

Some prospects for managing *peltata*.

*William Stuart Kirkham**

Introduction

Merremia peltata is a species of liana of the family Convolvulaceae that has been identified as an invasive species of environmental concern in several Pacific Island Countries, including Samoa (Meyer, 2000, Space and Flynn, 2002). This plant species is not well understood, especially in regard to its invasive behavior and how best to manage it. This paper presents preliminary results from a year-long research project investigating the distribution and vegetative communities of *M. peltata* across a lowland area of Samoa, in which the landscape has undergone several periods of disturbance, both natural and anthropogenic, and exhibits varying degrees of recovery and invasion. Studied by itself, *M. peltata* suppresses species diversity when it acts as ground cover and also aids the spread of other vines such as *Mikania micrantha*, but appears to support species diversity when it is in canopy. Furthermore, certain native pioneering tree species appear to be able to compete successfully with *Merremia peltata*, and the common lowland forest species *Pometia pinnata* appears to be resilient against the vine. When vegetation communities are analyzed on a landscape scale, plots dominated by *M. peltata* ground cover show a greater similarity to lowland rainforest than to plots located in the coconut zone, dominated by non-native invasive ground cover, more frequently disturbed by people and livestock, and showing different paths of succession. *M. peltata* thus appears to be a part of the succession inherent to lowland rainforest recovery more so than a species external to the rainforest ecosystem and invading it. Management options, ranging from the most labor and capital intensive to the least, including active planting of trees to shade out *M. peltata*, planting early successional trees such as *Macaranga harveyana* or *Cananga odorata* to uplift it from the ground, followed by planting of forest species at a later date, or simply letting succession occur at its own rate.

Background: *Merremia peltata*, disturbance ecology, tropical cyclones and Samoa

The biology and ecology of *Merremia peltata* are not well understood. While some regard the species as an exotic invader of Pacific Island ecosystems (Meyer, 2000), others identify the plant as a native species likely to be harmful to native ecosystems (Whistler, 1995a, 2002) or as either native or ancient Polynesian introduction behaving invasively (Space and Flynn, 2002). In Samoa, this species occurs up to an elevation of around 300 meters (Whistler 1995a), and thus only affects lowland ecosystems. This species increases its distribution and abundance in two ways, either vegetatively, by sprawling into neighboring areas and rooting from its nodes or by seeds, although early research in the Solomons observed a low seed viability rate, and creeping may thus be its primary means of reproduction (Bacon, 1982). *M. peltata* has apparently been in the Pacific for hundreds of years (Whistler, pers. com.) but has only become invasive in the years following tropical cyclones Ofa (1990) and Val (1991) according to comments from local government officials. Disturbance thus appears to be an ecological contributing factor to this invasion.

Disturbance is an important topic in regard to the ecology of invasions. The idea of the ecosystem is based in so-called “equilibrium-based” ecologies, where an ecosystem is viewed as a closed and bound assemblage of species that tends towards a stable equilibrium or

* Mr. Kirkham is a PhD candidate and former Peace Corps volunteer in Samoa

climax community, and in such views, disturbance is regarded as destroying the ecosystem, whereas ecologists are beginning to widely study ecosystem function inclusive of disturbance (Botkin, 1990). Indeed, many definitions of invasive species are grounded in equilibrium perspectives (Meyer, 2000). Disturbance-based ecological perspectives are beginning to inform studies of plant invasions, suggesting, for instance, that island ecosystems are vulnerable to invasion not because of island species evolving under low competitive pressure but because island ecosystems are vulnerable to disturbances that boost soil nutrients and make island environments more accessible to a wider variety of species (D'Antonio and Dudley, 1995). The vulnerability of islands to disturbance relates to questions of scale.

The spatial and temporal scale of disturbances to the spatial and temporal scale of the affected ecosystem and its processes governs how the vegetation responds to the disturbance. Where the scale of the disturbance is greater than the landscape (such as tropical cyclones acting upon islands) and with greater frequency than successional rates, the ecosystem becomes constituted by those particular disturbance processes and is said to be part of a specific "disturbance regime." Where disturbance is small in relation to the spatial scale of an ecosystem and of short duration and frequency relative to ecosystem processes (such as tree fall), the disturbed areas are quickly reincorporated back into the ecosystem. Where disturbance is of a commensurable spatial and temporal scale to an ecosystem and its processes, transformation of the ecosystem can take place (Turner et al., 2001).

For cyclones, the pattern of disturbance typically relocates biomass and its attendant nutrients to the forest floor as well as increasing temperatures and light availability to the ground (Silver, et al., 1996), which can create opportunities for species invasion. Recovery of the canopy occurs in a few years at low levels of tree mortality (Scatena et al. 1996), and soil nutrients also rapidly return to pre-cyclone levels in a few months (Silver et al., 1996), so with cyclone disturbance, the window of opportunity for invasives to become established is short. Also, managed forest areas, where trees are planted in ways to maximize individual tree growth, show a higher rate of mortality than non-managed areas and different recovery paths (Fu, et al. 1996).

For Samoa, several vectors of disturbance have been acting on lowland ecosystems for several hundred years. Kirch (1984) indicates that Samoa, on an archeological time scale, has been subjected to a high frequency of cyclones. Whistler (1995b) describes the growth of tree height as being limited by frequent cyclones. It thus appears that the time between cyclones is shorter (even at one hundred year intervals) than the life span of the forest trees, and Samoa's ecology likely represents a cyclone disturbance regime. Most economic activity, from ancient time to present, has been concentrated in the lowland areas and has occurred on spatial and temporal scales similar to that of lowland forest ecosystems and their processes, and have thus been more transformative, possibly altering successional pathways and contributing to the diversity of lowland forest types (Mueller-Dombois and Fosberg, 1998). For the *Merremia peltata* invasion, the feedback between the social and biotic environments resulting from Cyclones Ofa and Val, the expansion of taro plantations for export and food security and the subsequent taro blight have all contributed to creating conditions for the invasion. The high mortality rates to trees from the cyclones, coupled with the loss of vertebrate dispersers and their habitat has likely slowed down recovery times and increased vulnerability to invasions (Elmqvist, et al., 1994). The expansion of taro plantations that peaked at the time of the blight occurred at a rate greater than population growth and represented the greatest disturbance to lowland rainforest ecosystems in at least the past century (Paulson, 1993). The disturbance was short-lived, relative to ecosystem

processes, and may not have occurred at a sufficient temporal scale to affect permanent change despite its occurrence on a commensurable spatial scale.

Study site and methods

Research was carried out in the village of Fa,ala on the island of Savai'i. Being a participant in the Tafua Peninsula Rainforest Preserve agreement, the village possesses land in the lowland region in various degrees of forestation, intensity of use and recovery. As such, it represents an ideal location for examining *Merremia peltata* across a wide range of habitats.

A total of 27 sample plots were studied across the village lands ranging from elevations just below 300 meters to lower elevations in the peninsula. Plots were selected randomly in a Geographic Information System and programmed into a handheld GPS unit. Plot size was 10 X 10 meters, and cover estimates were obtained by running transects diagonally across the quad, with 29 points separated by a distance of 1 meter each. Species occurring at each point were recorded as ground cover (below 2 meters height) or canopy (above 2 meters height). All stem diameters greater than 1 centimeter were also measured. Other environmental variables, such as physical and chemical soil properties and light availability, were also collected, but are not included in this preliminary analysis.

Analysis at this point centers around cover information for the species collected from each plot. The occurrence of each species at each transect point is expressed as a percentage of total points in the plot (species occurrence as a percentage of 29). One level of analysis involves constructing scatter plots of individual species against others species or against other factors such percentage of canopy in general or number of species. Another level of analysis examines the structure of the vegetation community in plots, disaggregating the data into classifications of vines, non-vine ground cover and non-vine canopy, plotting the number of species of each found at each transect point. A third level studies the plots on a landscape scale, generating a clustered dendrogram (using Euclidean distance measures and Ward's method of establishing linkages, McCune and Grace, 2002) to discern groupings of similarity of species communities. Finally, the diameter measurements of the various tree species were plotted against each other for each plot as a means of identifying successional stages. Combing these four levels of analysis provides a detailed understanding of how *Merremia peltata* functions in these lowland ecosystems.

Findings

The findings presented here suggest that while there may be some biodiversity concerns regarding *Merremia peltata* in the short term, this species appears to function as a successional component of lowland forest ecosystems. Viewed in this light, management concerns revolve around the question of how to quickly restore ecological services by accelerating successional processes.

Figure 1 depicts several scatter plots relating *Merremia peltata* cover in each plot to the total number of species in each, disaggregated by whether *M. peltata* acts as ground cover or as a component of the canopy, relating *M. peltata* cover to the amount of canopy, and also relating this species to *Mikania micrantha* cover. *Merremia peltata* occurred in 22 of the 27 plots and occurred in 52% of the total number of in-plot transect points. *Mikania micrantha* occurred in 24 plots and in 43% of transect points. By comparison, *Nephrolepis hirsutula* is the next most common species, occurring in 16 plots and 22% of transect points (Table 1 shows the frequency of occurrence and overall ground cover for the plant species representing at least 5% total ground cover). Of the 139 total species encountered, these two vines were the most frequent and accounted for the greatest amount of cover. The two vines are typically

concurrent, although *Mikania micrantha* shows a greater degree of shade tolerance than *Merremia peltata*, and where shading is present, *Merremia peltata* cover thins and *Mikania micrantha* becomes more dominant (note inverse relationship between the two vines at low levels of *Merremia peltata* ground cover, but a direct relationship at higher levels of cover). Note also the strong inverse relationship of *M. peltata* to canopy, except at high levels of canopy cover, where canopy can serve as habitat if the vine can become established. Also, where *M. peltata* ground cover is high, species diversity is low, but the trend is reversed when the vine is in the canopy. Field observations indicate that where the soil is characterized by an irregular bouldery surface (*soata*), or has decaying fallen tree trunks present, such that microclimatic spaces are created between the vine cover and the ground surface, that more species are present, often a wide variety of ferns that are commonly seen in forest understory. The further off the ground the *M. peltata* is, the better the biodiversity it seems. Indeed, when this vine is in the canopy, it appears to rapidly cover gaps, preventing light from reaching the forest floor and altering successional pathways in favor of more shade tolerant species.

Pometia pinnata appears to be one of those species that benefits from this arrangement. Early field observations appeared to indicate that the older *P. pinnata* trees, probably cyclone survivors, appeared to be somewhat resilient to vines, having few twining up their smooth trunks (often with a mound of vines at the base where the vine mass slipped off under its own weight), and with less in the canopy, or where it was in the canopy, not smothering it very efficiently. Given that *P. pinnata* is one of the most common lowland rainforest species, especially in this area (Whistler, 2002, Mueller-Dombois and Fosberg, 1998, Elmqvist et al., 1994) and that it exhibits an elevational range commensurate with *Merremia peltata* (up to 500 meters, Whistler, 2002), and given the vines long presence in the country, it may be likely that these two species are linked successional, and that *Merremia peltata* may select for the high frequency of *Pometia pinnata*. Also, quite often where a plot occurred upslope and appeared to be a fallowed taro plantation, with no standing trees and almost completely covered in *M. peltata*, there were frequently large remnant *P. pinnata* trees nearby; the greatest levels of vine infestation appeared to be occurring in areas of recently cleared *Pometia* forest. Figure 2 details the empirical data regarding *Pometia pinnata* from the study plots. This tree species appears to be extremely sensitive to groundcover, only becoming frequent under high percentages of canopy. It appears to need to have competing groundcover shaded out in order to become established. There is also a strong direct relationship between total *P. pinnata* coverage and occurrence of *Merremia peltata* in the canopy. Similar graphs for *Rhus taitensis* are provided for comparison. Although there is a similar response between the two tree species to canopy coverage and *Merremia peltata* groundcover, *Rhus taitensis* is not prominently featured under *M. peltata* dominated canopy. There thus appears to be a relationship between the *Merremia peltata* and *Pometia pinnata*, but this suggests that there is an intermediate successional step between this vine and tree; there has to be a canopy for the vine to be in before *P. pinnata* succession can begin.

Macaranga harveyana and *Cananga odorata* are two species frequently observed in and around plots dominated by *Merremia peltata* ground cover. Figure 3 depicts several scatter plots. *Macaranga harveyana* displays a greater correlation to high incidents of *Merremia peltata* groundcover than to the vine in the canopy. *Cananga odorata* shows a greater similarity to *Pometia pinnata* in response to *Merremia peltata*, with the notable exception of being less sensitive to the vine as groundcover. Figure 4 depicts stem diameter measurements for various plots. Plots 15 and 18 are both early successional plots, depicting close relationships between *Macaranga harveyana* and *Cananga odorata*. Plots 48 and 51 lie

in the peninsula forest, and show *Pometia pinnata* following *C. odorata* in succession, followed closely by other native forest species. Further evidence linking *Merremia peltata* to forest ecosystems is given by Figure 5, depicting the cluster dendrogram displaying grouped similarity of vegetation community. Figure 6 gives some typical examples of vegetation structure from the broad groupings. Group I from the dendrogram are plots that are dominated by *Merremia peltata*, with the plots in Group Ia having structures dominated by the vines *M. peltata* and *Mikania micrantha*. Group Ib have structures dominated by forest species, with canopy being the leading component. Group II are areas best described as being in the “coconut zone” with *Cocos nucifera* being the dominant on the landscape and weedy non-native groundcover being the dominant structural characteristic. Interestingly, the canopy-dominant plots of Group Ib represent an ecological community more similar to the vine dominated plots of Group Ia than to Group II. This suggests an ecological connection between the vine and canopy dominated structures. Some plots display characteristics of both Group I and Group II communities; frequency of human use appears to shift classification towards Group II, however. Table 1 also depicts how the cover of the dominant plant species disaggregates across Group I and Group II, and it reveals that most non-native weedy species are associated more with Group II plots, and suggests competitive exclusion of these species by *Merremia peltata*, and that this vine may be an important species in reclaiming native habitat from non-natives. Notable exceptions include *Mikania micrantha*, *Dioscorea bulbifera* and *Funtumia elastica* which show similar coverage across both Groups I and II.

Conclusions and recommendations

The cyclones of the early 1990s, the expansion of the taro zone for export and the taro blight of 1993 have combined to affect a large scale disturbance across the entire lowland area, opening large areas of habitat for *Merremia peltata* invasion. *Merremia peltata* appears to be part of the natural *Pometia pinnata* forest succession. Areas of recently export-expanded taro zone have occurred at a smaller time scale than ecological processes and are rapidly being reincorporated back into a forest ecosystem. As resource pressure on the coconut zone eases, and disturbance of some areas become less frequent, these areas of longer-duration disturbance are showing early signs of re-incorporation. In lowland rainforest, the vine is acting to close gaps in the canopy and alter successional pathways away from pioneer species and toward more shade-tolerant ones. One option for management is simply to do nothing, and allow nature to take its course.

The loss of ecological services associated with deforestation, for example the disruption of hydrological processes in vital catchment areas, necessitates an approach that may require more active control of the plant. One option is to exploit its shade intolerance and plant trees to shade it out. This technique is labor intensive, however, in that not only will trees need to be planted, but they must be tended to prevent the vines from getting into the canopy. There may be other problems associated with targeting the plant itself, in that other species such as *Mikania micrantha* are likely to become more dominant as the *Merremia peltata* recedes. This could be an option to pursue in conjunction with community forestry objectives, where individual households opting into the program could tend their trees or whereby simply performing other activities on the same land could provide sufficient disturbance to suppress the *Merremia peltata*.

A third option involves co-opting *Merremia peltata*. As ground cover, *Merremia peltata* suppresses the other non-native weeds that would likely be present as ground cover in its absence (*Mikania micrantha* excepted). In the canopy, it helps to hand succession over from

pioneer species to those more resembling climax species. An option may be to plant areas of *Merremia peltata* groundcover first with *Macaranga harveyana* and later with *Cananga odorata*, then following up with *Pometia pinnata* and other forest species. Scattering seeds, rather than establishing seedlings in nurseries, may be sufficient for this method. The low labor input and its self-maintaining strategy may make this a viable option.

References

- Bacon, P. S. 1982. The weedy species of *Merremia* (Convolvulaceae) occurring in the Solomon Islands and a description of a new species. *Botanical Journal of the Linnean Society* 84: 257-264.
- Botkin, Daniel. 1990. *Discordant Harmonies: a New Ecology for the Twenty-First Century*. New York: Oxford University Press.
- D'Antonio, C. M. and T. L. Dudley. 1995. Biological Invasions as Agents of Change on Islands Versus Mainlands. In *Islands: Biological Diversity and Ecosystem Function*. Vitousek, P.M., L. L. Loope, and H. Anderson, eds. Berlin: Springer.
- Elmqvist, Thomas, William E. Rainey, Elizabeth D. Pierson and Paul A. Cox. 1994. Effects of Tropical Cyclones Ofa and Val on the Structure of a Samoan Lowland Rainforest. *Biotropica* 26: 384-391.
- Fu, Shenglei, Carlos Rodríguez Pedraza and Ariel E. Lugo. 1996. A Twelve Year Comparison of Stand Changes in a Mahogany Plantation and a Paired Natural Forest of Similar Age. *Biotropica* 28 (4a): 515-524.
- Kirch, Patrick Vinton. 1984. *The Evolution of Polynesian Chiefdoms*. Cambridge: Cambridge University Press.
- McCune, Bruce and James B. Grace. 2002. *Analysis of Ecological Communities*. Glendon Beach, Oregon: MJM Software Design.
- Meyer, Jean-Yves. 2000. Preliminary review of the invasive plants in the Pacific islands (SPREP Member Countries). In *Invasive species in the Pacific: A technical review and draft regional strategy*. Greg Sherley, ed. Samoa: South Pacific Regional Environment Program.
- Mueller-Dombois, Dieter and F. Raymond Fosberg. 1998. *Vegetation of the Tropical Pacific Islands*. New York: Springer.
- Paulson, Deborah D. 1993. Understanding Tropical Deforestation: the Case of Western Samoa. *Environmental Conservation* 21: 326-332.
- Scatena, F. N., S. Moya, C. Estrada, and J. D. Chinea. 1996. The First Five Years in the Reorganization of Aboveground Biomass and Nutrient Use Following Hurricane Hugo in the Bisley Experimental Watersheds, Luquillo Experimental Forest, Puerto Rico. *Biotropica* 28 (4a): 424-440.
- Silver, Whendee L., Fred N. Scatena, Arthur H. Johnson, Thomas G. Siccama and Fiona Watt. 1996. At What Temporal Scales Does Disturbance Affect Belowground Nutrient Pools? *Biotropica* 28 (4a): 441-457.
- Space, James C. and Tim Flynn. 2002. *Report to the Government of Samoa on Invasive Plant Species of Environmental Concern*. Honolulu: USDA Forest Service Pacific Southwest Research Station Institute of Pacific Island Forestry.
- Turner, Monica G., Robert H. Gardner and Robert V. O'Neill. 2001. *Landscape Ecology in Theory and Practice: Patterns and Process*. New York: Springer-Verlag.
- Whistler, W. Arthur. 2002. *The Samoan Rainforest. A Guide to the Vegetation of the Samoan Archipelago*. Honolulu: Isle Botanica.
- _____. 1995a. *Wayside Plants of the Islands: a Guide to the Lowland Flora of the Pacific Islands*. Honolulu: Isle Botanica.

_____. 1995b. The Cloud Forest of Samoa. In *Tropical Montane Cloud Forests*. L. S. Hamilton, J. O. Juvik and F. N. Scatena, eds. Ecological Studies No. 110. New York: Springer-Verlag.

Species	Origin	Freq.	Cover (%)		
			Total	Group I	Group II
<i>Merremia peltata</i>	N/AI	22	52	45	7
<i>Mikania micrantha</i>	NWT	24	43	25	18
<i>Nephrolepis hirsutula</i>		16	22	6	16
<i>Cocos nucifera</i>	N	12	14	1	13
<i>Oplismenus compositus</i>	PT/AI	15	13	4	9
<i>Eriochloa procera</i>	OWT	8	11	1	10
<i>Blechnum pyramidatum</i>	NWT	13	9	1	8
<i>Hyptis rhomboidea</i>	NWT	9	9	2	7
<i>Cananga odorata</i>	AI	9	8	8	1
<i>Pometia pinnata</i>	N	7	8	7	1
<i>Ruellia prostrata</i>	OWT	12	8	0	8
<i>Dioscorea bulbifera</i>	OWT/AI	15	7	4	3
Fern 1		4	6	6	0
<i>Paspalum conjugatum</i>	NWT	13	6	2	4
<i>Funtumia elastica</i>	OWT	7	5	2	3
Fern 2		14	5	4	1

Table 1. Frequency and cover of all plant species encountered in the survey that account for at least 5% of cover. **Key:** Freq. = Frequency (total number of quads out of a total of 27); Cover = percentage cover across all quadrats in a group, where Total refers to all 27 quadrats and Group I and Group II refer to the groupings in Figure 5; N = Native, AI = Ancient Introduction, PT = Pantropical, OWT = Old World Tropics, NWT = New World Tropics. Source for origins: Whistler 1995a, 2002.

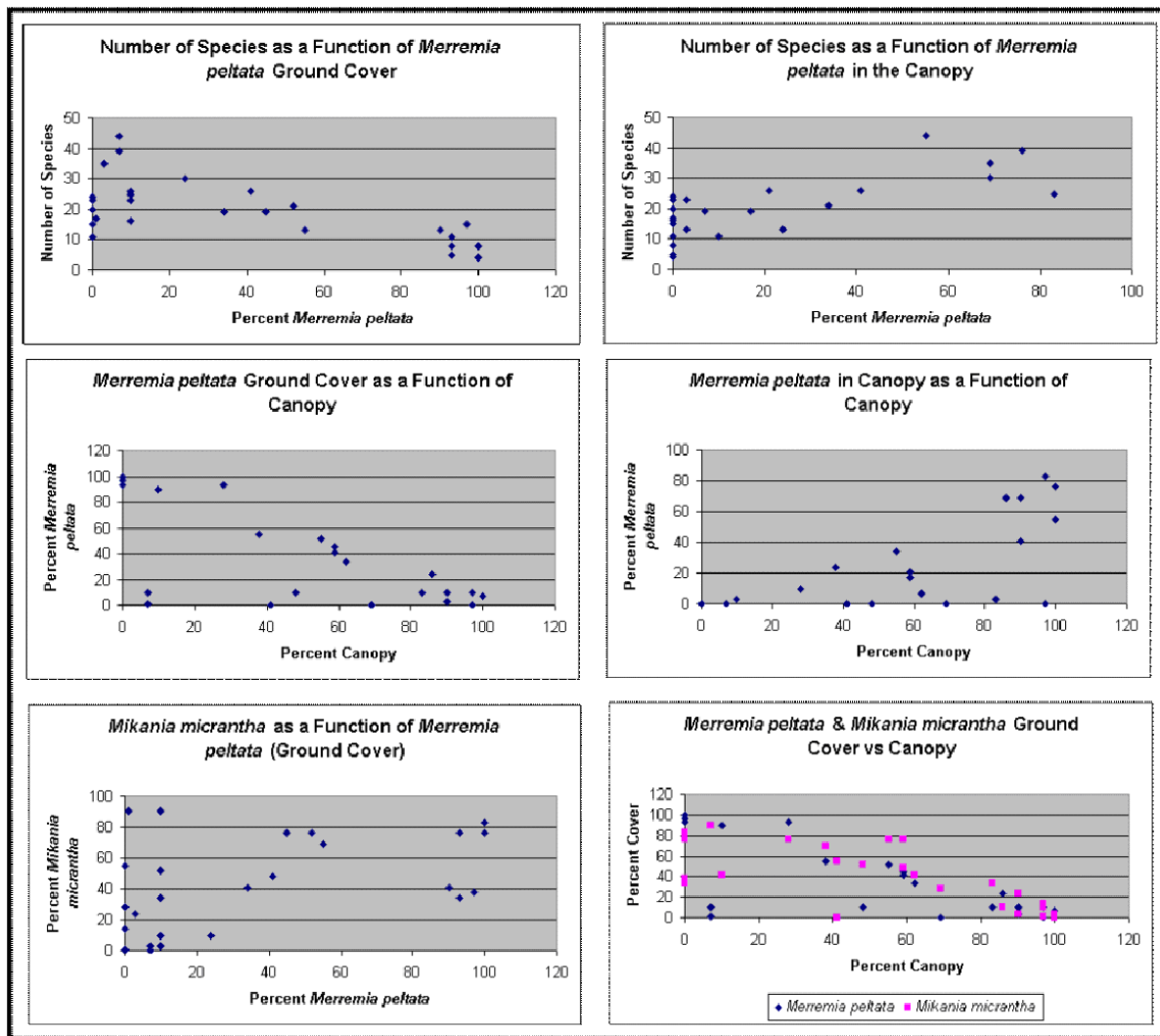


Figure 1. Relationship of *Merremia peltata* to species number, canopy, and *Mikania micrantha*.

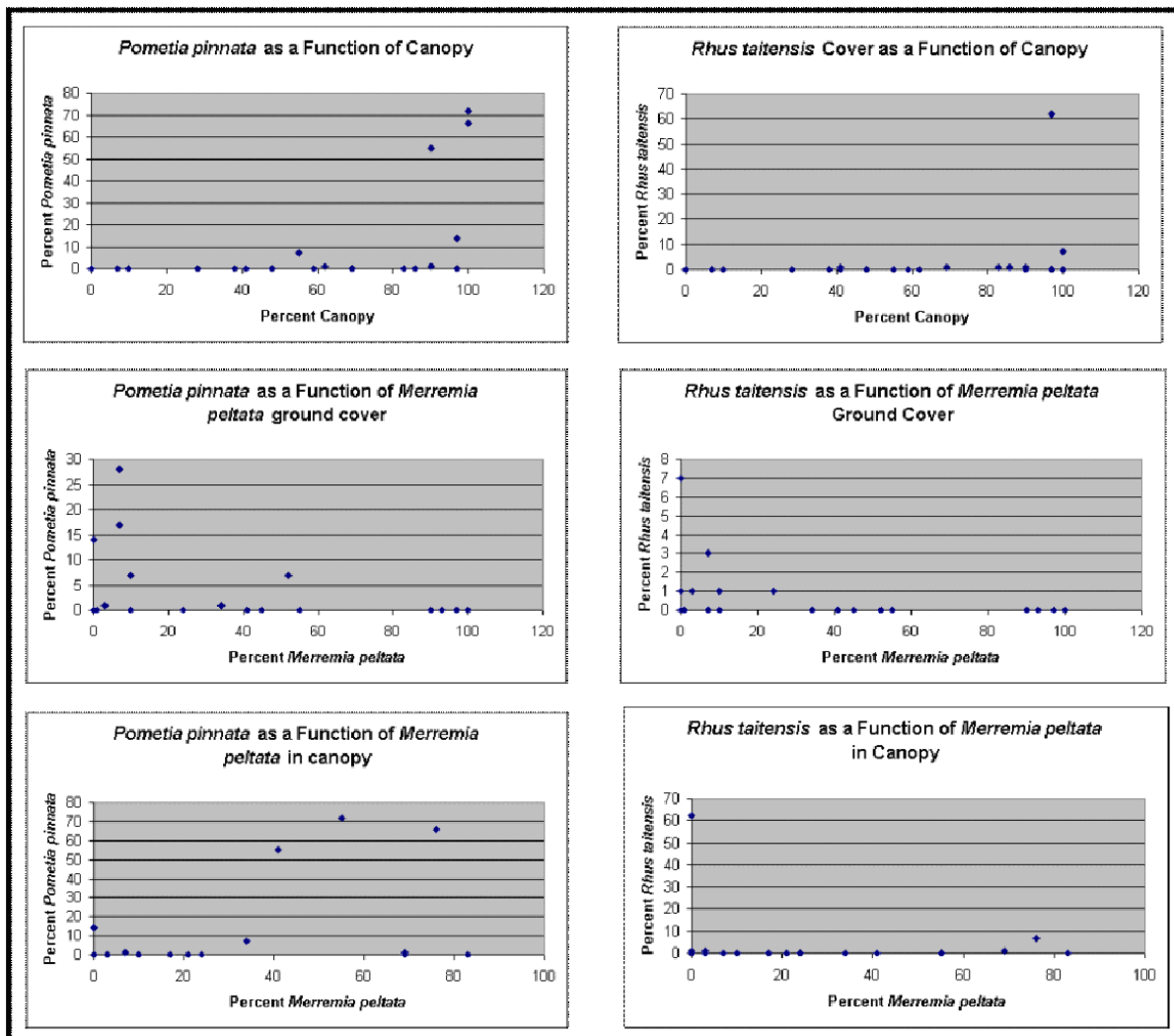


Figure 2. Relationship of *Pomotia pinnata* to canopy and *Merremia peltata*, with comparison to similar relationships for *Rhus taitensis*.

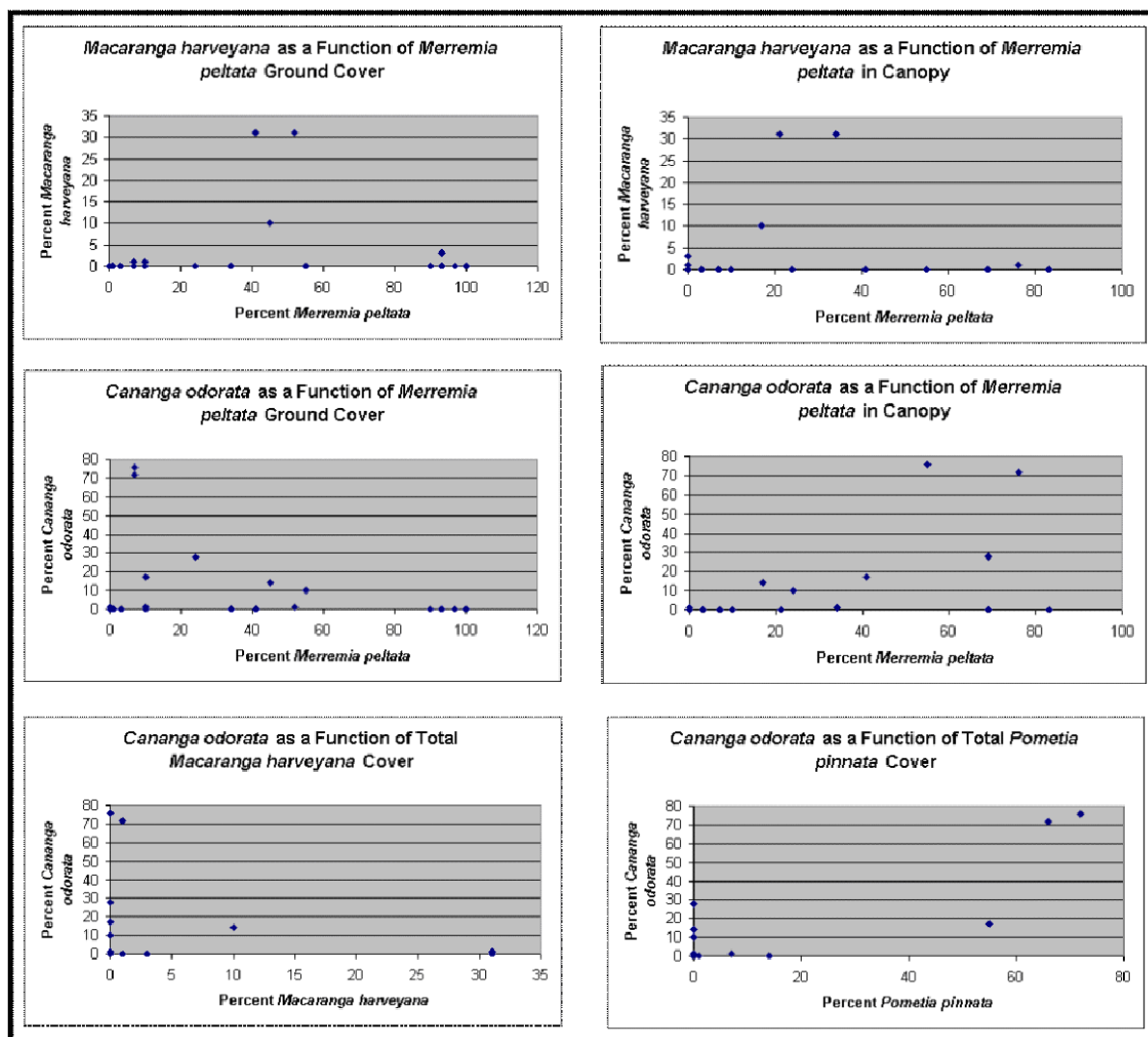


Figure 3. Relationships of *Macaranga harveyana*, *Cananga odorata*, *Pometia pinnata*, and *Merremia peltata*.

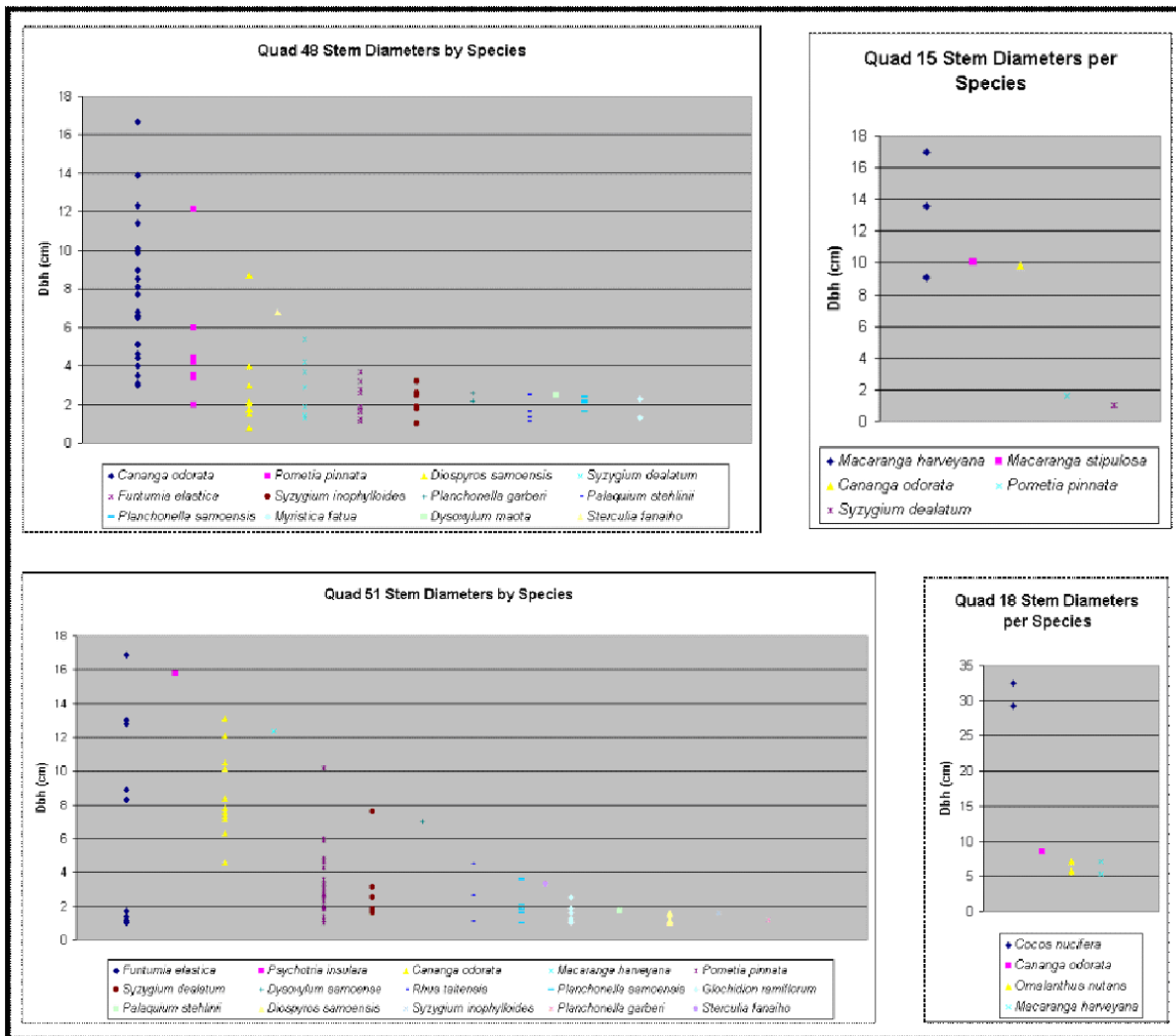


Figure 4. Stem diameters disaggregated by species.

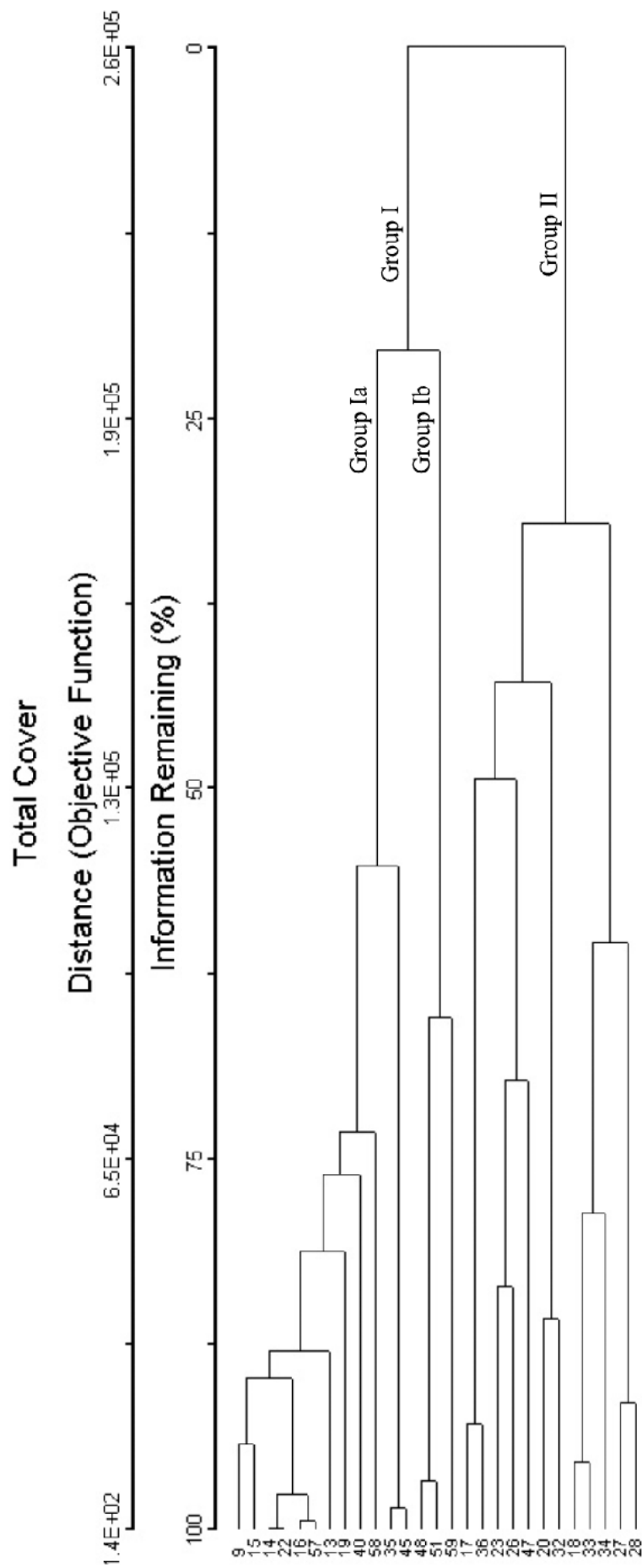


Figure 5. Cluster Dendrogram

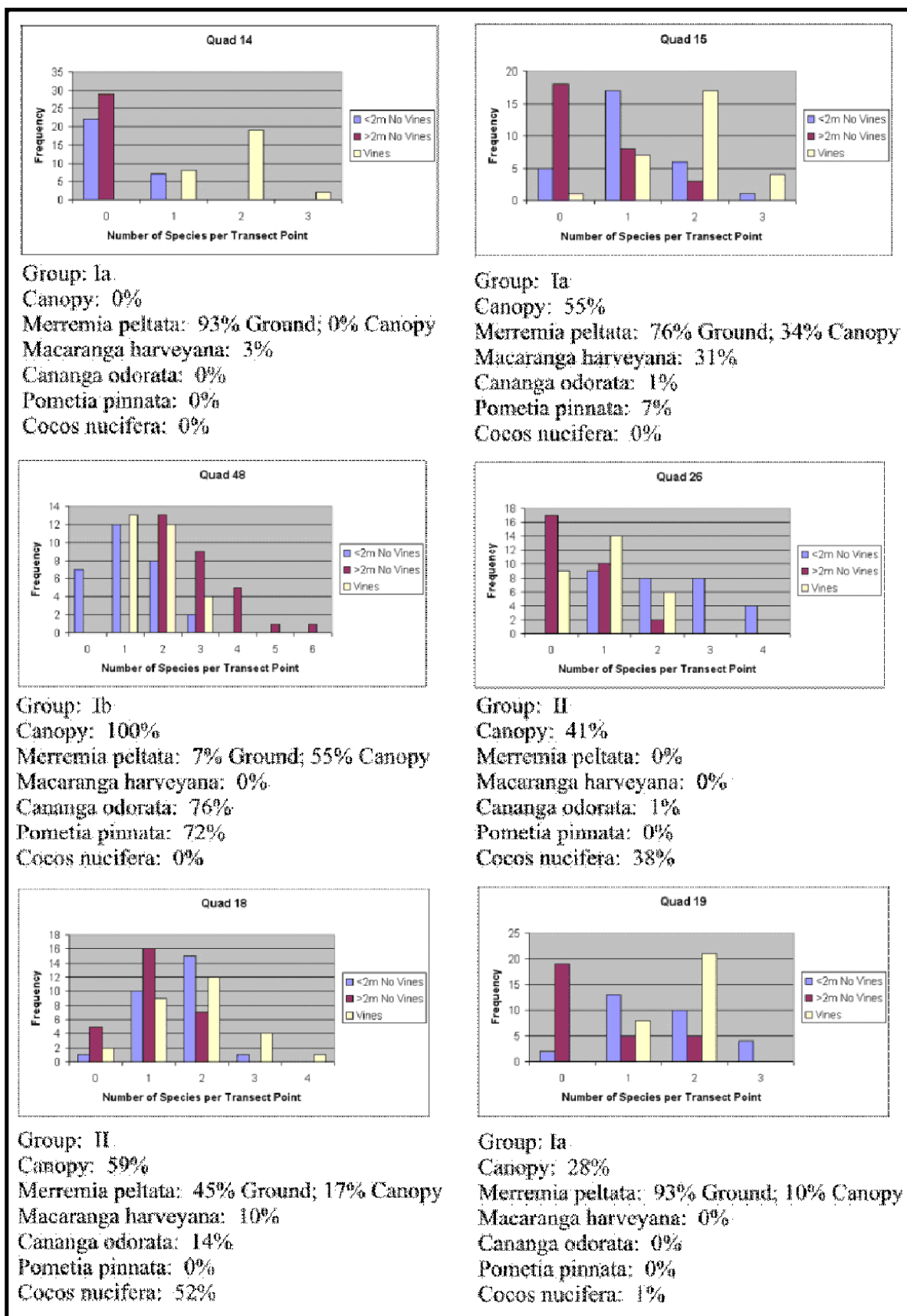


Figure 6. Structure of vegetation communities.