobalanopsis sessilifolia* 0.5, *Dendropanax dentiger* 0.5, *Cinnamomum subavenium* 0.2, *Symplocos heishanensis* 0.2, *Prunus phaeosticta* 0.2, *Litsea elongata* var. *mushaensis* 0.2, *Cyclobalanopsis longinux* 0.2

Shrubs: *Eurya loquaiana* 14, *Barthea barthei* 7, *Symplocos wikstroemiifolia* 3, *Myrsine stolonifera* 2, *Damnacanthus indicus* 1, *Viburnum urceolatum* 0.5, *Callicarpa randaiensis* 0.1

Herbs: *Plagiogyria dunnii* 27, *Dryopteris formosana* 17, *Diplopterygium chinensis* 9, *Plagiogyria euphlebia* 8, *Ctenitis kawakamii* 4, *Diplazium kawakamii* 3, *Plagiogyria formosana* 3, *Arachniodes rhomboidea* 2, *Microlepia tenera* 1, *Polystichum parvipinnulum* 0.5, *Lepisorus thunbergianus* 0.5, *Athyrium erythropodum* 0.5, *Asplenium normale* 0.2, *Dryopteris austriaca* 0.2, *Viola adenothrix* 0.1

Lianas: *Smilax arisanensis* 2, *Hydrangea integrifolia* 0.5, *Maclura cochinchinensis* 0.2, *Rubus trianthus* 0.2, *Stauntonia obovatifoliola* 0.1

Epiphytes: *Mecodium polyanthos* 0.5, *Vittaria flexuosa* 0.5, *Araiostegia parvipinnata* 0.3

2.06 *Adinandro lasiostylae-Chamaecyparidetum formosensis* ass. nov. hoc loco

Nomenclature type relevé: 02-0614 (holotypus hoc loco designatus)

Trees: *Tsuga chinensis* var. *formosana* 23, *Chamaecyparis formosensis* 19, *Cyclobalanopsis sessilifolia* 11, *Sycopsis sinensis* 7, *Neolitsea acuminatissima* 6, *Symplocos migoi* 4, *Symplocos morrisonicola* 4, *Symplocos arisanensis* 4, *Acer morrisonense* 3, *Adinandra lasiostyla* 3, *Trochodendron aralioides* 2, *Daphniphyllum himalaense* subsp. *macropodum* 2, *Ilex goshiensis* 1, *Fatsia polycarpa* 0.5, *Cyclobalanopsis stenophylloides* 0.5, *Ilex tugitakayamensis* 0.5, *Litsea elongata* var. *mushaensis* 0.5, *Symplocos stellaris* 0.5, *Acer palmatum* var. *pubescens* 0.5, *Pasania kawakamii* 0.5, *Prunus phaeosticta* 0.3, *Ligustrum sinense* 0.1, *Cleyera japonica* var. *taipinensis* 0.1

Shrubs: *Eurya leptophylla* 8, *Viburnum foetidum* var. *rectangulatum* 3, *Damnacanthus indicus* 1, *Berberis mingetsuensis* 0.5, *Microtropis fokienensis* 0.5, *Rhamnus pilushanensis* 0.5, *Skimmia reevesiana* 0.5, *Damnacanthus angustifolius* 0.5, *Mahonia japonica* 0.1, *Euonymus spraguei* 0.1, *Ardisia crenata* 0.1, *Rubus kawakamii* 0.1, *Viburnum urceolatum* 0.1

Herbs: *Plagiogyria formosana* 67, *Dryopteris formosana* 4, *Arachniodes rhomboidea* 2, *Plagiogyria euphlebia* 1, *Monachosorum henryi* 0.5, *Acrophorus stipellatus* 0.5, *Ophiopogon japonicus* 0.5, *Arthromeris lehmannii* 0.5, *Pellionia radicans* 0.5, *Dennstaedtia scabra* 0.1, *Disporopsis fuscopicota* var. *arisanensis* 0.1, *Polypodium argutum* 0.1, *Polystichum hancockii* 0.1, *Polystichum parvipinnulum* 0.1, *Polystichum wilsonii* 0.1, *Dryopteris atrata* 0.1, *Lepisorus obscurevenulosus* 0.1, *Ctenitis transmorrisonensis* 0.1, *Rubia lanceolata* 0.1, *Dryopteris sparsa* 0.1, *Rubus pectinellus* 0.1, *Calanthe puberula* 0.1, *Loxogramme salicifolia* 0.1, *Lysionotus pauciflorus* 0.1, *Strobilanthes rankanensis* 0.1, *Elatostema trilobulatum* 0.1, *Athyrium erythropodum* 0.1, *Microsorium buergerianum* 0.1, *Athyrium subrigescens* 0.1, *Asarum macranthum* 0.1, *Goodyera foliosa* 0.1, *Goodyera kwangtungensis* 0.1, *Ophiorrhiza japonica* 0.1, *Oxalis acetosella* subsp. *griffithii* var. *formosana* 0.1, *Goodyera velutina* 0.1, *Calanthe arcuata* 0.1

Lianas: *Hydrangea integrifolia* 1, *Stauntonia obovatifoliola* 0.5, *Hedera rhombea* var. *formosana* 0.1, *Celastrus kusanoi* 0.1, *Tripterospermum taiwanense* 0.1, *Lonicera acuminata* 0.1, *Smilax arisanensis* 0.1

Epiphytes: *Vittaria flexuosa* 1, *Asplenium wilfordii* 0.1, *Pyrrosia sheareri* 0.1, *Mecodium polyanthos* 0.1, *Elaphoglossum yoshinagae* 0.1, *Crypsinus echinosporus* 0.1, *Araiostegia parvipinnata* 0.1

2.07 *Cyclobalanopsio stenophylloidis-Chamaecyparidetum formosensis* Ching-Yu Liou ex Ching-Feng Li et al. 2014 ass. nov. hoc loco

Nomenclature type relevé: 30-0096 (holotypus hoc loco designatus)

Trees: *Chamaecyparis formosensis* 25, *Camellia brevistyla* 6, *Tsuga chinensis* var. *formosana* 6, *Pasania hancei* var. *ternaticupula* 3, *Litsea morrisonensis* 3, *Vaccinium wrightii* 3, *Pasania kawakamii* 2, *Cyclobalanopsis longinux* 2, *Elaeocarpus japonicus* 2, *Ligustrum liukiuense* 1, *Machilus japonica* 1, *Eurya gnaphalocarpa* 0.5, *Carpinus rankanensis* 0.5, *Photinia serratifolia* 0.5, *Quercus tatakaensis* 0.5, *Neolitsea acuminatissima* 0.5, *Osmanthus matsumuranus* 0.5, *Pourthiaea villosa* var. *parvifolia* 0.3, *Itea parviflora* 0.3, *Rhododendron formosanum* 0.3, *Cyclobalanopsis stenophylloides* 0.3, *Ilex hayataiana* 0.3, *Lithocarpus lepidocarpus* 0.1

Shrubs: *Yushania niitakayamensis* 36, *Rhododendron rubropilosum* 17, *Symplocos formosana* 15, *Eurya acuminata* 12, *Damnacanthus indicus* 11, *Eurya crenatifolia* 2, *Viburnum propinquum* 1, *Rubus formosensis* 0.1, *Berberis kawakamii* 0.1, *Sageretia thea* 0.1, *Euonymus spraguei* 0.1

Herbs: *Monachosorum henryi* 11, *Plagiogyria formosana* 11, *Asarum macranthum* 0.1, *Acrophorus stipellatus* 0.1, *Ophiopogon intermedius* 0.1, *Arachniodes rhomboidea* 0.1, *Dryopteris formosana* 0.1, *Coniogramme intermedia* 0.1, *Pellionia radicans* 0.1, *Sarcopyramis napalensis* var. *bodinieri* 0.1, *Selaginella delicatula* 0.1, *Selaginella remotifolia* 0.1, *Selaginella stauntoniana* 0.1, *Luzula effusa* 0.1, *Pilea aquarum* subsp. *brevicornuta* 0.1, *Lysimachia ardisioides* 0.1, *Lysionotus pauciflorus* 0.1, *Plagiogyria euphlebia* 0.1, *Elatostema trilobulatum* 0.1, *Polystichum hancockii* 0.1, *Polystichum parvipinnulum* 0.1, *Polystichum stenophyllum* 0.1, *Viola formosana* 0.1, *Lepisorus morrisonensis* 0.1, *Microsorium buergerianum* 0.1

Lianas: *Hedera rhombea* var. *formosana* 0.1, *Heterosmilax japonica* 0.1, *Pileostegia viburnoides* 0.1, *Piper kadsura* 0.1, *Lonicera acuminata* 0.1, *Hydrangea integrifolia* 0.1, *Aristolochia heterophylla* 0.1, *Rubus swinhoei* 0.1, *Smilax lanceifolia* 0.1, *Stauntonia obovatifoliola* 0.1, *Tetrastigma umbellatum* 0.1, *Trachelospermum jasminoides* 0.1, *Ficus pumila* 0.1, *Ficus sarmentosa* var. *nipponica* 0.1

Epiphytes: *Mecodium polyanthos* 0.2, *Araiostegia parvipinnata* 0.1, *Pyrrosia lingua* 0.1, *Pyrrosia sheareri* 0.1, *Lemmaphyllum microphyllum* 0.1, *Vandenboschia auriculata* 0.1, *Lepisorus pseudoussuriensis* 0.1, *Vittaria flexuosa* 0.1, *Asplenium wilfordii* 0.1

2.08 *Castanopsio carlesii-Chamaecyparidetum formosensis* ass. nov. hoc loco

Nomenclature type relevé: 20-0123 (holotypus hoc loco designatus)

Trees: *Castanopsis cuspidata* var. *carlesii* 24, *Chamaecyparis formosensis* 23, *Neolitsea acuminatissima* 9, *Lithocarpus lepidocarpus* 6, *Adinandra formosana* 6, *Machilus thunbergii* 5, *Gordonia axillaris* 4, *Litsea acuminata* 4, *Prunus phaeosticta* 3, *Symplocos arisanensis* 3, *Dendropanax dentiger* 2, *Illicium arborescens* 2, *Lithocarpus amygdalifolius* 2, *Rhododendron leptosanthum* 1, *Ilex hayataiana* 1, *Ligustrum liukiuense* 0.5, *Eurya strigillosa* 0.5, *Cyclobalanopsis morii* 0.5, *Symplocos caudata* 0.5, *Symplocos sonoharae* 0.5

Shrubs: *Hydrangea chinensis* 14, *Eurya loquaiana* 14, *Blastus cochinchinensis* 10, *Damnacanthus indicus* 5, *Viburnum integrifolium* 2, *Bredia oldhamii* 2, *Microtropis fokienensis* 0.5, *Vaccinium randaiense* 0.5, *Eurya chinensis* 0.5, *Ardisia crenata* 0.5, *Callicarpa randaiensis* 0.1

Herbs: *Dryopteris formosana* 8, *Asplenium normale* 7, *Plagiogyria dunnii* 6, *Monachosorum henryi* 5, *Plagiogyria formosana* 3, *Sarcopyramis napalensis* var. *bodinieri* 2, *Polystichum piceopaleaceum* 2, *Plagiogyria euphlebia* 2, *Polystichum parvipinnulum* 2, *Lecanthus peduncularis* 0.5, *Pellionia radicans* 0.5, *Carex brunnea* 0.5, *Lycopodium serratum* var. *longipetiolatum* 0.1, *Lysionotus pauciflorus* 0.1, *Arachniodes rhomboidea* 0.1, *Dryopteris sparsa* 0.1, *Microsorium buergerianum* 0.1, *Elatostema trilobulatum* 0.1, *Lepisorus thunbergianus* 0.1

Lianas: *Smilax lanceifolia* 2, *Stauntonia obovatifoliola* 0.1, *Smilax sieboldii* 0.1, *Embelia laeta* var. *papilligera* 0.1

Epiphytes: *Vaccinium emarginatum* 0.1, *Araiostegia parvipinnata* 0.1, *Mecodium polyanthos* 0.1, *Vittaria flexuosa* 0.1, *Lemmaphyllum microphyllum* 0.1

2.09 *Arachniodo rhomboideae-Chamaecyparidetum formosensis* ass. nov. hoc loco

Nomenclature type relevé: 11-0096 (holotypus hoc loco designatus)

Trees: *Taiwania cryptomerioides* 31, *Machilus japonica* 20, *Cyclobalanopsis morii* 13, *Chamaecyparis formosensis* 11, *Ligustrum sinense* 3, *Castanopsis cuspidata* var. *carlesii* 2, *Eurya glaberrima* 1, *Perrottetia arisanensis* 1, *Schefflera taiwaniana* 1, *Litsea elongata* var. *mushaensis* 1, *Fatsia polycarpa* 0.5, *Eurya strigillosa* 0.5, *Neolitsea acuminatissima* 0.5, *Tetradium glabrifolium* 0.5, *Ilex tugitakayamensis* 0.3, *Acer kawakamii* 0.2, *Ligustrum liukiuense* 0.1, *Oreocnide pedunculata* 0.1, *Acer morrisonense* 0.1

Shrubs: *Hydrangea angustipetala* 3, *Callicarpa formosana* 2, *Ardisia crenata* 1, *Rubus kawakamii* 1, *Eurya leptophylla* 0.5, *Daphne arisanensis* 0.5, *Viburnum foetidum* var. *rectangulatum* 0.5, *Mahonia oiwakensis* 0.5, *Salix fulvopubescens* 0.2, *Sambucus chinensis* 0.1, *Rubus croceacanthus* 0.1

Herbs: *Miscanthus floridulus* 43, *Strobilanthes flexicaulis* 12, *Polygonum chinense* 8, *Arachniodes rhomboidea* 6, *Pellionia radicans* 5, *Ellisiophyllum pinnatum* 5, *Microsorium buergerianum* 4, *Dryopteris formosana* 2, *Hydrocotyle nepalensis* 2, *Diplazium amamianum* 1, *Selaginella doederleinii* 0.5, *Lepisorus monilisorus* 0.5, *Ctenitis apiciflora* 0.5, *Pteris scabristipes* 0.1, *Ophiorrhiza japonica* 0.1, *Dryopteris sparsa* 0.1, *Eutrema japonica* 0.1, *Peperomia reflexa* 0.1, *Lysionotus pauciflorus* 0.1, *Pilea plataniflora* 0.1, *Urtica thunbergiana* 0.1, *Monachosorum henryi* 0.1, *Plagiogyria euphlebia* 0.1, *Anoectochilus formosanus* 0.1

Lianas: *Smilax china* 1, *Hedera rhombea* var. *formosana* 0.5, *Tetrastigma umbellatum* 0.5, *Schizophragma integrifolium* var. *fauriei* 0.1, *Smilax bracteata* 0.1, *Lonicera acuminata* 0.1, *Stauntonia obovatifoliola* 0.1, *Actinidia chinensis* var. *setosa* 0.1, *Pileostegia viburnoides* 0.1, *Hydrangea integrifolia* 0.1, *Thladiantha nudiflora* 0.1

Epiphytes: *Lemmaphyllum diversum* 1, *Pyrrosia sheareri* 0.5, *Vittaria flexuosa* 0.5, *Araiostegia parvipinnata* 0.5

2.10 *Symploco wikstroemiifoliae-Machiletum thunbergii* ass. nov. hoc loco

Nomenclature type relevé: 02-2069 (holotypus hoc loco designatus)

Trees: *Chamaecyparis formosensis* 36, *Machilus thunbergii* 15, *Litsea acuminata* 8, *Fatsia polycarpa* 8, *Machilus japonica* 7, *Sloanea formosana* 6, *Prunus phaeosticta* 3, *Pasania kawakamii* 2, *Itea parviflora* 2, *Pyrenaria shinkoensis* 2, *Cinnamomum subavenium* 2, *Elaeocarpus japonicus* 1, *Cyclobalanopsis longinux* 1, *Adinandra formosana* 0.5, *Phoebe formosana* 0.5, *Acer kawakamii* 0.5, *Ficus erecta* var. *beecheyana* 0.5, *Ilex ficoidea* 0.5

Shrubs: *Symplocos wikstroemiifolia* 3, *Lasianthus fordii* 3, *Microtropis fokienensis* 2, *Eurya loquaiana* 1, *Skimmia reevesiana* 0.5, *Symplocos formosana* 0.5, *Eurya crenatifolia* 0.5, *Barthea barthei* 0.5, *Vaccinium merrillianum* 0.2, *Lasianthus appressihirtus* 0.2, *Damnacanthus indicus* 0.1

Herbs: *Diplazium dilatatum* 39, *Elatostema lineolatum* var. *majus* 33, *Selaginella delicatula* 2, *Pellionia radicans* 1, *Collabium chinense* 0.5, *Microsorium buergerianum* 0.5, *Asplenium normale* 0.5, *Monachosorum henryi* 0.5, *Parathelypteris glanduligera* 0.5, *Arachniodes rhomboidea* 0.5, *Calanthe densiflora* 0.5, *Dictyocline griffithii* 0.5, *Begonia formosana* 0.3, *Polypodium amoenum* 0.2, *Hemiboea bicornuta* 0.2, *Acrophorus stipellatus* 0.2, *Plagiogyria euphlebia* 0.2, *Lepisorus monilisorus* 0.1, *Plagiogyria stenoptera* 0.1, *Asarum macranthum* 0.1, *Lysionotus pauciflorus* 0.1, *Strobilanthes rankanensis* 0.1, *Coptis quinquefolia* 0.1, *Alpinia intermedia* 0.1, *Asarum caudigerum* 0.1, *Rubus pectinellus* 0.1, *Cyrtomium hookerianum* 0.1, *Selaginella mollendorffii* 0.1

Lianas: *Smilax lanceifolia* 2, *Hydrangea integrifolia* 0.5, *Cayratia japonica* 0.5, *Embelia laeta* var. *papilligera* 0.5, *Piper kadsura* 0.2, *Stauntonia obovatifoliola* 0.1, *Rubus mesogaeus* 0.1

Epiphytes: *Asplenium antiquum* 4, *Vandenboschia auriculata* 2, *Crepidomanes bilabiatum* 2, *Mecodium polyanthos* 0.1, *Vittaria flexuosa* 0.1, *Prosaptia contigua* 0.1

2.11 *Pileo brevicornutae-Machiletum japonicae* ass. nov. hoc loco

Nomenclature type relevé: 29-0166 (holotypus hoc loco designatus)

Trees: *Chamaecyparis formosensis* 45, *Machilus japonica* 26, *Machilus zuihoensis* var. *mushaensis* 24, *Litsea acuminata* 21, *Litsea elongata* var. *mushaensis* 10, *Cyclobalanopsis stenophylloides* 8, *Cyclobalanopsis longinux* 5, *Elaeocarpus japonicus* 5, *Pasania kawakamii* 4, *Acer morrisonense* 3, *Acer serrulatum* 3, *Michelia compressa* 3, *Alnus formosana* 3, *Pourthiaea beauverdiana* var. *notabilis* 3, *Prunus phaeosticta* 3, *Morus australis* 1, *Cephalotaxus wilsoniana* 1

Shrubs: *Eurya loquaiana* 8, *Maesa japonica* 5, *Damnacanthus indicus* 3, *Ardisia crenata* 1

Herbs: *Pilea melastomoides* 45, *Pilea angulata* 15, *Diplazium kawakamii* 10, *Monachosorum henryi* 5, *Pteris wallichiana* 3, *Arachniodes festina* 3, *Diplazium amamianum* 3, *Selaginella mollendorffii* 3, *Strobilanthes rankanensis* 3, *Arachniodes rhomboidea* 3, *Cyrtomium hookerianum* 3, *Urtica thunbergiana* 3, *Pilea aquarum* subsp. *brevicornuta* 3, *Polystichum hancockii* 1, *Selaginella delicatula* 1, *Polystichum parvipinnulum* 1, *Coniogramme intermedia* 1, *Hemiboea bicornuta* 1, *Pteris setulosocostulata* 1, *Elatostema parvum* 1, *Diplazium wichurae* 1, *Polypodium formosanum* 0.1

Lianas: *Tetrastigma umbellatum* 3, *Trachelospermum jasminoides* 1, *Pileostegia viburnoides* 0.1, *Piper kadsura* 0.1, *Ficus sarmentosa* var. *nipponica* 0.1

Epiphytes: *Pyrrosia sheareri* 0.1, *Araiostegia parvipinnata* 0.1, *Pyrrosia lingua* 0.1, *Vittaria flexuosa* 0.1

Appendix S1. Literature review of nomenclature used for *Chamaecyparis* forest in Taiwan.

The review is based on PhD theses, papers in journals and books. Only studies containing synoptic table for the described vegetation types were considered. Only vegetation types containing either *Chamaecyparis formosensis* or *C. obtusa* var. *formosana* as diagnostic, constant or dominant species were treated as *Chamaecyparis* forest. The rows of the table were sorted by the publication year. If there are several names of one vegetation type in a row, these names are proposed to be synonyms by the latest publication in the same cell.

No.	**Vegetation type**	**Habitat**	**Characteristic species**	**Dominant or common species**	**This study**
1	*Rhodoreto-Chamaecyparidetum taiwanensis* Tokio Suzuki 1952	**Ecoregion:** NE **Altitude**: 1400 m **Soil:** Podzol	*Plagiogyria glauca, Rhododendron formosanum, Trochodendron aralioides*	*Araiostegia parvipinnata, Barthea barthei, Chamaecyparis obtusa* var. *formosana, Rhododendron formosanum, Trochodendron aralioides, Vittaria zosterifolia*	1.05
2	*Pellionieto-Tsugeturn sinensis* Tokio Suzuki 1952	**Ecoregion:** NE **Altitude**: 2000 m	*Ainsliaea latifolia* subsp. *henryi, Chamaecyparis obtusa* var. *formosana, Coptis quinquefolia, Daphniphyllum himalaense* subsp. *macropodum, Liriope minor, Mitchella undulata, Rhus ambigua, Sarcopyramis napalensis* var. *bodinieri, Selliguea echinospora*	*Chamaecyparis obtusa* var. *formosana, Yushania niitakayamensis*	1.04

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
3	*Chamaecyparidion taiwanensis* Tokio Suzuki 1952	**Ecoregion:** NE **Altitude**: 1400 m **Soil:** Podosol	*Chamaecyparis obtusa* var. *formosana*, *Cyclobalanopsis sessilifolia*, *Elatostema trilobulatum*, *Loxogramme remotefrondigera*, *Illicium anisatum*, *Vaccinium japonicum* var. *lasiostemon*	*Chamaecyparis obtusa* var. *formosana*, *Cyclobalanopsis sessilifolia*, *Myrsine* seguinii, *Pleione bulbocodioides*, *Vandenboschia radicans*	Alliance 1
4	*Symplocos caudata-Chamaecyparis formosensis* ass. (Chian et al. 2010); *Cyclobalanopsis morii-Chamaecyparis formosensis* ass. (Yeh & Liao 2009); *Chamaecyparis formosensis-Castanopsis cuspidata* var. *carlesii* subtype (Yang 1991)	**Ecoregion:** SW **Altitude:** 1800-1900 m **Inclination:** > 40˚	*Chamaecyparis formosensis*, *Osmanthus enervius*, *Symplocos caudata*	*Adinandra formosana*, *A. lasiostyla*, *Barthea barthei* , *Blastus cochinchinensis*, *Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Dendropanax dentiger*, *Eurya loquaiana*, *E. strigillosa*, *Fatsia polycarpa*, *Gordonia axillaris*, *Hydrangea chinensis*, *Ilex goshiensis*, *Illicium anisatum*, *I. arborescens*, *Neolitsea aciculata*, *Osmanthus kaoi*, *Rhododendron leptosanthum*, *Symplocos caudata*, *S. migoi*, *S. morrisonicola*, *S. sonoharae*, *Vaccinium randaiense*, *Viburnum arboricolum*	2.08
5	*Chamaecyparis formosensis-Alnus formosana* subtype (Chung 1995; Liou & Tseng 1999)	**Ecoregion:** CW **Altitude:** 2300-2500 m **Inclination**: 34-43˚ **Soil rockiness**: 1-3 (on the scale of 1-5) **Whole-Light Sky**: 42-65% **Aspect:** 20-40˚	*Alnus formosana*, *Chamaecyparis formosensis*	*Acer morrisonense*, *Alnus formosana*, *Callicarpa randaiensis*, *Chamaecyparis formosensis*, *Cephalotaxus wilsoniana*, *Cinnamomum insularimontanum*, *Daphniphyllum glaucescens* subsp. *oldhamii*, *D. himalaense* subsp. *macropodum*, *Deutzia pulchra*, *Eurya strigillosa*, *Litsea morrisonensis*, *Neolitsea acuminatissima*, *Picea morrisonicola*, *Pilea matsudai*, *Polygonum chinense*, *Schefflera taiwaniana*, *Sinopanax formosana*, *Strobilanthes flexicaulis*, *Trochodendron aralioides*	NOT *Chamaecyparis* forest

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
6	*Acer morrisonense-Daphniphyllum himalaense* subtype (Chung 1995; Liou & Tseng 1999)	**Ecoregion:** CW **Altitude:** 2300-2500 m **Inclination**: 5-30˚ **Topography:** valleys **Soil rockiness**: 2-3 (on the scale of 1-5) **Whole-Light Sky**: 56-65%	*Acer morrisonense*, *Chamaecyparis formosensis*, *Daphniphyllum himalaense* subsp. *macropodum*	*Acer morrisonense*, *Alnus formosana*, *Arachniodes rhomboides*, *Chamaecyparis formosensis*, *Cephalotaxus wilsoniana*, *Coniogramme intermedia*, *Daphniphyllum himalaense* subsp. *macropodum*, *Deutzia pulchra*, *Euonymus spraguei*, *Eurya acuminata*, *Eurya glaberrima*, *Gynostemma pentaphyllum*, *Hedera rhombea* var. *formosana*, *Hydrangea angustifolia*, *H. aspera*, *H. chinensis*, *H. integrifolia*, *Lecanthus peduncularis*, *Ligustrum sinense*, *Litsea morrisonensis*, *Mahonia oiwakensis*, *Monachosorum henryi*, *Neolitsea acuminatissima*, *Pellionia radicans*, *Photinia niitakayamensis*, *Pilea rotundinucula*, *Plagiogyria glauca*, *Polygonum chinense*, *P. parvipinnulum*, *Rhododendron pseudochrysanthum*, *Schefflera taiwaniana*, *Stachyurus himalaicus*, *Strobilanthes flexicaulis*, *Symplocos morrisonicola*, *Tetrastigma umbellatum*, *Trochodendron aralioides*, *Viburnum foetidum* var. *rectangulatum*	2.06
7	*Taxus sumatrana-Cyclobalanopsis stenophylloides* subtype (Chung 1995; Liou & Tseng 1999)	**Ecoregion:** CW **Altitude:** 2300-2500 m **Soil rockiness**: with huge rocks inside the plots **Whole-Light Sky**: 54% **Aspect:** eastern-facing	*Chamaecyparis formosensis*, *Taxus sumatrana*	*Acer morrisonense*, *Arachniodes rhomboidea*, *Berberis kawakamii*, *Chamaecyparis formosensis*, *Cephalotaxus wilsoniana*, *Cinnamomum insularimontanum*, *Cyclobalanopsis stenophylloides*, *Damnacanthus indicus*, *Deutzia pulchra*, *Eurya acuminata*, *E. strigillosa*, *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Mahonia oiwakensis*, *Microsorium buergerianum*, *Neolitsea acuminatissima*, *Onychium contiguum*, *Picea morrisonicola*, *Pittosporum illicioides*, *Sageretia thea*, *Symplocos modesta*, *S. morrisonicola*, *Taxus sumatrana*, *Trochodendron aralioides*	NOT *Chamaecyparis* forest
8	*Chamaecyparis formosensis-Chamaecyparis obtusa* var. *taiwanensis* (Chung 1995)	**Ecoregion:** CW **Altitude:** 2200-2500 m	*Chamaecyparis formosensis*, *Chamaecyparis obtusa* var. *formosana*	*Acer morrisonense*, *Chamaecyparis formosensis*, *C. obtusa* var. *formosana*, *Eurya strigillosa*, *Litsea morrisonensis*, *Neolitsea acuminatissima*, *Photinia niitakayamensis*, *Pittosporum illicioides*, *Taiwania cryptomerioides*, *Viburnum foetidum* var. *rectangulatum*	NOT RECOGNIZABLE

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
9	*Chamaecyparis formosensis-Taiwania cryptomerioidies* subtype (Chung 1995)	**Ecoregion:** CW **Altitude:** 2200-2500 m	*Chamaecyparis formosensis, Taiwania cryptomerioides*	*Arachniodes rhomboidea*, *Castanopsis cuspidata* var. *carlesii*, *Chamaecyparis formosensis*, *Cinnamomum insularimontanum*, *Cyclobalanopsis stenophylloides*, *Cunninghamia konishii*, *Deutzia pulchra*, *Lecanthus peduncularis*, *Lithocarpus lepidocarpus*, *Machilus japonica*, *Neolitsea acuminatissima*, *Photinia niitakayamensis*, *Pilea rotundinucula*, *Plagiogyria glauca*, *Strobilanthes flexicaulis*, *Taiwania cryptomerioides*	NOT RECOGNIZABLE
10	*Litsea acuminata* forest type (Chung 1995)	**Ecoregion:** CW **Altitude:** 1800 m	*Litsea acuminata*	*Arachniodes rhomboidea*, *Ardisia cornudentata* subsp. *morrisonensis* var. *stenosepala*, *Chamaecyparis formosensis*, *Cinnamomum insularimontanum*, *Coniogramme japonica*, *Cyclobalanopsis stenophylloides*, *Eriobotrya deflexa*, *Euchresta formosana*, *Ficus pumila* var. *awkeotsang*, *F. sarmentosa* var. *nipponica*, *Hemiboea bicornuta*, *Hydrangea integrifolia*, *Itea parviflora*, *Lithocarpus lepidocarpus*, *Litsea acuminata*, *L. coreana*, *Machilus japonica*, *M. thunbergii*, *M. zuihoensis*, *Michelia compressa*, *Mucuna macrocarpa*, *Ophiorrhiza japonica*, *Oreocnide pedunculata*, *Pasania kawakamii*, *Pittosporum illicioides*, *Rhododendron leptosanthum*, *Strobilanthes rankanensis*	2.10 2.07 2.11
11	*Acer morrisonense-Chamaecyparis formosensis* ass. (Liou 2003); *Chamaecyparis formosensis* forest type (Liou & Tseng 1999); *Cyclobalanopsis stenophylloides-Chamaecyparis formosensis* vegetation type (Huang et al. 1999); *Neolitsea acuminatissima-Cyclobalanopsis pachyloma* vegetation type (Huang et al. 1999)	**Ecoregion:** CW **Altitude:** 2300-2500 m **Inclination**: 4-45˚ **Topography:** middle slopes down to valleys **Soil rockiness**: 1-3 (on the scale of 1-5) **Whole-Light Sky**: 40-65%	*Acer morrisonense*	*Acer kawakamii*, *A. morrisonense*, *Alnus formosana*, *Berberis kawakamii*, *Cephalotaxus wilsoniana*, *Chamaecyparis formosensis*, *Cinnamomum insularimontanum*, *Cyclobalanopsis stenophylloides*, *Damnacanthus indicus*, *Daphniphyllum himalaense* subsp. *macropodum*, *Eurya acuminata*, *E. strigillosa*, *Mahonia oiwakensis*, *Neolitsea acuminatissima*, *Picea morrisonicola*, *Pittosporum illicioides*, *Symplocos modesta*, *S. morrisonicola*, *Trochodendron aralioides*	NOT *Chamaecyparis* forest

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
12	*Chamaecyparis obtusa* var. *formosana* forest (Chou et al. 2000)	**Ecoregion:** NW **Altitude**: 1725-2000 m **Inclination**: 6-40˚ **Topography**: middle slopes down to valleys **Soil rockiness**: 0-35% **Whole-Light Sky**: 33-75%		*Adinandra formosana*, *Ardisia japonica*, *Asarum* sp., *Barthea barthei*, *Chamaecyparis obtusa* var. *formosana*, *Coptis quinquefolia*, *Damnacanthus angustifolius*, *Dendropanax dentiger*, *Illicium anisatum*, *Mecodium polyanthos*, *Miscanthus sinensis*, *Neolitsea acuminatissima*, *Pellionia radicans*, *Rhododendron formosanum*, *Sarcopyramis napalensis* var. *delicata*, *Schefflera taiwaniana*, *Skimmia reevesiana*, *Smilax* sp., *Ternstroemia gymnanthera*, *Tsuga chinensis* var. *formosana*	1.04
13	Mixed coniferous broad-leaved forest type (Kao & Su 2001)	**Ecoregion:** EN **Altitude:** 2060 m **Inclination**: 33˚ **Topography:** upper slope **Soil rockiness**: 3 (on the scale of 1-5) **Whole-Light Sky**: 78%		*Chamaecyparis formosensis*, *Cleyera japonica*, *Cyclobalanopsis morii*, *Dendropanax dentiger*, *Eurya leptophylla*, *E. loquaiana*, *Lyonia ovalifolia*, *Myrsine stolonifera*, *Neolitsea acuminatissima*, *Pasania hancei* var. *ternaticupula*, *Plagiogyria glauca*, *Pieris taiwanensis*, *Pinus armandii* var. *mastersiana*, *Rhododendron kawakamii*, *Rhododendron pseudochrysanthum*, *Tsuga chinensis* var. *formosana*, *Vaccinium bracteatum*, *V. japonicum* var. *lasiostemon*, *Viburnum sympodiale*, *V. urceolatum*	1.01 1.02
14	*Chamaecyparis formosensis*-*Machilus japonica* forest type (Kao & Su 2001)	**Ecoregion:** EN **Altitude:** 2000 m **Inclination**: 22-45˚ **Soil rockiness**: 2-5 (on the scale of 1-5) **Whole-Light Sky**: 66-73% **Aspect:** North to East		*Acer morrisonense*, *Actinidia chinensis* var. *setosa*, *Alnus formosana*, *Chamaecyparis formosensis*, *Clematis henryi*, *Damnacanthus angustifolius*, *Damnacanthus indicus*, *Daphniphyllum himalaense* subsp. *macropodum*, *Ficus sarmentosa* var. *nipponica*, *Hedera rhombea* var. *formosana*, *Hydrangea angustifolia*, *H. integrifolia*, *Litsea acuminata*, *L. elongata* var. *mushaensis*, *Machilus japonica*, *Monachosorum henryi*, *Osmanthus lanceolatus*, *Pasania harlandii*, *P. kawakamii*, *Pittosporum daphniphylloides*, *Plagiogyria glauca*, *Pourthiaea beauverdiana* var. *notabilis*, *Prunus phaeosticta*, *Schisandra arisanensis*, *Symplocos arisanensis*, *Trochodendron aralioides*	2.07

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
15	*Chamaecyparis formosensis-Machilus japonica* type (Chen et al. 2002)	**Ecoregion:** NW **Altitude**: 1600-1700 m **Inclination**: 15-40˚ **Topography:** valleys	*Chamaecyparis formosensis*, *Fatsia polycarpa*, *Ilex micrococca* and *Maesa japonica*	*Arachniodes rhomboidea*, *Chamaecyparis formosensis*, *Cyclobalanopsis longinux*, *Damnacanthus indicus*, *Eurya acuminata*, *Ilex hayataiana*, *Litsea acuminata*, *Machilus japonica*, *Microsorium buergerianum*, *Pellionia radicans*, *Plagiogyria euphlebia*, *Prunus phaeosticta*, *Vandenboschia auriculata*	2.10 2.07
16	*Pinus taiwanensis-Tsuga chinensis* var. *formosana* type (Chen et al. 2002)	**Ecoregion:** NW **Altitude**: 2000 m **Inclination**: 15˚ **Topography:** upper slopes **Soil rockiness:** 15% **Whole-Light Sky:** 47-65%	*Pinus taiwanensis*	*Chamaecyparis obtusa* var. *formosana*, *Cyclobalanopsis sessilifolia*, *Dryopteris formosana*, *Myrsine stolonifera*, *Neolitsea acuminatissima*, *Pinus taiwanensis*, *Plagiogyria glauca*, *P. euphlebia*, *Rhododendron leptosanthum*, *Symplocos morrisonicola*, *Tsuga chinensis* var. *formosana*	1.01
17	*Rhododendron formosanum-Chamaecyparis obtusa* var. *formosana* ass. (Chen et al. 2002, Chen 2004, Wei & Chen 2007)	**Ecoregion:** NE & NW **Altitude:** 1405-2435 m **Inclination**: 8-30˚ **Topography:** lower slopes up to ridges **Soil rockiness:** 5-15% **Whole-Light Sky:** 61-63%	*Diplopterygium glaucum*, *Myrsine stolonifera*, *Plagiogyria dunnii*, *Rhododendron formosana*, *Vaccinium randaiensis*, *Viburnum sympodiale*	*Acrophorus stipellatus*, *Araiostegia parvipinnata*, *Barthea barthei*, *Chamaecyparis obtusa* var. *formosana*, *Cleyera japonica*, *C. japonica* var. *taipinensis*, *Damnacanthus angustifolius*, *Dendropanax dentiger*, *Diplopterygium glaucum*, *Elaeocarpus japonicus*, *Eurya crenatifolia*, *Illicium anisatum*, *Mecodium polyanthos*, *Microtropis fokienensis*, *Myrsine stolonifera*, *Neolitsea acuminatissima*, *Plagiogyria dunnii*, *P. glauca*, *Pyrenaria shinkoensis*, *Rhododendron formosanum*, *Schefflera taiwaniana*, *Shortia rotundifolia*, *Smilax arisanensis*, *S. lanceifolia*, *Ternstroemia gymnanthera*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*, *Vaccinium japonicum* var. *lasiostemon*, *Vittaria flexuosa*	1.04

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
18	*Schima superba-Chamaecyparis obtusa* var. *formosana* type (Chen et al. 2002; Wei & Chen 2007)	**Ecoregion:** NE & NW **Altitude:** 1809-1935 m **Inclination**: 7-30˚ **Topography:** lower slopes up to ridges **Soil rockiness:** 6-12% **Whole-Light Sky:** 39-43%	*Eurya acuminata*, *Machilus japonica* and *Schima superba*	*Arachniodes rhomboidea*, *Barthea barthei*, *Chamaecyparis obtusa* var. *formosana*, *Cyclobalanopsis longinux*, *C. sessilifolia*, *Damnacanthus indicus*, *Elaeocarpus japonicus*, *Ilex hayataiana*, *Illicium anisatum*, *Monachosorum henryi*, *Neolitsea acuminatissima*, *Pellionia radicans*, *Plagiogyria euphlebia*, *Plagiogyria glauca*	NOT RECOGNIZABLE
19	*Cunninghamia konishii-Chamaecyparis formosensis* ass. (Liou 2003); *Cunninghamia konishii-Cinnamomum insularimontanum* forest type (Fu et al. 2004)	**Ecoregion:** CW **Altitude:** 2000 m **Inclination:** 0-10˚ **Soil rockiness:** 3-4 (on the scale of 1-5) **Whole-Light Sky:** 40-45%	*Cunninghamia konishii*	*Carpinus rankanensis*, *Cinnamomum insularimontanum*, *Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Cunninghamia konishii*, *Eurya crenatifolia*, *Eurya leptophylla*, *Litsea morrisonensis*, *Machilus japonica*, *Picea morrisonicola*, *Prunus phaeosticta*	NOT *Chamaecyparis* forest
20	*Cyclobalanopsis stenophylloides-Chamaecyparis formosensis* ass. (Liou 2003); *Cyclobalanopsis stenophylloides-Pasania hancei* forest type (Fu et al. 2004)	**Ecoregion:** CW **Altitude:** 2100 m **Inclination**: 20-35˚ **Soil rockiness**: 3 (on the scale of 1-5) **Whole-Light Sky**: 35-65%	*Cyclobalanopsis stenophylloides*	*Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *C. stenophylloides*, *Eriobotrya deflexa*, *Fatsia polycarpa*, *Ilex hayataiana*, *Litsea morrisonensis*, *Machilus japonica*, *Neolitsea acuminatissima*, *Pasania hancei* var. *ternaticupula*, *P. kawakamii*, *Rhododendron leptosanthum*, *Viburnum arboricolum*	2.09

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
21	*Litsea elongata* var. *mushaensis-Chamaecyparis formosensis* ass. (Liou 2003)	**Ecoregion:** CW **Altitude:** 2100-2300 m **Inclination**: 14-20˚ **Soil rockiness**: 2 (on the scale of 1-5) **Whole-Light Sky**: 35-45%	*Litsea elongata* var. *mushaensis*	*Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Eurya glaberrima*, *Eurya leptophylla*, *Litsea elongata* var. *mushaensis*, *Machilus japonica*, *Mahonia oiwakensis*, *Neolitsea acuminatissima*, *Prunus buergeriana*, *Prunus phaeosticta*, *Schefflera taiwaniana*	2.07
22	*Picea morrisonicola-Chamaecyparis obtusa* var. *formosana* (Liou 2003)	**Ecoregion:** CW **Altitude:** 2000-2500 m **Inclination**: 15-50˚ **Soil rockiness**: 2-4 (on the scale of 1-5) **Whole-Light Sky**: 60-65%	*Picea morrisonicola*	*Chamaecyparis formosensis*, *C. obtusa* var. *formosana*, *Cunninghamia konishii*, *Picea morrisonicola*, *Pinus armandii* var. *mastersiana*, *Symplocos morrisonicola*	NOT *Chamaecyparis* forest
23	*Tsuga chinensis* var. *formosana-Chamaecyparis formosensis* ass. (Liou 2003)	**Ecoregion:** CW **Altitude:** 2300-2500 m	*Tsuga chinensis* var. *formosana*	*Chamaecyparis formosensis*, *Cyclobalanopsis stenophylloides*, *Daphniphyllum himalaense* subsp. *macropodum*, *Eurya loquaiana*, *Litsea elongata* var. *mushaensis*, *Neolitsea parvigemma*, *Pasania hancei* var. *ternaticupula*, *Trochodendron aralioides*, *Tsuga chinensis* var. *formosana*,	2.07
24	*Tsuga chinensis* var. formosana-*Chamaecyparis obtusa* var. *formosana* ass. (Liou 2003); *Castanopsis carlesii* forest type (Fu et al. 2004)	**Ecoregion:** CW **Altitude:** 1995-2350 m **Inclination**: 3-30˚ **Soil rockiness**: 2-4 (on the scale of 1-5) **Whole-Light Sky**: 45-70%	*Tsuga chinensis* var. *formosana*	*Castanopsis cuspidata* var. *carlesii*, *Chamaecyparis obtusa* var. *formosana*, *Cyclobalanopsis morii*, *C. stenophylloides*, *Dendropanax dentiger*, *Eurya glaberrima*, *E. loquaiana*, *Ilex goshiensis*, *Pinus taiwanensis*, *Microtropis fokienensis*, *Neolitsea acuminatissima*, *Pasania hancei* var. *ternaticupula*, *Rhododendron leptosanthum*, *Schefflera taiwaniana*, *Symplocos morrisonicola*	1.01

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
25	*Chamaecyparis formosensis* all. (Liou 2003)	**Ecoregion:** CW	*Acer morrisonense*, *Cunninghamia konishii*, *Cyclobalanopsis stenophylloides*, *Litsea elongata* var. *mushaensis*, *Tsuga chinensis* var. *formosana*	*Celastrus punctatus*, *Chamaecyparis formosensis*, *Damnacanthus indicus*, *Deutzia taiwanensis*, *Eurya chinensis*, *Eurya crenatifolia*, *E. leptophylla*, *Hydrangea angustipetala*, *Ilex bioritsensis*, *Ligustrum morrisonense*, *L. pricei*, *Mahonia oiwakensis*, *Neolitsea parvigemma*, *Osmanthus enervius*, *Pasania hancei* var. *ternoticupula*, *Pieris taiwanensis*, *Symplocos caudata*, *Taiwania cryptomerioides*, *Viburnum arboricolum*, *Viburnum sympodiale*, *Viburnum urceolatum*	NOT RECOGNIZABLE
26	*Chamaecyparis obtusa* var. *formosana* all. (Liou 2003)	**Ecoregion:** CW	*Tsuga chinensis* var. *formosana*	*Chamaecyparis obtusa* var. *formosana*, *Pinus armandii* var. *mastersiana*, *Prunus taiwaniana*, *Symplocos morrisonicola*	NOT RECOGNIZABLE
27	*Chamaecyparis formosensis*-*Symplocos caudata* ass. (Yu 2003);	**Ecoregion:** NE **Altitude:** 1000-1900 m **Topography:** middle slopes up to ridges	*Chamaecyparis formosensis*	*Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *C. sessilifolia*, *Daphniphyllum glaucescens* var. *oldhamii*, *Elaeocarpus japonicus*, *Illicium anisatum*, *Machilus thunbergii*, *Symplocos caudata*	1.05
28	*Cyclobalanopsis sessilifolia*-*Tsuga chinensis* var. *formosana* aubass. (Yu 2003);	**Ecoregion:** NE **Altitude:** 1700-2300 m **Topography:** ridges	*Cyclobalanopsis sessilifolia*	*Camellia brevistyla*, *Eurya glaberrima*, *Ilex pedunculosa*, *Illicium anisatum*, *Microtropis fokienensis*, *Neolitsea acuminatissima*, *Osmanthus heterophyllus*, *Rhododendron leptosanthum*, *Tsuga chinensis* var. *formosana*, *Viburnum foetidum* var. *rectangulatum*	1.01
29	*Tsuga chinensis* var. *formosana* subass. (Yu 2003)	**Ecoregion:** NE **Altitude:** 2355-2721 m **Topography:** ridges		*Eurya glaberrima*, *Ilex sugerokii* var. *brevipedunculata*, *Illicium anisatum*, *Lyonia ovalifolia*, *Microtropis fokienensis*, *Neolitsea acuminatissima*, *Rhododendron pseudochrysanthum*, *Schefflera taiwaniana*, *Skimmia reevesiana*, *Tsuga chinensis* var. *formosana*, *Viburnum erosum*, *Viburnum integrifolium*, *Viburnum sympodiale*	1.01 1.02

No.	**Vegetation type**	**Habitat**	**Characteristic species**	**Dominant or common species**	**This study**
30	*Tsuga chinensis* var. *formosana* all. (Yu 2003)	**Ecoregion:** NE & NW **Topography:** ridges	*Ilex sugerokii* var. *brevipendunculata*, *Lyonia ovalifolia*, *Microtropis fokienensis*, *Schefflera taiwaniana*, *Skimmia reevesiana*, *Sorbus randaiensis*, *Tsuga chinensis* var. *formosana*, *Viburnum erosum*,	*Tsuga chinensis* var. *formosana*	Alliance 1
31	*Chamaecyparis formosensis* ass. (Chen 2004)	**Ecoregion:** NE & NW **Altitude**: 1450-1760 m **Topography**: middle slopes	*Chamaecyparis formosensis*	*Acrophorus stipellatus*, *Arachniodes rhomboidea*, *Damnacanthus indicus*, *Elaeocarpus japonica*, *Eurya crenatifolia*, *Fatsia polycarpa*, *Itea parviflora*, *Litsea acuminata*, *Machilus japonica*, *Microsorium buergerianum*, *Pasania kawakamii*, *Pellionia radicans*, *Pilea matsudai*, *Plagiogyria glauca*, *Prunus phaeosticta*, *Rhododendron leptosanthum*, *Strobilanthes rankanensis*, *Trochodendron aralioides*, *Vittaria flexuosa*	2.10
32	*Chamaecyparis obtusa* var. *formosana-Tsuga chinensis* var. *formosana* ass. (Chen 2004)	**Ecoregion:** NE & NW **Altitude**: 1339-2721 m **Topography:** middle slopes up to ridges	*Asarum taipingshanianum*, *Chamaecyparis obtusa* var. *formosana*, *Coptis quinquefolia*, *Ilex sugerokii* var. *brevipedunculata*, *Lyonia ovalifolia*, *Pinus armandii* var. *mastersiana*, *Yushania niitakayamensis*	*Acrophorus stipellatus*, *Araiostegia parvipinnata*, *Arisaema formosanum*, *Chamaecyparis obtusa* var. *formosana*, *Eurya glaberrima*, *Hydrangea integrifolia*, *Ilex sugerokii* var. *brevipedunculata*, *Illicium anisatum*, *Lepisorus thunbergianus*, *Microtropis fokienensis*, *Neolitsea acuminatissima*, *Plagiogyria glauca*, *Rhododendron pseudochrysanthum*, *Rhus ambigua*, *Sorbus randaiensis*, *Skimmia reevesiana*, *Schefflera taiwaniana*, *Trochodendron aralioides*, *Tsuga chinensis* var. *formosana*, *Photinia niitakayamensis*, *Sarcopyramis napalensis* var. *bodinieri*, *Yushania niitakayamensis*	1.01 1.02 1.04

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
33	*Cyclobalanopsis sessilifolia-Chamaecyparis obtusa* var. *formosana* ass. (Chen 2004)	**Ecoregion:** NE & NW **Altitude:** 1775-2225 m **Topography:** lower slopes up to ridges	*Cyclobalanopsis sessilifolia*, *Ilex hayataiana*	*Arachniodes rhomboidea*, *Araiostegia parvipinnata*, *Chamaecyparis obtusa* var. *formosana*, *Cyclobalanopsis sessilifolia*, *Dryopteris formosana*, *Eurya crenatifolia*, *Ilex hayataiana*, *Litsea elongata* var. *mushaensis*, *Neolitsea acuminatissima*, *Pasania kawakamii*, *Pellionia radicans*, *Plagiogyria glauca*, *Polystichum parvipinnulum*, *Prunus campanulata*, *P. phaeosticta*, *Pyrrosia sheareri*, *Strobilanthes rankanensis*, *Trochodendron aralioides*, *Yushania niitakayamensis*, *Viburnum foetidum* var. *rectangulatum*, *Woodwardia unigemmata*	2.06
34	*Litsea acuminata-Chamaecyparis formosensis* type (Wei & Chen 2007)	**Ecoregion:** NE & NW **Altitude:** 1602-1816 m **Topography:** valleys	*Litsea acuminata*	*Arachniodes rhomboidea*, *Barthea barthei*, *Chamaecyparis formosensis*, *Cyclobalanopsis longinux*, *C. sessilifolia*, *Damnacanthus indicus*, *Eurya loquaiana*, *E. strigillosa*, *Ilex hayataiana*, *Illicium anisatum*, *Michelia compressa*, *Monachosorum henryi*, *Neolitsea acuminatissima*, *Pellionia radicans*, *Plagiogyria euphlebia*, *Prunus phaeosticta*	2.10
35	*Machilus thunbergii-Chamaecyparis formosensis* type (Wei & Chen 2007)	**Ecoregion:** NE & NW **Altitude:** 1086-1608 m **Topography:** middle slopes down to valleys	*Machilus thunbergii*	*Acrophorus stipellatus*, *Barthea barthei*, *C. formosensis*, *Chamaecyparis obtusa* var. *formosana*, *Cinnamomum subavenium*, *Diplazium dilatatum*, *Elaeocarpus japonica*, *Eurya crenatifolia*, *Litsea acuminata*, *Machilus thunbergii*, *Monachosorum henryi*, *Plagiogyria dunnii*, *P. euphlebia*, *P. glauca*, *Ternstroemia gymnanthera*	1.05 2.10
36	*Rhododendron leptosanthum-Chamaecyparis obtusa* var. *formosana* type (Wei & Chen 2007)	**Ecoregion:** NE & NW **Altitude:** 1710-2190 m **Topography:** lower slopes up to ridges	*Litsea elongata* var. *mushaensis*, *Machilus japonica* and *Rhododendron leptosanthum*	*Barthea barthei*, *Chamaecyparis obtusa* var. *formosana*, *Cleyera japonica*, *C. japonica* var. *taipinensis*, *Cyclobalanopsis sessilifolia*, *Damnacanthus indicus*, *Dendropanax dentiger*, *Elaeocarpus japonicus*, *Eurya crenatifolia*, *Ilex hayataiana*, *Illicium anisatum*, *Myrsine stolonifera*, *Neolitsea acuminatissima*, *Plagiogyria dunnii*, *Plagiogyria euphlebia*, *P. glauca*, *Symplocos morrisonicola*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*	Alliance 1

No.	Vegetation type	Habitat	Characteristic species	Dominant or common species	This study
37	*Tsuga chinensis* var. *formosana-Chamaecyparis obtusa* var. *formosana* type (Wei & Chen 2007)	**Ecoregion:** NE & NW **Altitude:** 1985-2270 m **Topography:** middle slopes up to ridge	*Tsuga chinensis* var. *formosana*	*Chamaecyparis obtusa* var. *formosana*, *Eurya crenatifolia*, *E. glaberrima*, *Illicium anisatum*, *Myrsine stolonifera*, *Neolitsea acuminatissima*, *Osmanthus heterophyllus*, *Plagiogyria glauca*, *Rhododendron formosanum*, *Skimmia reevesiana*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*	1.04
38	*Schefflera taiwaniana-Chamaecyparis formosensis* ass. (Yeh & Liao 2009)	**Ecoregion:** SW	*Berberis kawakamii*, *Eurya glaberrima*, *Illicium anisatum*, *Osmanthus heterophyllus*, *Schefflera taiwaniana*, *Rhododendron pseudochrysanthum*, *Tsuga chinensis* var. *formosana*	*Chamaecyparis formosensis, Tsuga chinensis* var. *formosana*	1.03

APPENDIX S2. COCKTAIL DETERMINATION KEY

1 WITH 3 [*Castanopsis cuspidata* var. *carlesii*, *Chamaecyparis formosensis*, *Litsea acuminata*, *Machilus thunbergii*, *Neolitsea acuminatissima*] AND WITH 3 [*Cyclobalanopsis morii*, *Eurya strigillosa*, *Lithocarpus amygdalifolius*, *Lithocarpus lepidocarpus*, *Machilus japonica*, *Symplocos sonoharae*] AND WITH 3 [*Blastus cochinchinensis*, *Callicarpa randaiensis*, *Damnacanthus indicus*, *Eurya loquaiana*, *Hydrangea chinensis*] AND WITH 2 [*Lemmaphyllum microphyllum*, *Mecodium polyanthos*, *Vaccinium emarginatum*, *Vandenboschia auriculata*, *Vittaria flexuosa*] AND WITH 3 [*Dryopteris formosana*, *Elatostema trilobulatum*, *Monachosorum henryi*, *Plagiogyria euphlebia*, *Plagiogyria formosana*, *Sarcopyramis napalensis* var. *bodinieri*] AND WITHOUT 3 [*Carpinus kawakamii*, *Carpinus rankanensis*, *Cinnamomum insularimontanum*, *Cinnamomum subavenium*, *Cyclobalanopsis glauca*, *Eriobotrya deflexa*, *Michelia compressa*, *Pinus morrisonicola*, *Pittosporum illicioides*, *Pseudotsuga wilsoniana*] AND WITHOUT 3 [*Machilus zuihoensis* var. *mushaensis*, *Malus doumeri*, *Meliosma callicarpifolia*, *Neolitsea aciculata* var. *variabillima*, *Pasania hancei* var. *ternaticupula*, *Schima superba*, *Sloanea formosana*] AND WITHOUT 3 [*Cyclobalanopsis longinux*, *Cyclobalanopsis sessilifolia*, *Cyclobalanopsis stenophylloides*, *Ilex ficoidea*, *Michelia compressa*, *Ternstroemia gymnanthera*]........................2.08

2 WITH 3 [*Elatostema trilobulatum*, *Litsea acuminata*, *Machilus thunbergii*, *Monachosorum henryi*, *Polypodium amoenum*, *Sarcopyramis napalensis* var. *bodinieri*] AND WITH 4 [*Arachniodes rhomboidea*, *Ardisia crenata*, *Asplenium normale*, *Damnacanthus indicus*, *Eurya loquaiana*, *Plagiogyria stenoptera*] AND WITH 4 [*Adinandra lasiostyla*, *Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Eurya strigillosa*, *Gordonia axillaris*, *Machilus japonica*, *Neolitsea acuminatissima*, *Schefflera taiwaniana*] AND WITHOUT 3 [*Cyclobalanopsis longinux*, *Cyclobalanopsis sessilifolia*, *Cyclobalanopsis stenophylloides*, *Ilex ficoidea*, *Michelia compressa*, *Ternstroemia gymnanthera*] AND WITHOUT 3 [*Daphniphyllum glaucescens* subsp. *oldhamii*, *Ilex formosana*, *Litsea elongata* var. *mushaensis*, *Photinia niitakayamensis*, *Symplocos formosana*, *Yushania niitakayamensis*] AND WITHOUT 3 [*Beilschmiedia erythrophloia*, *Lyonia ovalifolia*, *Pasania harlandii*, *Pinus taiwanensis*, *Rhododendron formosanum*, *Sinopanax formosana*, *Vaccinium dunalianum* var. *caudatifolium*] AND WITHOUT 2 [*Camellia transnokoensis*, *Diplazium petri*, *Maesa japonica*, *Mahonia japonica*, *Malus doumeri*].......................................2.08

3 WITH 5 [*Chamaecyparis obtusa* var. *formosana*, *Dendropanax dentiger*, *Eurya glaberrima*, *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*] AND WITHOUT 3 [*Cleyera japonica*, *Cleyera japonica* var. *taipinensis*, *Ilex hayataiana*, *Litsea elongata* var. *mushaensis*, *Symplocos caudata*, *Symplocos morrisonicola*, *Ternstroemia gymnanthera*] AND WITHOUT 3 [*Barthea barthei*, *Damnacanthus angustifolius*, *Eurya crenatifolia*, *Rubus corchorifolius*, *Skimmia reevesiana*, *Viburnum foetidum* var. *rectangulatum*] AND WITHOUT 3 [*Chamaecyparis formosensis*, *Cinnamomum subavenium*, *Ilex goshiensis*, *Itea parviflora*, *Litsea acuminata*, *Machilus japonica*, *Machilus thunbergii*] AND WITHOUT 4 [*Castanopsis cuspidata* var. *carlesii*, *Cyclobalanopsis morii*, *Cyclobalanopsis stenophylloides*, *Elaeocarpus japonicus*, *Michelia compressa*, *Pinus armandii* var. *mastersiana*, *Symplocos arisanensis*, *Symplocos migoi*, *Trochodendron aralioides*] AND WITHOUT 2 [*Acer kawakamii*, *Acer morrisonense*, *Alnus formosana*, *Pinus armandii* var. *mastersiana*, *Pinus taiwanensis*, *Quercus variabilis*, *Tetradium glabrifolium*, *Ulmus uyematsui*] AND WITHOUT 3 [*Fagus hayatae*, *Ilex sugerokii* var. *brevipedunculata*, *Ilex suzukii*, *Ligustrum liukiuense*, *Pourthiaea villosa* var. *parvifolia*] AND WITHOUT 3 [*Adinandra formosana*, *Camellia brevistyla*, *Cyclobalanopsis longinux*, *Daphniphyllum himalaense* subsp. *macropodum*, *Gordonia axillaris*, *Neolitsea aciculata* var. *variabillima*, *Ilex hayataiana*, *Photinia niitakayamensis*] AND WITHOUT 4 [*Ardisia crenata*, *Camellia transnokoensis*, *Damnacanthus angustifolius*, *Damnacanthus indicus*, *Euonymus spraguei*, *Eurya leptophylla*, *Microtropis fokienensis*, *Skimmia reevesiana*] AND WITHOUT 3 [*Acer morrisonense*, *Ilex tugitakayamensis*, *Ilex yunnanensis* var. *parvifolia*, *Osmanthus heterophyllus*, *Pasania hancei* var. *ternaticupula*, *Sorbus randaiensis*] AND WITHOUT 3 [*Cyclobalanopsis sessilifolia*, *Fagus hayatae*, *Styrax formosana*, *Symplocos*

eriostroma, *Viburnum integrifolium*, *Viburnum sympodiale*] AND WITHOUT 3 [*Chamaecyparis formosensis*, *Ilex formosana*, *Ilex lonicerifolia*, *Ligustrum pricei*, *Photinia niitakayamensis*, *Pourthiaea lucida*, *Schima superba*, *Sycopsis sinensis*, *Symplocos konishii*] AND WITHOUT 3 [*Aralia bipinnata*, *Cyclobalanopsis stenophylloides*, *Deutzia taiwanensis*, *Pieris taiwanensis*, *Prunus campanulata*, *Rhododendron oldhamii*, *Stachyurus himalaicus*] 1.02

4 WITH 3 [*Neolitsea acuminatissima*, *Rhododendron formosanum*, *Symplocos morrisonicola*, *Tsuga chinensis* var. *formosana*, *Vaccinium japonicum* var. *lasiostemon*, *Yushania niitakayamensis*] AND WITH 2 [*Chamaecyparis obtusa* var. *formosana*, *Plagiogyria euphlebia*, *Plagiogyria formosana*, *Rhododendron leptosanthum*, *Schefflera taiwaniana*] AND WITHOUT 2 [*Castanopsis cuspidata* var. *carlesii*, *Daphniphyllum himalaense* subsp. *macropodum*, *Elaeocarpus japonicus*, *Litsea morrisonensis*, *Machilus thunbergii*, *Picea morrisonicola*, *Schima superba*] AND WITHOUT 2 [*Daphniphyllum glaucescens* subsp. *oldhamii*, *Eurya strigillosa*, *Ilex formosana*, *Pasania hancei* var. *arisanensis*, *Pinus morrisonicola*, *Vaccinium randaiense*] AND WITHOUT 2 [*Cyclobalanopsis sessilifolia*, *Eurya loquaiana*, *Fagus hayatae*, *Symplocos arisanensis*, *Viburnum sympodiale*, *Viburnum urceolatum*] AND WITHOUT 2 [*Barthea barthei*, *Cunninghamia konishii*, *Damnacanthus indicus*, *Pinus armandii* var. *mastersiana*, *Pinus taiwanensis*] AND WITHOUT 2 [*Arachniodes rhomboidea*, *Chamaecyparis formosensis*, *Hedera rhombea* var. *formosana*, *Lonicera acuminata*, *Polystichum parvipinnulum*, *Stauntonia obovatifoliola*] AND WITHOUT 2 [*Camellia tenuifolia*, *Dryopteris formosana*, *Dryopteris lepidopoda*, *Monachosorum henryi*, *Pieris taiwanensis*, *Plagiogyria dunnii*] AND WITHOUT 2 [*Barthea barthei*, *Cleyera japonica* var. *taipinensis*, *Styrax formosana*, *Ternstroemia gymnanthera*] AND WITHOUT 2 [*Cleyera japonica* var. *longicarpa*, *Ilex yunnanensis* var. *parvifolia*, *Rhododendron rubropilosum*, *Vaccinium wrightii*, *Viburnum formosanum*] 1.02

5 WITH 4 [*Chamaecyparis obtusa* var. *formosana*, *Dendropanax dentiger*, *Eurya glaberrima*, *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum*, *Rhododendron leptosanthum*, *Tsuga chinensis* var. *formosana*] AND WITH 3 [*Acrophorus stipellatus*, *Arthromeris lehmannii*, *Asplenium normale*, *Diplopterygium glaucum*, *Elatostema trilobulatum*, *Plagiogyria dunnii*, *Plagiogyria euphlebia*, *Plagiogyria formosana*] AND WITH 4 [*Cleyera japonica*, *Cleyera japonica* var. *taipinensis*, *Ilex hayataiana*, *Litsea elongata* var. *mushaensis*, *Symplocos caudata*, *Symplocos morrisonicola*, *Ternstroemia gymnanthera*] AND WITH 2 [*Araiostegia parvipinnata*, *Mecodium badium*, *Mecodium polyanthos*, *Vittaria flexuosa*, *Xiphopteris okuboi*] AND WITH 3 [*Barthea barthei*, *Damnacanthus angustifolius*, *Eurya crenatifolia*, *Rubus corchorifolius*, *Skimmia reevesiana*, *Yushania niitakayamensis*] AND WITHOUT 3 [*Chamaecyparis formosensis*, *Cinnamomum subavenium*, *Ilex goshiensis*, *Itea parviflora*, *Litsea acuminata*, *Machilus japonica*, *Machilus thunbergii*].. 1.04

6 WITH 4 [*Coptis quinquefolia*, *Dendropanax dentiger*, *Eurya crenatifolia*, *Illicium anisatum*, *Neolitsea acuminatissima*, *Viburnum sympodiale*] AND WITH 3 [*Barthea barthei*, *Damnacanthus angustifolius*, *Elatostema trilobulatum*, *Plagiogyria formosana*, *Skimmia reevesiana*] AND WITH 3 [*Acrophorus stipellatus*, *Chamaecyparis obtusa* var. *formosana*, *Daphniphyllum himalaense* subsp. *macropodum*, *Eurya glaberrima*, *Ilex hayataiana*, *Rhododendron formosanum*] AND WITH 3 [*Ilex sugerokii* var. *brevipedunculata*, *Mecodium polyanthos*, *Schefflera taiwaniana*, *Styrax formosana*, *Symplocos arisanensis*, *Trochodendron aralioides*] AND WITH 2 [*Araiostegia parvipinnata*, *Asplenium wilfordii*, *Vittaria flexuosa*, *Xiphopteris okuboi*] AND WITHOUT 3 [*Camellia tenuifolia*, *Carex breviculmis*, *Fagus hayatae*, *Polystichum parvipinnulum*, *Pourthiaea villosa* var. *parvifolia*, *Viburnum erosum*, *Viola formosana*] AND WITHOUT 3 [*Cinnamomum subavenium*, *Cyclobalanopsis morii*, *Eurya leptophylla*, *Ilex micrococca*, *Pyrenaria shinkoensis*, *Sassafras randaiense*] AND WITHOUT 3 [*Ilex formosana*, *Itea parviflora*, *Michelia compressa*, *Neolitsea aciculata*, *Symplocos migoi*, *Symplocos stellaris*] 1.04

7 WITH 3 [*Acer morrisonense*, *Cleyera japonica* var. *taipinensis*, *Eurya glaberrima*, *Neolitsea acuminatissima*, *Pasania kawakamii*, *Prunus campanulata*, *Trochodendron aralioides*, *Tsuga chinensis* var. *formosana*] AND WITH 3 [*Chamaecyparis formosensis*, *Chamaecyparis obtusa* var. *formosana*, *Cyclobalanopsis sessilifolia*, *Fatsia polycarpa*, *Michelia compressa*, *Prunus*

phaeosticta, *Taiwania cryptomerioides*, *Ternstroemia gymnanthera*] AND WITH 3 [*Adinandra lasiostyla*, *Cyclobalanopsis stenophylloides*, *Daphniphyllum himalaense* subsp. *macropodum*, *Elaeocarpus japonicus*, *Ilex goshiensis*, *Ilex tugitakayamensis*, *Rhododendron leptosanthum*, *Schefflera taiwaniana*] AND WITH 3 [*Acrophorus stipellatus*, *Dryopteris formosana*, *Microsorium buergerianum*, *Plagiogyria euphlebia*, *Plagiogyria formosana*, *Polystichum parvipinnulum*] AND WITH 3 [*Ficus sarmentosa* var. *nipponica*, *Hydrangea integrifolia*, *Lonicera acuminata*, *Smilax arisanensis*, *Stauntonia obovatifoliola*, *Schizophragma integrifolium* var. *fauriei*, *Hedera rhombea* var. *formosana*] AND WITH 3 [*Ardisia crenata*, *Damnacanthus angustifolius*, *Damnacanthus indicus*, *Euonymus spraguei*, *Eurya leptophylla*, *Microtropis fokienensis*, *Skimmia reevesiana*] AND WITH 3 [*Litsea elongata* var. *mushaensis*, *Sycopsis sinensis*, *Symplocos arisanensis*, *Symplocos heishanensis*, *Symplocos migoi*, *Symplocos morrisonicola*, *Symplocos stellaris*] AND WITHOUT 3 [*Carpinus kawakamii*, *Carpinus rankanensis*, *Gordonia axillaris*, *Photinia serratifolia*, *Photinia serratifolia* var. *lasiopetala*, *Picea morrisonicola*, *Pinus armandii* var. *mastersiana*, *Pinus morrisonicola*, *Pinus taiwanensis*, *Prunus spinulosa*, *Pseudotsuga wilsoniana*] AND WITHOUT 3 [*Castanopsis cuspidata* var. *carlesii*, *Cinnamomum subavenium*, *Litsea acuminata*, *Machilus japonica*, *Machilus thunbergii*, *Schima superba*] AND WITHOUT 3 [*Acer morrisonense*, *Alnus formosana*, *Lyonia ovalifolia*, *Photinia niitakayamensis*, *Picea morrisonicola*, *Pinus taiwanensis*, *Platycarya strobilacea*, *Quercus variabilis*] 2.06

8 WITH 4 [*Damnacanthus indicus*, *Dryopteris formosana*, *Eurya loquaiana*, *Plagiogyria euphlebia*, *Plagiogyria formosana*, *Polystichum parvipinnulum*] AND WITH 4 [*Adinandra lasiostyla*, *Cyclobalanopsis sessilifolia*, *Ilex goshiensis*, *Neolitsea acuminatissima*, *Pasania kawakamii*, *Symplocos migoi*] AND WITH 3 [*Chamaecyparis formosensis*, *Cyclobalanopsis stenophylloides*, *Daphniphyllum himalaense* subsp. *macropodum*, *Litsea elongata* var. *mushaensis*, *Michelia compressa*, *Sycopsis sinensis*] AND WITH 3 [*Araiostegia parvipinnata*, *Calanthe puberula*, *Stauntonia obovatifoliola*, *Symplocos arisanensis*, *Vittaria flexuosa*] AND WITH 3 [*Actinidia callosa*, *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Schizophragma integrifolium* var. *fauriei*, *Smilax arisanensis*, *Zanthoxylum scandens*] AND WITHOUT 3 [*Callicarpa randaiensis*, *Cyclobalanopsis morii*, *Gordonia axillaris*, *Hydrangea chinensis*, *Litsea acuminata*, *Machilus thunbergii*, *Prunus buergeriana*, *Schima superba*] AND WITHOUT 3 [*Alnus formosana*, *Cyclobalanopsis longinux*, *Eurya crenatifolia*, *Machilus japonica*, *Rubus corchorifolius*, *Sassafras randaiense*, *Strobilanthes flexicaulis*] AND WITHOUT 3 [*Acer kawakamii*, *Acer serrulatum*, *Juglans cathayensis*, *Liquidambar formosana*, *Pinus taiwanensis*, *Pittosporum illicioides*, *Zanthoxylum ailanthoides*] 2.06

9 WITH 3 [*Chamaecyparis formosensis*, *Litsea acuminata*, *Machilus japonica*, *Machilus thunbergii*, *Neolitsea acuminatissima*] AND WITH 3 [*Damnacanthus indicus*, *Eurya leptophylla*, *Eurya loquaiana*, *Symplocos formosana*, *Viburnum taitoense*, *Yushania niitakayamensis*] AND WITH 3 [*Cyclobalanopsis longinux*, *Litsea elongata* var. *mushaensis*, *Litsea morrisonensis*, *Pasania hancei* var. *ternaticupula*, *Pasania kawakamii*, *Pourthiaea beauverdiana* var. *notabilis*] AND WITH 3 [*Arachniodes rhomboidea*, *Dryopteris formosana*, *Microsorium buergerianum*, *Monachosorum henryi*, *Plagiogyria formosana*, *Polystichum hancockii*] AND WITH 3 [*Acer kawakamii*, *Cyclobalanopsis morii*, *Fatsia polycarpa*, *Ligustrum pricei*, *Prunus phaeosticta*, *Trochodendron aralioides*] AND WITH 2 [*Asplenium normale*, *Diplazium kawakamii*, *Elatostema trilobulatum*, *Ophiopogon intermedius*, *Polystichum parvipinnulum*] AND WITHOUT 3 [*Acer serrulatum*, *Cephalotaxus wilsoniana*, *Juglans cathayensis*, *Ligustrum sinense*, *Malus doumeri*, *Zanthoxylum ailanthoides*] AND WITHOUT 3 [*Ailanthus altissima* var. *tanakai*, *Alnus formosana*, *Pinus taiwanensis*, *Platycarya strobilacea*, *Pseudotsuga wilsoniana*, *Quercus variabilis*, *Ulmus uyematsui*] AND WITHOUT 3 [*Callicarpa randaiensis*, *Hydrangea chinensis*, *Ligustrum morrisonense*, *Pittosporum illicioides*, *Swida controversa*, *Viburnum betulifolium*] AND WITHOUT 3 [*Acer serrulatum*, *Alnus formosana*, *Cinnamomum insularimontanum*, *Deutzia taiwanensis*, *Michelia compressa*, *Oreocnide pedunculata*, *Prunus campanulata*] 2.07

10 WITH 3 [*Machilus japonica*, *Microsorium buergerianum*, *Monachosorum henryi*, *Neolitsea acuminatissima*, *Polystichum parvipinnulum*, *Yushania niitakayamensis*] AND WITH 3

[*Cyclobalanopsis stenophylloides*, *Dryopteris formosana*, *Pasania kawakamii*, *Pilea aquarum* subsp. *brevicornuta*, *Pourthiaea beauverdiana* var. *notabilis*] AND WITH 3 [*Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Schisandra arisanensis*, *Schizophragma integrifolium* var. *fauriei*, *Stauntonia obovatifoliola*] AND WITH 2 [*Chamaecyparis formosensis*, *Eurya loquaiana*, *Litsea elongata* var. *mushaensis*, *Litsea morrisonensis*] AND WITH 4 [*Acer palmatum* var. *pubescens*, *Arachniodes rhomboidea*, *Eurya leptophylla*, *Fatsia polycarpa*, *Ophiorrhiza japonica*, *Pasania hancei* var. *ternaticupula*, *Pellionia radicans*, *Polystichum hancockii*, *Symplocos formosana*, *Viburnum arboricolum*] AND WITHOUT 3 [*Ctenitis apiciflora*, *Hydrangea angustipetala*, *Osmanthus kaoi*, *Rubus kawakamii*, *Sarcopyramis napalensis* var. *delicata*, *Symplocos modesta*, *Symplocos stellaris*, *Thelypteris uraiensis*] AND WITHOUT 3 [*Adinandra lasiostyla*, *Cyclobalanopsis sessilifolia*, *Euonymus spraguei*, *Symplocos heishanensis*, *Symplocos migoi*, *Symplocos morrisonicola*] AND WITHOUT 3 [*Daphniphyllum himalaense* subsp. *macropodum*, *Mahonia oiwakensis*, *Picea morrisonicola*, *Pittosporum illicioides*, *Prunus spinulosa*, *Quercus tatakaensis*] AND WITHOUT 3 [*Acer serrulatum*, *Alnus formosana*, *Cinnamomum insularimontanum*, *Deutzia taiwanensis*, *Michelia compressa*, *Oreocnide pedunculata*, *Prunus campanulata*] AND WITHOUT 3 [*Elaeocarpus japonicus*, *Fagus hayatae*, *Juglans cathayensis*, *Miscanthus sinensis*, *Pourthiaea villosa* var. *parvifolia*, *Rubus corchorifolius*, *Schima superba*, *Sloanea formosana*] AND WITHOUT 3 [*Celtis sinensis*, *Eriobotrya deflexa*, *Helicia formosana*, *Lindera megaphylla*, *Neolitsea parvigemma*, *Phoebe formosana*] 2.07

11 WITH 3 [*Chamaecyparis obtusa* var. *formosana*, *Dendropanax dentiger*, *Eurya glaberrima*, *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum*, *Rhododendron leptosanthum*, *Tsuga chinensis* var. *formosana*] AND WITH 3 [*Cinnamomum subavenium*, *Ilex goshiensis*, *Itea parviflora*, *Prunus phaeosticta*, *Pyrenaria shinkoensis*, *Schima superba*, *Ternstroemia gymnanthera*] AND WITH 3 [*Barthea barthei*, *Damnacanthus angustifolius*, *Damnacanthus indicus*, *Eurya loquaiana*, *Myrsine stolonifera*, *Symplocos wikstroemiifolia*, *Viburnum foetidum* var. *rectangulatum*] AND WITH 2 [*Arachniodes rhomboidea*, *Dryopteris formosana*, *Plagiogyria dunnii*, *Plagiogyria euphlebia*, *Plagiogyria formosana*] AND WITH 3 [*Cyclobalanopsis longinux*, *Elaeocarpus japonicus*, *Ilex tugitakayamensis*, *Litsea acuminata*, *Machilus thunbergii*, *Michelia compressa*, *Symplocos morrisonicola*] AND WITHOUT 3 [*Engelhardia roxburghiana*, *Gordonia axillaris*, *Meliosma squamulata*, *Myrsine seguinii*, *Syzygium buxifolium*, *Tricalysia dubia*] AND WITHOUT 3 [*Ardisia crenata*, *Euonymus spraguei*, *Eurya leptophylla*, *Microtropis fokienensis*, *Rubus kawakamii*, *Skimmia reevesiana*] AND WITHOUT 3 [*Chamaecyparis formosensis*, *Cyclobalanopsis stenophylloides*, *Fatsia polycarpa*, *Ficus erecta* var. *beecheyana*, *Ilex uraiensis*, *Machilus japonica*, *Neolitsea aciculata* var. *variabillima*, *Pasania kawakamii*, *Symplocos sonoharae*] AND WITHOUT 3 [*Fagus hayatae*, *Ilex sugerokii* var. *brevipedunculata*, *Ilex suzukii*, *Ligustrum liukiuense*, *Litsea elongata* var. *mushaensis*, *Pourthiaea villosa* var. *parvifolia*, *Symplocos caudata*] AND WITHOUT 3 [*Daphniphyllum himalaense* subsp. *macropodum*, *Elaeocarpus sylvestris*, *Eurya strigillosa*, *Ilex ficoidea*, *Litsea elongata* var. *mushaensis*, *Osmanthus matsumuranus*, *Pasania hancei* var. *ternaticupula*, *Symplocos caudata*] AND WITHOUT 3 [*Eurya crenatifolia*, *Lasianthus appressihirtus* var. *maximus*, *Lasianthus fordii*, *Lasianthus microphyllus*, *Lasianthus wallichii*, *Maesa japonica*, *Rubus corchorifolius*, *Symplocos formosana*] AND WITHOUT 3 [*Beilschmiedia erythrophloia*, *Castanopsis cuspidata* var. *carlesii*, *Illicium arborescens*, *Lithocarpus amygdalifolius*, *Machilus japonica* var. *kusanoi*, *Machilus zuihoensis*, *Meliosma callicarpifolia*, *Neolitsea konishii*] AND WITHOUT 3 [*Diospyros morrisiana*, *Fagus hayatae*, *Pasania konishii*, *Symplocos eriostroma*, *Symplocos caudata*, *Viburnum formosanum*, *Yushania niitakayamensis*] AND WITHOUT 3 [*Elaeocarpus sylvestris*, *Engelhardia roxburghiana*, *Eurya leptophylla*, *Gordonia axillaris*, *Lasianthus fordii*, *Lithocarpus amygdalifolius*, *Meliosma squamulata*, *Pasania cornea*, *Pasania harlandii*, *Styrax formosana*] 1.05

12 WITH 3 [*Chamaecyparis obtusa* var. *formosana*, *Myrsine stolonifera*, *Neolitsea acuminatissima*, *Rhododendron formosanum*, *Symplocos morrisonicola*, *Yushania niitakayamensis*] AND WITH 3 [*Barthea barthei*, *Elaeocarpus japonicus*, *Ilex goshiensis*, *Michelia compressa*, *Rhododendron leptosanthum*] AND WITH 3 [*Castanopsis cuspidata* var. *carlesii*, *Machilus thunbergii*, *Plagiogyria dunnii*, *Skimmia reevesiana*, *Ternstroemia gymnanthera*, *Trochodendron aralioides*]

AND WITH 2 [*Damnacanthus angustifolius*, *Dendropanax dentiger*, *Symplocos stellaris*, *Symplocos wikstroemiifolia*, *Viburnum urceolatum*] AND WITHOUT 2 [*Eurya hayatae*, *Helicia rengetiensis*, *Lithocarpus lepidocarpus*, *Vaccinium bracteatum*] AND WITHOUT 2 [*Alnus formosana*, *Eustigma oblongifolium*, *Pseudotsuga wilsoniana*, *Vaccinium japonicum* var. *lasiostemon*] AND WITHOUT 2 [*Adinandra lasiostyla*, *Cyclobalanopsis stenophylloides*, *Microtropis fokienensis*, *Sycopsis sinensis*, *Symplocos migoi*] AND WITHOUT 3 [*Elaeocarpus sylvestris*, *Engelhardia roxburghiana*, *Eurya leptophylla*, *Gordonia axillaris*, *Lasianthus fordii*, *Lithocarpus amygdalifolius*, *Meliosma squamulata*, *Pasania cornea*, *Pasania harlandii*, *Styrax formosana*] AND WITHOUT 2 [*Pinus armandii* var. *mastersiana*, *Pinus taiwanensis*, *Rhus succedanea*, *Sassafras randaiense*] AND WITHOUT 2 [*Cinnamomum insularimontanum*, *Cyathea loheri*, *Ilex maximowicziana*, *Ilex uraiensis*, *Illicium tashiroi*] AND WITHOUT 2 [*Eurya nitida*, *Litsea lii*, *Schima superba* var. *kankaoensis*, *Vaccinium dunalianum* var. *caudatifolium*]............1.05

13 WITH 3 [*Chamaecyparis obtusa* var. *formosana*, *Dendropanax dentiger*, *Eurya glaberrima*, *Illicium anisatum*, *Neolitsea acuminatissima*, *Rhododendron formosanum*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*] AND WITH 3 [*Cleyera japonica*, *Cyclobalanopsis morii*, *Elaeocarpus japonicus*, *Rhododendron leptosanthum*, *Symplocos arisanensis*, *Symplocos morrisonicola*, *Trochodendron aralioides*] AND WITH 3 [*Ardisia crenata*, *Damnacanthus angustifolius*, *Eurya loquaiana*, *Microtropis fokienensis*, *Skimmia reevesiana*, *Viburnum urceolatum*] AND *(* WITH 3 [*Cleyera japonica* var. *taipinensis*, *Cyclobalanopsis sessilifolia*, *Ilex goshiensis*, *Ilex tugitakayamensis*, *Schefflera taiwaniana*, *Symplocos migoi*] OR WITH 3 [*Barthea barthei*, *Damnacanthus indicus*, *Eurya leptophylla*, *Myrsine stolonifera*, *Rhododendron pseudochrysanthum*, *Skimmia arisanensis*, *Viburnum sympodiale*] *)* AND WITHOUT 3 [*Castanopsis cuspidata* var. *carlesii*, *Cyclobalanopsis stenophylloides*, *Daphniphyllum himalaense* subsp. *macropodum*, *Litsea acuminata*, *Litsea elongata* var. *mushaensis*, *Machilus japonica*, *Machilus thunbergii*, *Pasania kawakamii*] AND WITHOUT 3 [*Adinandra lasiostyla*, *Chamaecyparis formosensis*, *Itea parviflora*, *Michelia compressa*, *Prunus phaeosticta*, *Sycopsis sinensis*, *Symplocos heishanensis*] AND WITHOUT 3 [*Alnus formosana*, *Photinia niitakayamensis*, *Pinus armandii* var. *mastersiana*, *Pinus morrisonicola*, *Pinus taiwanensis*, *Pseudotsuga wilsoniana*] AND WITHOUT 3 [*Cunninghamia konishii*, *Cyclobalanopsis longinux*, *Eurya strigillosa*, *Pyrenaria shinkoensis*, *Taiwania cryptomerioides*] 1.01

14 WITH 3 [*Cyclobalanopsis sessilifolia*, *Neolitsea acuminatissima*, *Schefflera taiwaniana*, *Symplocos morrisonicola*, *Tsuga chinensis* var. *formosana*] AND WITH 3 [*Camellia tenuifolia*, *Damnacanthus angustifolius*, *Eurya leptophylla*, *Eurya loquaiana*, *Microtropis fokienensis*, *Viburnum urceolatum*] AND WITH 3 [*Cleyera japonica* var. *taipinensis*, *Dendropanax dentiger*, *Ilex goshiensis*, *Rhododendron leptosanthum*, *Symplocos migoi*, *Trochodendron aralioides*] AND WITH 3 [*Ainsliaea latifolia* subsp. *henryi*, *Ainsliaea macroclinidioides*, *Araiostegia parvipinnata*, *Dryopteris formosana*, *Plagiogyria formosana*, *Yushania niitakayamensis*] AND WITH 2 [*Cyclobalanopsis morii*, *Cyclobalanopsis stenophylloides*, *Eurya glaberrima*, *Symplocos stellaris*] AND WITHOUT 3 [*Ardisia crenata*, *Castanopsis cuspidata* var. *carlesii*, *Michelia compressa*, *Pasania kawakamii*, *Pittosporum illicioides*, *Rubus kawakamii*, *Schima superba*, *Viburnum foetidum* var. *rectangulatum*] AND WITHOUT 3 [*Chamaecyparis formosensis*, *Gordonia axillaris*, *Litsea acuminata*, *Litsea elongata* var. *mushaensis*, *Machilus japonica*, *Prunus phaeosticta*, *Ternstroemia gymnanthera*] AND WITHOUT 3 [*Eriobotrya deflexa*, *Pinus morrisonicola*, *Pinus taiwanensis*, *Pittosporum illicioides*, *Pseudotsuga wilsoniana*, *Quercus variabilis*] AND WITHOUT 3 [*Acer morrisonense*, *Callicarpa randaiensis*, *Daphne arisanensis*, *Daphniphyllum glaucescens* subsp. *oldhamii*, *Mahonia oiwakensis*, *Pourthiaea beauverdiana* var. *notabilis*].....1.01

15 WITH 4 [*Castanopsis cuspidata* var. *carlesii*, *Chamaecyparis formosensis*, *Cyclobalanopsis longinux*, *Cyclobalanopsis stenophylloides*, *Elaeocarpus japonicus*, *Fatsia polycarpa*, *Litsea acuminata*, *Litsea elongata* var. *mushaensis*, *Machilus japonica*, *Machilus thunbergii*, *Neolitsea acuminatissima*, *Pasania kawakamii*] AND WITH 3 [*Cinnamomum subavenium*, *Dendropanax dentiger*, *Itea parviflora*, *Prunus phaeosticta*, *Pyrenaria shinkoensis*, *Ternstroemia gymnanthera*] AND WITH 3 [*Ficus sarmentosa* var. *nipponica*, *Hydrangea integrifolia*, *Pileostegia viburnoides*,

Piper kadsura, *Smilax lanceifolia*, *Stauntonia obovatifoliola*] AND WITH 2 [*Camellia tenuifolia*, *Eurya crenatifolia*, *Maesa japonica*, *Sarcandra glabra*, *Symplocos wikstroemiifolia*] AND WITHOUT 3 [*Chamaecyparis obtusa* var. *formosana*, *Eurya glaberrima*, *Ilex tugitakayamensis*, *Illicium anisatum*, *Rhododendron formosanum*, *Symplocos arisanensis*, *Symplocos morrisonicola*, *Tsuga chinensis* var. *formosana*] AND WITHOUT 3 [*Cyclobalanopsis glauca*, *Daphniphyllum glaucescens* subsp. *oldhamii*, *Elaeocarpus sylvestris*, *Eriobotrya deflexa*, *Mallotus japonicus*] AND WITHOUT 3 [*Engelhardia roxburghiana*, *Gordonia axillaris*, *Meliosma squamulata*, *Myrsine seguinii*, *Syzygium buxifolium*, *Tricalysia dubia*] AND WITHOUT 3 [*Camellia brevistyla*, *Diospyros morrisiana*, *Eurya nitida*, *Ligustrum liukiuense*, *Ligustrum sinense*, *Symplocos caudata*] AND WITHOUT 3 [*Beilschmiedia erythrophloia*, *Cryptocarya chinensis*, *Helicia formosana*, *Oreocnide pedunculata*, *Randia cochinchinensis*, *Rhus succedanea*, *Schefflera octophylla*, *Turpinia formosana*] AND WITHOUT 3 [*Machilus zuihoensis* var. *mushaensis*, *Malus doumeri*, *Meliosma callicarpifolia*, *Neolitsea aciculata* var. *variabillima*, *Pasania hancei* var. *ternaticupula*, *Schima superba*, *Sloanea formosana*] AND WITHOUT 3 [*Blastus cochinchinensis*, *Clerodendrum trichotomum*, *Ficus formosana*, *Hydrangea chinensis*, *Lasianthus fordii*, *Lasianthus wallichii*, *Maesa perlaria* var. *formosana*, *Psychotria rubra*] AND WITHOUT 3 [*Diospyros morrisiana*, *Fagus hayatae*, *Pasania konishii*, *Symplocos eriostroma*, *Symplocos caudata*, *Viburnum formosanum*, *Yushania niitakayamensis*].. 2.10

16 WITH 4 [*Acrophorus stipellatus*, *Litsea acuminata*, *Machilus thunbergii*, *Monachosorum henryi*, *Pellionia radicans*] AND WITH 3 [*Arachniodes rhomboidea*, *Cyclobalanopsis longinux*, *Davallia mariesii*, *Plagiogyria euphlebia*, *Prunus phaeosticta*] AND WITH 3 [*Ardisia crenata*, *Damnacanthus indicus*, *Diplazium dilatatum*, *Dryopteris formosana*, *Mecodium polyanthos*, *Sarcopyramis napalensis* var. *bodinieri*] AND WITH 3 [*Hydrangea integrifolia*, *Pileostegia viburnoides*, *Schizophragma integrifolium* var. *fauriei*, *Smilax lanceifolia*, *Stauntonia obovatifoliola*, *Tripterospermum taiwanense*] AND WITH 3 [*Alpinia intermedia*, *Elaeocarpus japonicus*, *Eurya loquaiana*, *Lasianthus fordii*, *Maesa japonica*, *Selaginella doederleinii*] AND WITH 3 [*Araiostegia parvipinnata*, *Asplenium wilfordii*, *Liparis bootanensis*, *Liparis caespitosa*, *Osmanthus matsumuranus*, *Pyrrosia lingua*, *Vittaria flexuosa*] AND WITHOUT 3 [*Cyclobalanopsis sessilifolia*, *Daphniphyllum glaucescens* subsp. *oldhamii*, *Elaeocarpus sylvestris*, *Gordonia axillaris*, *Helicia formosana*, *Machilus japonica* var. *kusanoi*, *Meliosma squamulata*, *Sloanea formosana*] AND WITHOUT 3 [*Elatostema lineolatum* var. *majus*, *Engelhardia roxburghiana*, *Hydrangea chinensis*, *Ilex ficoidea*, *Machilus zuihoensis* var. *mushaensis*, *Meliosma callicarpifolia*, *Polygonum chinense*, *Strobilanthes flexicaulis*] AND WITHOUT 3 [*Athyrium arisanense*, *Diplazium mettenianum*, *Ilex hayataiana*, *Illicium arborescens*, *Lithocarpus lepidocarpus*, *Skimmia reevesiana*, *Sycopsis sinensis*] AND WITHOUT 3 [*Diospyros morrisiana*, *Eurya acuminata*, *Ficus erecta* var. *beecheyana*, *Lindera akoensis*, *Myrica rubra*] AND WITHOUT 3 [*Cyclobalanopsis longinux*, *Engelhardia roxburghiana*, *Lasianthus fordii*, *Myrsine seguinii*, *Schima superba*, *Syzygium buxifolium*, *Tricalysia dubia*].. 2.10

17 WITH 4 [*Chamaecyparis formosensis*, *Litsea acuminata*, *Machilus japonica*, *Machilus zuihoensis* var. *mushaensis*, *Pasania kawakamii*, *Pourthiaea beauverdiana* var. *notabilis*] AND WITH 3 [*Begonia formosana*, *Dryopteris formosana*, *Elatostema parvum*, *Elatostema trilobulatum*, *Pilea angulata*, *Pilea aquarum* subsp. *brevicornuta*, *Pilea funkikensis*, *Pilea melastomoides*, *Polystichum parvipinnulum*, *Selaginella delicatula*, *Selaginella mollendorffii*, *Selaginella remotifolia*] AND WITH 3 [*Cyclobalanopsis stenophylloides*, *Daphniphyllum himalaense* subsp. *macropodum*, *Fatsia polycarpa*, *Lithocarpus lepidocarpus*, *Litsea elongata* var. *mushaensis*, *Perrottetia arisanensis*, *Prunus phaeosticta*] AND WITH 3 [*Arachniodes rhomboidea*, *Carex brunnea*, *Coniogramme intermedia*, *Diplazium kawakamii*, *Ellisiophyllum pinnatum*, *Microsorium buergerianum*, *Polypodium formosanum*, *Thelypteris esquirolii*] AND WITH 2 [*Actinidia chinensis* var. *setosa*, *Ficus sarmentosa* var. *nipponica*, *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Piper kadsura*, *Tetrastigma umbellatum*] AND WITH 2 [*Araiostegia parvipinnata*, *Pyrrosia sheareri*, *Vandenboschia auriculata*, *Vittaria flexuosa*] AND WITHOUT 3 [*Acer palmatum* var. *pubescens*, *Cyclobalanopsis longinux*, *Cyclobalanopsis morii*, *Cyclobalanopsis sessilifolia*, *Ligustrum pricei*, *Neolitsea acuminatissima*, *Pasania hancei* var. *ternaticupula*, *Schefflera taiwaniana*,

Trochodendron aralioides] AND WITHOUT 3 [*Celtis sinensis*, *Eriobotrya deflexa*, *Helicia formosana*, *Lindera megaphylla*, *Neolitsea parvigemma*, *Phoebe formosana*] AND WITHOUT 3 [*Camellia tenuifolia*, *Euonymus spraguei*, *Eurya leptophylla*, *Lasianthus fordii*, *Microtropis fokienensis*, *Rubus kawakamii*, *Skimmia reevesiana*, *Viburnum taitoense*, *Yushania niitakayamensis*] AND WITHOUT 3 [*Beilschmiedia erythrophloia*, *Castanopsis cuspidata* var. *carlesii*, *Cinnamomum macrostemon*, *Engelhardia roxburghiana*, *Lagerstroemia subcostata*, *Litsea akoensis*, *Pasania cornea*, *Saurauia tristyla* var. *oldhamii*, *Schefflera octophylla*] AND WITHOUT 3 [*Cinnamomum osmophloeum*, *Gordonia axillaris*, *Michelia compressa*, *Morus australis*, *Osmanthus matsumuranus*, *Symplocos konishii*] AND WITHOUT 3 [*Elaeocarpus japonicus*, *Elaeocarpus sylvestris*, *Ficus erecta* var. *beecheyana*, *Juglans cathayensis*, *Sloanea formosana*, *Symplocos heishanensis*, *Turpinia ternata*] AND WITHOUT 3 [*Ailanthus altissima* var. *tanakai*, *Alnus formosana*, *Eurya crenatifolia*, *Fraxinus griffithii*, *Idesia polycarpa*, *Ligustrum sinense*, *Stachyurus himalaicus*, *Swida controversa*, *Ulmus uyematsui*] AND WITHOUT 3 [*Callicarpa formosana*, *Cinnamomum insularimontanum*, *Helicia rengetiensis*, *Hydrangea chinensis*, *Ilex goshiensis*, *Neolitsea konishii*, *Pittosporum illicioides*, *Viburnum foetidum* var. *rectangulatum*] AND WITHOUT 3 [*Cephalotaxus wilsoniana*, *Cyclobalanopsis stenophylloides*, *Eurya leptophylla*, *Picea morrisonicola*, *Prunus spinulosa*, *Quercus spinosa*, *Rhododendron rubropilosum*, *Sinopanax formosana*] AND WITHOUT 3 [*Callicarpa randaiensis*, *Camellia tenuifolia*, *Cleyera japonica*, *Helwingia japonica* subsp. *taiwaniana*, *Ilex ficoidea*, *Schima superba*]......................................2.11

18 WITH 3 [*Diplazium amamianum*, *Diplazium kawakamii*, *Microsorium buergerianum*, *Monachosorum henryi*, *Pellionia radicans*, *Pilea aquarum* subsp. *brevicornuta*, *Pilea rotundinucula*, *Polystichum hancockii*] AND WITH 3 [*Chamaecyparis formosensis*, *Cyclobalanopsis stenophylloides*, *Litsea acuminata*, *Machilus japonica*, *Machilus zuihoensis* var. *mushaensis*, *Pasania kawakamii*] AND WITH 3 [*Arachniodes festina*, *Arachniodes rhomboidea*, *Itea parviflora*, *Piper kadsura*, *Tetrastigma umbellatum*, *Urtica thunbergiana*] AND WITH 3 [*Ardisia crenata*, *Cyrtomium hookerianum*, *Damnacanthus indicus*, *Eurya loquaiana*, *Hydrangea integrifolia*, *Plagiogyria euphlebia*, *Polypodium formosanum*, *Polystichum parvipinnulum*, *Prunus phaeosticta*] AND WITHOUT 3 [*Asplenium antiquum*, *Asplenium wilfordii*, *Davallia mariesii*, *Embelia lenticellata*, *Lemmaphyllum microphyllum*, *Oplismenus hirtellus*] AND WITHOUT 3 [*Camellia caudata*, *Castanopsis fabri*, *Cyathea spinulosa*, *Lagerstroemia subcostata*, *Phoebe formosana*, *Saurauia tristyla* var. *oldhamii*, *Turpinia ternata*] AND WITHOUT 3 [*Castanopsis cuspidata* var. *carlesii*, *Cyclobalanopsis morii*, *Cyclobalanopsis sessilifolia*, *Litsea morrisonensis*, *Neolitsea acuminatissima*, *Symplocos formosana*, *Trochodendron aralioides*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*] AND WITHOUT 3 [*Beilschmiedia erythrophloia*, *Elaeocarpus japonicus*, *Eriobotrya deflexa*, *Michelia compressa*, *Osmanthus matsumuranus*, *Sloanea formosana*, *Tricalysia dubia*, *Turpinia formosana*] AND WITHOUT 3 [*Cinnamomum subavenium*, *Crepidomanes bilabiatum*, *Lasianthus fordii*, *Microtropis fokienensis*, *Pyrenaria shinkoensis*, *Symplocos wikstroemiifolia*] AND WITHOUT 3 [*Alnus formosana*, *Carpinus rankanensis*, *Celtis sinensis*, *Juglans cathayensis*, *Morus australis*, *Stachyurus himalaicus*, *Ulmus uyematsui*] AND WITHOUT 3 [*Callicarpa formosana*, *Cinnamomum insularimontanum*, *Gordonia axillaris*, *Hydrangea chinensis*, *Oplismenus compositus*, *Rhododendron leptosanthum*] AND WITHOUT 3 [*Aucuba chinensis*, *Eurya crenatifolia*, *Eurya strigillosa*, *Illicium arborescens*, *Neolitsea aciculata*, *Picea morrisonicola*, *Skimmia reevesiana*, *Viburnum taitoense*].................2.11

19 WITH 3 [*Acer kawakamii*, *Chamaecyparis formosensis*, *Cyclobalanopsis morii*, *Neolitsea acuminatissima*, *Tsuga chinensis* var. *formosana*] AND WITH 3 [*Eurya leptophylla*, *Eurya loquaiana*, *Microtropis fokienensis*, *Rhododendron pseudochrysanthum*, *Rubus formosensis*, *Rubus kawakamii*, *Yushania niitakayamensis*] AND WITH 2 [*Arachniodes rhomboidea*, *Dryopteris formosana*, *Dryopteris lepidopoda*, *Plagiogyria formosana*, *Polygonum chinense*, *Polystichum parvipinnulum*] AND WITH 2 [*Eurya glaberrima*, *Litsea elongata* var. *mushaensis*, *Litsea morrisonensis*, *Pasania hancei* var. *ternaticupula*, *Symplocos morrisonicola*, *Trochodendron aralioides*] AND WITHOUT 3 [*Cyclobalanopsis sessilifolia*, *Fatsia polycarpa*, *Ilex goshiensis*, *Machilus japonica*, *Pasania kawakamii*, *Symplocos arisanensis*, *Symplocos heishanensis*, *Symplocos migoi*, *Symplocos stellaris*] AND WITHOUT 3 [*Castanopsis cuspidata* var. *carlesii*,

Chamaecyparis obtusa var. *formosana*, *Dendropanax dentiger*, *Machilus thunbergii*, *Pourthiaea beauverdiana* var. *notabilis*, *Rhododendron leptosanthum*, *Schefflera taiwaniana*] AND WITHOUT 3 [*Ellisiophyllum pinnatum*, *Microsorium buergerianum*, *Monachosorum henryi*, *Ophiopogon intermedius*, *Polypodium argutum*, *Strobilanthes rankanensis*, *Urtica thunbergiana*, *Woodwardia unigemmata*] AND WITHOUT 3 [*Cleyera japonica*, *Daphniphyllum glaucescens* subsp. *oldhamii*, *Gordonia axillaris*, *Ilex hayataiana*, *Ilex tugitakayamensis*, *Pseudotsuga wilsoniana*, *Symplocos glauca*, *Ternstroemia gymnanthera*] AND WITHOUT 3 [*Alnus formosana*, *Deutzia pulchra*, *Lyonia ovalifolia*, *Pieris taiwanensis*, *Pinus taiwanensis*, *Pittosporum illicioides*, *Rhododendron rubropilosum*] AND WITHOUT 2 [*Berberis kawakamii*, *Euonymus spraguei*, *Hydrangea chinensis*, *Symplocos formosana*, *Symplocos modesta*] AND WITHOUT 3 [*Cephalotaxus wilsoniana*, *Cyclobalanopsis stenophylloides*, *Eurya leptophylla*, *Picea morrisonicola*, *Prunus spinulosa*, *Quercus spinosa*, *Rhododendron rubropilosum*, *Sinopanax formosana*] AND WITHOUT 3 [*Daphniphyllum himalaense* subsp. *macropodum*, *Euonymus spraguei*, *Picea morrisonicola*, *Pittosporum illicioides*, *Pourthiaea beauverdiana* var. *notabilis*, *Sycopsis sinensis*] AND WITHOUT 3 [*Pieris taiwanensis*, *Pinus taiwanensis*, *Rhododendron formosanum*, *Vaccinium bracteatum*, *Vaccinium dunalianum* var. *caudatifolium*, *Vaccinium emarginatum*, *Viburnum sympodiale*, *Viburnum urceolatum*].. 1.03

20 WITH 3 [*Chamaecyparis formosensis*, *Hydrangea integrifolia*, *Neolitsea acuminatissima*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*] AND WITH 3 [*Cyclobalanopsis stenophylloides*, *Elatostema trilobulatum*, *Eurya leptophylla*, *Hedera rhombea* var. *formosana*, *Lonicera acuminata*, *Pasania hancei* var. *ternaticupula*, *Plagiogyria formosana*] AND WITH 3 [*Ainsliaea latifolia* subsp. *henryi*, *Carex brunnea*, *Cephalotaxus wilsoniana*, *Cyclobalanopsis morii*, *Eurya glaberrima*, *Litsea morrisonensis*, *Trochodendron aralioides*, *Viburnum foetidum* var. *rectangulatum*] AND WITHOUT 3 [*Daphniphyllum himalaense* subsp. *macropodum*, *Euonymus spraguei*, *Picea morrisonicola*, *Pittosporum illicioides*, *Pourthiaea beauverdiana* var. *notabilis*, *Sycopsis sinensis*] AND WITHOUT 3 [*Camellia brevistyla*, *Damnacanthus indicus*, *Microsorium buergerianum*, *Ophiopogon intermedius*, *Prunus phaeosticta*, *Rhododendron leptosanthum*, *Rhododendron rubropilosum*, *Vaccinium japonicum* var. *lasiostemon*] AND WITHOUT 3 [*Castanopsis cuspidata* var. *carlesii*, *Cyclobalanopsis sessilifolia*, *Plagiogyria euphlebia*, *Smilax arisanensis*, *Stauntonia obovatifoliola*, *Symplocos arisanensis*, *Viburnum urceolatum*] AND WITHOUT 3 [*Berberis kawakamii*, *Deutzia pulchra*, *Miscanthus floridulus*, *Miscanthus sinensis*, *Pieris taiwanensis*, *Pinus taiwanensis*, *Pseudotsuga wilsoniana*, *Smilax menispermoidea*] AND WITHOUT 3 [*Carpinus rankanensis*, *Cinnamomum insularimontanum*, *Daphniphyllum glaucescens* subsp. *oldhamii*, *Elaeagnus thunbergii*, *Eurya chinensis*, *Litsea elongata* var. *mushaensis*, *Mahonia oiwakensis*, *Pileostegia viburnoides*] AND WITHOUT 3 [*Abies kawakamii*, *Acer kawakamii*, *Ilex bioritsensis*, *Ligustrum morrisonense*, *Luzula taiwaniana*, *Quercus spinosa*, *Viburnum betulifolium*, *Viburnum parvifolium*] AND WITHOUT 3 [*Elaeocarpus japonicus*, *Ilex ficoidea*, *Ilex formosana*, *Ilex hayataiana*, *Ilex pedunculosa*, *Rhododendron formosanum*] AND WITHOUT 3 [*Cephalotaxus wilsoniana*, *Cyclobalanopsis stenophylloides*, *Eurya leptophylla*, *Picea morrisonicola*, *Prunus spinulosa*, *Quercus spinosa*, *Rhododendron rubropilosum*, *Sinopanax formosana*].. 1.03

21 WITH 3 [*Chamaecyparis formosensis*, *Litsea acuminata*, *Litsea elongata* var. *mushaensis*, *Machilus japonica*, *Neolitsea acuminatissima*, *Pasania kawakamii*, *Symplocos morrisonicola*] AND WITH 3 [*Arachniodes rhomboidea*, *Dryopteris formosana*, *Microsorium buergerianum*, *Pellionia radicans*, *Plagiogyria euphlebia*, *Plagiogyria formosana*, *Polystichum parvipinnulum*] AND WITH 3 [*Araiostegia parvipinnata*, *Damnacanthus indicus*, *Eurya leptophylla*, *Eurya loquaiana*, *Hedera rhombea* var. *formosana*, *Hydrangea integrifolia*, *Vittaria flexuosa*] AND WITH 2 [*Acrophorus stipellatus*, *Asplenium normale*, *Elatostema trilobulatum*, *Hydrangea angustipetala*, *Lepisorus monilisorus*, *Mecodium polyanthos*, *Monachosorum henryi*, *Pilea plataniflora*] AND WITHOUT 3 [*Dryopteris lepidopoda*, *Polystichum prionolepis*, *Rubus kawakamii*, *Schefflera taiwaniana*, *Stachyurus himalaicus*, *Tsuga chinensis* var. *formosana*, *Yushania niitakayamensis*] AND WITHOUT 3 [*Castanopsis cuspidata* var. *carlesii*, *Cinnamomum subavenium*, *Cleyera japonica* var. *taipinensis*, *Cyclobalanopsis sessilifolia*, *Gordonia axillaris*, *Rhododendron leptosanthum*,

Schima superba, *Sloanea formosana*, *Trochodendron aralioides*] AND WITHOUT 3 [*Ctenitis kawakamii*, *Davallia mariesii*, *Eupatorium cannabinum* subsp. *asiaticum*, *Oplismenus compositus*, *Polygonum thunbergii*, *Polypodium argutum*, *Selaginella involvens*, *Strobilanthes rankanensis*] AND WITHOUT 3 [*Arthromeris lehmannii*, *Athyrium arisanense*, *Diplazium kawakamii*, *Dryopteris sparsa*, *Plagiogyria stenoptera*, *Polystichum biaristatum*, *Polystichum piceopaleaceum*, *Rubus pectinellus*, *Sarcopyramis napalensis* var. *bodinieri*] AND WITHOUT 3 [*Adinandra lasiostyla*, *Carpinus rankanensis*, *Daphniphyllum himalaense* subsp. *macropodum*, *Ilex tugitakayamensis*, *Illicium anisatum*, *Ligustrum pricei*, *Litsea morrisonensis*, *Neolitsea aciculata*, *Neolitsea aciculata* var. *variabillima*, *Prunus phaeosticta*] AND WITHOUT 3 [*Alpinia intermedia*, *Diplazium dilatatum*, *Ellisiophyllum pinnatum*, *Nephrolepis auriculata*, *Pilea aquarum* subsp. *brevicornuta*, *Polygonum chinense*, *Polystichum hancockii*, *Sarcopyramis napalensis* var. *delicata*, *Selaginella delicatula*] AND WITHOUT 3 [*Cyclobalanopsis morii*, *Dendropanax dentiger*, *Ilex goshiensis*, *Osmanthus heterophyllus*, *Pasania hancei* var. *ternaticupula*, *Picea morrisonicola*, *Pieris taiwanensis*, *Trochodendron aralioides*, *Viburnum foetidum* var. *rectangulatum*] AND WITHOUT 3 [*Adinandra formosana*, *Beilschmiedia erythrophloia*, *Cyclobalanopsis stenophylloides*, *Daphniphyllum glaucescens* subsp. *oldhamii*, *Elaeocarpus sylvestris*, *Engelhardia roxburghiana*, *Ficus erecta* var. *beecheyana*, *Helicia formosana*, *Illicium arborescens*, *Lithocarpus amygdalifolius*, *Lithocarpus lepidocarpus*] AND WITHOUT 3 [*Acer kawakamii*, *Acer morrisonense*, *Acer serrulatum*, *Alnus formosana*, *Lyonia ovalifolia*, *Photinia niitakayamensis*, *Pinus morrisonicola*, *Pinus taiwanensis*] 2.09

Curriculum Vitae

Ching-Feng Li (Woody)

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EDUCATION

Master (1994–1997):

Department of Forestry, Faculty of Agriculture, National Taiwan University, Taipei, Taiwan.

Thesis: *Vegetation succession of the Machilus-Castanopsis zone in the north-western region of Taiwan*.

Bachelor (1989–1994):

Department of Forestry, Faculty of Agriculture, National Taiwan University, Taipei, Taiwan.

WORKING EXPERIENCE

2009–present: Research Assistant at Masaryk University, Czech Republic

1. Species richness and heterogeneity of oak forest in the Czech Republic.
2. Cloud forest in Taiwan.
3. Beta-diversity along the elevation gradient in Taiwan.
4. Beta-diversity of oak forest in the Czech Republic.

2006: One-year research visit in the Czech Republic.

1. Comparison of IVI and the Braun-Blanquet scale.
2. Input of the Taiwanese vegetation database into Turboveg and JUICE.

1999–2006: Research assistant in Taiwan.

1999–2003 in the Institute of Wildlife Conservation, National Pingtung University of Science and Technology

1. Seed dispersal by frugivorous birds in a tropical forest.

2. Ecological observation of Mandarin duck.

3. Survey of mammals and birds in the southern part of Taiwan.

2003–2006 in Faculty of Forestry, National Taiwan University

1. Vegetation survey and mapping project.

2. Succession of coastal forest.

1997–1999: Army duty in Taiwan.

RESEARCH SKILLS

Experimental design; Field survey (including plants, birds and mammals in Taiwan); Telemetry; Software operation including R program, ArcGIS (ArcMap), Turboveg and JUICE.

LANGUAGES

Mandarin Chinese, Taiwanese, English

FIELDS OF INTEREST

Vegetation ecology (focus on subtropical mountain forest vegetation), seed dispersal, behavioural ecology, conservation biology and macroecology.

PUBLICATIONS IN SCI JOURNALS

2013

Li, C.-F., Chytrý, M., Zelený, D., Chen, M.-Y., Chen, T.-Y., Chiou, C.-R., Hsia, Y.-J., Liu, H.-Y., Yang, S.-Z., Yeh, C.-L., Wang, J.-C., Yu, C.-F., Lai, Y.-J., Chao, W.-C. & Hsieh, C.-F. 2013. Classification of Taiwan forest vegetation. *Applied Vegetation Science* 16: 698–719.

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2010

Chytrý, M., Danihelka, J., Axmanová, I., Božková, J., Hettenbergerová, E., **Li, C.-F.**, Rozbrojová, Z., Sekulová, L., Tichý, L., Vymazalová, M. & Zelený, D. 2010. Floristic diversity of an eastern Mediterranean dwarf shrubland: the importance of soil pH. *Journal of Vegetation Science* 21: 1125–1137.

Zelený, D., **Li, C.-F.** & Chytrý, M. 2010. Pattern of local plant species richness along a gradient of landscape topographical heterogeneity: result of spatial mass effect or environmental shift? *Ecography* 33: 578–589.

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Sun, Y., Wang, Y. & **Li, C.** 2000: Habitat selection by Tawny fish-owl (*Ketupa flavipes*) in Taiwan. *Journal of Raptor Research* 34: 102-107.

PRESENTATIONS AT INTERNATIONAL CONFERENCES

Li, C.-F., Zelený, D., Chen, T.-Y. & Hsieh, C.-F. 2013. *Chamaecyparis* forest in Taiwan. The 56th symposium of the International Association for Vegetation Science. Tartu, Estonia. (Oral presentation in English).

Li, C.-F., Zelený, D., T.-Y. Chen, Hsieh, C.-F. & Chytrý, M. 2013. Distance decay of floristic composition along temperature and moisture gradient in Taiwan. The 6th biennial conference of International Biogeography Society. Miami, Florida, USA. (Poster presentation in English).

Li, C.-F., Zelený, D., Chen T.-Y. & Hsieh, C.-F. 2012. Distance decay of floristic composition along temperature and moisture gradient in Taiwan. The 55th symposium of the International Association for Vegetation Science. Mokpo, Korea. (Oral presentation in English).

Li, C.-F. & Zelený, D. 2012. Use of supervised classification method in a region without long phytosociological tradition: case study from Taiwan. The 21st international workshop of European Vegetation Survey. Vienna, Austria. (Oral presentation in English).

Li, C.-F., Tichý, L., Zelený, D., Chytrý, M., Lai, Y.-J., Hsieh, C.-F., Chen, M.-Y., Chen, T.-Y., Chiou, C.-R., Hsia, Y.-J., Liu, H.-Y., Yang, S.-Z., Yeh, C.-L. & Wang, J.-C. 2010. Hump-shaped species richness pattern along elevation gradient in Taiwan: a result of mid-domain effect or heterogeneity? The 95th annual meeting of Ecological Society of America. Pittsburgh, Pennsylvania, USA. (Poster presentation in English).

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TEACHING EXPERIENCE

2008–2013 Field course of Geobotany. Teaching assistant. Brno, Czech Republic.

2012 Analysis of community ecology data in R program. Teaching assistant. Rome, Italy. http://www.davidzeleny.net/anadat-r/doku.php/en:anadat-r

2008 JUICE workshop on the 17th international workshop of European Vegetation Survey. Teaching assistant. Brno, Czech Republic.

2007 JUICE workshop. Teaching assistant. Taipei & Pingtung, Taiwan.

AWARDS

2012 The best oral presentation of a young scientist at the 55th Symposium of the International Association for Vegetation Science, Mokpo, Korea. http://www.iavs.org/AwardsPresentation.aspx

2009 The best oral presentation of research assistant in the group of Ecology and Conservation at the Symposium of Chinese Forestry Association in the 98th calendar year of Republic of China (Taiwan), Taichung, Taiwan.